PB83-107318

Access Management for Streets and Highways

Implementation Package
FHWA-IP-82-3

June 1982

U.S. Department of Transportation

Federal Highway Administration

FOREWORD

This Implementation Package explains how to apply various design and traffic control techniques for reducing the frequency and severity of traffic conflicts at driveways. Warrants are provided for applying the techniques along with methods for evaluating them.

Research on access control is included in the Federally Coordinated Program of Research and Development as Project 1J, "Improved Geometric Design."

The "Access Management for Streets and Highways" report was prepared by PRC Voorhees. It includes guidance for establishing a comprehensive access management program, and a review of the access policies of Wisconsin, Pennsylvania, and Colorado.

Additional copies of this report can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

R J Betsold

R. J. Betsold
Director
Office of Development

NOTICE

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

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-IP-82-3		PB83 107318

4. Title and Subtitle	5. Report Date
Access Management for Streets and Highways	June, 1982
	6. Performing Organization Code
7. Author(s) John W. Flora, Kenneth M. Keitt	8. Performing Organization Report No.
9. Performing Organization Name and Address PRC Voorhees 1500 Planning Research Drive McLean, Virginia 22102	10. Work Unit No. (TRAIS) 31J3253
	11. Contract or Grant No. DTFH61-80-C-00085
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration Office of Development, Washington, D.C. 20590	13. Type of Report and Period Covered Implementation Package June, 1980 - January, 1982
	14. Sponsoring Agency Code HDV-21 P-0315

15. Supplementary Notes Access control studies are included in the Federally Coordinated Program of Research and Development as Project 1J, "Improved Geometric Design." Mr. George Pilkington is the Research Manager and Mr. Michael Robinson is the Implementation Manager.

16. Abstract

Access management is an effective technique for reducing traffic conflicts associated with driveways and intersections. Most highway agencies have a comprehensive access management policy, but current practices show a wide variation in effectiveness. Therefore, to further promote and encourage effective access management techniques, this report on "Access Management for Streets and Highways" was developed.

The report provides design details and traffic operation methods for reducing the frequency and severity of traffic accidents at driveways. Evaluation techniques along with warrants are provided to aid in the selection of the appropriate control measure. Guidance for establishing a comprehensive access management program along with a review of the access policies for the States of Wisconsin, Pennsylvania, and Colorado are included in the report.

17. Key Words	18. Distribution Statement
Access Control, Driveways, Access Management, Highway Design, Traffic Operations	Unrestricted- This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	221	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

Table of Contents, Continued

LIST OF FIGURES

List of Figures, Continued

LIST OF TABLES

List of Tables, Continued

CHAPTER I. INTRODUCTION

GENERAL

This course, entitled "Access Management for Streets and Highways," was prepared by PRC Voorhees for the Federal Highway Administration. For additional information on this course, contact an FHWA division office or the National Highway Institute, Federal Highway Administration (HHI-2), Washington, D.C. 20590.

COURSE DESCRIPTION

"Access Management for Streets and Highways" is a training course designed to acquaint highway personnel with the safety and operational effectiveness of various access management techniques. The course contains a review of the existing programs and techniques in general use relative to their advantages/disadvantages from a technical, social, economic and political standpoint. The necessity of a comprehensive access management program which involves legislative, technical and enforcement components is discussed as well as how various agencies are involved and the necessary coordination.

Emphasis is placed on design guidelines for specific techniques utilized to manage access. Warrants for the use of different techniques are provided. Methods used to evaluate the techniques from an engineering, operational, and economic standpoint are also stressed.

Application to existing as well as proposed roadway systems is included and the differences in approach explained. Site plan review, an important element of an access management program, is discussed in the context of administrative procedures as well as technical considerations.

To enhance its utility as a working reference, literature sources are included in the appendix. Design guidelines, as well as other useful references, are also included as appendices.

COURSE OBJECTIVES

It is important that the participant understands the value of access management and the advantages/disadvantages associated with the actions involved. Primarily, the course is designed to prepare the participants to be able to:

- Assess the safety and operational impacts of alternative access management techniques.
- Select the design, location and control devices associated with access programs.
- Review permit applications for appropriate features.
- Recognize the various elements involved in developing and executing an effective access management program.

COURSE ORGANIZATION AND MATERIAL

This textbook comprises the principal source document and is intended not only to serve during the course presentation but also as a continuing reference. Handout material will be distributed, as needed, to supplement the text. Slides and vu-graphs will be used to illustrate major points in each session.

During lecture periods, emphasis will be placed on group participation to elicit comments on current practices from various jurisdictions and geographic areas. Course participants are urged to contribute to each subject area by giving their ideas and relating case studies with which they are familiar.

SCHEDULE AND PROCEDURES

Table I.1 gives the course outline and suggested daily schedule. In actual practice the schedule will be flexible with more or less time being spent on individual sessions depending on the interest of the participants.

Table I.1. Course Outline

FIRST DAY

<u>Session 1:</u>

Introduction

<u>Session 2:</u>

Need for Access Management

- Technical
- Social
- Economic
- Political
- Legal

Benefits of Access Management

- Operational
- Safety
- Economic

<u>Session 3:</u>

Elements of a Comprehensive Program

- Legislation
- Technical
- Enforcement
- Coordination of Involved Agencies

<u>Session 4:</u>

Existing Comprehensive Programs

<u>Session 5:</u>

Retrofit Programs for Existing Roadways

SECOND DAY

<u>Session 6:</u>

Techniques for Access Management

<u>Session 7:</u>

Design Guidelines

<u>Session 8:</u>

Evaluation of Techniques

- Engineering
- Operational
- Economic

THIRD DAY

<u>Session 9:</u>

Workshop on Application of Techniques

<u>Session 10:</u>

Review of Workshop Results

<u>Session 11:</u>

Site Plan Review

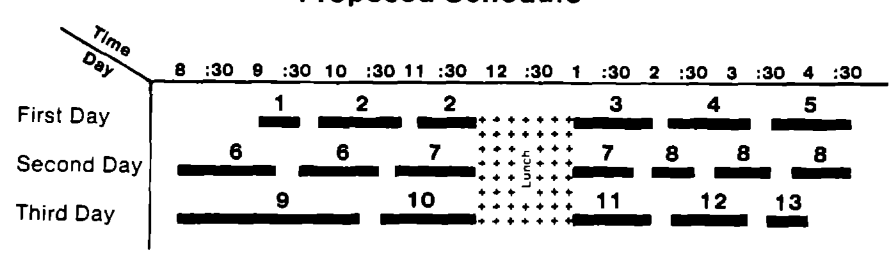
<u>Session 12:</u>

Site Plan Review Workshop

<u>Session 13:</u>

Summary and Evaluation

Proposed Schedule



Legend:
#indicates session number
blank area indicates break

CHAPTER II. NEEDS AND BENEFITS

NEED FOR ACCESS MANAGEMENT

Management of access, or lack of it, is best illustrated by the miles of strip commercial development so often found along major arterials throughout the country. Figure II.1 provides a typical example of this type of development.

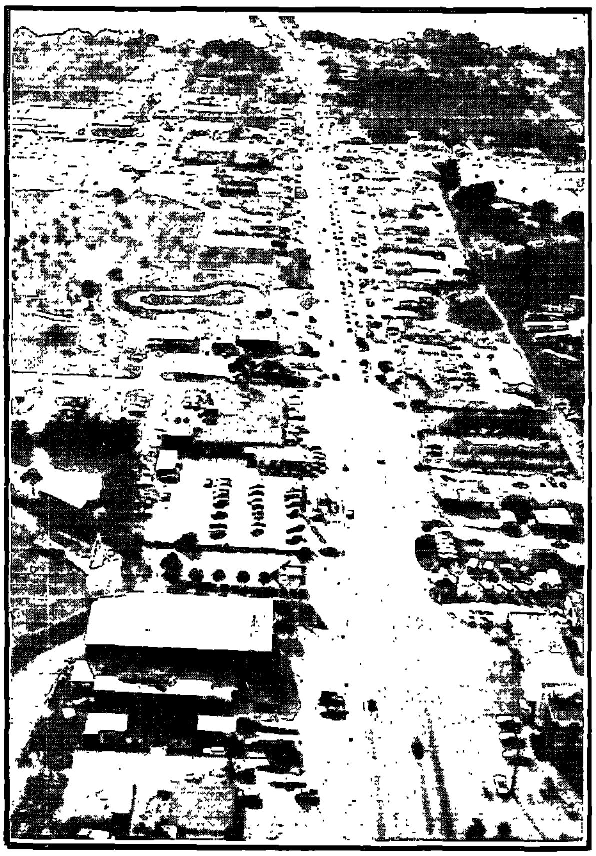


Figure II.1. Strip Development

Without an access management program, the normal chain of events involves a cyclical program that requires constant capital investment for roadway improvements and/or relocation. This cycle, graphically shown in Figure II.2, is a result of continually trying to satisfy traffic demands which are often a result of increased business activity, which is influenced by improved traffic conditions, which leads to further traffic demands.

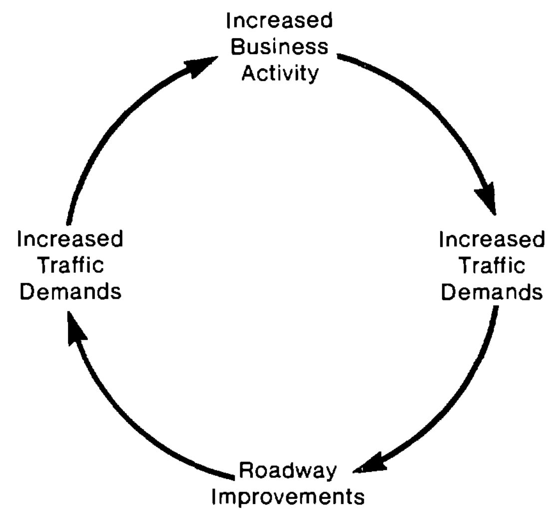
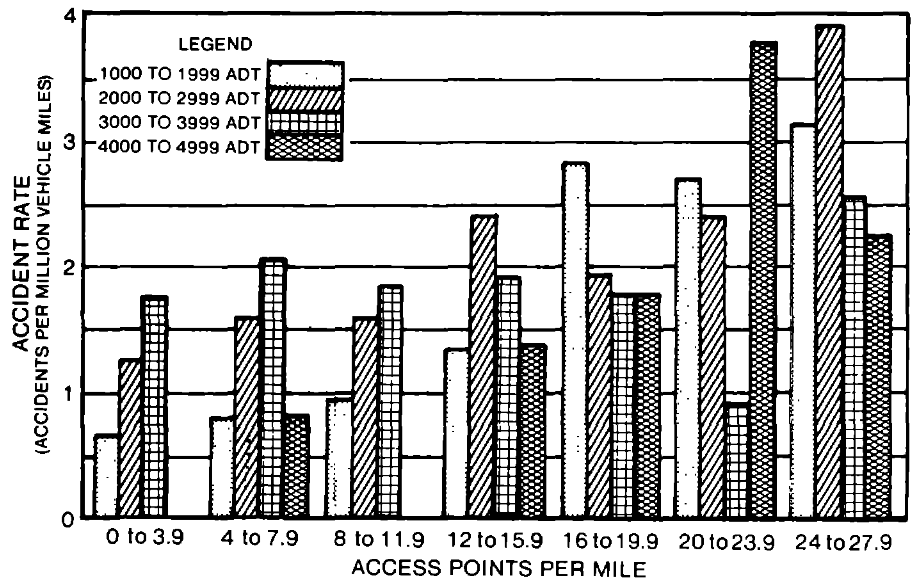


Figure II.2. Business Growth and Roadway Improvement Cycle

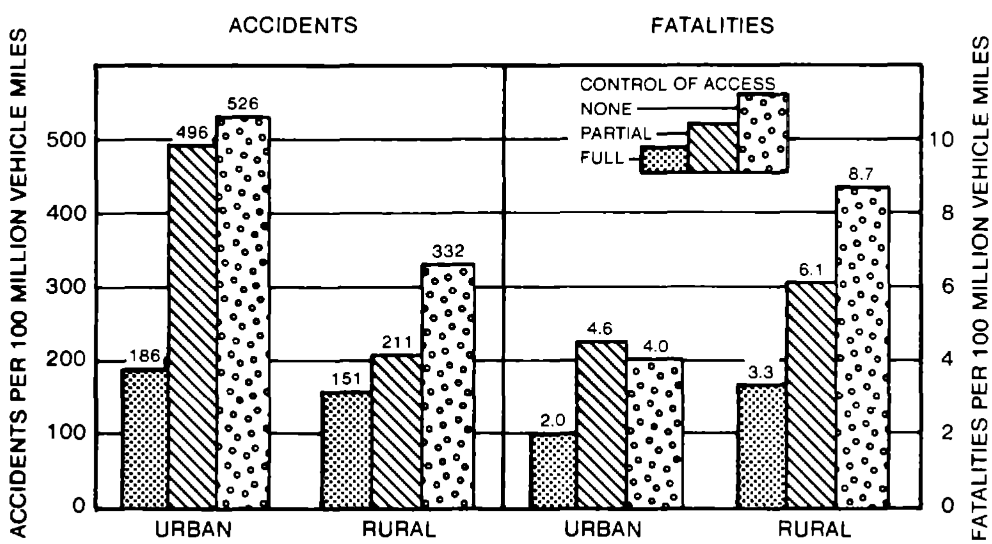
In these situations, however, it is not necessarily the increase in traffic volume which instigates the demands for widening or relocation of the facility. The number of potential conflict points among vehicles rises as a result of an increasing number of driveways, causing the capacity at a specific level of service to diminish. Vehicle delay increases, and safety and comfort are reduced.

Figure II.3 shows a comparison of accidents for roadway sections with different traffic volumes and access point frequencies. Figure II.4 illustrates the effect of access control on accidents and fatalities. Though drawn from different studies, both show a generally increasing accident rate as the number of access points increases.



Source: Reference 1.

Figure II.3. Accident Rates for Road Sections With Different Traffic Volumes and Access Point Frequencies



Source: Reference 2.

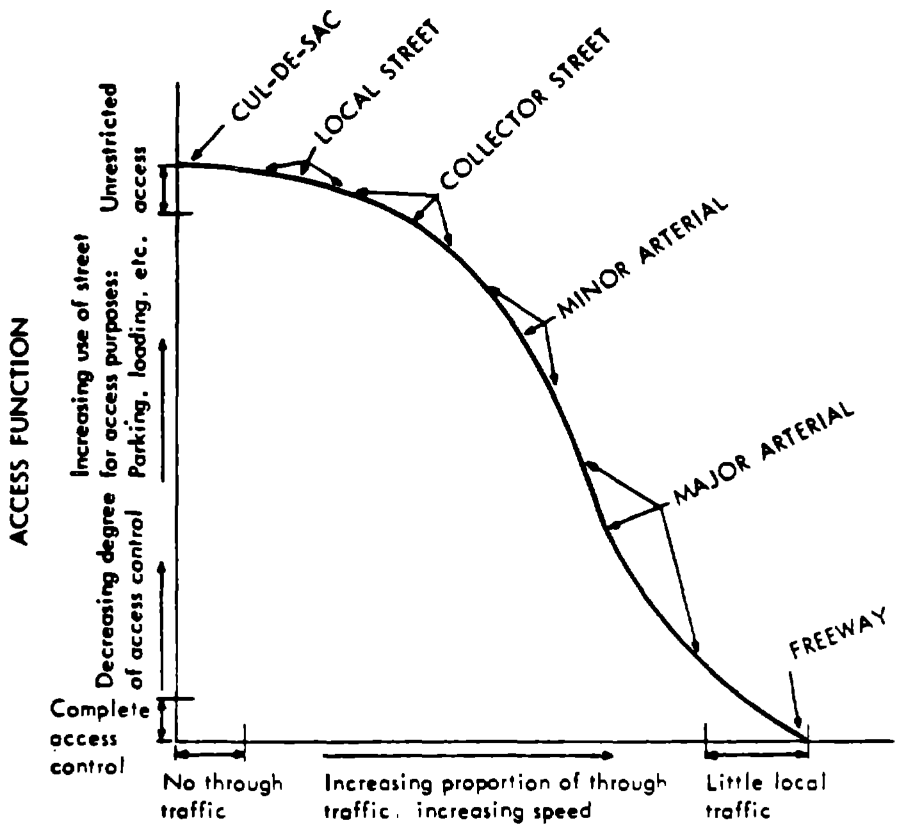
Figure II.4. Effect of Control of Access on Accidents and Fatalities in Urban and Rural Areas

In addition to dramatic improvements in safety, traffic management techniques related to access control also substantially reduce delay.

The importance, therefore, of an access management program is to preserve highway safety and capacity by providing an economical alternative to the more costly, time-consuming and socially disruptive roadway reconstruction or relocation.

TRAFFIC SERVICE VERSUS ACCESS TO PROPERTY

The conflict between the safe and efficient movement of traffic and access to abutting properties has long been recognized as a limiting constraint in traffic operations and transportation systems management. Where maximum efficiency of traffic movement is achieved, direct access to the roadway is limited and, conversely, minimal restraint on roadway access severely reduces the safe, efficient movement of through traffic. Figure II.5 graphically displays the relationship of these two functions relative to the accepted functional classifications of the roadway system. Where the safety and efficiency of traffic movement have been clearly defined as being of highest priority, highway designers and administrators have had little trouble in defining the need, policies and standards essential to obtaining necessary control of access



Source: Reference 3

Figure II.5. Relationship Between Control of Access and Traffic Movement

(i.e., freeways). Likewise, at the other end of the scale, property access is clearly the dominant characteristic of local streets such as cul-de-sacs. The components of the roadway system lying between these two extremes on the scale, however, are subject to a wide variety of policies and standards. As a result, they vary substantially among jurisdictions across the country.

Application of access control techniques to this "middle classification" of streets--collectors and arterials--is often a controversial issue among the individuals and agencies affected. Property owners generally feel that a condition of ownership implies certain property rights to adjoining road facilities and that any change in access patterns will be detrimental to business. Highway officials, charged with maintaining the safety and traffic-carrying capacity of the roadway system, are often accused of being insensitive to the needs of property owners and the community when they propose the use of access management procedures. Local community governments, while concerned with safety and traffic movement, are also concerned with the establishment of substantial industrial or commercial development in order to provide a sound tax base. Major roadways through a town provide an ideal location for this development, and any restrictions on access to these highways is often intepreted as interference with their ability to attract potential industries or businesses. On the other hand, almost all recognize that strip development along arterials is generally unattractive and blighting, and undesirable to a community in spite of the potential benefits it may bring.

It has become clear that neither of the extremes in the traffic service versus access control curve is applicable to arterial and collector streets, and highways. A balanced, comprehensive program which provides reasonable access while maintaining safety and efficiency in traffic movement is therefore essential.

ACCESS CONTROL TECHNIQUES IN USE

Investigation of policies in the various states reveal that the prevalent access control techniques in use today are those associated with commercial driveways. Table II.1 illustrates the regulatory techniques used by many states in controlling commercial entrances.

Table II.1. Current State Policies on Driveway Standards

- Twenty-one states require a minimum width for driveways; most common range is between 20 feet and 30 feet.
- Forty-three states restrict the maximum width of driveways; most common range is between 40 feet and 50 feet.
- Thirty-seven states require a minimum turning radius with variance dependent on rural or urban conditions; most common for rural is 10 feet to 20 feet and most common for urban is 2.5 feet to 5 feet.
- Forty states restrict the minimum skew angle for commercial driveways; most common range is between 60° and 90°.
- Twenty states restrict the minimum setback distance which is typically about 10 feet to 15 feet.
- Thirty-nine states require a minimum spacing between driveways; typical range about 10 feet to 25 feet for urban areas, and about 25 feet for rural areas.
- Thirty-seven states have a minimum standard for corner clearance; typically about 20 feet to 25 feet for urban areas, and about 40 feet to 50 feet for rural areas.

Elimination of entrances is also a technique in common use today. It is used primarily where no curbing exists and free ingress and egress are common along the entire length of the roadway. Sometimes done in conjunction with, or as a result of, drainage improvements, the construction of curbs with selected access points along the property frontage greatly reduces the potential conflict points. Pima County, Arizona, like many other areas, is presently involved in such a program.

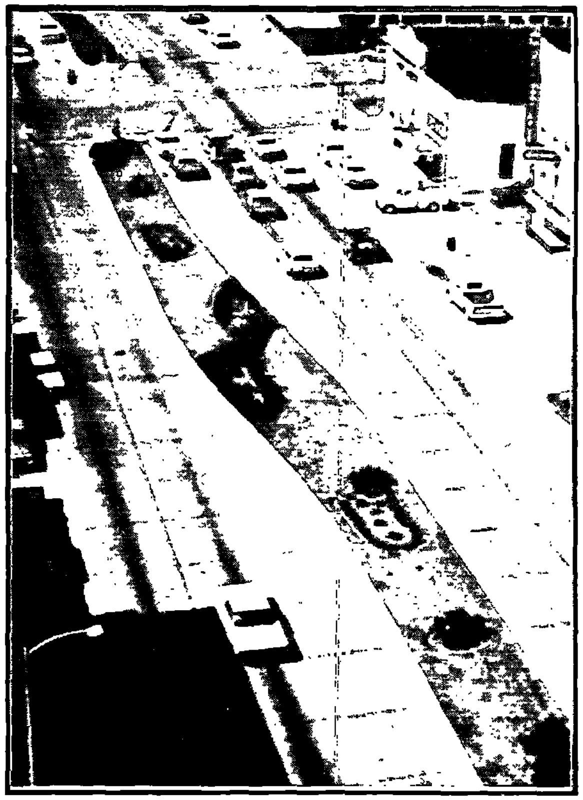


Figure II.6. Median Barrier With Alternating Left-Turns

The use of medians is also a widespread technique used to manage access. Medians are used to control and shelter left-turn movements (involved in 70 percent of all driveway accidents) and generally serve to channelize and organize traffic (Figure II.6).

In developed urban areas, however, installation of medians has often met with resistance from abutting businesses and the use of two-way, left-turn lanes are being used in many of these situations (Figure II.7). While not as effective in preventing left-turn movements, they do remove the left-turning vehicle from the through traffic lane and result in substantial reduction in delay to through traffic and usually a 35 percent reduction in accidents.

Figure II.7. Two-Way Left-Turn

Another widely used access management technique, although not usually recognized as such, is the requirement for adequate internal design and provision for circulation on commercial sites. This is important in moving vehicles quickly onto and off of streets and keeping extraneous circulating vehicles out of the traffic stream (Figure II.8).

Other techniques widely used include the removal of parking to improve

Figure II.8. Internal Circulation Provisions

sight distance at driveways and channelization of entrances and exits to control access points (Figure II.9). Frontage (or service) roads are also often used to provide an optimum degree of access management with respect to accommodating roadside development while providing efficient and safe traffic flow. Not applicable in many situations due to right-of-way restrictions and high costs, they do, however, provide for concentration of access/egress to the main roadway while providing reasonable access to abutting properties.

SOCIAL, ECONOMIC AND POLITICAL PROBLEMS

In the process of implementing access control measures, problems or considerations of a non-technical nature often arise. Depending on the jurisdiction (state or local) and formality of control standards, uniformity may not be maintained in the interpretation, application and enforcement of control measures. Nationwide, the comprehensiveness of access control guidelines runs from one end of the spectrum (little or none) to the other (rigid standards); the structure for approving and reviewing applications is just as broad.

As most access control programs are presently structured, the lack of consistency and interjurisdictional coordination presents the greatest problems.

This lack of consistency is primarily a result of the fact that most policies are based on a set of given standards which are to apply to all situations. Where they appear not to apply, the reviewing official is authorized to make changes or exceptions based on good engineering judgment. Depending on the individual, his training, and his

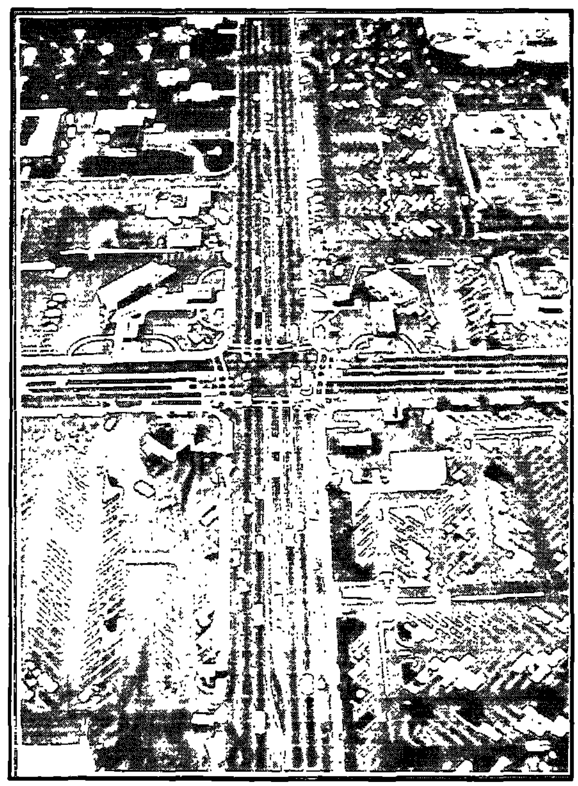


Figure II.9. Control of Access Points

perception of the problem, this can lead to a variety of treatments to similar situations and is often perceived by the public as being arbitrary. Where standards have been developed based on the flow of traffic, roadway classification and development characteristics, there is less need for the reviewing official to deviate from policy, and greater uniformity and applicability result.

Interjurisdictional coordination, or more realistically the lack of such, is another major problem. Though most states have policies that apply to all roadways in which there is state financial involvement, access control regulations and the manner in which they are administered vary considerably between the state and localities and among the localities themselves. Consequently, decisions rendered on each level are subject to differing points of view and considerations. Unfavorable decisions against commercial establishments, or lack of uniformity in application of existing control measures, often result in business relocation considerations or unsightly strip development along commercial arterials. Either case may have an adverse effect on property values and future development potential within a corridor.

Political pressure is exerted on officials when unfavorable decisions are rendered or when the effect of an access control action threatens the perceived stability, habit or status of an established community. For instance, changes which affect accessibility to commercial or industrial developments could conceivably affect future expansion, land values, or business volumes. Controls implemented with these consequences would definitely serve to stir opposition from the targeted community; often resulting in legal battles which incur unwanted monetary expenditures, loss of time and political ill-will.

The lack of comprehensive, site-specific guidelines which can be applied uniformly across all jurisdictions is the major disadvantage of most policies currently in use.

LEGAL CONSIDERATIONS

In the consideration of an access management program, a number of questions arise as to the legal position of the jurisdiction in placing restrictions on access to abutting property.

Zeiring (5) stated that the owners of land abutting arterial highways (other than limited access highways) have as a condition of ownership, certain property rights relating to highway access. While the interpretation of these rights varies slightly from state to state, a general doctrine of the rights of abutters can be drawn from judicial decisions and judicial interpretation of existing statutes.

A critical issue in the interpretation of this right is the extent to which the state or highway authority can restrict this right before the abutter's rights have been compromised, and the state must make financial compensation to the landowner.

As shown in Table II.2, abutters are not entitled to unlimited access, only to reasonable access. The number and location of access driveways to a particular land parcel may be regulated by the highway authority. Also, the access permitted to an abutter may be indirect or circuitous; that is, an abutter may be required to travel a longer distance than desired to get to his property because of one-way streets, median barriers, or service roads. In addition, direct access to a highway may be denied if the abutter still retains reasonable access to the highway through the local street network. Determination of when access limitations are "reasonable" has generally been left to court interpretation on a case-by-case basis. Finally, reasonable restrictions on the design and construction of the driveway itself are appropriate uses of government regulatory power.

Table II.2. Compensatory and Non-Compensatory Access Restrictions and Regulations

Abutter Entitled to Compensation if:	Abutter Not Entitled to Compensation if:
1. All access to the highway network is totally denied;	1. Access is circuitous, or regulated reasonably;
2. Access permitted him is insufficient for the "highest and best use" of property;	2. Access restrictions are sufficient for the "highest and best use" of property;
3. Special injury is incurred to one specific property through access restrictions;	3. No special injury is suffered;
4. Highway frontage, if the otherwise landlocked property is rebuilt as limited access facility;	4. New limited access facility is constructed on new right-of-way;
5. Highway improvements damage his use of property through relocation of access points.	5. Highway improvements require site design or parking area changes through relocation of access points.

Source: Reference (5)

Netherton (1), in reviewing case law dealing with the introduction or upgrading of access control on existing facilities, found a sharp contrast between the way improvements within the traveled way were treated as oppposed to the way those improvements in the margin were treated.

They indicate that the prohibition of turns, designation of one-way streets, and rerouting of traffic constitute a legitimate exercise of the police power and do not constitute compensable damages. For example, in the case of Department of Public Works and Buildings vs. Maybee, Illinois, May 1961, a median was constructed in an existing roadway in front of a service station. In denying compensation, the court followed the theory that where the property owner's free and direct access to the lane of traffic abutting his property has not been taken or impaired, there is no taking. Once on the highway, he is in the same position and subject to the same police power as every other member of the traveling public. However, when the access control measures are applied to the margin of the traveled-way or the right-of-way (e.g., curbs, fences, refusal to permit driveway cuts, driveway closures, etc.), or when the facility is reconstructed at a wider cross section, the use of the police power becomes more controversial.

The access rights of abutters are protected by one general principle: the access granted to an abutter must be suitable for his property to be developed to its highest and best use. For example, the owner of a shopping center cannot be restricted to a driveway of a size normally considered standard for a single residential home because it would not allow him to handle the large traffic flow normally associated with such development. If any land parcel is zoned for industrial or commercial development, or if there is a significant probability that the zoning might soon be changed to one of these designations, the property owner must be permitted access suitable for the type and quantity of traffic normally expected as a result of such development.

This obviously implies that there should be a strong relationship between the capacity and design of a highway facility and the zoning designation of adjacent property. Because these two factors are frequently under different jurisdictions, however, this relationship is frequently unclear or nonexistent.

An abutter is not entitled to direct access to new limited access highways or freeways. However, if an existing highway is redesignated as a limited access way, or if a new limited access road is constructed on the right-of-way of an existing uncontrolled facility, then the owner is entitled to compensation for the loss of direct access. Finally, if an abutter has access to a highway that is in some way deficient or dangerous to the general public, that access can be revoked without requiring compensation. Additionally, if a highway department makes corridor improvements and decides to relocate existing access driveways as part of the improvement program, the abutter must pay all costs for laying out his property to use the designated access points. These two factors provide state highway departments with considerable leverage in making improvements to existing highways where unsafe access patterns currently exist.

As stated, however, legal interpretations in each state can vary. Local legal counsel should be involved in the development of any particular program.

BENEFITS OF ACCESS MANAGEMENT

A well-conceived, comprehensive access management program can save lives and reduce costs to motorists without resorting to large investments of capital funds for massive reconstruction. By implementing one or a combination of prescribed traffic management techniques which serve to minimize the adverse effects of vehicle conflicts, safety can be improved, delays reduced, and major capital expenditures postponed or eliminated.

The actions that can be taken to manage access fall mainly into four categories:

- Limiting the number of conflict points
- Separating basic conflict areas
- Limiting deceleration requirements
- Removing turning vehicles or queues from sections of the through lanes

Implementation of techniques within these categories can have a substantial impact on accident and delay reduction. Table II.3 provides an indication of the general benefits that can be derived from a range of access management actions.

The benefits or disbenefits associated with adequate levels of access control can be quantified by evaluating user costs, accident costs, and costs associated with implementing needed highway improvements. User costs are measurable in terms of savings received utilizing highway or street facilities. Elements of user

Table II.3. General Benefits of Access Control Management Techniques

- Two-way left-turn lanes: 35 percent reduction in total accidents (12, 13).

- Alternating left-turn lanes: 28 percent reduction in total accidents (14).

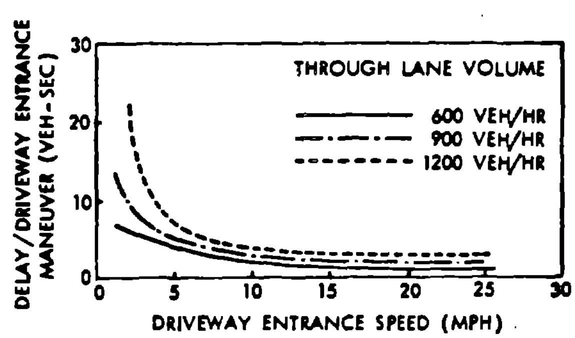
- Driveway width controls: 0.40 accidents reduced annually per driveway (15).

- Visual cues for driveways: Suspended red-yellow flashing beacon at a single commercial driveway --53 percent reduction in total accidents; advance warning sign and flashing beacon--24 percent reduction in total accidents; and driveway illumination--42 percent reduction in total accidents (16).

- Left-turn deceleration lanes: 50 percent reduction in total accidents (8, 9).

- Driveway accident breakdown: Right-turn enter--15 percent of total accidents; right-turn exit--15 percent of total accidents; left-turn enter--43 percent of total accidents; left-turn exit--27 percent total accidents (15).

- Delay versus driveway, entrance speed (17).



- One-way operations: 25 percent reduction in total accidents (6); 25 percent reduction in delay (10).

- Parking: 15 percent reduction in total accidents by preventing parking on the traveled way (10, 19).

cost measurement can be made by considering: passenger delay, fuel consumption, tire wear, oil consumption, maintenance costs, accelerated depreciation, and air pollution. Costs associated with these elements have been estimated at $4.50 per hour per vehicle (4). In a national Highway Traffic Safety Administration study (7), average accident costs were estimated at $2,800 per vehicle.

As an example, using these figures, it is estimated that the installation of a two-way, left-turn lane could reduce accidents 35 percent and produce a monetary savings as a result of delay reduction of approximately $31,000 per year on a roadway with average daily traffic in excess of 15,000 vehicles and 30 to 60 driveways per mile (4). Specific benefits relative to accident reduction and savings in delay are further considered in Chapter VII for various access control techniques.

The social and environmental aspects of the use of access management techniques must also be considered. When roadways are widened or relocated to new rights-of-way, dislocation of people and business is often the result. Natural features and landscaping are sometimes altered to the detriment of the community. Many access management techniques offer a viable alternative to this costly and often unpopular reconstruction.

The following discussion gives several examples of the effectiveness of some of the techniques.

Case Study 1

This case study involved measures taken to correct a problem that was occurring in the area of an entrance to a major shopping mall (1,250,000 square feet). A diagram of the location is shown in Figures II.10 and II.11. In this case the problem was caused by vehicles coming off the freeway ramp and trying to cross two lanes of traffic and make a left turn into the shopping mall. Vehicles performing this maneuver were stopping at the end of the ramp while waiting to get across the through lanes. They were also blocking the through lanes of Route 123 when the left-turn lane would fill up as was generally the case.

Due to the speed (45 mph speed limit) and high volumes on Route 123, there was both a safety and delay problem present. The off-ramp was experiencing delay from the stopped vehicles, and Route 123 was experiencing backups over one-half mile long during the p.m. peak.

In order to correct this problem, two actions were taken by the highway department. The first action was to separate the left-turning vehicles from through vehicles by constructing a channelizing island between the left and through lanes. A channelizing island was also constructed between the right through lane and the ramp acceleration lane. These two islands physically prevented vehicles from the off-ramp crossing into the left-turn lane. Figure II.12 shows the location of the islands. Once vehicles from the

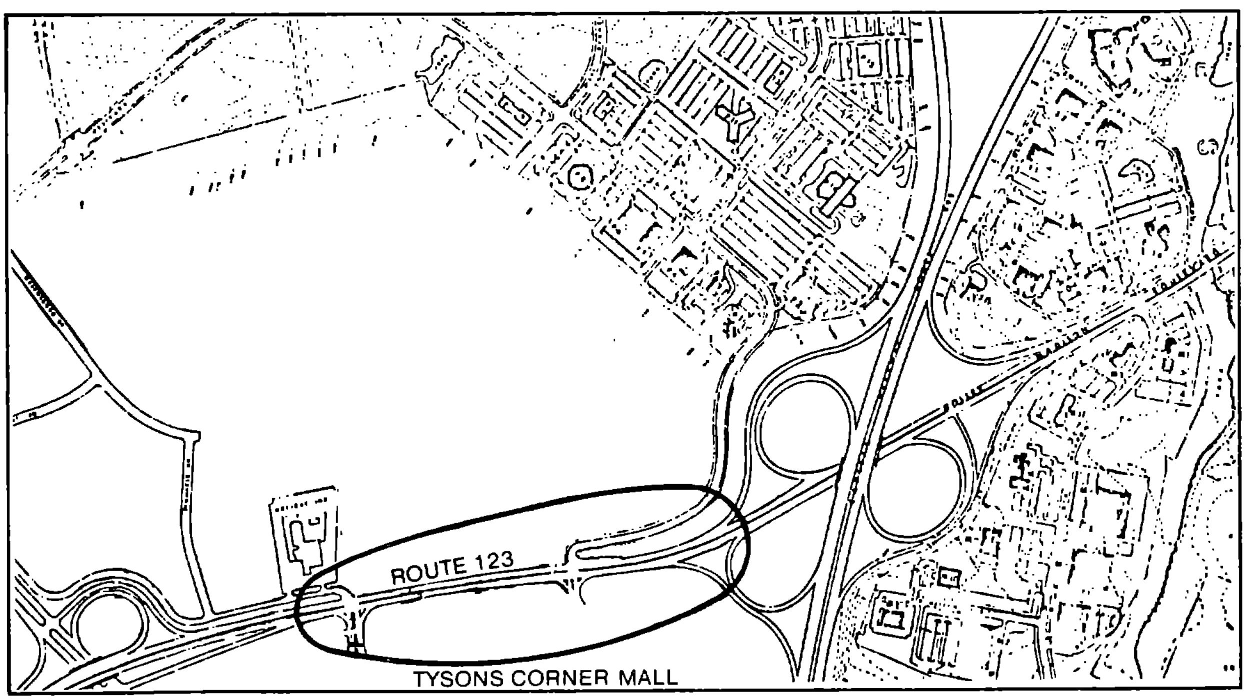


Figure II.10. Site Location

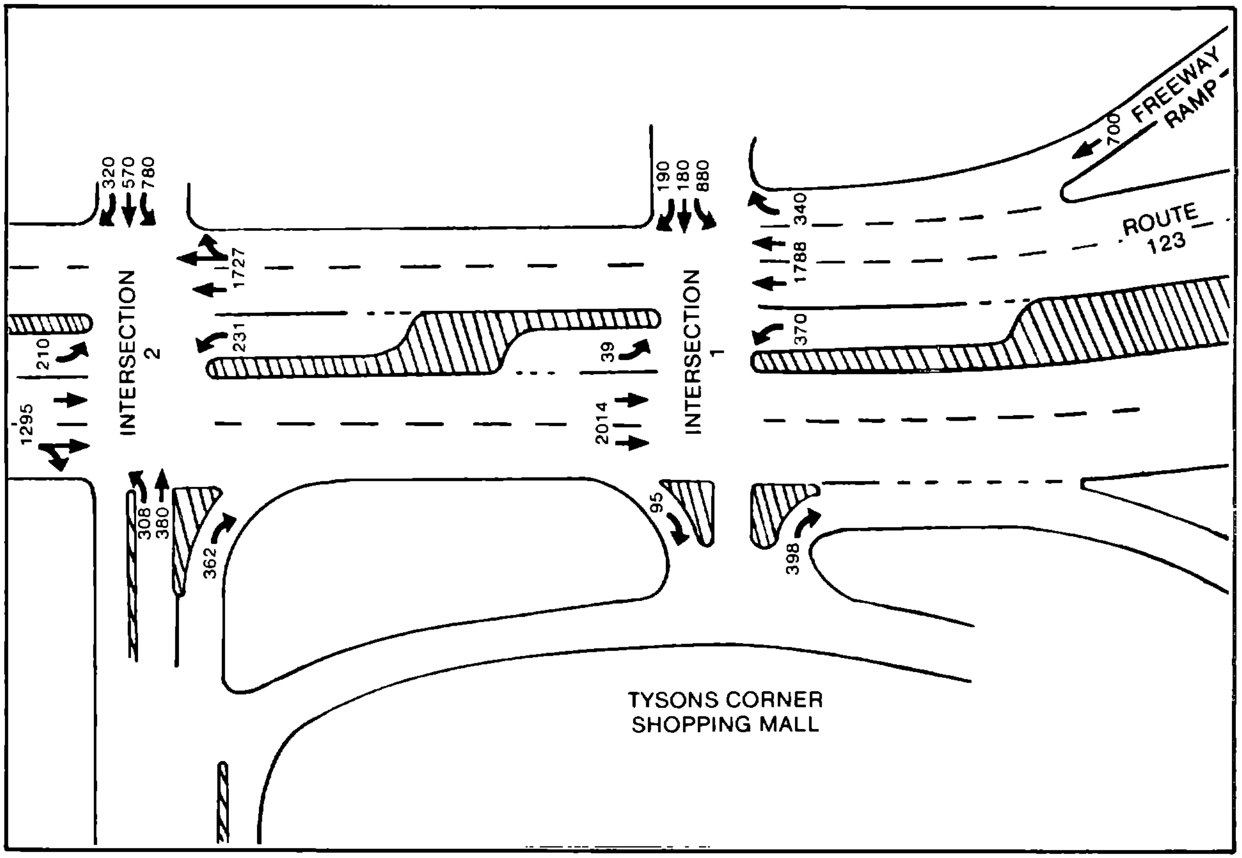


Figure II.11. Plan View Before Modifications

off-ramp were prevented from entering the left-turn lane, there was a slight problem of illegal left turns being made from the left through lane. Increased police enforcement in the area was initiated to control the illegal turns.

As can be seen in Figure II.11, there was another access to the mall at the next intersection. The second action taken by the highway department was to realign Route 123 at the second intersection to provide a dual left turn into the mall. This action provided additional storage capacity for left turns at the second intersection so there would not be a spillback problem created by the diverted left turns. This new alignment is shown in Figure II.12.

Case Study 2

This case study is an example of a traffic engineering department's efforts to control the access at a median crossover serving an entranceway which serves the Arlington Hall Army Intelligence Building. A location sketch of the site is shown in Figure II.13. In a five-year period there had been 24 accidents located in the immediate area of the median crossover at the main gate entrance to Arlington Hall (Figure II.14). Twenty-two of these accidents were either westbound vehicles

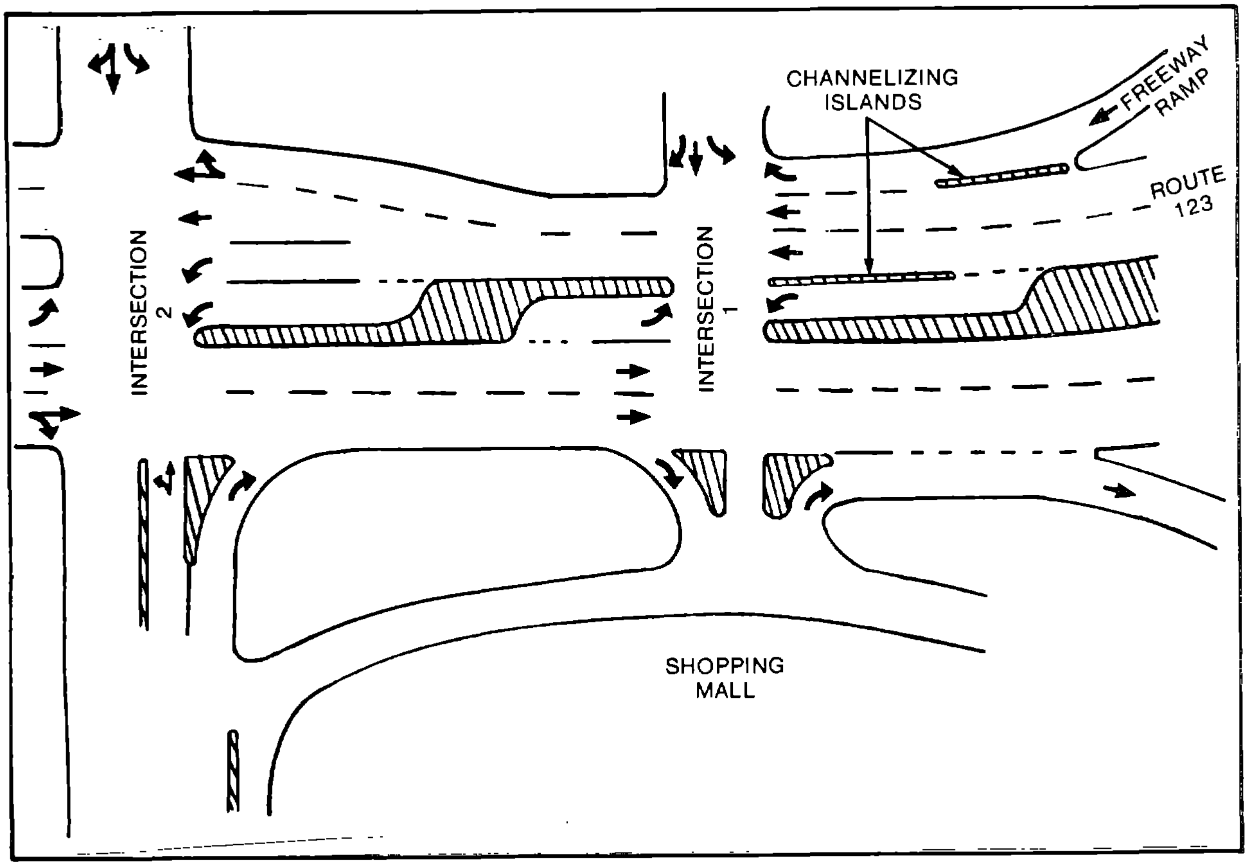


Figure II.12. Plan View After Modifications

involved in a rear-end collision or westbound vehicles making left turns into the entranceway. The remaining two accidents involved left-turn vehicles leaving Arlington Hall and colliding with westbound vehicles.

Due to the number of accidents occurring at this location, the Arlington County Traffic Engineering Division decided that the median crossover should be closed to prevent westbound vehicles from turning left into Arlington Hall and also to prevent vehicles exiting Arlington Hall from making a left turn onto westbound Arlington Boulevard. Therefore, barrels were placed in the median to prevent use of the crossover.

In a ten-month period following the placement of the barrels, only one accident occurred, this being a rear-end collision in the westbound direction. Although accidents were greatly reduced at this location, the problem had not been solved. In a ten-month period prior to closing the crossover, there had been fifteen accidents at the intersection of Arlington Boulevard and George Mason Drive. In a ten-month period after the closing of the crossover, the number of accidents at this intersection increased to 36.

In this case, the traffic engineers recognized a problem at the Arlington Hall entrance that was due to an unrestricted median crossover. The severe impacts on

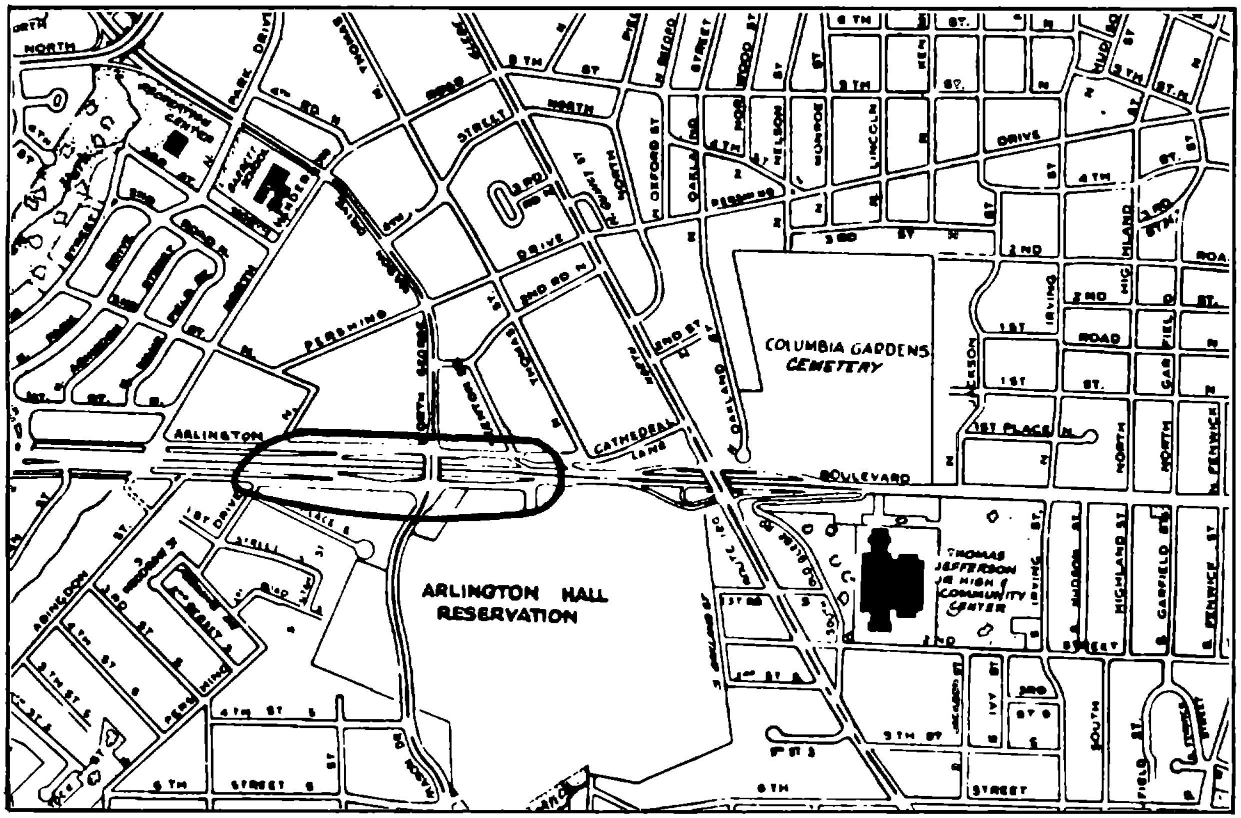


Figure II.13. Site Location

the George Mason Drive intersection caused by solution for the Arlington Hall problem were not anticipated, however. This action created a capacity problem at the intersection of Arlington Boulevard and George Mason Drive. With the increase in accidents at the George Mason Drive intersection, this intersection became the number one accident location in the county. This segment of Arlingotn Boulevard was later improved with the construction of a grade-separated interchange at George Mason Drive.

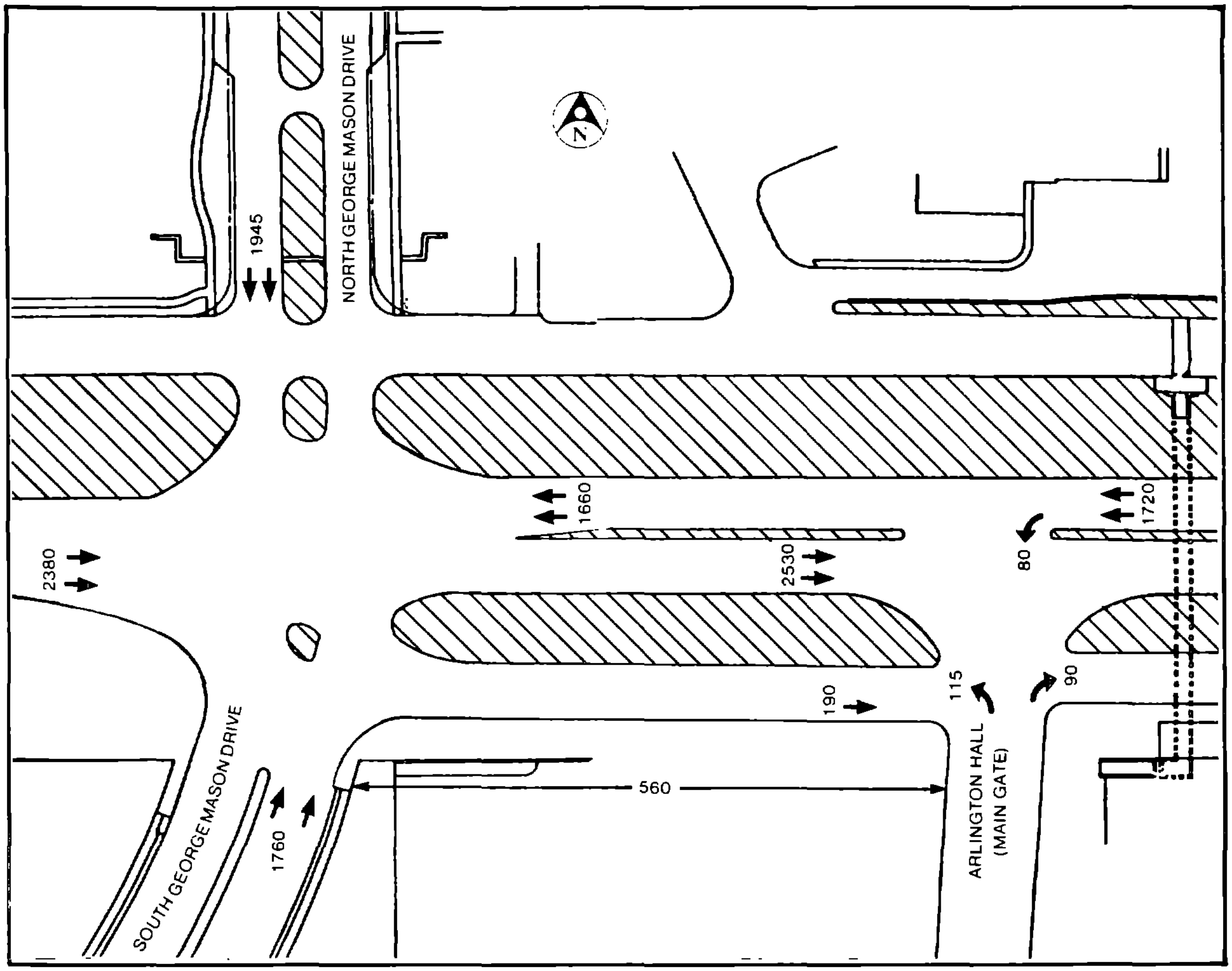


Figure II.14. Plan View with Peak-Hour Volumes

CHAPTER II REFERENCES

1. Staffield, P. R. "Accidents Related to Access Points and Advertising Signs in Study," Traffic Quarterly, January 1953.

2. Box, P. C. "Traffic Control and Roadway Elements--Their Relationship to Safety-Chapter 5, Driveways, Highway Users Federation for Safety and Mobility (1970).

3. A Policy on Design of Urban Highways and Arterial Streets -- 1973, American Association of State Highway Officials.

4. FHWA-RD-76-85, "Evaluation of Techniques for the Control of Direct Access to Arterial Highways," August 1975.

5. Zeiring, E. A. "Highway Access Management: Preserving Public Investment in the Highway Network." Presented at 59th Annual Meeting, Transportation Research Board, Washington, D.C., 1979.

6. Netherton, Ross D. "A Summary and Reappraisial of Access Control," Highway Research Bulletin 345, 1962.

7. National Highway and Traffic Safety Administration. "Need to Improve Benefit/Cost Analysis in Setting Motor Vehicle Safety Standards," July 1974.

8. Wilson, James E. "Simple Types of Intersection Improvements," Highway Research Board Special Report 93, 1967.

9. Jorgensen, Roy E., and Associates, Inc. "Evaluation of Criteria for Safety Improvements on the Highway," 1966.

10. Bruce, John A. "One-Way Major Arterial Streets," Highway Research Board Special Report 93, 1967.

11. Carmody, Douglas J. "Second Year Report: Modesto's One-Way Streets," Street Engineering, Vol.5, No. 3, March 1960.

12. Sawhill, R. B., and D. R. Neuzil. "Accidents and Operations Characteristics on Arterial Streets with Two-Way Median Left-Turn Lanes," Highway Research Board Record 31, 1963.

13. Ray, J. C. "Installation of a Two-Way Median Left-Turn Lane," Traffic Engineering, March 1961.

14. Thomas, R. C. "Continuous Left-Turn Channelization and Accidents," Traffic Engineering, Vol. 37, No. 3, December 1966.

15. Box, Paul C. "Driveway Accident Studies, Major Traffic Routes, Skokie, Illinois," Unpublished, 1968.

16. Tamburri, Thomas N., et al. "Evaluation of Minor Improvements," Highway Research Record 257, 1968.

17. Stover, Vergil G., et al. "Guidelines for Medial and Marginal Access Control on Major Roadways," NCHRP Report 93, 1970.

18. Box, Paul C. "The Curb Parking Effect," Public Safety Systems, Vol. 33, No. 1, January/February 1968.

19. Michigan Department of State Highways, Traffic and Safety Division. "Evaluation of Four Safety Projects," TSD-G-207-72.

CHAPTER III. ELEMENTS OF A COMPREHENSIVE PROGRAM

NEED

The planning for streets and highways is becoming an integral part of the comprehensive planning process of jurisdictions rather than just an adjunct or coordinated procedure. As such, it becomes important that the continued serviceability of a facility be assured through the inclusion of an access management program in this planning process.

A major problem that often exists in access management today is lack of coordination among the various levels of government. It is not unusual for severe ambiguities to exist in respective access control policies at state, county, and city levels.

Construction and maintenance of most major arterials usually involves State financing in some form. While most states retain some control over these roadways, it is often left to the local jurisdictions to regulate access. Local agencies regard commercial development as essential to a sound tax base, and conflicts between the desire to maintain the design capacity of the roadway and the need to serve business often develops. Ideally, a balance needs to be established so that funds provided for construction of a roadway network are not eroded, and local communities can encourage well-planned growth.

In many instances, governmental roots are such that there is often resentment by local governments to the exercise of controls on a state level. Where state funds are involved, however, a strong case can be made for a legitimate effort to maintain the integrity of the use of those monies.

The establishment of an access management program, developed with the cooperation of all affected jurisdictions, is needed as a first step. The content and form of this program are critical and must recognize the different problems associated with developed and undeveloped areas, and be responsive to the needs and problems associated with urban and rural environs. The policy cannot be so restrictive that it ignores the need for development, yet it should provide a basis for maintaining the quality of traffic flow for which the facility was designed.

The major elements of a viable access management program can be described under four main categories:

- Legislation
- Technical
- Enforcement
- Coordination among agencies

LEGISLATION

The development and adoption of an access management policy is the first essential step toward effective access management.

This policy establishes the goals of the program and defines the mechanisms through which these goals will be accomplished. This policy also serves to unify the various agencies within a jurisdiction which must be involved and to assign responsibility for implementation.

Another important aspect of a clearly-defined access policy is the legal basis which it may create. Through a realistic statement of objectives and goals, access management is tied to transportation needs and the welfare of the general public. It also provides for more uniform application of regulatory measures, thus minimizing the argument by many opponents that they are being arbitrarily discriminated against.

If the program is to work, it must be developed in such a manner as to be suitable under a matrix of design conditions and traffic characteristics. Techniques and regulations suitable to rural areas may not be feasible in urban areas, and goals may differ between the two. The policy must be developed with a common objective and described around parameters such as roadway function, traffic characteristics, and physical and locational conditions. To try to impose the same guidelines on an urban arterial that may be applicable to a high-speed rural facility may lead to loss of valuable economic development, but more often, it leads to arbitrary exceptions which, in the course of time, serve to destroy the program.

Several agencies have adopted policies which base access control on the type and character of roadway as well as traffic conditions. Generally the format of a policy will include:

- Authority and purpose for program establishment
- Designation of administering authority
- Categorization of roadways to determine extent and application of access control
- Procedures for application for access to roadways
- Appropriate design guidelines

As an example of those subjects contained in an access management policy, Table III.1 provides the Table of Contents for the State Highway Access Code recently adopted by Colorado. This policy is presented in its entirety in Appendix B.

Roadway Categories

After establishing the legal basis for the program--authority to act, purpose, goals--an important step in policy development is the categorization of all roadways in the highway system. By developing categories based on roadway character, type and traffic service characteristics, access controls can be more reasonably applied as the situation requires. This provides for greater uniformity and reduces the number of instances where exceptions must be made when the controls do not fit the situation. The categories may vary to accommodate local conditions; however, generally, they provide a functional description of the roadway and a greater or lesser degree of access control as warranted by the road function.

The following describes five typical categories of roadways:

1. Category One, a freeway with access permitted at determined interchanges.
2. Category Two, a divided parkway or expressway with well-spaced intersections and usually frontage roads where necessary to limit direct access.
3. Category Three, a medium-to-high speed primary or other major arterial and includes most major two-lane and multi-lane roadways in rural and urban areas.
4. Category Four, a slower speed arterial or secondary highway in a developed area where the amount of existing adjacent development, existing cross streets and driveways would make it very difficult to impose the higher standards of Category Three.

Table III.1. Table of Contents State Highway Access Code State of Colorado

TABLE OF CONTENTS

State of Colorado
State Department of Highways
4201 East Arkansas Avenue
Denver, Colorado 80222

5. Category Five, major and minor collector streets and others not suitable for the higher control categories.

The primary differences between the five access categories is whether direct private property access is permitted and if so where, and the spacing between intersecting streets and roads and traffic signals. Category One permits only freeway interchanges and entrance ramps with other public streets and roads and no private direct access. Category Two is similar to One except that intersections with public streets and roads are permitted provided they are at least one-half mile apart. Private property access is put onto frontage roads unless a temporary exception is necessary when no reasonable alternative is available.

The majority of non-freeway major arterials are in Category Three. In rural areas, individual properties will be permitted direct access to the highway when there is no reasonable access to other local roads. Direct access will be kept to a minimum. In developed and developing areas, a strong effort will be made to direct all private access to local streets and roads. Cross streets with the highway will be limited to one-half mile intervals where feasible. This arrangement helps maintain the roadway at a higher speed limit with greater traffic capacity and safety. It significantly reduces the number of traffic signals and congestion.

Category Four is applied only on roadway sections where existing intensive development, small parcels, and lack of an adequate supporting street network requires greater frequency of direct access to individual parcels and more frequent cross streets. Each abutting parcel is allowed direct access to the highway provided it can be safely designed. Public street intersections are as frequent as one-quarter-mile spacing.

Category Five is restricted to collector streets. The amount of access permitted in this category is consistent with collector design.

Examples of typical criteria which could be applied to each category are shown in the Colorado State Highway Access Code presented in Appendix B.

These categories are established by joint consultation of officials from all affected jurisdictions and all roadways are assigned a relevant category. It is important that agreement be reached on assignment of particular roadways to each category.

Access Permit Applications

The legislative aspect of a comprehensive program also contains the requirements and procedures for obtaining a permit from State and local officials for access to a roadway. The policy states the necessity of obtaining a permit, procedures and general time frame involved in the application, and gives the location(s) where such applications may be made. Figure III.1 provides a graphic view of a permit application process. This is provided as an example only. It must be altered to suit jurisdictional conditions.

This process should provide ample opportunity for the reviewer and applicant to meet and discuss details of the application, particularly in cases where provisions of the application necessitate denial.

In some areas, the local government assigns the permit review and issuance process solely to the State government. In these cases, application should be made directly to the appropriate State official. Copies of action taken should be sent to the locality upon completion of review so officials will know if a permit was issued or denied in their area. Again, as in the case where application is made to the locality, provision should be made in the

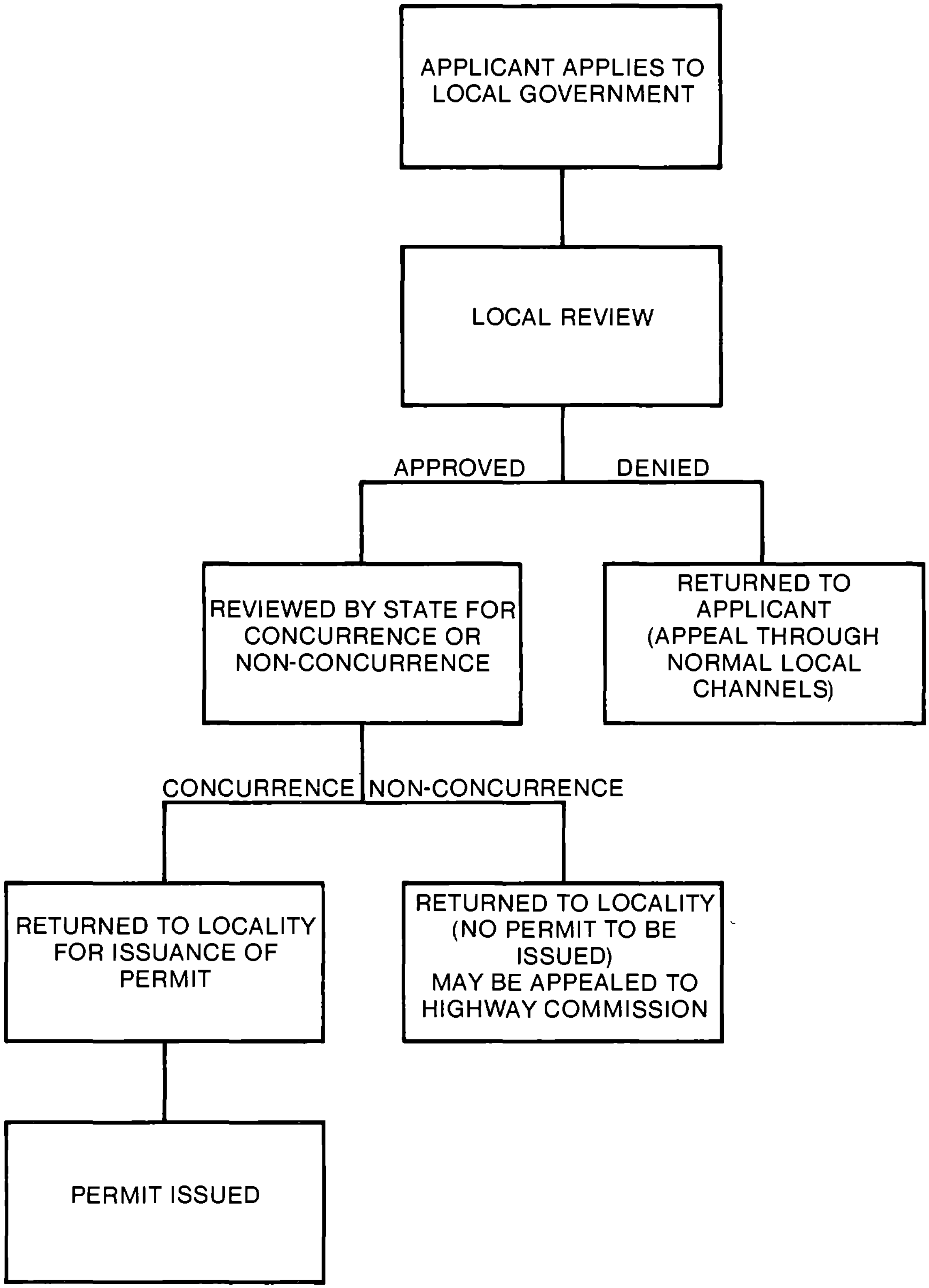


Figure III.1. Example of Permit Application Process

policy for meeting with the applicant, particularly in those cases which may result in denial.

Variance

Most agencies recognize that conditions will occur which may place undue hardship on an individual if the guidelines of an access policy are strictly followed. Consequently, provisions should be made for review of each situation and variations made within prescribed guidelines based on the sound application of engineering principles and judgment. These variations must be carefully applied and controlled; however, it is essential that the policy has provision for the inevitable exception.

TECHNICAL

The second major element in a comprehensive access management program is the technical provisions. These are the criteria and guidelines which must be established to control the number, location, and design of access points on a roadway. Chapter VI discusses the various techniques which have proven useful in access management, and Appendix A provides design guidelines for these techniques. Adoption of guidelines is essential if the program is to be uniformly and fairly implemented. There are two major advantages to having complete written guidelines. First, implementation is more consistent and uniform inasmuch as all reviewers are following the same criteria with less personal bias. Second, the public is aware of what will be required when buying or developing a parcel of land and/or submitting application for access.

ENFORCEMENT

Enforceability of a program is also a critical consideration during its development. There must be provisions for monitoring adherence to regulations and for taking action against violators. The enforcement process should not be unduly expensive or so cumbersome that the responsible agencies become lax. This will inevitably lead to the dissolution of the program.

Most access control techniques associated with highway operations and design, (unless they require additional rights-of-way or encroach onto private property) can be implemented and enforced with police powers. An abutter must comply with regulations necessary for efficient traffic movement. Thus when access is indirectly restricted by median strips, one-way streets, crossovers, curbs, guardrails, driveway permits, and parking ordinances, the restriction is a consequence of highway operational control and is a legitimate result of police powers needed to manage traffic movements.

Access control techniques having to do with driveway location or driveway design can be implemented with police power if the intent of the technique is merely to regulate access. These techniques, however, are more successful if they are made general policy.

Eminent domain is another source of enforcement authority used by State and local governments. Eminent domain empowers the jurisdictional authority to appropriate private property rights when it is deemed necessary in the best interests of the public at large and is generally used to take land for some public purpose. It also requires that compensation be made to the property owner for the damage done or property taken. An obvious example of eminent domain is the taking of land for the construction of a highway, but eminent domain can also be used more subtly to allow the "purchase" of access rights to an existing roadway.

Access can be restricted as long as these restrictions do not interfere with the abutter's use of his property. As soon as the restrictions become too strict, the individual's property rights have been damaged, and he is entitled to compensation. Under eminent domain, access regulations can be established that would otherwise be considered illegal because payment is made to the property owner for excessive damage done through those regulations. Therefore, where State or local governments deem it essential for the public welfare that access be restricted past the point where the land can be developed to its highest and best use, it can invoke eminent domain to pay the landowners for the damage done by the loss of access.

The disadvantage of eminent domain is that the amount of compensation required may be quite large. Where access is denied an otherwise landlocked parcel, all development on the site has effectively been prohibited, and the State or local jurisdiction, for all practical purposes, must buy the land from its owner. For a site that might potentially have contained a large commercial or industrial development, this could be prohibitively expensive. In addition, excessive use of eminent domain would not be acceptable to local governments who may wish to encourage development.

Policy development should include consideration of how its provisions will be enforced. Will there be enough manpower to adequately follow up and inspect construction to assure compliance with permit requirements? This could be a major consideration in whether the process is administered at a State or local level. Experience has shown that without followup to check on compliance, the program soon collapses.

COORDINATION AMONG AGENCIES

Within any jurisdiction there are a number of agencies directly or indirectly involved in access management. The recognition of the roles played by these agencies and coordination to assure consistency in the administration and enforcement of access management techniques is a requirement in the development of a comprehensive program.

The following administrative processes, often under several different agencies, are usually involved in access management:

- Zoning Regulations
- Subdivision Approval
- Site Plan Review
- Issuance of Building Permits
- Issuance of Occupancy Permits
- Issuance of Driveway Permits
- Street Design and Construction

Zoning

Many localities have several effective access control techniques included in their zoning regulations. These regulations often reflect support for the driveway or curb-cut regulations that have been established, either by duplicating those design requirements or by stating requirements for compliance with driveway permit standards. It is particularly important that local zoning codes affirm different sets of design standards for different types of development; the establishment of different regulations for different land uses is a long-established and well-accepted function of zoning regulations.

The following statement from the Zoning Ordinance of the City of Chesapeake, Virginia, provides a typical illustration:

> Section 4-1.3 Barriers Required, Ingress, Egress
>
> A. Curbs, walls, fences or similar devices shall be located along the perimeter of parking lots, garages, and storage areas,

except at entrances and exits indicated on approved parking plans.

B. Such barriers shall be so designed and located to prevent parked vehicles from extending beyond property lines of parking lots and garages and to protect public rights-of-way and adjoining properties from damaging effects of surface drainage from parking lots.

C. Parking lots, garages and storage areas shall be designed and constructed so that all maneuvering to park and unpark can take place entirely within property lines of lots, garages and storage areas.

D. The use of streets, sidewalks, alleys or other public rights-of-way for parking and maneuvering to and from off-street parking spaces is prohibited except where such maneuvering is necessary in the use of driveways for access to and from single-family and two-family dwellings in residential or office districts.

E. Ingress and egress to parking areas shall be limited to driveway entrances and exits specified in parking area plans as approved by the Department of Public Works.

Of particular importance is the requirement that all manuevering be done on-site.

Zoning is also used as an effective tool when a developer seeks to change the designated use of his property to a use which would attract more traffic. While rezoning cannot normally be conditioned on the provision of public works improvements, it is quite often denied because of the lack of adequate facilities to handle the proposed use.

Building set-back lines and cone-of-vision areas are often prescribed in local zoning ordinances.

Subdivision Approval

The subdivision approval process affords authorities the opportunity to control access to major roads. Techniques included in most subdivision regulations provide for:

- Establishing minimum building set-back distances from major highways or reference right-of-way lines
- Minimizing connecting points with major roadways
- Requiring internal street systems of adequate capacity to serve generalized traffic
- Assuring adequate frontage to provide proper ingress/egress

Portions of the subdivision statutes for the State of Wisconsin are also presented in Appendix C as an example of how this process is used to manage access.

Site Plan Review

Prior to issuance of permits for improvements, many jurisdictions require that the plan for physical site improvements be reviewed by applicable agencies. This usually includes those responsible for traffic management and gives them the chance to regulate access point location or design. Modifications can be required that reduce or eliminate the adverse impact that poorly-designed access could have on the roadway.

Building Permits

Prior to issuance of a building permit for all structures other than one- or two-family dwellings, many localities require written certification from the applicable agency that the site plan has been reviewed and approval is granted. As described in the previous paragraph, site plan review includes review of proposed access. The building permit proccess, therefore, is another means of assuring that access has been adequately considered.

Occupancy Permit

Many cities require the issuance of a Certificate of Use and Occupancy whenever the use of a structure changes. This certificate is granted only after approval of various agencies including those responsible for traffic management. Access control techniques can be required to offset projected adverse impacts on traffic.

Driveway (Curb-Cut) Permits

The single most-widely used process for controlling access to public streets is the driveway permit process. Generally, prior to construction of any type of access point to a public street, a permit giving approval to do so must be acquired from the governmental agency with responsibility for the roadway. Plans must be submitted, and general guidelines for geometrics and construction followed. While potentially a powerful tool for access management, the guidelines are often too general and lack comprehensiveness. Coupled with a lack of consistent implementation, this process seldom provides the degree of benefit which it is capable of producing. Excerpts from the St. Charles, Missouri, ordinance related to driveway permits are included as a reference in Appendix D. Wording and driveway specifications vary with different jurisdictions; however, the general intent is the same.

CHAPTER IV. EXISTING PROGRAMS

RANGE OF CURRENT POLICIES

At the present time, all states and many local jurisdictions throughout the country have some type of policy to regulate access to the roadways under their respective control. The comprehensiveness of these policies and the degree to which they are applied differ widely however.

Some jurisdictions, both state and local, feel that each situation is so unique that a comprehensive body of law concerning access control would be too restrictive. Their policies simply state that access to the roadway can only be had after obtaining a permit from the governing body. This permit process and any standards prescribed are usually based on "sound engineering judgment". Few, if any, general conditions or standards are legislated, and each situation is reviewed and administered according to the individual judgment of the reviewing official.

Other jurisdictions have taken steps to classify all roadways and prescribe written standards for access based upon roadway function and traffic characteristics.

The majority of states, cities, and counties, however, fall somewhere between these two categories. A policy is adopted which requires a permit for access to the roadway. Provision is made for review based on general standards for driveway widths, spacing and location with respect to an intersection. Very few of these standards, however, are based on traffic characteristics and roadway function.

In an attempt to exercise tighter control over the location and design of access points, some states have devised other means of controlling access locations. In Oregon, for example, access points have been assigned to all land parcels abutting state highways, whether or not any development has taken place. This guarantees that all spacing and design guidelines can be safely met, and requires potential developers to consider the location of the access point as a constraint in site design. There also exists a somewhat different permit process through which landowners can request additional or relocated access driveways, subject to the approval of the highway commission.

Many cities across the country such as Portsmouth, Virginia, New Orleans, Louisiana, and Kansas City, Missouri, use the site plan review process to control access construction. No building permits for commercial construction will be issued without approval of the driveways by the agencies responsible for traffic movement.

Broward County, Florida, requires a "no access easement" to be dedicated alongside all new roads that are submitted for approval for plot recordation. Anyone wishing access to property abutting this roadway must apply to the County for approval which will be granted or denied based on general standards and application of good engineering judgment.

Most local jurisdictions practice some form of access control management without adoption of a formal policy. Zoning ordinances prescribe set-back lines for buildings to be constructed adjacent to a roadway; they often contain general requirements for driveway widths, and distances from intersections. Subdivision regulations seek to prevent irregular lots with inadequate frontage for access, and usually limit access points to a major roadway. Site plan review, generally established by ordinance, often prescribes certain conditions relative to geometric design, spacing, frequency, and location of driveways.

The variations in policy comprehensiveness and implementation in jurisdictions around the country stem from many factors. It has only been in the relatively recent past that the importance of access control has begun to be realized by the majority of traffic system managers and others engaged in the movement of traffic. The difficulty in adopting and implementing a policy that would work in a variety of situations (i.e., urban areas versus rural areas) and the lack of adequately trained manpower have also contributed to the lack of viable programs.

Adoption of comprehensive policies has also been hampered by interjurisdictional disagreement. Many cities feel that the regulations sought by state agencies are too restrictive; that they would be detrimental to the commercial or industrial development essential to their economy. They feel that they need greater flexibility to deal with unusual situations. The states, however, feel that they have a heavy monetary investment in the construction and maintenance of many streets within the cities and that they have a right and an obligation to the public to see that these investments are protected.

Experience in many cities and states, and discussions with the authorities in various agencies indicate that even where a written policy exists, there is often a wide variation in the way it is actually administered. The policies are usually so general that the entire approval process is left up to the "good engineering judgment" of local representatives to make whatever adjustments or recommendations they feel are most appropriate for the particular situation. This often leads to different levels of access control even within the same jurisdiction and provides a strong case for opponents who claim the policies are discriminatory and arbitrary.

Another major problem, particularly at the state level, is the lack of adequately trained manpower to administer and enforce access management provisions. Consequently, there is often little on-site inspection or followup to determine level of compliance.

Examples of existing programs that are being used in selected areas are described in the following.

WISCONSIN

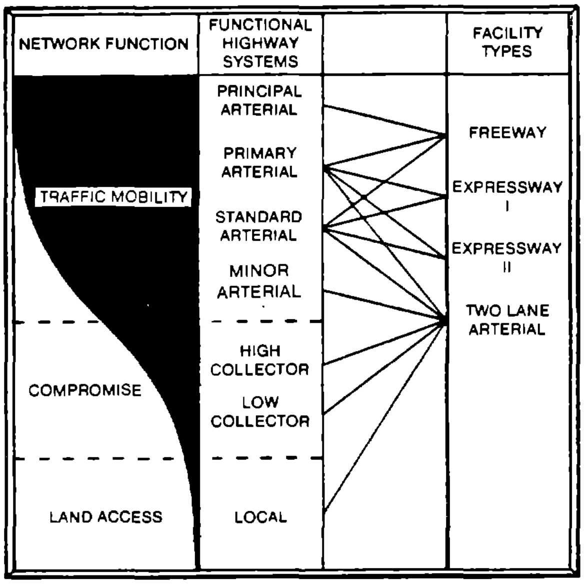
The State of Wisconsin has recognized the need for access management as a major ingredient of highway planning. "The State Highway Planning Program does not end with the production and adoption of a functional system plan. Such a plan is of little value unless refined and converted into working tools assuring its implementation. Making the functional system plan an integral part of the on-going highway development process is, therefore, essential to plan implementation."(1)

Several significant actions relating to that objective have been or are being taken by the State Highway Commission. Among these are:

> The development of access type and spacing criteria and highway design standards related to route function, level of service and traffic volume.

Essentially, the Wisconsin program provides for development of functional classification of the highway system and relates this to facility type. Utilizing these classifications, type of access control and spacing of access points is then prescribed within the plan. Figure IV.1 shows the relationship of functional highway classifications and facility types.

A concept basic to the development of the State Highway Plan has been that the level of service to be provided for each facility should be commensurate with the function of the facility. In other words, the concept assumes that the longer the trips or the more active the centers to be served by a facility, the higher should be the level of service provided; i.e., principal arterials should provide higher levels of service than primary arteials, primary arterials higher than standard, and so on down the functional ladder.



SOURCE: State Highway Commission of Wisconsin.

Figure IV.1. Relationship of Functional Highway Classification Systems and Facility Types

For simplicity, the State Highway Plan relates level of service to average operating speed, though a more precise definition would include such other factors as traffic interruptions, freedom to maneuver, safety, driving comfort and convenience, and operating costs.

Several geometric design features plus the traffic volume of a highway facility combine to produce an actual level of service for that facility. Thus, only when these features meet or exceed certain criteria for the particular traffic volume and route function, can the highway designer be assured that his product will produce the desired level of service. The features most critical to level of service are those relating to points of access, to widths and types of roadway, surface, and to geometrics of grade and curvature.

Thus, to assure that highway improvements would be so designed as to implement the level of service objectives of the State Highway Plan, it was necessary to produce highway function-related criteria, or standards, for access type and spacing, and for geometric design standards.

Past practice in state highway design in Wisconsin had been to select pertinent geometric standards based essentially only on traffic volume variations, although topography and traffic composition had been considerations. Thus, the levels of service to be provided were generally commensurate with the volume of traffic regardless of the function of the route. Such a practice often resulted in overdesign of facilities of lower function and underdesign of facilities of higher function. It also, of course, resulted in a variable level of service on any route as the traffic volume fluctuates.

Recognition of the importance of functional systems and their dependency upon design characteristics led to the incorporation of route function in Wisconsin's latest highway design standards. These standards limit the number of design classes which may apply to any one functional system, while allowing such variance in geometric characteristics within a particular functional classification as may accommodate different traffic volume ranges without appreciable change in the level of service. These standards represent an important step in the process.

A comparable set of criteria for the type and spacing of points of access were

Table IV.1. Guidelines for Access Type and Minimum Spacing for Suburban Areas

Intersecting Highway	Major Route Under Study and Design Year ADT / Design Year ADT	Standard Arterial 20,000-30,000	Standard Arterial 10,000-20,000	Standard Arterial 3,500-10,000	Standard Arterial < 3,500	Minor Arterial 5,000-25,000	Minor Arterial < 5,000
Standard Arterial	20,000-30,000	1C					
	10,000-20,000	1C	2E				
	3,500-10,000	2E	2E	2E			
	< 3,500	2E	2E	2E	2E		
Minor Arterial	5,000-25,000	1C	2E	2E	2E	2E	
	< 5,000	2E	2E	2E	2E	2E	2G
High-Type Collector	> 2,500	2E	2E	2F	2F	2F	2G
	< 2,500	2E	2E	2F	2F	2F	2G
Low-Type Collector	> 2,500	2E	2E	2F	2F	2F	2G
	< 2,500	2E	2E	2F	2F	2F	2G
Local	> 2,500	2E	2E	2F	2F	2F	2G
	< 2,500	2E	2E	2F	2F	2F	2G
Private	All Volumes	2F	2G	2G	2G	2G	2G

Legend:

Minimum Access Spacing

A: 5 miles
B: 2 miles
C: 1 mile
D: 2,000 feet
E: 1,000 feet
F: 500 feet
G: 300 feet

Access Type

0: No Access
1: Interchange
2: At-Grade

Source: Adopted from Reference 1.

Table IV.2. Guidelines for Access Type and Minimum Spacing for Rural Areas

Intersecting Highway	Design Year ADT (Major Route Under Study and Design Year ADT →)	Standard Arterial 5,000-10,000	Standard Arterial 3,000-5,000	Standard Arterial 1,000-5,000	Standard Arterial < 1,000	Minor Arterial 1,000-5,000	Minor Arterial < 1,000
Standard Arterial	5,000-10,000	1B					
	3,000-5,000	1B	2D				
	1,000-3,000	2D	2D	2D			
	< 1,000	2D	2D	2D	2D		
Minor Arterial	1,000-5,000	1B	2D	2D	2D	2D	
	< 1,000	2D	2D	2D	2D	2D	2G
High-Type Collector	> 500	2D	2D	2E	2E	2E	2G
	< 500	2D	2D	2E	2E	2E	2G
Low-Type Collector	> 500	2D	2D	2E	2E	2E	2G
	< 500	2D	2D	2E	2E	2E	2G
Local	> 500	2D	2D	2E	2E	2E	2G
	< 500	2D	2D	2E	2E	2E	2G
Private	> 500	2D	2E	2E	2E	2E	2G
	< 500	2E	2F	2F	2F	2F	2G

Legend:

Minimum Access Spacing
- A: 5 miles
- B: 2 miles
- C: 1 mile
- D: 2,000 feet
- E: 1,000 feet
- F: 500 feet
- G: 300 feet

Access Type
- 0: No Access
- 1: Interchange
- 2: At-Grade

Source: Adopted from Reference 1.

developed. These criteria relate both to route function and traffic volume. Understandably, the frequency of allowable access decreases as the function and traffic volume increase. Similarly, the type of access (at-grade intersection, interchange, or closure or separation) varies with the function and traffic volume but in this case the function and traffic volume of both facilities must be considered. Table IV.1 and Table IV.2 were developed as guidelines for rural and suburban areas.

PENNSYLVANIA

The Pennsylvania Department of Transportation has issued regulations stating that "...no driveway, local road, or drainage facility or structure shall be constructed or altered within State highway right-of-way and no drainage facility of the Department shall be altered or connected onto without first obtaining a permit from the Department..."(2) The Regulations define a complete program including legislative authority, procedures, driveway requirements and design guidelines, and enforcement information. Figure IV.2 provides a composite of the table of contents of this document to illustrate its comprehensiveness.

In Pennsylvania, all encroachments onto state highways are required to be approved by the State Highway Department. The Regulations provide, however, that those localities who wish may review applications before they go to the State and provide comments and recommendations. The Regulations state that "...The Department will consider any comments or recommendations resulting from this review prior to approving the access permit..."

Location and design requirements are based primarily on "...the amount and type of traffic that it (the driveway) is expected to serve and the type and character of the roadway which it accesses." Driveways are separated into four categories, based on the amount of traffic they are expected to serve. A description of each classification and typical examples of land uses normally associated with each follows:

- Minimum-use driveway. A driveway normally used by not more than 25 vehicles per day, such as:

  (A) Single-family dwellings, duplex houses

  (B) Apartments with five units or less

- Low-volume driveway. A driveway normally used by more than 25 vehicles per day but less than 750 vehicles per day, such as:

  (A) Office buildings

  (B) Elementary and junior high schools

  (C) Car washes

- Medium-volume driveway. A driveway normally used by more than 750 vehicles but not less than 1,500 vehicles per day, which does not normally require traffic signalization, such as:

  (A) Motels

  (B) Fast food restaurants

  (C) Service stations and small shopping centers or plazas

- High-volume driveway. A driveway normally used by more than 1,500 vehicles per day, which often requires traffic signalization, such as:

  (A) Large shopping centers

  (B) Multi-building apartments or office complexes

Pennsylvania Department of Transportation

Regulations

67 Pennsylvania Code . . . Chapter I

Governing

ACCESS TO AND OCCUPANCY OF HIGHWAYS

BY DRIVEWAYS AND LOCAL ROADS

CONTENTS

Figure IV.2. Title Page and Contents of Pennsylvania Department of Transportation Regulations

Standards are then provided by the Department for location, width, grade, sight distance, and other design parameters based on the classification of driveway and the speed of roadway and type of traffic. Figure IV.3 provides an example of the design criteria provided which must be adhered to in access design.

The major problem facing Pennsylvania and a concern of many jurisdictions is the lack of manpower to carry out the program. Lack of adequately trained technicians at both the State and local levels precludes adequate administration and enforcement of the access management program. This is a very common problem throughout all jurisdictions and one which can only be solved through reallocation of resources as the importance of access management is recognized.

COLORADO

The State of Colorado has developed a comprehensive statewide plan which prescribes access control based on classification of the roadway according to function and traffic characteristics.

A copy of this access code is included in Appendix B. The important element to be stressed in this plan is not necessarily the individual provisions, but the coordination and involvement of all jurisdictions. Without acceptance and commitment from everyone involved, access management programs have little chance for success.

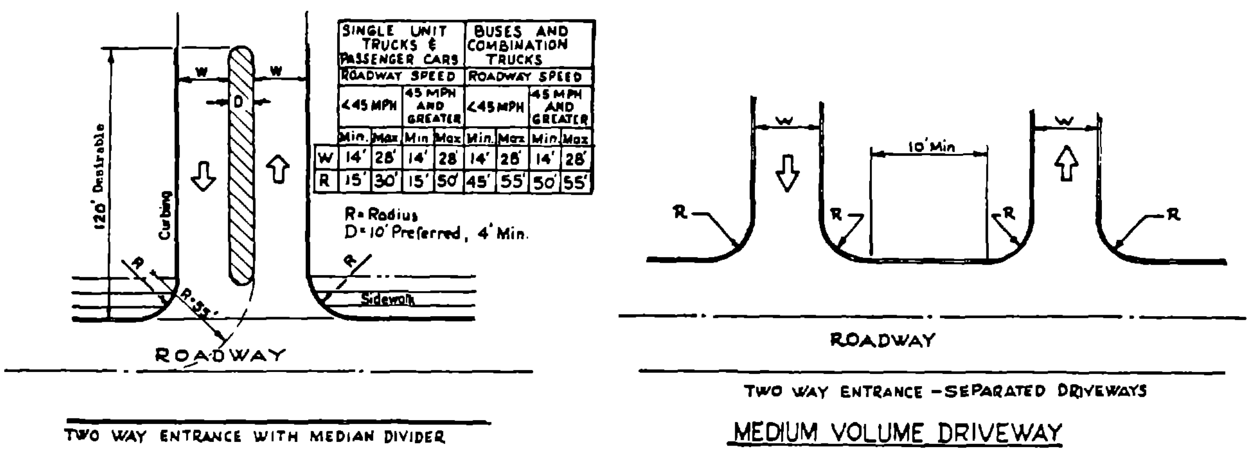


Figure IV.3. Design Criteria Example from Pennsylvania Department of Transportation

CHAPTER IV REFERENCES

1. State of Wisconsin. Wisconsin State Highway Plan, Chapter V "Highways II. The Plan"

2. Pennsylvania Department of Transportation. "Regulations Governing Access to and Occupancy of Highways by Driveways and Local Roads" (67 PA. Code. . . Chapter 1).

CHAPTER V. RETROFIT PROGRAM

The problems of applying access control to a developed arterial pose one of the greatest challenges to the traffic manager today. Many studies have documented the damaging effects that access points have on the quality of traffic flow provided by a roadway. The official responsible for safe, efficient movement of traffic is certainly aware of increasing accident rates and reduced levels of service that occur with an increase in traffic, an increase in access points, or, as is usually the case, both.

To introduce a program of access control on an existing roadway, however, is often very difficult. There could be technical problems in highly developed areas which make some access techniques physically impossible to implement. Social and political pressures will develop from those that feel that their access is being unduly restricted. There will be many situations that require comparing the cost of economic hardship to an individual to the benefits accruing to the general public.

Discussions in Chapter II concerning legal, social and political aspects of access management are particularly relevant in retrofit situations and should be thoroughly understood by those responsible for implementing an access control program for retrofit projects.

TECHNIQUES APPLICABLE TO RETROFIT PROGRAMS

There are a variety of techniques that can be used in retrofitting an existing roadway with stricter access control. The majority of these fall into four basic categories:

- Driveways
- Medians
- Frontage roads
- Miscellaneous

Driveways

Location of driveways is critical if they are not to interfere with the safety and operations of the street and sidewalk.

It is important to locate driveways away from major intersections. This constraint is as much for the ability to enter and leave the property as for the benefit of intersection safety and operations. Exiting a driveway during peak-hour conditions at traffic signals is difficult where the queue of standing or slow-moving vehicles never allows a sufficient gap for entry into the highway. Many jurisdictions place a 10- to 50-foot limit between the edge of the near driveway to curb return radius at the corner. This distance will allow the driver to properly align himself in a traffic lane before entering the intersection. It also eliminates unusual crossing angles through the pedestrian crosswalk area. It should be noted that left turns from driveways within 100 to 200 feet of a major intersection should be prohibited either by sign or by a center median. Visibility of the movement for vehicles making left turns from the cross street is poor within this area. Another locational constraint is to place driveways either at median openings or 150 feet or more from the nearest opening.

Driveway width and turning radius affect the speed at which vehicles enter or exit. The probability of vehicles entering and exiting simultaneously also makes it important that adequate width be provided to avoid blockage. For commercial driveways, many jurisdictions require a minimum width of 20 and 30 feet for one-way and two-way driveways. Maximum widths are usually between 30 and 40 feet at the property line, and 50 feet at the curb; however, these should relate to a variety of operational characteristics as is discussed in Chapter VII.

Preceding page blank

The number of driveways and spacing between them are important design elements. This desired spacing is based on several factors including function of main roadway, speeds of through traffic, and entering and exiting driveway traffic. Traffic simulation studies by Stover et al. (1) indicated that spacing of access points at distances greater than 1.5 times the distance needed for the entering vehicle to accelerate to the speed of the through traffic stream increases the absorption characteristics of the traffic stream and decreases delay to entering vehicles. Table V.1 indicates recommendations based on separate research efforts for minimizing conflicts caused by driveway spacing.(1)

While these represent desirable spacings, it is often not possible to provide such generous spacing in actual practice, particularly when trying to adapt an access control program to an existing situation.

Many jurisdictions limit the amount of frontage utilized for driveways to 60 percent; others limit entrances to one every 75 or 100 feet. What is important is limiting the access points to those that are essential for full realization of land use potential and maximum roadway efficiency. Minimum guidelines for spacing include requiring at least 24 feet between ends of driveway curb radii and 12 feet between end of radii and property line. These dimensions should be used along with applicable driveway design standards.

Essential to the control of driveway access is an effective driveway (or curb cut) permit program. Anyone wishing to create or alter a driveway must have a permit from the appropriate jurisdiction which has the authority to approve, disapprove, and assure compliance with stated specifications. The importance of maintaining adequate levels of service requires that the curb cut program receive high priority.

Table V.1. Minimum Spacing of Driveways and Other Unsignalized Access Points to Alleviate Overlapping Right-Turn Conflict Areas for Adjacent Access Points on Urban Arterials

Arterial Speed	Minimum Spacing: Glennon et al.(a)	Minimum Spacing: Stover(b)
35 mph	150 feet	100 feet
40 mph	185 feet	180 feet
45 mph	230 feet	310 feet

(a) Measured near curb to near curb based on: 8.5 fps^2 deceleration for vehicle in right-hand through traffic lane, 2.1 fps^2 acceleration from 0 mph start for 30 mph arterial speed and 1.7 fps^2 acceleration of all higher arterial speeds. Source: Ref. 2.

(b) Measured center to center of driveway based on: vehicle in right-hand lane through traffic lane cannot change lanes and decelerates 15 mph below arterial speed, vehicle exiting driveway accelerates from 0 mph to arterial speed -- 15 mph at an average acceleration of 3.1 fps^2. Source: Ref. 3.

Design guidelines concerning driveway location, spacing, number and geometric considerations are discussed in Chapter VII.

Medians

Left turns entering and exiting driveways account for the majority of total driveway accidents and a substantial amount of delay.

Box (4), in his studies in Skokie, Illinois, found that 70 percent of driveway accidents occurred from left-turning vehicles to or from a driveway. Medians, therefore, can be an effective way of eliminating this left turn or protecting left turns waiting to enter a driveway from the roadway.

The introduction of a raised median on an existing roadway in a developed area is often controversial. The highway official recognizes that accidents and delays will be reduced if the median is installed. The roadside business with no direct opening opposite his entrance feels that he will suffer financially. In many situations, both are right. In one research effort, a study was conducted in three cities to measure the economic impact of medial access control. These results are quoted as follows:

"These studies of three Texas cities attempt to answer two questions about customer traffic: first, the extent to which a median would restrict it and, second, the influence that the change would have on the sales of the business concerned.

The assumption that losses in left-turn customer traffic are offset by increases in right-turn traffic was not completely borne out. Customer turns appear to be inversely related to city size and traffic volume. In the two smaller cities, there was an increase in right-turn customer traffic after the median was built. In San Antonio, however, where traffic volume and speeds were high, there was a reduction in right turns. In the three cities as a whole, the reduction in total customer traffic averaged about 10% after the median was installed.

The analysis of turning movements in San Antonio indicated a 59% reduction in the left-turn and U-turn movements and a 23% reduction in the right-turn movements into businesses in the after period. Businessmen along the route felt that the increased traffic speed made it more hazardous to make right turns into businesses. They believed the motorist feared a rear-end accident when slowing down to make a right-turn; consequently, he passed by, rather than risk an accident.

Regardless of the reasons for the change, medial access control clearly has an influence on customer traffic. Superficially, this seems of overwhelming importance to the commercial sector. But further analysis indicates that the total volume of traffic is not of paramount importance to the abutting operations; rather it is the economic composition of the customer traffic. A comparison was made to relate changes in individual business volumes to changes in left-turn ingress traffic. When all firms that lost sales were grouped together, their aggregate loss in left-turn traffic was 49%. Those that gained in sales lost only 26% of their left-turn traffic.

This shows some relationship between the losses in left turns and losses in business volumes. This relationship is not strong enough, however, to allow accurate predictions of the influence of a restriction in left-turn traffic on an individual firm's sales volume. Many additional factors such as management, general location, extent of competition, etc., are equally important in determining this effect.

For analysis of the overall sales volume effect of the median installation, the businesses were divided into two groups, traffic-serving and nontraffic-serving. The traffic-serving group was mainly service stations, motels, and restaurants. Table V.2 shows that both the traffic- and nontraffic-serving firms in the study areas generally had a decline in sales in the after period while comparable control areas showed a modest increase in sales.

Table V.2. Sales Volume Comparison

	Sales Volume	
	Before Median	After Median
Pleasanton		
A. Traffic-Serving Businesses		
1. Study Group	100	95.8
2. Control Group	100	100.8
B. Nontraffic-Serving Businesses		
1. Study Group	100	82.4
2. Control Group	100	104.3
San Antonio		
A. Traffic-Serving Businesses		
1. Study Group	100	76.4
2. Control Group	100	102.0
B. Nontraffic-Serving Businesses		
1. Study Group	100	103.4
2. Control Group	--	--

From an economic standpoint, the stimulus to new growth was perhaps the most significant effect of the median program. The program created attractive and desirable commercial sites in each of the three areas. The desirability of these sites was demonstrated by the rapid influx of new businesses after the construction period. Some business lost by older firms may have been absorbed by the new firms.

The construction process itself produced the most severe shock to the economic system of the community. This effect was most severe in Baytown, the middle-sized city, where some businesses were completely isolated from traffic for varying lengths of time. The effect was less severe in Pleasanton, the smallest city, where local customers had few alternatives for shopping. In San Antonio, the largest city, the effect was less uniform. Certain kinds of firms, such as service stations, were severely affected, but their losses were offset by gains in the nontraffic-serving businesses. After the construction was completed, total business volume began to rapidly recover. After a full year with the median, total business volume was above the pre-construction level in both San Antonio and Baytown. Some of this gain was due to the establishment of new businesses along the facility, and many older firms were still below their base volumes. In general, the businesses operating in older, less modern, less well-kept buildings were not able to regain their lost sales volumes. More modern firms with vigorous, progressive management most often increased their sales.

In another analysis shown in Table V.3, the sales of firms with median openings were compared with the sales of firms without median openings. In the aggregate, there appears to be no advantage for a firm to be located near a median opening. For traffic-serving businesses, however, there seems to be a distinct advantage of having a median opening. The variation in sales of firms, both with and without median openings, strongly supports the contention that "individual management or management's reaction to changing conditions exerts a much stronger influence on sales than does specific location in relation to median openings."

A technique that has worked well in many situations, particularly existing, developed areas, has been the two-way left-turn lane in lieu of a median. This technique provides many of the benefits of shadowing left-turning vehicles while providing access. It is not applicable in

Table V.3. Effect of Median Openings on Sales Volume

	Sales Volume	
	Before Median	After Median
Firms at Median Opening		
1. Traffic-Serving Businesses	100	99
2. Nontraffic-Serving Businesses	100	68
3. Total	100	89
Firms Not at Median Opening		
1. Traffic Serving Businesses	100	56
2. Nontraffic-Serving Businesses	100	100
3. Total	100	94

all situations, however, and the warrants and effectiveness evaluations described in Chapter VI and Chapter VIII should be thoroughly considered.

In the upgrading of a roadway from two to four or more lanes, the introduction of some type of median control should always be considered in the interests of safety and preservation of design capacity.

In the installation of a new, raised median or the analysis of effectiveness of an existing one, the median openings require special attention. Chapter VII provides guidelines for the spacing and design of median openings.

Frontage or Service Roads

In situations involving high-volume, high-speed arterials, it is often feasible to consider the construction of frontage roads in a retrofit program. This is an expensive technique and often time-consuming when right-of-way has to be purchased.

Frontage roads allow the jurisdiction complete control of access to the arterial and provide for loading and parking which might otherwise have to be accepted on portions of the arterial.

There are several general design considerations which will affect safe, efficient frontage road use:

- A separation of at least 150 feet will allow the frontage road to operate reasonably well at the cross streets. Outer separations of less than this require special treatment.
- Frontage roads which can be terminated each block operate well with respect to the arterial and its cross streets. This type of design should be considered if continuity of the frontage road is not a requirement.
- One-way, rather than two-way frontage roads should be used, if possible.
- A minimum outer separation of 8 feet should be used, for pedestrian refuge, safe placement of traffic control devices, and for landscaping.
- Visibility at intersections of frontage roads/cross streets/arterials should be maximized due to complex and confusing movements.
- Pedestrian and bicycle movements should utilize the frontage roads, as should on-street parking needs.

Miscellaneous

In the miscellaneous category of techniques which are applicable to retrofitting are actions such as signalization of high-volume driveways, installation of one-way operation, channelization, speed control, and prohibition of movements.

The retrofitting process should be continuous. Access control techniques, just as other traffic management actions, may become obsolete as conditions change. Warrants and measures of effectiveness described in Chapter VI and Chapter VII should be used as criteria to evaluate the applicability of existing access control measures to current conditions. This should be done whenever accident rates begin to show an increase, but, as a minimum, every five years. A typical sequence may be the evolution of a roadway from a situation where no separate provisions are made for left turns, to a two-way left-turn lane, to a raised median with protected left-turn bays. Each would be warranted under different conditions of left turns and through movement volumes. At some point, channelized driveways may have to be upgraded with signalization as volumes increase. The function of a roadway may change from collector to arterial due to traffic re-routing or land use changes. This would require analysis of all access-associated conflicts to determine the degree of upgrading necessary for the new conditions.

IMPLEMENTATION

The application of access control techniques to existing situations requires a well-coordinated program involving the jurisdictional operating agencies, and the general public. Above all, there needs to be a well-defined policy adopted by the jurisdiction which defines access control in terms of public welfare and transportion safety and efficiency. Zoning regulations, subdivision requirements, site plan review, and the process for obtaining building permits, curb cut permits, and occupancy permits should all be reviewed and coordinated to project the same objectives relative to access control. The need for a comprehensive, balanced program, as defined in Chapter III, is essential for successful retrofit programs.

A well-documented engineering study complete with economic evaluation should be conducted. This study should outline objectives of improvements, define and quantify specific problems (accidents, delays), and develop alternative solutions to reduce the impact of these problems. Alternatives should be realistically evaluated and, where benefits clearly outweigh all costs, proposed for implementation.

Throughout this entire process, it is very important that the public be kept informed. Public meetings should be held in the area to be affected as soon as it is decided that studies should be undertaken. The reaction of businesses along a roadway where it is proposed to install a median, close excess driveways or reduce their width is often very negative. A full understanding of the realistic projected impacts and benefits that can accrue is essential. It is also important that the general public, as well as the businesses directly affected, be made knowledgeable of potential impacts inasmuch as they are the ones who stand to gain the most.

Politically, a retrofit program may be very difficult for elected officials to support due to the real and imagined impacts on affected businesses. It is very important to document these individual impacts as well as those accruing to the general public. The alternative cost of new construction or new rights-of-way in order to accommodate existing and projected traffic safely and at reasonable levels of service is often a very persuasive argument. Of utmost importance, however, is making sure that the elected officials have full documentation and adequate reasons if they are going to be asked to do something that may be construed as being detrimental to a segment of their constituency.

The legal problems associated with implementation were discussed in Chapter II; however, it is important that local legal counsel be involved from the very beginning. Legal interpretations regarding marginal access changes have been varied and need to be reviewed from the standpoint of local precedent.

CHAPTER V REFERENCES

1. Stover, Virgil.; Adkins, William G.; and Goodnight, John C. "Guidelines for Medial and Marginal Access Control on Major Roadways,: NCHRP Report 93, 1970.

2. Glennon, et al. Technical Guidelines for the Control of Direct Access to Arterial Streets, Report FHWA-RD-76-87, Volume 11, pg. 158.

3. Course notes for CE/PLAN 612 Texas A&M University by V. G. Stover.

4. Box, P.C. "Traffic Control and Roadway Elements--Their Relationship to Safety--Chaper 5, Driveways," Highways Users Federation for Safety and Mobility, 1970.

ACCESS MANAGEMENT TECHNIQUES

Following adoption of a comprehensive policy, the next step in the development of an access control program is the identification of effective control measures which will enhance the safe and efficient movement of traffic. These measures include all traffic operations actions which serve to minimize the frequency and severity of traffic conflicts associated with driveways.

A traffic conflict is defined as an event involving two vehicles where evasive action is required by one or both drivers to avoid collision. This corrective action can involve acceleration, deceleration, path correction, or any combination of the three. The severity of the conflict depends on the degree of the evasive action required.(1)

An example of potential conflict points at a typical four-way intersection is shown in Figure VI.1.

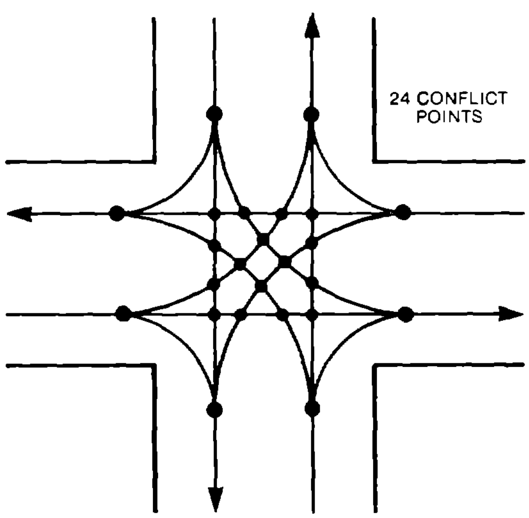


Figure VI.1. Conflict Points at a Typical Four-Way Intersection

These conflicts can be substantially reduced through the application of various access management techniques. An example of how this can be achieved is illustrated in Figure VI.2 where only right turns in and right turns out are permitted at a driveway location.

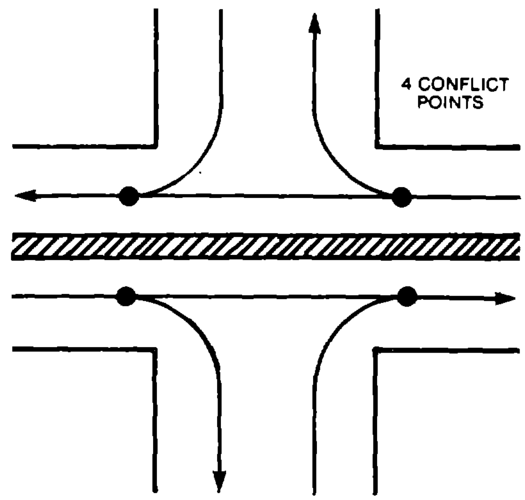


Figure VI.2. Driveway Intersection With Restricted Access

Under high-volume conditions, such a design can serve to enhance the safe and efficient operation at a particular location.

Four major functional objectives essential to the goal of minimizing the frequency and severity of traffic conflicts associated with driveways are identified as follows:

- <u>Limit the number of conflict points</u>: These techniques directly reduce the frequency of either basic conflicts or encroachment conflicts, or reduce

Preceding page blank

the area of conflict at some or all driveways on the highway by limiting or preventing certain kinds of maneuvers.

- Separate basic conflict areas: These techniques either reduce the number of driveways or directly increase the spacing between driveways or between driveways and intersections. They indirectly reduce the frequency of conflicts by separating turning vehicles at adjacent access points and by increasing the decision-process time for the through driver between successive conflicts with driveway vehicles at successive driveways.

- Reduce deceleration requirements: These techniques reduce the severity of conflicts by increasing driveway turning speeds, by decreasing through highway speeds, or by increasing driver perception time.

- Remove turning vehicles from the through lanes: These techniques directly reduce both the frequency and severity of conflicts by providing separate paths and storage areas for turning vehicles.

Using these functional objectives as a guide, 66 alternative actions or techniques have been identified. These techniques are listed in Table VI.1 where they are categorized by functional objectives.

A discussion of each of these techniques is provided in Appendix A of this document.

Table VI.1. Access Management Techniques

CATEGORY A

LIMIT NUMBER OF CONFLICT POINTS

- A-1: Install median barrier with no direct left-turn access
- A-2: Install raised median divider with left-turn deceleration lanes
- A-3: Install one-way operations on the highway
- A-4: Install traffic signal at high-volume driveways
- A-5: Channelize median openings to prevent left-turn ingress and/or egress maneuvers
- A-6: Widen right through lane to limit right-turn encroachment onto the adjacent lane to the left
- A-7: Install channelizing islands to prevent left-turn deceleration lane vehicles from returning to the through lanes
- A-8: Install physical barrier to prevent uncontrolled access along property frontages
- A-9: Install medial channelization to control the merge of left-turn egress vehicles
- A-10: Offset opposing driveways
- A-11: Locate driveway opposite a three-leg intersection or driveway and install traffic signals where warranted
- A-12: Install two one-way driveways in lieu of one two-way driveway
- A-13: Install two two-way driveways with limited turns in lieu of one standard two-way driveway
- A-14: Install two one-way driveways in lieu of two two-way driveways
- A-15: Install two two-way driveways with limited turns in lieu of two standard two-way driveways
- A-16: Install driveway channelizing island to prevent left-turn maneuvers
- A-17: Install driveway channelizing island to prevent driveway encroachment conflicts
- A-18: Install channelizing island to prevent right-turn deceleration lane vehicles from returning to the through lanes
- A-19: Install channelizing island to control the merge area of right-turn egress vehicles
- A-20: Regulate the maximum width of driveways

CATEGORY B

SEPARATE BASIC CONFLICT AREAS

- B-1: Regulate minimum spacing of driveways
- B-2: Regulate minimum corner clearance
- B-3: Regulate minimum property clearance
- B-4: Optimize driveway spacing in the permit authorization stage
- B-5: Regulate maximum number of driveways per property frontage
- B-6: Consolidate access for adjacent properties
- B-7: Require highway damages for extra driveways
- B-8: Buy abutting properties
- B-9: Deny access to small frontage
- B-10: Consolidate existing access whenever separate parcels are assembled under one purpose, plan, entity, or usage
- B-11: Designate the number of driveways regardless of future subdivision of that property
- B-12: Require access on collector street (when available) in lieu of additional driveway on highway

CATEGORY C

LIMIT DECELERATION REQUIREMENTS

- C-1: Install traffic signals to slow highway speeds and meter traffic for larger gaps
- C-2: Restrict parking on the roadway next to driveways to increase driveway turning speeds
- C-3: Install visual cues of the driveway
- C-4: Improve driveway sight distance
- C-5: Regulate minimum sight distance
- C-6: Optimize sight distance in the permit authorization stage
- C-7: Increase the effective approach width of the driveway (horizontal geometrics)
- C-8: Improve the vertical geometrics of the driveway
- C-9: Require driveway paving
- C-10: Regulate driveway construction (performance bond) and maintenance
- C-11: Install right-turn acceleration lane
- C-12: Install channelizing islands to prevent driveway vehicles from backing onto the highway
- C-13: Install channelizing islands to move ingress merge point laterally away from the highway
- C-14: Move sidewalk-driveway crossing laterally away from highway

CATEGORY D

REMOVE TURNING VEHICLES FROM THE THROUGH LANES

- D-1: Install two-way left-turn lane
- D-2: Install continuous left-turn lane
- D-3: Install alternating left-turn lane
- D-4: Install isolated median and deceleration lane to shadow and store left-turning vehicles
- D-5: Install left-turn deceleration lane in lieu of right-angle crossover
- D-6: Install medial storage for left-turn egress vehicles
- D-7: Increase storage capacity of existing left-turn deceleration lane
- D-8: Increase the turning speed of right-angle median crossovers by increasing the effective approach width
- D-9: Install continuous right-turn lane
- D-10: Construct a local service road
- D-11: Construct a bypass road
- D-12: Reroute through traffic
- D-13: Install supplementary one-way right-turn driveways to divided highway (noncapacity warrant)
- D-14: Install supplementary access on collector street when available (noncapacity warrant)
- D-15: Install additional driveway when total driveway demand exceeds capacity
- D-16: Install right-turn deceleration lane
- D-17: Install additional exit lane on driveway
- D-18: Encourage connections between adjacent properties (even when each has highway access)
- D-19: Require two-way driveway operation where internal circulation is not available
- D-20: Require adequate internal design and circulation plan

Source: Adapted from Reference 1.

CHAPTER VI REFERENCES

1. J.A. Azzeh, et al., FHWA-RD-76-85, Evaluation of Techniques for the Control of Direct Access to Arterial Highways, 1975.

CHAPTER VII. DESIGN GUIDELINES

The design elements involved in the application of access management techniques are those concerned primarily with the following:

- Operational Controls
- Geometric Design Criteria
- Physical Site Parameters

This chapter discusses each of these elements and provides general design guidelines for consideration in the use of applicable techniques. Specific design criteria are provided in Appendix A along with a discussion of each technique.

Of particular importance, however, is the fact that these criteria are only guidelines, they do not constitute design standards which must be blindly accepted. Design elements for any particular situation must be arrived at by considering the operational requirements of the users as well as the physical site parameters. Figure VIII.1 indicates the factors which must be considered in developing an appropriate design.

DESIGN VEHICLE

The physical characteristics of vehicles and the proportion of different sized vehicles in the traffic stream are important and positive controls in the design of access management techniques. It is therefore necessary to examine all vehicle types and establish a representative-sized vehicle that needs to be accommodated. Two general classes of vehicles are typically used -- the passenger vehicle and trucks. In the design of any access management techniques, the largest design vehicle likely to be encountered with considerable frequency must be taken into account to determine the design of the critical elements.

Vehicle Performance

Acceleration and deceleration rates of vehicles are often critical parameters in determining access management design.

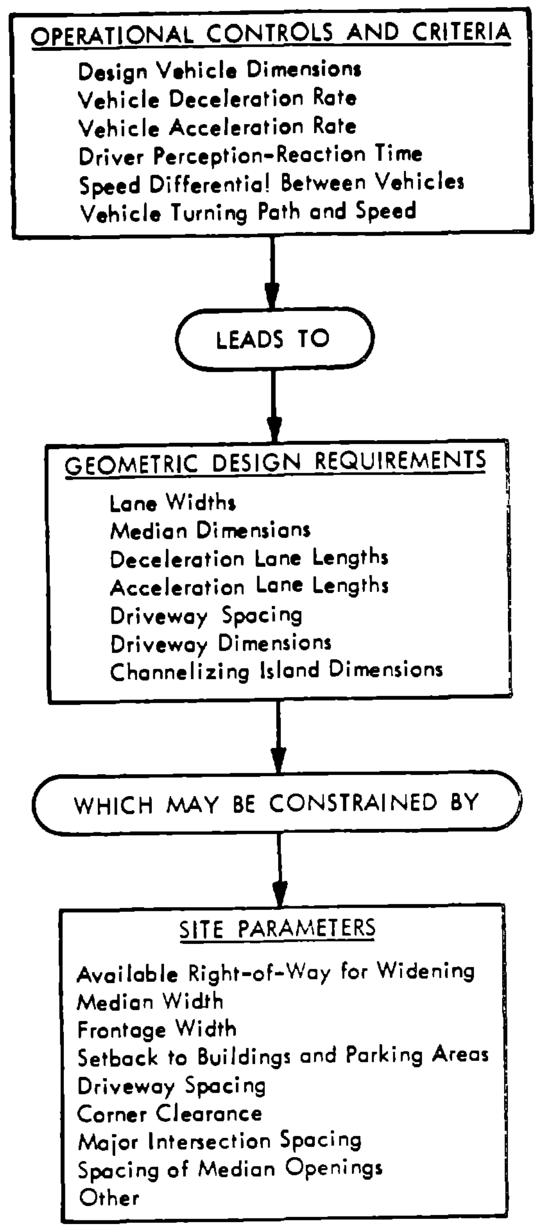


FIGURE VII.1. STEPS IN DEVELOPING DESIGN CRITERIA

Source: Adapted from Reference 1.

These rates often govern the dimensioning of such design features as acceleration and deceleration lanes, driveway dimensions, and sight distances.

With the passenger car, relatively rapid accelerations and decelerations are possible. Because of this, the passenger car seldom controls design, and it is often necessary to consider the performance characteristics of the other types of vehicles that are expected to be encountered.

Minimum Turning Paths

Most design elements affecting access control must consider the required area needed by different types of vehicles to complete their turning maneuvers. The principal dimensions affecting design are the minimum turning radius, the wheelbase, and the path of the inner rear tire. Table VII.1 gives the minimum turning radii of selected design vehicles. These are also illustrated in Figure VII.2.

The P-design vehicle will satisfy the requirements for all passenger car vehicles. The SU-design vehicle requirements are suitable for all single-unit trucks and smaller buses. However, on most facilities serving truck traffic or larger buses, the design vehicle for semi-trailer combinations must be considered. Of the three truck tractor semi-trailer combinations, the WB-50 is the most critical for design purposes.

TABLE VII.1. MINIMUM TURNING RADII OF DESIGN VEHICLES

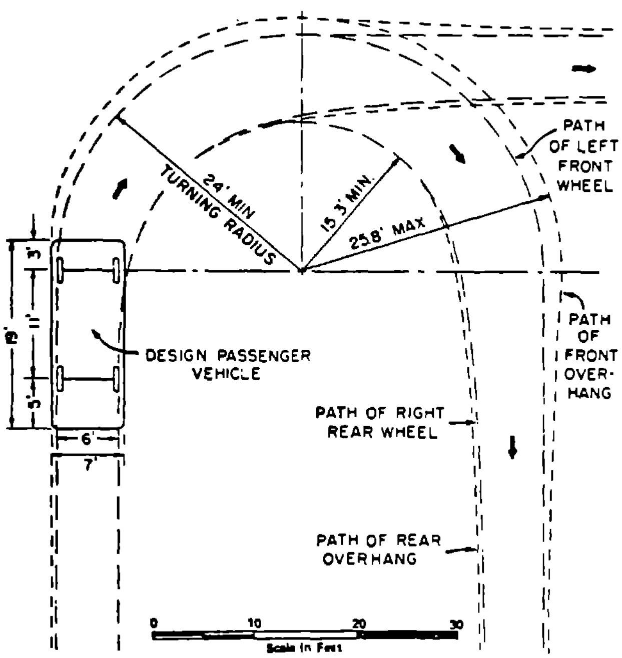
Design Vehicle Type	Symbol	Min. Inside Radius (Feet)	Minimum Turning Radius (Feet)
Passenger Car	P	15.3	24
Single-Unit Truck	SU	28.4	42
Single-Unit Bus	BUS	23.1	42
Semi-trailer Intermediate	WB-40	19.9	40
Semi-trailer combination large	WB-50	19.8	45
Semi-trailer Full-trailer combination	WB-60	22.5	45

GEOMETRIC DESIGN REQUIREMENTS

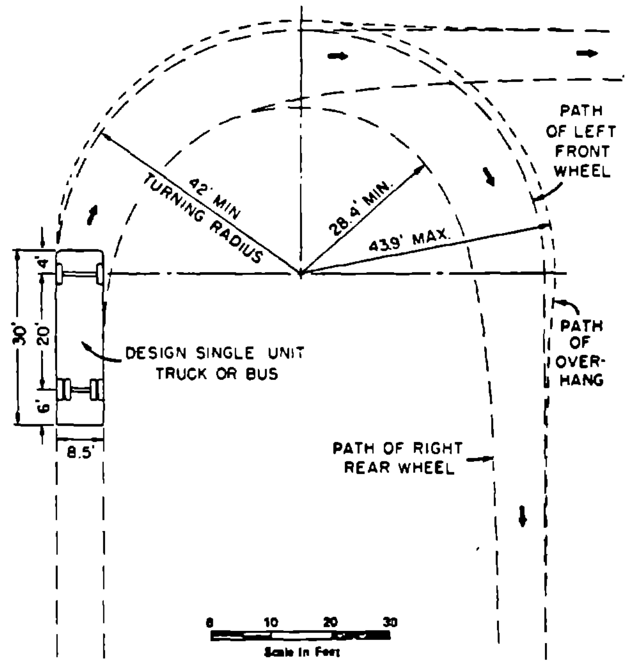
Geometric design deals with the visible dimensions of a roadway and involves those elements which have a direct bearing on driver behavior and traffic performance. Thus, its main purpose is to provide for the safe, efficient, and consistent movement of traffic. For this reason, geometric design has a very important role in the design of access management techniques.

Lane Widths

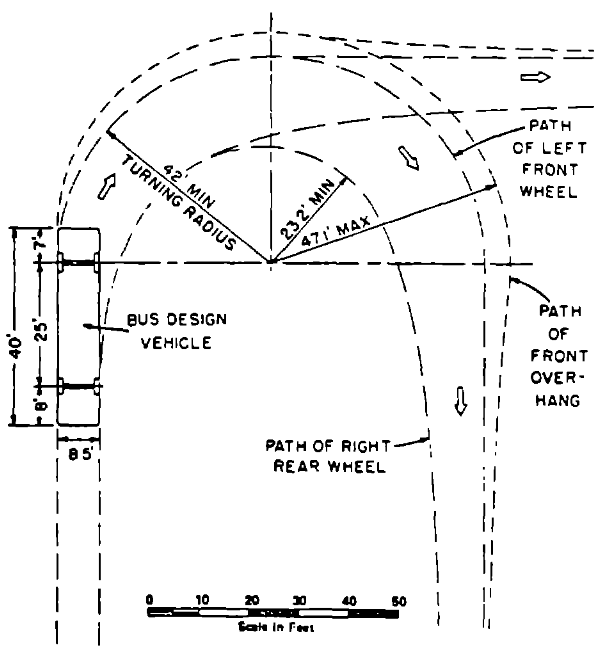
No feature of a highway has a greater influence on the safety and comfort of driving than the width of lanes that are used. In most urban areas, 10 foot to 13-foot lane widths are generally used with a 12-foot lane being the most predominant, especially on roadways having operating speeds greater than 40 mph. On roadways having operating speeds less than 40 mph, reduced lane widths are commonly used,



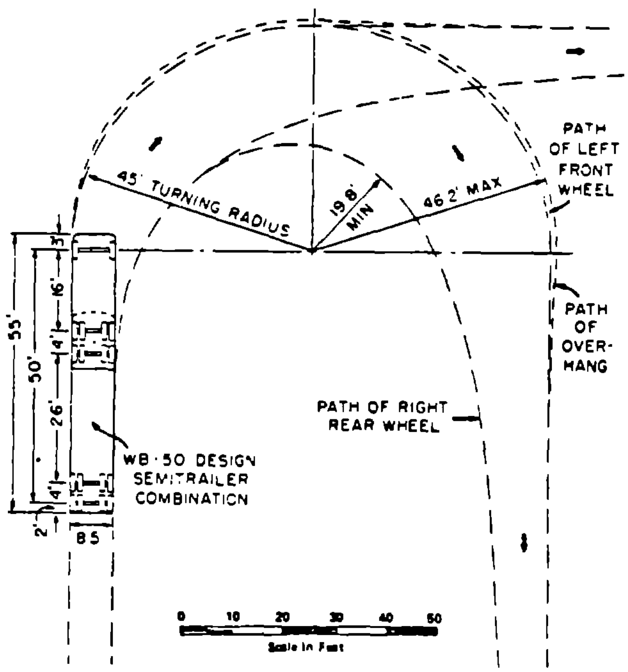
MINIMUM TURNING PATH FOR
P DESIGN VEHICLE



MINIMUM TURNING PATH FOR
SU DESIGN VEHICLE



MINIMUM TURNING PATH FOR
BUS DESIGN VEHICLE



MINIMUM TURNING PATH FOR
WB-50 DESIGN VEHICLE

FIGURE VII.2. DESIGN VEHICLE TURNING PATHS

Source: Reference 2

especially where right-of-way and existing development become stringent controls. An 11-foot lane width is adequate for through lanes and 10-foot lanes are typically used for turn lanes. These lane widths, however, must be used with judgment. If heavy truck traffic is anticipated, an additional 1-foot of width is desirable. Also, where unequal width lanes are used, it is desirable to locate the wider lane on the outside adjacent to the curb for the larger vehicles that typically occupy that lane.

Medians

A median is defined as that portion of a divided highway separating traffic that is traveling in opposing directions. In terms of access control, they are used primarily to control left turns, U-turns, and crossing movements at designated locations.

There are basically two types of medians used in access control; raised medians and flush (painted) medians. Raised medians are usually classified into one of three groups: narrow barrier medians of from 2 to 8 feet, which are used to prohibit left turns and crossovers; medians with turn bays of from 12 to 20 feet wide, which are used to provide exclusive left-turn lanes; and, wide medians, used to shadow vehicles crossing the arterial and also to provide double left-turn lanes at major intersections.

Painted medians are also classified into three groups: those which prohibit midblock crossings and provide for intersection turns only; those which have left-turn bays to allow access to specific driveways and cross streets; and those which provide for continuous two-way left turns.

Major elements involved in median design for access control include width, spacing of openings, and the geometrics of median noses at openings. The following is a discussion of each of these elements.

Median Widths -- Medians should be as wide as feasible but of a dimension that is in balance with other design components of the roadway cross section. The general range of median widths is from a minimum of 2 feet for the "narrow barrier" median up to approximately 80 feet which approaches two independently-designed roadways.

In access control, one of the most important functions of medians is to provide for left turns at intersections. To achieve this, it is desirable to have a median width of at least 18 feet which provides for a 12-foot turning lane and a 6-foot separator. The practical minimum for left turns at extremely restricted locations is a median width of 14 feet which provides for a 10-foot turning lane and a 4-foot median separator.

On urban arterials with numerous driveways on each side of the street, it is sometimes desirable to provide for a two-way, left-turn lane which enables left turns to be made from the median from both directions. With this concept, a median width of 12 feet to 14 feet is desirable.

In some instances, a vehicle moving from a driveway or side street has difficulty in finding an acceptable gap in the major street traffic to cross two streams of traffic. In such cases, it may be desirable to provide a median as a shield for a vehicle waiting in the median opening for a break in traffic. This typically requires a median of approximately 24 feet in width.

To accommodate vehicles making U-turns at median openings, the width of a median becomes a key design element. One requirement for a satisfactory design for a U-turn is that the width of the highway, including the median, be sufficient to permit the turn to be made without encroachment beyond the outer edge of the roadway. Figure VII.3 gives the minimum designs for median width for various design vehicles.

TYPE OF MANEUVER	M — Min. width of median — feet for design vehicle				
	P	WB-40	SU	BUS	WB-50
	Length of design vehicle				
	19'	50'	30'	40'	55'
Inner Lane to Inner Lane	32	60	64	68	70
Inner Lane to Outer Lane	20	48	52	56	58

FIGURE VII.3. MEDIAN DESIGNS FOR U-TURNS

A passenger vehicle requires a minimum width of 20 feet to turn from the inner lane to the outer lane of a two-lane opposing movement. Similarly, a WB-50 requires a 58-foot median.

Median End Treatments -- The form of treatment given to the end of a median adjacent to lanes of opposing traffic depends largely on the available width. In nearly all cases of raised medians, the median end is curbed to delineate the lane edge and to provide space for signs, markers, and lighting standards. For 4-foot-wide sections, the shape of the nose is usually semicircular as is shown in Figure VII.4.

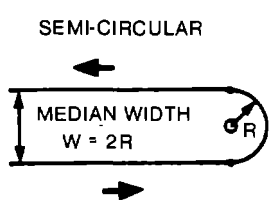


FIGURE VII.4

For median ends wider than 4 feet, a bullet-nose design as shown in Figure VII.5 is used to conform better with the paths of the turning vehicles.

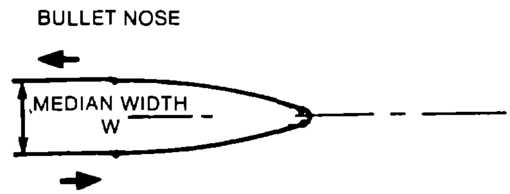


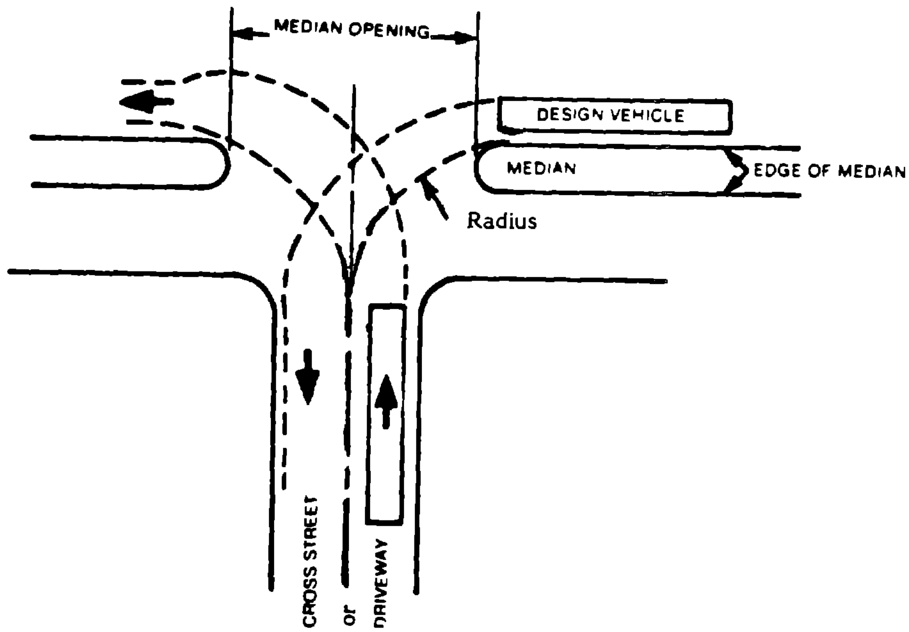
FIGURE VII.5

The bullet nose is formed by two symmetrical portions of control radius arcs that closely fit the path of the inner rear wheel of the selected design vehicle. The advantage is that the driver of the left-turning vehicle has a better guide for the maneuver and the need for encroachment is minimized.

Length of Median Openings -- For any typical 3-or 4-leg intersection on a divided roadway, the length of the median opening should be as great as the width of the crossroad roadway pavement, but in no case less than 40 feet. Where the crossroad is a divided highway, the length of the opening should be at least equal to the width of the crossroad roadway plus that of the median width plus 8 feet. The 40-foot minimum length of opening does not apply to openings for U-turns as discussed earlier.

Spacing between median openings is provided in Table VII.2. In all cases openings should not be provided where safety to vehicular traffic will be sacrificed.

Figure VII.6 shows minimum median opening designs based on a control radius of 40 feet and 75 feet for a 90-degree intersection. The control radius is made tangent to the upper median edge and to the



Passenger Design Vehicle		
	Median Opening (Feet)	
Median Width	Bulletnose Median	Semicircular Median
4'*	76'	76'
6'	60'	74'
8'	53'	72'
10'	47'	70'
12'	43'	68'
14'	40' min	66'
16'	40' min	64'
20'	40' min	60'
24'	40' min	56'
32'	40' min	48'

Control Radius of 40'

Semi-Tractor Trailer Design Vehicle		
	Median Opening (Feet)	
Median Width	Bulletnose Median	Semicircular Median
4'*	122'	146'
6'	115'	144'
8'	110'	142'
10'	105'	140'
12'	100'	138'
14'	96'	136'
16'	92'	134'
20'	85'	130'
24'	78'	126'
32'	67'	118'

Control Radius of 75'

*Bulletnose should be modified to accomodate turning radius.

FIGURE VII.6. MINIMUM MEDIAN OPENINGS

centerline of the undivided crossroad, thereby locating the semicircular median end or forming a portion of a bullet nose end. The resulting length of median opening varies with the width of median as shown in the accompanying tables.

TABLE VII.2. MEDIAN OPENING SPACING

Running Speed (mph)	Minimum Spacing Between Median Openings (feet)	
30	250	
40	300	Plus 25 feet for each car to be stored in the trun lane at maximum queue length.
45	350	
50	425	
55	500	
All Speeds:	Openings provided at all arterials, all collectors, and some local streets.	
Source:	Ref. (4)	

Auxiliary Lanes

The primary purpose of auxiliary lanes is to provide storage for turning vehicles, both left and right. A secondary purpose is to provide space for turning vehicles to decelerate from the normal speed of traffic to a safe speed for the turns or for stopping. Additionally, auxiliary lanes may be provided for loading or unloading passengers from buses or from passenger cars. Another type of auxiliary lane is the acceleration lane. These lanes are typically used at intersections with no signal control where it may be desirable to provide an area for vehicles turning right or left onto a major street from a cross street to accelerate to a speed which allows them to merge safely with the through traffic.

Auxiliary lanes should be at least 10 feet wide and preferably 12 feet wide. Desirably, the lane width should be in addition to that of the gutter pan. The length of auxiliary lanes for turning vehicles typically consists of three components: (1) deceleration length, (2) storage length, and (3) taper. The total length of the auxiliary lane should be the sum of the length for these components. Common practice, however, is to accept a moderate amount of deceleration within the through lanes and to consider the taper as part of the deceleration length.

Some important design criteria to be considered with auxiliary lanes are discussed in the following.

Left-Turn Lanes -- The use of storage lanes for left turns or U-turns is extremely important in urban areas where capacity and safety are problems. Along arterials, as few as 20 to 50 left turns per hour can seriously disrupt flow in through lanes if an exclusive lane is not provided.

The storage length of an exclusive left-turn lane is a critical design element. Inadequate length presents a safety problem in that vehicles queuing in the lane will eventually back into the through traffic lanes. Also, utilization of the turn lane will be impaired if this occurs, as vehicles desiring to move into the turn lane will be unable to do so and must wait for the through lane to move ahead. Also, through lane capacity is reduced when turning vehicles have backed into the through lane and are not moving.

There are several techniques used to determine necessary storage length. Some cities have established "minimum" lengths for lanes with low turn volumes. Typical minimum lengths are 100 or 150 feet. Other jurisdictions have used concepts from capacity charts and nomographs to set the storage length. Still others have used a "rule of thumb" from the AASHTO Red Book which suggests that by using 1.5 or 2.0 times the number of vehicles which arrive at a uniform rate during the peak period, a good estimate of the volume to be stored is obtained.

The important factors which determine the length needed are:

- The design year volume for the peak hour
- An estimate for the number of cycles per hour if the location is signalized
- The type of signal phasing and timing which will control the left-turn movement

The designer can use the following guides in setting the storage length of a turn lane:

- Assume each vehicle to be stored uses 25 feet of length.
- Use a minimum storage length of 100 feet if the number of left turns per hour (design peak hour) is 60 or less.
- For signalized locations use the following formulation:

  $$L = \frac{(K)(V)(25)}{(N)}$$

  where:

  L = design length for left-turn storage, in feet

  K = constant, generally a value of 2.0 is used

  V = estimated left-turn volume during design peak hour, in vehicles per hour

  N = number of cycles per hour, in design peak hour

- If a double (side by side) left-turn bay is installed, assume that a length of 0.6 x L will be sufficient. However, double left turns normally must be given a left-turn signal phase to operate properly.
- For calculated lengths of L equals 300 feet or greater, or for left-turn volumes exceeding 300 vehicles per hour, it is desirable to consider the use of other techniques such as double left-turn lanes.
- In order to reduce the total length of queues formed in the left-turn lane, it is a desirable practice to allow "permissive" turns to be made following "protected" turn phases. Permissive turns are made when gaps in opposing traffic occur and can increase the capacity of a turn lane by from 20 to 50 percent.

Right-Turn Lanes -- The required length for a right-turn lane is calculated in the same manner as described for left-turn lanes. Signal timing, pedestrian activity, and vehicle arrival patterns are the most important aspects for consideration when designing the length. Normally, a minimum storage length of 100 feet should be provided. Width of a right-turn lane is usually set at 10 to 11 feet, with the 10-foot dimension being quite adequate unless large trucks and buses are using the lane. An important factor in establishing a right-turn lane is the location of bus stops. It may be necessary, for example, to relocate a nearside stop to midblock or to the farside if a right-turn lane is introduced.

Tapers for Left-Turn Lanes -- In order to develop the width needed for exclusive turn lanes, a transition must be effected. This transition, or taper, allows a driver to recognize that an exclusive lane is being developed and also allows some deceleration to occur prior to entering the storage lane itself. There are two viewpoints on how a taper should be designed.

By using a short taper, the presence of an exclusive turn lane is more pronounced and drivers are less likely to "stray" into the lane by mistake. Also, a shorter taper allows for a longer, full-width storage area. The second viewpoint argues that longer tapers are more desirable from an aesthetic standpoint and also that a driver is able to use the area for deceleration, thus increasing safety in the through lane.

Because capacity considerations are becoming more critical in most urban areas, current practice appears to be moving toward the use of shorter tapers and correspondingly longer lengths for full-width storage lanes. Thus, the following general guides are presented:

> A minimum taper length of 60 feet should be used.
>
> For typical urban arterials, a taper of 90 feet is adequate.
>
> For high-speed arterials (40 to 50 miles per hour), the taper should be increased to 150 feet if possible.

There are many ways to shape the taper area, and the AASHTO Red Book illustrates a straight-line taper, a partial tangent taper, and tapers based on symmetrical and asymmetrical reverse curves.

Tapers for Adding or Dropping Lanes -- When a right-turn lane is added to the roadway, the taper used can be rather short. In general, a 10:1 taper will be aesthetically and operationally adequate, and may be of any design including a straight line. When a lane is dropped, usually on the far side of a major intersection, the taper used must be gradual so that drivers have the opportunity to merge safely into the adjacent lane. Taper rates of 30:1 or 40:1 are usually adequate, with the flatter taper being used for higher speed roadways. A 30:1 taper means that a 12-foot lane can be dropped in 360 feet and that after 180 feet a vehicle will begin to encroach on the adjacent lane. Adequate warning signs must accompany any lane drop situation, regardless of the adequacy of the taper design.

Tapers for Redirecting Lanes -- When a left-turn storage lane is designed along an arterial which has no median or only a narrow median, it is necessary to move the through lanes laterally to attain the necessary width at the intersection. For speeds up to 40 miles per hour, a taper of 25:1 or 30:1 should be used. For speeds in excess of 40 miles per hour, a 40:1 taper works well. When speeds are quite low (20 to 25 miles per hour), the designer may revert to tapers of 15:1 or 20:1 if space problems exist. Figure VII.7 illustrates design guidelines for various tapers used for urban conditions. The AASHTO Blue Book contains a complete discussion of recommended values for acceleration and deceleration lanes for rural conditions, some of which may be applicable to high-type design, high-speed urban roadways.

Channelization

Channelization is the separation or regulation of conflicting traffic movements into definite paths of travel by means of traffic islands or pavement markings to facilitate the safe and orderly movement of both vehicles and pedestrians. Proper channelization increases capacity, improves safety, provides maximum convenience and instills driver confidence. Improper channelization has the opposite effect and may be worse than none at all. Over-channelization should be avoided as it can create confusion and worsen operations.

Design of channelization usually involves the following significant controls: the type of design vehicle, the cross sections on the cross streets, the expected vol-

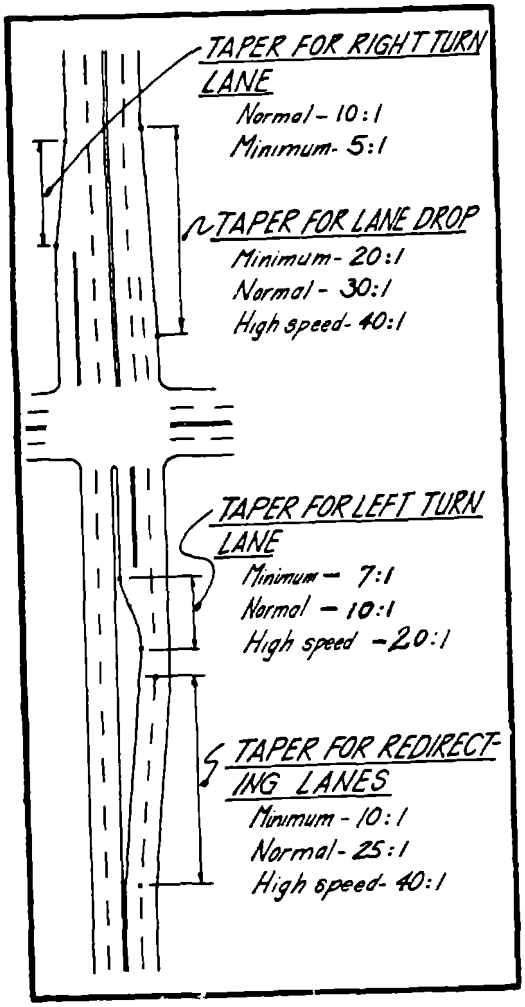


FIGURE VII.7

umes in relation to capacity that are expected to use the intersection, the number of pedestrians, the speed of vehicles, the location of any required bus stops, the type of traffic control, and location of traffic control devices. In addition, the physical controls such as right-of-way and terrain have an effect on the extent of channelization that is economically feasible.

Design Principles -- The following principles should be followed in the design of channelization. The extent to which they are applied will depend upon features of the overall design.

1. Motorists should not be confronted with more than one decision at a time.
2. Unnatural paths, such as reverse curvature, or a left-turn maneuver requiring an initial turn to the right, should be considered only under special situations.
3. Area of vehicle conflict should be reduced as much as possible. However, merging and weaving areas should be as long as conditions permit. Channelization should be used to keep vehicles within well-defined paths that minimize the area of conflict.
4. Traffic streams that cross without merging and weaving should intersect at or near right angles.
5. Angle of intersection between merging streams of traffic should be small.
6. Points of crossing or conflict should be well separated from other such points in the total plan.
7. Refuse areas for turning vehicles should be provided clear of through traffic.
8. Prohibited turns should be blocked wherever possible.
9. Location of essential control devices should be established as a part of the design of a channelized intersection.

10. Channelization may be desirable to separate the various traffic movements where multiple-phase signals are used.

Islands -- An island is a defined area between traffic lanes for control of vehicle movements or for pedestrian refuge. Within an intersection, a median or an outer separation is considered an island.

Islands generally are either elongated or triangular in shape, and are situated in areas normally unused as vehicle paths, the dimensions depending upon the particular intersection layout. Islands should be located and designed to offer little hazard to motor vehicles, be relatively inexpensive to build and maintain, and occupy a minimum of roadway space but yet be commanding enough that motorists will not drive over them deliberately. Island details are dependent upon particular conditions and should be designed to conform to the general principles which follow.

Channelizing islands should be placed so that the proper course of travel is immediately obvious, easy to follow, and of unquestionable continuity. When designing an island, attention should be given to the fact that the driver's eye view is different from a plan view. Particular care must be taken where the channelization is on or beyond a crest vertical curve, however slight, or where there is substantial horizontal curvature on the approach to or through the channelized area. Islands should allow for traffic streams in the same general direction to converge at small angles and align crossing movements to nearly right angles. The outline of islands should be easy flowing curved lines or straight lines nearly paralled to the line of travel. Where islands separate turning traffic from through traffic, the radii of curbed portions should equal or exceed the minimum for the turning speeds expected. Drivers should not be confronted suddenly with an unusable area in the normal vehicle path. Islands first approached by traffic should be indicated by a gradually widening marking or a conspicuously roughened strip that directs traffic to one side in a path easily traversed at the likely normal speeds.

Islands should be sufficiently large to command attention. The smallest island that normally should be considered is one that has an area of at least 75 square feet and preferably 100 square feet. Accordingly, triangular islands should be not less than about 12 feet, and preferably 15 feet, on the side after rounding of corners. Elongated or divisional islands should be not less than 4 feet wide and 20 to 25 feet long.

Islands should be highly visible at all times. For most conditions, delineation by mountable curbs is preferable to barrier curbs. On streets in congested areas, where vehicular speeds are low, steep-faced island curbs 6 to 8 inches in height are appropriate for protection of pedestrians, signal and lighting standards, signs, etc. Raised islands are sometimes difficult to see at night because of the glare from oncoming headlights or from distant luminaires or roadside businesses. Accordingly, where raised islands are used, the intersection should have fixed-source lighting. Island shapes, sizes, delineation, offset, etc., are discussed further and illustrated in Part V of the Manual on Uniform Traffic Control Devices.

The approach end of an island should be conspicuous to approaching drivers and should be definitely clear of vehicle paths, physically and visually, so that drivers will not veer from the island. A raised delineator (nonrigid) may be desirable on the approach end, particularly if the island is so narrow that it could be straddled by vehicles. The offset from the travel lane to the approach nose should be normally about 2 feet. For median islands, the face of curb at the approach island nose should be offset at least 2 feet, and preferably 4 feet, from the normal (median) edge of pavement. The median island should then be gradually widened to its full width. For other islands, the total nose offset should be 4 to 6 feet from the normal edge of through pavement, and 2 to 3 feet from the pavement edge of a turning roadway.

Where a shoulder is carried through the intersection, the island should be placed at the outside of the shoulder. However, where speeds are high and the island is preceded by a deceleration lane or a gradually widening auxiliary pavement, it may be desirable to offset the nose of large islands 2 to 4 feet outside the edge of shoulder. In heavily-developed areas, an offset as small as 1-foot may be appropriate for barrier curbs where the approach nose of the island is offset and tapered, particularly where pedestrian traffic is a factor.

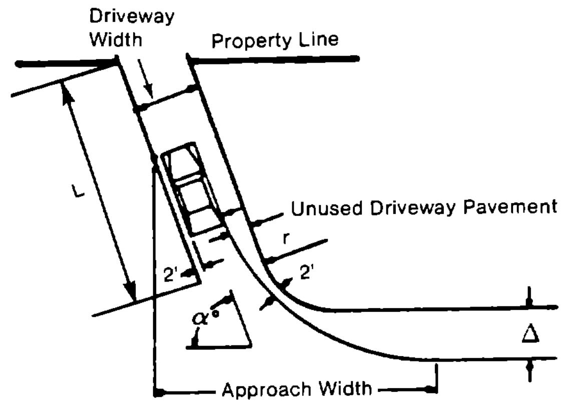


FIGURE VII.8. DRIVEWAY DESIGN ELEMENTS

Source: Reference (1)

Driveways

The speed at which vehicles can safely and effectively negotiate turning maneuvers at driveways is governed by several design parameters: driveway width, return radius, lateral offset, approach angle, approach flare, and usable driveway length. Figure VII.8 shows the various design components that typically need to be considered.

Table VII.3 illustrates the relationship between turning maneuvers and design elements for various vehicular turning speeds. These combinations of design elements can be utilized to develop safe and efficient driveway designs. A more detailed description of how these design elements were developed can be found in Reference (1).

Vertical Geometrics -- Adequate design of driveway grades should reflect concideration for basic functions of the highway and the site which the driveway serves. Generally, in order to safely perform ingress/egress maneuvers, driveway profiles should provide for sufficient clearance between the vehicle and driveway surface. Figure VII.9 illustrates an acceptable driveway profile.

The shoulder slope usually varies from 1/2"/foot (4 percent) to 3/4"/foot (6 percent). However, the shoulder slope should be maintained for the full width when constructing the driveway.

For grade changes greater than those shown, vertical curves at least 20 feet long should be constructed and length "A" should be increased. Grades (G_2) shall be limited to 15 percent for minimum-use driveways and from 5 percent to 8 percent for low-, medium- or high-volume driveways within the right-of-way.

TABLE VII.3. DRIVEWAY LANE WIDTHS AS A FUNCTION OF DRIVEWAY OFFSET AND RETURN RADIUS

FOR A 90 DEGREE DRIVEWAY ANGLE— α

Turning Speed = 6.6 mph — Driveway Length = 33 feet

Driveway Offset (feet) (Δ)	Driveway Return Radius (feet) (r)					
	0	5	10	15	20	25
0	--	--	23	20	17	14
2	--	24	20	17	14	--
4	24	21	17	14	--	--
6	21	18	15	14	--	--
8	19	16	14	--	--	--
10	17	17	14	--	--	--

Turning Speed = 10 mph — Driveway Length = 51 feet

Driveway Offset (feet) (Δ)	Driveway Return Radius (feet) (r)					
	0	5	10	15	20	25
0	--	--	--	23	20	16
2	--	--	24	21	18	14
4	--	--	23	20	17	14
6	--	25	21	18	15	14
8	25	22	19	16	14	--
10	23	20	17	15	14	--

Turning Speed = 15 mph — Driveway Length = 74 feet

Driveway Offset (feet) (Δ)	Driveway Return Radius (feet) (r)						
	10	15	20	25	30	35	40
0	--	--	--	--	23	20	17
2	--	--	--	24	20	17	14
4	--	--	24	21	17	14	--
6	--	25	21	18	15	14	--
8	25	22	19	16	14	--	--
10	23	20	17	15	14	--	--

FOR A 30 DEGREE DRIVEWAY ANGLE— α

Turning Speed = 25 mph — Driveway Length = 115 feet

Driveway Offset (feet) (Δ)	Driveway Return Radius (feet) (r)								
	0	5	10	15	20	25	30	35	40
0	23	23	22	21	20	20	19	19	18
2	20	20	19	19	18	18	17	17	17
4	17	16	16	16	15	15	15	14	--
6	15	15	14	--	--	--	--	--	--
8	14	--	--	--	--	--	--	--	--
10	14	--	--	--	--	--	--	--	--

Turning Speed = 30 mph — Driveway Length = 172 feet

Driveway Offset (feet) (Δ)	Driveway Return Radius (feet) (r)				
	0	10	20	30	40
0	--	--	--	--	--
2	--	--	--	25	24
4	23	23	22	21	20
6	20	20	19	18	17
8	18	18	17	16	16
10	16	16	15	15	14

Source: Reference (1)

FOR A 45 DEGREE DRIVEWAY ANGLE — α

Turning Speed = 20 mph | Driveway Length = 73 feet

Driveway Offset (feet) (Δ)	Driveway Return Radius (feet) (r)								
	0	5	10	15	20	25	30	35	40
0	--	--	--	24	23	22	21	20	18
2	25	24	23	21	20	19	18	17	16
4	21	20	19	18	17	16	15	15	14
6	18	17	17	16	15	14	--	--	--
8	16	15	15	14	--	--	--	--	--
10	15	14	--	--	--	--	--	--	--

Turning Speed = 25 mph | Driveway Length = 121 feet

Driveway Offset (feet) (Δ)	Driveway Return Radius (feet) (r)								
	0	5	10	15	20	25	30	35	40
4	--	--	--	--	--	--	--	--	25
6	--	--	--	--	25	24	23	22	21
8	--	25	24	23	22	21	21	20	19
10	23	22	22	22	20	19	19	18	17

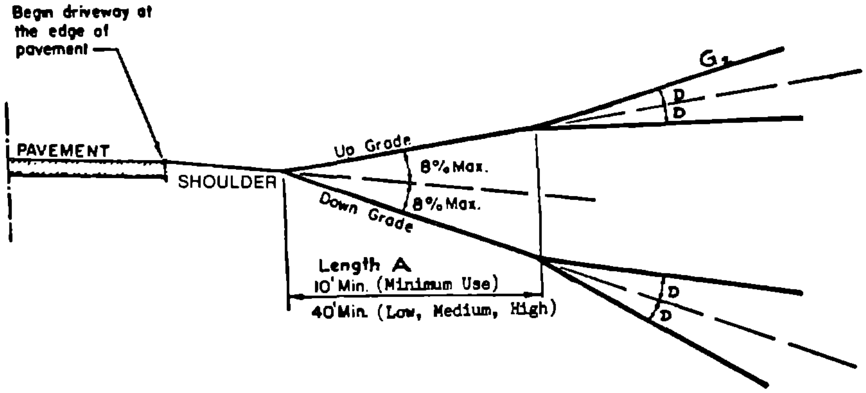
FOR A 60 DEGREE DRIVEWAY ANGLE — α

Turning Speed = 15 mph | Driveway Length = 74 feet

Driveway Offset (feet) (Δ)	Driveway Return Radius (feet) (r)							
	0	5	10	15	20	25	30	35
0	--	25	23	21	19	17	15	14
2	24	22	20	18	17	15	14	--
4	20	18	17	16	14	--	--	--
6	18	16	15	14	--	--	--	--
8	16	15	14	--	--	--	--	--
10	14	--	--	--	--	--	--	--

Turning Speed = 20 mph | Driveway Length = 137 feet

Driveway Offset (feet) (Δ)	Driveway Return Radius (feet) (r)								
	0	5	10	15	20	25	30	35	40
2	--	--	--	--	--	--	--	--	24
4	--	--	--	--	--	25	23	22	20
6	--	--	--	25	23	22	20	19	18
8	--	25	24	22	21	20	18	17	16
10	24	23	22	20	19	18	16	15	14



Recommended Grade Changes (D)

	ADT	Desirable	Maximum
Low Volume Driveway	(0-500)	+6 percent	Controlled by Vehicle Clearance
Medium Volume Driveway	(500-1500)	±3 percent	±6 percent
High Volume Driveway	(>1500)	0 percent	±3 Percent

FIGURE VII.9. VERTICAL GEOMETRICS FOR DRIVEWAYS

Frontage Roads

Frontage roads are access control measures that have numerous functions, depending on the kind of arterial highway they serve and the character of the surrounding commercial area. They segregate local traffic from the higher-speed through traffic, and intercept driveways of abutting commercial establishments. Cross connections between the through traffic lanes and frontage roads, usually provided in conjunction with crossroads or intersections, furnish the means of access between through roads and adjacent property. Thus, the through character of the highway is preserved and is unaffected by subsequent development of the roadside.

The frontage-road system can add tremendous flexibility to the operation of a highway when utilized as an auxiliary facility. A continuous frontage-road system provides maximum land service to properties abutting the highway facility. Also, during periods of saturated flow on urban highways, frontage roads provide the operational flexibility often required to alleviate congestion on the system.

The frontage road, as an access control measure, reduces the frequency and severity of conflicts along the highway by preventing direct left turns and removing slower-turning vehicles from the through lanes. This technique decreases delay on the highway for through vehicles as a result of the elimination of marginal stream friction. Some tradeoffs are realized by increasing the frequency of conflicts and delay by indirect routing for some maneuvers.

Design -- Key factors which should be considered in frontage road design are the following:

- A separation of at least 150 feet will allow the frontage road to operate reasonably well at the cross streets. Separations of less than this require special treatment.

- Frontage roads which can be terminated each block operate well with respect to the arterial and its cross streets. This type of design should be considered if through continuity of the frontage road is not a requirement.

- One-way rather than two-way frontage roads should be used to enhance operations and safety.

- A minimum outer separation of 8 feet should be used, for pedestrian refuge, safe placement of traffic control devices, and for landscaping.

- Visibility at intersections of frontage roads/cross streets/arterials should be maximized due to complex and confusing movements.

- Pedestrian and bicycle movements should utilize the frontage road, as should on-street parking needs.

- Connections between the arterial and frontage road are an important element of design. Slip ramps or simple openings in a narrow outer separation generally work reasonably well.

- For frontage roads of a local service character, it is necessary to provide only for passing an occasional parked vehicle. For one-way, low-speed, low-volume operation, the minimum width can be approximately 28 feet. For two-way operation, an additional parking lane is generally desirable which requires a minimum width of 36 feet.

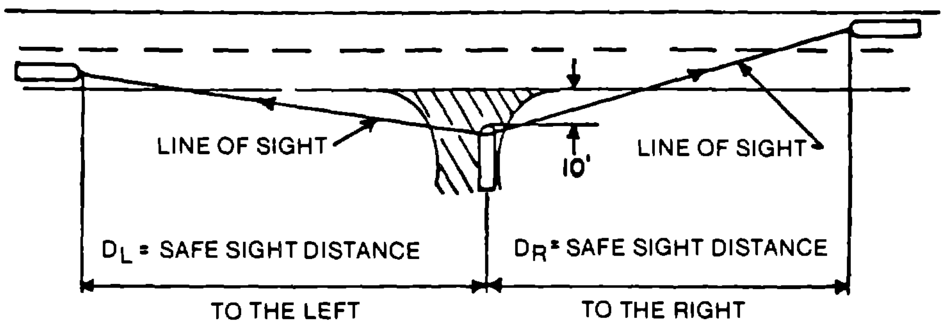
Sight Distance

At minor intersections and driveways along an arterial street, greater than minimum stopping sight distance should be available along the arterial because of the time required by vehicles, particularly trucks, to cross the arterial from a "stop" position. This sight distance should be sufficient to avoid the hazard of collision between a vehicle starting from the "stop" position to cross the highway and a vehicle on the through highway operating at the design speed and appearing after the crossing movement has begun.

Table VII.4 summarizes the required sight distance along an arterial for a vehicle waiting to cross the arterial. The width of the median is not accounted for in this table and may be ignored if the median is narrow; however, where the width of the median is 20 feet or more for a passenger vehicle or 40 feet or more for a truck, the required sight distance can be computed on a 2-stop crossing.

TABLE VII.4. REQUIRED SIGHT DISTANCE ALONG ARTERIAL STREETS FOR A VEHICLE STOPPED ON THE CROSS ROAD TO CROSS THE ARTERIAL

Design vehicle crossing arterial	Sight distance DR and DL in feet per 10 mph of arterial design speed, for arterial width of:		
	2 Lanes	4 Lanes	6 Lanes
P	100	120	130
SU	130	150	170
WB-50	170	200	210



CHAPTER VII REFERENCES

1. J.A. Azzeh, et al. Evaluation of Techniques for the Control of Direct Access to Arterial Highways, FHWA RD 76-85, 1975.

2. JHK and Associates, Design of Urban Streets Student Textbook, 1977.

3. American Association of State Highway Officials, A Policy on Design of Urban Highways and Arterial Streets - 1973.

4. Virgil Stover, William G. Adkins, John C. Goodnight. Guidelines for Medial and Marginal Access Control on Major Roadways, NCHRP Report 93, 1970.

CHAPTER VIII. EVALUATION OF TECHNIQUES

In the consideration of alternative actions, it is necessary that a common basis of evaluation be developed. The following sections provide criteria for evaluating access management techniques in three areas:

- Engineering Feasibility
- Operational Effectiveness
- Economic Viability

ENGINEERING EVALUATION

Evaluation from an engineering standpoint considers the geometric design and operational requirements for implementation of a technique. With a complete set of design and operational requirements available, the highway agency can determine if a particular technique can be physically implemented at a particular site. If the site meets the geometric requirements for the technique, the technique is technically feasible for that location. If the geometric requirements are not met, the technique is infeasible and should be abandoned in favor of some other alternative.

Operational controls and criteria deal primarily with vehicle, driver, and traffic characteristics. These characteristics determine the geometric requirements of physical control implementation. These are available from many sources and design manuals which describe characteristics for various vehicle classifications and situations. References 1 and 2 provide information regarding characteristics used in developing access control technique designs shown in Chapter VII and Appendix A of this text.

Physical restrictions to implementation appear as longitudinal or transverse constraints. Major longitudinal constraints include insufficient property frontage widths, driveway spacings, corner clearances, major intersection spacings, and median opening spacings. Major transverse constraints include insufficient right-of-way width, median width, or setbacks (to buildings or parking areas).

Table VIII.1 illustrates the range of possible major physical constraints that could affect implementation of the techniques described in Chapter VI. These are general considerations to be used in selecting alternatives. Each technique selected as an alternative solution must be evaluated on the basis of physical conditions actually existing along the roadway when it is to be implemented.

OPERATIONAL EFFECTIVENESS EVALUATION

Operational conditions on a roadway can be defined by measures of effectiveness (MOE's) such as travel time, interruptions, freedom to maneuver, operating costs, safety, and comfort and convenience. The operational benefit of alternative access management measures can thus be compared if their individual impact on these MOE's is known. In an effort to establish this relationship, a study was conducted of the impact of various access management techniques on accidents and delay (1).

The information in this study was developed using several site specific parameters:

- Level of development (number of commercial driveways per mile)
- Highway traffic volume
- Driveway traffic volume

Preceding page blank

Technique	No Constraint	Available ROW for Widening	Median Width	Property Frontage Width	Setback to Buildings and Parking Areas	Driveway Spacing	Corner Clearance	Major Inter-section Spacing	Spacing of Median Openings	Other
	Possible Major Physical Constraints to Implementation									
A-1		●			●			●		
A-2		●			●			●		
A-3										●
A-4							●			
A-5			●							
A-6		●			●					
A-7			●							
A-8					●					
A-9			●							
A-10				●	●	●	●			
A-11				●	●	●		●		
A-12				●	●	●	●			
A-13				●	●				●	
A-14	●									
A-15				●	●	●			●	
A-16				●	●	●				
A-17					●					
A-18		●								
A-19		●		●			●			
A-20					●					
B-1				●		●				
B-2				●		●				
B-3				●						
B-4	●									
B-5	●									
B-6					●				●	
B-7	●									
B-8	●									
B-9	●									
B-10	●									
B-11	●									
B-12					●					
C-1								●		
C-2	●									
C-3	●									
C-4					●					●
C-5				●	●	●	●			
C-7				●	●	●				
C-8										●
C-9	●									
C-10	●									
C-11		●		●		●				
C-12										●
C-13				●	●	●				
C-14		●			●					
D-1		●			●			●		
D-2		●			●			●		
D-3		●			●					
D-4		●			●					
D-5			●						●	
D-6			●							
D-7					●					
D-8	●									
D-9		●			●					
D-10		●						●		
D-11										●
D-12										●
D-13				●	●					
D-14					●					
D-15				●	●	●				
D-16		●		●	●	●	●			
D-17				●	●	●				
D-18										●
D-19	●									
D-20										●

TABLE VIII.1 GENERAL ENGINEERING FEASIBILITY OF TECHNIQUES

To simplify the evaluation, these parameters were each categorized as low, medium or high, based on the values shown in Table VIII.2.

The results of this study are summarized in Table VIII.3 which provide an indication of the annual reduction in accidents or hours of delay which can be expected if a particular technique is implemented.

The combinations of site parameters used in quantifying and classifying the effectiveness measures are: (1) highway volume and level of development; (2) highway volume and driveway volume; or (3) highway volume alone. Each of these parameters are designated in the tables as high, medium, or low as previously defined. As the tables are constituted, highway volume is always the primary site paramater, and level of development and driveway volume are secondary site parameters.

Not all techniques are included in Table VIII.3 due to difficulty in obtaining credible information. Further details of the derivation of this data can be found in Reference 1.

ECONOMIC EVALUATION

The economics of implementing access control techniques are highly variable because of many aspects that are either locational or activity-dependent. In this period of ever-tightening budgets and increased competition for available funds, however, it is essential that the implementing officials be able to economically justify their proposed capital expenditures. Comparison of expected benefits, both quantitative and/or qualitative, with proposed expense is necessary during the early planning stages to determine project feasibility.

While a variety of methods are available for developing this comparison, the benefit/cost ratio and utility/cost ratio are two of the most widely used.

Benefit/Cost Method

Benefit/Cost Method is perhaps the most widely used by street and highway agencies. This method states the relative worth of several alternatives in terms of ratio between the annual benefits derived from the project and the annual costs, including both capital and maintenance costs. An assumed interest rate must be used to place all dollar values on an annual basis for the life of the project. Ratios greater than 1.0 indicate that the project is economically sound. Analysis may be done on either the incremental benefits and costs of moving upward among the project alternatives or may be computed for each on a total cost and benefit basis.

In presenting benefit-cost ratios, it is useful to group projects into two or three gro ps (e.g., 1.0 to 3.0 as "low priority", 4.0 to 9.0 as "medium", and above 9.0 as "high priority" projects) in order to minimize insignificant differences in the numerical ratio. It has been found that policy or political groups making decisions on priorities sometimes blindly accept insignificant differences—say of 0.2--in ratios as being "absolute" and will set priorities accordingly. By grouping a number of projects in broad categories, the programming of street projects can retain flexibility as preliminary design is taking place; with one project being substituted for another if obstacles arise.

Usually, the inclusion of benefits in time savings will be controversial. Unless a strong case can be made for including this factor, it is best eliminated from the process or used simply as a subjective factor to favor one or another project of otherwise equal desirability.

TABLE VIII.2. OPERATIONAL EVALUATION PARAMETERS

Level of Development	Number of Commercial Driveways per Mile	Average
Low	0-30	15
Medium	31-60	45
High	>60	75
Highway Volume	**ADT Range**	**ADT Average**
Low	0-5,000	3,000
Medium	5,001-15,000	10,000
High	>15,000	20,000
Commercial Driveway Volume	**ADT Range**	**ADT Average**
Low	0-500	250
Medium	501-1,500	1,000
High	>1,500	2,000

TABLE VIII.3-A. PREDICTION OF DELAY AND ACCIDENT REDUCTION

FUNCTIONAL OBJECTIVE A -- LIMIT NUMBER OF CONFLICT POINTS

Techniques with Quantified Benefits

			Annual Accident Reduction and/or (Annual Hours of Delay Reduction)								
			Highway Volume								
			Low			Medium			High		
		Operational Parameter (a)	Operational Parameter Level			Operational Parameter Level			Operational Parameter Level		
Technique	Option		Low	Medium	High	Low	Medium	High	Low	Medium	High
A-1	*	2	-2.7	1.8	6.3	-4.0	4.7	13.6	-5.0	8.1	21.3
A-2	*	2	2.2	5.8	10.7	4.1	11.2(2628)	20.7(6059)	6.3	17.2(6935)	31.2(17046)
A-3	*	2	---	---	---	---	9.9(30405)	13.6(36500)	---	14.9(73000)	20.4(91250)
A-4	1	3	0.12(-358)	0.28(-358)	0.43(-358)	0.20(-3975)	0.49(-3975)	0.76(-3975)	0.28(-15735)	0.67(-15735)	1.02(-15735)
	2	3	0.17(-358)	0.42(-358)	0.65(-358)	0.30(-3975)	0.74(-3975)	1.14(-3975)	0.42(-15735)	1.00(-15735)	1.53(-15735)
A-5	1	1	0.08	0.19	0.29	0.14	0.33	0.51	0.19	0.45	0.69
	2	1	0.05	0.13	0.19	0.09	0.22	0.34	0.12	0.30	0.46
	3	1	0.13	0.31	0.49	0.23	0.55	0.85	0.31	0.75	1.15
A-6	*	2	0.25	0.40	.055	0.50	0.79	1.09	0.76	1.20	1.63
A-8		1	---	---	---	---	0.4	0.4	---	0.4	0.4
A-10		1	0.40	0.90	1.60	0.7	1.7	2.6	1.0	2.3	3.6
A-11		1	-0.58	-0.60	-0.60	-1.0	-1.0	-0.8	-1.4	-1.4	-1.2
A-12		1	0.02	0.07	0.11	0.05	0.12	0.18	0.06	0.16	0.26
A-13		1	0.09	0.21	0.32	0.15	0.37	0.57	0.21	0.50	0.77
A-14		1	0.28	0.70	1.08	0.50	1.22	1.88	0.68	1.66	2.56
A-15		1	0.34	0.84	1.30	0.60	1.46	2.26	0.82	2.00	3.06
A-16	1	1	0.05	0.13	0.19	0.09	0.22	0.34	0.12	0.30	0.46
	2	1	0.08	0.19	0.29	0.14	0.33	0.51	0.19	0.45	0.69
	3	1	0.13	0.31	0.49	0.23	0.55	0.85	0.31	0.75	1.15
A-17	1	1	0.010	0.025	0.039	0.018	0.044	0.068	0.025	0.060	0.092
	2	1	0.008	0.019	0.029	0.014	0.033	0.051	0.019	0.045	0.069
	3	1	0.013	0.032	0.049	0.023	0.055	0.085	0.031	0.075	0.115
A-19		1	0.08	0.19	0.29	0.014	0.033	0.051	0.019	0.045	0.069
A-20		1	---	---	---	---	0.4	0.4	---	0.4	0.4

* Note: All benefits expressed as benefits per installation except those marked "*" indicating benefits per mile of improvement.

a. Operational Parameter Code
1. Driveway volume
2. Level of development (commercial driveways per mile)
3. Accidents dependent on driveway volume and delay dependent only on highway volume

TABLE VIII.3-B. PREDICTION OF DELAY AND ACCIDENT REDUCTION

FUNCTIONAL OBJECTIVE B -- SEPARATE BASIC CONFLICT AREAS

Techniques with Quantified Benefits

Technique	Option	Operational Parameter (a)	Annual Accident Reduction and/or (Annual Hours of Delay Reduction) — Highway Volume: Low — Operational Parameter Level: Low	Low: Medium	Low: High	Medium — Operational Parameter Level: Low	Medium: Medium	Medium: High	High — Operational Parameter Level: Low	High: Medium	High: High
B-5		2	0.25	0.25	0.25	0.49	0.49	0.49	0.73	0.73	0.73
B-6		1 (c)	0.10	0.33	---	0.17	0.50	---	0.20	0.70	---
B-9		1	0.26	---	---	0.45	---	---	0.62	---	---
B-10		2	0.25	0.25	0.25	0.49	0.49	0.49	0.73	0.73	0.73
B-12		1	---	---	---	0.19	0.47	0.73	0.36	0.87	1.33

* Note: All benefits expressed as benefits per arterial driveway eliminated, or collector driveway added.

a. Operational Parameter Code
1. Driveway Volume
2. Accidents dependent only on highway volume

TABLE VIII.3-C. PREDICTION OF DELAY AND ACCIDENT REDUCTION

FUNCTIONAL OBJECTIVE C -- LIMIT MAXIMUM DECELERATION REQUIREMENTS

Techniques with Quantified Benefits

Technique	Option	Operational Parameter (a)	Annual Accident Reduction and/or (Annual Hours of Delay Reduction) — Highway Volume: Low — Operational Parameter Level: Low	Low: Medium	Low: High	Medium — Operational Parameter Level: Low	Medium: Medium	Medium: High	High — Operational Parameter Level: Low	High: Medium	High: High
C-2		1	0.016	0.038	0.058	0.027(23)	0.066(91)	0.102(182)	0.037(30)	0.090(122)	0.138(243)
C-3	1	1	0.05	0.13	0.20	0.09	0.23	0.36	0.13	0.32	0.48
	2	1	0.02	0.06	0.09	0.04	0.11	0.16	0.06	0.14	0.22
	3	1	0.04	0.11	0.16	0.08	0.18	0.29	0.10	0.25	0.39
C-4		2	1.9	3.0	4.2	3.8	6.0	8.2	5.7	9.0	12.3
C-7		1	0.016	0.038	0.058	0.027(23)	0.066(91)	0.102(183)	0.037(30)	0.090(122)	0.138(243
C-8		1	(25.3)	(101.4)	(202.8)	(50.6)	(202.8)	(405.6)	(75.9)	(304.2)	(608.4)
C-9		1	(25.3)	(101.4)	(202.8)	(50.6)	(202.8)	(405.6)	(75.9)	(304.2)	(608.4)
C-10		1	(25.3)	(101.4)	(202.8)	(50.6)	(202.8)	(405.6)	(75.9)	(304.2)	(608.4)
C-11		1	0.02	0.05	0.07	0.03	0.08	0.13	0.05	0.11	0.17
C-12		1	---	---	---	---	0.4	0.4	---	0.4	0.4
C-13		1	0.008	0.019	0.029	0.014	0.033	0.051	0.019	0.045	0.069

* Note: All benefits expressed as benefits per driveway except for C.4, which is in benefits per mile of parking removed.

a. Operational Parameter Code
1. Driveway volume
2. Level of development (commercial driveways per mile)

TABLE VIII.3-D. PREDICTION OF DELAY AND ACCIDENT REDUCTION

FUNCTIONAL OBJECTIVE D -- REMOVE TURNING VEHICLES OR QUEUES FROM SECTIONS OF THE THROUGH LANES

Techniques with Quantified Benefits

			Annual Accident Reduction and/or (Annual Hours of Delay Reduction)								
			Highway Volume								
			Low			Medium			High		
		Operational Parameter (a)	Operational Parameter Level			Operational Parameter Level			Operational Parameter Level		
Technique	Option		Low	Medium	High	Low	Medium	High	Low	Medium	High
D-1	*	2	4.4	7.1	9.7	8.8	13.9(2628)	19.0(6059)	13.3	20.9(6935)	28.6(17046)
D-2	*	2	4.4	7.1	9.7	8.8	13.9(2628)	19.0(6059)	13.3	20.9(6935)	28.6(17046)
D-3		2	1.7	3.5	6.4	3.2	7.1(2628)	13.3(6059)	5.1	11.6(6935)	21.0(17046
D-4		1	0.13	0.32	0.49	0.23	0.55(263)	0.85(606)	0.31	0.75(694)	1.15(1705)
D-5		1	---	0.13	0.19	---	0.22	0.34	1.2	3.0	4.5
D-6		1	0.02	0.04	0.07	0.03	0.07	0.11	0.04	0.10	0.16
D-7		1	0.026	0.063	0.047	0.045	0.11(263)	0.17(345)	0.062	0.15(694)	0.23(973)
D-8		1	0.01	0.03	0.04	0.02	0.04	0.07	0.03	0.06	0.09
D-9	*	2	---	1.4	2.1	---	1.8	3.6	---	3.3	4.9
D-14		1 (c)	---	---	---	---	-0.15	-0.03	---	-0.03	-0.03
D-16		1	0.02	0.05	0.07	0.03(23)	0.08(91)	0.13(183)	0.05(32)	0.11(122)	0.17(243)

* Note: All benefits are expressed as benefits per installation except those marked "*", indicating benefits per mile of improvement.

a. Operational Parameter Code

1. Driveway Volume
2. Accidents dependent only on highway volume

Costs

In this analysis, costs are defined as cost of land acquisition, project design and construction, and any dislocation or other social costs. Inasmuch as the purpose of the analysis is to relate the annual benefits received to the annual costs incurred, it is necessary that these costs be annualized by applying a capital recovery factor to the initial costs and a uniform present worth series factor to any salvage value. Both of these factors are variable—depending on the period of analysis and the vestcharge rate (often called interest or opportunity cost).

Approximate costs were developed for the 66 access management techniques described in Chapter VI.

It was recognized at the time of development however, that because of the high variation in construction costs due to inflation, geographical location, time of year, method of construction, and other variables, the prices developed for each technique were best used as relative indicators for comparing several alternatives. For this reason, Table VIII.4 has been developed using the categories and costs developed; however, all prices have been reduced to a unit value and each technique calibrated against that unit. This will enable the designer to compare one technique with another through the development of unit cost figures for his area and conditions. A technique with an index rating of 50 would be 50 times as expansive as a technique with a rating of 1. By developing costs for a technique with a unit (1) rating, general cost estimates can be assumed for other techniques. It must be emphasized, however, that it is still essential that specific costs be developed for any construction estimate when anything but a general approximation is needed.

In evaluating the costs of a few techniques, it was evident that the costs were highly variable and site-dependent. Difficulty in estimating a representative cost was apparent, and therefore no specific costs were estimated for these techniques. In these cases, it was felt the specific location, conditions and parameters need to be carefully evaluated to obtain a representative cost estimate.

Benefits

Benefits are usually expressed as a reduction in costs to the road user. Implementation of access management techniques will usually impact two main areas:

- Accident costs
- Costs associated with time of vehicle operation

Accident Costs

Traffic accidents result in costs to society, whether they are direct or indirect costs. These costs include property damage, medical costs, productivity losses, and social welfare losses.

Costs Associated with Time of Vehicle Operation

Any vehicle entering or leaving a direct access point on the highway has the potential of influencing the progress of through vehicles. The driveway maneuver can delay other drivers by causing them to change lanes, decelerate, or stop completely. These influences are increased when highway or driveway geometrics are inadequate for the existing conditions. Excessive delay can also be experienced by vehicles exiting a driveway due to inadequate design or control. Factors most often constituting these time-related costs include:

1. Driver/Passenger Time Delay
2. Fuel Consumption
3. Tire Wear
4. Oil Consumption
5. Maintenance Costs
6. Depreciation

TABLE VIII.4 RELATIVE IMPLEMENTATION COSTS OF ACCESS MANAGEMENT TECHNIQUES

Functional Objective A -- Limit Number of Conflict Points

Technique	Construction Option	Relative Cost Index
A-1: Install Median Barrier With No Direct Left-Turn Access	1. Basic construction - median barrier on existing paved median and jug-handle or cloverleaf construction	370
	2. Basic construction plus additional pavement widening	608
	3. Basic construction plus additional pavement widening and right-of-way acquisition	798
A-2: Install Raised Median Divider With Left-Turn Deceleration Lanes	1. Basic construction - raised median with openings on existing paved median	195
	2. Basic construction plus additional pavement widening	738
	3. Basic construction plus additional pavement widening and right-of-way acquisition	1,180
A-3: Install One-Way Operations on the Highway	1. Signing and striping	15
A-4: Install Traffic Signal at High-Volume Driveways	1. Two-phase pretimed signal installation	30
	2. Three-phrase semi-actuated signal installation	60
A-5: Channelize Median Openings to Prevent Left-Turn Ingress and/or Egress Maneuvers	1. Channelizing island to prevent left-turn egress maneuvers	2
	2. Channelizing island to prevent left-turn egress	2
	3. Close median opening to prevent all left-turn maneuvers	2
A-6: Widen Right Through-Lane to Limit Right-Turn Encroachments onto the Adjacent Lane to the Left	1. Highway widening	186
	2. Highway widening and right-of-way acquisition	282
A-7: Install Channelizing Island to Prevent Left-Turn Deceleration Lane Vehicles From Returning to Through Lanes	1. Channelizing island on existing median	3
A-8: Install Physical Barrier to Prevent Uncontrolled Access Along Property Frontages	1. Barrier curb	144
A-9: Install Median Channelization to Control Merge of Left-Turn Egress Vehicles	1. Channelizing island on existing median	1
A-10: Offset Opposing Driveways	1. Close and relocate driveway	9
A-11: Locate Driveway Opposite a Three-Leg Intersection or Driveway and Install Traffic Signals Where Warranted	1. Two-phase pretimed signal installation	30
	2. Signal installation plus closing and relocating driveway	39
A-12: Install Two One-Way Driveways in Lieu of One Two-Way Driveway	1. Convert two-way driveway to one-way operation and construct additional one-way driveway	6
	2. Close two-way driveway and construct two one-way driveways	5

Table VIII.4, Continued

Technique	Construction Option	Relative Cost Index
A-13: Install Two Two-Way Driveways with Limited Turns in Lieu of One Standard Two-Way Driveway	1. Construct one driveway and channelize both driveways	8
	2. Close one driveway and construct two channelized driveways	16
A-14: Install Two One-Way Driveways in Lieu of Two Two-Way Driveways	1. Signing	1
A-15: Install Two Two-Way Driveways with Limited Turns in Lieu of Two Standard Two-Way Driveways	1. Channelize two angled driveways	2
	2. Close two driveways and construct two angled limited-turn driveways and medial turning bays	34
	3. Channelize two t-driveways	2
A-16: Install Driveway Channelizing Island to Prevent Left-Turn Maneuvers	1. Driveway widening and channelization to prevent left-turn egress vehicles	4
	2. Driveway widening and channelization to prevent left-turn egress vehicles	4
	3. Driveway widening and channelization to prevent both left-turn ingress and egress vehicles	7
A-17: Install Driveway Channelizing Island to Prevent Driveway Encroachments Conflicts	1. Medial channelizing island and driveway widening	2
	2. Driveway curbing (one side)	1
	3. Medial channelizing island, driveway widening, and driveway curbing (one side)	3
A-18: Install Channelizing Island to Prevent Right-Turn Deceleration Lane Vehicles from Returning to the Through Lanes	1. Channelizing island	3
	2. Channelizing island and deceleration lane widening	8
	3. Channelizing island, deceleration lane widening, and additional right-of-way acquisition	10
A-19: Install Channelizing Island to Control the Merge Area of Right-Turn Egress Vehicles	1. Channelizing island and driveway widening	4
A-20: Regulate the Maximum Width of Driveways	1. Curbing	1

Table VIII.4, Continued

Functional Objective B -- Separate Basic Conflict Areas

Technique	Construction Option	Relative Cost Index
B-1: Regulate Minimum Spacing of Driveways	1. Close one driveway	2
	2. Close and relocate one driveway	8
B-2: Regulate Minimum Corner Clearance	1. Close one driveway	2
	2. Close and relocate one driveway	8
B-3: Regulate Minimum Property Clearance	1. Close one driveway	2
	2. Close and relocate one driveway	8
B-4: Optimize Driveway Spacing in the Permit Authorization Stage	1. Implemented during the permit authorization stage	NC[2]
B-5: Regulate Maximum Number of Driveways per Property Frontage	1. Close one driveway	2
B-6: Consolidate Access for Adjacent Properties	1. Close two driveways and construct one driveway on property line	11
	2. Close one driveway and construct one driveway on property line	8
B-7: Require Highway Damages for Extra Driveways	1. Basic construction - costs are highly variable	NC[1]
B-8: Buy Abutting Properties	1. Basic construction - costs are highly site-specific	NC[1]
B-9: Deny Access to Small Frontage	1. Basic construction - costs are highly variable and dependent on land value	NC[1]
	2. Construct connection between properties	2
	3. Close one driveway and construct one driveway on property line	8
B-10: Consolidate Existing Access Whenever Separate Parcels are Assembled Under One Purpose, Plan, Entity, or Usage	1. Close one driveway	2
B-11: Designate the Number of Driveways Permitted to Each Existing Property and Deny Additional Driveways Regardless of Future Subdivision of that Property	1. Implemented during the permit authorization stage	NC[2]
B-12: Require Access on Collector Street (when available) in Lieu of Additional Driveway on Highway	1. Construct one driveway	6

1. No direct estimate.
2. No incremental cost.

Table VIII.4, Continued

Functional Objective C -- Limit Maximum Deceleration Requirements

Technique	Construction Option	Relative Cost Index
C-1: Install Traffic Signals to Slow Highway Speeds and Meter Traffic for Larger Gaps	1. Two-phase pretimed signal installation	30
C-2: Restrict Parking on the Roadway Next to Driveways to Increase Driveway Turning Speeds	1. Signing	<1
C-3: Install Visual Cues of the Driveway	1. Suspended red-yellow flashing beacon	6
	2. Advance warning sign and flashing beacon	1
	3. Driveway illumination	4
C-4: Improve Sight Distance by Preventing Parking on the Traveled Way, Either Totally or Partially	1. Signing	10
C-5: Regulate Minimum Sight Distance	1. Close and relocate one driveway	8
C-6: Optimize Sight Distance in the Permit Authorization Stage	1. Implemented during the permit authorization stage	NC[1]
C-7: Increase the Effective Approach Width of the Driveway	1. Increase return radii on both sides of driveway	1
C-8: Improve the Vertical Geometrics of the Driveway	1. Partial driveway reconstruction	2
	2. Mountable curb removal	1
C-9: Require Driveway Paving	1. Driveway paving	6
C-10: Regulate Driveway Construction (performance bond) and Maintenance	1. Implemented during the permit authorization stage	NC[1]
C-11: Install Right-Turn Acceleration Lane	1. Acceleration lane	10
	2. Acceleration lane and additional right-of-way acquisition	
C-12: Install Channelizing Islands to Prevent Driveway Vehicles from Backing onto the Highway	1. Channelizing islands	19
C-13: Install Channelizing Islands to Move Ingress Merge Point Laterally Away from the Highway	1. Channelizing island and driveway widening	4
C-14: Move Sidewalk - Driveway Crossing Laterally Away from Highway	1. Sidewalk relocation	3

1. No incremental cost.

Table VIII.4, Continued

Functional Objective D -- Remove Turning Volumes or Queues from Sections of the Through Lanes

Technique	Construction Option	Relative Cost Index
D-1: Install Two-Way Left-Turn Lane	1. Basic construction - median striping on existing median	16
	2. Basic construction plus additional pavement widening	560
	3. Basic construction plus additional pavement widening and right-of-way acquisition	1,000
D-2: Install Continuous Left-Turn Lane	1. Basic construction - median striping on existing median	25
	2. Basic construction plus additional pavement widening	806
	3. Basic construction plus additional pavement widening right-of-way acquisition	1,567
D-3: Install Alternating Left-Turn Lane	1. Basic construction - median striping on existing median	20
	2. Basic construction plus additional pavement widening	564
	3. Basic construction plus additional pavement widening and right-of-way acquisition	1,006
D-4: Install Isolated Median and Deceleration Lane to Shadow and Store Left-Turning Vehicles	1. Basic construction - median installation and highway widening	73
	2. Basic construction plus right-of-way acquisition	117
D-5: Install Left-Turn Deceleration Lane in Lieu of Right-Angle Crossover	1. Deceleration lane installation	15
D-6: Install Medial Storage for Left-Turn Egress Vehicles	1. Channelizing island and existing median alteration	10
D-7: Increase Storage Capacity of Existing Left-Turn Deceleration Lane	1. Storage increase for a continuous curbed median	13
	2. Storage increase for an isolated curbed median	28
	3. Storage increase for an isolated curbed median plus additional right-of-way acquisition	39
	4. Highway widening for two-lane left-turn bay at an isolated curbed median	71
	5. Highway widening plus additional right-of-way acquisition for two-lane left-turn bay at an isolated curbed median	130
D-8: Increase the Turning Speed of Right-Angle Median Crossovers by Increasing the Effective Approach Width	1. Uniformly widened crossover lane	2
	2. Flared crossover lane	1
	3. Increased return radius of median opening	1
	4. Increased median opening width	1
D-9: Install Continuous Right-Turn Lane	1. Basic construction - continuous right-turn lane	99
	2. Basic construction plus additional right-of-way acquisition	194

Table VIII.4, Continued

Technique		Construction Option	Relative Cost Index
D-10: Construct a Local Service Road	1.	Frontage road	NC[1]
D-11: Construct a Bypass Road	1.	Bypass road	NC[1]
D-12: Reroute Through Traffic	1.	Basic construction - costs are highly variable and location-dependent	NC[1]
D-13: Install Supplementary One-Way Right-Turn Driveways to Divided Highway (non-capacity warrant)	1.	Construct one one-way supplementary driveway	6
D-14: Install Supplementary Access on Collector Street When Available (non-capacity warrant)	1.	Construct one supplementary driveway at no cost to the highway agency	NC[2]
D-15: Install Additional Driveway When Total Driveway Demand Exceeds Capacity	1.	Construct additional driveway	6
D-16: Install Right-Turn Deceleration Lane	1.	Deceleration lane	9
	2.	Deceleration lane and additional right-of-way acquisition	16
D-17: Install Additional Exit Lane on Driveway	1.	Additional driveway lane construction	8
D-18: Encourage Connections Between Adjacent Properties (even when each has highway access)	1.	Connection between properties	2
D-19: Require Two-Way Driveway Operation Where Internal Circulation is Not Available	1.	Basic construction - costs are site-specific	NC[1]
D-20: Require Adequate Internal Design and Circulation Plan	1.	Basic construction - costs are highly variable and location-dependent	NC[1]

1. No direct estimate.
2. No incremental cost.

UTILITY/COST METHOD

With social, community, and environmental factors becoming more important in street projects, measures of non-quantifiable subject matter must be applied to estimate the approximate value of a project. Many procedures exist and are known by names such as "cost-effectiveness", "utility cost", and "value methodology". In essence, all deal with the same problem: how to combine quantifiable and non-quantifiable variables into a single figure of merit.

The principal steps in most of these new evaluation methods are:

- Goals and objectives for each project are set forth.
- The relative importance of each goal, and then each objective within a goal, is determined.
- A set of measures ("utility" measures) is defined for each objective. These are specific statements which allow the evaluators to determine how well a given design meets a given objective.
- Each utility measure is given a rating for each alternative under consideration. A rating scale from 1 to 5 or from 1 to 10 is commonly used.
- An effectiveness or utility score for each alternative is found by multiplying the objective weight by its rating, and then summing to obtain a single rating for the alternative.
- The utility or effectiveness rating for each alternative is compared with the project costs, usually in a "utility-cost" ratio. The alternative project having the highest ratio, either total or incremental, is considered the best alternative. Although these methods do indicate the relative merit of several alternatives, the numerical value of a utility cost ratio does not in itself describe the value of a project in the overall plan of public expenditures. What is sometimes done is to select the best alternative using utility-cost and then to develop a "benefit-cost" ratio to compare its value with other public projects.

Typical goals and objectives used for access management projects are shown in Table VIII.5.

TABLE VIII.5 GOALS AND OBJECTIVES FOR STREET IMPROVEMENTS

A. Objectives directly affecting the highway users:
   1. Minimize motor vehicle running cost
   2. Minimize motor vehicle travel time
   3. Minimize traffic accidents and their cost
   4. Maximize travel comfort and convenience

B. Objectives directly pertaining to highway design:
   5. Minimize the monetary cost of highway construction, maintenance, and operation
   6. Maximize the quality of travel service
   7. Provide for high-capacity facilities to be used by maximum percentage of total area traffic

C. Objectives related to community transportation:
   8. Maximize coordination and integration of total transportation system of all modes
   9. Provide adequate transportation to all land areas and land uses in accordance with land-use plans

D. Objectives related to community development factors:
   10. Enhance the achievement of the overall regional and community development plans
   11. Preserve and enhance the community goals and attributes in support of its desired type of community
   12. Enhance the provisions for national defense and emergency transportation
   13. Conserve open space

E. Objectives related to community social factors:
   14. Preserve the historical and "sacred" areas and objects
   15. Minimize the adversities to residents and establishments occasioned by ROW procurement and route location
   16. Preserve the desired social attributes of local areas and the community
   17. Provide for and preserve neighborhood unity
   18. Minimize air pollution
   19. Minimize the nuisance from noise
   20. Preserve and enhance natural beauty and scenic enjoyables
   21. Maximize the pleasing effects of aesthetics and design to achieve effects compatible with local areas
   22. Enhance the opportunities for recreation
   23. Minimize the disruption of activities during the construction phase

F. Objectives related to economic factors:
   24. Minimize the adverse consequences to business, trade, and industry, before, during, and after construction
   25. Maximize conservation of resources
   26. Preserve land values
   27. Promote land use in accordance with economic development plans

Source: Ref. 3

CHAPTER VIII REFERENCES

1. Azzeh, J. A. et al, Evaluation of Techniques for Control of Direct Access to Arterial Highways. FHWA RD 76-85; 1975.

2. Stover, Vergil G., et al., "Guidelines for Medial and Marginal Access Control on Major Roadways," NCHRP Report 93 (1970).

3. Winfrey, R. and Zellner, C., "Summary and Evaluation of Economic Consequences of Highway Improvements", NCHRP-122, HRB, Washington, D. C. 1971.

CHAPTER IX. APPLICATION OF TECHNIQUES

This chapter provides an overview into the use of the various access management techniques and an example of the application of the various principles described in the previous chapters. Situations will vary in different locations and among the various public agencies administering the program, however, the general elements involved in the approach to an access-related problem usually include:

- Definition of problem
- Inventory of operational and physical characteristics of roadway segment and area.
- Identification of alternative solutions
- Evaluation of alternative solutions
- Selection of alternative providing greatest operational and cost-effective solution

These steps are further defined in the following recommended procedure.

Step 1: Definition of problem. This step implies recognition that operational or safety conditions are not within parameters acceptable to the affected community. These obviously vary with the roadway character, urban or rural setting, type and volume of traffic, and community values. Many jurisdictions set theoretical accident rates and/or delay levels (or levels of service) beyond which they institute investigation.

Step 2: As a minimum, identify the operational and physical characteristics of the roadway segment to be studied including:

- Highway volume
- Driveway volume
- Level of development

These should be classified as high, medium, or low as per Table IX.1. The roadway segment should be physically identified as:

- Multilane divided
- Multilane undivided
- Two-lane

Step 3: Select the alternative techniques that may be applicable to the problem(s). This is accomplished through the use of Table IX.2:

- Select the segment of Table IX.2 (A, B, or C) which corresponds to the highway volume (high, medium, low)
- Find the horizontal section of that table that corresponds to the physical definition of the roadway (multilane divided, two-way, etc.)
- Enter that portion of the table within the column that describes the operational parameters of the roadway segment (level of development or driveway volume—high, medium, low). The techniques listed in this square are those which may be applicable to this particular situation
- Evaluate each of these techniques as per the procedures described in Chapter VIII
    - Engineering
    - Operational
    - Economics
- Select that technique (or group of techniques) which provides the greatest cost-effective solution in achieving the community's goals

TABLE IX.1. OPERATIONAL EVALUATION PARAMETERS

Level of Development	Number of Commercial Driveways per Mile	Average
Low	0-30	15
Medium	31-60	45
High	>60	75
Highway Volume	**ADT Range**	**ADT Average**
Low	0-5,000	3,000
Medium	5,001-15,000	10,000
High	>15,000	20,000
Commercial Driveway Volume	**ADT Range**	**ADT Average**
Low	0-500	250
Medium	501-1,500	1,000
High	>1,500	2,000

TABLE IX.2-A. WARRANTS FOR TECHNIQUES

LOW HIGHWAY VOLUME
(Less Than 5,000)

OPERATIONAL PARAMETERS

LOW				MEDIUM				HIGH			
Multilane Divided											
A	B	C	D	A	B	C	D	A	B	C	D
	8	2	14		8	2	14		8	1	14
	9	3	18		9	3	18		9	2	18
	10	4	19		10	4	19		10	3	19
	11	5			11	5			11	4	
	12	6			12	6			12	5	
		7				7				6	
		8				8				7	
		9				9				8	
		10				10				9	
										10	
Multilane Undivided											
A	B	C	D	A	B	C	D	A	B	C	D
10	8	2	14	10	8	2	14	4	8	1	14
	9	3	18		9	3	18	10	9	2	18
	10	4	19		10	4	19		10	3	19
	11	5			11	5			11	4	
	12	6			12	6			12	5	
		7				7				6	
		8				8				7	
		9				9				8	
		10				10				9	
										10	
Two-Lane											
A	B	C	D	A	B	C	D	A	B	C	D
10	8	2	14	10	8	2	14	4	8	1	14
	9	3	18		9	3	18	10	9	2	18
	10	4	19		10	4	19		10	3	19
	11	5			11	5			11	4	
	12	6			12	6			12	5	
		7				7				6	
		8				8				7	
		9				9				8	
		10				10				9	
										10	

TABLE IX.2-B. WARRANTS FOR TECHNIQUES

MEDIUM HIGHWAY VOLUME
(5,000 - 15,000)

OPERATIONAL PARAMETERS

Multilane Divided

LOW				MEDIUM				HIGH			
A	B	C	D	A	B	C	D	A	B	C	D
6	2	2	5	1	1	2	3	2	2	1	1
7	3	3	6	2	2	3	5	4	3	2	2
9	5	4	7	5	3	4	6	5	4	3	3
11	6	5	8	6	4	5	7	6	5	4	5
12	8	6	14	7	5	6	8	7	6	5	7
13	9	7	16	8	6	7	14	8	8	6	8
14	10	8	17	9	7	8	16	9	9	7	13
15	11	9	18	11	8	9	17	11	10	8	14
18	12	10	19	12	9	10	18	14	11	9	15
19		11	20	13	10	11	19	17	12	10	16
20		12		14	11	12	20	18		11	17
		14		15	12	13		20		12	18
				17		14				13	19
				18						14	20
				19							
				20							

Multilane Undivided

LOW				MEDIUM				HIGH			
A	B	C	D	A	B	C	D	A	B	C	D
10	5	2	4	1	1	2	3	2	4	1	1
11	6	3	14	2	4	3	4	3	5	2	2
12	8	4	16	3	5	4	14	4	6	3	3
14	9	5	17	8	6	5	16	8	8	4	5
15	10	6	18	10	8	6	17	10	9	5	7
18	11	7	19	11	9	7	18	11	10	6	8
19	12	8	20	12	10	8	19	14	11	7	13
20		9		14	11	9	20	16	12	8	14
		10		16	12	10		17		9	15
		11		17		11		18		10	16
		12		18		12		20		11	17
		14		19		13				12	18
				20		14				13	19
										14	20

Two-Lane

LOW				MEDIUM				HIGH			
A	B	C	D	A	B	C	D	A	B	C	D
10	5	2	4	3	1	2	3	3	4	1	3
11	6	3	14	8	4	3	4	4	5	2	4
12	8	4	16	10	5	4	14	8	6	3	14
14	9	5	17	11	6	5	16	10	8	4	15
15	10	6	18	12	8	6	17	11	9	5	16
18	11	7	19	14	9	7	18	14	10	6	17
19	12	8	20	15	10	8	19	16	11	7	18
20		9		16	11	9	20	17	12	8	19
		10		17	12	10		18		9	20
		11		18		11		20		10	
		12		19		12				11	
		14		20		13				12	
						14				13	
										14	

TABLE IX.2-C. WARRANTS FOR TECHNIQUES

HIGH HIGHWAY VOLUME
(More Than 15,000)

OPERATIONAL PARAMETERS

Multilane Divided

LOW				MEDIUM				HIGH			
A	B	C	D	A	B	C	D	A	B	C	D
6	2	2	5	1	1	2	3	2	2	1	1
7	3	3	6	2	2	3	5	4	3	2	2
9	5	4	7	5	3	4	6	5	4	3	3
11	6	5	8	6	4	5	7	6	5	4	5
12	7	6	14	7	5	6	8	7	6	5	7
13	8	7	16	8	6	7	14	8	7	6	8
14	9	8	17	9	7	8	16	9	8	7	9
15	10	9	18	11	8	9	17	11	9	8	10
18	11	10	19	12	9	10	18	14	10	9	11
19	12	11	20	13	10	11	19	17	11	10	12
20		12		14	11	12	20	18	12	11	13
		14		15	12	13		20		12	14
				17		14				13	15
				18						14	16
				19							17
				20							18
											19
											20

Multilane Undivided

LOW				MEDIUM				HIGH			
A	B	C	D	A	B	C	D	A	B	C	D
11	2	2	4	1	1	2	3	2	2	1	1
14	3	3	16	2	2	3	4	3	3	2	2
15	5	4	17	3	3	4	14	4	4	3	3
18	6	5	18	8	4	5	16	8	5	4	4
19	7	6	19	11	5	6	17	11	6	5	9
20	8	7	20	12	6	7	18	12	7	6	11
	9	8		14	7	8	19	14	8	7	12
	10	9		15	8	9	20	16	9	8	13
	11	10		16	9	10		17	10	9	14
	12	11		17	10	11		18	11	10	15
		12		18	11	12		20	12	11	16
		14		19	12	13				12	17
				20		14				13	18
										14	19
											20

Two-Lane

LOW				MEDIUM				HIGH			
A	B	C	D	A	B	C	D	A	B	C	D
11	2	2	4	3	1	2	3	3	2	1	3
14	3	3	14	8	2	3	4	4	3	2	4
15	5	4	16	11	3	4	14	8	4	3	9
18	6	5	17	12	4	5	16	11	5	4	11
19	7	6	18	14	5	6	17	12	6	5	12
20	8	7	19	15	6	7	18	14	7	6	14
	9	8	20	16	7	8	19	16	8	7	15
	10	9		17	8	9	20	17	9	8	16
	11	10		18	9	10		18	10	9	17
	12	11		19	10	11		20	11	10	18
		12		20	11	12			12	11	19
		14			12	13				12	20
						14				13	
										14	

CHAPTER IX. REFERENCES

1. J.A. Azzeh, et al., FHWA-RD-76-85, Evaluation of Techniques for the Control of Direct Access to Arterial Highways, 1975.

Essential to every access management program is the site plan review process. This procedure provides for the review of all proposed construction and improvement plans (public and private) to assess the probable impact the project would have on the street system, traffic movement and safety, and future transportation planning to assure compliance with existing regulations, including access-related requirements, and suggest changes where necessary.

As provided for in the jurisdiction's adopted policy, an applicant must request approval for access. This request should take the form of an application giving pertinent details regarding applicant, area location, use of site, any applicable fees, and a site plan or drawing which indicates all locational, geometrics, and physical design requirements. The site plan should be sufficient in detail to allow a qualified technician to review for the following factors:

1. Circulation pattern -- site plan and design should allow for all vehicular circulation to take place on-site and not on the street at any time.
2. Angle of driveways--are they conducive to safe, efficient entry and exit of site?
3. Driveway radii--are they designed to accommodate prevailing types of traffic and speeds on roadway as per design guidelines?
4. Driveway grade--does it provide for entry and exit at safe speed.
5. Sight distance--can adequate sight distance be provided for entry and exit?
6. Driveway Width--is width adequate to handle type and volumes of traffic?
7. Driveway Location--is location relative to intersection, other driveways, and/or property line within prescribed guidelines?
8. Total number of driveways--are there sufficient driveways to handle entering volume; can number of driveways be reduced?
9. Auxiliary lanes--is there a need to provide auixiliary lanes on the main roadway to handle entering or exiting traffic?
10. Projected conditions--is proposed site plan suitable for projected uses and expected traffic volumes.
11. Physical construction design--an all-weather surface and construction materials sufficient to withstand type and volume of traffic should be required.
12. General--Does overall design, circulation pattern, entrance/exit location provide for minimal impact on the street system consistent with providing reasonable access to the site for its proposed use?

Figure X.1 provides a typical site plan highlighting those areas of interest to the reviewer.

Guidelines to assist in site review are provided in Chapter VII and Appendix A; however, it is important that the review process be consistent with those standards adopted and used by the particular governing jurisdiction.

Jurisdictions should encourage their involvement during the conceptual status of site planning. This is particularly true on large sites where there is often multi-use

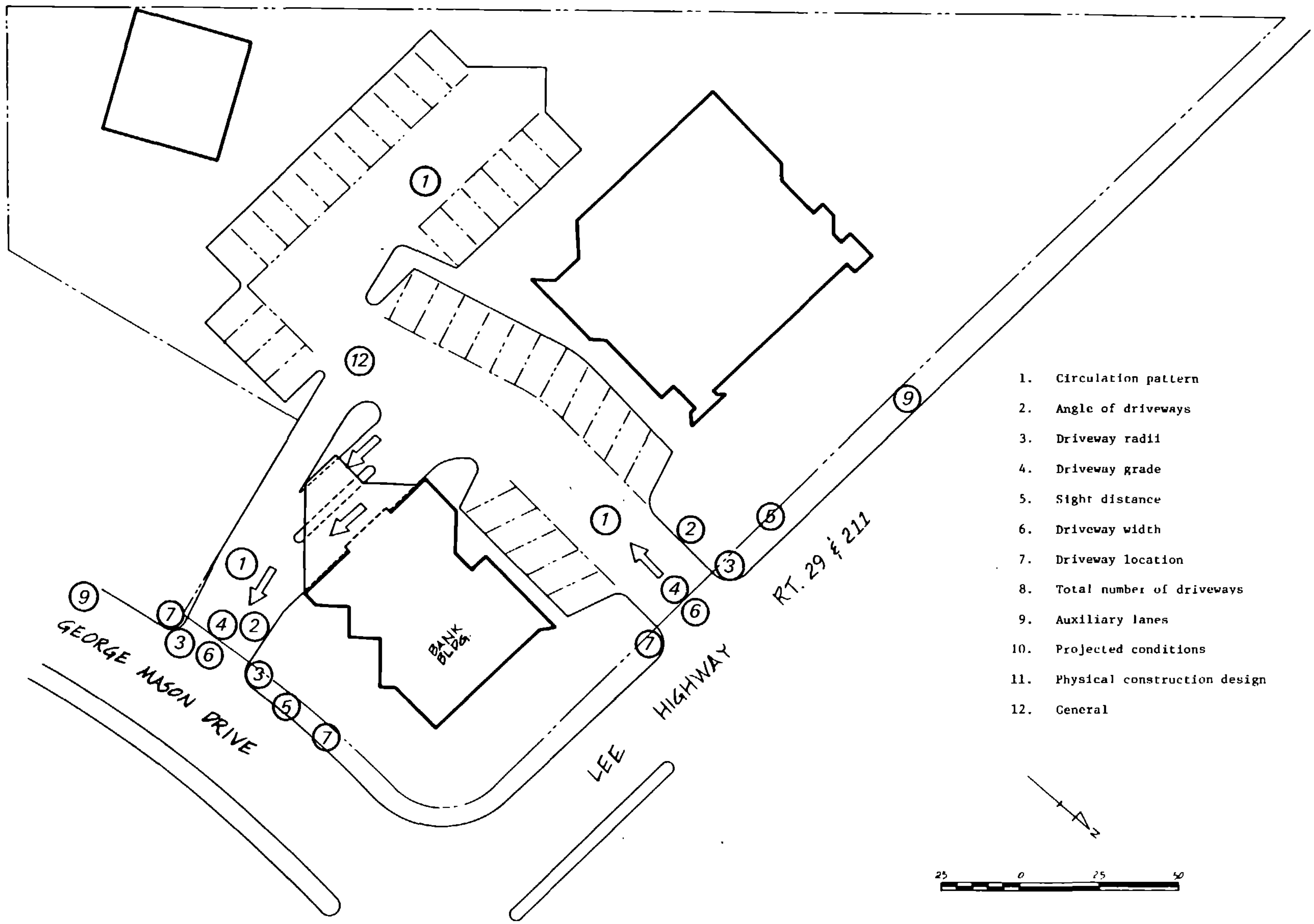


Figure X.1. Site Plan Evaluation

or staged construction. By meeting in the early stages of the project, owners/designers are made aware of the jurisdictions' concerns and requirements, and costly redesign and often ill-will can be avoided. Figure X.2 indicates the designation of access points on the conceptual site plan of a large multi-use area. The detailed site design can now be oriented around these prescribed access points.

Another important aspect of early jurisdictional involvement in site plan review is also evident in Figure X.2, Coordination of Access with Adjacent Property. In the figure, Garner Court (proposed) is being required by the jurisdiction to be located in such a position as to align with another roadway which has been platted (but not constructed) on adjacent property north of the site. In this situation, Garner Court will be platted and right-of-way reserved up the northern boundary of the site. The road will be constructed up to the point shown with a cul-de-sac provided until such time as the northern property is developed. When the developers of the northern tract apply for subdivision approval, they will be required to construct their roadway up to the cul-de-sac and remove the perimeters of the unused roadway on the circle. (This is sometimes retained as parking; roadway characteristics must be considered.)

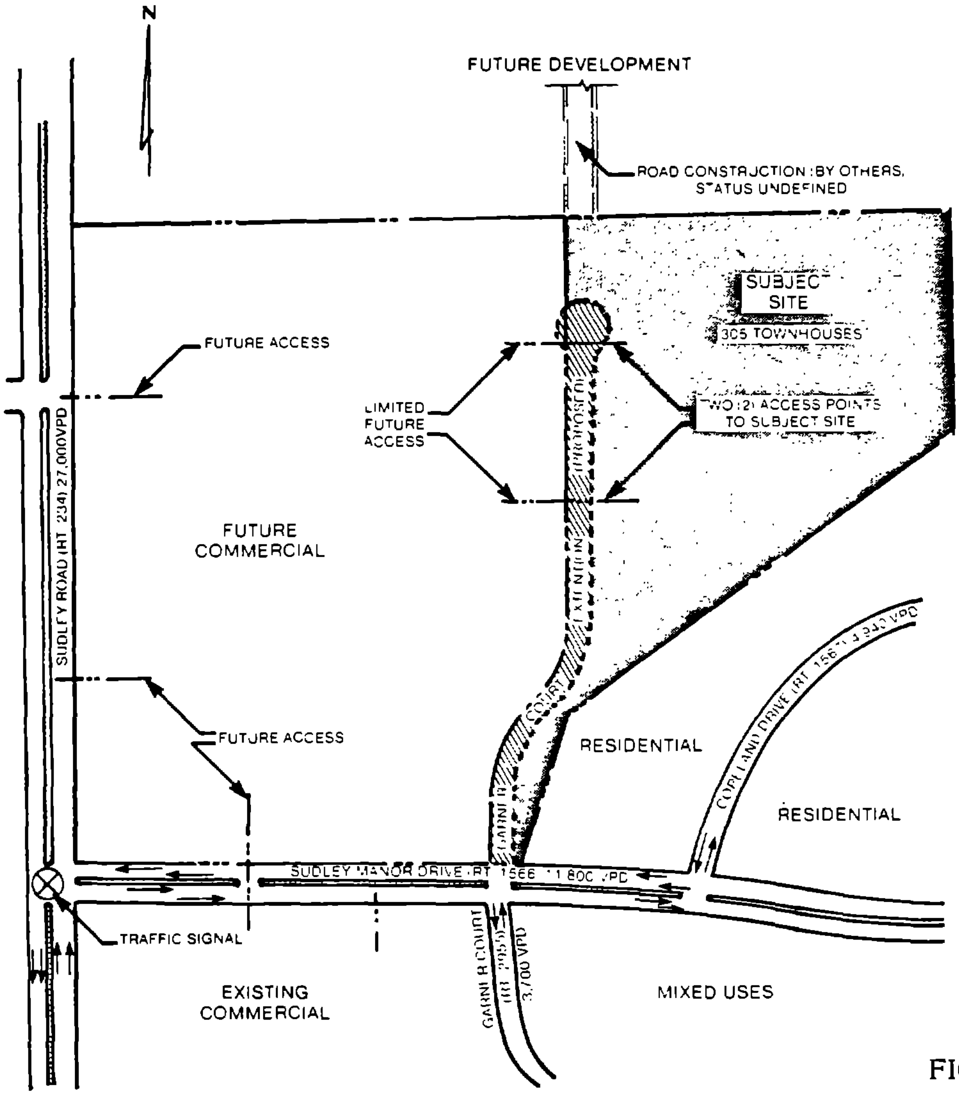


FIGURE X.2.
SITE ACCESS PLAN

APPENDIX A. ACCESS MANAGEMENT TECHNIQUES, WARRANTS AND DESIGN

A-1: INSTALL MEDIAN BARRIER WITH NO DIRECT LEFT-TURN ACCESS

The physical median barrier is a route design technique for controlling access on arterial highways. The barrier, which can be a New Jersey type or a simple barrier curb, eliminates direct left turns at all driveways and U-turns along the highway. Indirect left turns to driveways are accommodated by right-hand ramps (jug-handle) and crossovers or by cloverleaf loops at cross streets.

This technique reduces the basic conflict points from 9 to 2 at all driveways. More important, the barrier totally eliminates the more hazardous crossing conflict points at all driveways. The frequency of rear-end conflicts on the through lanes is expected to decrease as a result of the elimination of direct left turns; on the other hand, the frequency of right-turn conflicts at minor driveways will probably increase proportionally to the number of indirect left turns. Some tradeoff is realized by the creation of additional basic conflict points at indirect left-turn locations.

Warrants

This technique is generally warranted on multilane arterial highways with speeds greater than 40 mph, ADT's greater than 10,000 vehicles per day, and levels of development between 30-60 driveways per mile. Left-turning movements should equal or exceed 150 vph on a 1-mile section during peak periods. Also, this technique is warranted along highway sections where mid-block accident experience involving left-turning vehicles is excessive.

Design

Figures A.1.1 and A.1.2 indicate alternative ways of accommodating left-turns where technique A.1 is used. Critical elements to consider are ramp radius, width, and length to accommodate left-turning vehicles as per the volume, speeds, and types of vehicles expected. Guidelines are provided in Chapter VII and Reference 1.

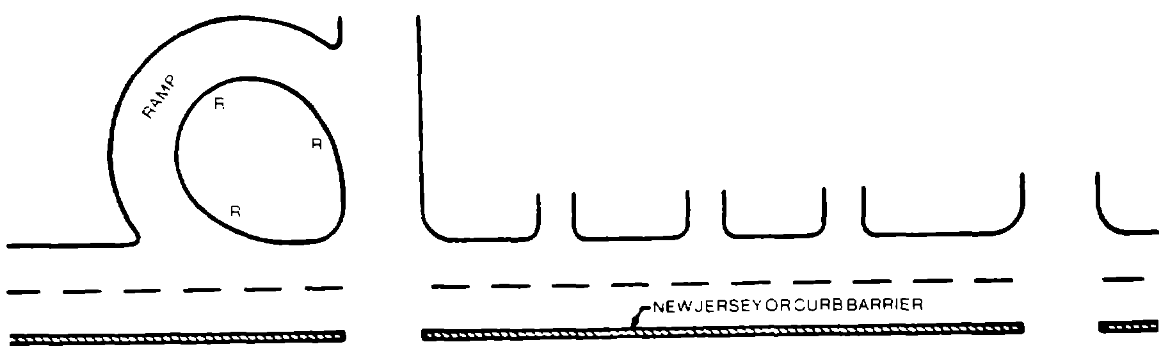


FIGURE A.1.1. MEDIAN BARRIER WITH INDIRECT LEFT-TURN RAMP (CLOVERLEAF LOOP)

Preceding page blank

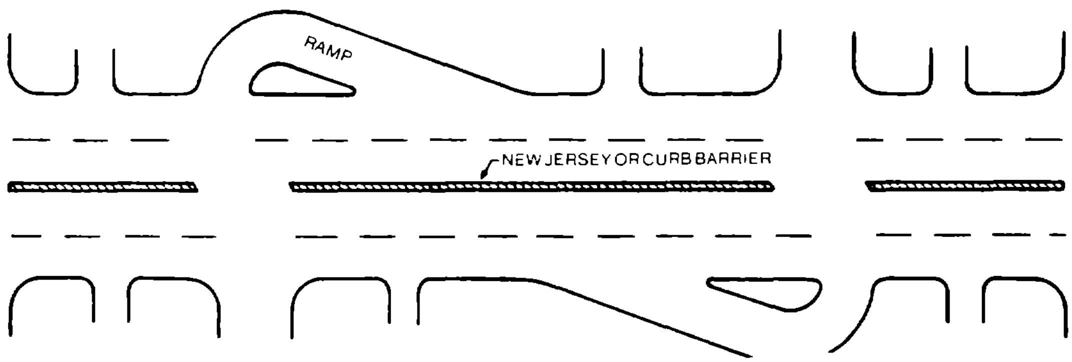


FIGURE A.1.2. MEDIAN BARRIER WITH INDIRECT LEFT-TURN RAMPS (JUG-HANDLE)

This median treatment directly controls access on urban multilane highways by preventing left turns and U-turns across the median except at a few designated locations. Access is provided with left-turn lanes at intersections and major driveways. In addition to preventing left turns at minor driveways, the raised median divider reduces stream friction by separating opposing traffic.

This technique reduces the frequency of total conflicts by reducing the basic conflict points from 9 to 2 at all minor driveways. More important, it completely eliminates the more hazardous crossing conflict points at these driveways. For intersections and major driveways, the frequency and severity of conflicts associated with left-turn vehicles are reduced by allowing deceleration and shadowing of these vehicles in left-turn lanes.

The median divider usually reduces the total number of driveway maneuvers. However, the maximum reduction in the frequency of conflicts is moderated by increases in right-turn volumes at minor driveways where desired left turns are accomplished through indirect, circuitous paths.

Warrants

This technique is generally warranted on multilane highways with speeds of 30 to 45 mph, ADT's greater than 10,000 vehicles per day, and levels of development greater than 30 driveways per mile. Left-turning movements should exceed 150 vph on a 1-mile section during peak periods. In addition, this technique may be warranted by a high-accident experience associated with mid-block, left-turning vehicles.

Design

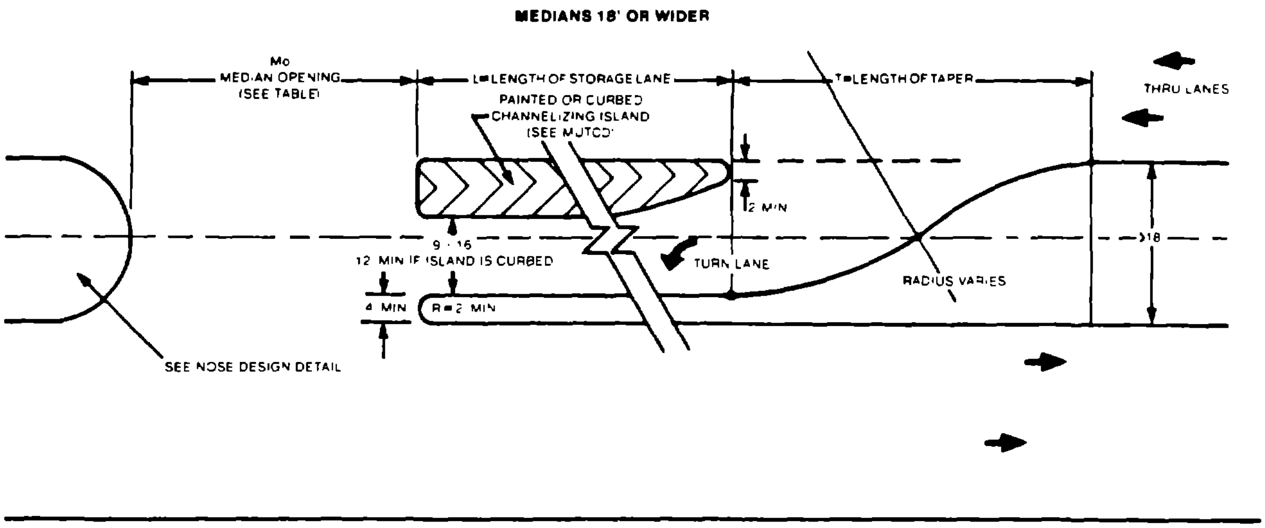
The storage length of an exclusive left-turn lane is a critical design element. Inadequate length presents a safety problem in that vehicles queueing in the lane will eventually back into the through traffic lanes. Also, utilization of the turn lane will be impaired if this occurs, as vehicles desiring to move into the turn lane will be unable to do so and must wait for the through lane to move ahead. Also, through lane capacity is reduced when turning vehicles have backed into the through lane and are not moving.

The important factors which determine the length needed are:

- The design year volume for the peak hour (DHV)
- An estimate for the number of cycles per hour if the location is signalized
- The type of signal phasing and timing which will control the left-turn movement

Design guideline are provided in Chapter - VII.

Based on median width (MW)--select applicable layout.



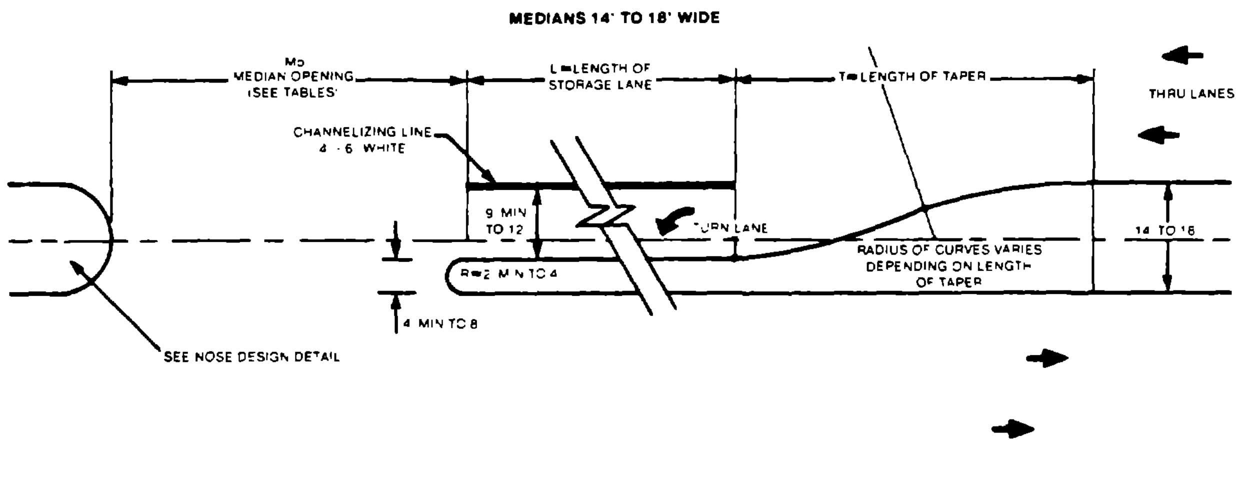


FIGURE A.2.1. LEFT-TURN LANES

A-3: INSTALL ONE-WAY OPERATIONS ON THE HIGHWAY

Converting an urban arterial highway to one-way operations is intended to facilitate better traffic movement by reducing the stream friction between opposing facilities. For a given roadway width, one-way operations can increase capacity by as much as 50 percent.

Improvements in safety result from one-way operations because the more severe opposing left-turn conflicts are eliminated at all driveways and intersections. Conflict points are reduced from 9 to 2 at driveways where right turns are permitted. No crossing conflicts are possible for these driveways. On the left side where left turns occur, the conflict points decrease from 9 to 3, with one crossing conflict point remaining.

When considering this technique for implementation, other system conditions must be reviewed to achieve the best solution for the problem at hand. For instance, turning conflicts are reduced at all intersections. Pedestrian-vehicular conflicts are also reduced because of the decrease in total movements. Also, one-way streets lend themselves to better signal progression. However, some trade-offs may occur by increasing the frequency of conflicts resulting from lane-changing encroachments, turns from a wrong lane, and indirect (around-the-block) maneuvers.

Warrants

As mentioned earlier, one-way operations can be implemented on two-lane and multilane undivided arterial highways, and a nearby parallel highway is needed to carry the reverse-direction traffic. Commercial driveways should number at least 30 per mile, and turning maneuvers into these driveways should comprise 30 percent or more of the total traffic over a 1-mile section during peak periods. Daily traffic volume should exceed 5,000 vehicles with posted speeds between 30 and 40 mph. Inadequate capacity could also warrant this technique. This technique is also warranted along highways exhibiting high accident rates with insufficient rights-of-way available for other remedial techniques.

A-4: INSTALL TRAFFIC SIGNAL AT HIGH-VOLUME DRIVEWAYS

Signals at high-volume driveways are intended to reduce the inordinate delay to driveway vehicles and to eliminate certain high-frequency conflict points by separating conflicting maneuvers in time. Increasing the number of signal phases decreases the number of conflict points to the level where only basic diverging conflict points remain. A two-phase signalized driveway will have five conflict points, and a three-phase signalized driveway will have only three conflict points.

If properly designed, installed, and maintained, traffic signals tend to reduce right-angle collisions, vehicular-pedestrian collisions, and opposing left-turn collisions. Additional benefits can accrue by creating larger gaps in the traffic stream at downstream driveway locations. Some tradeoffs may be introduced, however, by increasing rear-end conflicts on the highway and by creating queues that block nearby upstream driveways. Also, indiscriminate application of signals can increase total delay if delay to through vehicles is increased more than delay to driveway vehicles is decreased.

Warrants

Applicable warrants (MUTCD)[2] for signal installation at commercial driveways include consideration of traffic volumes and accident frequency.

The Minimum Vehicular Volume warrant is intended for application where the volume of intersecting traffic is the principal reason for consideration of signal installation. The warrant is satisfied when, for each of any 8 hours of an average day, the traffic volumes on the highway and on the driveway exceed those given in Table A.4.1.

The Interruption of Continuous Flow warrant applies when traffic volume on the highway is so heavy that traffic on the driveway suffers excessive delay or hazard. The warrant is satisfied when, for each of any 8 hours of an average day, the traffic volume on the highway and the on the driveway exceed those given in Table A.4.2.

Design

The Manual on Uniform Traffic Control Devices, and Transportation and Traffic Engineering Handbook provide specific criteria for various situations. State and local standards must also be applied to provide signalization consistent with other intersections in the area.

Type of controller operation (fixed-time, fully-actuated, etc.), number of phases, phase duration, and hours of operation will be dependent upon traffic volumes, site conditions, and method of operation.

TABLE A.4.1. MINIMUM VOLUME WARRANT FOR A TRAFFIC SIGNAL

Number of Lanes for Moving Traffic on Each Approach		Vehicles Per Hour Major Street (Total of Both Approaches	Vehicles Per Hour on Driveway (One Direction Only)
Major Street	Driveway		
1	1	500	150
2 or More	1	600	150
2 or More	2 or More	600	200
1	2 or More	500	200

TABLE A.4.2. INTERRUPTION OF CONTINUOUS FLOW WARRANT FOR A TRAFFIC SIGNAL

Number of Lanes for Moving Traffic on Each Approach		Vehicles Per Hour Major Street (Total of Both Approaches	Vehicles Per Hour on Higher-Volume Minor Street Approach (One Direction Only)
Major Street	Driveway		
1	1	750	75
2 or More	1	900	75
2 or More	2 or More	900	100
1	2 or More	750	100

Controls to be considered for installation include:

1. A minimum of two signal faces should be displayed to through traffic.

2. Unless physically impractical, at least one and preferably both of the signal faces should be located 40 to 120 feet beyond the stop line and within a field of view of approximately 20 degrees right and left, measured from the approach centerline at the stop bar. See Figure - A.4.1.

3. For suspended signals, the bottom of the signal housing should be 15 to 19 feet above pavement grade at the center of the roadway. For side-mounted signals, the bottom of the signal housing should be 8 to 15 feet above the sidewalk or, if none, above the pavement grade at the center of the roadway.

4. The two signal faces should be continuously visible for the distance shown for the applicable design speed unless physical obstructions exist.

Visability of Signal Faces

Percentile Speed (mph)	Minimum Visability Distance (feet)
20	100
25	175
30	250
35	325
40	400
45	475
50	550
55	625
60	700

When physical conditions prevent the driver from a continuous view of these two indications, an additional signal head may be added or the approach may be supplemented by suitable sign or hazard warning beacon advising the driver of signalization ahead.

5. Signal supports should be located as far as practical from the edge of the traveled way. As a minimum, they should be 2 feet behind the curb line, or where there is no curb, 2 feet

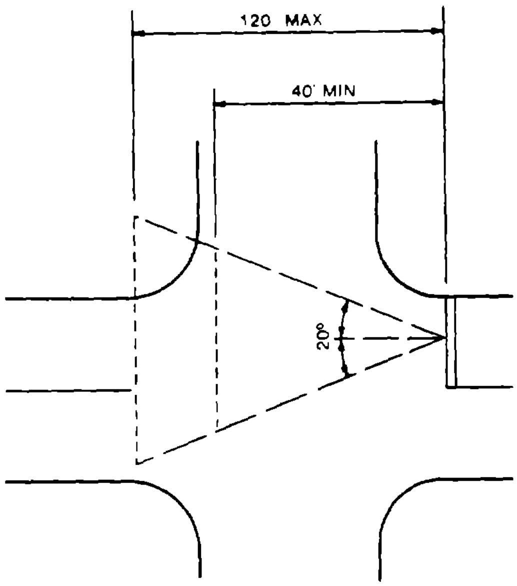


FIGURE A.4.1. SIGNAL PLACEMENT

beyond the edge of the usable shoulder.

Frequency of accident occurrence is sometimes a warrant for signal installation. Typical warrants are as follows:

1. An adequate trial of less restrictive remedies has failed to reduce the accident frequency.
2. Five or more reported accidents, of types susceptible of correction by traffic signal control, have occurred within a 12-month period, each accident involving personal injury or property damage to an apparent extent of $100 or more.
3. There exists a volume of vehicular and pedestrian traffic not less than 80 percent of the requirements specified either in the minimum vehicular volume warrant, the interruption of continuous traffic warrant, or the minimum pedestrian volume warrant.
4. The signal installation will not seriously disrupt progressive traffic flow.

A-5: CHANNELIZE MEDIAN OPENINGS TO PREVENT LEFT-TURN INGRESS AND/OR EGRESS MANEUVERS

This median technique directly controls access on highways by preventing left-turn ingress and/or egress maneuvers. The left-turn maneuvers are restricted by channelizing the medians on divided highways to physically prevent vehicles from crossing.

The technique reduces the frequency of total conflicts by reducing the basic conflict points from 9 to 5 when eliminating either left-turn ingress or egress maneuvers, and from 9 to 2 when eliminating both left-turn maneuvers at driveways. In particular, this measure eliminates the more severe crossing conflict points caused by left-turn ingress or egress movements. However, the maximum reduction in the frequency of conflicts is moderated by increases in right-turn maneuvers and other indirect left turns which are accomplished through circuitous paths.

Warrants

This technique is warranted on multilane divided highways with speeds of 30-45 mph, ADTs greater than 5,000 vpd, and levels of development greater than 30 driveways per mile. In particular, it is warranted at driveways where safety problems are caused by a small number of left-turn maneuvers. The prohibited turns should not exceed 100 vpd. Also, this technique may be justified at sites that meet accident warrants.

Design

Case I: (see Figure A.5.1) Highway Medial Channelization to Restrict Left Turn Egress Vehicles.

Case II: (see Figure A.5.2) Restriction of Left-Turn Ingress Maneuvers.

Case III: (see Figure A.5.3) Elimination of Egress and Ingress Maneuvers.

Note: Lane lengths, tapers. radii as per design guidelines in Chapter VII.

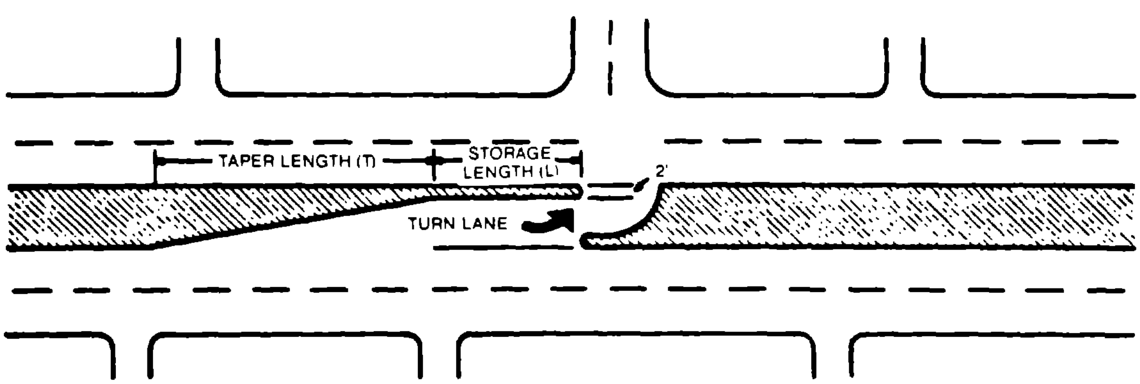


FIGURE A.5.1. HIGHWAY MEDIAN CHANNELIZATION TO RESTRICT LEFT-TURN EGRESS VEHICLES

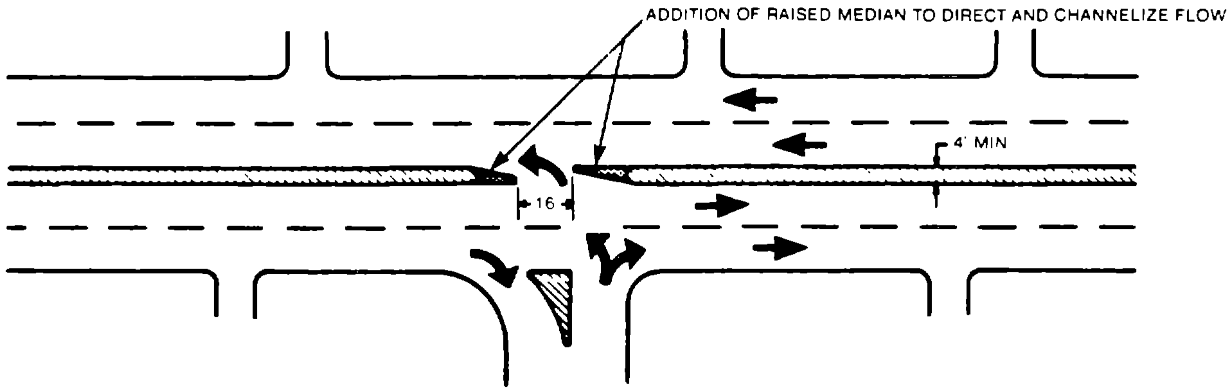


FIGURE A.5.2. HIGHWAY MEDIAN CHANNELIZATION TO RESTRICT LEFT-TURN INGRESS VEHICLES

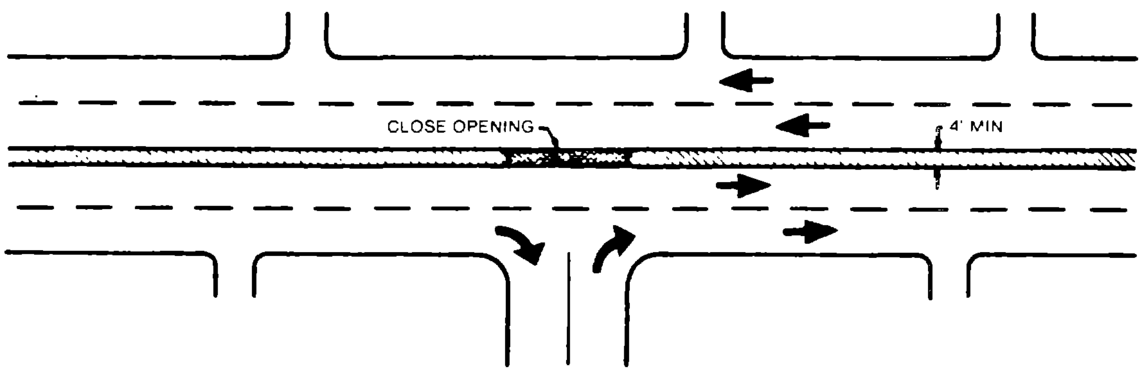


FIGURE A.5.3. MEDIAN OPENING CLOSURE TO RESTRICT INGRESS AND EGRESS VEHICLES

Source: Reference (3)

A-6: WIDEN RIGHT THROUGH-LANE TO LIMIT RIGHT-TURN ENCROACHMENTS ONTO THE ADJACENT LANE TO THE LEFT

The physical widening of a right through lane is intended to reduce the frequency of right-turn encroachment conflicts (sideswipe) on an arterial with narrow lanes and frequent driveways with inadequate approach width. Encroachment conflicts occur when right-turning driveway vehicles swing into the path of another vehicle in the adjacent lane to the left.

Warrants

Since encroachment conflicts due to right-turning driveway vehicles are the problem to be addressed with this technique, a level of development of 20 driveways is the major warranting condition. Traffic volume should exceed 5,000 vpd, and right-turn driveway entrance volume per mile should exceed 100 vehicles during the peak hour. Also, highway speeds should exceed 30 mph. This technique is also warranted where high accident rates indicate a right-turn encroachment problem exists.

Multiple driveways with narrow approach widths that only allow minimum turning speeds also warrant consideration of this technique.

Design

Practices and standards pertaining to the curb lane vary a great deal among urban areas. Additional factors such as gutter width and intended usage (buses, bicycles) should be considered. It is generally agreed that the curb lane, when not an exclusive parking lane, should be wider than the other lanes in order to facilitate turning vehicles and prevent encroachment onto adjacent left lane. A 12 foot lane exclusive of gutter area is recommended minimum.

A-7: INSTALL CHANNELIZING ISLAND TO PREVENT LEFT-TURN DECELERATION LANE VEHICLES FROM RETURNING TO THROUGH LANES

The installation of a channelizing island between a through and a left-turn lane can be applied on divided urban highways where encroachment problems between through and left-turning vehicles exist. The channelizing island will eliminate sideswipe conflicts between vehicles in the two adjacent lanes. An increase in the number of single-vehicle mishaps, however, may occur due to through vehicles striking the island.

Warrants

This technique is warranted on divided highways with greater than 10,000 vpd and at driveways with greater than 50 left-turn ingress vehicles during the peak hour. The site should be characterized by a history of encroachment conflicts due to left-turn vehicles reentering the through lanes.

Design

Figure A.7.1 illustrates recommended dimensions pertaining to application of this control technique. Information contained in Chapter VII should be reviewed to comply with applicable deceleration and storage requirements for vehicular speeds.

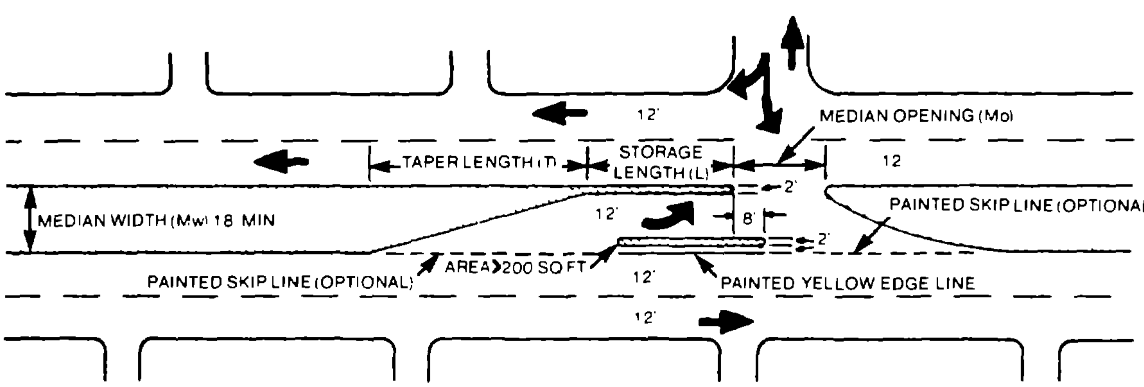


FIGURE A.7.1. CHANNELIZING ISLAND TO PREVENT LEFT-TURN DECELERATION LANE VEHICLES FROM RETURNING TO THROUGH LANES

A-8: INSTALL PHYSICAL BARRIER TO PREVENT UNCONTROLLED ACCESS ALONG PROPERTY FRONTAGES

The installation of a physical barrier along a single property or many adjacent frontages is a design technique for controlling access on all kinds of highways. The control of access can be accomplished by erecting fences, barriers, plantings, or curbs adjacent to the roadway or shoulder. Possibilities exist for the construction of rock walls, rail fences, or other structures that are compatible with the aesthetics of the area. Curbing, however, is the most common method.

This design technique reduces the total area of conflict by controlling and defining driveway openings. The frequency of conflicts is reduced because the number of possible conflict points is limited to the defined driveway openings.

Warrants

This technique is warranted on all highways where open access exists and where the highway ADT exceeds 10,000 vpd.

Where open access highways exist, this technique is warranted when the highway ADT exceeds 10,000 vpd and the level of development is greater than 45 driveways per mile. For consideration at single properties only, total driveway ADT should exceed 500 vpd. High accident rates involving the open access situation will also warrant this technique.

Design

Regulation of uncontrolled access along property frontages can be accomplished by several methods. Included in this list are:

- Barrier
- Curbing
- Shrubbery
- Railing

Of the above, curbing is widely used due to: (1) ease of installation; (2) low maintenance; and (3) effectiveness. Care however must be exercised when placing curb to review not only the impact on control of access, but also its affect on the site and roadway drainage.

A-9: INSTALL MEDIAN CHANNELIZATION TO CONTROL MERGE OF LEFT-TURN EGRESS VEHICLES

The installation of a channelizing island in a median opening will serve to control driveway access by channeling left-turning vehicles into and from the driveway. It will also effectively block vehicles from reentering the through lanes once they have been committed to a left-turn lane.

This technique should reduce the frequency of conflicts associated with left-turn egress vehicles because it reduces the total area of the merge conflict. In addition, it forces the left-turn vehicle to merge at a relatively flat angle, thereby minimizing the speed differential with through vehicles.

Warrants

This technique is warranted on divided highways with greater than 10,000 vpd and at driveways with greater than 50 left-turn egress vehicles during the peak hour. The site should be characterized by a history of merge conflicts associated with left-turn egress vehicles.

Design

Application of this technique is best-suited for multilane divided highways.

Design information pertinent to left-turn storage lanes can be obtained from Chapter VII. In addition to the recommended design shown in Figure A.9.1, construction of the channelization island should reflect:

- Clearly-defined path for egress movement
- Adequate safety area to contain merging vehicles
- Adequate merging lane width
- Elimination of bottleneck conditions

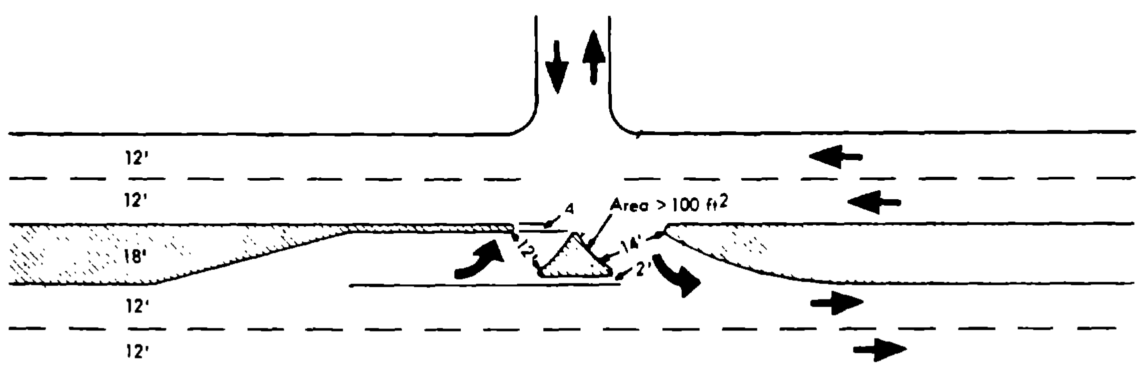


FIGURE A.9.1. CHANNELIZATION TO CONTROL LEFT-TURN EGRESS

A-10: OFFSET OPPOSING DRIVEWAYS

This technique involves the longitudinal separation of driveways on opposite sides of the highway, and it can be implemented either at existing locations or as an optimization practice when authorizing driveway permits.

Offsetting driveways should be considered if opposing driveways are causing crossing conflict problems. The separation distance will better facilitate driveway-to-driveway maneuvers and will eliminate the concentrated conflict area that is present with opposing driveways.

The functional objective of offsetting driveways is to limit the number of conflict points. Conflict points are reduced from 32 for directly opposing driveways (4-leg intersections) to 18 for the two offsetting driveways (two 3-leg intersections). The more severe crossing conflict points decrease from 16 to 6.

Implementing this technique will cause an increase in the frequency of left-turn ingress and right-turn egress maneuvers. Also an increase in weaving maneuvers results.

Warrants

This technique can be implemented on all undivided highways where the traffic volumes do not warrant 4-way traffic signals at driveway locations. Property frontage must also be sufficient to accomodate the 300-ft. driveway separation. Development near the driveway location should contain fewer than 45 driveways per mile with highway speeds ranging between 30 and 45 mph. Driveway volume should exceed 1,000 vpd and highway ADT should be less than 10,000. Driveway- to-driveway maneuvers should total at least 150 per day or 30 during the peak hour. Accident experience could also warrant the application of this technique.

Design

Greater interference with through traffic is likely when the driveways are offset as shown in Figure A.10.1b. The right-turn egress to left-turn egress maneuver poses a greater threat to traffic safety than does the left-turn egress to right-turn ingress manuever. Maximum benefits are obtained when driveways are separated by at least 300 feet.

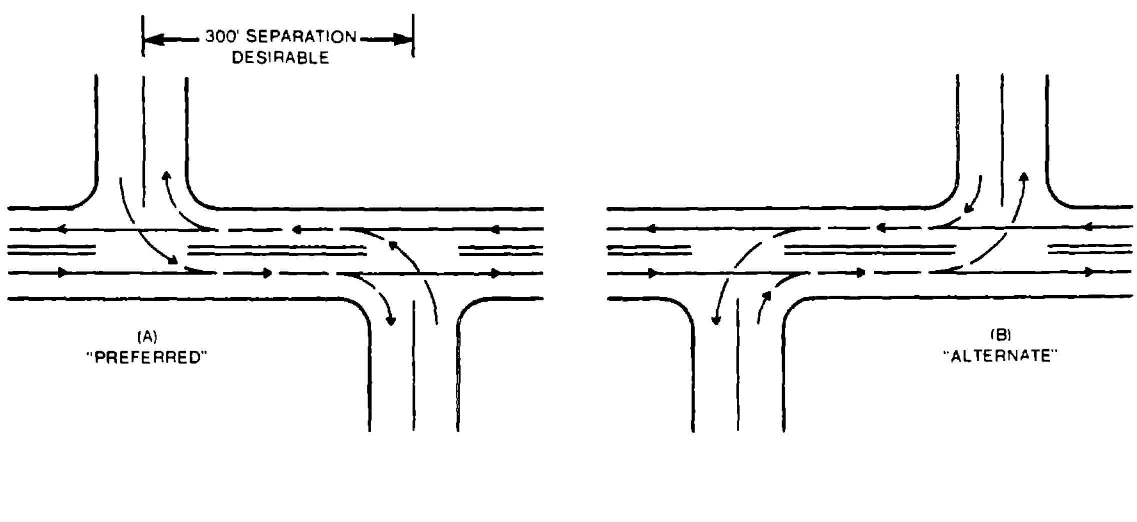


FIGURE A.10.1. DIFFERENCE IN WEAVING MANEUVERS RESULTING FROM DRIVEWAY OFFSET CONFIGURATION

A-11: LOCATE DRIVEWAY OPPOSITE A THREE-LEG INTERSECTION OR DRIVEWAY AND INSTALL TRAFFIC SIGNALS WHERE WARRANTED

Where traffic signal warrants can be satisfied (see Technique A-4), this measure involves locating a driveway opposite a three-leg intersection either during the driveway permit authorization process or by relocating an existing driveway. Traffic operations along an arterial are directly affected by the number and location of driveways or intersections. Interference to traffic operations should be minimized by constructing an additional driveway opposite an existing three-leg intersection rather than at a neighboring location. As the number of access points along an arterial decreases, the quality of traffic flow will usually improve unless congestion results at the access locations due to the turning vehicles. Because of the greater separation between driveways, a more efficient progression speed for through vehicles should be realized. The installation of traffic signals helps to regulate vehicle speeds and also controls the turning maneuvers.

Reducing the number of conflict points is the functional objective of this technique. Conflict points are reduced from 18 for the two separate three-leg intersections to 10 for three-phase signalization of a 4-leg intersection. The more severe crossing conflict points are reduced from six to three.

Warrants

This technique is warranted on all types of highways where sufficient frontage is available to locate a driveway opposite a three-leg intersection or driveway. If an existing driveway is being relocated, the separation distance before relocation should be less than 300 feet. Driveway-to-driveway maneuvers should number either 30 during the peak hour or 150 per day for a signalized location. Cross-street volume should exceed 1,000 vpd, and highway ADT should be greater than 10,000.

Design

The major elements associated with this technique are the driveway construction and traffic signal installation. Driveway design depends upon the specific function of the driveway and also the location and conditions under which the driveway will be operating. All design elements such as width, angle, radii, channelization, and vertical geometrics should provide for optimum driveway operations. These driveway design elements are specified in the Driveway Design section of Chapter - VII.

The second major design element related to this technique is the installation of traffic signals. All design elements such as signal sight distance, signal head height, signal support location, and number of phases are included in Technique A-4. All traffic signal installations need to meet at least one of the warrants in the MUTCD.

A-12: INSTALL TWO ONE-WAY DRIVEWAYS IN LIEU OF ONE TWO-WAY DRIVEWAY

This access control technique involves the opening of two one-way driveways to replace a single two-way driveway. Although it appears that this technique may decrease the overall safety of the location by increasing access points, it actually should increase safety through the resulting reduction in total conflict points.

The two one-way driveways, by limiting the turning maneuvers that can be made at each driveway, will have eight conflict points, two of which are crossing conflict points. The two-way driveway has nine conflict points, of which three are crossing conflict points. The overall benefit of implementing this technique is that one crossing conflict point is eliminated. Also, by separating the opposing driveway flows, head-on encroachment conflicts on the driveway are eliminated.

Warrants

This technique is warranted at point locations on all types of highways. The level of development should be less than 60 driveways per mile. Highway ADT should be greater than 10,000 vpd, and highway speeds should be less than 35 mph. At the commercial site, at least 40 vph should turn left across through traffic to enter the driveway during peak periods. Frontage widths should be at least 150 feet, where practical, to ensure that minimum driveway separation distances can be attained.

Design

Figure A.12 shows geometric layout. Several considerations must be made in order to effectively apply this technique including: traffic volume, geometry, and roadway width. Of primary importance in this design is the separation distance. As a rule, the greater the distance between the driveways, the more efficient and safer will be traffic operations.

Chapter VII contains minimum driveway separation distances applicable under this control measure. It is important that adequate internal circulation be provided when using this technique.

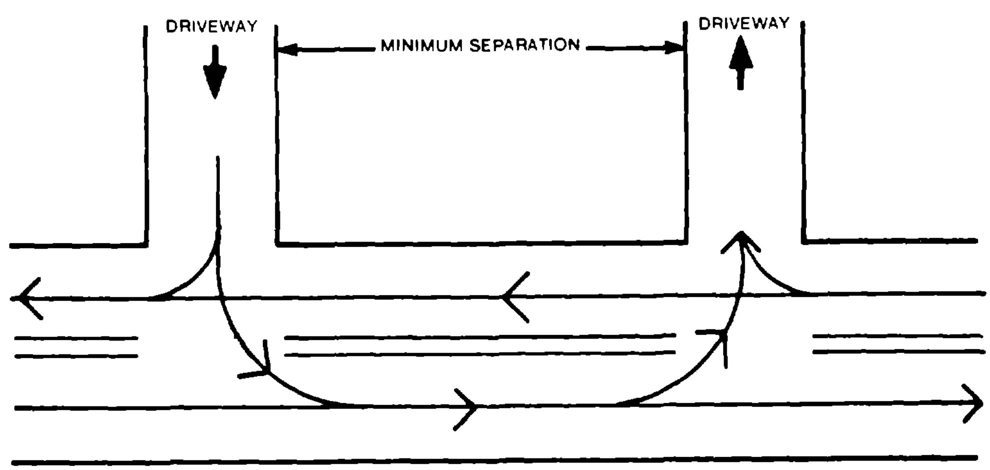


FIGURE A.12. MINIMUM DRIVEWAY SPACING

A-13: INSTALL TWO TWO-WAY DRIVEWAYS WITH LIMITED TURNS IN LIEU OF ONE STANDARD TWO-WAY DRIVEWAY

This access control technique is aimed at reducing conflicts at a single driveway location by replacing the single driveway with two limited-turn driveways. The immediate effect of this technique is that conflict points are reduced. The two driveways will have a total of six conflict points, two of which are crossing conflict points. The one two-way driveway has nine conflict points, three of which are crossing conflict points. Turning velocities can be increased by angling the driveways to receive turning vehicles.

Warrants

This technique is warranted at point locations on divided highways with sufficient median width. The level of development should be less than 60 driveways per mile. Highway ADT should be greater than 10,000 vpd, and highway speeds should be greater than 35 mph. At the commercial site, at least 40 vph should turn left across through traffic to enter the driveway during peak periods. Frontage widths should be at least 200 feet, when practical, to ensure that minimum separation distances can be attained.

Design

Figure A.13 shows a recommended layout for two two-way driveways along a rural divided highway. The driveway angle with the through lanes is typical; however, a minimum of 45° is allowable. In urban settings, the driveway angle is nearer 90°. Distances between the driveways should follow recommendations outlined in Chapter VII.

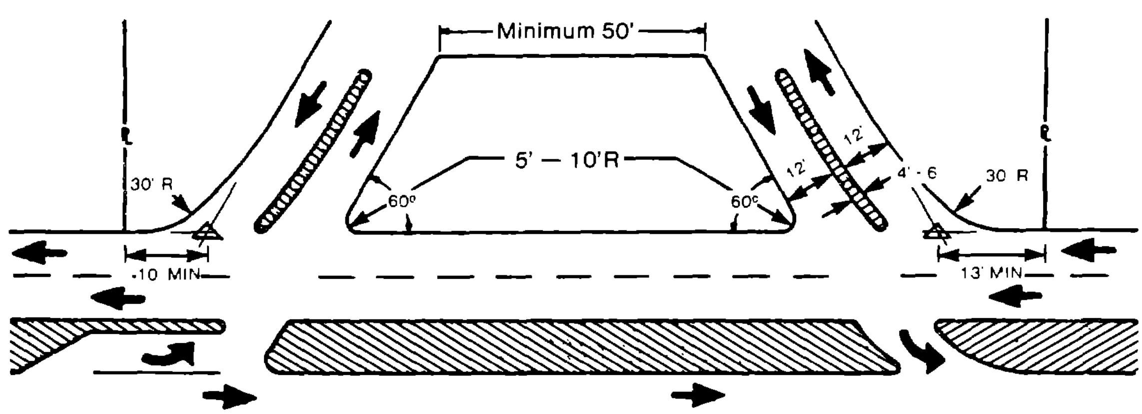


FIGURE A.13. TWO-WAY DRIVEWAYS WITH LIMITED TURNS

A-14: INSTALL TWO ONE-WAY DRIVEWAYS IN LIEU OF TWO TWO-WAY DRIVEWAYS

This driveway operations technique is aimed at limiting the number of basic conflict points at a single property. Specifically, it reduces the number of crossing conflict points by changing driveway operations from two two-way driveways to two one-way driveways. This technique is applied during the permit-authorization stage or at existing sites with appropriate reconstruction. The directional control accompanying one-way operations will result in improved driveway and highway operations by allowing a smaller variety of maneuvers to be made at each driveway. As a result, highway speeds will increase, and delay times will be reduced.

Accident frequencies are expected to decrease because the total number of conflicting points will be reduced from 18 to 10. Four crossing, three merge, and three diverge conflict points are eliminated at the two driveways. Accident severities are not expected to substantially decrease.

Possible detrimental effects may occur because turns made into, or from, the wrong driveway may initiate a severe conflict. Also, if a vehicle misses the intended entrance driveway, no other opportunity will exist to enter the other driveway.

Warrants

This technique is warranted on all types of highways where highway speeds are less than 50 mph and traffic volumes greater than 10,000 vpd. At point locations, individual driveway volumes should be greater than 300 vpd. Frontage width requirements are determined by the driveway separation and highway speed. The minimum acceptable frontage width is 120 feet, for a highway speed of 20 mph. High accident rates involving driveway maneuvers will also warrant this technique.

Design

The individual direction of travel on the driveways is an important consideration with this technique. The driveways should be operationally arranged so that the one-way directions are egress and then ingress proceeding downstream. Table A.14 lists the recommended driveway separation distances to be used with this technique.

TABLE A.14
RECOMMENDED
DRIVEWAY SPACING DISTANCES

Highway Speed (mph)	Driveway Spacing (ft)
20	85
25	105
30	125
35	150
40	185
45	230
50	275

A-15: INSTALL TWO TWO-WAY DRIVEWAYS WITH LIMITED TURNS IN LIEU OF TWO STANDARD TWO-WAY DRIVEWAYS

This technique is aimed at reducing conflicts at properties by replacing two two-way driveways with two limited-turn driveways. This can be done during the permit authorization stage or at an existing location with appropriate reconstruction.

This technique reduces the frequency of conflicts at a single property by eliminating four crossing, four merge, and four diverge conflict points. Accident severities and vehicular delays are not expected to change substantially. Turning velocities can be increased by angling the driveway to receive turning vehicles.

Warrants

This technique is warranted at point locations on all types of highways. The level of development should be less than 60 driveways per mile. Highway ADT should be greater than 10,000 vpd, and highway speeds should be greater than 35 mph. At the commercial site, at least 40 vph should turn left across through traffic to enter the driveway during peak periods. Frontage widths should be at least 200 feet, where practical, to ensure that minimum separation distances can be attained. The technique will also be warranted at locations where accident experience indicates a change in driveway operations.

Design

In the design of this technique, consideration should be given to limiting the number of conflict points between ingress/-egress vehicles and through movements. Access driveway approaches preferably should be positioned between 90°-60° to the highway and 60°-45° in special cases. On high speed roads, an angle of 60° is preferred to facilitate the higher speed. In no event shall the angle be less than 45°. Figure A.15 shows a recommended layout for a high speed roadway.

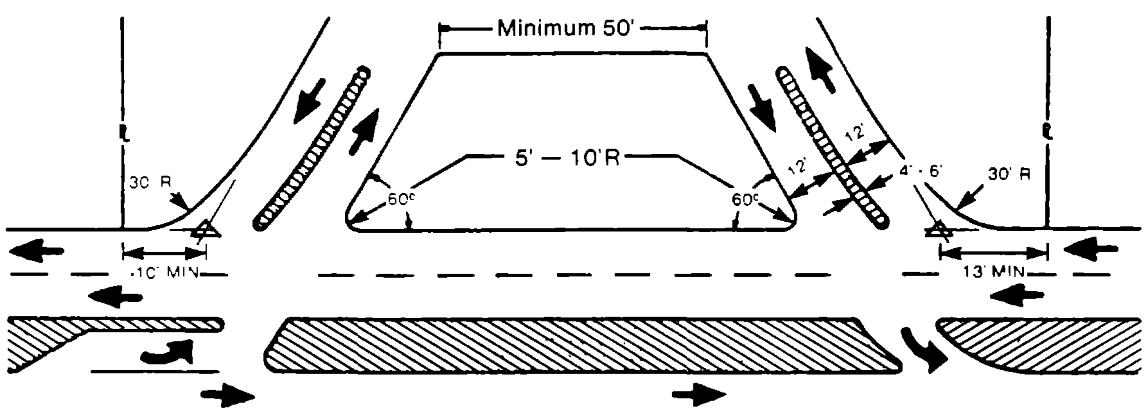


FIGURE A.15. ANGLED TWO-WAY DRIVEWAYS WITH LIMITED TURNS

A-16: INSTALL CHANNELIZING ISLAND TO PREVENT LEFT-TURN MANEUVERS

This driveway design technique directly controls access by preventing left-turn ingress and egress maneuvers. The left-turn maneuvers are restricted by a channelizing island in the driveway throat. The main objective of this technique is to reduce the number of conflict points by limiting the basic crossing conflicts.

The technique reduces the frequency and severity of conflicts by reducing the basic conflict points from nine to two at a driveway. This measure completely eliminates the crossing conflicts that accompany left-turn ingress and egress maneuvers. However, the reduction in conflicts is moderated by a possible increase in right-turn and indirect left-turn maneuvers. Travel time may increase to vehicles denied the opportunity to make left turns.

Warrants

This technique is warranted on undivided highways with speeds of 30-45 mph, ADT's greater than 5,000 vpd, and driveway volumes of at least 1,000 vpd. The prohibited turns should number less than 100 vpd. High left-turn accident rates will also warrant this technique.

Design

Regulation of left-turning traffic by using channelization islands is an effective means of prohibiting unsafe ingress/egress manuevers. The island construction should be offset a minimum of 4 feet from the traveled throughway and be of sufficient width to effectively deter unwanted maneuvers. Figures A.16.1 through A.16.3 show recommended geometric layouts to eliminate unwanted movements. In addition, placement of turn prohibition signs (R3-1, R3-2) as outlined in the MUTCD will serve as a motorist warning device.

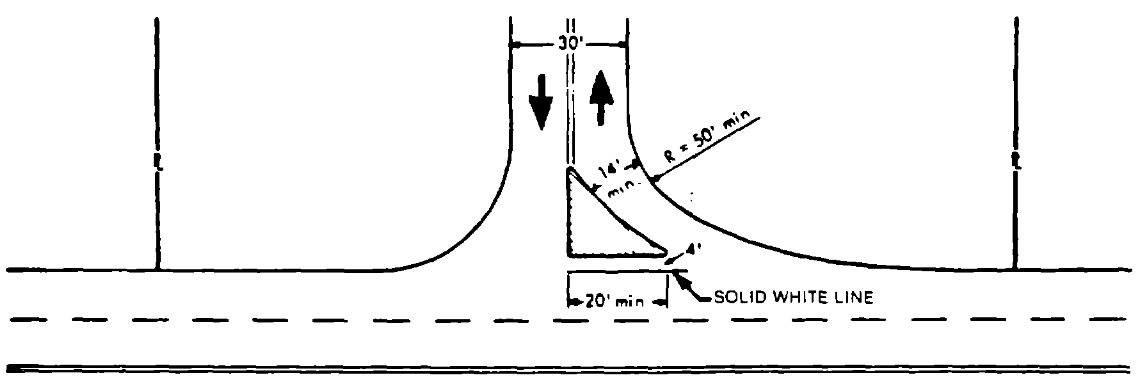


FIGURE A.16.1. DRIVEWAY CHANNELIZING ISLAND TO PREVENT LEFT-TURN INGRESS MANEUVERS

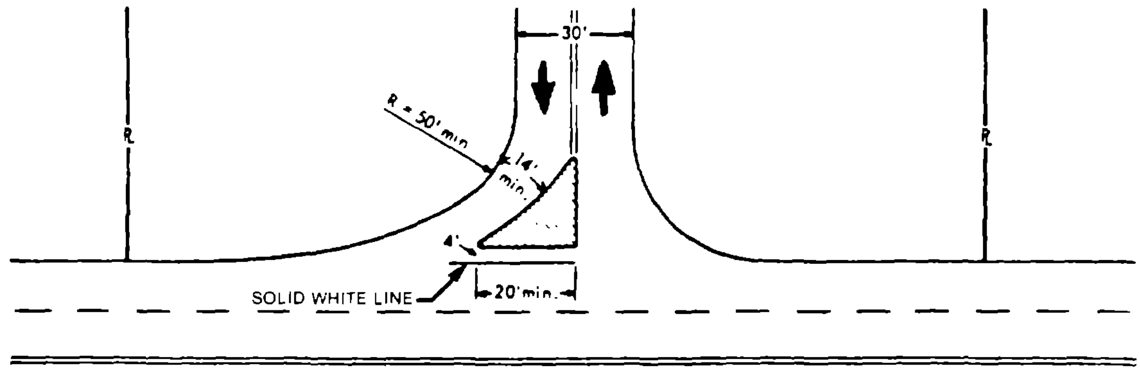


FIGURE A.16.2. DRIVEWAY CHANNELIZING ISLAND TO PREVENT LEFT-TURN EGRESS MANEUVERS

Source: Reference (3)

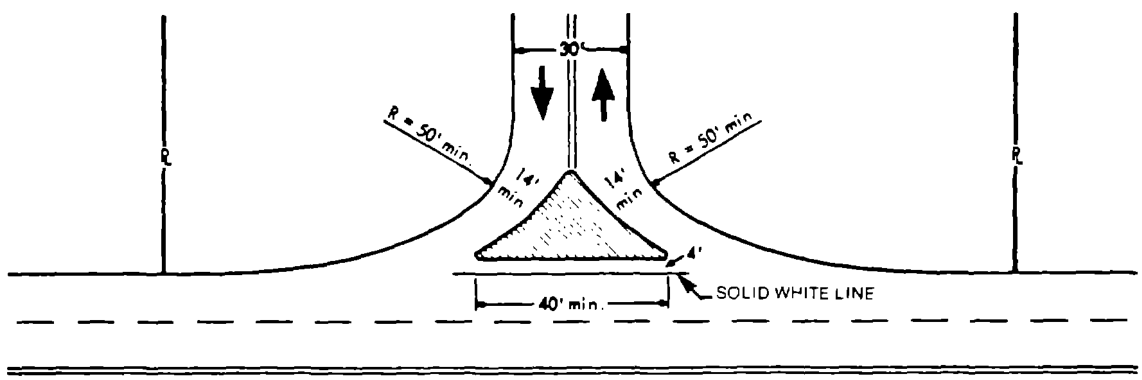


FIGURE A.16.3. DRIVEWAY CHANNELIZING ISLAND TO PREVENT LEFT-TURN EGRESS AND INGRESS MANEUVERS

A-17: INSTALL DRIVEWAY CHANNELIZING ISLAND TO PREVENT DRIVEWAY ENCROACHMENT CONFLICTS

This access control measure involves the construction of a driveway median island to control ingress and egress vehicle maneuvers. The technique can be applied either to existing driveways or in the permit authorization stage.

The technique will reduce head-on encroachment conflicts between driveway ingress and egress vehicles. Ingress and egress traffic will be directed to separate sides of the driveway median island. Some increases in single-vehicle accidents can be expected due to driveway vehicles striking the island.

Warrants

This technique is applicable on all types of highways and for driveways with two-way operations. A history of driveway head-on accidents between opposing vehicles or between entering and parking vehicles would warrant this treatment. Highway traffic volume should exceed 5,000 vpd with speeds ranging from 25-45 mph. At least 500 vpd or 100 vehicles during the peak hour should utilize the driveway before constructing medial channelization.

Design

Installation of a driveway median should be made to prohibit encroachment by opposing vehicles. The width of the median should be from 4 feet to 10 feet; the length from 25 feet to 120 feet. The offset of the island with respect to the through lanes should be at least 5 feet. If construction takes place on an existing driveway, adequate space for the safe operation of driveway vehicles must be achieved. Figure A.17 presents minimum geometric considerations for successfully implementing this technique.

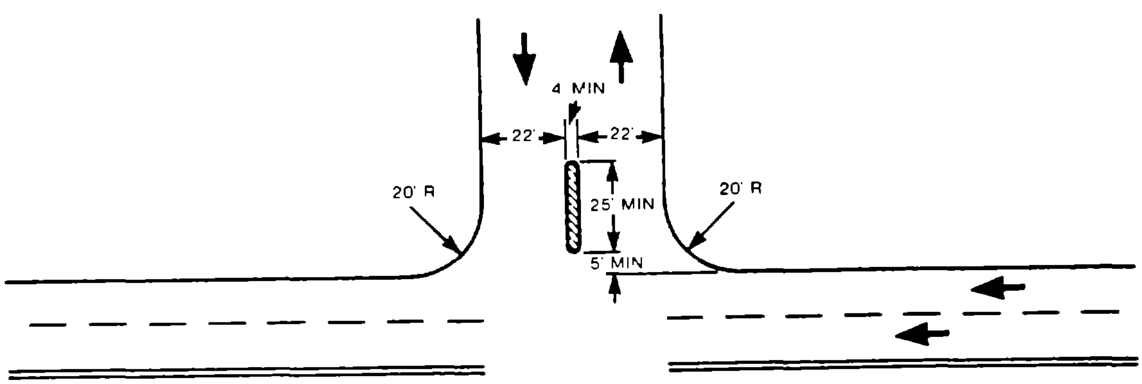


FIGURE A.17. DRIVEWAY MEDIAN CHANNELIZING ISLAND

A-18: INSTALL CHANNELIZING ISLAND TO PREVENT RIGHT-TURN DECELERATION LANE VEHICLES FROM RETURNING TO THROUGH LANES

The application of this technique involves installing a channelizing island to separate through-lane and right-turn deceleration lane vehicles. The channelizing island prevents turning vehicles from encroaching on the through lanes and also guides the decelerating driver into the driveway by defining the desired vehicle path.

The functional objective of this treatment is to eliminate the encroachment conflict point for right-turn ingress vehicles. A reduction in encroachment (basically sideswipe) conflicts will occur. However, an increase in the number of single-vehicle mishaps may occur due to vehicles striking the island.

Warrants

This technique is applicable to all highways with greater than 10,000 vpd. At least 50 right-turn ingress vehicles should enter the driveway during the peak hour. The site should be characterized by a history of encroachment conflicts due to right-turn ingress vehicles reentering the through lanes.

Design

The purpose of this design is to separate through and right-turn deceleration vehicles from unnecessary conflict. Construction of a raised median will adequately achieve the goal. This median should possess the following dimensions and characteristics:

- 2-feet in width
- 2-foot separation from through traffic lanes
- Minimum of 6-foot extension into intersection
- Reflectorization for nighttime driving
- Extend far enough to prohibit reentry into through lanes
- Consist of sufficient lane width to safely accommodate traffic

Additionally, signing such as W12-1 and R3-2 should be utilized as an informational aid. Figure A.18 shows a typical layout.

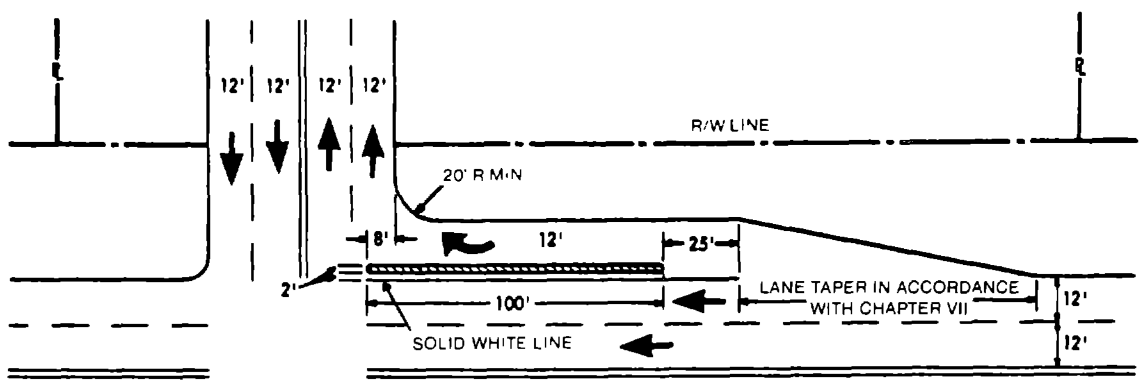


FIGURE A.18.1 CHANNELIZING ISLAND TO PREVENT RIGHT-TURN DECELERATION LANE VEHICLES FROM RETURNING TO THROUGH LANES

A-19: INSTALL CHANNELIZING ISLAND TO CONTROL THE MERGE AREA OF RIGHT-TURN EGRESS VEHICLES

This driveway design technique reduces the frequency of conflicts by reducing conflict areas. The channelizing island will designate the correct right-turn egress path and more clearly define the merge area.

The technique will reduce accident frequency and severity between right-turn egress vehicles and through traffic. These reductions will result from moving the basic conflict area longitudinally from the immediate driveway intersection. Delay is not expected to change. Possible tradeoffs might occur because of vehicles striking the channelizing island.

Warrants

This technique is warranted on all types of highways. Highway volumes should exceed 10,000 vpd, and highway speeds should be from 25 to 45 mph. Right-turn egress maneuvers should exceed 30 per hour. Total driveway volume should be less than 100 vph. This technique can also be applied at locations where accident histories indicate that an egress merge problem exists.

Design

The intent of this design is to control egress movements by directing flow to desired path. Island size and position must be such that presence and function are clearly delineated to the motorist. Refer to Figure A.16.2 for recommended geometric layout. The addition of appropriate signing (W4-1, MUTCD) will aid through-moving motorist of the impending merge.

A-20: REGULATE THE MAXIMUM WIDTH OF DRIVEWAYS

This is a regulatory technique aimed at reducing conflict areas by defining the maximum width of driveway openings on the highway. The maximum width is a function of the types of vehicles using a facility as well as their entering or exiting speeds. This technique is applicable at a point location or as a standard for all driveways. Curbing is usually used to define the extent of a driveway opening.

The reduction in potential conflict areas is expected to be accompanied by a reduction in accident frequencies and severities. No tradeoffs are anticipated by regulating maximum driveway widths.

Warrants

This technique is warranted on all highway types where excessively large driveway widths exist. Highway volumes should exceed 5,000 vpd, and highway speeds should be less than 45 mph. Driveway volumes should exceed 250 vpd. The technique is also warranted for general application along highways that experience high accident rates associated with undefined driveways.

Design

Maximum driveway width is a function of design parameters appropriate to the expectant vehicle usage. Consideration must be given to highway operating conditions, volume, geometry, sight distance, angle of intersection, and alignment (vertical and horizontal) as described in Chapter VII. Information contained in several techniques should be consulted in the initial phase.

B-1: REGULATE MINIMUM SPACING OF DRIVEWAYS

The minimum spacing of driveways is a regulatory method used by many agencies to regulate the frequency of access points along highways. This technique can be implemented at existing locations or during the driveway permit authorization stage. Strategies for achieving this objective at existing driveways include closing of driveways or closing and relocating driveways.

This technique indirectly reduces frequency of conflict by separating adjacent, basic conflict areas and limiting the number of basic conflicts points per length of highway. The technique is expected to reduce the severity of rear-end conflicts as it allows more deceleration distance and perception time for motorists. Some tradeoffs may be realized by increasing average delay and rear-end conflicts at driveways as a result of increasing the average volume per access point.

Warrants

This access control technique is generally warranted for all types of arterials where conflict areas overlap and delays are excessive. Highways with volumes greater than 5,000 vpd and speed greater than 25 mph are candidates for consideration. Also, the technique is warranted on arterials which have a level of development ranging from 30-60 driveways per mile and frontage widths greater than 100 feet. Minimum driveway volumes greater than 200 vph at peak periods are necessary for warranting this technique.

Design

Table B.1 contains desirable separation distances applicable to driveways on all types of roadways.

TABLE B.1. DESIRABLE SEPARATION OF ADJACENT DRIVEWAYS

Highway Speed	Minimum Spacing
20 mph	85
25 mph	105
30 mph	125
35 mph	150
40 mph	185
45 mph	230
50 mph	275

This access control standard regulates the distance between a crossroad intersection and the nearest driveway location. In this text, corner clearance is defined as the distance, measured along the back of the arterial curb, from the nearest edge of a driveway to the nearest edge of the intersection.

This technique moves the basic driveway conflict area away from the vicinity of an intersection by regulating the distance from the driveway to the intersection. The major effect is that the minimum spacing of access points is increased, resulting in larger stopping sight distances and driver perception times. An additional effect is that driveway vehicles will be delayed less by standing queues at signal-controlled intersections. A possible tradeoff is that access to some corner commercial properties may be partially or totally denied.

Warrants

This technique may be applied on all types of highways where corner lot driveways create conflict and delay problems to through and driveway traffic. Highway ADT and speed should exceed 5,000 vpd and 25 mph, respectively. Severe limitations on corner frontage widths may render this technique impractical at locations with frontage widths less than 100 feet.

Design

This technique is aimed at minimizing driveway/intersection conflicts by preventing blockage of driveways upstream of an intersection due to standing traffic queues. Minimum driveway setback distances should take into consideration typical traffic queue lengths while permitting sufficient movement to driveway vehicles. In rural areas, the corner clearance from the end of the radius should be a minimum of 20-40 feet; in urban areas, 10-20 feet.

B-3: REGULATE MINIMUM PROPERTY CLEARANCE

The regulation of minimum property clearance distances is an access control standard that helps increase the minimum spacing of access points. Property clearance is the distance, measured along the arterial curb, from the extended property line to the nearest edge of the driveway.

The technique is expected to reduce deceleration requirements on the highway. Conflicts will be reduced because drivers are allowed more perception time between successive conflict areas.

Warrants

This technique may be applied on all highway types where insufficient property clearance contributes to conflicts and delays to the through and driveway traffic. Highway ADT and speed should exceed 5,000 vpd and 25 mph.

Design

Table B.1 contains recommended clearances between driveways.

This is a general operating practice that maximizes the spacing of adjacent driveways during the permit authorization stage. The technique is intended to supplement the operational benefits expected from Technique B-5, "Regulate Minimum Driveway Spacing."

This technique indirectly reduces the frequency of conflicts by separating adjacent conflict areas and limiting the number of basic conflict points per length of highway. The implementation of the technique is expected to reduce the severity of conflicts as it allows more deceleration distance and perception time between driveways.

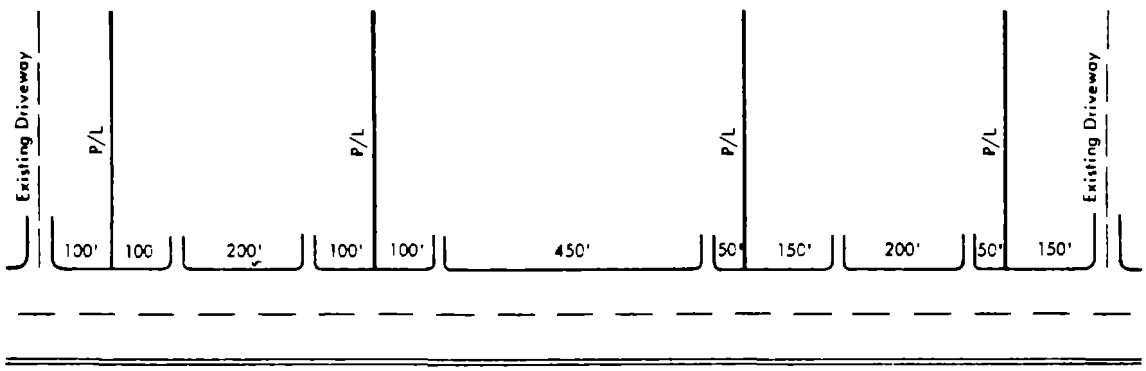
Warrants

This technique is warranted for all types of highways. Its application is limited to the permit authorization stage. Highways with volumes and speeds greater than 5,000 vpd and 25 mph, respectively, are prime candidates. Also, the technique is warranted on arterials which have an anticipated level of development range from 30-60 driveways per mile. Minimum anticipated driveway volumes of 1,000 vpd are required.

Design

This technique is aimed at maximizing spacing between adjacent driveways along an arterial. Application of this technique is intended to supplement the information contained in Technique B.1. Figure B.4.1 contains two arrangements: a.) minimum non-optimized driveway spacing and b.) optimized driveway spacing.

a -- Minimum Driveway Spacing



b -- Optimized Arrangement

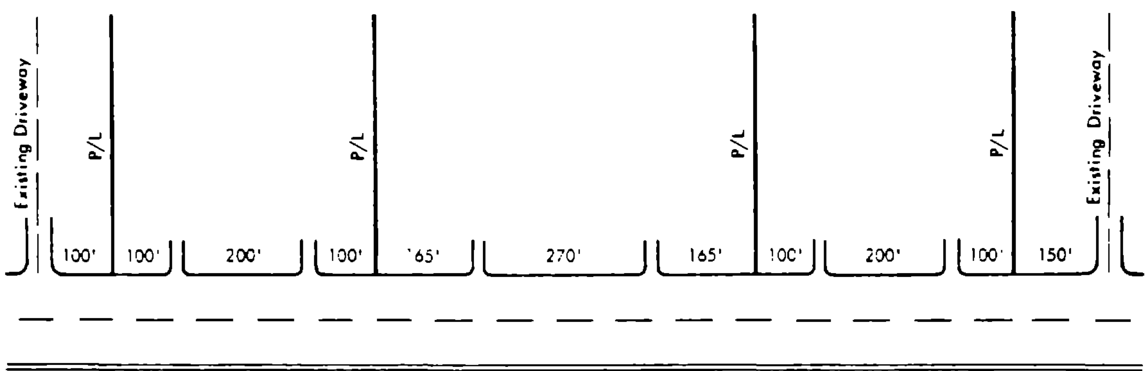


FIGURE B.4.1. OPTIMIZED DRIVEWAY PLACEMENTS

B-5: REGULATE MAXIMUM NUMBER OF DRIVEWAYS PER PROPERTY FRONTAGE

This general access control standard limits the number of driveways per property relative to the length of available frontage. It is a route alternative that minimizes the number of driveways per length of highway.

Generally, regulating the maxmium number of driveways per property frontage limits the number of conflict areas and provides turning drivers more time and distance to execute their maneuvers.

Basic conflict points will be reduced proportionately to the reduction in driveways. This results in a reduction in the frequency of conflicts. The severity of conflicts should also decrease because deceleration requirements are lessened.

If, because of the application of this technique, traffic volume increases significantly at existing driveway locations, an increase in the frequency of conflicts at these locations is likely. Also, regulating the number of driveways permitted for a specific frontage length could have a significant impact on the business activity at that location. These problems should be considered before denial for an additional driveway is given or before an existing driveway is closed.

Warrants

The application of this access control measure is warranted on all existing arterial highways or as a standard for all new facilities. For implementation on existing highways, highway volumes and speeds should exceed 5,000 vpd and 30 mph. Total access volumes to a property should exceed 500 vpd.

Design

The allowable number of driveways typically follows the recommendations outlined below:

- Normally, only one driveway is permitted for residential usage and no more than two permitted for non-residential usage.
- If property frontage exceeds 600 feet, an additional driveway may be permitted.
- Development may be restricted to a single ingress/egress point if served by an adequate collector road.

B-6: CONSOLIDATE ACCESS FOR ADJACENT PROPERTIES

This general operating practice encourages adjacent property owners to construct joint-use driveways in lieu of separate driveways. Strategies for implementing this technique include closing existing driveways or authorizing joint-use driveways.

A prime example of this technique is the neighborhood shopping center, where access to several properties is provided by a few access points. The feasibility of this technique is viewed primarily at the permit-authorization stage. The joint driveway will cause a reduction in the concentration of driveways along an arterial. The reduction in driveway concentrations is expected to be accompanied by a reduction in the frequency and severity of conflicts.

Warrants

This technique is warranted on all types of highways. Highway ADT should exceed 10,000 vpd and highway speeds should be greater than 35 mph. Driveway pairs with more than 50 vehicles using each driveway per hour will be good candidates for this technique.

Design

The physical means by which access can be consolidated between two adjacent properties involves construction of a joint use driveway between the two properties. It is recommended that the joint-use driveway be owned by both property owners. That is, the driveway should be located precisely straddling the property line dividing the two establishments. This practice will not enable either owner the opportunity to deny or restrict access to his neighbor's property.

The resulting joint-use parking area should be accompanied by an efficient internal circulation plan. Internal circulation is discussed in detail in connection with Technique C-20, Require Adequate Internal Design and Circulation Plan. Consideration should also be given the driveway design parameters of return radii, offset distances, alignment angles and land widths, which are discussed in Chapter VII.

B-7: REQUIRE HIGHWAY DAMAGES FOR EXTRA DRIVEWAYS

This general access control policy requires the abutting property owner or developer to pay for highway damages if he desires an additional driveway beyond the number considered suitable and sufficient for access. The additional driveways are permitted only if they conform to other established driveway regulations. The compensation should reflect the increased operating and accident costs assumed by the motoring public. Payment for damages can be required either on existing facilities or for sites being developed.

The policy of requiring highway damages must be established by statute, code, ordinance or other means in order to be enforceable. Such a policy should help to discourage the construction of additional driveways. The average spacing of access points would be increased and driveway maneuvers will create less interference with through vehicle movement, thereby achieving better compatibility between accessibility and traffic operations.

Conflict points are indirectly reduced if the technique is a successful deterrent to additional driveways. A reduction in the frequency of conflicts would follow. The increased separation distance between basic conflict areas would increase perception time and lessen deceleration requirements, thus decreasing the severity of conflicts.

Warrants

Requiring highway damages for extra driveways must be applied in the planning stage. This technique is applicable to higher volume highways using specified standards for the number of driveways permitted for specific frontage widths.

Design

The guidelines for implementation of this technique will derive from the basic driveway spacing policy of the highway agency. Chapter VII provides guidelines.

B-8: BUY ABUTTING PROPERTIES

This access control measure is aimed at reducing the frequency of access points by purchasing small parcels that remain after a highway improvement. This elimination of potential access points can aid substantially in protecting the functional integrity of the highway by minimizing the frequency and severity of conflict points.

B-9: DENY ACCESS TO SMALL FRONTAGE

The denial of access to small frontages is a regulatory policy that prohibits direct access to the arterial highway. Legal problems are usually encountered and are concerned with the availability of suitable and sufficient access. Compensation is required if suitable and sufficient access cannot be provided.

This technique, as in other regulatory driveway location techniques, separates basic conflict areas by limiting the number of access points. The frequency and severity of conflicts will be reduced because conflict areas are further separated, and driver perception times and distances are increased. The number of frontages which are denied access affects the degree to which the frequency and severity of conflicts is changed.

B-10: CONSOLIDATE EXISTING ACCESS WHENEVER SEPARATE PARCELS ARE ASSEMBLED UNDER ONE PURPOSE, PLAN, ENTITY, OR USAGE

This is a general operating practice that requires specific changes on commercial sites when they are assembled for development or redevelopment. The consolidation is accomplished by voiding existing driveway permits upon alteration of the property functions. The new permit authorization depends on the developer's plans to use some existing driveways and close or relocate other driveways.

The objective of this technique is to increase average spacing of access points along the highway. The consolidation of driveways reduces the number of access of points and thereby increases the spacing of driveways. The increase in driveway spacing provides motorists of turning vehicles more time and distance to properly execute their maneuvers. The severity of conflicts should decrease because deceleration requirements are lessened.

B-11. DESIGNATE THE NUMBER OF DRIVEWAYS TO EACH EXISTING PROPERTY AND DENY ADDITIONAL DRIVEWAYS REGARDLESS OF FUTURE SUBDIVISION OF THAT PROPERTY

This is a general regulatory policy which designates the maximum number of driveways permitted to each existing property before development. The implementation of this technique requires an advance planning policy with a formal planning document made readily available to abutters. Such policy denies additional driveways regardless of future subdivision of that property.

The objective of this technique is to maintain average spacing of access points along the highway. This objective is achieved by regulating the maximum number of driveways per property frontage. The increase in average driveway spacing provides motorists turning into driveways with more time and distance to properly execute their maneuvers.

This access control measure increases the minimum spacing of access points. This results in a reduction in the frequency of conflicts. The severity of conflicts should also decrease because deceleration requirements are lessened.

B-12. REQUIRE ACCESS ON COLLECTOR STREET (WHEN AVAILABLE) IN LIEU OF ADDITIONAL DRIVEWAYS ON HIGHWAY

This access control technique is aimed at maintaining the average spacing of driveways by locating additional driveways on collector streets instead of on the arterial highway when the existing driveways on a property are utilized to their capacity.

This technique will reduce conflict frequency and severity by diverting some driveway vehicles to the collector street location where traffic volumes and speed are lower.

C-1: INSTALL TRAFFIC SIGNALS TO METER TRAFFIC FOR LARGER GAPS

The size of traffic gaps on the arterial is an important factor influencing traffic flow and driver behavior. The installation of additional traffic signals at intersections or major driveways is an operational technique that helps create sufficient traffic gaps and allows driveway vehicles the appropriate use of these gaps. Closely-spaced traffic signals will also tend to regulate highway speeds, which will lessen the speed differential between through vehicles and driveway vehicles. Less time and distance will be necessary for deceleration of through vehicles that conflict with turning vehicles.

Larger gaps and slower speeds reduce the severity of conflicts between merging and diverging streams of traffic. Also, some reductions in delay to driveway vehicles is expected. The major tradeoff associated with this technique is the increased delay to through vehicles.

Warrants

This technique is applicable on all types of highways where, because of the lack of adequate gaps for driveway vehicles, speed differentials between through and turning vehicles are critical. Warrants discussed in Technique A.4 and Reference 2 should be met.

Design

Installation of signals must conform to the requirements of the MUTCD, as described in Technique A-4 of this Appendix.

C-2: RESTRICT PARKING ON THE ROADWAY NEXT TO DRIVEWAYS TO INCREASE DRIVEWAY TURNING SPEEDS

This technique increases the turning speed by removing constraining obstacles, specifically parked vehicles, from areas adjacent to driveways. Parked vehicles may indirectly contribute to driveway accidents by limiting the sight distance or influencing the turning paths of driveway vehicles. This technique is intended as a point measure, although route applications are also feasible.

This technique will reduce the severity and frequency of conflicts by removing, and merging, driveway vehicles at higher speeds. Severity is reduced because the speed differential between turning and through vehicles is reduced. Conflict frequency also benefits from the increase in turning velocity. One possible tradeoff that accompanies this technique is a reduction in parking capacity.

Warrants

This technique is warranted at any driveway location where parked vehicles cause excessively slow turning speeds resulting in rear-end conflicts between right-turning and through vehicles. All highway and driveway ADT ranges, and all levels of development will benefit from this technique's application.

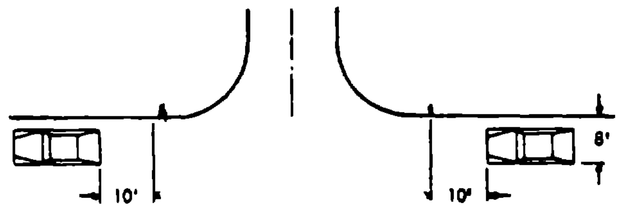


FIGURE C.2. RECOMMENDED MINIMUM PARKING RESTRICTION ADJACENT TO DRIVEWAY OPENINGS

Design

In the design of driveways, consideration should be given to ensure safe and efficient merging of driveway vehicles with through movements. Figure C.2 shows the recommended practice.

In addition to the design elements in Figure C.2, sight distance requirements in Chapter VII should be adhered to.

Adequate sight distance and visual realization of the driveway location are very important factors to the safe and efficient operation of driveways and highways. Many existing driveways, however, lack adequate visual cues and are the scene of many vehicular and pedestrian conflicts.

Visual cues of driveways serve to limit maxmium deceleration requirements of highway vehicles by increasing driver perception time. Consequently, the severity of conflicts should be lessened. Rear-end conflicts are expected to decrease the most.

Warrants

Since sight distance could be a major problem, any isolated driveways with intersection sight distances less than the minimum, as set up by AASHTO, would warrant this technique. A level of development of less than 30 driveways per mile and daily highway volumes of greater than 2,500 are needed. Highways speeds should exceed 35 mph.

The advance warning sign with flashing beacon would apply to isolated driveways with volumes greater than 500 vehicles per day. The red-yellow flashing beacon and driveway illumination schemes require driveway ADT's greater than 1,000. The advance warning is also warranted when high accident rates indicate localized problems.

Design

If circumstances exist which cannot be eliminated by guidelines recommended in Technique C.2, advanced warning will be required. Consideration must be given to the geometric and grade layout, traffic level, and roadway type. Recommended visual cues include: flashing beacons, warning signs, contrasting pavements, reflectorized treatments, driveway lighting, or any combination of the above mentioned. Installation of warning devices should adhere to recommendations outlined in the MUTCD.

C-4: IMPROVE DRIVEWAY SIGHT DISTANCE

Adequate sight distance at driveway entrances is required to allow driveway egress drivers a sufficient view of the highway for acceptable gaps, and to provide through drivers the necessary perception, reaction, and braking distances to avoid collision with a driveway-egress vehicle that has entered the highway.

There are numerous causes of reduced sight distance including, but not limited to, highway geometrics and topography, foliage and/or other landscaping, parked vehicles, and physical structures. Statutes should be adopted which authorize the governing jurisdiction to maintain a clear-visibility triangle which has the driveway and main street as two of its legs with the hypotenuse between these two enclosing a prescribed area.

This action calls for altering existing site conditions to increase the available sight distance at the driveway. The terrain can be altered by cutting down hillsides, removing walls and fences, or moving signs and billboards. Alterations to the roadway include flattening horizontal and vertical curves.

On many arterials, sight distance is limited by the presence of parked vehicles in the roadway. It has become increasingly difficult for drivers to see a driveway through the windows of modern designed parked cars. Eye contact is frequently impossible because the line of sight between the highway and driveway is blocked by parked vehicles. One way to reduce these disadvantages is to prevent or restrict parking space along a highway.

Often commercial establishments with insufficient setback distances and internal parking problems will use the unpaved highway right-of-way for parking. This should not be encouraged by municipal or state authorities. If encroachment on public land has contributed to accidents on or off the traveled way, steps should be taken to prohibit and prevent the practice. Stepped-up enforcement of regulations may be an effective deterrent. Other remedies should be tried if more critical problems occupy police time.

The unused portion of the right-of-way can be separated from the property by methods suggested for Technique A-8.

Warrants

This technique is warranted at all existing driveways where adequate sight distance is not available. High accident experience due to inadequate sight distance will also warrant this technique.

Design

In addition to utilization of information contained in Techniques C.2 and C.3 to increase driveway sight distance, elimination or alteration of physical and geometric barriers should be considered as an enhancement to driveway sight distances. Improved sight distance can result from altering roadway alignment (horizontal and vertical curves) and eliminating physical obstructions (shrubbery, fencing, walls, etc.). Chapter VII provides guidelines for minimum sight distances at entrances.

C-5: REGULATE MINIMUM SIGHT DISTANCE

This regulatory policy is designed to control driveway location by imposing minimum sight distance standards for driveways. The policy takes effect by closing and relocating existing driveways or by regulating new driveways in the permit authorization stage. Regulation of sight distance is generally more applicable to suburban-rural locations.

The technique enables the driver of a vehicle, which is on the driveway, to see a sufficient distance in both directions along the highway and to enter the highway without creating a hazardous situation. The increased sight distance also decreases the speed differential between highway and driveway vehicles by allowing the through driver more perception time, which helps to reduce maximum deceleration requirements. These conditions should lead to a reduction in the severity of conflicts.

Warrants

The application of this technique should always be considered in the permit authorization stage. Application to existing highways is appropriate where high-accident rates are associated with sight distance restrictions.

Design

Chapter VII provides recommended sight distances applicable to this technique.

C-6: OPTIMIZE SIGHT DISTANCE IN THE PERMIT AUTHORIZATION STAGE

This is an operating policy which considers driveway location to optimize sight distance. Optimizing sight distance occurs in the permit authorization stage after a thorough review of the driveway location plans. The review enables the driveway to be located where maximum sight distance is available, consistent with other locational controls.

The technique enables the driver of a vehicle, which is stopped on the driveway outside the edge of the traveled way, to see a sufficient distance in both directions along the highway to enter the highway without creating a hazardous situation. Optimizing the sight distance also decreases the required speed differentials between highway and driveway vehicles. Drivers are afforded more perception time which helps to reduce maximum deceleration requirements. These conditions lead to a reduction in the severity of conflicts.

Warrants

Requests for driveway permits in the authorization stage warrant this access control treatment. All highway types are candidates with particular attention to high-speed highways.

Design

Although frontage widths pose some limitations on the actual location, driveways should be located at the point of optimum sight distance along the frontage. This technique attempts to achieve sight distances greater than required minimums as given under Technique C.4.

This technique is a driveway design technique aimed at limiting the maximum deceleration requirements on the highway. The technique affects driveway operations by increasing the driveway turning speeds. Strategies for implementing this technique involve optimizing various driveway design parameters.

Conflict severity will be reduced with this technique by decreasing the maximum deceleration requirements for highway vehicles. Delay to through vehicles will also be reduced by increasing the turning speeds of ingress and egress vehicles.

Warrants

This technique has general application to all driveways. It should always be a part of the design process for all planned or reconstructed driveways. Also, it should be considered as a general accident countermeasure for medium-to-high volume existing driveways.

Design

The speed at which vehicles can safely and effectively negotiate turning maneuvers is governed by several design parameters including: driveway width, return radius, lateral offset, approach angle, approach flare, and usable driveway length. Figure C.7.1 shows the various design components that effect a change in the approach width.

Tables in Chapter VII contain the results of examinations between turning maneuvers and design elements for various vehicular speeds. From these tables, it is recommended that the various combinations of design elements be utilized to develop safe, efficient driveway designs.

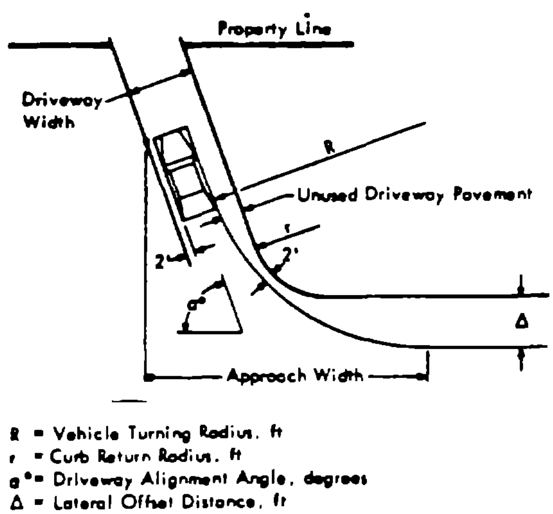


FIGURE C.7.1. DRIVEWAY DESIGN ELEMENTS

C-8: IMPROVE THE VERTICAL GEOMETRICS OF THE DRIVEWAY

This technique is a general design standard for new and existing driveways in which driveway profile guidelines are specified. These guidelines allow vehicles to efficiently execute driveway maneuvers without the vehicle experiencing severe bouncing. Providing adequate driveway profiles will result in desirable driveway turning speeds only when the other driveway geometric characteristics will permit such speeds.

Increasing driveway turning speeds limits maximum deceleration requirements on the highway and therefore decreases conflict severity. Improvements to the drive way profile should not adversely affect utility installations or drainage requirements.

Warrants

Application of this technique is desirable on all newly constructed or reconstructed driveways and on existing facilities where the driveway profile is adversely affecting traffic operations. Highway speeds should be at least 25 mph, and driveways should accommodate greater than 100 vpd. High accident experience could also warrant this method.

Design

Adequate design of driveway grades should reflect consideration for basic functions of the highway and the site which the driveway serves. Generally, in order to safely perform ingress/egress maneuvers, driveway profiles should provide for sufficient clearance between the vehicle and driveway surface. Chapter - VII provides guidelines for acceptable driveway profiles.

C-9: REQUIRE DRIVEWAY PAVING

This technique is a general access control standard in which the structural integrity of the driveway is ensured by using a hard-surface treatment.

Without driveway paving, desired driveway speeds are difficult to maintain because of potholing, ponding, and illdefined maneuver paths. With paving, interference to through vehicles and conflict severity are reduced because the maximum deceleration requirement is limited.

Warrants

This technique is warranted at all commercial driveways where excessive interference to highway-driveway operations results form the absence of driveway paving. Highway speeds should exceed 25 mph, and driveway volume should exceed 100 vpd. High accident rates due to unpaved driveways will also warrant this technique.

Design

Appropriate driveway thicknesses and surfaces shall be installed to withstand expectant driveway usage; and be applied to extend the entire length necessary for a smooth transition between the highway and driveway. Minimum recommended thickness for commercial usage should be based on soil conditions and type and volume of traffic. Typical guidelines include:

- 6" base stone plus 1½" asphalt, or
- 4" reinforced concrete, or
- 7" non-reinforced concrete

C-10: REGULATE DRIVEWAY CONSTRUCTION (PERFORMANCE BOND) AND MAINTENANCE

This technique is an access control policy that ensures a permanent and structurally adequate driveway surface. The strategy used in regulating construction is a performance bond that is required prior to construction. Maintenance is regulated by specifications included in the driveway permit, and regular enforcement of these regulations is needed to ensure adequate operations. The functional objective of the technique is to increase driveway speeds which in turn limits the deceleration requirements of through vehicles. A reduction in the severity of conflicts is the anticipated result.

Warrants

This technique is warranted for all driveways during the driveway permit process. Highway speeds should be at least 25 mph, and driveways should accommodate at least 100 vpd. This policy is most applicable to urban-suburban areas.

Design

In order to ensure that the construction of a driveway is sound and structurally adequate, a performance bond should be required from the contractor. This bond should be requested prior to construction and be of adequate value to cover any warranty period.

Driveway maintenance is typically outlined in the permit-granting stage and plays a necessary function in maintaining adequate driveway operation and service life.

This design technique reduces through-lane deceleration requirements by facilitating higher speed driveway merge maneuvers. The merge maneuver is facilitated by a right-turn acceleration lane for use by right-turn egress driveway vehicles. This technique can be applied both during the permit-authorization stage or at existing facilities.

The speed of driveway to highway merges is increased by allowing driveway vehicles the necessary length to accelerate. The merge maneuver can be accomplished more safely when the speed is more compatible with highway running speeds.

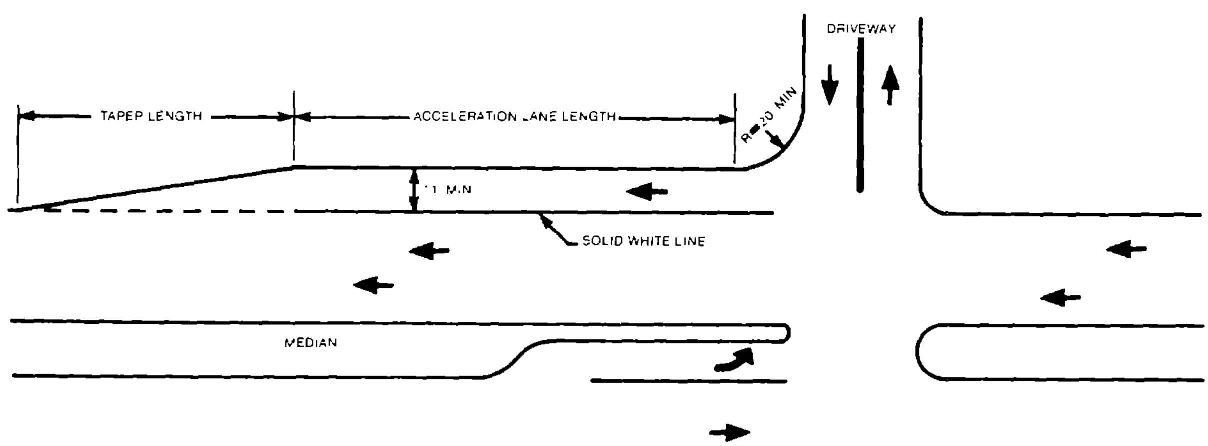
Merge and rear-end conflicts are expected to decrease because of a reduction in the deceleration requirement of through vehicles. Increased perception times will also result.

Warrants

This technique is warranted on all highway types. Highway volumes should exceed 10,000 vpd, and speeds should be greater than 35 mph. The technique should be implemented only at driveways that have at least 75 right-turn egress movements during peak demand periods. Property frontages should exceed the recommended length of the acceleration lane. High accident rates involving right-turn egress vehicles will also warrant this technique.

Design

A right-turn acceleration lane should be of sufficient width and length to allow safe, efficient merging maneuvers to occur. Chapter VII contains recommended dimensions to construct acceptable merging lanes. (See Figure C.11.1.)



C.11.1. RIGHT-TURN ACCELERATION LANE

C-12: INSTALL CHANNELIZING ISLANDS TO PREVENT DRIVEWAY VEHICLES FROM BACKING ONTO THE HIGHWAY

This driveway design technique is aimed at reducing through-lane deceleration requirements by preventing driveway vehicles from backing onto the highway from a parking area. The strategy for acheiving this objective is to construct channelizing islands at existing locations to prohibit this maneuver. The islands can be located either on the right-of-way or inside commercial properties. Candidate locations for this technique are characterized by commercial parking areas flat-graded to the highway, with no physical distinction between the two areas. This method will define where access to a property should be made.

The technique will reduce the total area of conflict by controlling and defining driveway openings. Conflict severity will be reduced by prohibiting uncontrolled access along property frontages. Possible detrimental effects may include an increase in through-vehicle conflicts with the installed island.

Warrants

This technique is warranted on all highways where open access exists with ADT's greater than 10,000. Highway speeds should be less than 45 mph. Driveway volumes should exceed 200 vpd. High accident rates involving vehicles backing onto the highway will also warrant the technique.

Design

The design of islands to accomplish this technique is dependent upon geometric layout and highway speeds. Islands should be of adequate size to discourage undesirable maneuvers but clearly define intent and direction for the turning vehicle. The island should conform to the channelization guidelines provided in Chapter VII.

C-13: INSTALL CHANNELIZING ISLAND TO MOVE INGRESS MERGE POINT LATERALLY AWAY FROM THE HIGHWAY

This driveway design technique is aimed at limiting the maximum deceleration requirements of the through lanes. The driveway channelizing island will move the ingress merge point laterally away from the highway enabling ingress vehicles to enter the driveway at higher speeds because other driveway vehicles will not interfere with the turning maneuver.

This technique is expected to reduce the severity of rear-end and merge conflicts. Possible tradeoffs may accompany this technique due to through and driveway vehicles striking the channelizing island.

Warrants

This technique is warranted on all highway types. Highway volumes should exceed 10,000 vpd, and speeds should be less than 45 mph. Driveway volumes should exceed 1,000 vpd and at least 40 right-turn ingress movements per hour should occur over peak-use periods. Sites that have a history of frequent ingress conflicts will warrant special consideration.

Design

The design of this channelizing device should be of adequate size to command motorist attention and clearly define directional path. The sides which parallel the through and driveway lanes should be of sufficient length to effectively control affected vehicles. As in the case of all islands, lane width should be sufficient to accommodate expected traffic volumes. Islands should conform to the channelization guidelines provided in Chapter VII.

C-14: MOVE SIDEWALK-DRIVEWAY CROSSING LATERALLY AWAY FROM HIGHWAY

This technique involves moving sidewalks, that are adjacent to driveways, laterally away from the highway. Interference between driveway ingress vehicles and through traffic will decrease because ingress vehicles are provided sufficient storage space on the driveway to avoid pedestrian conflicts. A reduction in conflict severity between through vehicles and driveway ingress vehicles is expected because the maximum deceleration requirements for through vehicles are lessened. Conflict severity between driveway ingress vehicles and pedestrians is also expected to be reduced because of the increased deceleration distance provided.

Warrants

This technique is applicable for all types of highways and at driveways where pedestrian crossings cause interference between highway and driveway vehicles. Highways with volumes and speeds greater than 5,000 vpd and 30 mph, respectively, are applicable. Driveway volume should exceed 100 during the peak hour, and pedestrian crossings should total two or more during the same hour. The site layout must also provide adequate distance for the sidewalk shift.

Design

Sidewalk location is the key to the proper utilization of this technique. The placement should be at a distance which permits vehicular storage from through lanes and provides for minimal pedestrian contact. A minimum sidewalk setback distance of 25-feet is recommended.

D-1: INSTALL TWO-WAY LEFT-TURN LANE

A two-way left-turn lane is provided to remove left-turning vehicles from the through lanes and store those vehicles in a median area until an acceptable gap in opposing traffic appears. The two-way left-turn lane completely shadows turning vehicles from both through-lane traffic streams. Thus, accident severity and frequency reductions will result. Frequency is reduced by removing stopped or slow left-turning vehicles from the through lanes and severity is reduced by allowing additional perception time to reduce left-turn crossing conflicts. Delay to through vehicles will also be reduced because left-turning vehicles and queues will not block the through lanes.

Warrants

This technique is warranted on multilane highways that have closely-spaced driveways with a uniform and medium density of left turns along the highway. Highway volumes and speeds should exceed 10,000 vpd and 30 mph. The level of development should exceed 60 driveways per mile, with less than 10 high-volume driveways. Left-turn driveway maneuvers per mile should total at least 20 percent of through volume during peak periods. High accident rates involving left-turn maneuvers will also warrant this technique.

Design

Figure D.1.1 illustrates the major design considerations applicable under this Technique. Traffic lane widths of 12 feet are desirable, however, existing conditions, particularly in urban settings may dictate lane width modifications.

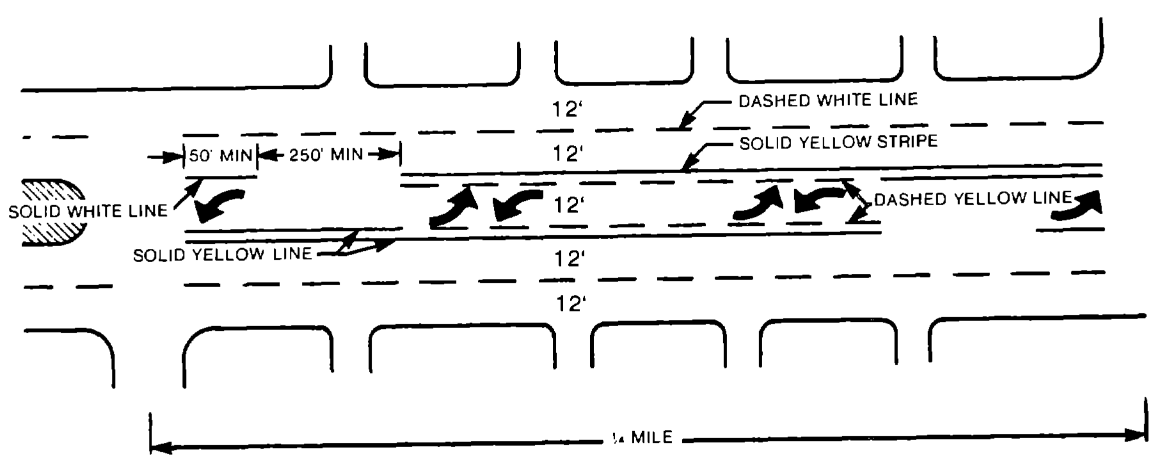


FIGURE D.1.1. TWO-WAY LEFT-TURN LANE

This technique is similar to the two-way left-turn lane, except that it provides individual left-turn lanes for each traffic direction. Each left-turn lane is continuous, except at intersections where a small far-side channelizing island discourages through movements. Left-turn vehicles can be stored in the continuous left-turn lane until an acceptable gap in opposing traffic appears. The continuous left-turn lane will completely shadow turning traffic from both traffic streams. Accident frequency is reduced by removing stopped or slow vehicles from the through lanes, and accident severity is reduced by allowing through vehicles additional perception time to avoid left-turn crossing conflicts. Delay to through vehicles will also be reduced because left-turn vehicles and queues will not block the through lanes.

Warrants

This technique is warranted on multilane highways that have occasional cross streets and closely spaced driveways with a uniform and medium density of left turns along the highway. Highway volume and speed should be greater than 10,000 vpd and 30 mph, respectively. At least 60 driveway should be served by 1 mile of highway, and high-volume driveways should number less than 10. Left-turn maneuvers should total at least 20 percent of through vehicles during peak periods along 1 mile of highway. High accident rates involving left-turn movements will also warrant this technique.

Design

Application of this technique follows similar requirements discussed in Technique D.1. The major difference is that sufficient width is available to permit construction of exclusive directional left-turn lane. If warranted and adequate space is available, an exclusive left-turn lane can be provided for each division of flow (see Figure D.2.1).

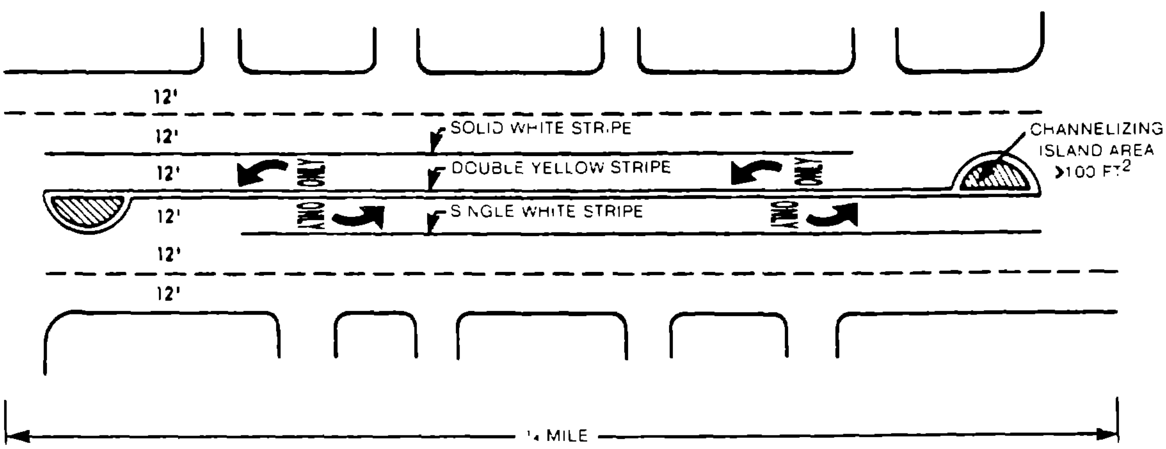


FIGURE D.2.1. CONTINUOUS LEFT-TURN LANE

The alternating left-turn lane will allow one traffic direction to have the opportunity to cross the median into driveways, and after a determined distance, the left-turn lane is physically opened to the opposing direction traffic. Thus, both traffic directions have a unique left-turn lane available for continuous left-turn maneuvers over a limited section of highway. Left-turn access to some driveways is prevented because when the left-turn lane is available to one traffic direction, the opposing traffic cannot attempt a left turn.

Accident frequency and severity reductions will result from the implementation of this technique. Frequency is reduced by removing stopped or slow-moving vehicles and queues from the through lanes, and severity is reduced by allowing through vehicles additional perception time to avoid left-turn crossing conflicts. Delay to through vehicles will also be reduced because left-turning vehicles will not block the through lanes.

Warrants

This technique is applicable on all types of highways where sufficient space is available for construction of medial turn lanes. Median widths greater than 11 feet are necessary. Multilane undivided highways with an odd number of lanes will readily accomodate this technique by converting the odd lane to an alternating left-turn lane. Application is particularly appropriate where concentrations of driveways alternate from one side of the highway to the other.

Highways volumes and speeds greater than 10,000 vpd and 35 mph, respectively, will warrant the technique. Left-turn movements should exceed at least 15 percent of the through traffic over 1 mile of highway during peak driveway demand periods. The level of development should be greater than 45 driveways per mile with spacing between major driveways or intersections greater than 1,000 feet. High accident rates due to left-turn crossing movements of adjacent driveways will also warrant the technique.

Design

Alternating left-turn lanes can be used when property access is required and road way width is limited. Figure D.3.1 exhibits typical usage; length of storage lanes and taper should be determined as in Chapter VII.

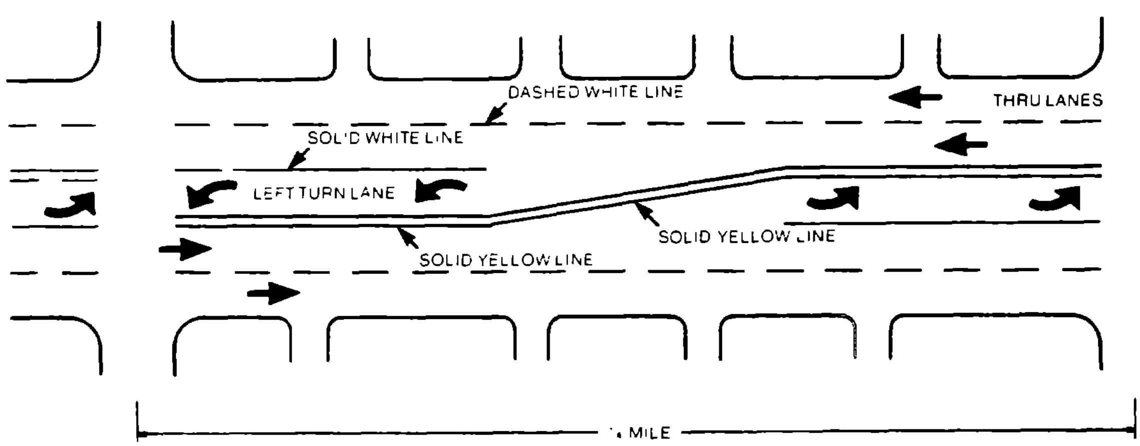


FIGURE D.3.1 ALTERNATING LEFT-TURN LANE

D-4: INSTALL ISOLATED MEDIAN AND DECELERATION LANE TO SHADOW AND STORE LEFT-TURNING VEHICLES

The functional objective of this technique is to remove turning vehicles or queues from the through lanes at a major driveway. Improvements in left-turning operations result from the isolated median and deceleration lane which shadows and stores the left-turning vehicles.

By providing higher diverging speeds and removing the stopped left-turning vehicles from the through lanes, a reduction in the frequency and severity of rear-end conflicts at the driveway should occur. Also, the severity of left-turn crossing conflicts should be reduced because the turning drivers are allowed additional perception time. Some tradeoffs may occur because of through vehicles colliding with the channelizing islands.

Warrants

All undivided highways are candidates for this technique. Typical locations would have levels of development of less than 30 driveways per mile, driveway volumes greater than 1,000 vpd, and highway volumes greater than 10,000 vpd. Left-turn volume should exceed 100 vph during the peak period.

Design

The decision components of this technique are the deceleration lanes (taper and storage), median islands, and the tapering length of the highway. Design parameters for the deceleration taper and storage lengths appear in Chapter VII. In many cases, additional rights-of-way will be needed to facilitate construction of needed deceleration lanes and median islands. Figures D.4.1 and D.4.2 provide design guidelines.

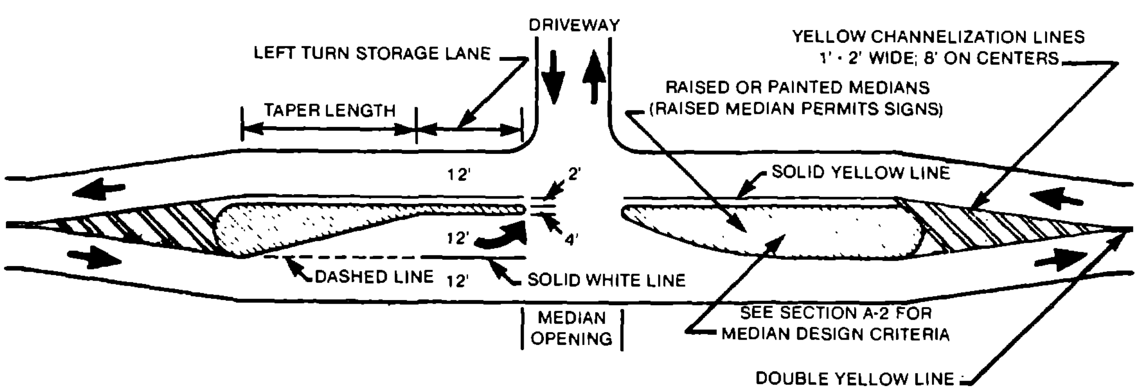


FIGURE D.4.1. ISOLATED DECELERATION LANE DESIGN

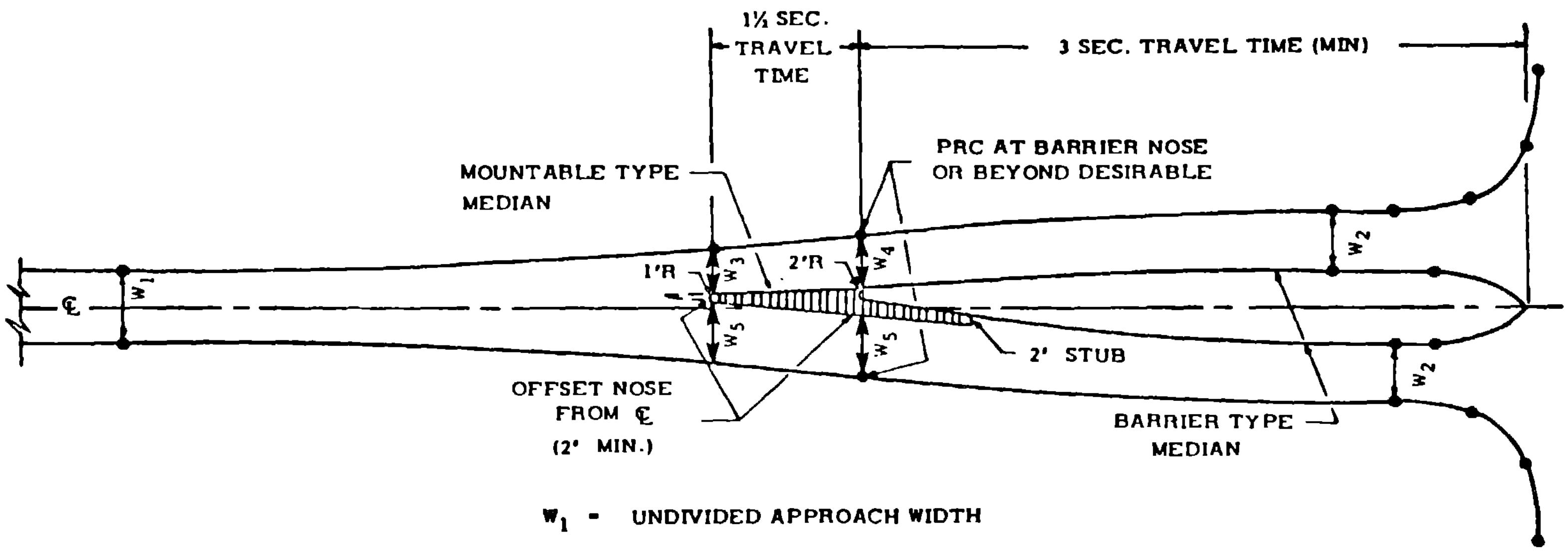
FIGURE D.4.2. DESIGN CRITERIA FOR CHANNELIZATION APPROACHES

NOTE:

1. WIDTH OF ISLAND CONTROLLED BY NOSE PLACEMENT AS DETERMINED BY CONTROL RADII AND ANGLE OF INTERSECTION OR ADDED LEFT TURN LANE.

2. VERTICAL AND HORIZONTAL ALIGNMENT ON APPROACH TO PROVIDE MINIMUM STOPPING SIGHT DISTANCE.

3. CONTROL DIMENSION, W, SHOULD BE FROM EDGE TO EDGE OF PAVEMENT AND SHOULD NOT INCLUDE GUTTER FLAG.



W_1 = UNDIVIDED APPROACH WIDTH

W_2 = DIVIDED APPROACH WIDTH

$W_3 = \frac{W_1}{2}$ OR 14' WHICHEVER IS LARGER

$W_4 = \frac{W_3 + W_2}{2}$ DESIRABLE

$W_5 = W_2 + 1'$

D-5: INSTALL LEFT-TURN DECELERATION LANE IN LIEU OF RIGHT-ANGLE CROSSOVER

This median treatment facilitates left-turn access to a driveway by providing a left-turn deceleration lane in place of a right-angle crossover. The principal objective is to remove turning vehicles or queues from the through lanes, thereby improving the left-turn operations.

The frequency and severity of rear-end conflicts is reduced because turning vehicles can diverge at higher speeds and because stopped vehicles or queues are removed from the through lanes. The severity of left-turn opposing conflicts should decrease because the left-turning drivers will have more perception time in which to make their decisions.

This technique should only be considered where a median opening exists and there is sufficient median width for a deceleration lane.

Warrants

All multilane divided highways with median widths of 14 feet or greater are potential locations for this application. A median opening must exist in order to provide for turning maneuvers. The development near this location should include fewer than 45 driveways per mile with major driveways or intersections 1/4-1/2 mile apart. Highway speeds should exceed 35 mph, and driveway ADT and highway ADT should be greater than 1,000 and 10,000, respectively. Left turns should total 10 percent of the peak-period traffic volume.

Design

Design considerations are similar to those described in Chapter VII.

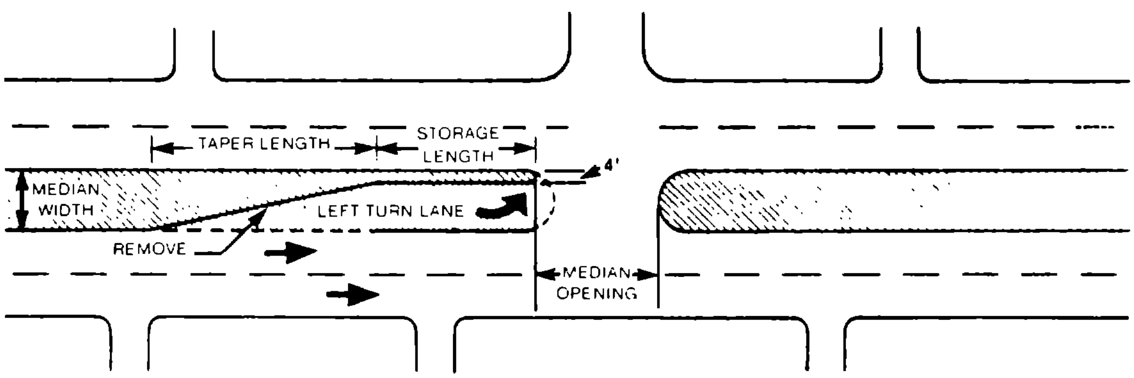


FIGURE D.5.1. LEFT-TURN DECELERATION LANE IN LIEU OF RIGHT-ANGLE CROSSOVER

D-6: INSTALL MEDIAL STORAGE FOR LEFT-TURN EGRESS VEHICLES

The installation of medial storage for left-turn driveway egress vehicles on multilane divided highways improves left-turn operations by removing those turning vehicles from the through lanes of the highway. This allows left-turn egress drivers additional perception time, which in turn reduces the severity of left-turn egress merge conflicts.

Warrants

All multilane divided highways with median widths of at least 18 feet are applicable locations. A median opening has to exist in order to provide for the turning maneuvers. A development of less than 45 driveways per mile near the location is necessary, and highway speeds should range from 30-45 mph. Highway volume should exceed 10,000 vpd, and left-turning egress volume should exceed 300 vpd. Frequency of left-turn accidents could also constitute a warrant for this improvement.

Design

A minimum median width of 18 feet is needed for this treatment. Also, a lane width of at least 14 feet must be maintained between the channelizing island and the median end. The island should occupy at least 100 square feet in order that the path of left-turning vehicles is well-defined. The island should be offset from the through lanes by a 2-feet safety area. Guidelines are provided in Chapter VII.

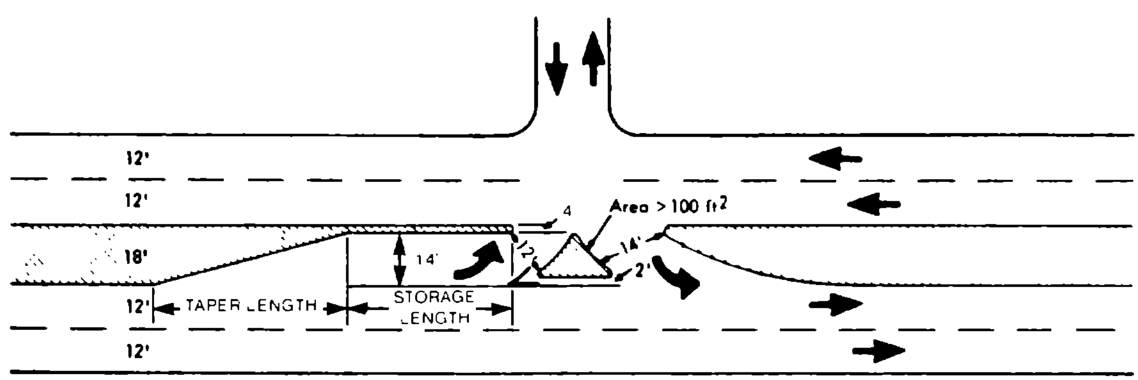


FIGURE D.6.1. MEDIAN STORAGE FOR LEFT-TURN EGRESS VEHICLES

D-7: INCREASE STORAGE CAPACITY OF EXISTING LEFT-TURN DECELERATION LANE

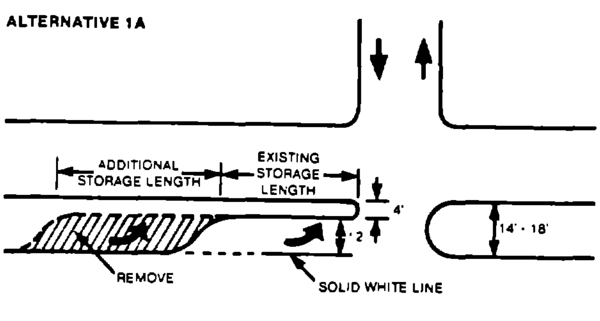
The deceleration lane shadows and stores left-turning vehicles from the main stream of traffic. When the storage capacity becomes insufficient to handle the turning volume, the safety and capacity of the through lanes is adversely affected. An acceptable solution involves increasing the storage capacity of the deceleration lane to accommodate most peak-period turning vehicles. The effects on operation are reductions in the frequency and severity of rear-end conflicts.

Warrants

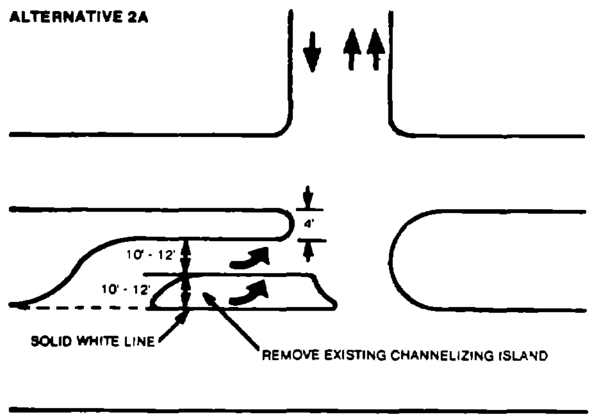
All multilane divided highways with existing deceleration lanes and insufficient storage lengths are applicable locations. A level of development for the highway section should contain fewer than 45 driveways per mile with major driveways or intersections 1/4-1/2 mile apart. Driveway ADT and highway ADT should exceed 1,000 and 10,000, respectively.

Design

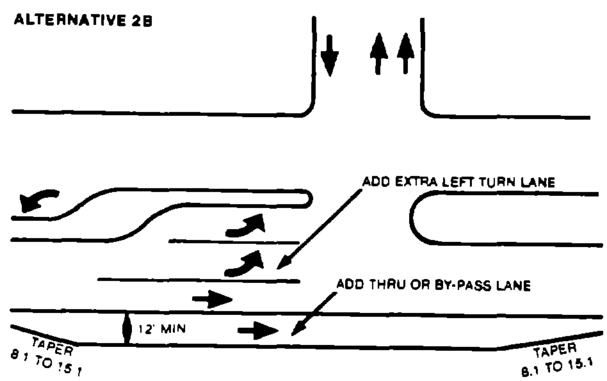
The design of this technique involves two alternatives. These alternatives are: (1) increasing the length of an existing storage lane where sufficient median length is available; or (2) widening the highway to facilitate left-turning maneuvers from two lanes. The second condition considers the possibility of right-of-way acquisition. Several construction options exist under each of these conditions.



Increase Storage Capacity
Extend Left-Turn Lane
(for Median Widths 14'-18')



Increase Storage Capacity Add
Second Left-Turn Lane
(for Medians 24' and greater)



Increase Storage Capacity
(for Median Widths 14'-18'
Where Existing Lane Cannot be Extended)

The design for storage capacity should be based on the through traffic volumes for both directions, the percentage of left turns in the one direction, and the highway speed. Design parameters are discussed in Chapter VII.

D-8: INCREASE THE TURNING SPEED OF RIGHT-ANGLE MEDIAN CROSSOVERS BY INCREASING THE EFFECTIVE APPROACH WIDTH

This technique is aimed at improving the left-turning maneuvers of vehicles at median openings. The objective is achieved by increasing the approach width and thereby increasing the turning speed of crossover vehicles. The improved design of media crossover reduces the severity of rear-end conflicts by reducing the maximum deceleration requirements of through vehicles following turning vehicles.

Warrants

The application of this technique is possible on multilane divided highways with median widths exceeding 4 feet. Level of development should exceed 15 driveways per mile, and traffic volume should exceed 5,000 vpd on the highway.

Design

1. Increase the width of the left lane in the vicinity of the median opening. A sufficient lane width for arterial highways is from 11-13 feet. These lane widths are considered adequate for comfortable maneuvers by turning vehicles. A minimum of 2 feet widening is recommended for this design. Also, a 10:1 taper is desirable for proper operation. Figure D.8.1 is a typical layout of the proposed design.

2. Increase the left-lane width by flaring. The minimum flare offset should be 2 feet at a rate of 15:1 taper. Figure D.8.2 is a typical design.

3. Increase the approach width by increasing the return radius of the side of the median nearest to the turning vehicle. This geometric improvement is suggested for median having a width of 15 feet or more. Figure D.8.3 illustrates the technical design elements of the proposed improvement.

4. Increase the total width of the median opening. The additional width helps turning vehicles to perform the maneuver with larger radii. The total width of the opening, however, should not exceed 50 feet. Figure D.8.4 is a typical design of this case.

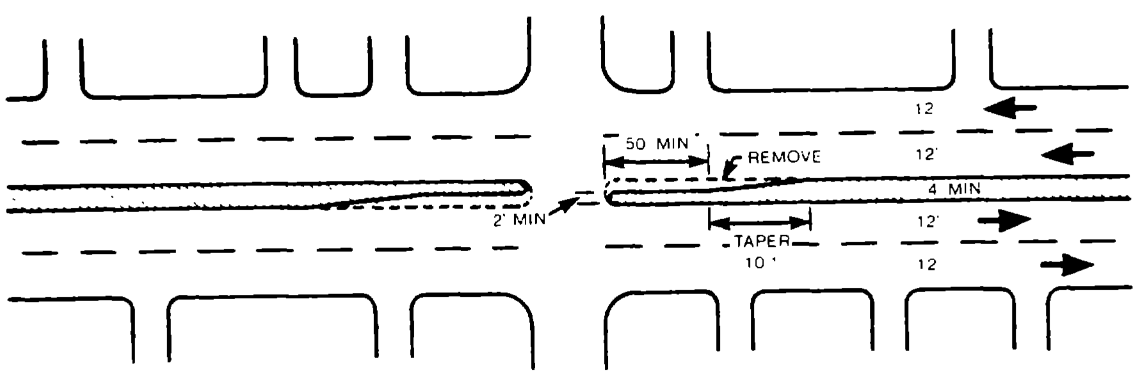


FIGURE D.8.1. WIDENING OF LEFT LANE

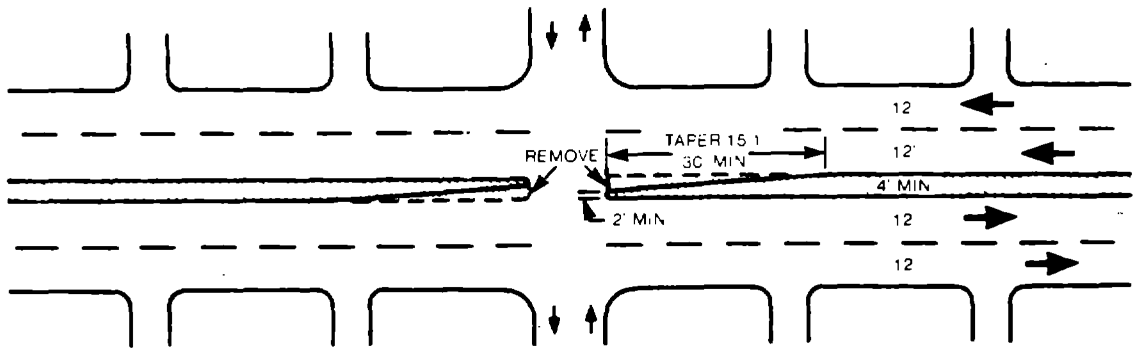


FIGURE D.8.2. WIDENING OF LEFT LANE

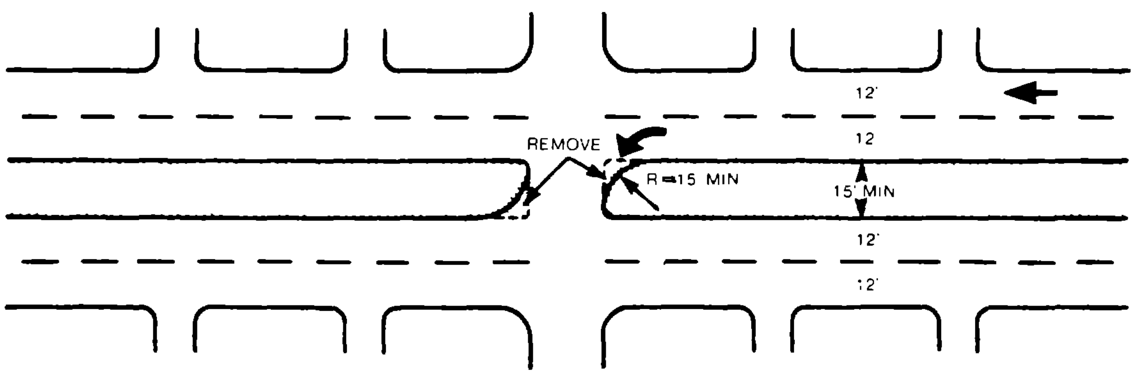


FIGURE D.8.3. INCREASING THE APPROACH WIDTH

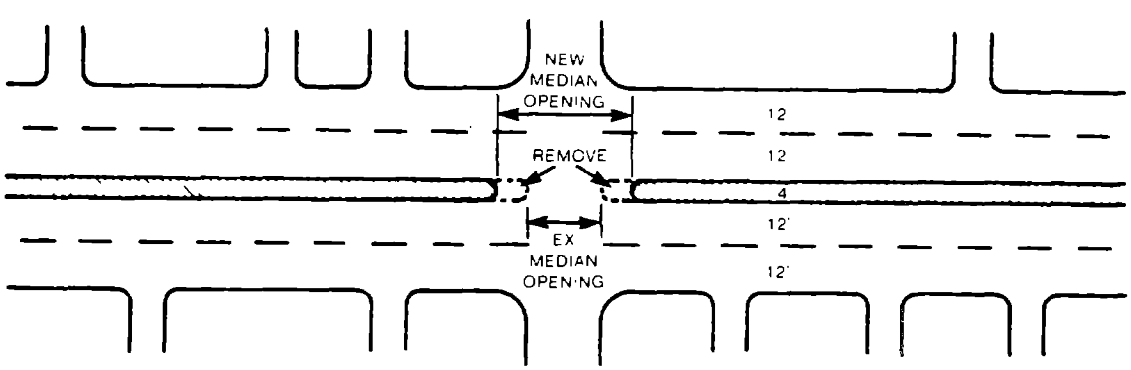


FIGURE D.8.4. WIDENING THE MEDIAN OPENING

A continuous right-turn lane is essentially a combination of a right-turn acceleration and deceleration lane that is extended to accommodate several nearby driveways. It is used along a section of highway where driveways cannot otherwise accommodate right-turning queues and/or high enough right-turn speeds. This technique reduces the frequency and severity of rear-end conflicts by removing turning vehicles at higher speeds and by shadowing right-turn queues.

Warrants

This technique is warranted on all types of highways with volumes exceeding 15,000 vpd, levels of development greater than 60 driveways per mile, and speeds above 30 mph. Right-turning vehicles per mile should exceed 20 percent of the directional highway ADT.

Design

Application of this technique is appropriate where access to driveways cannot be achieved at safe right-turn speeds. Figure D.9.1 exhibits typical guidelines. Variation in lane widths are common. Chapter VII contains typical design considerations.

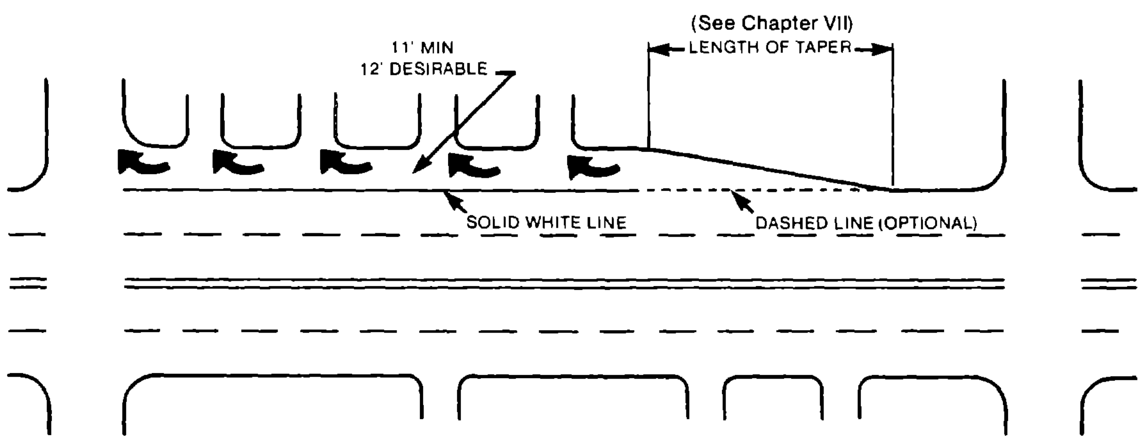


FIGURE D.9.1. CONTINUOUS RIGHT-TURN LANE

D-10: CONSTRUCT A LOCAL SERVICE ROAD

Frontage roads are access control measures that have numerous functions, depending on the kind of arterial highway they serve and the character of the surrounding commercial area. They segregate local traffic from the higher-speed through traffic, and intercept driveways of abutting commercial establishments. Cross connections between the through traffic lanes and frontage roads, usually provided in conjunction with crossroads or intersections, furnish the means of access between through roads and adjacent property. Thus, the through character of the highway is preserved and is unaffected by subsequent development of the roadside.

The frontage-road system can add tremendous flexibility to the operation of a highway when utilized as an auxiliary facility. A continuous frontage-road system provides maximum land service to properties abutting the highway facility. Also, during periods of saturated flow on urban highways, frontage roads provide the operational flexibility often required to alleviate congestion on the system.

The frontage road, as an access control measure, reduces the frequency and severity of conflicts along the highway by preventing direct left turns and removing slower-turning vehicles from the through lanes. This technique decreases delay on the highway for through vehicles as a result of the elimination of marginal stream friction. Some tradeoffs are realized by increasing the frequency of conflicts and delay by indirect routing for some maneuvers.

Warrants

Frontage roads are warranted in the planning stage for primary divided arterials with speeds of 4-55 mph and an anticipated high level of development (greater than 60 driveways/a mile). Usually traffic volumes exceeding 20,000 vpd are associated with this type of development.

Design

Key factors which should be considered are discussed in Chapter VII.

D-11: CONSTRUCT A BYPASS ROAD

The continued growth of commercial strips along major arterials has magnified the problem of access control. Many highway agencies have been unable to alleviate congestion occurring in the vicinity of such commercial developments. Attempts to relieve the congestion have ultimately led to building a bypass route--a technique currently utilized by most state highway agencies.

Bypasses provide motorists with the opportunity to avoid heavily developed or congested areas without conflicting with local traffic. As a result, this technique reduces the frequency and severity of conflicts on both facilities by separating longer-distance and faster-moving through traffic (including trucks) from slower local traffic.

Warrants

Bypasses are warranted when the arterial for which it substitutes has a traffic volume greater than 20,000 vpd, a level of development greater than 60 driveways per mile, and when no other access control technique can solve the problem. Excessive accident rates may also warrant a bypass.

Design

Design and construction of a bypass route is subjected to the same standards applicable to major highways. Appropriate design standards based on intended use should be followed. Established documents such as "A Policy on Geometric Design for Rural Highways," "A Policy on Design of Urban Highways and Arterial Streets" and "Design Standards for the Interstate System," "Geometric Design Standards for Highways Other Than Freeways," and "Geometric Design Guide for Local Roads and Streets" should be consulted.

D-12: REROUTE THROUGH TRAFFIC

In this technique, the separation of through traffic from local traffic is achieved by using other adjacent facilities to reroute through traffic. The technique helps to reduce congestion and the frequency and severity of conflicts by separating and rerouting higher-speed through vehicles to where they have less potential of conflict with slower-speed local traffic.

Warrants

Rerouting through traffic is warranted when the number of access points on arterials exceeds 80 driveways per mile, and ADT is over 20,000 vpd. Also, this technique is warranted when other on-site techniques are infeasible. Frequent accidents associated with driveway maneuvers could also constitute a warrant for application of this technique.

D-13: INSTALL SUPPLEMENTARY ONE-WAY RIGHT-TURN DRIVEWAYS TO DIVIDED HIGHWAY

This driveway location technique is aimed at removing turning vehicles and queues from sections of the through lanes. Strategies for achieving this objective involve installing supplementary one-way right-turn driveways to an existing T-driveway on divided highways. The supplementary driveways can be installed to serve both egress or ingress vehicles.

This technique is intended at high-volume driveways to eliminate conflicts on the driveway and secondary rear-end conflicts on the highway associated with right-turn maneuvers. Where the T-driveway has only one lane, each for ingress and egress, this technique will add substantially to the total driveway capacity.

Warrants

This technique is warranted at high-volume driveways on multilane highways that have volumes and speeds greater than 10,000 vpd and 30 mph. A minimum 300-foot frontage width is desirable.

Design

This control measure is particularly applicable at large commercial or industrial complexes such as regional shopping centers and industrial parks. Sufficient frontage area is required to construct safe, adequate driveways, which do not present undue interference with through-moving vehicles. Figure D.13.1 presents a typical layout recommended for this technique.

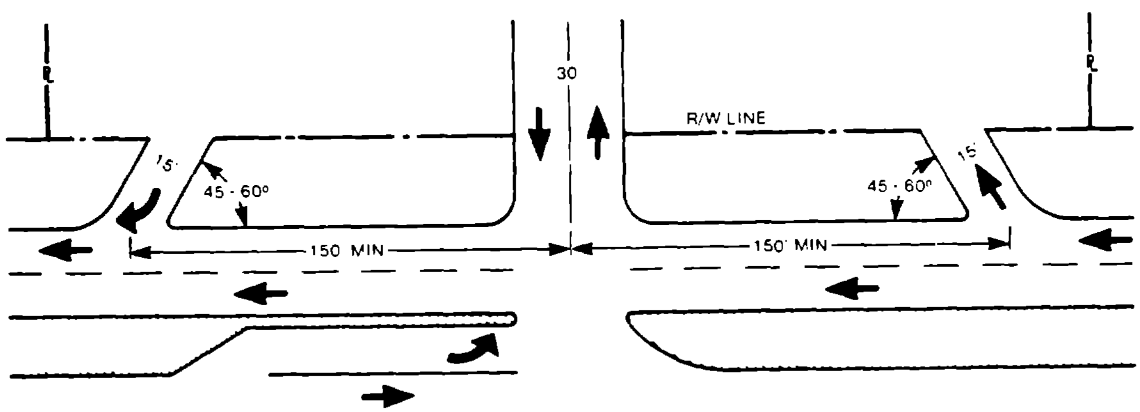


FIGURE D.13.1. SUPPLEMENTARY ONE-WAY RIGHT-TURN DRIVEWAYS

D-14: INSTALL SUPPLEMENTARY ACCESS ON COLLECTOR STREET WHEN AVAILABLE

This driveway location technique is aimed at removing turning vehicles or queues from sections of the through lanes. The strategy for achieving this objective is to provide supplementary access to a single property at a collector street location. The technique provides an additional access point for vehicles to use when entering or exiting a property.

The average volume of all driveways to a property will decrease after the supplementary driveway absorbs some of the total volume. Conflict frequency will be reduced on the highway, and total conflict severity should be reduced by moving some of the conflicts to the lower speed collector. Delay to arterial and driveway vehicles will be reduced because the individual driveway volumes are smaller.

Warrants

This technique is warranted on all types of unlimited access highways. Levels of development greater than 45 driveways per mile will especially warrant consideration. The availability of a suitable collector street is essential to this technique. The individual existing driveways need not be utilized to a high percentage of their capacities.

D-15: INSTALL ADDITIONAL DRIVEWAY WHEN TOTAL DRIVEWAY DEMAND EXCEEDS CAPACITY

This is a technique aimed at removing turning queues or vehicles from sections of the through lanes. The technique provides supplementary access to single properties when the demand for access exceeds existing driveway capacity.

The additional driveway will reduce the delay occurring to through and driveway vehicles by allowing an additional access point for vehicular use. Speeds on the highway may be increased because the length of queues waiting to enter a driveway will be reduced. The technique will also allow driveway turning maneuvers to be made with less delay.

Although additional conflict points are introduced by the driveway additions, the frequency of rear-end conflicts may decrease, under certain conditions of driveway use, because the length of turning highway queues is reduced.

Warrants

This technique is applicable on all highway types. The demand for an access must be such that delays and conflicts are frequent. Driveways with volumes greater than 5,000 vpd located on highways with traffic volumes and speeds greater than 10,000 vpd and 35 mph, respectively, are prime candidates.

D-16: INSTALL RIGHT-TURN DECELERATION LANE

This driveway design technique is aimed at removing turning vehicles or queues from sections of the through lanes. The deceleration lane will reduce the severity of rear-end conflicts on the highway by allowing right-turn vehicles to leave the through lanes at a high speed.

Warrants

This technique is applicable on all highway types. Highway ADT's should exceed 10,000 vpd, and highway speeds should be at least 35 mph. Driveway volume should exceed 1,000 vpd with at least 40 right-turn ingress movements during peak periods. This technique should not be applied on frontages less than 150 feet in width, or where the deceleration lane will restrict access to upstream properties. High accident rates involving right-turn ingress vehicles will also warrant this technique.

Design

Design guidelines are provided in Chapter VII.

This technique involves construction of an additional driveway exit lane to better facilitate egress maneuvers. Right-turn and left-turn egress maneuvers are made more efficiently because drivers are not delayed by egress vehicles wanting to turn in the opposite direction. The egress capacity of the driveway is also significantly increased.

Total driveway delay should decrease significantly because of the increased capacity due to the separation of egress-turning maneuvers. However, if insufficient approach length is available, a reduction in the capacity potential may result because of internal conflicts associated with considerable weaving at the exit.

Warrants

This technique is applicable for all highway types and at driveway locations where egress maneuvers are hindered because separate turning lanes are not provided. Highway speeds should normally exceed 30 mph with highway volumes surpassing 5,000 vpd. Existing driveway volumes should exceed 1,000 vpd (approximately 500 egress vehicles).

Design

In the design of the technique, consideration must be given to driveway width, traffic volumes, internal circulation and highway operation. The additional lane should be sufficiently wide to safely accommodate turning vehicles and long enough to provide adequate storage with minimal impact to internal circulation. If the additional lane services left-turning vehicles, adequate signalization is necessary to facilitate traffic operation.

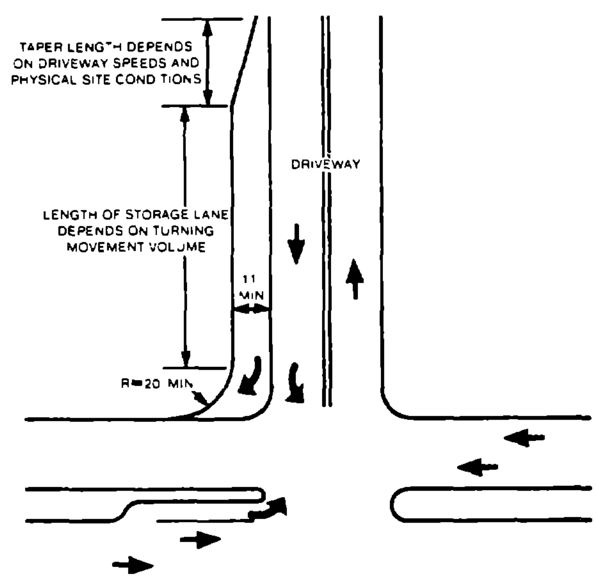


FIGURE D.17.1. INSTALLATION OF ADDITIONAL EXIT LANE ON DRIVEWAY

D-18: ENCOURAGE CONNECTIONS BETWEEN ADJACENT PROPERTIES

This driveway operation technique is aimed at removing turning vehicles or queues from the through lanes. The strategy for achieving this objective is to encourage adjacent property owners to permit property-to-property movements away from the highway.

A prime example of this access control measure is the neighborhood shopping center, where several adjacent properties are served by one open parking lot area. The patrons frequenting nearby establishments do not need to exit onto the highway and then enter the neighboring driveway.

Highway conflicts will be reduced because the highway will no longer be used in traversing from one property to the next.

Warrants

This technique is warranted on all highway types. Of particular interest are adjacent properties with small frontage widths. All highway ADT volumes and highway speeds from 25 to 45 mph will exist at the candidate locations. Driveway volumes should exceed 500 vpd.

Design

This technique is intended to serve adjacent properties through use of common access points. Thought must be given to internal circulation and storage space for driveway vehicles as well as geometric layout and existing highway operation.

D-19: REQUIRE TWO-WAY DRIVEWAY OPERATION WHERE INTERNAL CIRCULATION IS NOT AVAILABLE

This driveway design and operations technique is aimed at removing recirculating driveway vehicles or queues from the through lanes. The strategy for implementing this technique is to require two-way driveway operations in lieu of one-way operations at locations where internal circulation is not available. This technique is intended to be implemented in the permit stage; however, it may be implemented at existing locations to alleviate specific problems.

The number of conflict points will be minimized by implementing this technique because recirculating vehicles will not use the highway; however, total conflicts will not necessarily be reduced. Increased congestion and delay may result internally or at the driveway entrance.

Warrants

The technique is warranted on all highway types. The internal circulation of the parking area must be shown to be inadequate for one-way operation. Particular attention should be paid to properties whose frontage widths are less than 100-feet. Driveway volumes should be less than 250 vpd. This technique is not recommended on higher volume driveways.

Design

Application of this technique requires that adequate driveway design practices be utilized to achieve maximum use of limited space. Discussions contained in Chapter VII should be consulted for specific considerations pertaining to approach width, signalization, auxiliary lanes, driveway width, and internal circulation.

D-20: REQUIRE ADEQUATE INTERNAL DESIGN AND CIRCULATION PLAN

This is a general access control policy that may be utilized on existing facilities or in the driveway permit stage. An adequate internal design and circulation plan is intended to ensure harmony between highway, driveway, and internal operations. Driveway and internal operations will be improved by providing adequate internal property design and controls. Through traffic will experience a decrease in interference because the internal design will minimize queuing on the highway and vehicles searching for parking places are able to recirculate internally. Conflict frequency and severity are expected to decrease because deceleration requirements are lessened.

Warrants

This technique is applicable to all types of highways. Implementation is feasible on existing facilities but primary consideration should be given this policy during site plan approval. Highway speeds should equal at least 25 mph and highway volumes should exceed 5,000 vpd. For small commercial establishments, driveway volume should exceed 100 vpd. Peak-hour driveway volume for large commercial establishments, such as shopping centers, should number at least 150 vehicles.

Design

Application of this technique is dependent upon a number of factors including available space, traffic volumes, highway operation, internal circulation requirements, geometry, and site location. Several techniques should be consulted for discussions pertaining to the operational efficiency of the driveway and which address minimizing conflicts with through-moving vehicles.

Internal circulation designs should provide adequate handling of limited parking and maneuvering areas; minimize internal interference by supplying storage areas to egressing movements; and distribute ingressing vehicles into the main circulation pattern with minimal hesitation and confusion. The following list reflects recommendations by which this technique can be properly applied.

1. General location of driveway entrances should be approved by code authorities before the major effort toward maximum capacity planning begins.

2. Rectangular-shaped parking areas are the most efficient.

3. Wherever possible, the long sides of parking areas should be parallel.

4. Curved, triangular, and other irregularly shaped parking areas should be avoided.

5. Traffic aisles should be aligned parallel to the long dimension of the parking areas where feasible.

6. Irregularly shaped areas should be designed with the traffic aisles parallel to the longest side.

7. Traffic aisles should serve two rows for stalls; that is, they should be double-loaded.

8. The perimeter of the parking area should be lined with parking stalls to the maximum extent.

9. Parking areas serving combined parking-use functions, such as combined customer and employee parking, should be designed to provide distinctly separate areas and traffic control for each use function.

10. Traffic flow and control should be analyzed carefully for optimum efficiency.

11. Landscaping and lighting should be designed after the optimum maximum capacity design has been achieved. If the maximum capacity design is altered to suit other criteria (such as an owner's request for greater stall width, changes in direction of traffic aisles, etc.), lighting fixtures should be located so the parking area may be converted to the maximum capacity design without requiring relocation of the lighting standards. Where feasible, landscaping should be planned in the same manner, especially where irrigation and sprinkler systems with underground water piping are included.

LIST OF REFERENCES (APPENDIX A)

1. A Policy on Design of Urban Highways and Arterial Streets - 1973, American Association of State Highway Officials.

2. "Manual on Uniform Traffic Control Devices for Streets and Highways," U.S. Department of Transportation, Federal Highway Administration, 1971.

3. Glennon, J.C., Technical Guidelines for the Control of Direct Access to Arterial Highways, FHWA-RD-76-87, 1975.

APPENDIX B. THE STATE HIGHWAY ACCESS CODE

THE
STATE HIGHWAY ACCESS CODE

ADOPTED BY THE COLORADO STATE HIGHWAY COMMISSION
JULY 16, 1981

EFFECTIVE ON AUGUST 31, 1981

State of Colorado
State Department of Highways
4201 East Arkansas Avenue
Denver, Colorado 80222

TABLE OF CONTENTS

STATEMENT OF BASIS AND PURPOSE REGARDING THE RULE AND REGULATION KNOWN AS THE STATE HIGHWAY ACCESS CODE BY THE COLORADO HIGHWAY COMMISSION

This code is based upon the authority granted in C.R.S. 1973, 43-2-147, as amended (hereafter "the act"). The act sets forth certain requirements before this code could be adopted as a rule and regulation. All these requirements have been met.

After the act was passed in 1979, a task force was established to draft the code. The task force consisted of members from a variety of disciplines, including engineers,.Department of Highway personnel, representatives of the Colorado Municipal League and Colorado Counties Incorporated, representatives of counties, an attorney, and other people involved on a day-to-day basis with access approaches. Every municipality and county was provided with a draft proposed code and invited to provide comments and to attend a public meeting to discuss the draft. These meetings were held to comply with subsection 43-2-147-(2) of the act.

On November 15, 1979 the code was submitted to the legislative council as required by subsection 43-2-147(2) of the act. The council, in turn, submitted the code to the legislative committees of reference of the second regular session of the 52nd General Assembly.

At a joint meeting of the House and Senate Transportation Committees held on March 13, 1980 the code was rejected and referred to the Interim Committee on Transportation for re-working during the summer. Pursuant to specific directions from the joint committees the Department of Highways held a series of public meetings throughout the state to collect public comments to assist in the summer legislative review. Prior to the meetings every unit of local government was provided the latest draft of the code and invited to make comments and attend one of several meetings held around the state.

After a series of hearings before the interim committee, in which amendments were made to the code, the code was resubmitted on January 7, 1981, to the committeess of reference in the 1st regular session of the 53rd General Assembly. The committees decided to take no further action on the code, thus clearing the way for the Colorado Highway Commission to adopt the code as a rule and regulation.

The purpose of this rule and regulation (hereafter "rule") is to implement the act by providing specified uniform procedures and standards to guide the public, local governments, and the Department of Highways in the administration of permitting access approaches.

The major purpose of the procedural section of the rule is to ensure there is an orderly and uniform method for the administration of access permits. The purpose of the classification and design specification sections is to aid the department in determining if an access permit should be granted and to ensure the public°s health, safety, and welfare is protected, smooth traffic flow is maintained, highway right-of-way drainage is maintained, the functional level of the highways is maintained, and the property owner°s right of access to the general street system is protected.

The rule establishes design standards and criteria to be followed in applying for, granting or denying, building, using and maintaining access approaches, and sets forth the procedures to follow and standards to apply in reconstructing and relocating existing access approaches and in requesting a court to enjoin violations of the access code.The rule also defines the functional classifications into which all state highways shall be placed, and sets forth the procedure for the Highway Commission to follow in determining the functional classifications of state highways.

The design standards set forth in the rule are based upon national and state standards intended to ensure the safety of the motorist and pedestrian. The standards and specifications in the code are based in part upon the references in section 1.5 of the code and in part upon the engineering expertise and judgment of the engineers involved in drafting the code. The design standards and specifications are not intended to be inflexible, but rather are to be used as general guidelines that will apply in most situations. The national and state design standards are considered to represent the "state of the art" in highway engineering. They are reference sources known and accepted in the highway design profession.

In brief, the rule implements the act and provides a reference for the public and the personnel of the State Department of Highways in applying for and administering, respectively, permits for access to state highways.

-iii-

SECTION ONE
INTRODUCTION

1.1 Authority:

These standards are promulgated pursuant to CRS 1973, as amended, 43-2-147. The State Department of Highways and local governments are authorized by the Statute to regulate vehicular access to or from any public highway under their respective jurisdiction from or to property adjoining a public highway. The State Highway Commission is directed to adopt a state highway access code for the implementation of the Statute on all state highways. The Commission shall determine the functional classification of all state highways.

1.2 Purpose:

It is the purpose of this code to provide the procedures and standards necessary to protect the public health, safety and welfare, to maintain smooth traffic flow, to maintain highway right-of-way drainage, and to protect the functional level of public highways while meeting state, regional, local, and private transportation needs and interests.

The lack of adequate access manangement on the highway system and the proliferation of driveway and other access approaches is a major contributor to highway accidents and the greatest single factor behind the functional deterioration of highways in the State. As new access approaches are constructed and traffic signals erected, the speed and capacity of the highway decrease, and congestion and hazards to the traveling motorist increase. As a result, significant amounts of tax dollars must be spent to widen highways, provide additional operation and safety measures and construct new highways. The economic and social costs of widening major highways are becoming almost prohibitive.

This code is based upon the authority granted in the Act and considers existing and projected traffic volumes, the functional classification of public highways, adopted local transportation plans and needs, drainage requirements, the character of lands adjoining the highway, adopted local land use plans and zoning, the type and volume of traffic to use the driveway, other operational aspects of the driveway, the availability of vehicular access from local streets and local roads rather than a state highway, reasonable access by local streets and local roads, and the public health, welfare, and safety.

Section one discusses the authority, purposes and structure of the code, and defines those words that are technical or variable in their meanings and require definition for the purposes of this code. Section two provides the administrative procedures for implementation of this code which shall be followed with due regard for the rights and privileges of all interested parties. Section three defines five categories of standards to ensure smooth traffic flow and to maintain the functional level of the public highways. Section three shall be used to determine if an access approach should be allowed within the context of the highway's function in the transportation system and the assigned access category. Section four provides standards for the design and construction of all access approaches. These standards are based upon criteria and specifications that are necessary to ensure the public health, welfare, and safety.

1.3 Implementation:

After the effective date of the access code, no person shall construct any driveway providing vehicular access to or from any state highway from or to property adjoining a state highway without an access permit issued by the appropriate local authority or designated issuing authority, with the written approval of the State Department of Highways.

Access permits shall be issued only in compliance with the code and may include terms and conditions authorized by the access code. In no event shall an access approach be allowed or permitted, that is detrimental to the public health, welfare, and safety.

Vehicular access to or from property adjoining a state highway shall be provided to the general street system, unless such access has been acquired by a public authority. Police, fire, ambulance, and other emergency stations shall have a right of direct access to state highways. After the effective date of the Act, no person may submit an application for subdivision approval to a local authority unless the subdivision plan or plat provides that all lots and parcels created by the subdivision will have access to the state highway system in conformance with this code. The provisions of this code shall not be deemed to deny reasonable access to the general street system.

1.4 <u>Definitions:</u>

1. "Acceleration lane" means a speed-change lane, including tapered areas, for the purpose of enabling a vehicle entering a roadway to increase its speed to a rate at which it can more safely merge with through traffic.

2. "Access approach" means any driveway or other point of access such as a street, road or highway that connects to the state highway.

3. "Access category" means the degree to which access approaches are controlled according to the five categories described in section three.

4. "Access control plan" means a roadway design plan which designates preferred access locations and their designs for the purpose of bringing those portions of roadway included in the access control plan into conformance with their access category to the extent feasible. Also called an access management plan.

5. "Act" means CRS 1973, 43-2-147, as amended.

6. "ADT" means the average two-way daily traffic in number of vehicles for the specified year.

7. "Applicant" means owner of property or representative of owner applying for an access permit.

8. "Appropriate local authority" means the board of county commissioners if the driveway is to be located in the unincorporated area of a county and the governing body of the municipality if the driveway is to be located within an incorporated municipality.

9. "Bandwidth" means the time in seconds or the percent of cycle between a pair of parallel speed lines which delineate a progressive movement on a time-space diagram. It is a quantitative measurement of the through traffic capacity of a signal progression system. A 10% bandwidth has very little traffic capacity, while a 40% bandwidth has good traffic capacity.

10. "Code" means for the purposes of this code the STATE HIGHWAY ACCESS CODE.

11. "Control of access" means the condition in which the right of owners or occupants of land abutting to a roadway, is controlled by public authority.

12. "Controlled-access highway" means every highway, street, or roadway in respect to which owners or occupants of abutting lands and other persons have no legal right of access to or from the same except at such points only and in such manner as may be determined by the public authority having jurisdiction over such highway, street, or roadway. [CRS 1973, 42-1-102(13)]

13. "Deceleration lane" means a speed-change lane, including tapered areas, for the purpose of enabling a vehicle that is to make an exit turn from a roadway to slow to a safe turning speed after it has left the mainstream of faster-moving traffic.

14. "Department" means for the purposes of this code the State Department of Highways.

15. "Design Hour Volume" also "DHV" means a traffic vehicle volume determined for use in the geometric design of highways. For the purposes of this code, the DHV shall be the 30th highest hourly volume occuring daily in the 20th year unless otherwise specified.

16. "Divided highway" means a highway with separated roadways for traffic in opposite directions, such separation being indicated by depressed dividing strips, raised curbings, traffic islands, or other physical separations or indicated by standard pavement markings or other traffic control devices.

17. "Driveway" means an access approach from private property or from public property that is not a public street, road or highway.

18. "Functional classification" means a classification system that defines a public roadway according to its purposes in the local or statewide highway plans.

19. "General street system" means the interconnecting network of city streets, county roads, and state highways in an area.

20. "Grade separation" means a crossing of two roadways, or a roadway and a railroad, at different levels.

21. "Gradient" means the rate of regular or graded ascent or decent.

22. "Highway" means the entire width between the boundary lines of every way publicly maintained when any part thereof is open to the use of the public for purposes of vehicular travel or the entire width of every way declared to be a public highway by any law of this state. [CRS 1973, 41-1-102(33)]

23. "Interchange" means a grade separation where the crossing roadways are interconnected by directional ramps providing for connecting movements between the roadways.

24. "Issuing authority" means the government entity which issues access approach permits and includes the board of county commissioners, the governing body of a municipality, and the State Department of Highways.

25. "Lane" means the portion of a roadway for the movement of a single line of vehicles and does not include the gutter of the roadway or shoulder.

26. "Local road" means a county road, as provided in CRS 1973, 43-2-108 and 43-2-109.

27. "Local street" means a municipal street, as provided in CRS, 1973, 43-2-123 and 43-2-124.

28. "Median" means that portion of a highway separating the opposing traffic flows.

29. "Other points of access" means public local streets, roads and highways that are not driveways.

30. "Peak hour volume" means for the purposes of this code the same as design hour volume (DHV).

31. "Permit issue date" means the date of issue of the approved access permit as recorded on the permit form.

32. "Potential for signalization" means an access approach that has the potential within the life of the permit, to have an 8th highest hourly volume projected to occur on an average day that exceeds 50 vehicles.

33. "Roadway" means that portion of a highway improved, designed or ordinarily used for vehicular travel exclusive of the berm or shoulder. In the event a highway includes two or more separate roadway "roadway" refers to any such roadway separately but not to all such roadways collectively.

34. "State highway" means a highway on the state highway system as defined in CRS 1973, 43-2-101.

35. "Sight distance" means the distance visible to the driver of a passenger vehicle measured along the normal travel path of a roadway to the roadway surface or to a specified height above the roadway when the view is unobstructed by traffic.

36. "Signal" or "signalization" means a traffic control signal or device.

37. "Signal progression" means the progressive movement of traffic at a planned rate of speed without stopping through adjacent signalized locations within a control system.

38. "Speed change lane" means a separate lane for the purpose of enabling a vehicle entering or leaving a roadway to increase or decrease its speed to a rate at which it can more safely merge or diverge with through traffic. Acceleration and deceleration lanes are speed change lanes.

39. "Stopping sight distance" means the distance required by a driver of a vehicle, traveling at a given speed, to bring his vehicle to a stop after an object on the roadway becomes visible. It includes the distance traveled during the perception and reaction times and the vehicle braking distance.

40. "Storage lane" means additional lane footage added to a deceleration lane to store the maximum number of vehicles likely to accumulate during a critical period without interfering with the thru travel lanes.

41. "Time-space diagram" means a chart on which the distance between signals and signal timing is plotted against time. The chart, when completed, indicates signal progression, bandwidth and speed of traffic.

42. "Vph" means vehicles per hour and shall be counted or estimated at the highest hourly volume for all references to vph in this code unless otherwise specified. A vehicle entering or exiting an access approach will be considered a count.

43. "Working day" means any day that the permittee can prosecute a normal day of work exclusive of delays as a result of inclement weather, labor disputes and material shortages.

1.5 References:

The standards and specifications contained in parts three and four of this code are based upon good engineering judgement and the following engineering references used by the State Department of Highways.

1. A Policy on Design of Urban Highways and Arterial Streets, American Association of State Highway and Transportation Officials, Washington, D.C., 1973.

2. Transportation and Traffic Engineering Handbook, Institute of Traffic Engineers, Washington, D.C., 1976.

3. Manual on Uniform Traffic Control Devices for Streets and Highways, (M.U.T.C.D.) U.S. Department of Transportation and the Federal Highway Administration, Washington, D.C., 1978.

4. The Colorado Supplement to the Manual on Uniform Traffic Control Devices for Streets and Highways, State Department of Highways, as amended.

5. The following manuals and standards of the State Department of Highways:

   a. Roadway Design Manual, 1980 as amended

   b. Materials Manual, 1981, as amended

   c. Construction Manual, 1981, as amended

   d. Standard Specifications for Road and Bridge Construction, 1981

   e. M & S Standard Plans, 1980

6. Evaluation of Techniques for the Control of Direct Access to Arterial Highways, Report No. FHWA-RD-76-85, Federal Highway Administration, Washington, D.C., 1975.

7. Trip Generation, second edition, Institute of Transportation Engineers, 1979.

SECTION TWO
ADMINISTRATION

2.1 The following procedures are supplied to conform with the administrative requirements of the Act.

2.2 Access Categorization of State Highways

1. The State Highway Commission shall assign to each state highway section or segment of highway an access category from section three of this code based upon the present National Highway Function Classification, consideration of existing and projected traffic volumes, the functional classification of public highways, adopted local transportation plans and needs, the character of lands adjoining the highway, adopted local land use plans and zoning, the availability of vehicular access from local streets and roads rather than a state highway and reasonable access by city streets and county roads.

2. The process to determine the assigned access category shall be as follows: (1) the Department shall prepare a draft category assignment schedule and a illustrative map consistent with section 2.2.1, for each state highway section or segment within each county, (2) the appropriate parts of the draft documents shall be sent to the appropriate local governments and the metropolitan planning organizations for their review and comment, (3) at the request of the appropriate local authority, public meetings shall be scheduled by the Department to consider proposed revisions, (4) based upon the results of the meeting, attempts shall be made to resolve any differences, (5) if any disagreements remain unresolved, a statewide advisory committee shall be set up by the Department as an impartial review board to resolve the remaining disagreements between the Department and the reviewers, (6) the completed draft shall be presented to the Highway Commission in public hearing for final action, (7) the approved category assignment schedule shall be made available to the public, all permit issuing authorities and local governments.

3. Local government or the Department may submit to the State Highway Commission requests for changes in the adopted access categories for sections of State Highway within their jurisdiction. All requests shall include an explanation for the requested change consistent with the purposes of the Act and the standards of this code. The Department shall review and provide a recommendation to the Commission on each request. The local government or jurisdiction shall be notified of requested changes by the Department at least 60 days prior to Highway Commission action. Local government will be provided with a copy of all pertinent documents 30 days prior to commission action. A meeting between the local government and the Department shall be held if the local government so requests. The Highway Commission shall act upon pending category change requests no less than once each six calendar months, and more often as necessary. All reasonable local government requests that are in compliance with the purposes of this code and the procedures outlined in Section 2.2.1, of the code, shall receive a favorable recommendation from the Department.

2.3 Obtaining A Permit

1. The Act provides local government the authority to issue access permits to state highways within their jurisdiction with the written approval of the Department. The local government may request the Department administer or assist in the administration of driveway permits.

2. Persons wishing to apply for access to a State Highway should contact their local government or the Department of Highway's District Maintenance Superintendent in their region to determine who is responsible for processing permit applications. Requests must be submitted on standard access permit application forms obtainable from the issuing authority.

3. Upon written request to the Department by the appropriate local authority, the Department shall administer or assist in the administration of driveway permits to the state highway system in that jurisdiction. The request shall specify the extent to which the Department will administer the permit process. This authorization may be changed by the appropriate local authority at any time by written request to the Department. Changes in authorization shall take effect upon receipt of the written request by the Department. If the appropriate local authority requests the Department to process the access permit application but requires local approval prior to final action, this will constitute Department assistance, not administration.

2.4 Application for an Access Permit to the State Highway When the Appropriate Local Authority is the Issuing Authority

1. The applicant shall submit his access approach request on authorized Department forms to the appropriate local authority. The local authority shall date and initial the original and carbon copy. The carbon copy acts as notice to the Department of the beginning of the maximum 45 days review period for the issuing authority. The carbon copy shall be mailed or delivered to the local office of the Department within ten days of application. After 45 days, if the Department has not received notice from the issuing authority of their final action on the permit application, the Department shall contact the issuing authority and take final action on the application within 20 days as required by the Act.

2. Upon receipt of a completed permit application and required attachments on authorized Department forms, the issuing authority shall use this code, and the Act and any other applicable State statutes for evaluating the application and preparing an access permit. The issuing authority should work cooperatively with the applicant and attempt to resolve all conflicts with the code prior to taking final action on the permit. It is recommended that the issuing authority consult with the Department to help avoid any differences that might arise during Department review. The issuing authority shall complete its review and take final action to approve or deny within 45 days.

3. Requests for variance from the standards of this code may be submitted to the issuing authority by the applicant and shall be considered an attachment to the permit application. The request for the variance shall include specific and documented reasons for the request. Review of the variance request shall be consistent with section 2.9 of this code.

4. The completed permit shall conform to all sections of this code. Variance procedures, section 2.9, may be used where the design standards of this code are not entirely applicable given proposed access approach site specific conditions and local considerations. If the appropriate local authority does not approve the permit application, it shall 1) return the permit application marked denied along with any attachments and a written explanation of the decision to the applicant, and 2) provide the Department with a copy of the denied application and the written explanation. The Department shall not reverse the denial decision by the local authority. Any appeal by the applicant of local action shall be to the local authority and be consistent with the standard appeal procedures of the local government. The Department shall be notified of appeals made based upon local denials.

5. If the issuing authority completes and approves the permit, the issuing authority shall sign the permit and transmit the permit with all attachments to the appropriate district engineer of the Department. Within 20 days from receipt of the transmitted materials, the Department must act upon the permit or such permit shall be deemed approved. Transmittal of the permit application, unsigned by the appropriate local authority, for the purpose of obtaining the Department's comments prior to local approval, does not constitute the initiation of the 20 day review period.

6. If the permit is approved by the appropriate local authority the Department shall review the permit for compliance with this code, and the Act and other state statutes which may be applicable. If necessary, the Department shall discuss the permit application with the applicant and the local issuing authority. Before denying a permit, the Department shall request a meeting between the local government, the applicant, and the Department, and attempt to resolve differences.

   If the Department denies the application, the Department shall return the application and attachments marked 'denied' to the applicant along with a written explanation for the decision, and shall provide the local authority with a copy of the denied permit and the written explanation.

7. If the Department approves the permit, the permit shall be signed by a duly authorized representative of the Department and transmitted to the applicant. The applicant shall sign the permit if he accepts the terms and conditions and return the entire permit with the require permit fee to the Department in the attached envelope. When the Department has not received the signed copy and fee from the applicant within 60 days, the permit shall be deemed unacceptable to the applicant and therefore denied. After receiving the signed permit and fee the Department shall mark the permit paid, assign a permit number to the permit and return an original copy to the applicant. The Department shall transmit a copy of the completed permit and the collected fee to the local government. If the applicant does not agree to all the terms and conditions of the permit the permit shall be deemed denied.

8. The permitted access approach shall be completed in accordance with the terms and conditions of the permit prior to being used. In accepting the permit the applicant agrees to all terms and conditions of the permit. Should the applicant choose to contest a denied application, or the terms and conditions of a permit, he must do so within 60 days of receipt of the notice of denial or receipt of the permit transmitted for his signature.

2.5 <u>Application for an Access Permit to the State Highway when the State Department of Highways is the Issuing Authority</u>

1. The applicant shall submit his completed application and required attachments to the appropriate district engineer of the Department on authorized Department forms. The Department shall use this code, and the Act and any other applicable state statutes for evaluating the application and preparing an access permit. The Department should work cooperatively with the applicant and attempt to resolve all conflicts with this code prior to taking final action on the application. If the Department fails to act within 45 days upon a requested access permit, such permit shall be deemed approved. Transmittal of an approved permit for the applicants signature, section 2.5.5, or transmittal of the denied application, section 2.5.4, constitutes action as required by the Act.

2. Requests for variance from the standards of this code may be submitted to the District Engineer by the applicant and shall be considered an attachment to the permit application. The request for the variance shall include specific and documented reasons for the request. Review of the variance request shall be consistent with section 2.9 of this code.

3. The completed permit shall conform to all sections of this code. Variance procedures, section 2.9, may be used where the design standards of this code are not entirely applicable given proposed access approach site specific conditions and local considerations. Before denying a permit, the Department shall request a meeting between the applicant, local government and the Department and attempt to resolve differences.

4. If the Department denies an application, the Department shall return the application and attachments marked 'denied' to the applicant along with a written explanation for the decision.

5. If the Department approves an application, a permit shall be prepared and signed by the duly authorized representative of the Department and transmitted to the applicant. The applicant shall sign the permit if he accepts the terms and conditions and return the entire permit with the required permit fee to the Department in the attached envelope. When the Department has not received the signed copy and fee from the applicant within 60 days, the permit shall be deemed unacceptable to the applicant and therefore denied. After receiving the signed permit the Department shall mark the permit paid, assign a permit number to the permit and return an original copy to the applicant. The Department shall transmit a copy to the appropriate local authority if so requested. If the applicant does not agree to all the terms and conditions of the permit, the permit shall be deemed denied.

6. The permitted access approach shall be completed in accordance with the terms and conditions of the permit prior to being used. In accepting the permit the applicant agrees to all terms and conditions of the permit. Should the applicant choose to contest a denied application, or the terms and conditions of a permit, he must do so within 60 days of receipt of the notice of denial or receipt of the permit transmitted for his signature.

2.6 Access Approaches that are not Driveways

Requests for access approaches to the state highway which are not driveways, such as public locals road and local streets, shall be administered by the Department as discussed under 2.5. The local government shall be considered the applicant. The Department shall work cooperatively with local government realizing that the access will serve many property owners. Access approaches to subdivisions and other developments shall be considered driveways until they become dedicated local public roads or streets.

2.7 Further Action on Approved or Denied Permit Applications

1. Any party who has received an adverse decision by the Department may request and shall receive a hearing before the State Highway Commission or before a hearing officer, at the discretion of the Commission. If a hearing is held before a hearing officer, and thereafter either party is dissatisfied with the result, appeal must be made to the State Highway Commission in conformance with the provisions of the "State Administrative Procedure Act". The State Highway Commission may affirm, reverse, or modify the decision of the Department or hearing officer. The Commission decision is final and subject to judicial review pursuant to the provisions of CRS 1973, 24-4-101, et seq, as amended, known as "The State Administrative Procedure Act."

   Should the applicant (1) choose to contest a permit application denied by the Department or (2) choose to contest any of the terms or conditions of the permit, he must do so within 60 days of receipt of notice of denial or receipt of the approved permit. The applicant shall make his request for the hearing in writing and submit it to the local engineering district office of the Department. The request shall include reasons the applicant is appealing the action and may include recommendations by the applicant that would be acceptable to him. It is recommended the applicant pursue a request for a variance if he has not done so already, prior to requesting a Highway Commission hearing.

2. The permit shall be deemed denied if the access approach is not under construction within one year of the permit issue date. A time extension, not to exceed one year for each extension, may be requested of the issuing authority in writing by the applicant prior to expiration of the permit. Denial of an extension may occur only when the issuing authority assertains and documents that unforeseen and significant changes in highway traffic operations or proposed access approach operation, have or will occur that were not accounted for in the issuing of the permit. The issuing authority shall notify the Department of all the approved or denied extensions within ten days.

3. The permitted access approach shall be completed in accordance with the terms and conditions of the permit prior to being used. In accepting the permit, the applicant agrees to all terms and conditions of the permit. If the applicant does not agree to all the terms and conditions of the permit, the permit shall be deemed denied.

4. The expected dates of construction and use of the access approach shall be included on the application form. The applicant shall notify the individual or the office specified on his permit of the pending construction at least 48 hours prior to construction in State Highway rights-of-way. The access approach shall be completed in an expeditious and safe manner and shall be finished within 45 days from initiation of construction within the right-of-way. A construction time extension not to exceed 30 working days may be requested from the individual or office specified on the permit.

5. The construction of the access approach and its appurtenances as required by the terms and conditions of the permit shall be completed at the expense of the applicant except as provided in section 2.7.9.

6. The issuing authority and or the Department shall inspect the access approach during construction and upon its completion and ensure that all terms and conditions of the permit are met.

7. It is the responsibility of the owner of the property to ensure the use of the access approach to the property is not in violation of this code, permit terms and conditions or the Act. The terms and conditions of the permit are binding upon all assigns, successors-in-interests and heirs.

8. When a permitted driveway is constructed or used in violation of this code, permit terms and conditions, or the Act, either the issuing authority or the Department or both may obtain a court order enjoining violation of the access code, permit terms and conditions, or the Act. Such access permits may be revoked by the issuing authority if, at any time, the permitted driveway and its use fail to meet the requirements of the Act, the access code, or the terms and conditions of the permit.

9. Reconstruction, relocation, or conformance with this code of any driveway, whether constructed before, on or after June 30, 1979, may be required by the Department with written concurrence of the appropriate local authority either at the property owner's expense if the reconstruction or relocation is necessitated by a change in the use of the property or a change in the type of driveway operation or at the expense of the Department if the reconstruction or relocation is necessitated by changes in road or traffic conditions. The necessity for the relocation or reconstruction shall be determined by reference to the standards set forth in this code.

2.8 Illegal Access Approaches

The Department may install barriers across or remove any driveway providing direct access to a state highway which is constructed without an access permit after the effective date of the code. The property owner shall be sent immediate written notice of the Department's action. Where practicable, the Department will notify the property owner and or illegal access user of pending action.

2.9 Variance Procedures

1. A Request for variance from the standards of this code shall be submitted to the issuing authority with a permit application and shall be considered an attachment to the permit application form. The request for the variance shall include specific and documented reasons for the request.

2. The issuing authority shall consider the variance request along with the permit application. If in the opinion of the issuing authority the variance request is consistent with the requirements of section 2.9, the variance may be accepted. If the remainder of the permit is in order, the permit shall be approved and the accepted variance attached.

3. In the consideration of the variance request, the issuing authority shall determine to the best of its ability if the following circumstances are met: (1) there is exceptional and undue hardship on the applicant, (2) a variance would not be detrimental to the public health, welfare and safety, and (3) a variance is reasonably necessary for the convenience and welfare of the public.

   In the evaluation of the variance criteria two and three, valid consideration shall be given to the land use plans, policies, and local traffic circulation operations of the local jurisdiction.

4. If the variance request cannot be authorized, the issuing authority shall continue to process the permit application to determine if a permit can be approved without a variance.

5. At any time during the review by the issuing authority of the permit application, the applicant may supplement his application with a variance request.

6. When in the opinion of the Department all of the following circumstances are met, then it shall authorize a variance from the standards of this code: (1) there is exceptional and undue hardship on the applicant, (2) a variance would not be detrimental to the public health, welfare, and safety, and (3) a variance is reasonably necessary for the convenience and welfare of the public.

7. The Department shall review all materials sent with the variance and permit requests and may request additional information from the applicant or the issuing authority.

8. The conclusions of the Department regarding the variance shall be in writing with all pertinent information attached and shall be included as part of the permit application record. The Department shall include in its action any special terms and conditions that shall be imposed on the permit if approved.

2.10 Access Control Plans

1. Either the Department or the appropriate local authority may at their discretion develop an access control plan for a designated portion of State highway.

2. An access control plan is to provide the appropriate local authority and the Department with a comprehensive roadway access design plan for a designated portion of State Highway for the purpose of bringing that portion of highway into conformance with its access category to the extent feasible given existing conditions. The access control plan shall indicate existing and future access locations and all roadway access design elements, including traffic signals, that are to be modified and reconstructed, relocated, removed, added, or remain. All traffic signals or modifications shall meet the requirements of the Manual on Uniform Traffic Control Devices as required by state and federal statutes. The plan shall specify the assigned access category of the roadway and to the extent practicable, conform to all standards and specifications in part four of this code. A public meetings shall be held during the development phase of the plan. All property owners abutting the State Highway shall be notified by the Department or the appropriate local authority.

3. The plan must receive both the approval of the Department and the appropriate local authority to become effective. After an access control plan is in effect, modifications to the plan shall receive the approval of the appropriate local authority and the approval of the Department. Where an access control plan is in effect, all action taken in regards to access approaches shall be in conformance with the plan and this code unless both the Department and the appropriate local authority approve a variance under section 2.9 of this code.

2.11 Processing Forms

The Department shall provide at reasonable cost to the issuing authority all necessary forms for the processing of access approach applications, including the permit form, and any other forms necessary to ensure consistent record keeping and legal and administrative action on the part of all those charged, in whole or part, with the administration of this code.

2.12 Conformance of Subdivisions

After June 21, 1979, no person or persons may submit an application for the subdivision of property abutting a state highway to a local authority unless the subdivision plan or plat provides that all lots and parcels created by the subdivision will have access to the state highway system in conformance with this the State Highway Access Code. Direct access from the subdivision to the highway shall be permitted only if the access approach meets the requirements of this code.

2.13 Improvements to a Lawful Access Approach

The property owner or representative serviced by a lawful access approach may make a physical improvements to the access approach with the permission of the issuing authority. The applicant shall make his request on standard permit application forms and specify that his request is for improvements per this subsection. Processing shall be the same as discussed under 2.4 and 2.5 except the Department and appropriate local authority may only take action on the request for improvement. Denial of the application for improvements does not constitute revoking the existing access approach authorization.

SECTION THREE
ACCESS CATEGORY STANDARDS

3.1 This section provides a five step access classification system that ties the control of access and related design elements such as location of access and traffic signals to the functional purpose of each highway. The purpose of classifying the state highway system into different levels of access control is to help ensure the protection of the functional integrity of each highway in the state system according to its purpose. The amount, frequency and location of access approaches and traffic signals have a direct effect on the capacity, speed, and safety of the highway.

The functional characteristics presented in each category describe that category according to its intended use and purpose in the highway plan. Design standards describe the major design elements, that in the opinion of the Department, must be achieved to protect the function of the highway so categorized.

3.2 Each state highway section or segment of highway shall be classified as provided in section 2.2 of this code. The existing design of the highway is not required to meet the design characteristics of the category assigned to the particular section at the time it is assigned to a category. All new access control decisions shall be made according to the assigned category. This provides a mechanism for improving a highway to its functional purpose and integrity. The development of an access control plan is recommended to improve existing conditions and is the most effective way to deal with site specific conditions. Access permits issued after the effective date of this code shall meet the design standards of section three.

Along a few sections of federal-aid state highway, access rights were obtained and recorded by deed at the time of highway construction. An access deed either restricts all direct access or restricts direct access to specific locations. Where access is controlled by deed, it may be necessary to obtain the prior approval of the U. S. Federal Highway Administration.

3.3 Category One

Functional Characteristics

These highways are capable of providing high speed and high volume traffic movements over long distances in an efficient and safe manner, including interstate, interregional, intercity, and in larger urban areas, intracity travel. Federal-aid interstate highways are typical of this category.

Design Standards

All opposing traffic movements shall be separated by physical constraints such as grade separations and median separators. Access, consisting of directional ramps, shall be suitably spaced and designed to provide the minimum differential between the speed of the through traffic stream and the speed of the merging or diverging vehicles. Location and design of access shall be determined on an individual basis by the Department in accordance with their authority under CRS 1973, 43-3-101, et seq as amended, and federal regulations governing federal-aid highway design and construction. Each access allowed to a category one highway must receive the approval of the State Highway Commission.

3.4 Category Two

Functional Characteristics

These highways are capable of providing high speed and high volume traffic movements, usually over long distances, in an efficient and safe manner providing for the majority of interstate, interregional, and intercity, travel needs and some intracity travel needs in larger urban areas. Service to abutting land is subordinate to providing service to major traffic movements. The function of a Category Two is similar to Category One. Category Two is sometimes an early stage to development to a Category One where Category One design elements will be incorporated at a future date when priorities and funds allow.

Design Standards

1. Typical spacing of intersecting streets, roads and highways shall be planned on intervals of one mile and normally based upon section lines where appropriate. One-half mile spacing shall be permitted only when no reasonable alternative access exists.

2. Private direct access shall not be permitted except when the property in question has no other reasonable access to the general street system. When direct access must be provided, the following shall be in effect:

   a. The access approach shall continue until such time that some other reasonable access to a lower functional category street or highway is available and permitted. The access approach permit shall specify the future reasonable access location and, if known, the date the change will be made. At no time shall the property be denied reasonable access to the general street system.

   b. All private direct access permitted under paragraph two above shall be for right turns only unless: (1) the access approach does not have the potential for signalization, and (2) out of direction movement exceeds two miles, and (3) a left turn movement can be designed that meets all safety requirements.

   c. No additional access shall be provided upon the splitting or dividing of existing parcels or contiguous parcels under the same ownership or control. All access to the newly created properties shall be provided internally from the existing access approach(es) or a new access approach determined by the permit application process based upon the requirements of this code.

3. All access provided shall be done so with the understanding that if the highway is reconstructed to a Category One, alternative access may be provided by a frontage road or other means.

4. Opposing traffic movements shall be separated by physical constraints such as grade separation or a median separator of sufficient design to physically prevent illegal movements.

5. Junctions with heavy volume cross streets should be either grade separations or interchanges.

6. Traffic signals should be programmed to allow 45 mph speeds and a desirable bandwidth of at least 50%. Signals at intersections with major cross streets should be programmed to optimize both streets equally.

3.5 Category Three

Functional Characteristics

These highways are capable of providing medium to high speeds and medium to high volume traffic movements over medium and long distances in an efficient and safe manner, providing for interregional, intercity and intracity travel needs. Direct access service to abutting land is subordinate to providing service to traffic movement.

Design Standards

1. It is the intent that all Category Three highways be capable of achieving a posted speed limit of at least 45 mph and preferably 55 mph in undeveloped areas. The posted speed limit shall be used to meet the requirements of this code unless an approved access control plan to impove the highway requires that a higher speed limit be used.

2. Private direct access to the state highway system shall be permitted only when the property in question has no other reasonable access to the general street system or if the denial of direct access to the state highway would be deterimental to the traffic flow of the general street system. When direct access must be provided, the following shall be considered.

a. Such access shall continue until such time that some other reasonable access to a lower functional category street or highway is available and permitted. The access permit shall specify the future reasonable access location and, if known, the date the change will be made. At no time shall the property be denied reasonable access to the general street system. Subdivisions should be designed, if possible, to provide for alternative access at a future date.

b. No more than one access approach shall be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that: (1) additional access would be significantly beneficial to the safety and operation of the highway or (2) allowing only one access approach would be in conflict with local safety regulations.

c. On two-lane undivided highways, access approaches shall be limited to right turns only unless either (1) the approach does not have the potential for signalization, and (2) a left turn shall not create unreasonable congestion or safety problems, and (3) the approach is at least 500 feet from the nearest signalized intersection; or (4) the approach does not have the potential for signalization and it can be shown that allowing left turns would significantly reduce congestion and safety problems at a nearby interesection; or (5) the approach meets the requirements of 3.5.4. below.

d. Access approaches on highways other than two-lane undivided highways shall be limited to right turns only unless either (1) the approach does not have the potential for signalization, and (2) it can be shown that allowing left turns would significantly reduce congestion and safety problems at a nearby intersection; or (3) there are no intersections, existing or planned, which allow a U-turn; and left turns can be safely designed without signalization; or (4) the approach meets the requirements of 3.5.4. below.

3. Since intersecting streets, roads and highways may in time warrant signalization, it is required that all intersecting streets, roads and highways, meet the signal spacing criteria under 3.5.5. below. Those that do not meet these requirements shall be limited to right turns only unless they meet the requirements of 3.5.2c and d above.

4. Private access approaches which have the potential for signalization and desire left turn movements must (1) meet the signalization spacing requirements for intersecting public streets, roads and highways, as per 3.5.5 below and (2) shall not interfere with the location, planning, and operation of the general street system and access to nearby properties.

5. Spacing and signalization

a. For those rural highway sections where existing traffic signals are infrequent and where significant development is not expected in the foreseeable future, spacing of all intersecting public streets, roads and highways shall be on one-half mile intervals, plus or minus approximately 200 feet, and based upon section lines where appropriate and feasible. Where topography makes one-half mile intervals inappropriate, location of public approaches shall be determined by topography, property ownerships, property lines and physical design constraints. The final location should serve as many properties and interests as possible to reduce the need for direct private access to the state highway.

b. In urban areas and developing areas where higher volumes are present or growth is expected in the foreseeable future that will require signalization, it is imperative that the location of all public approaches be planned carefully to ensure good signal progression. Generally a spacing of one-half mile for all intersections should be maintained. This spacing is usually desirable to achieve good speed, capacity, and optimum signal progression.

However, to provide flexibility for existing conditions and ensure optimum two-way signal progression, an approved traffic engineering analysis shall be made to properly locate all proposed connecting access approaches that may require signalization. An optimum two-way progression pattern shall be established between two public intersections that bracket the proposed approach as chosen by the Department. These bracketing intersections should be about one mile apart and be considered acceptable, existing or possible future, signal locations. The progression pattern calculation shall use a cycle length of between 80 and 120 seconds and a travel speed of 45 mph unless the posted speed limit is less. A desirable bandwidth of 40% shall be used where existing conditions allow. In order to reduce the proliferation of delays to the motorist, a minimum of 30% bandwidth shall be used where the existing optimum bandwidth is below 30%. Where intersections have no signals presently but are expected to have signals, a 60% mainline, 40% cross street cycle split shall be assumed. The green time allowed to the cross street shall be considered no less than the time which is required for a pedestrian to cross the main line at four feet per second.

c. Those junctions which would reduce the optimum bandwidth if a traffic signal were installed shall be limited to right turns.

d. When an existing access approach meets the warrants for a traffic signal as defined in the Manual on Uniform Traffic Control Devices and the location does not meet the requirements of 3.5.5, a median separator should be installed or the access approach designed to direct vehicles into right turns only. These design solutions may not be practicable or feasible where there are physical constraints such as curbs, sidewalks, structures, and lack of rights-of-way. Piecemeal median separators are usually not desirable and could pose other safety and highway operation difficulties. The reconstruction, relocation, closure, or conformance of the access approach with this code may be required to ensure that the purposes of this code and the Act are met.

e. This code does not authorize or require the installation of traffic signals. This is governed by the Manual on Uniform Traffic Control Devices under CRS 1973, as amended, 42-4-501.

3.6 Category Four

Functional Characteristics

These highways are capable of providing for moderate travel speeds and moderate traffic volumes for medium and short travel distances providing for intercity, intracity and intercommunity travel needs. There is a reasonable balance between access and mobility needs within this category.

Design Standards

1. It is the intent that all Category Four highways be capable for achieving a posted speed limit of 35 mph. The posted speed limit shall be used to meet the requirements of this code unless an approved access control plan to improve the highway requires that a higher speed limit be used.

2. Private Direct Access

   a. No more than one access approach shall be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that (1) additional access approaches would not be detrimental to the safety and operation of the highway and are necessary for the safety and efficient use of the property, or (2) allowing only one access approach would be in conflict with local safety regulations and the additional access would not be detrimental to public health, safety and welfare.

b. On two-lane undivided highways, access approaches shall be limited to right turns only unless either (1) the approach does not have the potential for signalization, and (2) left turns shall not create unreasonable congestion or safety problems, and (3) the approach is at least 500 feet from the nearest signalized intersection; or (4) a signal will not be required and it can be shown that allowing left turns would significantly reduce congestion and safety problems at a nearby intersection; or (5) the approach meets the requirements of 3.6.4 below.

c. Access approaches on highways other than two-lane undivided highways shall be limited to right turns only unless either (1) the approach does not have the potential for signalization, and (2) it can be shown that allowing left turns would significantly reduce congestion and safety problems at a nearby intersection; or (3) there are no intersections, existing or planned, which allow a U-turn and left turns can be safely designed without signalization; or (4) the approach meets the requirements of 3.6.4 below.

3. Since intersecting streets, roads and highways may in time warrant signalization, it is required that all intersecting streets, roads and highways meet the signal spacing criteria under 3.6.5. below. Those that do not meet these requirements shall be limited to right turns only unless they meet the requirements of 3.6.2b and c above.

4. Private access approaches which have the potential for signalization and desire left turn movements must (1) meet the signalization spacing requirments for intersecting public streets, roads and highways, as per 3.6.5. below and (2) shall not interfere with the location and operation of the general street system and access to nearby properties.

5. Spacing and Signalization

a. For those rural highway sections where existing traffic signals are infrequent and where significant development is not expected in the foreseeable future, spacing of all major intersecting public streets, road and highways should be on one-half mile intervals plus or minus approximately 200 feet and based upon section lines where appropriate and feasible. Where topography makes one-half mile intervals inappropriate, location of public approaches shall be determined by topography, property ownerships, property lines and physical design constraints. Minor intersections that have the potential for signalization should be located to meet the requirements of paragraph b that follows. Where the criteria of paragraph b is impracticable, a quarter mile interval shall be used. The final location should serve as many properties and interests as possible to reduce the need for more public streets and direct private access to the state highway.

b. In urban areas and developing areas where higher volumes are present or growth is expected in the foreseeable future that will require signalization, it is imperative that the location of all public approaches be planned carefully to ensure good signal progression. Where at all feasible, major intersection spacing shall be on either one mile or one-half mile interval spacing. This spacing allows the greatest flexibility for locating minor signalized intersections between major intersections while maintaining good traffic signal progression, and highway capacity. Additional minor intersections that require traffic signals may be permitted where they will not restrict the signal progression bandwidth established by those major intersections that bracket the proposed intersection. Where there is one-half mile spacing of major intersections, minor intersections can be located generally within about 550 feet of a one-half mile interval location. This may allow up to six signals in a one mile section. Where there is one mile spacing of major intersections, minor intersections can be located at quarter mile intervals allowing up to four signals per mile. While this category allows more signals per mile than Category Three, it is still desirable to keep signals to a minimum if possible.

c. To provide flexibility for existing conditions and ensure optimum two way signal progression, an approved traffic engineering analysis shall be made to precisely locate all proposed connecting access approaches that may require signalization. An optimum two way progression pattern shall be established between two major intersections that bracket the proposed approach as chosen by the Department. These bracketing intersections should be about one mile apart and considered acceptable, existing, or possible future signal locations. The progression pattern calculation shall use a cycle length of between 80 and 120 seconds and travel speed of 35 mph unless the posted speed is less. A desirable bandwidth of 30% shall be used where existing conditions allow. In order to reduce the proliferation of delays to the motorist, a minimum of 20% bandwidth shall be used where the existing optimum bandwidth is below 20% and there is little or no chance to improve the bandwidth. Where intersections have no signals presently but are expected to have signals, a maximum of 50% cross street cycle split shall be assumed. The green time allowed to the cross street shall be considered no less than the time which is required by a pedestrain to cross the main line at four feet per second.

d. Those junctions which would reduce the optimum bandwidth if a traffic signal were installed shall be limited to right turns.

e. When an existing access approach meets the warrants for a traffic signal as defined in the Manual on Uniform Traffic Control Devices and the location does not meet the requirements of 3.6.5, a median separator should be installed or the access approach designed to direct vehicles into right turns only. These design solutions may not be practicable or feasible where there are physical constraints such as curbs, sidewalks, structures, and lack of rights-of-way. Piecemeal median separators are usually not desirable and could pose other safety and highway operation difficulties. The reconstruction, relocation, closure, or conformance of the access approach with this code may be required to ensure that the purposes of this code and the Act are met.

3.7 Category Five

Functional Characteristics

These highways allow for low to medium travel speeds and are typified by traffic movements over short distances. Access needs take priority over through traffic movements without compromising the public health, welfare, or safety. Providing reasonable and safe access to abutting property is the primary purpose of this access category. Category Five shall be assigned only to those sections of state highway that serve as frontage or service roads where there is no intended purpose of providing for through traffic movements.

Design Standards

1. Generally a posted speed limit of at least 25 mph is acceptable. The existing posted speed limit shall be used in all access approach permit and design decisions.

2. Minimum spacing between signals is that which is necessary for the safe operation and proper design of adjacent intersections. Preference in traffic signal timing shall be given to highways of a higher access category.

3. Left turns shall be allowed provided required safety and design standards are met.

4. The number of access approaches to a parcel shall be controlled by the minimum spacing requirements (section 4.9.14) and safety and design considerations in section four of this code.

SECTION FOUR
DESIGN STANDARDS AND SPECIFICATIONS

4.1 The following design and construction standards and specifications are those which the Department has developed to protect the public health, safety, and welfare; maintain smooth traffic flow; maintain highway right-of-way drainage; and to protect the functional level of public highways.

4.2 When an application for access to a state highway meets the necessary criteria of section three of this code, section four shall be used to precisely locate, design and construct the access approach within the limitations set forth in Section Three. When a local government is the issuing authority and it has established by ordinance or resolution design standards more stringent than those appearing in this section then such standards shall govern when required by the local government.

4.3 If an access approach meets Section Three criteria and is unable to comply with Section Four criteria, the access approach permit should be denied unless a variance is authorized in accordance with Section Two of this code. The most recent edition of the references in Section 1.5 may be used when determining the design standards to be applied to a variance under Section 2.9.

4.4 Access Approach Width

1. Access approach width shall be measured exclusive of the radii or flares, between the ends of the return radii for approaches without curbs and those with street style curbed entrances. Driveways with curb cuts shall be measured behind the flared section.

2. Sixteen to 24 feet of width shall be used for two-way approaches when the single unit vehicle volume does not exceed 5 vph, except as noted in 4.4.3. below.

3. Twenty-five to 35 feet of width shall be used for two-way approaches when any one or more of the following apply to the approach:

   a. Single unit volume exceeds 5 vph

   b. Multi-unit vehicles are intended to use approach

   c. Single unit vehicles will exceed 30 feet in length

   d. Special equipment exceeds 16 feet in width

4. One-way access approaches shall have a width of 16 feet to 24 feet. If two one-way access approaches are adjacent to each other, they shall be divided by a raised median at least 4 feet wide and no more than 25 feet wide.

5. When a public street, road, or highway intersects with a state highway the design criteria of the local government and the Department shall be used to select an appropriate access approach width subject to the approval of the Department. No two-way public approach(es) shall be less than 25 feet in width.

4.5 Access Approach Radii

1. No access approach shall have an equivalent turning radius of less than 20 feet except as permitted in section 4.5.6.

2. A minimum of 50 foot equivalent turning radii shall be used for driveways when multi-unit vehicles, or single unit vehicles exceeding 30 feet in length, are intended to use the driveway on a daily basis.

3. The access approach equivalent turning radii shall not be less than that necessary to accommodate the turning radius of the largest vehicle for which the access approach is intended to use on a daily basis.

4. If the frequency of multi-unit vehicles, or single unit vehicles over 30 feet in length, is such that two of these vehicles, one entering and one exiting, use the access at the same time, radii shall be adequate to accommodate both vehicles with no turning conflicts.

5. The issuing authority shall determine when and if curb tapers or curb returns are required in accordance with existing or planned conditions.

6. When a public street, road, or highway intersects with a state highway the design criterion of the local government and the Department shall be used to select an appropriate radii, corner and intersection design subject to the approval of the Department.

4.6 Access Approach Surfacing

1. All access approaches shall be surfaced immediately upon completion of earthwork construction and prior to being used.

2. The surfacing for all access approaches shall extend from the highway traveled way to the right-of-way line.

3. Surfacing material shall be specified by the Department according to the Department's standard design specifications and the conditions and use of the access approach and the highway. Gravel will be permitted where conditions allow for individual residential access approaches or field entrances, where curbs are not required.

4. Surfacing improvements shall not be allowed on the highway right-of-way between driveways, unless a concrete curb or other physical obstruction, such as a drainage ditch, is constructed to channelize access movements at permitted locations.

5. Surfacing material may be defined as gravel or pavement.

4.7 Speed Change Lanes

1. Speed change lanes for right turning movements are required according to the table and text following:

TABLE 4.7.1

Posted Speed of Highway in MPH

	25	30 to 40	45 to 50	55	For a
If the *DHV of the highway will exceed	500 1400	400 1200	200 800	150 600	2 lane highway 4 or more lanes
	DHV/ADT	DHV/ADT	DHV/ADT	DHV/ADT	
and the DHV OR ADT of the access approach will exceed	50/450 70/625	40/350 60/550	20/175 40/350	15/150 25/225	2 lane highway 4 or more lanes

*The DHV of the Highway may be obtained from the latest copy of the "Colorado traffic volume study" for State Highways or from the district office of the Department.

a. For highways with four or more thru travel lanes, DHV highway values shall be measured only in the direction of the access approach.

b. For six lane highways, right turning volumes exceeding 200 DHV or 1800 ADT require speed change lanes.

c. Where no curb and gutter is present, a shoulder shall be provided that matches the existing shoulder design along the highway. The shoulder should not be less than two feet.

d. A right turn acceleration lane is not normally required when the posted speed is 40 mph or less, nor is it required at a signalized intersection. It may be required where a high main line traffic volume makes the use of the acceleration lane necessary for vehicles entering the traffic stream through the use of acceleration and merging techniques.

2. For left turning movements, speed change lanes are required to be placed within the median according to the following table and text:

TABLE 4.7.2

Posted Speed of Highway in MPH

	25	30 to 40	45 to 50	55	
When DHV of the highway will exceed	500 1000	400 900	200 600	150 400	2 lane highway 4 or more lanes
	DHV/ADT	DHV/ADT	DHV/ADT	DHV/ADT	
and the left turning DHV or *ADT into the access approach will exceed	30/250 45/375	20/175 30/250	15/125 20/175	12/100 12/100	2 lane highway 4 or more lanes

* In high employment areas average weekday traffic estimates may be required to be used instead of ADT.

a. For highways with four or more thru travel lanes, DHV highway values shall be measured only in the direction of the median speed change lane.

b. A median area is required in order to construct a left turn speed change lane. Both deceleration and acceleration lanes shall be constructed within the median for those access approaches for which left turns are required to have speed change lanes according to Table 4.7.2. Left turn acceleration lanes are not required: 1) when the posted speed is below 40 MPH unless required for public safety by the Department°s district traffic and safety engineer, or 2) when the intersection is signalized, or 3) where the acceleration lane would interfere with left turn ingress movements to other driveways, or 4) when section 4.7.2c does not so require.

c. Where a median does not exist or where a painted median is less than 14 feet in width, a painted median of at least 14 feet, preferably 16 feet, not exceeding 18 feet in width, shall be constructed. Where there is a median of 14 feet in width or greater, the existing width shall be used. Where the existing median is of raised design any new median construction shall also be of raised design unless otherwise instructed by the Department. These design features will not be required where physical constraints, curbs, sidewalks, structures, and lack of available right-of-way restricts installation.

d. Table 4.7.2, was designed for a normal percentage mix of vehicle types. If the access approach will have a larger percentage of vehicles exceeding 30,000 pounds gross vehicle weight, values of one-half of the access approach values in the table may be used to require median speed change lanes in the interest of public safety.

e. <u>Trip Generation</u>, second edition, The Institute of Transportation <u>Engineers, 1979</u>, shall be used as a reference in estimating DHV and ADT values of access approaches where required by this code.

3. If the design of the access approach is within two different speed zones, the standards for the higher speed zone will apply. When public safety so requires due to site specific conditions, such as sight distance, a turn lane may be required even through the warrants in Table 4.7.2 are not met.

4. Speed change lanes shall normally be 12 feet wide exclusive of gutter pan or shoulder. If existing thru travel lanes are less than 12 feet wide or if local government standards recommend, a lesser width may be used provided a minimum of 10 feet of width is attained.

5. For the purposes of the tables in 4.7, the DHV for the access approach location is considered synonymous with the term 'average peak hour volume often used for development analysis.

6. Speed, as used in these tables, refers to the posted legal speed limit at the access location at the time of permit application. A higher design speed shall be used if the section of highway is presently being redesigned or reconstructed to a higher speed or an approved access control plan requires a higher speed.

7. Design hour volume, also called DHV, means an hourly traffic vehicle volume determined for use in the geometric design of highways. For the purposes of this code, the DHV shall be the 30th highest hourly traffic volume of the projection for the 20th year unless otherwise specified. The purpose in the use of the 20th year DHV is to help ensure the continued safety of the approach as road conditions change.

8. The applicant shall submit an estimate of the volume and type of traffic to use the access approach. The Department shall assist any applicant requesting DHV and ADT traffic estimates for the purpose of obtaining an access approach permit.

9. When the access approach will exceed a DHV of 50 vehicles per hour it is recommended that a traffic analysis be completed by the applicant in addition to 4.7.8 above.

10. When speed change lanes are required, they shall be the lengths required according to the following tables and text. Table 4.7.10 gives the distance required for changing speeds between the posted speed and the speed of the turn.

TABLE 4.7.10

Posted Speed	Stop Condition A	Stop Condition D	15 mph turn A	15 mph turn D	ratio for straight taper	Minimum "D" taper Ratio
20		160		100		
25	100	200	90	150	7.5:1	7.5:1
30	150	235	90	185	10:1	8:1
35	210	275	150	235	12.5:1	10:1
40	310	315	250	295	15:1	11.5:1
45	450	375	390	350	15:1	13:1
50	680	435	620	405	20:1	15:1
55	850	485	795	450	22.5:1	18.5:1
60	1020	530	970	500	50:1	22.5:1
65	1190	570	1140	540	50:1	N/A

The values under 'A' are for acceleration lengths according to the posted speed limit. The values under 'D' are for deceleration length according to the posted speed limit. All values are given in feet. These values are for generally flat grades of less than 3% gradient. For all grades of 3% or greater, multiplication factors contained in the tables under 4.7.12 shall be used. Minimum tapers apply only to deceleration lanes where it is not physically feasible to use the normal taper.

a. The length of a taper is calculated by multiplying the width of the speed change lane by the ratio value associated with the posted speed in the table. A 25 mph zone and a 12 foot wide speed change lane at a 7.5:1 ratio, requires a 90 foot taper.

b. The length of the speed change lane shall be the sum of the appropriate length from Table 4.7.10, adjusted by 4.7.12 if applicable, plus the taper, plus any storage requirements under 4.7.11, for all access approaches where: (1) turning movement DHV exceeds by twice the access approach turning movement values in Tables 4.7.1 or 4.7.2 which require speed change lanes, or (2) the number of vehicles in excess of 30,000 pounds gross vehicle weight using the approach exceeds 3 DHV and are at least 25% of the appropriate values in Tables 4.7.1 or 4.7.2 or (3) the access approach is on an access Category Two highway.

c. The length of the required taper shall be considered a part of the appropriate speed change length value given in Table 4.7.10 for all those approaches not included under 4.7.10b. The applicant that qualifies for this shorter length may choose, at his discretion, to design to the specifications of paragraph 4.7.10b above if the Department approves. This paragraph shall not be applied to highways with posted speed in excess of 55 MPH

d. Due to difficult physical or legal constraints and in the interest of providing some degree of safety rather than none at all, it may be necessary to forego all, or part of, the deceleration length and provide only the taper and storage lengths. This minimum design criteria shall be used only on highways posted at 35 MPH or less when the requirements of 4.7.10 b and c are not feasible and, 1) the access category is four or five, or 2) the highway has, in that section, four or more intersections per mile per side and there is driver expectancy of speed changes, turning movements and weaving movements along that section of highway.

e. If a straight line taper is used, the ratios in the right columns of Table 4.7.10 are to be used. The value given is the ratio of taper length to speed change lane width. Partial tangent tapers, or symmetrical reverse curve tapers, or asymmetrical reverse curve tapers, may also be used provided a radius of at least 150 feet is used in curve calculations.

f. Where it is necessary to establish a left turn median island, tapers required for redirecting main travel lanes shall be according to the following table.

TABLE 4.7.10f

Posted speed in MPH	30 or less	35	40	45	50	55 and above
Straight taper ratio	20:1	25:1	30:1	40:1	45:1	50:1

11. For deceleration lanes where vehicle turning movements are 30 DHV or greater, additional storage length is required to accommodate turning vehicles according to the following table.

TABLE 4.7.11

Turning vehicles per hour	30	60	100	200	300
Required length in feet	25	50	100	175	250

a. For every 15 DHV of trucks larger than single unit, the length of the average truck plus 10 feet shall be added to the storage length required by 4.7.11.

12. Speed change lanes may require changes in length in accordance with the following.

a. Deceleration lanes shall use the following multiplication factors in determining speed change length for all grades of 3% or greater. Grade is the ratio of the length on grade to the change in elevation. Multiply the factor given below times the length given in Table 4.7.10.

TABLE 4.7.12a

For all posted speeds	3 to 4.9% upgrade 0.9	3 to 4.9% downgrade 1.2
	5 to 7% upgrade 0.8	5 to 7% downgrade 1.35

b. Acceleration lanes shall use the following multiplication factors in determining speed change length for all grades of +3% or greater. Multiply the factor given below times the length given in Table 4.7.10.

TABLE 4.7.12b

Posted Speed	3 to 4.9% upgrade	3 to 4.9% downgrade
25	1.3	.7
40	1.3	.7
50	1.3	.65
55	1.4	.65
60	1.4	.6
	5 to 7% upgrade	5 to 7% downgrade
25	1.5	.6
40	1.5	.6
50	1.5	.55
55	1.6	.5
60	1.7	.5

4.8 Sight Distance

1. The following table shall be used to determine the required stopping sight distance necessary as measured from the traveling vehicle to the access approach.

TABLE 4.8.1

Posted speed, mph	30	35	40	45	50	55	60
Required stopping sight distance in feet	200	250	300	375	450	550	650

a. For calculating sight distance a height of 3.5 feet shall be used for the driver's eyes and a height of 6 inches shall be used for the object. The driver's eye and the object shall be placed at the centerline of the inside lane for measurement purposes.

b. This table is based on wet pavement conditions and the average vehicle maintaining the posted speed limit.

3. Permits shall not be issued that include any design elements or allow any turning movements, where the stopping sight distances are not adequate to allow the safe movement of any motorist using the access approach or motorist passing the access approach.

4. In addition to the stopping sight distances necessary for vehicles traveling on the highway to see objects in the traveled way it is also necessary to provide the entering vehicle adequate sight distance in order to enter or cross the highway. The following table shall be used to establish the minimum sight distance necessary for the entering vehicle.

TABLE 4.8.4

*Vehicle expected to enter or cross highway	Sight distance is given in feet per 10 mph of posted speed limit		
	2 lane	4 lane	6 lane
Passenger car	100	120	130
Single Unit Truck	130	150	170
Multi-unit Trucks	170	200	210

a. Sight distance shall be measured at a height of 3.5 feet between the entering driver and the oncoming vehicle.

b. The entering driver's eyes shall be considered to be 15 feet back from the edge of the traveled way.

c. If there is no median or if the median is too narrow to safely store a left turning or crossing vehicle, the entire roadway width shall be considered from the approach.

d. If the median can safely store the turning or crossing vehicle, then sight distance shall consider a two stop condition. The vehicle will stop once at the outside edge of the traveled way and again within the median. Each one-way highway direction shall be considered separately.

*e. The vehicle shall be the largest vehicle normally intended to use the access approach. Normally means exceeds an average of one per day.

f. After sight distance requirements are met and an access permit issued, a sign structure or parked vehicle shall not be permitted where it will obstruct the required sight distance.

4.9 Other Design Elements

1. For all curb cuts the vertical curve from the traveled way into the access approach shall be the flattest curve that can be obtained. To prevent center or overhang drag, with some allowance for load and bounce, crest vertical curves should not exceed a four inch hump in a 10-foot chord and sag vertical curves should not exceed a four inch depression in 10-foot chord. For access approaches that are not curb cuts including streets and private approaches using curb returns, the first 20 feet beyond the closest highway lane, including speed change lanes, shall slope down and away from the highway at a 2% grade to ensure proper drainage control. Exceptions may be made where steep topography, such as mountains, make this requirement very difficult. The approved design must protect the highway from drainage flows. Valley gutters and cross pans are not recommended.

2. Within the right-of-way, maximum grades shall be limited to ten percent for low volume residential driveways. All other access approaches shall be limited to a maximum of eight percent grade. Lesser grades may be required for drainage purposes.

3. The horizontal axis of an approach to the highway shall normally be at a right angle to the centerline of the highway and extend a minimum of 40 feet beyond the traveled way. An angle between 90 and 60 degrees shall be acceptable only if physical constraints require a skew angle less than 90 degrees. An angle less than 60 degrees is not acceptable.

4. Access approach specifications shall ensure that the access approach is designed and constructed in a manner that will encourage proper use by the drive. Access approaches for one-way operation shall be approved only when design conditions ensure one-way operation.

5. An access approach that has a gate across it shall be designed so that the longest vehicle using it can completely clear the traveled way when the gate is closed.

6. The access approach shall be designed to facilitate the movement of vehicles off the highway to prevent the queuing of vehicles on the traveled way. Access approaches shall not be approved for parking areas that require backing maneuvers within a state highway right-of-way. All off-street parking areas must include on-site maneuvering areas and aisles to permit user vehicles to enter and exit the site in forward drive without hesitation.

7. Fill slopes and cut slopes shall be constructed either to (1) current Department minimum standards or (2) to the slope of the existing highway near the approach, whichever is safer.

8. Access approach design shall provide for the safe movement of all highway right-of-way users, including but not limited to pedestrians, bicyclists, and the handicapped. Sidewalks may be required where appropriate or when requested by local government.

9. In the event it becomes necessary to remove any right-of-way fence, the posts on either side of the entrance shall be securely braced with an approved end post before the fence is cut to prevent any slacking of the remaining fence. All posts and wire removed shall be turned over to the engineering district representative of the Department.

10. Where necessary to remove or relocate a state highway traffic control device for the construction of a permitted access approach, such relocation or removal shall be accomplished by the applicant at his expense and at the direction of the Department. Any damage to the state highway beyond that which is allowed in the permit shall be repaired immediately.

11. Further details of construction and design including pavement thickness and specifications, curb design and specifications, roadway fill design and compaction, and other specific details shall be provided by the Department.

12. Adequate advance warning is required at all times during access construction, in conformance with the Manual on Uniform Traffic Control Devices for Streets and Highways. This may include the use of signs, flashers, barricades and flagmen. This is also required by CRS 1973,42-4-501, as amended. The Department and its duly appointed agents and employees shall be held harmless against any action for personal injury or property damage sustained by reason of the exercise of the permit.

13. Access approaches that cross or otherwise affect pedestrian, bicycle, or handicapped facilities shall have the necessary modifications to ensure the safe crossing of the access approach and the safe use of the facility by pedestrian, bicyclists and the handicapped.

14. All access approaches should be separated by a distance equal to the stopping sight distance values in Table 4.8.1. This allows the motorist reaction and stopping distance between driveways. When speed change lanes are present it is desirable that the distance between two access approaches are no less than the sum of the acceleration lane length of the first and the deceleration lane length of the second.

15. The hours of work on or immediately adjacent to the highway may be restricted by the Department due to peak hour traffic demands and other pertinent roadway operating restrictions.

16. A copy of the permit shall be available for review at the construction site. If necessary, minor changes and additions shall be ordered by the Department field inspector to meet unanticipated site conditions.

17. The permit may require the contractor to notify the individual or office specified on the permit at certain phases in construction to allow the field inspector to inspect various aspects of construction such as concrete forms, subbase, and base course compaction.

4.10 Drainage

1. All access approaches shall be constructed in a manner that: (1) shall not cause water to enter onto the roadway, and (2) shall not interfere with the drainage system on the right-of-way.

2. The applicant shall provide, at his own expense, drainage structures for his access approach which will become an integral part of the existing drainage system. The type and condition of these structures must meet the approval of the Department in unincorporated areas. Approval must be obtained from the municipality in incorporated areas.

3. Drainage structures: (1) shall not restrict the existing drainage system, (2) drainage pipe shall be a minimum of 18 equivalent inches in diameter, (3) where hydrological studies have been completed, the drainage shall be designed to handle at least the 2-1/2 year storm, for underground system and a five year storm for side drains but not less than the existing drainage system.

4. The highway drainage system is for the protection of the state highway right-of-way. It is not designed or intended to serve the drainage requirements of abutting properties beyond that which has historically flowed to the state right-of-way. Drainage to the state highway right-of-way shall not exceed the undeveloped historical flow. The use of controlled flow retention ponds or storm sewers should be considered to control this flow from developed properties. When curb and gutter is required, the drainage ditch should be eliminated by installing a storm sewer system.

4.11 Maintenance

1. The occupant and the property owner of the property serviced by the access approach shall be responsible for (1) meeting the terms and conditions of the permit and, (2) the removal or clearance of snow or ice upon the access approach(es) even though deposited on the access in the course of the Department highway snow removal operations. The Department shall maintain in unincorporated areas the highway drainage system, including those culverts under the access approach which are part of that system within the right-of-way. The permittee, his sucessors and assigns, are responsible for the maintenance of the access approach beyond the travel and speed change lanes.

END

Chapter Hy 33

LAND SUBDIVISION PLATS ABUTTING STATE TRUNK HIGHWAYS AND CONNECTING STREETS

Hy 33.01 Purpose. (1) PURPOSE OF CHAPTER 236, WIS. STATS. The purpose of chapter 236 is "to regulate the subdivision of land to promote public health, safety and general welfare; to further the orderly layout and use of land; to prevent the overcrowding of land; to lessen congestion in the streets and highways; to provide for adequate light and air; to facilitate adequate provision for water, sewerage, and other public requirements; to provide for proper ingress and egress; and to promote proper monumenting of land subdivided and conveyancing by accurate legal description. The approvals to be obtained by the subdivider as required in this chapter shall be based on requirements designed to accomplish the aforesaid purposes."

(2) PURPOSE OF RULES AND REGULATIONS. Accordingly, the purpose of these rules is to specify minimum standards necessary to meet the requirements of state highway commission review of land subdivision plats abutting the state trunk highway system as provided under section 236.13 (1) (e) as follows:

"(e) The rules of the state highway commission relating to provision for the safety of entrance upon and departure from the abutting state trunk highways or connecting streets and for the preservation of the public interest and investment in such highways or streets."

History: Cr. Register, September, 1956, No. 9, eff. 10-1-56.

Hy 33.02 Basic principles. Land subdivision tends to affect highways by generating traffic, increasing vehicular parking requirements, reducing sight distance, increasing driveways and other access points and, in general, impairing safety and impeding traffic movements. To control these tendencies and to carry out the purposes of chapter 236, Wis. Stats., the commission promulgates the following basic requirements in this section and the specific rules of subsequent sections of these rules and regulations:

(1) Local traffic generated in subdivisions abutting on a state trunk highway shall be served by an internal street system of adequate capacity, intersecting and connecting with state trunk highways at a minimum number of points and in a manner which is safe, convenient, and economical to maintain and regulate.

(2) Subdivisions shall be so laid out that the individual lots or parcels do not require direct vehicular access to the highway.

Preceding page blank

(3) To accomplish reasonable functional integration and coordination of roadways and private driveways:

(a) The commission, particularly in the absence of a local comprehensive general or master plan or official map, will consider not only the immediate plat before it, but also its relationship to the access requirements of adjacent and contiguous subdivisions and unplatted lands;

(b) These rules and regulations shall be applicable not only to the lands proposed to be subdivided but also to all lands owned by, or under option (formal or informal), contract or lease to the subdivider and which are contiguous to and adjoin the land being subdivided.

(4) Setbacks from the highway shall be provided as hereinafter specified.

(5) The subdivision layout shall include provision for surface drainage in such a manner that the existing highway drainage system is not adversely affected.

History: Cr. Register, September, 1956, No. 9, eff. 10-1-56.

Hy 33.03 Definitions for the purpose of these rules and regulations. (1) "State Trunk Highway" includes connecting streets as defined in section 84.02 (11), Wis. Stats.

(2) "Subdivision" is as defined in section 236.02 (7), Wis. Stats.; provided, however, that where the local unit of government, under section 236.45 (2), Wis. Stats., has adopted an ordinance governing the subdivision or other division of land which is more restrictive than the provisions of chapter 236, and has provided for commission review, these rules and regulations shall also apply to those subdivisions or other divisions of land as specified in the ordinance.

(3) "Subdivision abutting a state trunk highway" means

(a) A subdivision some part of which adjoins or abuts a state trunk highway; or

(b) A subdivision which includes streets one or more of which is to be laid out or dedicated as part of the subdivision, and which is to connect with a state trunk highway; or

(c) A subdivision which is separated from a state trunk highway by unplatted lands which abut the highway and the subdivision and are owned by, or under option (formal or informal), contract or lease to the subdivider.

(4) "Frontage street" or "frontage road" means a local street or road auxiliary to and located on the side of an arterial highway for service to abutting property and adjacent areas and for control of access.

(5) "Street" or "road" includes alleys.

History: Cr. Register, September, 1956, No. 9, eff. 10-1-56.

Hy 33.04 Required information. The subdivider shall show on the face of the preliminary plat or on a separate sketch at a scale of not more than 1,000 feet to the inch, the *approximate* distances and relationships for the following:

(1) The geographic relationship to the proposed subdivision of any unplatted lands which abut any state trunk highway and are contiguous to the proposed subdivision, and the ownership rights in and the subdivider's interest, if any, in these lands.

Sec. 26-13.1. Permit for construction, repair, etc., of sidewalk, curb, etc.—Required.

No person shall begin to construct, reconstruct, repair, alter or grade any sidewalk, curb, curb-cut, driveway or street without first obtaining a permit from the city engineer. (Ord. No. 3725, § 2.)

Sec. 26-13.2. Same—Application.

An applicant for a permit under section 26-13.1 shall file with the city engineer an application showing:

(a) Name and address of owner, or agent in charge of the property abutting the proposed work area.

(b) Name and address of party doing work.

(c) Location of work area.

(d) Attached plans showing details of the proposed alteration.

---

* As to injuring, etc., city property generally, see § 18-27 of this Revision.

(e) Estimated cost of the alteration.

(f) Such other information as the city engineer shall find reasonably necessary to the determination of whether a permit shall be issued. (Ord. No. 3725, § 8.)

Sec. 26-13.3. Same—Same—Filing and inspection fees.

The following fees shall accompany an application for a permit hereunder:

(a) The filing fees shall be five dollars for each residential property and ten dollars for each commercial property; provided, that when sidewalks, curbs, curb-cuts, driveways or streets are to be constructed, reconstructed, repaired or altered simultaneously, only one permit and fee shall be required. The city engineer shall issue a permit for the construction of improvements, by a subdivider or developer, in the development of a subdivision prior to the sale of the lot or lots involved, at no cost, except for the inspection fees in the following paragraph.

(b) The city engineer shall collect an inspection fee of two dollars per lot, for deposit into the general fund of the city, for the inspection of the construction of improvements, by a subdivider or developer, in the development of a subdivision. (Ord. No. 3725, § 9.)

Sec. 26-13.4. Same—Findings prerequisite to issuance.

The city engineer shall issue a permit hereunder when he finds:

(a) That the plans for the proposed operation are satisfactory.

(b) That the work shall be done according to the specifications of the city engineer.

(c) That the operation will not unreasonably interfere with vehicular and pedestrian traffic, the egress to and from the property affected and adjacent properties.

(d) That the health, welfare and safety of the public will not be unreasonably impaired. (Ord. No. 3725, § 10.)

Sec. 26-13.5. Same—Granted for driveways and curb-cuts.

The city engineer may grant permits for driveways and curb-cuts for each parcel of land under one ownership as follows:

(a) For driveways and curb-cuts for properties used for school, commercial or industrial purposes: Two driveways and curb-cuts not to exceed twenty-five feet in width for each driveway or an aggregate total of fifty feet; provided, that the city engineer may require that a six inch vertical curb be installed to properly delineate the driveways.

(b) For driveways and curb-cuts for single family residences: Two driveways and curb-cuts not to exceed an aggregate total of twenty-five feet.

(c) For driveways and curb-cuts for properties used as duplex or apartment dwellings: Two driveways and curb-cuts not to exceed an aggregate total of thirty-two feet.

(d) The minimum distance that a driveway shall be located from a street intersection shall be thirty feet. This measurement shall commence from the intersection of the tangent lines of the curb radius between the two intersecting streets. (Ord. No. 3725, § 3; Ord. No. 3790, § 1; Ord. No. 3805, § 1.)

Sec. 26-13.6. Same—Same—Council may authorize granting of additional permits.

The city council may authorize the city engineer to issue a permit for driveways and curb-cuts in addition to the above numbers and widths. (Ord. No. 3725, § 4.)

Sec. 26-13.7. Same—Work done at no cost to city; duration.

All work done under a permit issued under the provisions of sections 26-13 through 26-13.11 shall be done at no cost to the city. Permit shall become void after six months from issue date. (Ord. No. 3725, § 11.)

Sec. 26-13.8. Ingress and egress from public street; composition of curbs, sidewalks, etc.

(a) Ingress and egress to property from public streets shall be made only upon a properly constructed driveway. Curbs,

sidewalks and driveways shall be constructed of concrete in accordance with the specifications on file in the office of the city engineer.

(b) The city engineer, upon the written application of a property owner, may grant a temporary variance from the requirements of section 26-37 pertaining to the width and fall of sidewalks.

(c) The city engineer, upon the written application of a property owner, may grant a temporary variance from the requirements of subsection (a) relative to driveways being constructed of concrete and permit a temporary driveway constructed of asphalt when the subject property does not have, and is not required to have, sidewalks, and the abutting property does not have sidewalks.

(d) The temporary variances authorized in subsections (b) and (c) may be terminated by the city engineer at such time as sidewalks are planned or constructed on properties abutting the property for which temporary variances were granted. When a temporary variance is terminated, the property owner shall, within sixty days, construct sidewalks or driveways in accordance with section 26-37 and subsection (a) above.

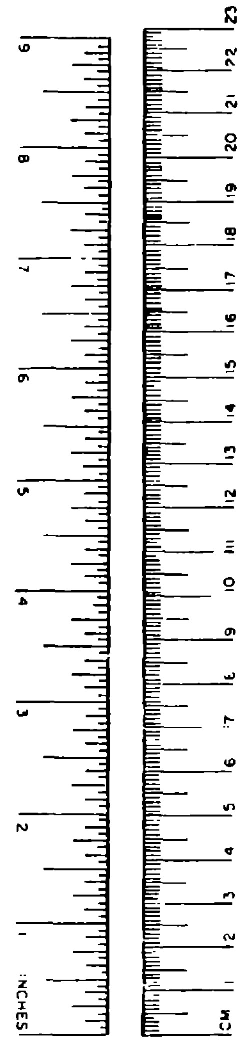
(e) Properties which have asphalt driveways prior to September 23, 1970, may be repaired, overlayed or sealcoated.

(f) Sidewalks and driveways may be constructed of brick or stone in District "H," historical site district, when a plan for such construction is approved by the city engineer and the board of architectural review; provided, that the city council, upon written petition, may grant permission for the construction of brick or stone sidewalks and driveways in any district within the city. (Ord. No. 3725, § 5; Ord. No. 3790, § 2, Ord. No. 72-49, § 2.)

METRIC CONVERSION FACTORS

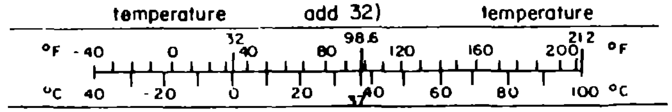
APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	2.5	centimetres	cm
ft	feet	30	centimetres	cm
yd	yards	0.9	metres	m
mi	miles	1.6	kilometres	km
		AREA		
in^2	square inches	6.5	square centimetres	cm^2
ft^2	square feet	0.09	square metres	m^2
yd^2	square yards	0.8	square metres	m^2
mi^2	square miles	2.6	square kilometres	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	megagrams	Mg
		VOLUME		
tsp	teaspoons	5	millilitres	ml
tbsp	tablespoons	15	millilitres	ml
fl oz	fluid ounces	30	millilitres	ml
c	cups	0.24	litres	l
pt	pints	0.47	litres	l
qt	quarts	0.95	litres	l
gal	gallons	3.8	litres	l
ft^3	cubic feet	0.03	cubic metres	m^3
yd^3	cubic yards	0.76	cubic metres	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
mm	millimetres	0.04	inches	in
cm	centimetres	0.4	inches	in
m	metres	3.3	feet	ft
m	metres	1.1	yards	yd
km	kilometres	0.6	miles	mi
		AREA		
cm^2	square centimetres	0.16	square inches	in^2
m^2	square metres	1.2	square yards	yd^2
km^2	square kilometres	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
Mg	megagrams	1.1	short tons	
		VOLUME		
ml	millilitres	0.03	fluid ounces	fl oz
l	litres	2.1	pints	pt
l	litres	1.06	quarts	qt
l	litres	0.26	gallons	gal
m^3	cubic metres	36	cubic feet	ft^3
m^3	cubic metres	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



BIBLIOGRAPHY

Agent, K. R. "At-Grade Versus Grade-Separated Interchanges," Traffic Engineering, Vol. 45 N6 (June 1975), pp. 22-24

Agent, K. R. Accident and Economic Analyses of Access Control on Several Bypasses, Kentucky Department of Highways, September 1972.

American Association State Highway Officials. A Policy on Design Standards Interstate System, Vol. 6.

Automotive Safety Foundation; Delaware State Highway Department; Bureau of Public Roads/U.S. "A Modern Highway Code for Delaware," HPR, State A-5

Azzeh, J. A.; Thorson, B. A.; Valenta, J. J.; Glennon, J. C.; and Wilton, J. C. "Evaluation of Techniques for the Control of Direct Access to Arterial Highways," Midwest Research Institute, Kansas City, Missouri, Final Report No. FHWA-RD-76-85, August 1975.

Barton-Aschman Associates, Incorporated. "Highway and Land-Use Relationships in Interchange Areas, Supplementary Report No. 1, Current Laws and Practices Affecting Interchange Area Planning," Chicago, Illinois, November 1963

Barton-Aschman Associates, Incorporated. "Highway and Land-Use Relationships in Interchange Areas, Supplementary Report No. 3, Case Studies of Selected Interchange Areas," Chicago, Illinois, February 1964

Baughman, C. B. "Warrants for Location and Design of Local Service Roads," Zement und Betong, Wien; Austria, October 1, 1975.

Billion, C. E., and Parsons, N. C. "Median Accident Study-Long Island, New York," Highway Research Board Bulletin, 1962, Vol. No. 308, pp. 64-79

Boeglin, R. E. Costs and Benefits of Access Control Alternatives for Rural Principal Arterials. U.S. Department of Transportation, Federal Highway Administration, March 1973

Paul C. Box & Associates. Driveways.

Brown, L. H.; Meck; and Stocks, A. H. "State Legislation Governing Planning and Land-Use Controls and the Value of Planning and Controls in Fostering Highway Protection and Economic Development--With Particular Reference to West Virginia and Bordering States," West Virginia University

Brown, R. D. "Highway Planning's Role in Developing Standards for Future Highways," American Association State Highway Officials Procedures, December 4, 1968

Preceding page blank

Colorado Department of Highways. "Roadway Design Manual," January 1972, pp. 221

Covey, F. M. "Impact of Police Power Controls Along the Wisconsin Trunk Highway System," Highway Research Board Bulletin No. 232, January 1959, pp. 84-105

Cribbins, P. D., and Summer, G. S. "The Correlation of Accident Rates with Geometric Design Component of Various Types of Highways," North Carolina State University, June 1964.

Cribbins, P. D.; Horn, J. W.; Beeson, F. V.; and Taylor, R. D. "Median Openings on Divided Highways: Their Effect on Accident Rates and Level of Service," Highway Research Record 188, 1967, pp. 140-157

Dawson, R. F., and Oppenlander, F. C. "Traffic Control and Roadway Elements -- Their Relationship to Highway Safety/Revised," Chapter 11: General Design, Highway User Federation Safety and Mobility, 1971

Duhaime, W. E.. "Limiting Access to Existing Highways," Highway Research Board Bulletin No. 140, 1956, pp. 76-83

Dunbar, D. W. "An Attorney General Looks at Highway Law," Highway Research Bulletin No. 237, 1960, pp. 8-15

Enfield, C. W., and McLean, J. C. "Controlling the Use of Access," Highway Research Board Bulletin No. 101, 1955, pp. 70-80

Erbe, N. A. "A Review and Some New Thinking on Control of Highway Access," Highway Research Board Bulletin No. 232, January 1959, pp. 49-78

Fee, J. A. "Interstate System Accident Research Study - I," Federal Highway Administration, October 1970

Fee, J. A.; Beatty, R. L.; Dietz, S. K.; Kaufman, S. F.; and Yates, F. G. "Comparison of Accident Experience on Interstate and Non-Interstate Highways--The Influence of Highway, Traffic, and Environmental Characteristics," Federal Highway Administration. October 1970.

Feifarek, A. "Administration of Highway Protection Laws," Highway Research Board Bulletin No. 140, 1956, pp. 72-75

Feifarek, A. J. "Judicial Review of Administrative Decisions in Highway Access Control," Highway Research Board Bulletin No. 345, January 1962, pp. 21-26

FHWA Task Force on Control of Access. Executive Summary and Position Paper on Control of Access, June 27, 1978.

Fisher, G. E.. "South Dakota-Highway Laws Research Study," South Dakota State University, School of Law, 1967.

Gern, R. C., and Joyner, H. R. "Crossroute Access Design in Interchange Areas," Highway Research Record 59, 1964, pp. 1-8

Glennon, J. C., and Azzeh, J. A. "Access Control On Arterial Highways," ASCE Journal of Transportation Engineering, Vol. 102, NTE 1, February 1976, pp. 75-90

Glennon, J. C.; Valenta, J. J.; Thorson, B. A.; and Azzeh J. A. "Technical Guidelines for the Control of Direct Access to Arterial Highways," Volume I. General Framework for Implementing Access Control Techniques," Federal Highway Administration, Washington, D.C., August 1975

Glennon, J. C.; Valenta, J. J.; Thorson, B. A.; and Azzeh, J. A. "Technical Guidelines for the Control of Direct Access to Arterial Highways, Volume II, Detailed Description of Access Control Techniques," Federal Highway Adminis tration, August 1975

Gwynn, D. W. "Accident Rates and Control of Access," Traffic Engineering, Vol. 37, No. 2, November 1966, pp. 18-21

Highway Research Board. "Guidelines for Medial and Marginal Access Control on Major Roadways," NCHRP Report No. 93, NCHRP Project 3-13, 1970

Highway Research Board. "Highway Capacity Manual 1965," HRB Special Report 87, 1965

Highway Research Board. "Legislative Purpose in Highway Law: An Analysis," HRB Special Report 39, 1958

Highway Research Board. "Statements of Needed Research in Capacity and Freeway Operation," HRB Circular No. 81, July 1968

Highway Research Board. "Bibliographical Notes on Recent Legal Periodical Writings and Papers," HRB Circular No. 4, June 1965, pp. 26-31

Highway Research Board. "Special Problems of Condemnation and Land Use Control," Highway Research Information Service, February 1968

"Highways II: The Plan," Wisconsin Department of Transportation, Division of Highways, 1968

Hutchinson, J. W.; Scott, W. A.; and Kennedy, T. W. "Medians of Divided Highways: Current Status of Knowledge and Annotated Bibliograpy," Highway Research Board Bibliography No. 34, 1963

Intermaggio, J. L. "Expressways," Highway Research Board Bulletin No. 140, 1956, pp. 60-65

International Federation of Automatic Control (West Germany). "Control in Transportation Systems," Proceedings of the IFAC/IFIP (International Foundation for Information Processing/IFORS (International Federation of Operational Research Societies) International Symposium 3rd, Columbus, Ohio, 1976

Johnson, A. E. "State Highway Officials and the Laws Project," Highway Research Board Bulletin No. 145, 1957, pp. 3-5

Kihlberg, J. K., and Tharp, K .J. "Accident Rates as Related to Design Elements of Rural Highways," Highway Research Board NCHRP Report No. 47, 1968, pp. 1-173

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 10, February 1948, pp. 1-18

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 18, April 1949, pp. 1-16

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 38, 1951, pp. 1-30

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Record 45, 1964, pp. 1-5

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 47, May 1947, pp. 1-17

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 55, 1952, pp. 1-32

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 77, 1953, pp. 1-35

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 101, 1955, pp. 1-39

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 113, 1956, pp. 1-53

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 140, 1956, pp. 1-54

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 169, 1957, pp. 1-39

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 189, 1958, pp. 1-56

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 273, 1960, pp. 1-66

Levin, D. R. "The Highway Interchange Land-Use Problem," Highway Research Board Bulletin No. 288, 1961, pp. 1-24

Levin, D. R. "Report of Committee on Land Acquisition and Control of Highway Access and Adjacent Areas," Highway Research Board Bulletin No. 343, January 1962, pp. 1-44

Lewis, H. "The Future of Abutters' Rights: Access," Highway Research Special Report 76, 1962, pp. 163-178

Lugar, M. E. "Procedure for West Virginia Highway Laws Revision," Highway Research Record 8, 1963, pp. 14-19

Marks, H. and Spitz, S. "A Review of Transportation Aspects of Land-Use Controls," Highway Research Board NCHRP Report 31, Project No. 8-5, 1966, pp. 1-41.

Morony, L. R. "The Laws Behind our Roads: A Plea for a More Enlightened Attitude," American Bar Association Journal, Vol. 43, No. 1, January 1967, pp. 15-18, 93-94.

Mulinazzi, T.E., and Michael, H.L. Correlation of Design Characteristics and Operational Controls with Accident Rates on Urban Arterials, Purdue & Indiana State Highway Commission, Report No. 35, December 1967.

Netherton, R. D. "A Summary and Reappraisal of Access Control," Highway Research Bulletin No. 345, January 1962, pp. 1-14

Nissel, S. N. "Control of Access and Police Power," Highway Research Bulletin No. 205, 1958, pp. 29-34.

Noble, C. M. "Engineering Design of Superhighways," American Road Builders Association, 1941 Convention Proceedings, pp. 183-217

Powers, L. "Regulation of Access vs. Control of Access in Oklahoma," Highway Research Bulletin No. 140, 1956, pp. 55-59.

Reese, H. B. "Legal Aspects of Limiting Highway Access," Highway Research Bulletin No. 77, 1953, pp. 36-50

Shattuck, I. S., and Rykken, K. B. "Highway and Thorofare Planning and Programming in Relation to Urban Planning and Development," Highway Research Bulletin No. 31, 1950

Stanhagen, W. H., and Mullins, J. J. "Application of Police Power and Planning Controls to Arterial Streets," Highway Research Bulletin No. 271, 1960, pp. 14-28

Stanhagen, W. H. "Highway Interchanges and Land-Use Controls," Highway Research Bulletin No. 288, 1961, pp. 32-60

Thomas, L. W. "Legal Implications of Control of Access to Uncontrolled-Access Highways," NCHRP Research Results Digest, April 1979

Thorson, B. A., and Glennon, J. C. "Evaluation of the Traffic Conflicts Technique," Federal Highway Administration, December 1975

Tipton, W. E. "Analysis of Access Violations on Controlled Access," Texas Transportation Institute, 1964

Tuemmler, F. W. "From the Planner's Viewpoint," Highway Research Special Report No. 17, 1954, pp. 23-27

Vardon, J. L. "The Design Concept for Highway 401-Toronto," Canadian Good Roads Association Proceedings, 1964

OVERALL COURSE EVALUATION

Your Job Title and Agency: ______________________________

Work Responsibilities: ______________________________

1. Describe the overall value of the course to you.

2. Will you, or an associate, find the textbook of value as a reference?

3. Describe any changes you would make in technical content of the course, including adding or dropping topics and level of detail.

4. Describe any changes you would make in the educational aspects of the course, including schedule and visual aids.

5. Which specific topic(s) was of greatest value to you? Why?

6. Which specific topic(s) was of least value to you? Why?

7. What suggestions do you have for improving future presentations of the course that have not been mentioned above?

8. What types of persons can best benefit from this course?

SPECIFIC COURSE EVALUATION

(Circle one for each category)

1 = Poor 2 = Below Average 3 = Average

4 = Good 5 = Excellent

	Material	Presentation	Visual Aids
1. Introduction	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
2. Needs and benefits	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
3. Elements of comprehensive program	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
4. Existing programs	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
5. Retrofit	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
6. Techniques for access management	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
7. Design Guidelines	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
8. Evaluation of techniques	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
9. Workshop on application of techniques	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
10. Review of workshop results	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
11. Site plan review	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
12. Site plan review workshop	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
13. Summary and evaluation	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

U.S. GOVERNMENT PRINTING OFFICE 1982-0- 522-046/8527

HDV-21/6-82(1M)