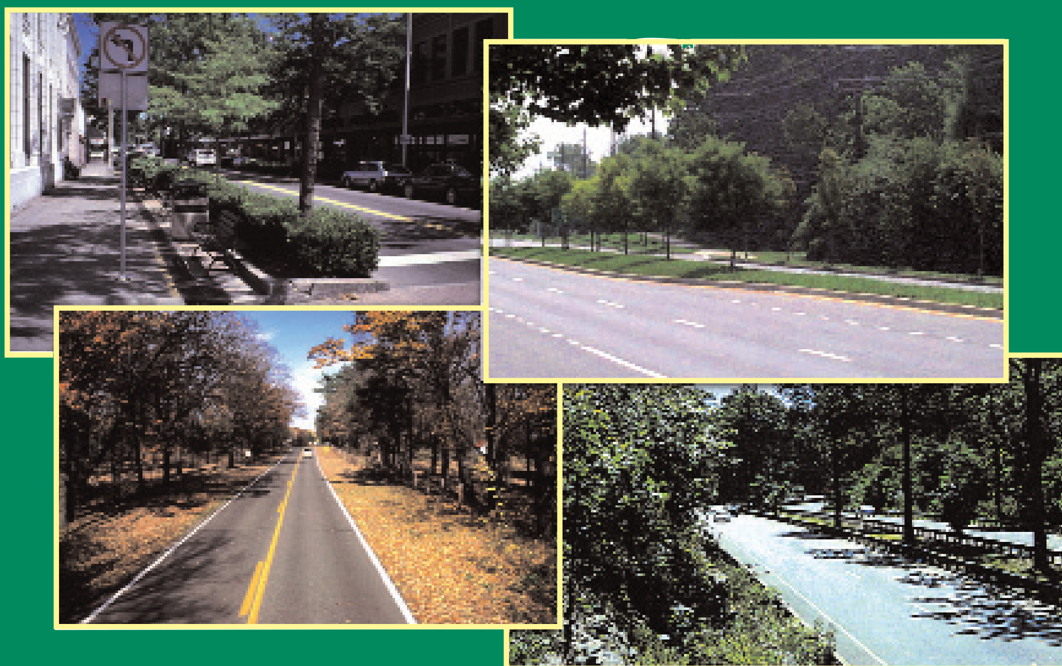

A Guide for Achieving *Flexibility* in Highway Design

May 2004

American Association of State Highway and Transportation Officials

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acknowledgments

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- Task Force on Environmental Design (Design)
- Task Force on Geometric Design (Design)
- Task Force for Roadside Safety (Design)
- Subcommittee on Legal Affairs (Administration)

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introduction

Context-sensitive solutions (CSS) are an emerging concept in highway project planning, design, construction, and maintenance in recent years. CSS reflects the need to consider highway projects as more than transportation. CSS recognizes that a transportation facility, by the way it is integrated within the community, can have far-reaching impacts (positive and negative) beyond its traffic or transportation function. The term CSS therefore refers to an approach or process as much as it does to an actual design or solution.

The term *Flexibility in Highway Design* was adopted by the Federal Highway Administration (FHWA) in their groundbreaking publication (issued in 1997) that demonstrated how agencies could accomplish the objects of CSS within accepted design processes and criteria. The core theme of the FHWA publication was flexibility—in design approaches, use of criteria, execution of design solutions, and incorporation of special or "unique" features:

> *This Guide* [*Flexibility in Highway Design*] *encourages highway designers to expand their consideration in applying the Green Book criteria. It shows that having a process that is open, includes good public involvement, and fosters creative thinking is an essential part of achieving good design.*

The terms *context-sensitive solutions*, *context-sensitive design*, and *flexibility in highway design* are used interchangeably by some. Other terms expressing the concepts include *place-sensitive design* and *Thinking Beyond the Pavement*. These terms all refer to the same process and result: a highway or transportation project that reflects a community consensus regarding purpose and need, with the features of the project developed to produce an overall solution that balances safety, mobility, and preservation of scenic, aesthetic, historic, and environmental resources.

A national conference sponsored by the Maryland State Highway Administration and FHWA in 1998 produced a definition of context-sensitive design that has been adopted by many:

> *Context sensitive design asks questions first about the need and purpose of the transportation project, and then equally addresses safety, mobility, and the preservation of scenic, aesthetic, historic, environmental, and other community values. Context sensitive design involves a collaborative, interdisciplinary approach in which citizens are part of the design team.*

CSS or flexibility in highway design therefore represents a comprehensive process that attempts to bring all stakeholders together in a positive, proactive environment with the objective being the completion of projects that meet transportation needs and are viewed as improvements or enhancements to the community through preservation efforts and sensitivity to local values. CSS recognizes the need to consider that transportation corridors may be jointly used by motorists, pedestrians, cyclists, and public transit vehicles. In addition to the movement of people, CSS also considers the distribution of goods and the provision of essential services.

The values presented in this guide do not imply that the existing streets and highways are unsafe, nor do they mandate the initiation of improvement projects. This guide is not intended to be a detailed design manual that would supersede the need for the application of sound principles by the knowledgeable design professional, nor is it intended to establish guidelines, criteria, or standards for the design of roadways. The use of the terms *guideline* or *criteria* in this document are not to be considered as a substitute or synonym for the word *standard*.

Historic Background on Flexibility in Design

The great interest in achieving flexibility in design is the culmination of many years of increased involvement of the public in transportation projects. Many State Departments of Transportation (DOTs) have experienced projects in which their rigid application of established criteria, practices, or solutions has come into conflict with community values. Some examples of these conflicts include the value of mature trees versus clear zones, lane width and capacity needs versus provision for bicycle lanes, road widening to meet a prescribed level of service. While the issues are many and complex, and tend to vary by location, transportation providers are recognizing these concerns and are now seeking to provide solutions that reflect appropriate sensitivity to community values.

Public policy objectives dealing with resource preservation and community values are highlighted by a range of national and state legislation on environmental and cultural resource protection, beginning with the National Environmental Policy Act of 1969, and continuing with more recent federal legislation such as the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, the National Highway System (NHS) Designation Act of 1995, and the Transportation Equity Act for the 21st Century (TEA-21) of 1998. This legislation demonstrates a clear, strengthened federal commitment toward the preservation of historic, scenic, and cultural resources in the development and implementation of transportation projects.

In response to these trends and legislation, a number of national initiatives and publications have encouraged and demonstrated more flexible and creative approaches to highway project development, including the American Association of State Highway and Transportation Officials' (AASHTO's) *Design Flexibility Case Study Report,* 1997; FHWA's *Community Impact Assessment,* 1996; FHWA's *Flexibility in Highway Design,* 1997; and FHWA's *Community Impact Mitigation Case Studies,* 1998.

Flexibility in Highway Design and the Design Profession

Flexibility in highway design has provoked some measure of discomfort and some misunderstandings both inside and outside the highway engineering design profession. Some have interpreted the initiative as advocating an end to the practice of design as it has been done in the past, or the abandonment of proven design criteria, guidelines, or design standards. Others have been concerned with perceptions of adverse outcomes from projects that are *flexibly* designed. Such concerns tend to focus on compromises in the safety of the solution, or on increased risk to the owning agency associated with potential tort lawsuits.

In the view of AASHTO, established processes and design guidance are not in conflict with the movement. Furthermore, a well-designed, *context-sensitive* design solution need not increase the risk of a tort lawsuit to an agency. AASHTO supports the concepts and principles of flexibility in highway design and feels that all professionals responsible for highway and transportation projects should understand how to accomplish a flexible design solution within current design processes and approaches.

This publication was prepared to add technical background to the knowledge base of highway and traffic engineers, planners, and other technical specialists who contribute to transportation solutions. It strives to emphasize that flexible design does not entail a fundamentally new design process, nor does it suggest new or revised design criteria. Rather, this publication sets out to show designers how to think flexibly, how to recognize the many choices and options they have, and how to arrive at the best solution for the particular context.

Achieving a flexible, context-sensitive design solution requires designers to understand the reasons behind processes, design values, and design procedures. Indeed, successful implementation of context-sensitive solutions will be largely based on the skills and abilities of the professional staff to incorporate context-sensitive design principles in each step of the project development process. This publication, combined with *Flexibility in Highway Design* published by the FHWA, represents a major step toward providing guidance to state DOTs and other agencies charged with transportation project development. However, this guide does not establish a set of best design practices or processes, nor does it mandate the use of flexible design concepts. In addition, the application of the concept of flexible design will vary between States and from project to project.

Organization of the Guide

This guide is intended to promote the incorporation of sensitive community and environmental issues into the design of highway facilities. It is organized to provide an overview and summary of key aspects of the highway project development process from initial planning through completion of construction plans.

Chapter 1 addresses the overall project development process, including the major steps of planning through final design, the background, applicability and use of design criteria, differences among project types, and project design decision making.

Lessons learned from successful context-sensitive projects suggest that the *alternatives development and evaluation stage*, early in project development, is where context sensitivity is achieved. Transportation alternatives must reflect early, continuous, and meaningful input from the public, resource and regulatory agencies, and affected stakeholders. Alternatives must also be developed with full knowledge and understanding of all physical and environmental constraints. They should reflect a creative, appropriate application of geometric design criteria and guidelines. This can occur only with an understanding of how such criteria have been developed, and how they are supposed to be used.

Chapter 1 emphasizes that the highway design process is flexible. The concept of flexibility may not be well understood by some highway designers; through this document and other related efforts, AASHTO is attempting to educate the design community.

Flexibility occurs with the many choices that a designer has, including selection of a design speed, designation of key design parameters such as the design vehicle, and decisions about the level of service to be provided. A context-sensitive design process provides a means for these choices to be presented to the public and discussed.

Flexibility continues with the application of design criteria to alternatives development. There is significant flexibility in the presentation of geometric design values published in the 2001 update to the AASHTO publication *A Policy on Geometric Design of Highways and Streets* (commonly known as the AASHTO Green Book). Designers, for example, have the ability to select a reasonable design speed from among a range of speeds appropriate for the type and location of the road. Flexibility is also imbedded in the presentation of many design elements in the AASHTO Green Book. A context-sensitive designer will take advantage of this flexibility.

Finally, there are occasions in which even the most creative use of design criteria produces an unacceptable or infeasible solution. The judicious application of *design exceptions* (the incorporation of design values outside the typical ranges to avoid a conflict or constraint) is appropriate in the context-sensitive design environment as long as the safety and legal risks are understood by the designer, are considered acceptable given site-specific conditions, and are documented well.

Chapter 1 closes with a discussion of the decision-making process. All involved with the project development process need to understand the decision process as it applies to each project. Transportation agencies, charged with the design, construction, operation, and maintenance of facilities, are normally the final decision-making authority. With this authority comes a responsibility to act in a manner that is open and honest, and that demonstrates sensitivity to the community.

Chapter 2 outlines the processes, tools, and techniques through which agencies can develop an understanding and incorporate such understanding of community interests in projects. Effective public involvement begins early, is maintained throughout the project, and is meaningful to the evolution of project plans and decisions.

Essential to a successful project is the identification and inclusion of all stakeholders, establishment of purpose and need, completion of early and thorough project scoping, and development and execution of a tailored public involvement program. Public involvement activities must be planned, budgeted, and managed like any other critical technical task. Techniques, guidelines, and references for conducting public involvement programs are contained in Chapter 2. This chapter also discusses the use of technologies such as visualization to promote and enhance public understanding of a project's visual attributes.

Chapter 2 also emphasizes the role that highway design professionals must play in the environmental planning process. A successful project not only meets community interests and goals, but also addresses regulatory requirements and resource agency concerns. Environmental studies and input occur in concert with, not separate from, highway engineering design. Alternatives development should reflect a complete understanding of environmental issues and should strive to demonstrate tradeoffs and choices that reflect such issues.

Many highway projects result in a series of decisions, commitments, and promises to stakeholders. Effective public involvement does not end with design decision making, but continues through implementation. Planning and design decisions made by project staff need to be communicated to agency management and need to be fully documented to assure compliance with commitments and promises as the project continues into construction. With this authority also comes the responsibility to provide a safe and efficient transportation system.

Chapter 3 is aimed at highway design professionals charged with the development and evaluation of highway alternatives. A common interest of both highway designers and the public is the enhancement of safety in every highway project. This task is sometimes easier said than done in the context of constrained corridors and given other community objectives. It is imperative that highway designers working in the context-sensitive environment demonstrate an understanding of the functional, operational, and safety basis behind their agency's design criteria to enable flexible, creative decisions. Chapter 3 provides an overview of key geometric elements, including a discussion of the models and assumptions used in the derivation of AASHTO design criteria, and a summary of current knowledge regarding operational and safety effects of design. Geometric features that are discussed include horizontal and vertical alignment, cross section, sight distance, intersections and access control, and bridges.

Chapter 3 also addresses in detail two specific concerns that repeatedly occur in context-sensitive projects: roadside design and traffic calming. Resolving potential safety conflicts with trees, decorative walls, and other roadside objects is a frequent problem in reconstruction projects. Designers faced with tradeoffs between maintaining the scenic character of a road and enhancing safety require an understanding of roadside design principles. With respect to traffic calming, the public frequently expresses concern about inappropriate speeds of traffic through towns, business districts, and residential streets. Providing a highway that promotes low-speed operation while meeting safety and mobility objectives is among the most prevalent context-sensitive design issues. Designers need to understand principles of traffic calming, what is effective (and what is not), and how to work with communities to develop effective traffic-calming projects where these are the proper approach to a problem.

Chapter 4 addresses major issues and concerns of agencies and design professionals regarding their responsibilities. Developing a project to meet the context-sensitive environment will take creativity by individuals and agencies charged with assessing design tradeoffs and making project decisions.

Design engineers are concerned with the legal implications of implementing design solutions outside the usual ranges. Many agencies have experienced lawsuits stemming from crashes. There is a widespread concern among design professionals that embracing context-sensitive design will increase an agency's and even an individual's exposure to the risk of being sued should a crash occur.

Design professionals and the public need to understand basic concepts of tort liability and sovereign immunity. Although state laws vary, tort laws generally draw important distinctions between *discretionary* and *ministerial* actions. Planning and design decisions that require the assessment of tradeoffs are considered to be discretionary functions, which are generally immune from tort actions. The legal principle is that judges and juries should not substitute their judgment for those of professionals in technical matters. The courts generally provide broad protection for those decisions where it can be shown that reasonable discretion was exercised. Ministerial actions generally involve clearly defined tasks performed with minimal leeway for personal judgment. These are typically implementation actions such as maintenance or construction at the operational level. It is these types of actions for which agencies are held liable if they are not performed adequately. This is not to say that the risk of a lawsuit involving design decisions is negligible. Note that state laws vary, and state court precedents may also vary. All highway designers need to understand the laws and regulations in place for the jurisdictions where they work.

A hindrance in the acceptance of context-sensitive design approaches by some has been a concern about the legal ramifications of design decisions that incorporate nontraditional design solutions. Chapter 4 notes that experience varies across the country. In some jurisdictions, very few successful tort actions involving highway agencies actually result from geometric design issues. In others, tort claims related to design are a continuing concern, and the risk of these claims needs to be understood. In general, it appears that the nature of tort laws and recent history suggests that designing innovative solutions should not necessarily increase the risk to an agency as long as appropriate risk management measures are undertaken.

Chapter 4 summarizes how highway design professionals can successfully accomplish flexibility in design while protecting the public and the legal interests of the owning agency. Transportation design professionals, as individuals as well as representatives of or consultants to agencies, have duties and responsibilities to act in a reasonable manner and to demonstrate adherence to good practice. Among the factors of great importance in the context-sensitive environment is the need to fully evaluate and document all reasonable alternatives. Thus, it would seem that the requirements for a successful context-sensitive project are consistent with good practice to minimize risk: openly developing and evaluating multiple alternatives, assessing tradeoffs among many variables including safety, and documenting all decisions.

The above is not to say that the context-sensitive design environment will be risk-free with respect to tort liability. Again, state laws, precedents, and practices vary. Furthermore, it is an unavoidable fact that DOTs face public and legal scrutiny for virtually all their actions. However, if a design team works closely with stakeholders, is creative within the bounds of good engineering practice, and fully documents all decisions, they will have gone a long way toward minimizing the risk associated with a future tort action should that occur.

As in the AASHTO Green Book, design values in this document are presented in both metric and United States (U.S.) customary units and were developed independently within each system. The relationship between the metric and U.S. customary values is neither an exact (soft) conversion nor a completely rationalized (hard) conversion. The U.S. customary values are those that would have been used had the figures been presented exclusively in U.S. customary units; the metric values are those that would have been used if the figures had been presented exclusively in metric units. Therefore, AASHTO advises the user to work entirely in one system and not attempt to convert directly between the two.

The experiences of states and other agencies that have led the way in context-sensitive design demonstrate many benefits. Incorporating meaningful public involvement; developing multiple, creative alternatives; and integrating environmental processes produce better context-sensitive solutions. The process, when applied successfully, is efficient in that it minimizes project delays and the need to re-design or re-study the project. In some cases, projects that have stalled or been shelved for long periods of time have been successfully completed through the application of context-sensitive design approaches. For these reasons, AASHTO encourages highway designers, transportation planners, traffic engineers, and others responsible for highway project development to familiarize themselves with the principles and concepts of context-sensitive design as outlined here, in the AASHTO Green Book, and in the Federal Highway Administration publication *Flexibility in Highway Design.*

chapter 1

The Project Development Process

The construction of a highway or street project is the culmination of a design process that is often lengthy, complex, and involves many agencies and individuals. During each stage of the process, important decisions are made that affect subsequent stages and the overall design outcome.

This chapter provides an overview of the entire highway project development process. It includes a discussion of the major stages of a highway project, background on the major inputs to highway design criteria and design, differences in types of projects, and the design decision-making process.

1.1 Overview of the Process

The highway project development process can be characterized as having four distinct stages, as illustrated in Figure 1-1. The four stages—concept definition, planning and alternatives development, preliminary design, and final design—generally apply to all projects from inception through construction and maintenance. Note that, depending on the size and complexity of a project, the overall process can take months to several years.

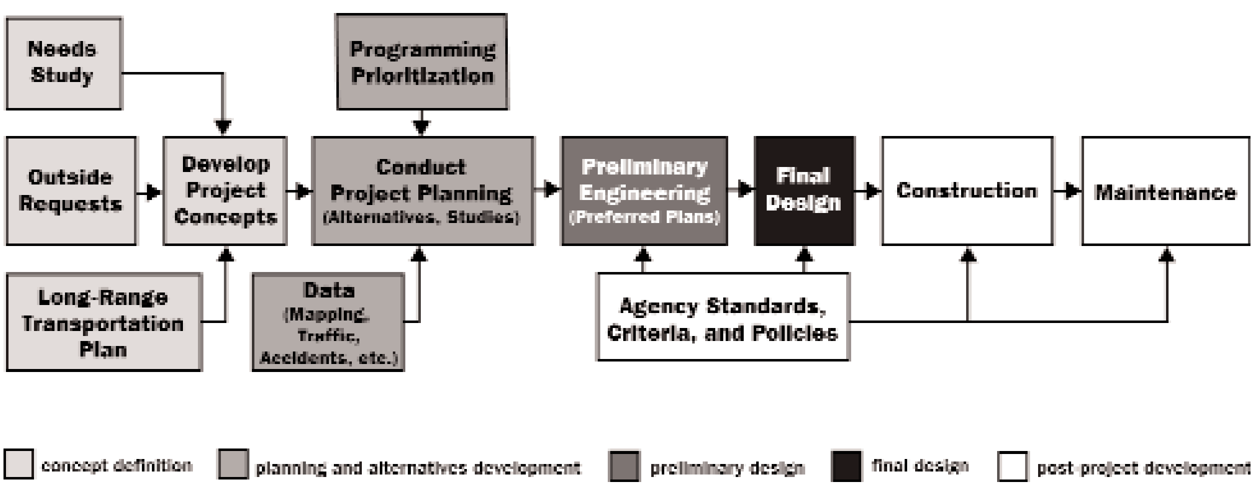

FIGURE 1-1
Typical Project Development Process

Departments of Transportation (DOTs) and other transportation agencies utilize a range of terminology to describe their process. The process outlined in Figure 1-1 and the terminology employed here are generally accepted. For the purposes of discussion, the process and terminology are as follows:

- ***Concept Definition***—The identification of a project, including its need, geographic limits, and other specifics to enable studies to begin.

- ***Planning and Alternatives Development***—The broad range of activities that result in the selection of a preferred plan that meets regulatory requirements and is sufficiently detailed to proceed with final design and construction.

- ***Preliminary Design***—The initial stage of the final design process to confirm right-of-way needs.

- ***Final Design***—Completion of design documents and specifications for construction of the project.

1.1.1 Concept Definition

In the *concept definition* stage, the purpose and need for a project or improvement is identified. Such need may come from regular performance monitoring (e.g., pavement condition, congestion, safety history), from a local governmental request made necessary by actions of others (e.g., in response to land use changes or development), by legislative direction, or by response to an emergency. Concept definition involves defining the need and purpose of an improvement, the limits of the project, and often the schedule and funding of the project.

A key to context-sensitive planning and design is developing a clear understanding during concept definition of the need for a project, which involves an understanding of the transportation problem and the context of the project area that requires addressing. In short, the concept definition stage represents an important decision of project stakeholders to take action by committing to solving a problem on a specific route or in a specified area or corridor. The details of the solution(s) are arrived at in subsequent project development stages.

1.1.2 Planning and Alternatives Development

The *planning and alternatives development* stages involve that part of the process in which alternatives are proposed and studied, environmental and community impacts are assessed, and decisions are reached about the key physical, environmental, community need, and operational aspects of the proposed project. *During this stage, the greatest opportunities and challenges for a flexible transportation solution occur.*

Once the purpose and need for a project have been determined with public input, design criteria are selected by the transportation agency and reviewed with the project stakeholders. Note that this occurs early in the overall project development process. The basis for the project design criteria will generally be the transportation agency's design guidelines. Project design criteria should recognize both the functionality of the roadway improvement (its use once it has been improved) and the values of the community.

During the *planning and alternatives development* stages, designers, working with planners, environmental specialists, the public, and agencies, have the greatest latitude to propose, study, and evaluate a full range of alternatives. Clearly, it is during this stage of the project that the designer can have the greatest influence on the quality of the design, which includes not only its traffic-carrying capability and safety performance, but also its effects on the community and surrounding land uses.

The *no-build* or no-action alternative is usually considered during this stage. As the designers and community consider various plans, it is always possible that no acceptable solution will be reached that addresses the purpose and need.

Each *build* alternative proposed for the project must satisfy the purpose and need agreed to by the full range of stakeholders. This understanding should be forged in the earliest stages of the project and modified as needed during project development. Appropriate consideration should be given to the environmental, scenic, aesthetic, historic, cultural, and natural resources of the area in addition to serving the motorists and other users in a safe and efficient manner. Accordingly, special attention should be paid to developing and/or refining design alternatives, transportation solutions, or features that are consistent with local interests and values while still addressing the safety and operational needs of the facility.

FIGURE 1-2
Public Information Meeting at which Design Alternatives Are Being Shown and Discussed

The alternatives development stage normally includes key aspects of geometric design. A feasible alternative is one that meets the project's purpose and need and is considered constructable and maintainable within the social, economic, and environmental constraints of the project area. This determination normally requires that an alternative be developed to sufficient detail to enable reasonable resolution of construction costs, right-of-way requirements, environmental effects, and traffic operational quality. In most cases, the highway designer prepares a "functional" geometric plan for each alternative to enable such analyses. Thus, geometric design plays a substantive role in this early planning stage. (For more detail on geometric design elements, refer to Chapter 3.)

Incorporating public input into the project begins early on during the planning and alternatives development stage (Figure 1-2). Indeed, *context-sensitive* project teams make an effort to fully understand community values *before any concepts or solutions are proposed.* This assures that the project will be developed to represent the needs of the highway users (both local and through travelers), as well as the community at large. Insights gained from public involvement activities outline the needs and concerns of the community. Understanding and addressing such needs can result in early community buy-in for the project before it has advanced to a stage where further changes cannot realistically be made or the project becomes unacceptable.

Maintaining sufficient contact with the public throughout the alternatives development stage is essential to ensure that all issues surrounding an improvement project are addressed in its design. Some issues may reflect major concerns about the project in general; others may involve details for which little may be known until later in the design. Knowing that all issues have been raised and are being addressed greatly reduces the chance that an unforeseen issue with substantive effects is raised during later preliminary and final design stages. It may also reduce any tension that could arise from participants concerned that their inputs are not being properly considered.

Appropriate and efficient incorporation of public involvement requires careful planning and execution, similar to other elements of project development. A complete discussion of public involvement in the design process is provided in Chapter 2.

Feasible alternatives must also meet environmental regulatory requirements. Thus, close coordination with many resource and regulatory agencies is essential during this stage of work. Also, appropriate analyses to document the effects of proposed alternatives occur during this stage of the project.

The culmination of the planning and alternatives development stage is the selection of a preferred plan or solution by the transportation agency. This is often accompanied by the completion and acceptance of an environmental document and endorsement by local stakeholders.

1.1.3 Preliminary Design

Preliminary design occurs following the acceptance of a preferred plan, only after all alternatives have been considered. In this stage in the process, the geometric elements of the highway or street are developed to sufficient detail to firmly establish their impacts and full right-of-way and construction requirements. The highway designer refers to agency design criteria, with all three-dimensional elements mathematically established. Field survey information is developed to sufficient detail to enable the definition of right-of-way, utility, and other information necessary to construct the project.

During preliminary design, the plan developed in the earlier planning stages is refined and adjusted to reflect greater knowledge learned about the location, including input on utilities, survey ties, specific concerns of property owners, etc. Design plans also evolve based on the consideration of constructability issues and maintenance of traffic during construction.

A project that has been carefully developed during the planning stages should not result in major, substantive changes in the preliminary design stage. Stakeholders, and in particular affected property owners, expect that the elements of the preferred plan described in the planning stage will be carried forward to design and construction.

At some point in the preliminary design process, the designer must prepare documentation of the design and significant design decisions. This may occur or begin at the end of the planning and alternatives development stage. Acceptance of a design value that is outside normal practice or design criteria of the project or agency must be highlighted and discussed in a document, which will support future inquiries of the agency about why the recommended solution was constructed.

The flexibility to address the design of a project in this context currently exists in the American Association of State Highway and Transportation Officials' *A Policy on Geometric Design of Highways and Streets (1)* (commonly known as the AASHTO Green Book) and in many state design manuals or guidelines. The use of ranges in most design criteria and the various functional classifications for a roadway provide design flexibility. Both motorized and non-motorized transportation modes must be considered in this stage.

1.1.4 Final Design and Construction

The *final design* stage of a project results in the production of complete plans, specifications, and construction bid documents of sufficient detail for the agency to contract for the actual construction of the project. Detailed aesthetic treatments are developed during this stage. It is common for some minor revisions to the plan to occur to save costs, improve constructability, and reflect refinements based on actual right-of-way acquisition negotiations and additional survey and mapping information. However, as with the preliminary design stage, the public, stakeholders, and affected property owners expect that the final plans will closely follow plans developed and presented in earlier stages and will follow the spirit of the commitments and decisions made in earlier stages.

It is vitally important that public involvement continue through this stage, as well as the stages that follow. It is common that seemingly minor field revisions be made during construction to design plans. Keeping the public abreast of such changes, and assuring that changes do not conflict with commitments or promises made during earlier project stages is essential. Indeed, for many projects, the most sensitive and potentially damaging stage of the work includes construction, when residents and business owners may be substantially affected by construction activities for many months. The public is interested in the timing of construction, detours, road closures and plans for maintaining traffic, and issues such as construction traffic, noise, dust, and other potential concerns. The public will also be interested in the impact of alternative transportation modes such as pedestrian, bicycling, and transit.

1.2 Philosophy of Geometric Highway Design

Geometric design is defined as the design of the visible dimensions of a highway, with the objective being the *forming* of the facility to meet the functional and operational characteristics of drivers, vehicles, pedestrians, and traffic. This is both a science and an art. Geometric design deals with features of location, alignment, profile, cross section, and intersections for a range of highway types and classifications.

The geometric form and dimensions of the highway should properly reflect driver safety, desires, expectations, comfort, and convenience. It should do so within the context of a host of constraints and considerations, including terrain, land use features, roadside and community effects, environmental effects, and cost considerations.

Central to the geometric design process is the application of design criteria and guidelines. Such criteria and guidelines provide acceptable dimensions or values for the purpose of producing a facility of a given quality (operational and safety) in a cost-effective manner. Experience has shown that the use of generally accepted practices and concepts and uniform design values can provide a reasonable degree of safety. A uniform approach to design provides a consistent "expectation" for the user (e.g., red light at the top of a signal indication, exit to the right, appropriate operating speed, etc.). This expectation is particularly important for the inexperienced driver, the older driver, the driver unfamiliar with the road or area, the distracted or inattentive driver, or the impaired driver. A uniform design approach also addresses the safety and other needs of pedestrians and bicyclists.

Designers are often required to be creative and sensitive in addressing the many facets of design to fit a particular situation. As designers respond to increasing concerns over community value and social, economic, and environmental constraints, the need for flexibility in the design process becomes more significant. Flexibility is best achieved by experienced design professionals in consideration of all known factors and related tradeoffs. Flexibility should not be viewed as a reduction in geometric criteria. Of course, in the pursuit of flexibility, the expected safety performance of the facility should be consistent with that expected of a design meeting published criteria.

For the above reasons, the final products of a well-executed design process may vary greatly between projects executed by different designers, even within the same agency, despite the fact that precisely the same set of design criteria is used. The difference may be based on differences in emphasis (e.g., producing the *lowest cost design* versus one with a higher degree of operational flexibility), the unique context of each location, the technical knowledge of the designer, and the amount of input from others in shaping the design. Clearly, designing safety and operational efficiency into highways is much more than applying and following conventional criteria.

The remaining parts of this chapter provide an overview of the factors that influence the highway design process and the thinking of designers. These include design controls, speed and design speed, types of projects and how designers should approach them, design constraints, and design decision making.

1.3 Design Criteria and Guidelines

The practice of geometric design is focused on design criteria. Design criteria are a collection of design dimensions, decision rules, and guidelines based upon formal research, past experience, and uniform driver expectation. The use of design criteria as a fundamental part of the practice of highway design is intended to provide consistency in the quality, appearance, and operational performance of the highway system. Such consistency is considered important, given that highway segments are designed and maintained by different agencies and individuals.

Design criteria reflect the collective knowledge from operational experience as well as the application of research. The basic criteria for geometric design of highways and streets are found in the 2001 AASHTO Green Book *(1)*.

The AASHTO Green Book *(1)* is intended for new construction of permanent roads and structures. Transportation Research Board Special Report 214, *Designing Safer Roads (3),* was developed to serve as a reference for use in the design of resurfacing, restoration, and rehabilitation (3R) projects. In addition, many states have developed their own criteria for 3R projects.

1.3.1 Historical Background

The design concepts and values found in the AASHTO Green Book *(1)* are based on established practice and research. AASHTO has become the focal point for basic geometric design practice in the United States. A national consensus emerged in the early part of the 20th century regarding the need for consistent highway design practice. As travel increased, the amount of constructed road mileage also increased. Over the years, as vehicles changed and operating speeds increased, motor vehicle crashes emerged as a concern and it became more and more evident that an organized, more rigorous approach to design was needed.

In 1914, the American Association of State Highway Officials (AASHO), as AASHTO was known prior to 1973, was created as an organization for state highway professionals to discuss practices. Since that time, it has served as the sponsor or steward for the evolution of highway design practice. Such design practice has evolved over the past 90 years in response to technological changes, the growth of the nation and economy, and social policy changes. Table 1-1 lists the evolution of AASHTO design guidance from 1938 to the present.

TABLE 1-1
Evolution of AASHTO (AASHO) Design Policies in the United States

A Policy on Highway Classification, September 16, 1938
A Policy on Highway Types (Geometric), February 13, 1940
A Policy on Sight Distance for Highways, February 17, 1940
A Policy on Criteria for Marking and Signing No-Passing Zones for Two and Three-Lane Roads, February 17, 1940
A Policy on Intersections at Grade, October 7, 1940
A Policy on Rotary Intersections, September 26, 1941
A Policy on Grade Separations for Intersecting Highways, June 19, 1944
A Policy on Design Standards-Interstate, Primary and Secondary Systems, 1945
Policies on Geometric Highway Design, 1950
A Policy on Geometric Design of Rural Highways, 1954
A Policy on Arterial Highways in Urban Areas, 1957
A Policy on Geometric Design of Rural Highways, 1965
A Policy on Design of Urban Highways and Arterial Streets, 1973
A Policy on Geometric Design of Highways and Streets, 1984
A Policy on Geometric Design of Highways and Streets, 1990
A Policy on Geometric Design of Highways and Streets, 1994
A Policy on Geometric Design of Highways and Streets, 2001

Source: *Traffic Engineering Handbook (2)*, Table 11-1

The AASHTO Green Book *(1)* was developed through the cooperative efforts of the AASHTO member departments (including the 50 states, the District of Columbia, and Puerto Rico), the Federal

Highway Administration (FHWA), and numerous research entities, including the Transportation Research Board (TRB), to enhance safety by providing uniform and cost-effective roadway features for motorists. As shown in Table 1-1, beginning with *A Policy on Highway Classification* published in 1938, AASHTO has developed numerous guides covering all aspects of highway design over the 60-plus years since the original policy. It is important to remember that following these guides can be affected by a need to consider alternative transportation modes, or to address environmental quality and social impacts (i.e., community values).

1.3.2 Research Basis

Incorporating ongoing research into highway design solutions is key toward assuring that concerns about safety, design risk, and liability are addressed. AASHTO design guidance is continually refined and revised based on results of research conducted at the state and national level. The National Cooperative Highway Research Program (NCHRP), administered through the TRB, has completed much research that directly addresses geometric design, safety, and traffic operations issues. The FHWA also conducts a substantial research program that contributes to the highway design knowledge base.

Research conducted nationally indicates what is acceptable, how acceptability is determined, and provides insights into the many ways that flexibility can be accomplished through the use of alternate or modified design criteria. Continual research on transportation issues provides additional data that will guide the selection of design criteria for future highway improvement projects and future revisions to the AASHTO Green Book *(1)*.

As research has been completed, lessons have been learned, and changes in the United States vehicle fleet and driver characteristics have occurred, AASHTO has responded by altering appropriate highway design criteria. For example, roadway width criteria, stopping sight distance design values, and roadside design approaches and design values have changed significantly over the years.

The evolution in design criteria continues to present challenges to designers dealing in particular with the reconstruction of existing streets and highways. Many such highways designed years ago met design criteria in place at the time they were built, but no longer meet current state criteria or criteria as published in the AASHTO Green Book *(1)* for new construction. This challenge is often difficult for the public to understand, particularly when a designer suggests that an improvement may be necessary to address a “non-standard” feature of a highway.

1.3.3 Intended Use of the AASHTO Green Book

Design guidance published in the AASHTO Green Book *(1)* reflect the consensus of AASHTO’s member departments regarding what constitutes good design practice nationally. In arriving at a consensus, AASHTO recognizes that each region or state has different conditions, constraints, and needs.

The AASHTO Green Book (1) is not intended, and never was intended, to be used solely as a standard upon which to base the design of every highway improvement. Rather, as is noted in the foreword of the Green Book *(1)*, “sufficient flexibility is permitted to encourage independent designs tailored to particular situations.” Such flexibility may be appropriate for a state wishing to use a different basis for design from that indicated in the AASHTO Green Book *(1)*, or for an individual designer working on a range of different projects.

The AASHTO Green Book *(1)* is clearly acknowledged within the United States highway profession as the definitive collection of geometric design values for highways. The FHWA has adopted the AASHTO Green Book *(1)* for use as a set of design criteria for new and reconstruction projects on the National Highway System (NHS). The NHS, a 160,000-mi (257,000-km) network of highways designated by Congress in 1995, provides a transportation network for national defense, commerce, intermodal connections, and interstate travel. The NHS includes the 46,000-mi (74,000-km) Interstate System. Although the NHS consists of approximately 4 percent of the nation's roads, it carries 42 percent of the travel.

Many states and localities have also adopted the AASHTO Green Book *(1)* for use as the basis of their state guidelines with no changes. However, the intent of the AASHTO Green Book *(1)* is that individual states, cities, and counties have the freedom to develop their own design guidelines and processes based on sound engineering principles that reflect local conditions and needs as well as the needs of the highway users. For such agencies, the design criteria in the AASHTO Green Book *(1)* can be a starting point or benchmark. Other published design criteria, such as that published by the Institute of Transportation Engineers, may also be referenced by an agency. The AASHTO Green Book *(1)* is thus a guide, a reference, and a basis for the development of an agency's guidelines. Terrain, climate, culture, values, and driving habits differ across the nation; what is good and acceptable in one location may not be satisfactory or practical in another. For example, AASHTO presents design criteria for horizontal curves with a full range of possible design values for maximum superelevation. The Green Book *(1)* does not prescribe or even favor one value over another. Rather, States are free to select one or more "maximum superelevation" values based on their climate, design preferences, or other considerations, and to design curves in their state accordingly. Thus, neighboring states may design curves differently from each other, yet both would be following the AASHTO "policy."

1.3.4 Background on Design Criteria

Designers and project stakeholders should understand the origin and nature of design criteria to enable good decisions about applicable project criteria and to assess potential design exceptions. This means understanding the functional basis for each design element, not just what the design values are.

Design criteria by their nature generally reflect a *safety conservative* philosophy within the context of overall cost-effectiveness. Acceptable design values for any feature are established to assure (to the best knowledge available) that the feature itself will not measurably contribute to increased risk of a crash. Thus, for example, design values used for stopping sight distance are generally greater than absolute values required for a driver to avoid a crash. Or, similarly, values for the width of a lane provide additional dimension beyond that necessary to avoid lateral conflicts with other vehicles. (We note here that many design values are established based not only on explicit safety considerations, but also to reflect other needs such as traffic operations, capacity, constructability, maintenance considerations, and other factors. Chapter 3 provides more background.) Such an approach to the development and use of design criteria is consistent with appropriate engineering principles for any significant infrastructure improvement. It is analogous, for example, to the safety factors included in typical structural designs for buildings.

The use of safety conservative criteria is appropriate as a general rule, given the permanent nature of the constructed alignment, and the difficulties and expense of correcting a design problem that results in poor safety performance. Designers must make many assumptions regarding design traffic and other conditions; their designs will be used by a wide range of vehicle types and driver capabilities; and the highway must perform safely under a range of environmental conditions. The road must also perform adequately for a constantly changing vehicle fleet. The public expects that designers will "get it right" the first time, and that the finished product will meet operational and safety expectations for a long time to come. Thus, the use of conservative design criteria is clearly appropriate as a foundation for highway design.

Designers may on occasion be confronted with a project in which, despite the best efforts to develop a creative design within the agency's criteria, an acceptable solution cannot be reached. Reaching an acceptable solution may require a designer to use a design value that is marginally outside normal design criteria. Only by understanding the actual functional basis of the criteria and design values can designers and transportation agencies recognize where, to what extent, and under what conditions a design value outside the typical range can be accepted as reasonably safe and appropriate for the site-specific context. This knowledge also allows the design professional to engage the public in an open discussion of what can and cannot be considered acceptable. Recognition can lead to creative yet safe designs when designers must look beyond the criteria due to a constraint or other site-specific problem.

For more insights in this area, refer to Chapter 3 for a discussion of the background behind design criteria for major highway elements.

1.3.5 Design Exceptions—Introduction

One important component of Federal and State regulation is the provision permitting the use of *exceptions* to established design criteria. A *design exception* is a statement of the rationale and need for a specific variance from an established geometric value, criterion, or guideline. The need for such exceptions may arise during the planning and preliminary design process, as alternatives are developed to greater detail and evaluated with input from the public and resource agencies. Put simply, it is sometimes the case that a design which meets full design criteria is unacceptable or unachievable for one or more reasons.

Exceptions to design criteria must be clearly justified by circumstances. Such circumstances should not be solely cost considerations, but should include unusual or significant site-specific constraints (environmental, land use) that preclude the use of normal design values. Design exceptions should be documented by the highway agency and the performance of these atypical designs monitored to assist in future decision making. When considering possible project components that may require design exceptions to the established design criteria, it is important that the resultant safety and risk aspects be 1) understood by the designer, and 2) properly communicated to project stakeholders.

Many designers are reluctant to use design exceptions because of concerns of agency and even personal liability in the future should a crash occur and a tort claim result. In the past 30 years, many state legislatures have given up sovereign immunity, opening agencies to the threat and actual occurrence of tort actions against their staff.

Tort law varies from state to state, and designers need to understand the prevailing laws and court precedents within their state or jurisdiction. The reader is directed to Chapter 4 of this guide for more insights on tort law. With respect to design exceptions, tort risk, and *flexibility* in design, the experiences of many states suggests that sensitivity to tort liability risk should focus as much or more on the design process and best risk management practices as on the actual design decision. Most State courts will require only that the agency act in a reasonable manner and document the reasons for such action. Where tort suits alleging design defects are successful, often the problem is not necessarily the use of a design value outside the typical range, but the lack of documentation as to what alternatives may have been considered and why the design was adopted. Designers are encouraged to understand the laws of the state in which they practice their profession, and to incorporate full engineering analysis and documentation procedures as part of their design process.

The need for design exceptions is not new and is not inextricably linked to the concept of *design flexibility*. Designers should understand that design exceptions are an acceptable and indeed useful tool *when evaluated and applied properly*. Just as design exceptions should not be sought routinely, acceptance of a design exception should not be viewed as an admission of failure. It does not mean that the design criteria are inappropriate or that a resulting design is automatically less safe substantively than a traditional design. (The reader is referred to Chapter 3, in which technical guidance is presented discussing the relationship between design values and substantive safety risk.) Finally, in discussing design exceptions and criteria with stakeholders, designers should avoid labeling a value that is outside the norm as "unsafe" in the specific circumstances unless he/she has a clear understanding or evidence that this is so.

The resources of a multidisciplinary team including the public can be helpful in determining the context of an improvement project, and perhaps the need for considering design exceptions. Flexible design guidelines ensure that exceptions to established design criteria, when necessary, may be developed with frequent and consistent public involvement and that the transportation agency is responsive to shared community values to the extent possible. An advisory team made up of transportation officials, citizens, local government officials, and other interested individuals can consider the design criteria for a particular project. This advisory team, during consideration of the purpose and need and the established design criteria, can participate in the weighing of impacts of various design elements against community values and the functionality of the improvement.

The professional highway or traffic engineer should provide such a team with the insights and background on the sources of the criteria, latest research on safety effectiveness of the specific design dimensions or features, and a professional recommendation about what can or should not be tried. The advisory team can address appropriate design criteria and the needs of the public, consider alternatives, and make recommendations for consideration by the transportation agency. Of course, the transportation agency, charged with building and maintaining the highway and with the overall responsibility for public safety and expenditure of public funds, is ultimately responsible for the project's design criteria and actual project design. The transportation agency also has the responsibility to communicate conditions where it has the opportunity to accommodate a community's shared values in design.

A properly documented design exception process (which includes a crash analysis, benefit-cost analysis, and rationale for deviation from the guidelines), supported with meaningful and timely public involvement, is essential for agencies operating in the context-sensitive design environment. Documentation of design exceptions is among the most important steps to protect a transportation agency against potential tort liability stemming from a crash. Refer to Chapter 4 of this guide for more details on tort liability and design exceptions.

1.4 Highway Design Controls

The highway design process is driven by the establishment of fundamental design controls. These include factors outside the control of the designer (terrain, location, and climate); and other factors including the functional classification of the highway (as defined by its expected use), traffic characteristics (volume, vehicle mix), and speed.

As noted below, many of the fundamental design controls are selected or determined by the design team working with stakeholders and the public. Developing a flexible design begins with appropriate consideration of those controls for which a choice can be made.

1.4.1 Functional Classification

The functional classification and design speed are the primary factors in setting the highway design criteria. The functional classification should be based on the anticipated operation of the highway. Functional classification refers to the types of trips, the mix of drivers, and the role of the highway within the overall highway system. Higher-classification facilities (controlled-access freeways, major arterials) are designed to carry larger volumes of through trips at speeds as high as is practical. Such facilities carry greater numbers of unfamiliar drivers. They also are intended to carry more and larger trucks and commercial vehicles.

Great emphasis should be placed on striving for the highest quality of service for the higher functional class facilities. Creativity is essential in the design of such facilities to provide a context-sensitive design that falls within traditional design criteria. Designers and decision makers should generally be more reluctant to incorporate significant or repeated design compromises for major arterial highways or freeways.

Lower classification facilities such as collectors and local roads serve different functions, including access to adjacent land uses and collection of traffic for access to higher-classification roads. Local roads and collectors may tend to carry somewhat lower traffic volumes over shorter distances at lower speeds. Local roads are driven primarily by familiar drivers making repeated trips. For such facilities, designers can generally be more open to design exceptions to address or accommodate a local constraint.

Note that the *ownership* of a road or street should not be confused with its functional classification. In general, state DOTs will be responsible for the higher-class facilities. However, many local units of government maintain responsibility for arterial highways as well as local streets.

Also, note that a roadway's formal classification as *urban* or *rural* may differ from actual site circumstances or prevailing conditions. An example includes a rural arterial route passing through a small town. The route may not necessarily be classified as urban, but there may be a significant length over which the surrounding land use, prevailing speeds, and transportation functions are more urban or suburban than rural. Designers need to recognize such situations and apply common sense judgments in interpreting design criteria and developing appropriate solutions or design approaches.

Designers, the public, and decision makers must recognize the different highway types in shaping and refining design alternatives. While upgrading the functional classification is often done successfully through reconstruction, reducing the functional classification of a route is much more difficult. Merely re-designating or re-signing a route does not guarantee that actual traffic patterns and uses will change. Where reclassification of a route is sought, it is often necessary to implement the provision of a suitable alternative route, or discourage traffic through the use of traffic calming or similar techniques.

1.4.2 Terrain

The character of the terrain or topography in which a highway exists affects the longitudinal and cross section characteristics of the road. The design should be consistent with the terrain. Designers should acknowledge terrain features and limitations in making design decisions. Some of the AASHTO Green Book *(1)* design criteria are sensitive to terrain. For example, shoulder widths are typically reduced in mountainous terrain. Drivers generally respond to the terrain, operating at higher speeds where the terrain and alignment are flatter and more open.

Note that the actual terrain is a design control over which the design team has no control. However, in some cases, designation of the terrain for a project (which in turn affects the selection of design values) may be a judgment of the designer. Designers can enhance their flexibility within design criteria through careful consideration of the appropriate terrain designation for a given project.

In flat terrain, the horizontal and vertical alignment generally will not be severe. Typical design speeds are higher, and design controls for grade are more restrictive. In rolling to mountainous terrain, the topography produces increasingly greater demands on the designer, who should respond accordingly. Lower design speeds are often used in more difficult terrain; design criteria allow for the use of steeper grades and narrower cross section values in such terrain.

1.4.3 Location

The location of the highway influences driver perceptions, general speeds, and the design approach. The AASHTO Green Book *(1)* contains separate design criteria for roads in rural areas and urban areas. Urban areas typically have more constraints and the impacts are more severe. For example, right-of-way is typically much more expensive or simply unattainable in urban areas.

Driver expectations and behavior differ in urban areas versus rural areas. Volumes are generally higher and traffic denser in urban areas; drivers are more concerned with pedestrians, bicyclists, parked vehicles, etc. A greater proportion of the traffic stream represents familiar drivers. Conversely, in rural areas there may be a greater number of infrequent or unfamiliar drivers, but fewer pedestrians and cyclists. Note that speeds are generally higher on rural roads, although many urban freeways and major arterial highways operate at high speeds throughout the day.

1.4.4 Traffic Volume

Traffic—volume and composition—is among the most important design controls. The greater the volume of traffic using the facility, the more important are its operational and safety characteristics. Research has confirmed that the single greatest contributor to the risk of a crash is traffic volume. Thus, the amount of traffic for which a highway is designed will be a primary factor in decisions on design exceptions or atypical design approaches.

A highway facility is designed not just for current traffic, but also expected or projected traffic over the life of the highway (20 years hence or longer). The volume of traffic at any point in time will vary significantly. Normal design practice calls for a *design hourly volume* (DHV) to be established, upon which the operational and geometric characteristics are based.

Designers should recognize that forecast traffic represents, at best, an estimate of what might occur on the road over a long period of time. A traffic forecast represents a technical analysis and policy consensus on the type and developed intensity of land use, the state of the highway network, future regional economic activity, presence of transit service, the needs of pedestrians and cyclists, and many other factors, all of which can vary or change significantly over time.

Design-year forecasts should not be viewed as certain or precise; context-sensitive design recognizes the inherent limitations and uncertainties of such forecasts.

Designers have some latitude in determining what levels of traffic may be appropriate for design. Most travel demand models predict a daily volume; translating average daily traffic (ADT) forecast to DHVs requires additional data and some judgment.

Figure 1-3 shows a typical cumulative plot of traffic volumes on an hourly basis, showing the highest hourly volume of a given year through lesser hourly demands. A designer may choose to design for the 30th or 50th highest hourly volume, which is a common approach for rural areas; or, as is common in suburban and urban areas, the 100th or even 200th highest hourly volume.

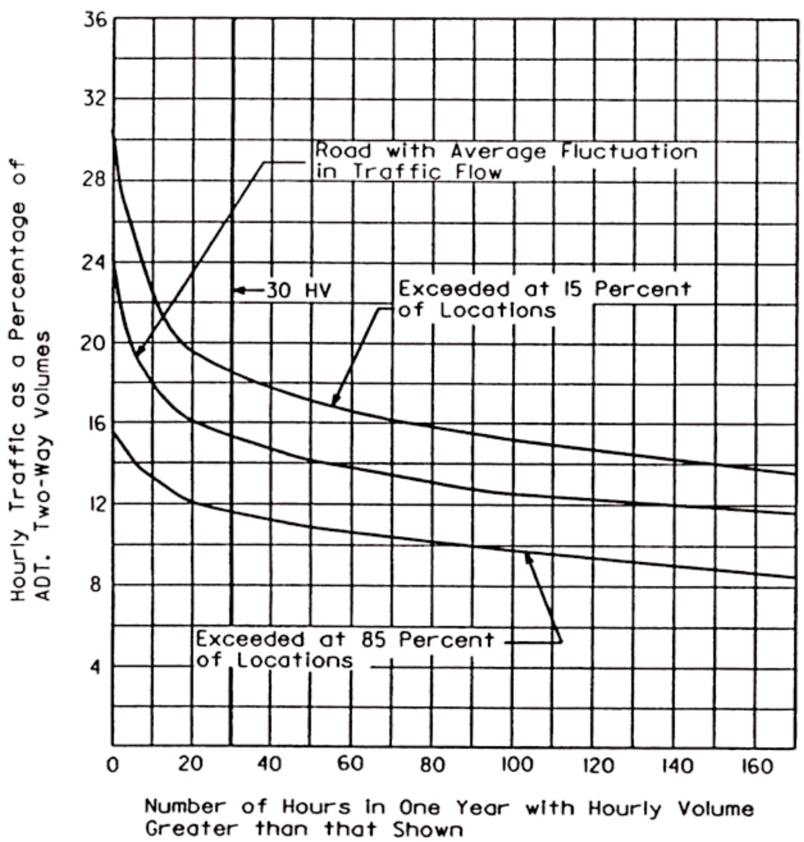

FIGURE 1-3
Alternative Design Hour Volume Curves

Accommodating a higher hourly volume may mean committing to a larger and more costly facility, and one with potentially greater adverse impacts. Judicious selection of a lower hourly volume (say, 100th versus 50th) may mean that a few more hours during the year will not be accommodated by the design at the intended level of service, but that the overall design will be sufficient during most of the year.

Designers should recognize that the selection of a DHV is an engineering decision that is independent of the other constraints and controls. Accompanying the determination of design hour traffic is the level of service to which the facility will be designed. The selected design level of service should reflect the project's purpose and need.

1.4.5 Level of Service

Part of the design process involves the selection of the *level of service* the facility should accommodate. Level of service is defined as a qualitative measure describing the operational conditions within a traffic stream and their perception by motorists and/or passengers and other transportation users. Conditions such as speed, travel time, freedom to maneuver, traffic interruptions, and comfort and convenience are used to describe levels of service.

Measures of level of service differ for each different highway type and element. Levels of service are characterized as A (free flow, little delay) through F, (breakdown, forced flow, representative of conditions where arriving traffic exceeds the capacity of the highway or highway feature), with level of service E representative of operation at capacity. The definition of level of service varies with the type of highway (two-lane rural, multilane arterial, freeway) and the highway segment in question (signalized intersection, ramp terminal, weaving section.) The reader is referred to the *Highway Capacity Manual* (TRB Special Report 209) *(4)* for details and background on technical procedures for determining level of service for the range of highway types.

The selected, specified level of service to be provided for the design hour traffic is a primary design control. Design levels of service traditionally relate to expectations of the public in the areas where the facility is located. Higher levels of service are generally expected in rural and less densely populated areas. In larger cities and developed suburban areas, the public expects or tolerates more congestion and lower levels of service.

The AASHTO Green Book *(1)* and many agencies provide general guidelines on design levels of service for different conditions. See Table 1-2 for recommended AASHTO levels of service. *Note, however, that these are for guidance only*. Failure to achieve a level of service indicated by Table 1-2 does not constitute a *non-standard* design decision. Indeed, it is common practice in major metropolitan areas to routinely design for certain levels of congestion (level of service D or E), recognizing the impracticality of constructing a highway or highway network to accommodate all potential future vehicle demand. Indeed, the AASHTO Green Book *(1)* includes discussion of the implications of and recommendations for designing for congestion, thus implying recognition of the practical problems associated with always providing a certain minimum level of service.

Selection of a design level of service represents an important design control that is a choice of the project team. This choice should be made carefully, with the input and understanding of the community and all stakeholders, and with reference to the project's purpose and need. In some cases, environmental regulatory requirements may affect this choice (e.g., for projects or locations in which demonstrated improvements to air quality are necessary). A flexible or context-sensitive approach for a project acknowledges the need to tailor the level of service to other design controls and constraints within the context of the project's purpose and need.

TABLE 1-2
Guide for Selection of Design Levels of Service

	Type of Area and Recommended Level of Service			
Highway Type	**Rural Level**	**Rural Rolling**	**Rural Mountainous**	**Urban and Suburban**
Freeway	B	B	C	C
Arterial	B	B	C	C
Collector	C	C	D	D
Local	D	D	D	D

Note: General operating conditions for levels of service
A—Free flow, with low volumes and high speeds.
B—Reasonably free flow, but speeds beginning to be restricted by traffic conditions.
C—In stable flow zone, but most drivers restricted in freedom to select their own speed.
D—Approaching unstable flow, drivers have little freedom to maneuver.
E—Unstable flow, may be short stoppages.
Source of table: Exhibit 2-32 in the AASHTO Green Book (1)
Source of notes: *Highway Capacity Manual* (4)

1.4.6 Design Driver and Vehicle

Highway design is generally based on the assumption that drivers are competent and capable. However, certain design criteria are based on relatively conservative assumptions regarding the capabilities of drivers to perceive and react to stimuli. Thus, design values for, as an example, braking at a sight restriction, are based on human factors and a capability that the vast majority of drivers exceed. This is necessary to accommodate the demands of a fatigued, inexperienced, or older driver who may be slower to react than most. The physical and operational characteristics of the design vehicle also influence certain aspects of the highway. Acceleration and deceleration capabilities, speeds achieved on upgrades, swept-path dimensions of turning vehicles, and height of the driver's eye are all design vehicle dimensions of interest.

AASHTO defines a range of *design vehicles* and their characteristics. There is no mandated use of any particular design vehicle for a project. The selection of an appropriate design vehicle should be made carefully with knowledge of the tradeoffs involved (especially with respect to the safety and overall operation of the facility) and input from the public. Designers should select an appropriate design vehicle that represents a cost- and space-effective choice for that project and location. As Figure 1-4 illustrates, for example, a transit bus may represent a reasonable design vehicle, given that the intersection is part of a regular bus route. Selection of a larger semi-trailer as a design vehicle may result in unacceptable impacts to sidewalks and neighboring properties.

FIGURE 1-4
Transit Bus May Be Appropriate Design Vehicle for Urban Intersection Design

1.5 Speed—A Fundamental Input to Design

Speed is among the fundamental inputs to design. The design of most of the elements of the highway is predicated first on the establishment of an assumed speed. The concept of *design speed* evolved and was eventually adopted by most AASHTO members by the early 1960s.

AASHTO has recently adopted a new definition of design speed:

> *Design speed is a selected speed used to determine the various geometric features of the roadway. The assumed design speed should be a logical one with respect to the topography, anticipated operating speed, the adjacent land use, and the functional classification of the highway.*

Traditional practice is to provide as high a design speed as is practical. This approach is consistent with the underlying premise that drivers wish to minimize their travel time and delay, and hence desire to travel at as high a speed as they feel comfortable and safe. Indeed, many designers consider design speed as a surrogate for design quality, with use of higher design speeds being considered the best or safest possible approach.

In the context-sensitive environment, particularly in urban areas, great care is suggested in selecting a speed that is reflective of local conditions and driver expectations, and which will not result in substantial problems or costs during execution of the design.

1.5.1 Selecting a Design Speed

The AASHTO Green Book *(1)* recommends that the selected design speed should accommodate a high percentile of drivers, including the reasonable and prudent driver. It is also important that design speed be consistent with driver expectations. Typically, the higher the functional classification, the higher the design speed.

The AASHTO Green Book *(1)* provides recommended ranges of values; however, it also states that where significant constraints are encountered, other appropriate values may be employed. Note that a relatively wide range of design speeds may be appropriate for a given highway type, location, and topography, as indicated in Table 1-3. The provision of a range in design speeds, combined with general guidance on selection of a design speed as noted above, represents perhaps the greatest flexibility afforded the designer by the AASHTO Green Book *(1)*. It is the intent of AASHTO that designers exercise judgment in the selection of an appropriate design speed for the particular circumstances and conditions.

TABLE 1-3
AASHTO Recommended Ranges in Design Speeds

	Type of Area and Appropriate Design Speed—mph (km/h)			
Highway Type	**Rural Level**	**Rural Rolling**	**Rural Mountainous**	**Urban and Suburban**
Freeway	70 (110)	70 (110)	50–60 (80–100)	50–70 (80–110)
Arterial	60–75 (100–120)	50–60 (80–100)	40–50 (60–80)	30–60 (50–100)
Collector	40–60 (60–100)	30–50 (50–80)	20–40 (30–60)	30 (50) (or higher)
Local	30–50 (50–80)	20–40 (30–60)	20–30 (30–50)	20–30 (30–50)

Source: AASHTO Green Book *(1)*

When determining the appropriate design speed—in addition to topography, anticipated land use, and functional classification—the designer should also consider the volumes and composition of the expected vehicular and non-vehicular traffic, the anticipated driver characteristics, and driver familiarity with the route. The designer should consider expected operations throughout the day, including both peak and non-peak hours. Indeed, off-peak traffic flow will generally control the selection of a reasonable design speed. The design speed may vary for any given route as it traverses rural, suburban, and urban areas.

Once these factors have been evaluated and an appropriate design speed determined, the geometric elements should be designed consistently to that level. Where this is not possible for one location or design element, a design exception may be justified.

Current accepted practice is to determine the design speed from observations of the existing or anticipated speed distributions of traffic traveling in fair weather in the off-peak hours. This practice reflects the need to accommodate the speeds of most (but not all) drivers. It also addresses the desirability of meeting the expectations of drivers based on the roadway environment. Numerous studies have indicated that reasonable and prudent drivers, as measured by the 85th percentile speed, will not significantly alter what they consider to be a safe operating speed, regardless of the posted speed limit unless there is constant heavy enforcement. In general, an appropriate design speed should be within approximately 5 mph (10 km/h) of travel speeds.

Higher design speeds impose greater challenges and constraints on designers. Designers faced with difficult or constrained conditions may consider selecting a lower design speed for an element or portion of the highway. This practice can cause problems in that a large number of drivers may not "behave" as the designer desires or intends them to. Designs based on artificially low operating speeds, instead of the anticipated operating speeds of the reasonable and prudent driver, can result in inappropriate geometric features that violate driver expectations and degrade the safety of the highway. The emphasis should be on the consistency of design so as not to surprise the motorist with unexpected features. Therefore, the design speed should not be based on the speed limit unless the speed limit is based on the anticipated 85th percentile operating speed or is otherwise considered reasonable given expected operating speeds or physical constraints of the built environment.

From the above, AASHTO recommends that designers not propose an alternative design speed for a highway or segment of a project as a design exception. A serious fundamental problem with accepting or allowing a *design exception* for design speed is based on its importance relative to all features of the highway. A reduction in the design speed may be unlikely to affect overall operating speeds. It will potentially result in the unnecessary reduction of all of the speed-related design criteria rather than just the one or two features that led to the need for the exception. The acceptable alternative approach to a design speed exception is to evaluate each geometric feature individually, addressing exceptions for each feature within the context of the appropriate or desirable design speed.

1.5.2 Design in the Lower Speed Environment

There are many situations in urban areas in which attempting to produce or design for lower speeds is appropriate. A low-speed environment is appropriate for residential streets, locations near schools and parks, and in downtown areas where there is considerable pedestrian traffic.

Given the historic equating of design speed with design quality, the notion of designing a *high-quality*, low-speed road is counter-intuitive to some highway engineers. Yet it is in many cases the appropriate solution to a sensitive neighborhood or other street design problem. The severity of pedestrian crashes, a significant concern in urban areas, is greatly increased as speeds increase. Context-sensitive solutions for the urban environment often involve creating a safe roadway environment in which the driver is encouraged by the roadway's features and the surrounding area to operate at low speeds.

1.5.3 Design Speed and Traffic Calming

Traffic calming is a growing concept that designers must increasingly consider. The term *traffic-calming* refers to a variety of physical measures to reduce vehicular speeds, primarily in residential neighborhoods. The lowering of operating speeds is often the appropriate solution to addressing safety problems. Such problems typically involve vehicle conflicts with pedestrians, bicyclists, and school children.

The above discussion on design speeds should not be construed as representing opposition to properly planned and designed traffic-calming measures. (Research has shown that measurable reductions in operating speeds are possible for some projects as part of a traffic-calming effort.) A local road or street, and in some instances a state highway that functions as a local road or street, may have an existing operating speed far in excess of the speed limit or the desired operating speed. Consistent with the spirit and intent of the design speed discussion on pages 67–68 of the 2001 AASHTO Green Book *(1)*, it is acceptable and consistent with good engineering practice to develop a design that will lower the anticipated operating speed.

Great care must be exercised to ensure that the proposed design will actually reduce the operating speeds to levels consistent with the safe operating speed for the design. The burden is on the individual designer of a traffic-calming feature to document a reasonable expectation that the proposed measures will reduce the operating speed.

The devices that may be used include geometric alternatives such as the introduction of a series of horizontal curves, signing, traffic-calming devices consistent with the new anticipated operating speed, and any other recognized and accepted technique with a proven track record for reducing speeds and maintaining safety. Once the design is complete, careful monitoring of the performance of the project should be undertaken to assure that speeds have indeed been reduced, and to provide valuable lessons for future traffic-calming projects.

Chapter 3 provides more detail on tools and techniques for traffic calming.

1.6 Project Types

In addition to maintenance activities, which constitute the majority of projects undertaken by a state transportation department, agencies typically construct three types of projects. These include:

- New construction (which may involve a roadway on new alignment or major widening or improvement to an existing facility)
- Reconstruction of existing highways
- Resurfacing, restoration, and rehabilitation (3R) projects

Differences among the three types can affect the outlook and decisions about design alternatives.

1.6.1 New Construction

For new roadways or highways on new alignment, the design process involves the evaluation of multiple possible corridors. A new alignment may be sought to serve newly developing land uses, as a bypass of an existing town, or as part of an integrated development plan. New corridor projects often involve the replacement of an older, lower capacity facility such as a two-lane highway that remains for local use, but where through traffic is relocated to a similar or larger highway on a different alignment.

The design process for new alignment corridors involves the identification of right-of-way within which the new road can be constructed. A *space-conservative* approach in the location process is recommended to select such corridors for a number of reasons. First, there is, by definition, no existing highway and no history of operational or safety problems such as speed observations or crash history upon which to base design decisions. This means, among other things, that the designer has less assurance that a design exception will be operationally acceptable for the specific site conditions. Second, projected travel patterns and forecast design volumes are less certain. Design-year traffic forecasts for new routes can be off by 50 percent or more. Third, designers seeking new rights-of-way have more latitude and more options for selecting alternative corridors. In these cases, every effort should be made to select and evaluate corridors where design exceptions will not be necessary.

1.6.2 Reconstruction of Existing Highways

For projects involving the reconstruction of an existing highway, greater flexibility in the design approach is often necessary. Constraints are generally much greater, resulting in greater impacts and costs. This is particularly true where an existing highway is being widened, and available right-of-way to accomplish such widening is limited or very expensive. In effect, the designer has only one corridor in which to work, and must arrive at an acceptable solution within that corridor regardless of the nature and severity of constraints.

Major reconstruction implies substantial changes to the three-dimensional features of the highway. Many reconstruction projects involve capacity expansion, such as widening from two lanes to four lanes. As noted previously, the geometry of many older highways does not meet current criteria. Existing corridors are typically constrained, leaving few opportunities to upgrade their alignment. Nonetheless, the design criteria contained in the AASHTO Green Book *(1)* are intended to apply to reconstruction projects.

Designers considering existing alignments should have a much more complete knowledge base about the existing road, which should be useful in making decisions about design exceptions or special, project-specific design criteria. There should be, for example, a well-documented history of traffic volumes and crashes over recent years, enabling good understanding of the actual safety and operational performance of the road given its current geometric conditions. It should be possible to conduct speed and travel time studies to relate the posted speed and typical or desired design speeds to the actual location. This knowledge base provides greater confidence in assessing and correcting existing problems, determining appropriate design speeds, and assessing design exceptions.

Design criteria for such reconstruction projects may appropriately reflect the unique project-specific conditions. Thus, for example, it may be acceptable to retain existing vertical alignment characteristics, even where these are determined to not meet current, full agency design criteria.

1.6.3 Resurfacing, Restoration, and Rehabilitation (3R) Projects

For non-Interstate projects involving resurfacing, restoration, or rehabilitation, achieving AASHTO Green Book *(1)* criteria is not required. Such projects by definition do not include substantive changes in the geometric character of the road, but a very important consideration is that they enhance safety. Most agencies utilize special design criteria for 3R projects. Criteria generally reflect an acceptance of existing features regardless of whether they meet current agency criteria for a new highway. Of course, an important consideration in retaining an existing design dimension for 3R projects is the safety and operational performance of the existing road.

The reader is referred to TRB Special Report 214, *Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation (3)*, which documents design criteria and approaches to the design of such projects. Also, many states have adopted their own 3R guidelines.

1.7 Design Constraints

Highway designers are confronted with a significant number of design constraints, opposing interests, and public demands for producing and delivering programs. Traditional constraints include those associated with the cost of construction, such as topography and terrain, or right-of-way restrictions. Design in the context-sensitive environment recognizes other constraints for which it may be difficult to assign a cost, but which nonetheless are considered important constraints by the community. Examples include access to farmland, protection of valued monuments or other civic symbols, avoidance of impacts to particular land uses, and provision of additional amenities for pedestrians and residents of the area.

Finally, there are many constraints associated with the adherence to national and/or state policies on environmental protection. Appendix A summarizes environmental regulations and the related issues that also become constraints on the designer.

It is the responsibility of the designer, working with other professionals, resource and regulatory agencies, local governments, and the public, to fully identify, understand, and address all project constraints.

1.8 Design Decision Making

The actual decision-making authority for a project action rests with the agency that has been entrusted with the ownership, management, and operation of the completed project. Transportation agencies responsible for the highway network have a duty to the public as a whole to make decisions that reflect the overall public good. This necessarily involves weighing tradeoffs and applying judgments about resource allocation that extend beyond the limits of the particular project. Decisions must reflect the needs of users of the highways, most of whom will never play a direct role in the project development process. Decisions must reflect overall agency constraints and competing needs for resources. Decisions are not the result of a “vote.” This is especially important for decisions primarily associated with highway safety, since only professional engineers should make such decisions.

With such decision-making authority rests a responsibility for decisions to be made openly, to be clearly explained, and to be defensible. Transportation agencies should institute a decision process and end result that is open and defensible to the public who will fund the project, use the project, and live with the effects of the project. Decision making must not be or appear to be arbitrary or secretive, and must be consistent and fair. A successful, context-sensitive project is one in which an understanding has been reached among all stakeholders regarding an action that addresses the purpose and need.

1.9 References

1. AASHTO. *A Policy on Geometric Design of Highways and Streets*. American Association of State Highway and Transportation Officials, Washington, DC, 2001.

2. ITE. *Traffic Engineering Handbook*. 5th ed. Institute of Transportation Engineers, Washington, DC, 1999.

3. TRB. *Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation*. Special Report 214. Transportation Research Board, National Research Council, Washington, DC, 1987.

4. TRB. *Highway Capacity Manual.* 3rd ed. Transportation Research Board, National Research Council, Washington, DC, 2000.

chapter 2

Context-Sensitive Solutions through Community Involvement

2.1 Introduction

The increasing interest and involvement of the general public and special interest groups in transportation projects can be traced as part of a long-term trend or focus on concerns about the environmental effects of public works projects. Beginning in 1969, the National Environmental Policy Act required federally-funded projects to undergo thorough analyses of their impacts to both natural and human environmental resources. Since that time, Congress has enacted a series of policy acts and regulations to strengthen and increase the commitment to environmental quality. In 1991, Congress strengthened the federal commitment to preserve historic, scenic, and cultural resources as part of the Intermodal Surface Transportation Efficiency Act (ISTEA). Section 1016(a) of ISTEA provides approval for transportation projects that affect historic facilities or are located in areas of historic or scenic value only if these projects are designed to standards or mitigation measures that allow for the preservation of these resources.

Thirty years of history in national environmental policy making reflects increasing public interest and concern about the effects of transportation projects. The general public and local officials now frequently question not only the design or physical features of a project, but also the basic premise or assumptions behind the project as put forth by the agency.

Many transportation agencies have responded positively to this trend, often producing high-quality solutions sensitive to community values. However, in many instances, conflicts have arisen between an agency's proposed solutions and the perceived impacts of the proposed project on the community and on valued scenic, historic, or other environmental or community resources. As a result, a great number of projects around the country have been significantly delayed or stopped, not for lack of funding or demonstrated transportation need, but for lack of agreement that the proposed solution would meet community and other non-transportation needs.

In response to these trends, recently enacted federal legislation (ISTEA in 1991; the National Highway System (NHS) Designation Act in 1995; and the Transportation Equity Act for the 21st Century (TEA-21) in 1998) and national publications (AASHTO's *Design Flexibility Case Study Report,* 1997; FHWA's *Community Impact Assessment,* 1996; FHWA's *Flexibility in Highway Design,* 1997; and FHWA's *Community Impact Mitigation: Case Studies,* 1998) have encouraged more flexible and creative approaches to project development. The 1995 NHS Act is the most recent, notable legislation that now affects how certain highway projects should be developed.

The NHS Act emphasized, among other things, flexibility in highway design to further promote preservation of historic, scenic, and aesthetic resources. This act provided funding capabilities for transportation enhancements and supported applications to modify design guidelines for the purpose of preserving important historic and scenic resources. Most importantly, it extended these considerations to federally-funded transportation projects not on the National Highway System.

A central theme in both recent legislation and publications is the encouragement of meaningful involvement of the public and others as a project is being developed. Transportation agencies now recognize that the process of developing and evaluating design alternatives, and selecting a preferred alternative to implement, is no longer (if it ever was) solely the responsibility of the agency. There are other *stakeholders*—those affected by the presence or features of the highway, including communities through which it passes, abutting landowners, businesses, and the users of the highway. These stakeholders expect to have a say in the process by which the highway project is studied and decisions are made.

Every project has a unique *context* comprised of the cultural, environmental, socioeconomic and physical features of the corridor and surrounding area. A primary goal of those within the transportation agency involved in project development should be to understand the context of the project area. The challenge is to recognize that not everyone will look at a project from the same perspective. Indeed, engineers, planners, landscape architects, other design professionals and external stakeholders will often view a project's context with distinctly different perspectives.

Utilizing the team approach enables a more thorough understanding of the project's true context. This understanding is essential before beginning any preliminary design activity. Note that identifying a project's context and the values of those in the community are important regardless of the project size or scope, or the environmental process (categorical exclusion [CE], environmental assessment [EA], or environmental impact statement [EIS]) to be followed. Achieving a context-sensitive solution requires interaction with the community, even for seemingly "small" or "routine" projects.

Key to understanding the project area context is the gathering of information from those who are familiar with the project area and the transportation needs of the project area including, to the extent practicable, the through traveler. This is often referred to as the *community*. The community can provide valuable information for determining the transportation needs and deficiencies of the area while also defining community values. The public information process, a critical component of the project, is intended to do this. *Context-sensitive solutions* influence the design process for transportation projects through the explicit consideration of the community values and environmental resources of the project area in the identification of problems to be solved, alternative solutions to be considered, and evaluation of the alternatives. It is a way of balancing safety, mobility, and transportation needs with those of preserving scenic, aesthetic, historic, cultural, environmental, and community values. It brings affected community and resource agency stakeholders into project development to produce a project that reflects community values.

From the above, it follows that producing a true *context-sensitive solution* is possible only through early and effective public involvement integrated with all phases of the planning, design, and environmental process. Effective public involvement includes the planning and allocation of appropriate resources consistent with agency guidelines and specific project needs. The program must be tailored to the specific needs of the project such as size, scope, and level of effort. With the above in mind, it is clear that effectively obtaining and incorporating public input for transportation projects entails the following key steps, discussed in greater detail throughout this chapter:

- Identify all stakeholders and actively listen and consider suggestions for the project.
- Maintain timely and coordinated contact with stakeholders throughout the project.
- Commit to an open and creative approach to solving problems.

2.1.1 Identify All Stakeholders

Developing a context of the project area requires the early and ongoing involvement of a full range of project stakeholders, including each community that will be impacted by all project development decisions. Project stakeholders include those with a personal or direct interest in the project (e.g., potentially affected property owners, business owners adjacent to the project), residents in the vicinity of the project, community-based organizations (such as non-profits), and community interest groups (such as the local chamber of commerce). Stakeholders also include local units of government, Metropolitan Planning Organizations, and those with regulatory responsibilities, including agencies such as the U.S. Army Corps of Engineers, state departments of environmental protection, state fish and game commissions, and others. Staff from the transportation agency responsible for the project are stakeholders as well. Indeed, there are often multiple stakeholders within a DOT (design, traffic engineering, public relations, maintenance, construction) with often conflicting viewpoints or interests.

Users and beneficiaries of a proposed project are among the most important stakeholders, but are also typically the most difficult to identify and engage. These stakeholders may include local residents, but also pedestrians, bicyclists, and commuters who live and work beyond the project limits. They may also include business owners, operators of freight or other transportation services such as transit agencies, or general business interests. A necessary but often challenging task in stakeholder identification is assuring that potential users of the project or facility are properly included throughout the process.

Early identification and involvement of all stakeholders is essential in all phases of project development, including the planning process. Their involvement provides important input in defining and refining a project’s study area, and in establishing and refining a project’s purpose and need. Stakeholders also supply valuable information to facilitate the development of project alternatives that address identified needs and are sensitive to community and environmental resources in the project area.

The identification and engagement of stakeholders is extremely important and should not be viewed as a separate task outside the project development process. Rather, to be effective and efficient, it should be fully integrated with other engineering and environmental project development tasks.

2.1.2 Maintain Timely and Coordinated Stakeholder Input

Full integration of public and agency involvement means that all input and response to suggestions must be timely, coordinated, and specific to each project. This requires careful budgeting, scheduling, and commitment of appropriate resources. For some projects, it may be necessary to assign a person devoted solely to developing, guiding, and conducting community and resource agency coordination processes. For other projects, community and agency involvement tasks may be shared among project development team members. It is extremely important, however, that the project development team have the expertise (with the commitment to "see it through") in conducting the community and resource agency involvement process.

Community input to project development helps determine what is designed and built, and how it will meet the needs of those that will use the project and live within the project area. For this to occur, it is critical that the transportation agency be proactive rather than reactive to those interests expressed by the community. This requires careful coordination of public involvement activities with project technical work.

2.1.3 Commit to an Open, Creative Approach to Problem Solving

An *open approach* to problem solving implies engaging the public in the definition and consideration of both problems and opportunities, and also in helping to develop solutions.

Transportation agencies should be prepared to bring the full array of strategies (i.e., demand reduction, traffic calming, and transportation management systems, as well as traditional infrastructure design) as possible solutions in projects prior to meeting with the public. Solutions should also reflect multimodal opportunities. Discussion of these items at public meetings, their incorporation if appropriate, and a willingness to revise or refine the preferred alternative is often key to building support for the design or other solution proposed by the agency.

It is also important for the transportation agency to recognize the value their staff adds to the planning and public involvement process. Their experience and breadth of knowledge can help local governments identify and analyze reasonable alternatives within the framework of motorist and pedestrian safety. They can provide assistance to local interests in an effort to consider the wide range of concerns of their community. Most importantly, they can be the major source of information for weighing and assessing the significant cost, safety, operational, environmental, and right-of-way tradeoffs that are inevitable in context-sensitive projects.

This chapter describes the process, tools, and techniques useful to a transportation agency to effectively and efficiently involve the public and other affected agencies and individuals in the environmental planning process for transportation projects.

2.2 Establishing Purpose and Need

Defining the purpose and need for a project is the first, fundamental step in the overall project development process. Central to this concept is the understanding by all stakeholders that a transportation problem has been identified, and an agency is committing resources to address that problem. Context-sensitive solutions require first asking questions about the purpose and need for a transportation project, then addressing safety, mobility, and transportation needs along with consideration of the preservation of scenic, aesthetic, historic, cultural, ecological, and community values. The resulting transportation project should satisfy the purpose and need as agreed to by a full range of project stakeholders, should result in a safe and efficient facility, and should be an asset to the communities through which it passes. Each project should be developed to achieve a level of excellence in people's minds by integrating community values whenever possible; but project development efforts should always remain within the context of the project's purpose and need.

Only after a clear understanding has been reached by all stakeholders regarding the need for the project, including what transportation issues and problems it is intended to address, can progress toward problem solving and actual implementation occur. The communities within the project area should therefore be involved in identifying the purpose and need for a transportation project as early as possible. This involvement continues into later phases of the project. Once project development activities are underway, community involvement becomes an integral part of the process that shapes the preliminary and final design of the project within the context of the agreed upon purpose and need.

Project needs can stem from any number of sources. These may include maintenance or improvement of pavement and structures conditions, response to observed traffic operational problems, reaction to an emerging safety problem, requests from local units of government, response to changes in land use and resultant travel demand shifts, or the execution of an element of a region's long-range plan. Initial needs identification can come from transportation agency personnel or from ongoing activities, from requests by local units of government, and even in response to complaints or concerns raised by the general public.

Whatever the reasons or source of the project, the project's purpose and need must consider the larger regional needs in addition to the project's immediate local area needs. Indeed, for many projects involving arterial or other higher-classification facilities, often the greatest need and potential benefit is attributable to those who may be least likely to provide specific input to the project—the users of the highway, many of whom may live away from the corridor. In the end, the study alternative that is designed and constructed will reflect an acceptable balance between traffic operations and the adjacent community, land uses, and affected property owners.

Each community within a project area should become involved in developing and refining the project's purpose and need, identifying their own community values, identifying and assessing transportation impacts on the community, and identifying avoidance, minimization, mitigation, and enhancement opportunities for the project. This level of active public involvement will result in better assessments and project decisions that reflect community values. In addition, community involvement enhances the credibility of the impact assessment process and its outcome.

Project purpose and need discussions involving the community can be handled in a variety of ways. These can range from informal information-gathering sessions to formal public meetings conducted by transportation departments. Meetings held early in project development can be used to provide the community with background on known traffic congestion or safety problems, corridor traffic forecasts, and their expected effect on future congestion. These help explain the agency's perspective on problems and needs, and set the stage for discussions about potential solutions. Project development teams should take advantage of any and all methods to interact with the local citizens, public officials, etc. Efforts should focus on gathering data, developing a rapport with the local community, and obtaining a sense of what solutions to the identified transportation needs should be in the context of the adjacent community.

2.3 Conducting Project Scoping

Once the need for a transportation project has been identified, it then becomes important to develop early consent concerning the specific environmental issues that will be addressed during development of the project. Project scoping involves the community, regulatory agencies, environmental resource agencies, and other affected groups. Project scoping focuses the early participation of resource and other agencies that will be responsible for input, review, and issuing permits for one or more aspects of the project. The identification of key environmental resources and issues, agreement on how they will be studied or addressed, the sources of data and methods for the assembly of data, and an understanding of each group's priorities and concerns are all part of the scoping process. A well-executed scoping process solicits early thoughts from each agency's representatives about what to prepare or look out for, what are or will be key issues, and how serious potential conflicts with a resource may be. It also includes discussion and acceptance of a project schedule, with agency representatives understanding the timing of review documents and committing to help the transportation agency meet its overall schedule. Table 2-1 shows the agencies typically involved in scoping for a highway project.

The scoping process begins the partnership efforts of the project team and all stakeholders and decision makers. Recognition of the need for participation by environmental and community groups, together with the project team, will enhance chances for successful on-time completion of a context-sensitive solution.

2.4 Building an Effective Public Involvement Program

To ensure truly effective project development, all transportation stakeholders, as well as state and local DOTs, must recognize the value and importance public participation adds to the transportation decision. Both the public and the transportation agency should engage in a broad range of activities to provide public outreach and involvement opportunities. These may be in conjunction with general transportation issues, the development of long-range transportation plans and multi-year improvement programs, or the implementation of specific projects.

Meaningful public involvement of citizens, local officials, and public agencies is one key element to a successful project. All parties' involvement in two-way discussion begins early, is sincere, is timely, is focused on the project, and is continuous. Good public involvement ensures that those who choose to participate and become involved know the problems to be solved, identify local items of value, and provide input to the possible solutions. Effective public involvement assures the public is not surprised by the construction of the project, and encourages public support for the operation of the transportation facility.

2.4.1 Develop a Public Involvement Plan

Effective public involvement does not just happen—it must be carefully planned, budgeted, and managed with the same attention to detail and execution as other elements of the project.

A key early phase in the management of a project is the development of a public involvement plan. This plan should lay out in clear terms how the agency will interact with the stakeholder community.

TABLE 2-1
Resource and Other Agencies Typically Involved in Project Scoping

U.S. Environmental Protection Agency (EPA)—The EPA has jurisdiction over air quality, wetlands, special waste, water quality, and NEPA documentation. Directly coordinated work includes review of NEPA documents. Of special note is the EPA's authority to veto Section 404 permits.

U.S. Army Corps of Engineers (Corps or USACE)—The Corps' jurisdiction includes work in waters of the United States, including rivers, streams, and wetlands. Coordinated work includes bridge and culvert replacements and repairs, fill or dredging in wetlands, and scour protection.

U.S. Department of the Interior, Fish and Wildlife Service (FWS)—The FWS has jurisdiction over federally listed threatened and endangered species. Coordinated work includes requesting review of Section 404 permit applications, review of field studies for threatened and endangered species, and development of mitigation plans.

Natural Resources Conservation Service (NRCS)—The NRCS has jurisdiction to delineate wetlands within agricultural areas per an agreement with the Corps of Engineers. However, they do not issue permits for impacts to these wetlands.

U.S. Department of Transportation—Federal Highway Administration (FHWA)—The FHWA has design approval authority over the design of highways on the National Highway System and other federally funded highways built and maintained by state and other agencies.

Other agencies with potential involvement may include:

National Park Service (NPS)—The NPS should be involved when projects pass through national park lands.

Metropolitan Planning Organization (MPO)—MPOs are responsible for the development of their urban area's transportation plan, in concert with local units of government and the state DOT.

U.S. Department of Housing and Urban Development (HUD)—HUD has jurisdiction over environmental justice issues.

U.S. Department of Transportation—Federal Aviation Administration (FAA)—The FAA may be involved for roads and highways serving or in proximity to airports.

U.S. Department of Transportation—Federal Transit Administration (FTA)—The FTA may be involved for matters related to public transit.

State Department of Natural Resources (DNR)—The state DNR is responsible for state-listed threatened and endangered species and wetlands. Coordinated work includes all work outside existing rights-of-way, work in streams and rivers, and work in wetlands.

State Historic Preservation Office (SHPO)—The SHPO has jurisdiction over historic and prehistoric resources, including buildings, bridges, and archaeological remains. Coordinated work includes review of Section 404 permits, impacts to non-ISTHA buildings, and work outside existing rights-of-way.

State Department of Agriculture (DOA)—The DOA is responsible for agricultural land within a given state. Coordinated work includes impacts to prime and important farmland.

State Environmental Protection Agency (EPA)—The state EPA is responsible for water quality and special waste. Coordinated work includes Section 401 and review of Section 404 permits, stormwater runoff from construction sites (NPDES permits), municipal separate stormwater (MS-4) permits, and leaking underground storage tanks.

A public involvement plan is, in effect, a blueprint of all project activities related to the project. The public involvement plan should clearly specify individual responsibilities, planned staff and other resources, and the roles of agency and any consultant staff. The plan should specify schedules and content of meetings, methods of advertising the meetings, and other similar activities.

The public involvement plan should be tailored to meet specific project and public needs and should be geared to efficiently and effectively understanding community values. It should reflect practical budget constraints, and be appropriate for the scale of the project and community. Not every project requires extensive public involvement or expensive multimedia campaigns. However, every project should be managed with the idea that some formal means of achieving public input is necessary for project success.

Some agencies prefer to lead the public involvement process, depending on consultant staff for preparation of exhibits and materials and meeting arrangements. Other agencies rely on the consultant responsible for conducting the design study to actively lead public involvement activities. Regardless of the approach, when utilizing consultants anywhere in the project planning, design, or real estate processes, the initial contract scope and budget should reflect the desired need for the consultant to attend and speak at several public meetings and prepare exhibits for those meetings.

2.4.2 Tailor the Public Involvement Program to Meet Specific Project and Public Needs

The proposed transportation project will have a long-lasting effect on the project area residents and their neighborhoods. Meaningful public involvement puts people first in all stages of planning and project development and leads to an enhanced transportation project. Each project may require a tailored public involvement plan to reach and involve the affected public who is the agency's customer. The transportation agency must be prepared to communicate with a public comprised of a wide range of education and cultural values. The use of electronic media may be effective for certain projects; for others, because of the nature of the affected public, one-on-one and/or traditional mailings may be the best approach.

The public will educate the transportation agency by pointing out the local values and desires. Conversely, the transportation agency will educate the public, potentially causing the motorists and pedestrians to re-examine their automatic responses as the agency develops plans to accommodate the anticipated needs or solve problems. Such education deals with explanations about safety related to design, cost, and feasibility of solutions or alternatives, and environmental constraints that must be considered.

Community involvement is most effective when there are multiple opportunities to share information and work out solutions. A public involvement program disseminates information through news releases, luncheon and dinner speakers, community television, talk radio, and newsletters, in addition to face-to-face meetings to exchange ideas. The right combination of media or techniques depends on the type and size of the project, characteristics of the public and stakeholders, and the nature of the project issues.

To encourage open dialogue, all written handout materials or press releases should include a name, phone number, and e-mail address for interested people to contact. Of course, the agency should promptly respond to questions or comments directed to the published address or phone number.

2.4.3 Build Community Consent through Open Communications

In executing the public involvement plan, the staff of the transportation agency must be responsive to local desires, as well as to the motorist's safety and the efficient operation of the transportation facility. The agency must determine the desired objective of any public involvement process. Planning for the public's participation in the development of the project is critical. Properly defining the problem is 90 percent of the solution. The *team* must:

- Obtain the right participants.
- Agree on the problem.
- Agree to openly discuss the process.
- Accommodate the views of others.

Throughout project development, the project development team has the responsibility to build community consent on major issues such as project purpose and need, the development of alternatives, and resource mitigation measures. Given this need, it is clear that the planning and project development processes must promote an open exchange of information and ideas among the community, the regulatory and resource agencies, and the project development team.

A well-organized community and agency involvement program effectively creates this open exchange, and guides discussion toward a resolution of key project issues. The goal of an effective public involvement program is to employ the techniques and practices that can focus community and resource agency dialogue in a productive and useful way. A demonstrated commitment to openness creates one *team* comprised of all project stakeholders working as partners, rather than fostering a divisive "we" and "they" atmosphere.

2.4.4 Strive for Inclusiveness

Many transportation agencies have found it difficult to fully embrace the concept of inclusiveness. Experience suggests, however, that seeking out and including activists and those formerly considered as *adversaries* is key to the development of an effective public involvement program. Project staff should seek out activists and other participants with different viewpoints as team members. Experience suggests they will not go away; however, if invited to be part of the process, their credibility within the community will require they participate in a fair, unbiased manner. Agencies that seek out and include disparate groups demonstrate a clear, defensible position at the conclusion of the project.

Transportation agencies should rely on local, community contacts to build an inclusive team. Obtain names from leaders and members of school PTAs, the city council, and service clubs (e.g., Kiwanis or Rotary clubs).

An important component of conflict resolution is full disclosure of all information and discussions needed to manage and resolve conflicting values of stakeholders. When parties are at odds, it can sometimes be due to a misunderstanding or lack of information. It is important that both sides disclose relevant information to resolve or at least manage conflict between competing values.

Striving for inclusiveness is in one sense “looking for trouble.” This proactive approach, while difficult for some to accept, more often than not proves to be the difference in project success. Problems and issues raised by members of the community do not go away if left unaddressed. Indeed, often relatively minor problems can become major impediments to progress if ignored or left unattended.

2.4.5 Maintain Continuity in the Public Involvement Program

Effective public involvement occurs not just during alternatives development, but throughout the project development process to construction. Developing *informed consent* (understanding and “owning” the project to the point that opposition is no longer present) for a project’s purpose and need begins during the planning phase. This phase is when the public, resource agencies, and local communities (including local planning organizations) are engaged in developing transportation improvement programs. Public involvement continues during preliminary design, during which traditional engineering activities are integrated with community and agency involvement to develop solutions consistent with the project’s purpose and need. Public involvement even continues during construction, when the adverse impacts (noise, dust, detours, driveway closures) are most evident, yet the benefits of the project are not yet apparent. Public involvement also continues beyond construction with highway maintenance. Maintenance staff are often the first to hear of problem areas and also have frequent contacts with community members and local officials. The community expects that the transportation agency will work with them during the most difficult time periods, i.e., when construction activities occur. Demonstrating the ability to deal with unexpected or unintended construction impacts can prevent the “souring” of an otherwise positive community attitude about the project.

2.4.6 Provide and Communicate Clear, Structured Decision-Making Processes

It is essential that the public and all stakeholders understand and consent to their roles on the project. An effective public involvement process explicitly addresses who will make the decisions on alternatives, what mechanisms or procedures will be followed, what data will be used, and how the decisions will be reached, documented, and communicated. The roles of the advisory committee members and representatives of local units of government should be clearly spelled out. It is important that any advisory group clearly understands its role in the project development and decision process. Usually this role is to advise and provide input, not be the decision maker. Unless it is the clear intent of the transportation agency, committee members should understand that the decision process will not be a “vote.” In most cases, the transportation agency responsible for the design, funding, and construction of the facility will have the final say. The agency’s decision will be based on a wide range of inputs and constraints, some of which may be external to the affected community. The public and local officials need to understand these constraints and responsibilities the agency must meet, with safety always being of paramount concern.

For controversial or difficult projects involving complex tradeoffs, special decision-making processes have been successfully employed to directly involve the input of stakeholders. Such processes can help stakeholders participate in the evaluation and characterization of tradeoffs, yet avoid the pitfalls of “voting” on a course of action or alternative.

Whatever process is used, it is crucial that all involved understand and accept their role from the outset; it is just as important that the transportation agency follow through on commitments to utilize input from stakeholders in the decision-making process.

2.4.7 References for Developing an Effective Public Involvement Program

A number of state DOTs have excellent reference materials that can be consulted for the creation of an effective public involvement process. Publications such as Pennsylvania DOT's *Public Involvement Handbook (4)*, Minnesota DOT's *Hear Every Voice (3),* and Pennsylvania DOT's *Needs Study Handbook (5)* can be consulted by transportation professionals for more information. These publications outline the tools and techniques available to designers/planners when developing community involvement programs and purpose and need statements. Readers are encouraged to contact their state DOT or municipal agency for their techniques or procedures.

2.5 Planning and Conducting Public Meetings

A central focus of most public information programs is public meetings. The format for public meetings may vary greatly depending upon the audience and the intent of the meeting. The following examples demonstrate a range of possibilities:

- **Gathering local values and concerns**—These might be general meetings that do not relate to any specific project (State Transportation Improvement Plan [STIP], needs appraisal, etc.) or might be precursor meetings for an anticipated construction project. They have particular importance, however, as a means of understanding and gaining insight into the project area context.

- **Advisory committees**—These identify key stakeholders and organize them into a community resource council as an advisory group to the study team. These councils are made up of selected key, non-technical people from groups in the project area such as the chamber of commerce, environmental groups, neighborhood and business groups, representatives of the minority and disabled communities, and other affected groups. They help provide input and response, and serve to focus the views and concerns of the communities. Note that the use of such councils or committees should not preclude the need for holding sufficient numbers of informational meetings for the general public.

- **Project public information meetings**—Throughout a project, a series of informational meetings may be held in which project issues are discussed, and input on alternatives is obtained. These meetings are normally informal and not necessarily required by regulation, but they can be effective supplements to formal public hearings.

- **Formal public hearing**—This is a project-specific meeting and is a requirement on a larger-impact "major action" highway project. Hearings incorporate a formal published record of public comments and questions. This record is often included with the environmental documentation for the project.

- **Real estate acquisition**—This meeting informs property owners in the path of the highway project. This meeting can occur when final design plans are about 50 percent complete. It presents preliminary right-of-way plans and is the precursor to the appraisal and offer to purchase activities. It also offers the opportunity for designers to adjust partial acquisitions based on unforeseen conflicts before the final design is completed.

- **Environmental permits**—Public meetings are sometimes required during the processing of permit applications. They are usually held by the permitting agency, with the transportation agency serving as a co-host at the hearing or meeting.

- **Administrative hearings**—These are used to gather public testimony prior to enacting administrative rules and are usually held in accordance with state law.

- **Preconstruction meeting**—This meeting can present the phasing of construction for the improvement (i.e., detours, one-way operations, parking restrictions, nighttime work, etc.) and the possible effects on local access and business operations.

Public participation is not limited to the specific meetings listed here. Indeed, for many projects, the most effective input is received through one-on-one meetings with individual property owners, small neighborhood groups, business owners, etc. These small meetings also require the preparation of an agenda and meeting notes as well as required follow-up actions. Agencies and their consultants should be prepared to budget for, plan, and hold such meetings as necessary in addition to formal or planned larger meetings. The public, governmental, and agency input will be used both to develop the design plans and to obtain the environmental clearance. In general, the reasons for these public meetings or hearings are to develop the purpose and need, develop and present alternatives, receive comments on alternatives, present the selected alternative, begin the right-of-way acquisition activity, and continue to keep the public informed during design and construction.

2.5.1 Effective Public Notification

Advertising major action meetings according to Federal Law (40 CFR 1506.10, 23 CFR 771.111) requires that specific time frames be established for the return of comments concerning the environmental document after the initial public notice. Many agencies place the public notice in a newspaper with local circulation at least 30 days before the formal public hearing. The public notice typically indicates that the “comment period” will remain open for 15 days or more after the public hearing. FHWA also specifies certain content for the public notice, such as the availability of the environmental document and who to call for more information. Effective public involvement in the context-sensitive environment, however, requires going beyond the minimum legal requirements to assure the public is reached.

For any public meeting, in addition to placing notices with a long lead time, it is a wise practice to also place notices in the same or additional newspapers about 5 to 7 days prior to the meeting. Depending on the neighborhood surrounding the project, placing notices in the common areas of apartments (office, laundry, and exercise rooms), churches, and shopping areas may help spread the word. Many communities operate local cable television stations, and notices can be broadcast in advance of the meetings, often at no cost to the agency.

2.5.1.1 Project Web Sites

The use of the Internet to disseminate and collect information has become routine in many areas. This can be an effective way of reaching a wide audience at relatively low cost. A Web page might be created for the project during the preliminary meetings and would then be an additional method for posting meeting notices. Web sites are also a means of maintaining ongoing contact with the public between meetings. Web sites are an effective way to communicate progress and to answer specific project questions, and should be designed to be accessible to those with visual impairments. The use of graphics, in addition to text, will make the Web site more attractive to use. In addition to announcing upcoming meetings, the site can be used to disseminate information and to collect opinions from those that visit the Web site. Data management programs enable the maintenance and categorization of questions and responses, which is particularly useful on large projects with substantial public interest. In addition, other interactive media such as CD-ROMs could be used to provide detailed information to those who are interested. In many cases, the cost of a CD-ROM is much less than the cost of a medium to large printed project report. However, access to computers is not universal, so this should not be the sole method of communication. A project Web site example is presented in Figure 2-1.

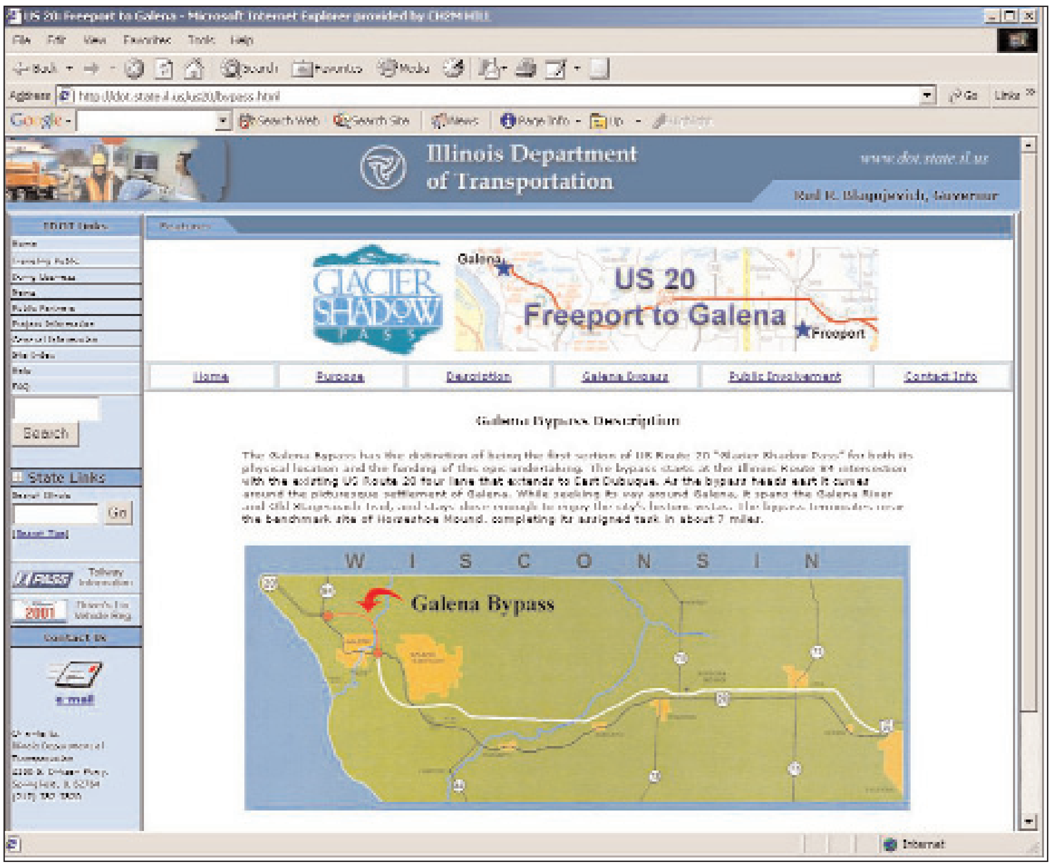

FIGURE 2-1
Web Site Page for a Highway Corridor Study

2.5.1.2 Reaching Nonresident Stakeholders

The project development and public input processes must also include the views or accommodate the needs of motorists (the traveling public). This subset of the public is not usually represented at public project meetings. Special effort is often necessary to ensure that the views of this user group are heard and addressed. When this group is under-represented, it is the responsibility of the agency to act as a surrogate to ensure that their interests are adequately met.

Staff from the transportation agency proposing to change its facility often serve as the representative for the motorist's views and needs. It is generally more effective for staff to seek out motorists and beneficiaries rather than speak for them. This task can be difficult and can require special efforts by the agency. For certain major projects, input could be obtained from pass-through motorists by a strategic media campaign involving both print and broadcast media outlets in the region combined with a hotline, toll-free telephone number. This hotline should be able to both disseminate information on the project and allow the caller to record his or her comments and/or be placed on the project's mailing list. Web sites and booths at community events are also effective ways of reaching nonresident stakeholders. Variable message signs may also be used, but some DOTs have policies about using these signs for purposes other than traffic management or safety. Use of variable message signs for public meeting announcements, therefore, would require coordination with agency policy.

The most effective means of gathering the views of nonresident commuting or mobility interests often focus on larger organizations that have a clear stake in the transportation benefits of a project. Major employers, major retail businesses and/or chambers of commerce, the American Automobile Association (AAA), trucking associations, and in some urban areas transportation management agencies, are all appropriate and potentially effective sources of meaningful, nonresident stakeholder input.

2.5.2 Public Meeting Content and Format

The public involvement program for a project should outline the number, schedule, purpose, and content of each public meeting. The main purpose of every public meeting is to share and trade information. A face-to-face discussion with the public enables the transportation agency to gain a deeper understanding of the area's features and local values than could be gained from only a visual review of the project area. The agency's staff must understand the context of those features and people in order to select and design the highway improvement that best fits a particular area. With a team approach, the agency must both learn from the public attending the meeting and convey to them the balance necessary between safety, cost, environmental concerns, and the desires expressed by the community.

Meetings with the public should be held at locally convenient times and locations. This might result in the need for a single session in the late afternoon and evening, or a split session during normal afternoon work hours with an evening session after the dinner hour. For lengthy projects serving a large area, repeating a meeting in different locations convenient to local residents is good practice. Afternoon and evening hours are also generally convenient times to use school cafeterias or large classrooms (Figure 2-2).

The ethnic and cultural character of the project area should be considered when scheduling a meeting, and significant dates on the various religious calendars should be avoided. Public meetings need to be arranged in a fashion that allows for equal representation from the community. Translators should be provided whenever needed, meeting locations should conform with the Americans with Disabilities Act (ADA) requirements, and transportation and child care should be considered to ensure that all members of the community can participate. Also, enough space should be provided for the public to visit with each other, as that is usually one side benefit of calling neighbors together for a transportation meeting.

FIGURE 2-2
Informal, Open-House Public Information Meetings Generate Effective One-on-One Discussions.

2.5.2.1 Open-House Format

The use of the *open-house* type of meeting is a recent trend in public meetings. Both this style and the more traditional formal-presentation style public hearing are useful in gathering from and sharing information with the public. In the open-house style, various rooms or stations can be provided with design, environmental, real estate, traffic, planning, and other information available. Project exhibits are provided at all locations. Such meetings are well staffed with professionals familiar with the project and prepared to discuss all aspects of it with all who attend. The meeting is open to the public for extended time periods (e.g., 4 p.m. to 8 p.m.). Some agencies prepare brief video or slide shows giving general project information and explaining the process, running these on a set schedule over the duration of the meeting. The public is invited to attend the meeting around their personal schedules, and to stay as long as they wish, focusing on those aspects of the project that interest or concern them the most. The “drop in, learn, and comment” format does not require them to sit through a long presentation just to give their input or to learn about the project. A separate room with court reporters (if the meeting is a public hearing) can be provided to take formal comments from those in attendance. Comments are also typically collected by the agency and consultant staff in attendance.

The open-house meeting has been shown to be the most effective format for achieving two-way information exchange. Open-forum meetings are generally preferred by the public. The public can receive individual attention to their issues and concerns without having to undergo what many find to be an intimidating experience of speaking in a formal hearing setting in front of a large audience. Multiple individuals can be accommodated simultaneously in this format. Research has shown that the level of public interaction increases significantly when agencies switch from a traditional public meeting process to the open-forum process. The open-house style also eliminates the “grandstanding” or “soapbox” opportunity that some speakers might try to seize in the presentation/comment style meeting.

Advantages of the open-house type of meeting are that more comments are generated, especially from people who will not speak into a microphone. The format allows for one-on-one conversations, which can offer substantive input and result in greater understanding of a particular problem or issues. This format also allows the opportunity to incorporate the views of organized opposition to the proposed improvement without disruption of the meeting. Organized groups can be offered space at the meeting, with the understanding that their viewpoint must be displayed in a respectful, non-confrontational manner.

The open-house format requires more work and substantially more resources to perform, particularly when large attendance is anticipated. It is important that agency and consultant staff carefully coordinate their input, how they answer questions, who speaks with media, etc. One risk of such meetings is that questions may be answered differently by the different staff in attendance.

2.5.2.2 Formal Meeting Format

Some transportation agencies continue to use more formal meetings and hearings. In such meetings, a presentation is made to the attendees and questions are fielded one by one, with all in attendance hearing each question and response. Formal meetings may be held for smaller projects in smaller towns where there will be fewer exhibits and little or no controversy is expected, while the open-forum type meeting may be used for larger projects where it is hoped that a large number of affected citizens will attend and a variety of opinions will be expressed.

The traditional, formal meeting format has the advantage of assuring that all attending receive exactly the same message and hear all comments and responses to questions. Such meetings also tend to require fewer agency and/or consultant staff than the open-house style.

A summary of these two meeting types follows:

TABLE 2-2
Public Meeting Formats

Advantages	Disadvantages
Open-House Style Meeting	
One-on-one interaction	Requires note-taking by staff
Broader input	Less provision for community dialogue
Less-biased input	May require longer times for meeting
Convenient for attendees	Requires greater resources to staff the meeting
Formal Presentation Style Meeting	
Consistent message is given	Can create climate of confrontation
Works well when little or no controversy is expected	Less workable for large groups
Requires fewer staff resources	Public finds microphones intimidating
	Public must sit through every question and answer

2.5.2.3 Other Meeting Formats

In addition to the open-house and formal presentation formats, there are a number of other public meeting styles that have been used successfully to solicit public participation. Many of these meetings are aimed at actively involving citizen or advisory groups in certain aspects of a project, such as problem definition, generation of solutions, or evaluation of alternative approaches. A charette usually focuses on a single issue, but when paired with visioning may be effective in eliciting ideas. There are also various other techniques, including breakout groups, workshops, seminars, roundtables, transportation fairs, and brainstorming sessions. Any or all of these formats may be considered by the agency, depending on the nature of the project, structure of advisory committees or panels, and resources available for such efforts.

2.5.2.4 Visualization as a Tool for Public Meeting Communications

Publicly sensitive projects often involve concerns about the visual aspects of the completed highway. Advances in computer techniques now enable agencies to provide the public with views of a project from important or key locations. Visualization techniques allow a much more meaningful presentation.

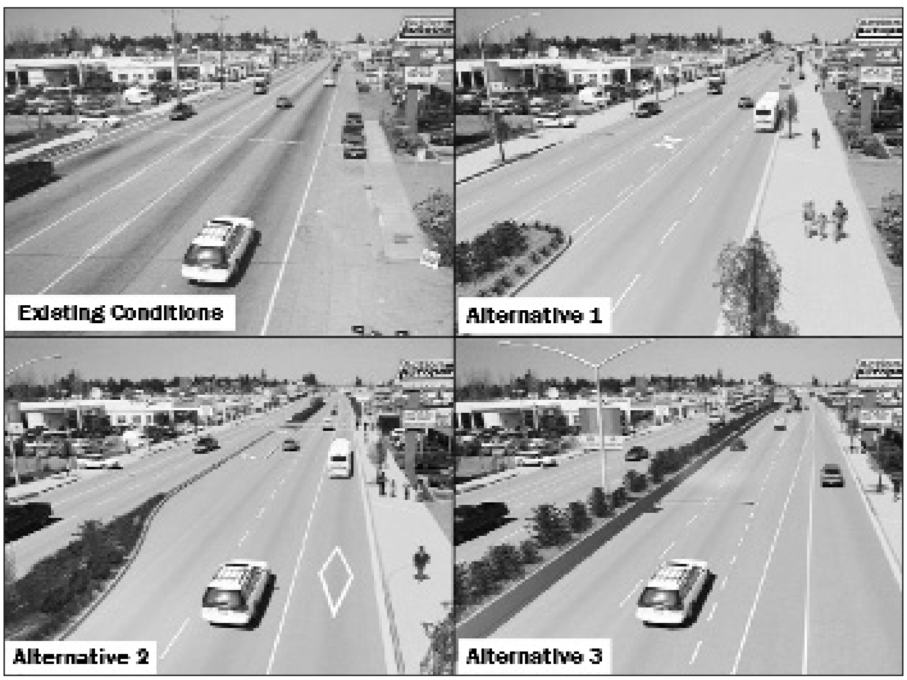

FIGURE 2-3
Visualizations Assist Public Understanding of Alternative Design Proposals

Figures 2-3 and 2-4 demonstrate the power of visualization in illustrating different alternatives, demonstrating impacts to adjacent land uses, and in assisting the understanding of complex solutions.

There are many techniques for providing visual and other insights into projects to the public. Two-dimensional touched-up photographs or still-shot video are now reasonably affordable and can be overlaid with preliminary computer-aided-design (CAD) work. Three-dimensional animation drawn on an actual video is now possible by joining video with CAD design work.

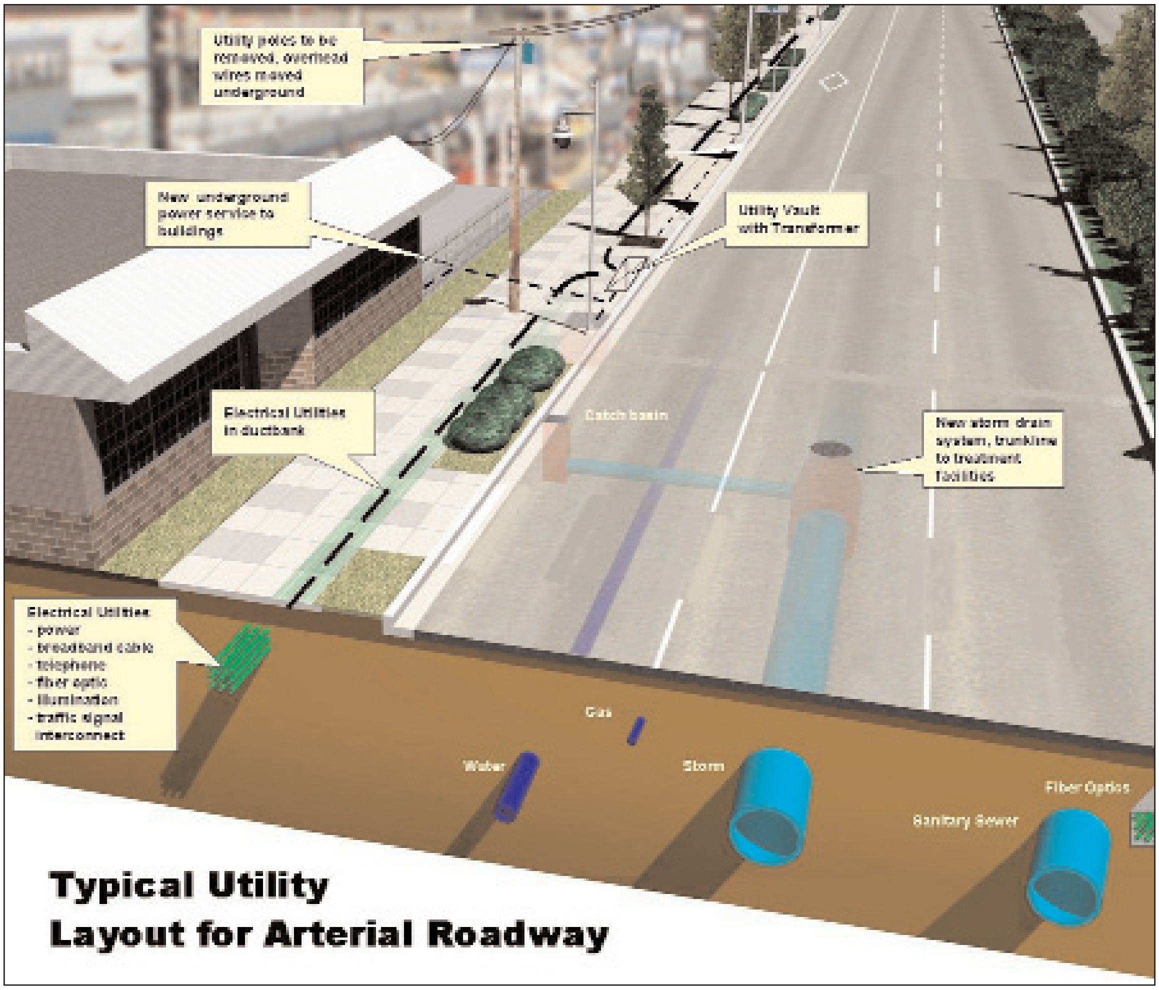

FIGURE 2-4
Visualizations Aid Understanding of Design Complexities

Employing visualization and other techniques requires the design portrayed to be consistent with the design proposed by the agency. CAD drawings used for visualizations must be true to scale in three dimensions. The public will expect the final product to look as they were shown, so care must be taken to ensure that this occurs. Caution needs to be exercised with regard to the accuracy of visualization features, such as the background and size of trees, signs, and light poles. Additionally, if visualizations appear to be well-polished early on, the public might infer that decisions have been finalized prior to the solicitation of their input.

Another effective use of visualization is to allow the designer and design team an opportunity to review their own work internally before the project is presented to the public.

2.5.2.5 Communications at the Meetings

The manner and skills of professional staff at meetings are critical to meeting success. All staff should talk with the public in terms they understand. When highway jargon is used (e.g., superelevation, degree of curve, clear zone, passing and stopping sight distance, shoulder, etc.), it must be clearly described to the public.

Some agencies design projects using the metric system. The general public may understand miles and feet, but may be unfamiliar with metric units of measure. Special care is needed to explain dimensions presented in the metric system. Some agencies have developed boards describing in simple terms metric units of measure compared with commonly understood United States customary measures.

Similar problems are encountered in describing environmental issues such as noise, and traffic operational issues such as level of service. Again, standard exhibits describing these concepts in simple terms are useful tools used by agencies in their public meetings.

2.5.2.6 Discussing Real Estate Issues

Real estate issues—property acquisition, easements, compensation for impacts to property, and changes in access—are generally among the most significant of stakeholder concerns. Whether they involve residential properties or businesses, a project can have actual or perceived direct economic impacts on property values. There is value in having the agency's real estate staff review proposed acquisitions before they are shown to the public in order to obtain their input on the potential cost and difficulty of acquiring property. Real estate staff might also suggest alternatives to purchase or easement.

Stakeholders are interested in not only the effects of an alternative or project, but also in the process that will be followed for appraisal, negotiation, compensation, and acquisition of their property. Relocation assistance and the rights of the property owners for businesses and homeowners are important. Property owners desire to understand these issues during project development; therefore, transportation agencies should not defer these discussions until after decisions are made.

Any public meeting on a proposed project is a good place to start discussions between potentially affected property owners and the agency. Thus, all potentially affected property owners are given the same information first-hand regarding the project and the agency's land acquisition procedures. These discussions can continue in one-on-one meetings as project specifics become available during the further development of detailed design.

Property owners' rights and agency responsibilities are complex, and vary from state to state. Agency policies regarding advance or hardship property acquisition may also vary. It is critical that transportation agencies provide accurate, consistent information to stakeholders throughout the process so that misunderstandings do not occur. Attendance at public meetings by experienced real estate staff from the agency is important. Other staff should be encouraged to direct public questions regarding real estate acquisition rights and process to those best capable of handling the questions. Many agencies prepare and make available printed brochures that outline the laws and regulations, and document property owners' rights with respect to the acquisition of their property.

Once a selected alternative has been announced and the preparation of design plans has progressed to the preliminary right-of-way plan stage, a public meeting can be held to begin the right-of-way acquisition process. This may typically occur 12 to 18 months after the public hearing. If there has not been continuous public involvement since the public hearing, this meeting should also be used to review the earlier community involvement that led to the adoption of the selected alternative and update the entire community on the progress toward actual construction. The agency gains credibility by providing factual notice of the proposed construction project and offering the public the chance to see preliminary design plans that show land requirements for the project and to discuss the project's current schedules.

A real estate meeting specifically provides an opportunity for the agency to meet the affected property owners one-on-one, review design plans, obtain their specific concerns and issues, and assure the owners that their individual concerns and issues will be reviewed and addressed. This meeting also offers an excellent opportunity for the agency to obtain the essential information and factual data required for ordering individual real estate appraisals on each affected ownership. General project information is made available, as are general information booklets and pamphlets outlining the agency's procedures in appraising and acquiring private property for public purposes. The property owner's first official contact with the agency's real estate staff is often much smoother in the setting of a public forum where others are encountering similar circumstances. It provides property owners the ability to discuss the project as well as their own situation with friends and neighbors in the presence of the agency's real estate representatives.

2.5.2.7 Follow-Up Activities After Public Meetings

A successful project meeting may result in the need for additional meetings that were not anticipated. Such additional meetings may be one-on-one discussions with a particular property owner or resident. However, all meetings are for a single purpose—to involve the public in helping create the best possible project that meets or exceeds the needs of both the users of the facility and the adjacent community and its residents.

It is critical that all requests for information, answers to questions, promises to meet, etc., be addressed in a timely manner. Public skepticism of an agency's commitment to listen and be influenced is greatly affected by their perception of how well an agency responds with actions following each meeting.

For public hearings, it is important to collect comments, prepare responses, and publish these within the official comment period.

2.6 Role of the Design Professional in the Environmental Process

Highway design and planning professionals have many important responsibilities in the project development process. Their overriding objective should be to work with the stakeholders to "shape" a project that best meets all significant concerns, needs, and interests. To accomplish this, the design professional participates actively in the environmental components of the project development process in a number of ways.

2.6.1 Develop Safe, Effective, Creative Alternatives

Design professionals have the challenging task of combining often conflicting community desires with good highway design practice to produce workable, acceptable solutions. The role of the design professional should be to understand and communicate good practice (design guidelines and criteria, what constitutes good practice and why) to stakeholders. The design professional should exhibit the ability to develop multiple, creative alternatives, each of which may have unique attributes and tradeoffs.

Design professionals must have sufficient understanding of the true operational and safety implications of various design features, enabling assessment of innovative solutions, or consideration of design exceptions where necessary. This requires the design professional to have and communicate a “feel” for the quantitative relative risk of a unique solution or design feature. The design professional must be able to strike a delicate balance between willingness to compromise on a particular design value or criterion while maintaining focus on the responsibility to provide a safe, functional facility.

2.6.2 Communicate Stakeholder Concerns and Issues to Decision Makers

Relaying the community’s requested outcomes to agency decision makers and management staff is an important aspect of the communication process, since an agency’s upper management cannot normally attend all public meetings. It is therefore important for the team leader or team to interact with management to define the direction the project is to take, what the project is to include, and to identify those participants outside the agency who should review the preliminary and interim plans. There usually will be an exchange of information with public representatives as additional project constraints or agency concerns are determined. The team leader may need internal approval before certain solutions can be explored further and that outcome can then be relayed to the public.

2.6.3 Participate in the Project Decision Process

The design professional has a responsibility to bring technical expertise to the decision process without injecting or promoting personal bias in that process. Alternatives assessment often entails a range of quantitative and qualitative data describing disparate features or issues about the project. Decision making in such context is complex and subject to potential or perceived bias. The credibility of the agency’s spokesperson is hard to gain and easy to lose. Credibility soars when the spokesperson is the source of honest information concerning the project.

The agency should admit errors or items that require modification. Uncertainty or lack of hard data or evidence about an impact should be admitted and addressed directly. If questions are asked that the agency does not have answers for, an offer should be made to find the answer and relate it later to the questioner. The design professional should play an active role in structuring, leading, providing data to facilitate, and directly participating in the decision process.

2.6.4 Incorporate Public Input with Environmental Documents

The transportation agency often prepares an environmental document that is made available to the public. It is necessary to complete this document before final design and construction can proceed. Projects using federal highway funding are required to examine the social, economic, and environmental impacts that will result.

The collection and addressing of comments from the public is an important part of the environmental process and documentation. The design professional has a responsibility to incorporate public input and comments.

The more significant the potential impacts of the proposed project, the more detailed and comprehensive the environmental documentation will be. Simple or routine projects, such as signing or road resurfacing, are often categorically excluded from the need for documentation (these projects are generally non-controversial). Some relatively simple projects may require a minor amount of project-specific environmental documentation to verify the Categorical Exclusion (CE) classification. An Environmental Assessment (EA) is prepared for mid-range projects that may have significant impacts on the environment (some controversy may occur with these projects). The EA is made available through public notice and a public hearing might be held. Following the public comment period, the environmental process may be concluded with the issuance of a Finding of No Significant Impact (FONSI).

Construction of new routes or major work on an existing route may require the preparation of a Draft Environmental Impact Statement (DEIS), followed by a public hearing and comment period. A Final EIS (FEIS) is then prepared, and the environmental clearance process culminates in the issuance of a Record of Decision (ROD) on the chosen alternative.

The EA and DEIS explain the project and discuss the alternatives that are being considered and the social, economic, and environmental impacts of each. After these documents are made available to the public for review and comment, the Final EA/FONSI and FEIS/ROD address the comments received through the public hearing process and the alternative selected. These documents are prepared for the public and for a number of federal, state, and local agencies. Members of the public must be made aware of where the environmental document (or its executive summary) will be available so that it may be used to provide comments concerning the project.

2.6.5 Document Project Decisions

The design professional has a duty to properly document all significant aspects of any design or project decision. Documentation supports addressing questions about why an action was taken for those who were not directly involved. Many projects take a long time to complete, with multiple design and construction phases. Stakeholder groups change membership, elected and appointed officials from local units of government change, and often the transportation agency transitions the project to different staff for execution of later phases of work.

One particularly important aspect of design documentation involves the acceptance of design exceptions as part of the recommended solution. The design professional must sufficiently document why such exceptions were required to support the agency position against potential future tort claims arising from a traffic crash occurring after construction. (For more discussion of this important issue, the reader is referred to Chapter 4.)

2.6.6 Assure Community Issues Are Addressed through the Construction Phase

The agency's team leader and the team should have the responsibility of ensuring that citizen input is reflected in the design plans and is maintained during construction. Construction may occur many years after public input was first given. Moreover, the project may pass through many hands internally within the agency from the time promises or commitments are made to the time final design plans are completed. This "passing on" of information, including commitments and promises to address design concerns, must take place despite changes in project and management staff. Some agencies produce a public involvement folder that details commitments and stays with the project team from phase to phase, including the handoff from design to construction.

2.7 Effective Public Involvement is Necessary to Produce Appropriate Outcomes

The results of effective community involvement on a project may include an agreement that further study is needed; support for a solution or approach; revision of design, right-of-way, or construction details; or even the delay, postponement, or cancellation of the project. *Time spent meeting with the public is always valuable regardless of the outcome.* Once public input is received, the project can then advance with known and documented public consensus. However, even for the few projects that do not advance to design or construction because of public dissatisfaction or lack of consensus, public meetings and community involvement should be seen as a worthwhile time and cost investment. The community is not well served when serious opposition to a proposed agency action does not surface until construction begins, rather than becoming known during the planning or design stages.

A true measure of project success, regardless of the solution implemented, is the degree to which the community at large, and each stakeholder, can feel a sense of involvement and even ownership of the project. Transportation agencies that commit to achieving a high level of public involvement on all their projects will find over time greater receptiveness and improved working relationships with communities.

2.8 References

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chapter 3

Highway Geometric Elements—Design and Safety Considerations for Context-Sensitive Project Solutions

3.1 Introduction

Geometric design is the assembly of the fundamental three-dimensional features of the highway that are visible to the driver and that affect its operational quality and safety. Geometric design includes the cross section, horizontal alignment, vertical alignment, and intersections.

Good geometric design is more than the assembly of mathematical elements into plans suitable for construction. Rather, it is the means by which knowledge from research and operational experience is brought to the users of the road. A skilled geometric highway designer or design team understands the human characteristics of drivers, bicyclists, and pedestrians as they relate to the driving task. A skilled designer also has knowledge of the physical and operational characteristics of vehicles. Finally, and perhaps most importantly, the skilled highway designer is able to translate this knowledge to the actual design of the highway. The designer should understand not only the structure and content of highway design guidelines and criteria, but also their functional basis.

Utilizing context-sensitive solutions presents unique challenges to highway designers. Traditional approaches to achieving mobility objectives—constructing new roads or the widening of existing roads—may not take full advantage of the overall range of possible solutions (e.g., multimodal solutions). Moreover, even where the appropriate solution involves primarily a highway design, often a more tailored, site-specific approach to design is needed and desired. Acceptable design solutions not only incorporate good design practice as outlined in the AASHTO Green Book *(2)*, but they also reflect a full understanding of community values and desires. A flexible or "context-sensitive" design is one that demonstrates a proper respect for and sensitivity to local constraints, valued community resources, and desires for unique features or design elements. Designers who strive to tailor their solutions to community desires achieve great satisfaction in the knowledge that the completed highway solution is viewed by the community as an asset.

Note that tailoring a solution more often than not is possible within the published design criteria. And, in those cases where a design value outside current guidelines is needed, designers and the community should understand the reasons for such solutions and accept the tradeoffs as being appropriate for the specific circumstances.

The ability to develop a context-sensitive solution by working within and sometimes outside design criteria, while maintaining the safety and operational integrity of the highway, requires a broad and deep understanding of the operational effects of highway geometry. For this reason, knowledgeable, experienced, professional highway engineers are essential for a successful context-sensitive project.

This chapter provides an overview of key geometric elements, their typical design dimensions, the basis for AASHTO guidance, and the use of the criteria and guidelines in the AASHTO Green Book *(2)* to effect a flexible design. The focus of the chapter is on design elements generally acknowledged to have the greatest influence on the operations, safety, physical impacts, and cost of a highway, road, or street.

Table 3-1 lists the major geometric elements that comprise the highway, and highlights those elements that are considered by many states and the FHWA to be of sufficient importance to require special consideration in the planning and design process.

TABLE 3-1
Controlling Geometric Design Criteria
[Design elements considered by FHWA to be of sufficient importance to require a "Design Exception Request" if design criteria are not met]

Design Speed	Vertical curvature
Lane width	Vertical clearance
Shoulder width	Stopping sight distance
Normal cross slope or crown	Bridge width
Radius of horizontal curve and superelevation	Horizontal clearance
Superelevation transition design	Structural capacity
Tangent grade	

Source: FHWA Policy Guide CFR 0625

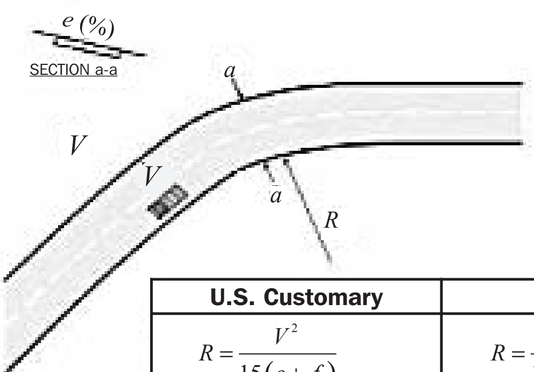
The reader is also encouraged to refer to other key references listed at the end of this chapter, which give further background on the material presented in this chapter.

3.2 Horizontal Alignment

The horizontal alignment of a highway is comprised of tangents, circular curves, and on occasion, spiral curves. The selection and assembly of these elements by the designer reflects the constraints, terrain, local conditions, and necessary linkages to intersecting roads.

Horizontal alignment design practice focuses on the design of horizontal curves as the controlling feature of the highway. Figure 3-1 illustrates the operational *model* on which AASHTO design guidelines are based. The design features of the curve—its radius, *R*, and superelevation, *e*, are based on the selected design speed and a factor, *f*, described as side friction. Superelevation is the amount of banking used for a horizontal curve. It reduces a vehicle's side friction demand and helps the driver steer through the curve. Additionally, the amount of superelevation allowable on a given highway is controlled by the maximum superelevation rate, which is set to limit operational problems at low speeds on snow and ice. Values for superelevation are normally established by a transportation agency as a matter of policy, typically based on values in the AASHTO Green Book *(2)*.

The transition between tangent and circular curve is an important aspect of horizontal alignment design. The transition refers to that segment of the alignment over which the full superelevation is developed, beginning with the normal cross slope of the tangent alignment. In most cases, the transition begins on a tangent and proceeds into part of the circular curve. The AASHTO Green Book *(2)* provides for, and some states incorporate, the use of spiral transitions between tangent and horizontal curves. While not essential elements of horizontal alignment design, spiral curves can provide advantageous operations on sharp and/or high-speed curves. Spiral curves help the driver-vehicle system adjust to the abrupt change in lateral acceleration produced by a tangent-to-curve transition.



U.S. Customary	Metric
$R = \frac{V^2}{15(e+f)}$	$R = \frac{V^2}{127(e+f)}$
where:	where:
R = Radius of circular curve (ft)	R = Radius of circular curve (m)
V = Design speed (mph)	V = Design speed (km/h)
e = Superelevation	e = Superelevation
f = Side "friction" or comfort	f = Side "friction" or comfort

FIGURE 3-1
AASHTO Horizontal Curve Model

3.2.1 Background on the AASHTO Design Model

Understanding the assumptions and intent of the AASHTO operational model leads to safe and effective design decisions. The AASHTO operational model assumes the driver/vehicle system operates as a point mass, with the vehicle centered in the lane, operating through the approach and into the curve at a constant speed equal to the design speed. AASHTO design procedures apply uniformly to all permanent highway types and all traffic volume levels. The model is intended to produce operations that avoid loss of control due to skidding, which would occur for a passenger car if the side friction demand exceeded the pavement friction provided by the tire/pavement interface. Appropriate values for curve radius for a given design speed are derived based on established values for side friction, *f*, which varies with the design speed.

Although loss of control to skidding is the nominal operational concern, the actual formulation of AASHTO guidance is based on somewhat different assumptions. Designers should recognize that the AASHTO horizontal curve design model, including the definition of values for *f* and *e*, is based on providing a level of comfort to drivers. Stated differently, controlling values for *f*, and hence radius, are based on field studies of what drivers are willing to accept in cornering.

The design values for *f* include a substantial margin of safety against loss of control for passenger cars due to skidding on most available dry pavement conditions. This margin of safety is appropriate given the need to consider lane changing, braking, evasive maneuvers, pavements that may be wet or slippery, and tire condition. Finally, research has shown that vehicles with higher centers of gravity such as large trucks tend to overturn rather than skid under certain combinations of curvature and speed.

3.2.2 Risk Assessment Guidelines

Knowledge of the AASHTO Green Book *(2)* assumptions helps designers manage the risk of accepting a design solution outside the typical ranges. Reliable information on actual speeds, site crash history, roadside conditions in the vicinity of the curve, and available pavement friction are all useful for assessing risk.

Research on the safety characteristics of curvature and other highway elements also offers insights. Studies have established a relationship among curvature, length of curve, cross section, traffic, and other factors for curves on higher speed rural roads. On lower speed urban streets, there is little direct evidence of adverse safety effects associated with marginal deficiencies in curvature.

Comparing the “effective” or operationally equivalent speed per the AASHTO Green Book *(2)* of a proposed curve with the appropriate design speed is a useful way to characterize relative risk. Stated differently, the “effective” maximum speed of a proposed curve (given its radius and superelevation) can be compared to expected or observed operating speeds. The difference represents a meaningful measure of the potential risk of employing that proposed design.

In considering the safety risk of a design exception for horizontal alignment (i.e., using a radius smaller than the minimum established by the AASHTO Green Book *(2)* for a given design speed), designers should consider the following:

- Risk is lower for lower volume highways and higher as traffic volume increases. Designers may be more willing to accept a design exception for, say, a roadway with 1,000 vehicles per day (vpd) versus one with 25,000 vpd.

- For roads with little or no truck traffic, risk may generally be acceptable if the effective or nominal speed of the proposed curve is within 5 mph to 10 mph (10 km/h to 15 km/h) of the appropriate design speed of the curve. (Refer to Chapter 1 of this publication for a discussion on the need to set appropriate design speeds.)

- For roads with substantial truck traffic, the risk increases due to trucks’ propensity to overturn at lower speeds than cars. For such roads, an acceptable nominal curve speed of 3 mph to 5 mph (5 km/h to 10 km/h) above the road’s design speed may be the maximum acceptable design exception.

- Risk varies with the length of curve (or central angle of the curve), with longer curves (having central angles greater than 30 degrees) representing a somewhat higher risk.

- The speed of vehicles entering a curve is influenced by the horizontal and vertical alignment on the approaches. Risk varies as a function of the approach speed distribution.

- Risk of serious crashes within curves is a function not only of the curve geometry, but also of the cross section, sight distance, and presence of intersections and driveways within the curve. Designers may be able to accept a greater nominal design exception in locations free of other confounding geometric features, and where the quality of the roadside is greater (e.g., where a wider than minimum clear zone exists on the outside of a sharp horizontal curve.)

The overall risk of a sharp horizontal curve also increases relative to the number of geometric elements that are below minimum design criteria values. For projects involving existing highways, designers should take advantage of their ability to study actual operating conditions and the history of the site to make effective design decisions. Observations of actual vehicle speed distributions provide insights. An analysis of the crash history, if available, should be used to determine whether the site currently operates with unacceptably high curve-related crash rates. The designer can then focus design efforts on the specific roadway features that may be contributing to such rates (e.g., the roadside or pavement surface friction).

For projects on new alignment, designers should strive to provide at least minimum radius curvature given that actual operating conditions cannot be measured but only estimated. In such cases, selection of an appropriate design speed for the alignment is particularly important.

3.2.3 Flexibility in the AASHTO Guidelines

The AASHTO Green Book *(2)* presents horizontal curve design values for a range of maximum superelevation rates ranging from 0.04 to 0.10. Agencies are free to adopt one or more ranges consistent with their terrain, climate, and other factors. Within a given design range for maximum superelevation, the full range of curvature and recommended superelevation is presented for the range of design speeds.

Designers are encouraged to use a range of curvature to establish a best alignment. Rigid adherence to minimum radius curvature is not recommended; rather, use of the full range of curvature is encouraged to fit the terrain, land use constraints, and desired operating speeds. Indeed, designers should be encouraged to use above minimum values (i.e., milder curvature) while keeping an appropriate balance of tangent and curve alignment. Although design guidelines specify one minimum value for radius as a function of design speed and superelevation, the above discussion suggests that design values less than those specified within the Green Book *(2)* may be acceptable under certain conditions. For reconstruction projects, when proposals are made to reduce the operating speed of the alignment in order to reduce construction costs or environmental impacts, the designer should carefully evaluate the crash history and alignment consistency. When less than minimum radius values are used, every effort should be made to employ appropriate mitigation measures to assure that safety will not be degraded. In some instances, actual operating speeds might be greater than the intended or nominal curve design speed. Mitigation measures may be appropriate at such locations.

3.2.4 Mitigating Tight Curvature

Where acceptance of nominally sharper-than-normal curvature appears to be an appropriate solution, the designer has many tools available to mitigate the potential adverse safety impacts. Widening the road and/or shoulder through the curve and improving the roadside may address crash severity. Relocating or closing intersections or driveways within the curve removes additional risk factors. Spot resurfacing or *wedging* of the pavement through the curve can increase available friction for cornering. Mitigation measures for horizontal curvature below typical ranges may include one or more of the following:

- Signing
- Delineation
- Increased superelevation
- Lane widening
- Shoulder widening
- Shoulder paving
- Increased clear zone

The importance of providing a forgiving roadside generally increases as the alignment becomes more severe due to the increased likelihood of errant vehicles. Greater emphasis should be placed on roadside safety when atypical alignment elements are used to reduce the cost and impacts of the project. Indeed, the decision to accept the use of atypical alignment may in part be based on the ability to compensate through special roadside design treatments.

Designers may also strive to reduce vehicle speeds on the approaches to the curve through other alignment revisions. The use of transition curves to *step down* operating speeds may be preferable to abrupt changes in alignments that violate driver expectancy. The use of spiral transitions has been shown to positively influence the safety and operations of some curves. Increasing superelevation through the curve may also be considered. While increased superelevation can help reduce crash rates for sharp horizontal curves, designers need to address potential adverse design impacts on the roadside, driveways, cross streets, and adjacent properties.

Finally, adequate justification should be provided and documented when the alignment will not conform to the design values in the AASHTO Green Book *(2)* or state guidelines.

3.3 Vertical Alignment (Grades)

The design of the vertical elements of the highway includes grade and vertical curvature. With respect to the latter, United States design practice is to use parabolic vertical curvature to connect grades. This section discusses design guidelines for grades. The design of vertical curvature is governed by meeting requirements for stopping sight distance, which is discussed in the following section.

The AASHTO Green Book *(2)* provides guidance for maximum and minimum grades on roadway alignments. Steep grades contribute to inefficient operations, and, when combined with other geometric features, can lead to a potential safety risk. Grades beneath the minimum can result in drainage problems, leading to increased maintenance costs and potential wet-weather safety problems.

3.3.1 Background on AASHTO Green Book Assumptions

The AASHTO Green Book *(2)* relates grade to terrain and functional classification. This guidance reflects a general design practice that is consistent with cost-effective design and general driver expectations.

The guidelines primarily are based on the effect that grades have on traffic operations. Steep grades reduce capacity, generally contribute to sight distance restrictions, and require longer stopping distances for downgrades. Long, steep downgrades may also increase vehicle speeds; hence, the combination of a downgrade followed by a sharp horizontal curve or an intersection may present a higher risk location.

Adverse effects on safety can occur if steep grades are sufficiently long such that speeds of heavy vehicles are significantly affected. Research suggests that a speed differential of 10 mph (15 km/h) between free-flowing traffic and a slowed heavy vehicle is a potential safety threshold. This threshold is most significant for two-lane highways where there is a reduced ability to pass.

Long, steep downgrades can create difficulties for large trucks as well. Their ability to safely brake or decelerate may be adversely affected.

3.3.2 Flexibility in the AASHTO Guidelines

As noted above, the information on grades reflects design practices related to cost and operational efficiency. The AASHTO Green Book *(2)* refers to "reasonable guide values for maximum designs," and further indicates that such guidelines are based primarily on traffic operational considerations as opposed to direct safety impacts. While designers should be encouraged to stay within the AASHTO Green Book *(2)* guidelines, flexibility may be acceptable to meet unique local conditions. For example, steeper than maximum grades may be acceptable if they are short, if heavy vehicle traffic is a relatively small proportion of total traffic, or if the total traffic volume is sufficiently low such that the adverse capacity effects of grade would be negligible. Also, steep grades can be acceptable if the designer is able to provide vertical curves long enough to enable sufficient stopping sight distance.

Less than minimum grades may be acceptable where the cross slope can be designed to compensate for drainage and where alignment is primarily tangent. Climate conditions may also allow for flexibility, i.e., where rainfall and/or freezing is relatively infrequent.

3.3.3 Mitigating Steep Grades

Where it is necessary to accept a steeper than normal grade, designers should evaluate the operational effects of the grade on heavy vehicles. The AASHTO Green Book *(2)* includes a set of design curves that enable estimation of vehicle speeds on upgrades. Use of these curves can help uncover where short, steep grades will have little adverse operational effect, and hence may be acceptable. Where it is necessary to design longer upgrades, mitigation measures can include provision for wider shoulders or climbing lanes. Mitigation of steep downgrades can include design of truck escape ramps, increased shoulder widths and clear zones at the bottom of the grade, and increased superelevation rates. Finally, designers should strive for greater than minimum horizontal curves at the bottom of steep downgrades.

Where design values outside the normal ranges are considered, mitigation efforts should focus on the potentially adverse operational issues discussed above. Acceptance of grades below the minimum can be accompanied by steeper than normal yet traversable cross slopes, special drainage designs, and special attention to the design of pavement edges at superelevation transitions to horizontal curves. Avoidance of flat spots along the pavement should be the objective. Designers can mitigate the use of a sub-minimum grade by carefully checking pavement contours and edge of pavement elevations, making local adjustments to ensure proper drainage as part of the final design process.

3.4 Coordination of Horizontal and Vertical Alignment

Designers are encouraged where possible to coordinate the horizontal and vertical alignment. The AASHTO Green Book *(2)* contains guidance on how to accomplish this, and demonstrates the visual and aesthetic benefits of coordinated alignment. A well-coordinated alignment fits the topography and terrain, and is pleasing to the driver.

3.5 Sight Distance

A fundamental principle of good design is that the alignment and cross section should provide adequate sight lines for drivers operating their vehicles. The term sight distance refers to that distance ahead for which a sight line is afforded a driver under the given design conditions and assumptions.

Design guidance provides for four types of sight distance: stopping sight distance (SSD), intersection sight distance (ISD), passing sight distance (PSD), and decision sight distance (DSD). Among these, SSD and ISD are generally the most important relative to safe vehicle operations. Providing SSD and ISD is often a controlling feature in design.

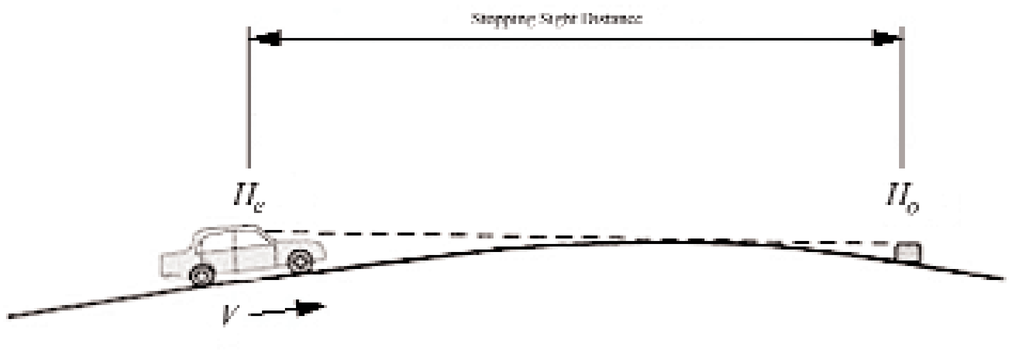
The provision for PSD is important primarily to provide optimal operations of two-lane highways. DSD is considered a desirable feature of design with the intent to provide drivers on approaches to decision points time to make navigational decisions. The rationale, criteria, and discussion of DSD in the AASHTO Green Book *(2)* treat the provision of DSD as advisory rather than mandatory.

3.5.1 AASHTO Stopping Sight Distance (SSD) Guidelines

Design values for SSD per the AASHTO Green Book *(2)* are based on an operational model of driver behavior. The model, illustrated in Figure 3-2, provides a sight line for a driver to see an object of a given height in the road ahead with sufficient preview distance to enable crash avoidance by braking to a full stop. The sight line can be limited by the vertical alignment of the road, or the combination of horizontal alignment and sight obstructions beyond the edge of pavement.

SSD values are the sum of distances for brake reaction time and actual braking distance. Derivation of distances for design purposes reflects the reaction times sufficient for most drivers, the braking ability of most vehicles under wet pavement conditions, and the friction provided by most pavement surfaces assuming good tires.

Design values for SSD influence highway elements in all three dimensions. Horizontally, SSD values affect the desired location of objects beyond the edge of pavement within the limits of a horizontal curve.



U.S. Customary	Metric
$SSD = 1.47Vt + \frac{1.075V^2}{a}$	$SSD = 0.278Vt + \frac{0.039V^2}{a}$
where:	where:
H_e = Height of driver's eye = 3.5 ft	H_e = Height of driver's eye = 1080 mm
H_o = Height of object = 2.0 ft	H_o = Height of object = 600 mm
V = Initial speed (mph)	V = Initial speed (km/h)
t = Perception/reaction time (2.5 sec)	t = Perception/reaction time (2.5 sec)
a = Deceleration rate = 11.2 ft/s ^{2}	a = Deceleration rate = 3.4 m/s ^{2}

FIGURE 3-2
Models for Stopping Sight Distance (SSD) and Parameters for Vertical Curves

Vertically, SSD values affect the desired minimum values for the length of parabolic vertical curve (either crest or sag). These values are a function of the design speed and amount of the change in grade through the vertical curve. The AASHTO Green Book *(2)* design values for crest vertical curvature are based on assumptions regarding the size and placement of the object, and the height of the driver's eye (assumed from the viewpoint of a passenger car.) Recent research has resulted in changes to the AASHTO operational model for SSD and vertical curvature and is reflected in the 2001 AASHTO Green Book *(2)*. For sag vertical curves, design values are based on sight lines provided by headlight beams.

The AASHTO model applies to all levels of traffic volume and all highway types equally. Design values for SSD are computed based on assumed driver behavior regarding perception and reaction, and the vehicle operating at design speed.

3.5.1.1 Background on the AASHTO Stopping Sight Distance Model

Much research over the past 20 years has provided insights into the safety risk of highways with limited SSD. Designers should understand the AASHTO Green Book *(2)* assumptions and the relationship of design values to safety measures in making effective context-sensitive design decisions.

The basic AASHTO model for SSD design has remained unchanged for over 40 years. Its original formulation reflected estimates of cost effectiveness of constructing alignments to accommodate a range of target object heights. Changes in the United States vehicle fleet led to revisions of AASHTO model parameters in 2001, which in turn resulted in revised design values for alignment features related to SSD. The evolution of the AASHTO Green Book *(2)* has resulted in many roadways falling outside current ranges for various criteria, even though they were designed to meet criteria that prevailed at the time of their original construction. A common problem faced by designers is thus deciding how to treat a highway to be reconstructed that is outside the current criteria per current SSD design guidelines.

Insights into the actual safety risk of such locations are useful to assist in alignment reconstruction decision making. First, it should be understood that AASHTO SSD values are not directly derived based on measures of safety performance (i.e., crash frequency). Over the years, most research has documented that SSD values provided in earlier versions of the AASHTO Green Book *(2)* significantly exceeded those associated directly with observable differences in SSD-related crash occurrence. Indeed, recent research published as *NCHRP Report 400 (20)* confirms that even on the most critical highway types (two-lane rural roads with high operating speeds), "moderate reductions in minimum sight distance do not appear to cause a safety problem." Stated differently, the AASHTO operational model for SSD produces design values for SSD and vertical curvature that generally provide a substantial margin of safety against the actual safety risk of a crash attributable to insufficient SSD.

Designers should also note that the AASHTO model produces the same set of design values for a given design speed irrespective of other conditions that relate to actual safety risk. Such factors should be considered in safety risk assessment and design decision making. The presence of a sight restriction in and of itself may not create a significant safety problem. The severity of the restriction (i.e., how deficient it is relative to a design value called for in the guidelines), traffic volume levels exposed to it, the length of highway over which the restriction occurs, and type of traffic activity within the sight restriction all influence actual crash risk that may be associated with the sight restriction.

For sag vertical curves, AASHTO assumptions are based on an operational model for night conditions in which the controlling feature is the headlight beam on the pavement ahead. AASHTO also provides a secondary design condition for shorter sag vertical curves, based on driver comfort.

3.5.1.2 Risk Assessment Guidelines

Figure 3-3 illustrates the above issues and demonstrates a useful tool for designers in assessing the risk of a location with limited SSD. Stopping sight distance profiles show the amount of SSD at each location and help designers relate the amount and location of a sight-restricted condition. These profiles also help direct an overall assessment of the severity and extent of the problem.

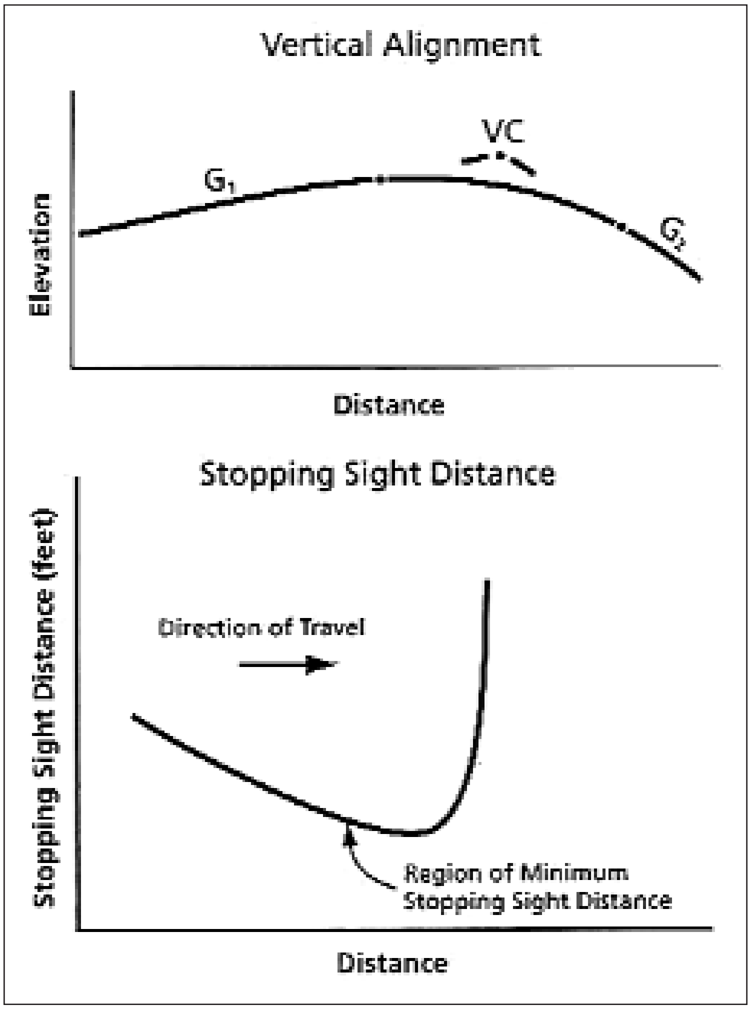


FIGURE 3-3
Example Stopping Sight Distance Profile

Looking beyond the AASHTO operational model, one can assess the risk of a location with limited SSD or SSD below current criteria. The following guidance is offered, based on research on SSD:

- The risk of a sight restriction is related to the traffic volume exposed to it.
- The risk of a sight restriction is greater where other features such as intersections, narrow bridges, high-volume driveways, or sharp curvature occur within the sight restriction.
- Where no high-risk features exist within the sight restriction, nominal deficiencies as great as 5 mph to 10 mph (10 km/h to 15 km/h) may not create an undue risk of increased crashes.
- The greater eye-heights associated with trucks, recreational vehicles, and other similar vehicles provide a greater margin of safety for vertical sight restrictions.

- Horizontal sight restrictions such as large buildings, signs, tree lines, etc., affect all vehicle types equally.

- When faced with a choice, designers should use shorter sag vertical curves in favor of providing the longest crest vertical curve possible.

3.5.1.3 Flexibility in the AASHTO Guidelines

Determination of SSD values is highly dependent on the selected design speed. Flexibility within the Green Book *(2)* is thus primarily provided by the ranges of design speeds afforded designers.

The 2001 edition of the Green Book *(2)* incorporates research from *NCHRP Report 400: Determination of Stopping Sight Distances (20)*. SSD values and associated vertical curve design requirements are less stringent than in previous editions for a given design speed. This may result in some additional flexibility to designers faced with reconstruction of roads built under previous guidelines.

3.5.1.4 Mitigating Limited Stopping Sight Distance. Risk assessment of SSD offers insights into mitigating a location with limited SSD. Increasing sight distance through the reconstruction (lengthening) of a vertical curve is typically considered first. This measure, however, is often expensive and may result in adverse impacts to access or adjacent rights-of-way. Other effective mitigation measures may include the relocation or removal of other features located within the sight-restricted alignment, spot widening the roadway or shoulder to increase space for crash avoidance, and signing, lighting, and delineation treatments. Note that for severe sight restrictions, improvements can be effective even if minimum SSD is not provided but some increase is gained. Where a project involves the reconstruction of an existing highway, which includes locations with limited vertical curvature and thus less than desirable SSD, designers should study the known crash history of the road and the locations to determine the extent of actual safety risk. Research and experience suggest that marginally deficient SSD may not translate into actual safety problems. The analysis should also consider the character of the roadway at the location of poor SSD. Referring to the above guidance, it may often be found that retention of the alignment that is just outside the traditional range is acceptable and more cost-effective than reconstruction to full criteria.

3.5.2 AASHTO Intersection Sight Distance (ISD) Guidelines

Intersections produce the potential for a variety of vehicle-vehicle conflicts. The probability of any conflict translating to a crash can be reduced through the provision of sufficient ISD. AASHTO guidance for ISD is consistent with that for stopping sight distance (SSD)—to provide a clear sight line for the driver to a potential point of conflict, enabling the driver to take appropriate action (deceleration or braking).

ISD design guidance recognizes the different operations associated with types of intersection maneuvers (left turns, right turns, crossing), traffic control and its allocation of right-of-way, and to the driver behavior and vehicle operating characteristics for each type of maneuver or condition.

3.5.2.1 Background on the AASHTO Intersection Sight Distance Model

AASHTO's ISD model, as published in the 2001 Green Book *(2)*, reflects recent research (*NCHRP Report 383: Intersection Sight Distance (19)*) on driver behavior and reaction to traffic under stopped and other traffic-control conditions. Intersection sight distance involves the provision of sight triangles at the approaches to intersections. These sight triangles, clear of sight obstructions, provide drivers on both minor (lower priority) and major roads the ability to perceive potential conflicts and react accordingly. Depending on the traffic control for a given approach, either the approach sight triangle or departure sight triangle is relevant to operation. Refer to the AASHTO Green Book *(2)* for more information.

Design guidance reflects a range in ISD for intersections with varying traffic control (signal, stop, yield, no control), and for types of maneuvers (left turns, right turns, crossing) from both minor and major approaches. The guidelines also consider the cross sectional features of the highway (i.e., number of lanes being crossed, and presence and width of median.) The new ISD values are derived and shown in the AASHTO Green Book *(2)* for the most prevalent vehicles—passenger cars—but the guidance also provides methods and recommended values for larger vehicles.

3.5.2.2 Flexibility in the AASHTO Guidelines

Provision for sufficient ISD is recognized in the AASHTO Green Book *(2)* as important for overall intersection operations. For unstopped approaches, the Green Book *(2)* notes that the provision of SSD will generally provide sufficient distance for drivers to perceive conflicts. Intersection sight distances that exceed stopping sight distances for unstopped vehicles "enhance traffic operations."

Designers are afforded flexibility in the key parameters for ISD design, including, most importantly, selection of the approach design speed. Designers also are expected to use judgment as to which design vehicle should be the basis for ISD computations: a passenger car or larger vehicle.

The AASHTO Green Book *(2)* also recognizes that intersections designed to operate with certain types of intersection control (signal, all-stop) require less stringent sight lines.

3.5.2.3 Mitigating Limited Intersection Sight Distance

Where limited ISD exists according to the AASHTO Green Book *(2)*, the designer has a number of options depending on the nature of the sight restriction. Every attempt should be made to eliminate sight restrictions such as trees, vegetation, signs, and movable obstacles. Where such obstacles cannot be moved, field investigations can determine whether the driver can safely position the vehicle such that actual sight lines (versus those specified in the design model) are clear.

Sight restrictions associated with vertical geometry require geometric revisions. These may include alignment reconstruction, but also may include the relocation of the intersection away from the sight restriction, closure of the intersection, or turn restrictions that eliminate higher risk movements. In urban areas, the creative use of turn restrictions, focusing traffic onto safer (perhaps signal-controlled) intersections, is a viable solution. Advance signing on the unstopped road to warn of the intersection can also be used. Finally, where volumes are high, sight restrictions significant, and a pattern of crashes related to the sight restriction is evident, traffic signal control may be the appropriate solution. Of course, visibility of the signal is important on all approaches, particularly along highways where traffic is unstopped for long distances and the presence of the signal may be unexpected.

3.5.3 AASHTO Passing Sight Distance (PSD) Guidelines

PSD is that distance provided to a driver on a two-lane road to pass a slower-moving vehicle in the same direction of travel. PSD, while desirable, is not normally considered as an essential element of a highway. Indeed, PSD applies only to two-lane highways and generally applies only in a lower volume rural setting. Lack of PSD affects the capacity and operational quality, but there is no direct evidence that links lack of PSD to a quantifiable safety risk.

3.5.3.1 Background on the AASHTO Passing Sight Distance Model

The AASHTO PSD model is a rationally defined model of the passing maneuver. It considers the passing maneuver as comprised of four separate actions involving three vehicles—the passing vehicle, the passed vehicle, and the oncoming vehicle in the opposing lane. Assumptions are made about the speeds and behavior of all three drivers in deriving PSD values for a given speed. AASHTO's PSD model assumes a driver sights the top of a vehicle, versus a lesser object height assumed for stopping sight distance (SSD). Refer to the AASHTO Green Book *(2)* for more information on the PSD model.

3.5.3.2 Flexibility in the AASHTO Guidelines

There is no requirement that PSD be provided for any two-lane road. Where it is possible to provide, PSD enhances the operation of the road, but it is not normally considered a "safety essential" design feature. Furthermore, PSD applies only to two-lane highways, and is not considered in the design of multilane facilities.

Research has demonstrated that AASHTO PSD values are conservative. Many drivers readily accept and safely execute passing maneuvers over shorter distances than are specified by the AASHTO Green Book *(2)*. Indeed, the *Manual on Uniform Traffic Control Devices* (MUTCD) uses shorter distances than AASHTO values for the marking of passing zones.

3.5.3.3 Mitigating Limited Passing Sight Distance

Insufficient PSD can degrade operations and increase risk-taking by drivers. The effects of insufficient PSD may not be evident or significant except where traffic volumes approach the capacity of the two-lane highway, or where the volume of heavy- or slow-moving vehicles is unusually great. Where operational or other evidence suggests lack of PSD is a problem, there are a number of measures designers can employ. These include construction of passing lanes, truck auxiliary lanes on long upgrades, or intermittent turn-outs for use by slower vehicles.

3.5.4 AASHTO Decision Sight Distance (DSD) Guidelines

Certain conditions place unusual demands on drivers. Where complex or instantaneous decision making and unusual maneuvers are required, good design practice is to provide additional sight distance so drivers have advance notice of the condition. The AASHTO Green Book *(2)* recommends the use of DSD for such locations (e.g., unusual or complex intersections, toll plazas, lane drops).

DSD is measured the same way as stopping sight distance (SSD). However, DSD values are much greater than those for SSD for a given design speed. AASHTO recommends the use of DSD only in special cases as mentioned above.

3.5.4.1 Background on the AASHTO Decision Sight Distance Values

DSD values are based on human factors research that addressed perception, response, and other required actions of drivers in complex situations. The AASHTO Green Book *(2)* recognizes a range of complexity of conditions, with corresponding sight distances varying as a function of design speed. The need for DSD and derived values for DSD have not been directly linked to the frequency of crashes at intersections or other locations.

3.5.4.2 Flexibility in the AASHTO Guidelines

AASHTO refers to DSD as "desirable" and "appropriate." Providing DSD is clearly recommended as an element of a high-quality alignment. The AASHTO Green Book *(2)* does not contain language mandating the provision of DSD. This is consistent with the view that DSD, while desirable, is not considered as essential as other sight distance requirements such as SSD or ISD.

3.5.4.3 Mitigating Insufficient Decision Sight Distance

Designers should strive to provide three-dimensional alignments that produce DSD as part of location planning and studies for new alignments, and in considering proposals to add new intersections and interchanges to existing highways. Where DSD should be available but is not provided, the AASHTO Green Book *(2)* indicates that traffic-control devices, advance warning, etc., should be employed.

3.6 Cross Section Elements

The roadway cross section includes the lane and shoulder widths, medians, border area, side slopes, and drainage channels. Figure 3-4 outlines major cross section elements of concern to designers. Design decisions for these elements are greatly influenced by factors such as traffic volume and composition (cars, trucks, buses, recreational vehicles, bicyclists, pedestrians), the nature of the adjacent land use (rural, suburban, urban), and availability of right-of-way.

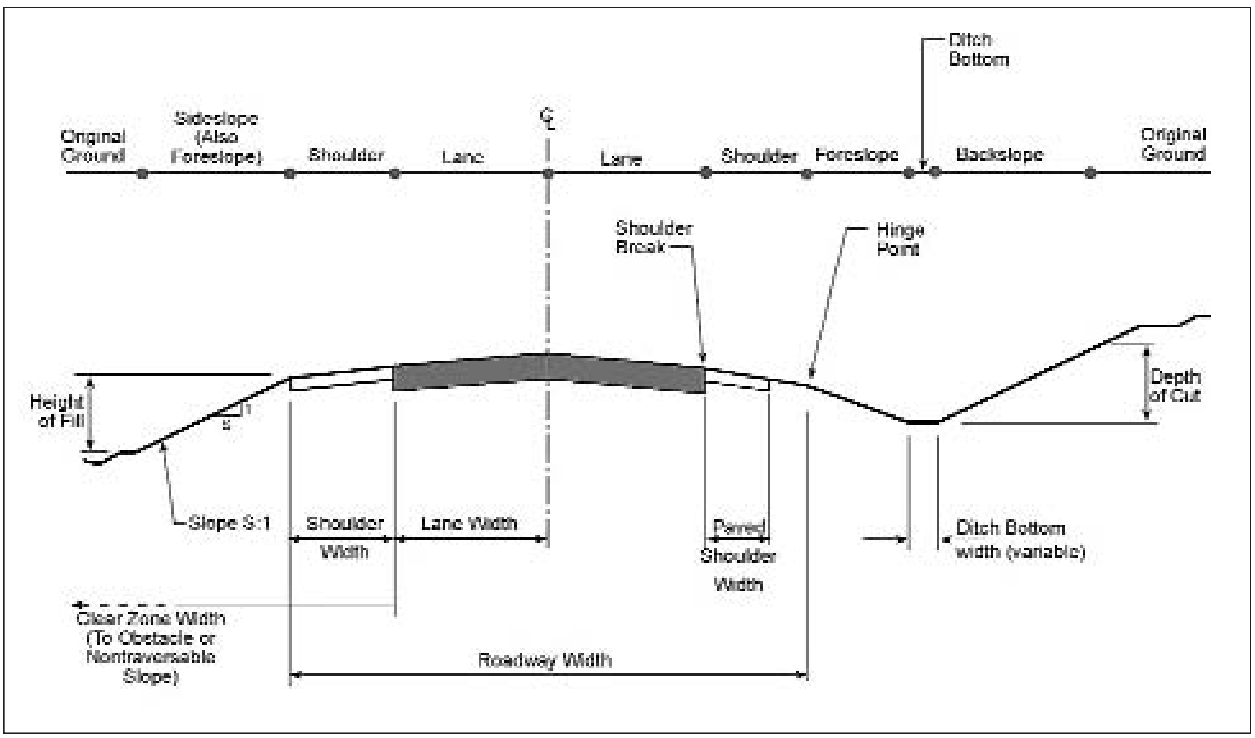


FIGURE 3-4
Major Elements of Rural Highway Cross Sections

The roadway elements of the cross section become increasingly important as the alignment becomes more curvilinear. Lane width, shoulder width, and shoulder surface type play an important role in traffic operation and safety. Therefore, care should be exercised when reducing lane or shoulder widths.

3.6.1 Lane Width

Lane width has an influence on the safety and comfort of the driver. The width of the travel lanes is influenced by the physical dimensions of cars and trucks, speeds, type of highway, and type of vehicle. Studies have shown that drivers tend to be more comfortable traveling at higher speeds on roads with wider lanes. The normal range of design lane width is between 9 ft (2.7 m) and 12 ft (3.6 m).

Wider lane widths are typically associated with higher speed roadways such as freeways, arterials in suburban areas, and two-lane rural arterial and collector highways. As speed and volumes increase, additional lane width is desirable to accommodate the variations in lateral placement of the vehicle within the lane. Greater lane widths also better accommodate wider vehicles in the traffic stream, such as trucks, buses, and recreational vehicles. Wider lane widths also marginally increase the capacity of the roadway.

Design for lane width should include consideration of the horizontal alignment. Adequate lane width is very important along horizontal curves since vehicles *off-track*, which means that their paths exceed the width of the vehicle. They require additional room to avoid encroaching into the opposing traffic, adjacent travel lanes, and the shoulder, which may also be used by pedestrians and/or bicyclists. Increased lane width reduces the demands placed on the motorists by reducing the amount of concentration needed to stay within the travel lane.

In urban areas and along rural routes that pass through urban settings, narrower lane widths may be appropriate. For such locations, space is limited and lower speeds may be desired. Narrower lane widths for urban streets lessen pedestrian crossing distances, enable the provision for on-street parking and transit stops, and enable the development of left-turn lanes for safety. Lesser widths also tend to encourage lower speeds, an outcome that may be desirable in urban areas. In considering the use of narrower lanes, however, designers should recognize that narrow travel lanes reduce vehicle separation from other vehicles and from bicyclists.

3.6.1.1 Background on AASHTO Lane Width Guidelines

Recommended design values for lane width in rural areas in the AASHTO Green Book *(2)* are generally reflective of safety and operational benefits estimated from research published in *NCHRP Report 362: Roadway Widths for Low Traffic Volume Roads (18)*. Lane width values in the AASHTO Green Book *(2)* vary with design traffic volumes, the selected design speed, and the terrain (reflecting general construction cost effectiveness).

AASHTO Green Book *(2)* values for lower-speed urban street lane widths are less rigorously derived. There is less direct evidence of a safety benefit associated with incrementally wider lanes in urban areas, compared with other cross sectional elements. Here, provision for a total cross section that considers left-turning vehicles, medians, and the needs of pedestrians and bicyclists should be considered in selecting appropriate lane widths and cross section based on safety considerations. NCHRP Reports 282 and 330 demonstrate the operational and safety effectiveness of various combinations of cross section values for urban arterials.

3.6.1.2 Flexibility in the AASHTO Guidelines

The AASHTO Green Book *(2)* recognizes the need for flexibility and provides that flexibility, citing how lane width can be tailored, to a degree, to fit the particular environment in which the roadway functions (e.g., low-volume rural roads or residential areas versus higher volume rural or urban facilities). The formulation of these values demonstrates considerable flexibility.

For lower speed, lower volume rural roads and highways with little or no truck traffic, lane widths as low as 9 ft (2.7 m) may be acceptable; lane widths substantially less than 12 ft (3.6 m) are considered adequate for a wide range of volume, speed, and other conditions.

For the reconstruction of rural two-lane highways, the AASHTO Green Book *(2)* notes that less than 12-ft or 3.6-m lane widths may be retained "where alignment and safety record are satisfactory." In other words, widening a narrow existing highway is not mandated if its safety performance is acceptable. Flexibility is also evident for lower-class roads and streets, with recommended narrower lane widths consistent with lower design speeds on such roads.

The discussion of lane width in the AASHTO Green Book *(2)* for urban areas also reflects a high degree of flexibility. It is noted that lane widths "may vary from 10 to 12 ft (3.0 to 3.6 m) for arterials." For lower classification facilities, similar flexible language encourages the tailoring of an urban street cross section to site-specific conditions.

3.6.1.3 Mitigating Narrow Lanes

The operational and safety effects of lane width are combined with those of other cross sectional elements. Knowledge of the total effects of lane width, shoulder width, and the roadside offers insights into mitigation when less than desirable lane widths may be necessary.

On two-lane rural highways, the total roadway width (lanes and shoulders) influences crash frequency. The quality of the roadside (slope, clear zone), in combination with the roadway, influences both the severity and frequency of crashes. Mitigation measures for narrow lanes on rural roads may thus include wider shoulders and improved roadsides. Indeed, designers should avoid design solutions that provide wider lanes at the expense of the roadside and/or shoulder. Such solutions may actually result in a net degradation in safety; as a minimum, they may be costly with little or no actual benefit. This is particularly the case for lower volume roads, on which the predominant crash type is run-off-road and highway capacity is not a major consideration.

Where narrower lanes are used, designers should consider lane widening at sharp horizontal curves. Special attention to centerline and edge line delineation and, except where bicycling is likely, the use of shoulder rumble strips to alert drivers are also mitigation measures appropriate for two-lane roads with narrow lane widths. Improved stopping sight distance (SSD) should also be considered as a mitigation measure.

For urban streets and highways, the mitigation of narrow lanes should focus on operational impacts or similar problems. Flush or raised medians should be considered where narrow lanes are used for four- or six-lane urban arterials.

3.6.2 Shoulder Width

As described in the AASHTO Green Book *(2)*, shoulders—whether paved or unpaved—serve a variety of functions. The shoulder is part of the clear zone. It also serves to improve capacity, provide safe refuge for disabled vehicles, enable crash avoidance maneuvers, and provide structural support for the traveled way. Studies have shown that run-off-road and some multi-vehicle crash rates decrease as the shoulder width is increased (with the safety effectiveness related to the accompanying lane width). Paving part or all of the shoulder also helps reduce crash rates further and helps to facilitate use of the road by bicyclists. Shoulder paving also reduces maintenance requirements. Additional guidance on shoulder design is provided in the AASHTO Green Book *(2)*.

One of the greatest safety benefits of shoulders is that they enable motorists to avoid crashes. Therefore, the shoulder should be flush/contiguous with the traveled way and curbs should be located at the back of shoulder when curbing is needed.

Shoulder widths typically vary from a minimum of 2 ft (0.6 m) on low-volume rural roads to 12 ft (3.6 m) on high volume, major highways. Regardless of width and surfacing, shoulders should be flush with the roadway surface and sufficiently stable to support vehicular use in all kinds of weather without rutting. Research has shown that pavement edge drop-offs are a significant contributor to loss of control, run-off-road crashes on rural highways.

Shoulders are not usually intended as pedestrian facilities, given their proximity to traffic and the lack of barrier or physical separation. AASHTO's *Guide for the Planning, Design, and Operation of Pedestrian Facilities (5)* provides guidance on meeting the needs of pedestrians.

3.6.2.1 Flexibility in the AASHTO Guidelines

The AASHTO Green Book *(2)* suggests flexibility for tradeoffs in lane and shoulder widths provided a minimum roadway width is achieved.

3.6.2.2 Mitigating Narrow Shoulder Widths

Where a "full width" shoulder cannot be achieved, the designer should strive to provide as wide a shoulder as possible that meets functional requirements. Table 3-2 from *NCHRP Report 254: Shoulder Geometrics and Use Guidelines (14)* shows functional requirements for a range of shoulder widths.

A major function of the shoulder is to act as part of the clear zone. Mitigating a narrow shoulder can include the provision of an extra-wide clear zone or milder sideslope to partially counteract the loss of the shoulder. The use of traversable ditch designs may also be appropriate where narrow shoulders are used.

Another important function is the storage of disabled or stopped vehicles. If a full, continuous shoulder is not possible, designers should at least seek to provide intermittent full-width turnouts, especially on higher-volume, high-speed roads. Vehicles involved in a crash that still occupy all or part of a travel lane are major causes of congestion, which in turn can create safety problems upstream of the incident. The provision for full or at least "operationally functional" shoulder width associated with vehicle refuge and law enforcement supports incident management.

In urban and some suburban areas, curbs are often used adjacent to the travel lanes where shoulders are not provided. When faced with topographical and/or environmental constraints, the designer may use curbing at the outside edge of the shoulder along with an enclosed drainage system. Curbing is primarily used to direct stormwater flow to enclosed drainage systems and to control access. Curbing may also be used for delineation and aesthetics. In these situations, appropriate transitions should be provided between the shoulder and the curbed cross section. Curbing has little, if any, redirective capacity at medium and high speeds and can destabilize vehicles or cause them to vault traffic barriers. The designer should be aware that curbs are not adequate to prevent a vehicle from leaving the roadway, and the curb provides a minimally redirective function only for vehicles traveling at very low speeds and low impact angles. Curbing should, therefore, be generally used only for access control, drainage, or erosion control. When curbing is needed for drainage control on moderate- or high-speed facilities, sloping curbs should be used, placed as far away as practical from the traveled way to minimize the destabilizing effects on vehicles that might strike it.

TABLE 3-2
Acceptable Shoulder Width Values for Shoulder Functions—Values in Feet (Meters)
Derived from: *NCHRP Report 254 (14)*.

	Functional Classification	
Shoulder Function	**Arterial**	**Collector and Local**
Drainage of Roadway and Shoulder	1 (0.3)	1 (0.3)
Lateral Support of Pavement	1.5 (0.45)	1 (0.3)
Encroachment of Wide Vehicles	2 (0.6)	2 (0.6)
Off-tracking of Wide Vehicles	2 (0.6)	2 (0.6)
Errant Vehicles (Run-Off-Road)	3 (0.9)	2 (0.6)
Bicycles	4 (1.2)	4 (1.2)
Pedestrians	4 (1.2)	4 (1.2)
Emergency Stopping	6 (1.8)	6 (1.8)
Emergency Vehicle Travel	6 (1.8)	6 (1.8)
Garbage Pickup	6 (1.8)	6 (1.8)
Mail and Other Deliveries	6 (1.8)	2 (0.6)
Emergency Call Box Services	8 (2.4)	6 (1.8)
Law Enforcement	8 (2.4)	6 (1.8)
Parking, Residential	8 (2.4)	7 (2.1)
Routine Maintenance	8 (2.4)	6 (1.8)
Major Reconstruction and Maintenance	9 (2.7)	9 (2.7)
Parking, Commercial	10 (3.0)	8 (2.4)
Parking, Trucks	10 (3.0)	N/A
Slow-Moving Vehicles	10 (3.0)	9 (2.7)
Turning and Passing at Intersections	10 (3.0)	9 (2.7)

Note: Metric values added.

3.6.3 The Roadside

The United States suffers approximately 40,000 traffic fatalities and 2,200,000 disabling injuries each year as a result of motor vehicle crashes. On the average day, more than 100 persons are killed and more than 6,000 persons sustain disabling injuries on highways in the United States. Traffic crashes impose a tremendous cost to society in medical expenses, worker losses, property damage, and emergency services, as well as pain and suffering. This cost to society is estimated at $230 billion per year, which is more than three times the amount spent in the Unites States to maintain highways each year.

While the number of fatalities each year has dropped by approximately 20 percent since the mid-1960s, the fatality rate per vehicle miles traveled has dropped by over 70 percent. Advancements in roadside design have played a significant role in this decline, as well as improvements in roadway design, vehicle safety driver education, and medicine, and reductions in drug and alcohol abuse. Unfortunately, roadside accidents still account for a large percentage of highway fatalities. About one in three highway fatalities is the result of a single vehicle run-off-road accident.

The concept of a forgiving roadside environment was developed in the 1960s. A key element of the concept was the creation of *clear zones* within which a driver might recover control and return to the roadway or at least achieve significant deceleration before striking a fixed object. Where fixed obstacles could not be removed from the clear zone or modified with breakaway features, consideration would be given to shielding them (e.g., by placing guardrail) to reduce the severity of vehicle encounters with the roadside.

Vehicles that leave the roadway may encounter objects or terrain features that will influence whether a serious crash occurs or not. Designers have long recognized the importance of appropriate roadside design in the overall safety of the roadway environment.

Elements of the roadside include the shoulder (discussed above) and curbs, slopes, man-made roadside objects, and natural objects such as trees. In urban areas, the roadside also includes parkway and space designated for pedestrian paths or sidewalks. Once a vehicle has left the roadway, a crash may or may not occur. The end result of the encroachment into the roadside depends on the physical characteristics of the roadside environment.

Context-sensitive roadside design is among the most difficult tasks faced by the designer, who should weigh the practicality, costs, and right-of-way impacts of *nominally safer* roadsides with their expected substantive effectiveness. While there is much information and some tools to support the analysis and design of the roadside, engineering judgment will ultimately have to play a primary role in the determination of the extent to which improvements can reasonably be made on any given project. Roadside design consistency is not as important as it is for design of the alignment and cross section. Therefore, when changes or a less than desirable design are made in the roadside design for one segment of a highway, one goal should be to improve the roadside along the remaining segments.

3.6.3.1 Clear Zone

Under ideal conditions, a vehicle that inadvertently leaves the roadway should encounter an area that would permit the driver to safely return to the roadway or bring the vehicle to a safe, controlled stop. This obstacle-free, graded area, is termed the *clear zone*.

Features of the clear zone that influence its effectiveness include the shoulder, slope, and width of object-free slope. The clear zone width will usually include a shoulder and a recoverable slope, and may include a traversable but nonrecoverable slope and a clear runout width. A traversable slope (or area) is one that a vehicle may cross without becoming destabilized and without incurring severe damage to the vehicle or injury to the occupants. Based on research, slopes of 1V:3H or flatter are considered traversable; slopes of 1V:4H or flatter are considered recoverable as well.

Background on Roadside Design. Design of the clear zone, including appropriate combinations of slope and width, is described in AASHTO's *Roadside Design Guide (3)*. This publication represents national consensus and practice, based in part on research studies on the operational and safety consequences of roadside encounters. Some studies were based on empirical observations of vehicle/roadside crashes; other studies included simulation supplemented by full-scale crash testing; and other research included syntheses of field studies of errant driver/vehicle behavior.

Roadside design procedures reflect the importance of traffic volume on relative safety risk and cost effectiveness. According to the *Roadside Design Guide (3)*, the desired clear zone width is a function of the design speed, traffic volume, roadside slopes, and the horizontal alignment. The intent of roadside design should be to design the roadside consistent with expected speeds of errant vehicles.

Whether the roadway is in a rural or urban environment is an important factor in roadside design. The most important consideration here is the design or operating speed of the traffic. For low speeds (25 mph or 40 km/h or less) such as exist in downtown urban areas, vertical face curbs have limited redirectional capabilities for errant vehicles. At speeds of greater than 25 mph (40 km/h), such as typically exist on suburban streets and highways, curbs may influence driver behavior but should not be expected to redirect errant vehicles. Here, designers should be concerned with the safety of the roadside beyond the curb. For high-speed highways (greater than 45 mph or 70 km/h), such as are prevalent in rural areas, shoulders are typically used and the full roadside represents an area of concern.

Flexibility in the AASHTO Guidelines. Designers need to understand the nature and proper use of the *Roadside Design Guide (3)*. *While clear zone dimensions are provided in this guide, they should not be viewed as either absolute or precise*. It is expected that the establishment of roadside design criteria and the design of the roadside is a site- or project-specific task for the designer. Also, the *Roadside Design Guide (3)* suggests that more than one solution may be evident or appropriate for a given set of conditions. Indeed, in presenting the core technical material on clear zone dimensions and design (see Figure 3-1 and Table 3-1 of the *Roadside Design Guide (3)*), it is noted that, "The designer must keep in mind site-specific conditions, design speeds, rural versus urban locations, and practicality. The distances obtained from Figure 3-1 and Table 3-1 [in the *Roadside Design Guide (3)*] should suggest only the approximate center of a range to be considered and not a precise distance to be held as absolute." The proper application of the guidelines in the *Roadside Design Guide (3)* should, in the long run, reduce the number and severity of roadside crashes without unreasonable costs or impacts to the surrounding environment.

Designers and the public should understand that, once a vehicle leaves the road, a crash or potentially serious encounter with the roadside may occur, regardless of the clear-zone width established by the designer. The selected clear-zone width is a compromise, based on engineering judgment, between what can practically be built and the degree of protection afforded the motorist. Limitations in available right-of-way, the location, frequency, and nature of roadside objects, or the presence of valued resources such as wetlands, or the need to provide for pedestrian or other activities may practically limit the clear-zone width. For both new and existing facilities, the selection and design of appropriate clear-zone dimensions should be the responsibility of a knowledgeable, professional design engineer trained and experienced in roadside design issues.

3.6.3.2 Roadside Elements

The most critical and obvious obstacles encountered on the roadside are those unyielding or fixed objects that could cause a sudden or instantaneous deceleration upon impact. Vertical reinforced concrete surfaces, such as bridge piers and abutments, yield the least of any roadside obstacles. Man-made objects such as utility poles, overhead sign structures, buildings, retaining walls, large drainage inlets and outlets, headwalls, and control boxes may also be potential obstacles.

There is an important distinction between two types of fixed objects. Most fixed objects require a moderate- to high-speed impact to produce a fatality. Others produce potentially fatal consequences when encountered at any speed. The designer should be aware of this distinction and should provide extra protection when the obstacle is a cliff, a deep body of water, a flammable liquids tank, or some other similar feature. The extra protection may typically include the use of a more substantial barrier system than would normally be warranted (depending on the vehicle mix).

Trees. Good design should provide for measures to reduce the likelihood of crashes with trees, which are the leading cause of roadside fatalities. The challenge to designers in the context-sensitive environment is to identify those trees most likely to present a significant threat to drivers such that their removal is warranted. This task is made difficult for a number of reasons. First, the relative concern associated with a given tree is influenced by many factors, including the volume of traffic exposed to it, the speed of traffic passing the tree, its location relative to the alignment and edge of shoulder, and the presence of other trees or objects behind or beyond the tree that would replace the removed tree as an obstacle. Second, trees are often considered a positive attribute of the roadway environment by the motoring and resident public. Clearly, in many cases, a “one size fits all” approach to providing an arbitrary clear zone may be unacceptable to the community, even where right-of-way acquisition is not an issue.

Tree removal can be expensive and have adverse environmental impacts. It is therefore important that it be done only where the removal will substantially reduce the risk of a vehicle/tree crash. Where trees are numerous, removal of isolated trees may not significantly reduce the overall vehicle/tree crash risk. However, isolated trees noticeably closer to the roadway may be prime candidates for removal or shielding. Roadside barriers should be used only when the severity of striking the tree is greater than that of striking the barrier. Barriers are longitudinal objects and, as such, the probability of their being struck will be greater than that associated with an individual tree. For existing facilities, knowledge of the corridor’s crash history can help in the decision of how to treat trees.

The condition of trees along the highway should be carefully considered. The timely removal of unsound trees or limbs is an overriding obligation, necessary to avoid unreasonable risk to adjacent property owners and to users of the highways and streets.

The public, municipalities, and other agencies often place considerable pressure on the designer hen work involves the removal of mature trees. The necessity for tree removal should be discussed with local officials and area residents prior to construction. The planting of additional trees outside the clear zone in areas where roadside encroachments are unlikely, and outside required sight lines, can be considered to mitigate tree removal.

While the designer may have little control over existing trees lining the roadway, special care should be taken in incorporating a landscape plan as part of a roadway improvement project. Effort should be made to avoid placing trees or other landscape features that will become fixed objects within the selected clear zone. Research has shown that the risk of an encounter with a tree increases significantly in severity for trees with diameters greater than 4 in (10 cm). Planting a continuous row of trees that will eventually become roadside objects within the right-of-way will in effect limit or define the clear zone. And, it should be understood that the likelihood of being able to remove such trees in the future is small assuming they are maintained, grow to maturity, and are a desired feature of the roadway.

Topography. Topographic features are also potential roadside obstacles. Abrupt positive changes in grade, transverse or longitudinal ditches, and drop-offs or cliffs can produce severe impacts. Transverse embankments can cause errant vehicles to impact or to launch into the air. The designer should consider all of the factors involved when judging whether or not to shield a rough cut slope.

The steepness of the roadside slope or sideslope, also termed foreslope, affects the likelihood of an errant vehicle rolling over versus recovering onto the traveled way. The use of flatter slopes not only reduces the crash rate but likely reduces rollover crashes, which are typically quite severe. Data show that only pedestrian and head-on crashes result in higher injury percentages. The *Roadside Design Guide (3)* provides guidance on slopes that will likely enable a motorist to recover onto the traveled way or traverse a side slope without rolling over. Consideration should be given to purchasing right-of-way to flatten slopes where doing so would not create negative environmental consequences. This will not only decrease the roadside obstacle, but will enhance the visual environment as the need for guardrail will be eliminated.

Roadside ditches can trap errant vehicles and cause them to redirect into culverts, headwalls, utility poles, and other fixed objects. The slope of the ditch may cause an errant vehicle to roll over, increasing the likelihood of occupant injury. Additionally, the backslope may abruptly stop the vehicle.

Utility Poles and Sign, Signal, and Luminaire Supports. Approximately 15 percent of all fixed object fatalities each year involve impacts with sign and lighting supports or utility poles. Most man-made objects within the clear zone can be designed to eliminate or minimize the danger they pose to motorists. For example, light posts, fire hydrants, and signposts can be made breakaway.

Although a traversable and unobstructed roadside is desirable, removal or relocation of the supports is not always possible, especially for highway signing and lighting. These elements should remain near the roadway to serve their intended function. In such instances, the use of breakaway devices may be the most appropriate choice.

Relocation of utilities underground is a solution that combines improved safety with better highway aesthetics (see Figure 3-5). Of course, placing utilities underground is expensive and not always practical. Where burying utilities underground is not practical, utility poles should be located as far from the traveled way as possible.

Miscellaneous Roadside Obstacles. Mail boxes, fences, gates, commercial signs, rocks, and other fixed objects can also pose serious safety concerns and should be evaluated when designing a reasonably safe roadside.

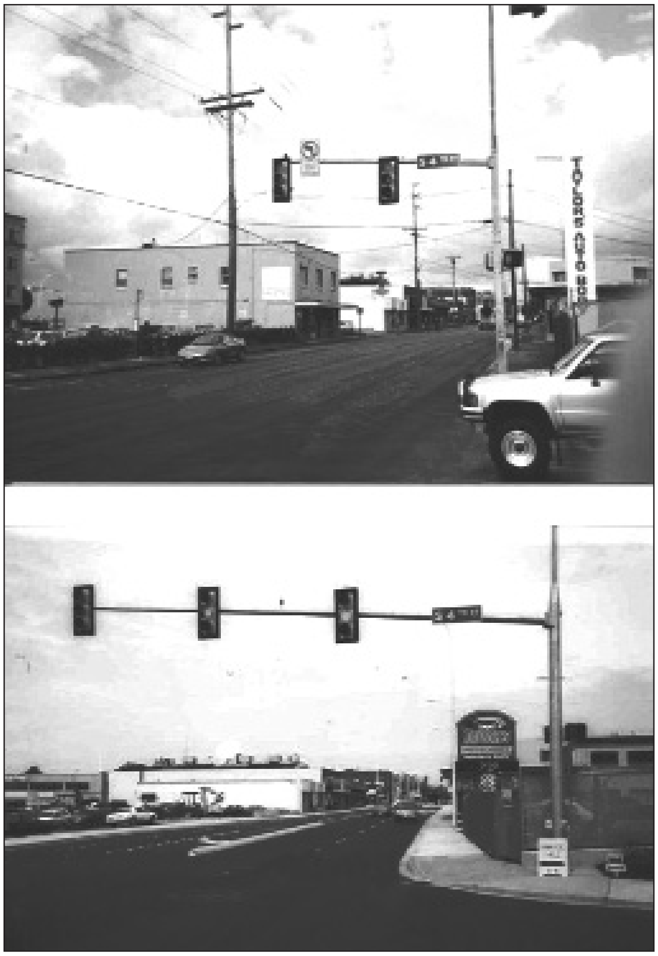


FIGURE 3-5
Placing Utilities Underground Improves Urban Clear Zones and Corridor Aesthetics

3.6.3.3 Roadside Design for Existing Facilities

Unlike a new facility where everything is built new and to current criteria, an existing facility may have been constructed to previous criteria and may contain components that have aged and possibly deteriorated. Further, the facility may include roadside barrier systems that are no longer considered to be a preferred system. It is generally economically prohibitive to upgrade all features on a project to current guidance every time work is done on that section of highway. Judgment should be exercised to decide whether a feature can still function adequately even though it does not conform to current guidance.

The proper risk assessment of an existing facility includes two primary activities. First, the relevant crash data should be reviewed for indications of features that are not performing well or locations where extra attention to roadside design might be appropriate. Second, a detailed site inspection should be performed to determine possible explanations for recorded crashes and to identify roadside safety concerns and features that do not conform to current guidelines. Crash histories of existing facilities are a very important factor in the selection of the final clear zone.

The major difference between roadside design for a resurfacing, restoration, or rehabilitation (3R) project and a reconstruction project is the effort that should be applied toward obtaining the desired clear-zone width. For reconstruction projects, the effort to achieve the desired width should extend to what is practical to attain when considering factors such as cost, environmental impacts, timeliness, etc. Conversely, on a 3R project, unless there is an accident history related to the roadside, any increase in the existing width may be limited to that which may be reasonably attained. While the *widths* that are developed for either type of project may vary, in both cases the *quality* of the zone (traversability, absence of fixed objects, etc.) should be similar.

Treatments for Existing Roadside Objects. The designer should consider, in sequence, the five categories of treatment options available to address obstacles within the design clear-zone distance. Ranked in order of safety with the most desirable listed first, these options are:

- Removal
- Relocation
- Modification
- Shielding
- Delineation

Designers should recognize that barriers installed to deflect vehicles away from fixed objects become fixed objects themselves. Preference should therefore be given to eliminating or relocating the fixed object, rather than placing a barrier in front of it, as the barrier will be both longer and closer to the highway and hence more prone to impact than the object being shielded. Note also that when a barrier is hit, the maintenance crews and vehicles pose a further obstacle during repair, and replacement of the barrier represents an added maintenance cost to the agency.

The selected treatment will vary since each project is unique, including the constraints and difficulties associated with any one measure. The designer should view each object as an individual opportunity to enhance that particular roadside environment from a safety perspective.

Removal and/or Relocation. Removal or relocation of the feature outside the clear area eliminates the need for traffic barriers. Features that can often be cost-effectively treated in this manner include commercial signs, trees, fences, and utility poles.

Modification of Objects. Options for modifying objects within the design clear-zone distance include:

- Flattening the embankment slope.

- Regrading the surrounding ground to safely redirect an errant vehicle over or around the feature and either back onto the road or onto traversable roadside.

- Redesigning the feature to be either traversable (e.g., providing a grate for a culvert) or to have surfaces that foster safe redirection.

- Implementing *breakaway* features such as frangible luminaire supports or breakaway sign supports.

Regrading the ground to achieve acceptable slopes around an object (e.g., a bridge embankment slope or boulder) or covering the object with material at an acceptable slope may sometimes be a preferred solution to installing a roadside barrier, which may present a greater area of exposure to impact than the original feature. The feature that has received the appropriate regrading or covering is no longer an obstacle, such as covered rock, and may be able to remain in place, thus avoiding removal costs.

About 15 percent of errant vehicles travel beyond the AASHTO recommended clear zone. Where fill is relatively inexpensive to provide and right-of-way is available, regrading beyond the clear zone may sometimes be cost-effective. Regrading may not only be a more cost-effective method of enhancing roadside safety, but it is also more aesthetically pleasing than traffic barriers. This solution also eliminates long-term maintenance costs for the barrier.

Changes in all three dimensions of roadside features, such as barriers, retaining walls, abutment walls, noise barriers, etc., should be gradually introduced in the direction of traffic. This gradual introduction will help prevent the vehicle from snagging on the feature, or from excessively decelerating or redirecting a vehicle at an abrupt angle. Drainage conduits that protrude through parallel and perpendicular embankments can snag, excessively redirect, or overturn a vehicle. Small drainage conduits within the clear zone should be cut to match the embankment. For larger diameters, they can be equipped with a tapered *bell* extension and a traversable grate that matches the embankment slope. Drainage conduits located beyond the clear zone may also need treatment if a ground feature might guide an errant vehicle onto the drainage end. The *Roadside Design Guide (3)* provides guidance and additional options regarding the appropriate treatment of these features.

Shielding Objects. Barriers may be warranted as shields when a fixed object, roadside obstacle, or nonconforming cross sectional or drainage feature cannot be removed from the design clear-zone width. Barriers may also be used to separate opposite direction traffic.

There are many different types and designs for barriers. Performance capability, site conditions, compatibility, costs, maintenance, aesthetics, and environmental considerations are all components of the barrier selection criteria. The barriers should be crashworthy for speeds at which they will likely be struck, regardless of the project's overall design speed, since operating speeds may vary along a highway.

Barrier crash testing procedures and vehicle parameters are specified in *NCHRP Report 350: Recommended Procedures for the Safety Performance Evaluation of Highway Features (17)*, published in 1993. The Federal Highway Administration (FHWA) mandates that all barriers and terminals installed on the National Highway System must pass or be judged by FHWA to be capable of passing the *NCHRP Report 350 (17)* test specifications.

Although barriers off the NHS might not carry the FHWA mandate, they should be adequately tested or judged to be crashworthy. While aesthetics are a concern, they should not be the controlling factor in the selection of a roadside barrier. Even in environmentally sensitive locations such as recreational areas and parks, it is important that the barrier selected be crashworthy as well as visually acceptable.

A number of crashworthy aesthetic traffic barriers have been developed (Figure 3-6). For example, the rustic color of weathering steel helps blend the barrier with the surrounding environment. Other examples include steel-backed timber barrier and a variety of concrete barriers with ornamental features.

Special attention should be paid to the barrier terminals. While a barrier that is impacted along its side will usually redirect a vehicle, the result of running into the end could be much more severe. There has been a major trend toward using crashworthy terminals that function as attenuating structures, cushioning the vehicle's impact by compressing, crushing, bending, folding, breaking, and otherwise mangling their own elements. Note that some crashworthy terminals are designed to break away upon impact, allowing the vehicle to pass behind. A clear area must be provided behind the barrier for the intended operation to occur.

FIGURE 3-6
Special Aesthetic Barrier and Guardrail Meeting *NCHRP Report 350 (17)* Test Requirements

Delineation. Where barriers are not practical or cost-effective, signs and delineation can be used to alert the motorist of the potential obstacle. Designers and the public should be aware that the effectiveness of delineation is related to the extent to which the driver can control the trajectory of the vehicle. Effective delineation may reduce the number of encroachments, and may in some cases slightly reduce speeds, but it cannot be expected to eliminate the potential for loss of control nor significantly reduce the severity of an encounter.

3.6.3.4 Roadside Design in the Urban Environment

While the clear roadside concept is always the goal of the designer, there are likely to be compromises in the urban area. Such compromises reflect the generally more restrictive nature of the right-of-way and roadside, the presence of other activities that compete for roadside space, and differences in community interests or desires. The focus of roadside design along urban streets should be on effective functional use of the border area—that dimension between the right-of-way line and edge of pavement. Effective use of this space (which may be as little as 10 ft [3 m] or less) involves provision for pedestrians, placement of utilities, signs, and other necessary objects such that they remain free from being struck by overhanging vehicles or other users within the right-of-way. It also includes provision for the storage of snow, and placement of landscaping, trees, ornamental structures, benches, etc., that contribute to the aesthetics or intended "feel" of the street, or that reflect the needs of pedestrians or other non-motor-vehicle users of the right-of-way (Figure 3-7).

FIGURE 3-7
The Urban Roadside Environment Includes Pedestrians, Utility Poles, and Other Objects Close to the Edge of Pavement

The urban street environment is generally associated with speeds of 45 mph (70 km/h) or less. The design should include offsetting lights, signs, etc., beyond the back of the curb as far from traffic as possible. It should carefully consider the placement of objects away from the sidewalk and away from intersections so that they do not impede the flow of pedestrians and do not become barriers to the sight lines of drivers, bicyclists, and pedestrians at intersections. Sometimes it is necessary to purchase additional right-of-way to provide for all users.

3.6.3.5 Flexibility in the AASHTO Roadside Design Guidelines

The AASHTO Green Book *(2)* is intended to be flexible with respect to roadside design treatments. It refers to the *Roadside Design Guide (3)* for use in general guidance; as noted previously, there may well be more than one solution that is acceptable for a given location. The *Roadside Design Guide (3)* also states this in its preface.

Within the AASHTO Green Book *(2)*, recommendations are made regarding clear-zone dimensions for different highway types in rural or urban areas. In rural areas, the recommended minimum is 10 ft (3 m); in urban areas the minimum value is 1.5 ft (0.5 m). A reading of the AASHTO Green Book *(2)* discussion, however, reveals that such guidance is not prescriptive or mandatory, but advisory. Indeed, the urban value of 1.5 ft (0.5 m) is associated with operational needs (car door conflicts with roadside objects) and not strictly safety issues (i.e., impacts to objects beyond the pavement).

Designers and their customers—the public, local elected officials, and others—should acknowledge that it is not possible to design a totally risk-free roadside, and thus it is not reasonable to expect a totally risk-free roadside. Once a vehicle leaves the road, adverse consequences likely will result. Achieving the safest possible roadside on any given project will require the best efforts of the designer, working with the alignment, land use, and other constraints. In addition, it will take the best efforts of maintenance and permitting operations to keep the roadside clear of obstacles.

Designers working in the context-sensitive environment will be successful if they understand the content and intent of the *Roadside Design Guide (3)* and the AASHTO Green Book *(2)*, and if they follow these general guidelines:

- Avoid setting an artificial design speed (i.e., unrealistically low).
- Apply a consistent roadside treatment approach for any project.
- Avoid the establishment of an arbitrary clear-zone width.
- Encourage the removal or relocation of signs, utility poles, and other fixed objects to improve both safety and aesthetics.
- Encourage safe landscaping, paying special attention to keep trees and tall bushes out of sight triangles at intersections, beyond the limits of the desired clear zone, and beyond the clear zone in medians on higher-speed highways and streets.

Designers should assume that vehicles would travel at the design speed or known operating speeds, rather than at the posted speed limit. If lower speeds than currently exist are desired, designers may opt for traffic-calming solutions intended to reduce speeds.

As noted in earlier sections of this chapter, special attention to the roadside is appropriate where a design exception is required for other geometric features such as cross section or alignment.

3.6.4 Medians

A median is an important consideration in the design of multilane facilities. The median is that portion of the roadway cross section between the traveled way of opposing directions of travel. The median width includes shoulders (paved or unpaved), slopes, any drainage swales or ditches, and, in some cases, barriers. Medians may be depressed, raised, or flush.

3.6.4.1 Medians on Rural Highways

The function of a median on a rural highway is to separate high-speed flows of traffic, producing a buffer against head-on crashes. The rural highway median can also be effective in reducing the headlight glare of oncoming vehicles, and can provide a benefit of improved aesthetics. The general range of median widths is from 4 ft (1.2 m) to 80 ft (24 m) or more. Research has demonstrated the overall safety benefits of wider medians. Accordingly, medians should be as wide as practical.

Median width influences the design of cross section features (shoulders, slopes, ditches) within the median. For higher-speed roads with narrow median widths, barrier protection may be necessary for safety. With median widths in excess of 50 ft (15 m), the designer can generally provide full left shoulders and recoverable slopes of 1V:6H while maintaining adequate ditch designs. Wider medians also allow for the retention of existing vegetation or new landscaping for aesthetics, and also help to reduce or eliminate headlight glare. Finally, wider medians can accommodate future roadway widening without requiring additional right-of-way.

Of course, the median width should be in balance with the other elements of the total roadway cross section. Wider medians require more right-of-way, and may result in greater environmental effects and/or increased construction costs.

Creative design in rolling or mountainous terrain may involve variable width medians, with each direction of travel designed on independent alignments to take advantage of natural terrain, avoid a particularly sensitive area, or provide a more aesthetically pleasing alignment for the users.

Many transportation agencies construct multilane rural highways with partial access control. These may include some at-grade intersections and limited driveway access to adjacent properties. Care should be taken in selecting a median width that provides for safe intersection operations. Very wide medians cause roads to operate as two separate intersections. Narrower medians require drivers on the stopped approach to find acceptable gaps in both directions of traffic. This condition may be particularly difficult for drivers of longer vehicles such as semi-trailers.

3.6.4.2 Medians on Urban Highways

As in rural areas, median width in urban areas also influences the design of cross section features (shoulders, slopes, ditches) within the median. Medians serve a safety and traffic operational function on urban highways and streets and are also beneficial as pedestrian refuges on wide streets. In addition to the safety benefits regarding head-on crashes, medians can contain left-turn lanes and thus function to protect left-turning vehicles from rear-end conflicts. Research has strongly supported the safety benefits of four-lane divided roads versus undivided roads with no median.

Medians in urban areas can be raised, depressed, or flush. Raised medians offer positive access control, and, with sufficient width, can also offer opportunities for landscaping or other aesthetic treatments. Many communities view the presence of a wider median as an opportunity to enhance the visual character of the roadway, and in many cases to make a distinctive statement to visitors of their area. Raised medians are thus often the focus of special landscaping ideas or treatments. Note that care should be taken in placing trees in medians of higher-speed arterials (i.e., those with speeds greater than 45 mph (70 km/h)), as typical vertical face curbs will not prevent roadside encroachment at higher speeds. Landscaping treatments should be limited in such cases to shrubs and small trees (those that will grow to no more than 4 inches in diameter at maturity). Where larger trees are desired, special barriers designed to redirect vehicles should be considered within the median. Stakeholders should be reasonably informed of the consequences of large fixed objects in the median. Care should be taken to encourage such treatments that require little or no maintenance.

Of course, medians limit the direct access to adjacent land uses except where median openings are provided. Arriving at an optimal solution to an urban arterial reconstruction effort that addresses the safety, access, and aesthetic issues is a common design problem in the urban environment. Flush driveable medians (i.e., arterials with two-way center left-turn lanes) are often used where there is substantial existing driveway activity and the imposition of access control is not acceptable. From a safety perspective, raised medians are preferred, but highways with two-way center left-turn lanes provide safety benefits as well. These are often designed in response to local concerns about loss of access. Streets with flush medians generally perform better than multilane, undivided streets.

Curbing is occasionally used to create raised medians to physically separate opposing directions of traffic and for aesthetics. As speeds increase, the suitability of raised medians without crashworthy barriers decreases. Designers should carefully consider roadside safety when designing medians of any type. Avoid types of curb, plantings, or installations of other objects in the median that reduce sight distances, create fixed objects, or destabilize errant vehicles.

The width of medians in urban areas can vary. Widths of 10 to 12 ft (3 to 4 m) provide sufficient space to *shield* a single left-turn lane. Widths of 26 to 30 ft (8 to 9 m) are appropriate for high-volume arterials where signalized intersections will require double left-turn lanes.

Even medians designed for widths less than 10 ft (3 m) can provide positive benefits. A 6-ft (1.8-m) width is sufficient for a raised median to safely store pedestrians between opposing traffic lanes. Narrow, raised medians also provide a means of positive access control.

3.6.4.3 Flexibility in the AASHTO Guidelines

The AASHTO Green Book *(2)* offers considerable flexibility in the use and design of medians. The Green Book *(2)* describes operational and safety advantages, provides appropriate widths for different functions, and discusses tradeoffs. The use of medians is clearly encouraged by the AASHTO Green Book *(2)*. Nothing in the AASHTO Green Book *(2)*, however, mandates the use of medians or their design dimensions.

Designers should understand the functions and benefits of medians and be prepared to provide median design treatments that fit within the overall cross section. The width and design of medians offers flexibility for the designer. Median width can be adjusted as necessitated by available right-of-way constraints and border area needs. Medians should be wide enough to allow the design vehicle to safely make a selected maneuver and to provide space for appropriate safety devices.

3.6.4.4 Mitigating the Effects of Narrow Medians

Where medians do not exist or cannot be provided, designers should strive to mitigate potential adverse effects. Left-turn restrictions and the institution of access control can reduce rear-end/left-turn conflicts.

Where narrow median widths exist in urban areas, designers can consider the re-allocation of cross section width. The provision of a minimally functional median dimension (i.e., to enable placement of raised barrier, provide left-turn storage, or shield pedestrians) can be accomplished through marginal narrowing of lanes, elimination of on-street parking, and re-striping lanes. The *Roadside Design Guide (3)* provides guidance on the use of barriers for narrow medians.

Turn-arounds and/or jughandles can be used to provide access where it is desired or in place of a center left-turn lane where sufficient width for a median does not exist.

3.7 Bridges

Highway bridges are key elements of the roadway infrastructure. Geometric considerations for new, replacement, or rehabilitated bridges deal primarily with the issues of deck width and its relationship to the roadway approaches and the horizontal and vertical clearances. Horizontal and vertical under-clearance, bridge loading, and provisions for pedestrians are all critical design criteria. This is due to the significant expense of bridge construction and their importance to the highway system.

Many existing bridges were designed with horizontal or vertical clearances that do not fully meet current design criteria. These may represent safety concerns, as these under-clearances may be subject to being struck by over-height vehicle loads, and bridge piers or abutments being struck by errant vehicles. Of course, the extent to which a bridge with horizontal or vertical clearances outside typical ranges represents an actual safety concern is based on site-specific conditions, including the type of traffic, speeds, roadway geometry, and other features.

Designers should review the safety history of a bridge before committing to reconstruct it to correct such geometric deficiencies. Bridge replacement can be expensive, and addressing clearance and width issues can result in substantial positive and negative impacts to approach road geometry.

Bridge aesthetics is a major concern for many context-sensitive design projects. Aesthetic bridge rails that meet required impact test parameters have been developed by some agencies to match aesthetic treatment of abutments and piers. Information on bridge aesthetics, ranging from scale and proportion to aesthetic details, may be found in *Aesthetic Guidelines for Bridge Design (12)* produced by the Minnesota DOT.

3.7.1 Flexibility in the AASHTO Guidelines

The replacement or retention of bridges having historic or aesthetic value or the design of bridges on very low-volume roads may justify traveled way widths less than the indicated minimum AASHTO Green Book *(2)* values. The width evaluation should be made by a design professional on an individual basis as part of the retention or removal decision-making process. Once the retention or replacement width decision is made, structural details, including bridge rails, should conform to AASHTO bridge specifications.

The AASHTO Green Book *(2)* offers flexibility by presenting ranges of bridge deck widths depending on functional classification and traffic volumes. Consideration of pedestrian and/or bicycle needs is in addition to these width recommendations. The AASHTO Green Book *(2)* further recognizes that there are situations where existing structures marginally meet the recommended width criteria, and makes provisions for structures to remain in place under certain circumstances. Where full bridge width is not achievable, interim measures (sufficient until complete reconstruction is necessary) are cited as appropriate, including signing and pavement marking. Likewise, where full vertical under-clearance cannot be achieved, lesser dimensions may be acceptable if an alternative route exists for trucks.

3.8 Intersections

Intersections are an important feature of highways. Intersection design affects the efficiency, safety, speed, capacity, and cost of operation of a highway. Intersections are conflict points for vehicular and pedestrian operations. Although intersections account for a very small part of the highway system, nearly half of motor vehicle crashes occur at intersections.

The objective of intersection design, as stated in Chapter 9 of the AASHTO Green Book *(2)*, is to "facilitate the convenience, ease and comfort of people traversing the intersection while enhancing the efficient movement of motor vehicles, buses, trucks, bicycles, and pedestrians. Intersection design should be fitted closely to the natural transitional paths and operating characteristics of its users." (p. 559)

Elements of safe intersection design include the following:

- Provision for sight distance, both in advance of the intersection and at the approaches to the intersection.
- Accommodation of appropriate traffic control.
- Provision for safe and efficient handling of left-turning vehicles.
- Avoidance of unusual and/or confusing alignment in proximity to the intersection.
- Sufficient capacity of the intersection to reduce adverse operational effects on the adjacent street system.
- Separation from and delineation of nearby adjacent intersections.

• Accommodation of pedestrians and bicyclists.

The configuration of an intersection will be significantly influenced by site-specific features and constraints. The number of legs, angles of intersection, cross sections of approaching roadways, and all potential users (motorists, pedestrians, transit vehicles, bicyclists) may affect the type of intersection solution as well as its design details. Note that in recent years roundabout intersections have evolved as potential solutions to intersection problems in rural, urban, and suburban areas. Designers are encouraged to understand and use as appropriate either conventional intersections or roundabouts as the site and problems dictate. A key reference for roundabout designs is *Roundabouts: An Informational Guide (8)* published by the FHWA.

Adequate sight distance is critical to intersection safety. Vegetation, buildings, and other objects should not block the line of sight and thus contribute to a decrease in safety. Design requirements for traffic signals, stop signs, and other traffic-control devices are integral to intersection geometric design.

Left-turning vehicles represent the greatest risk to safety and operations of intersections. Removing stopped or decelerating left turns from the through lanes enhances safety at both signalized and unsignalized intersections. The AASHTO Green Book *(2)* includes guidelines on warrants for left-turn lanes; in general, left-turn lanes should be provided wherever space permits for new design or major reconstruction projects.

The AASHTO Green Book *(2)* also provides guidance on design dimensions for left- and right-turn lanes. Here, special attention should be paid to vehicle operations on approaches to intersections. Design of left- and right-turn lanes should consider the needs of deceleration and acceleration as well as queuing at intersection approaches.

3.8.1 Design Vehicles Control Intersection Features

Most of the geometric features of an intersection are based on accommodating the off-tracking requirements of the design vehicle. AASHTO design vehicles provide the designer with the means to establish turning path requirements, and to develop curb return, median end treatments, and corner channelization.

Selection of an appropriate design vehicle for an intersection is among the most important context-sensitive design choices. Use of larger design vehicles (such as semi-trailers) will generally minimize encroachment of most vehicles into adjacent lanes and shoulders. However, design for large vehicles increases the size of the intersection, producing potentially adverse cost and land use impacts, and adversely affecting certain operations such as signal control and pedestrian crossings.

Selection of an appropriate design vehicle requires the designer to consider more than just the operational requirements of turning paths. While some designers may prefer to use the largest size vehicle that would ever use the intersection, this approach may not be cost-effective or even the most desirable. Selection of a design vehicle that arrives reasonably frequently may be a better approach, particularly for intersections in constrained urban areas. For urban streets, often the largest vehicle that is regularly present is a school or transit bus, or similar long vehicle. This may be the appropriate design vehicle for the design of intersection geometry given the limited space and lower frequency of larger vehicles such as semi-trailers.

Designers should recognize that the individual AASHTO design vehicles and their design turning characteristics are composites, representing relatively conservative dimensions. The actual vehicle fleet requires less space than may be implied by a given design vehicle. Conversely, trends toward larger vehicles suggest caution in selecting too small a design vehicle. Generally, a single unit truck or bus is the minimum design vehicle appropriate for all but low-volume local roads. Larger trucks such as multi-unit semi-trailers should be used for designated truck routes and facilities expected to carry substantial truck traffic.

3.8.2 Flexibility in the AASHTO Guidelines

The AASHTO Green Book *(2)* provides a great deal of flexibility in intersection design, which is appropriate given its complexity and the large number of factors the designer should consider. Design guidance rather than prescribed minimum dimensions is discussed in the AASHTO Green Book *(2)*.

While a great amount of technical detail on the design dimensions is required for any given design vehicle, design vehicles for different cases or conditions are not specified or mandated in the AASHTO Green Book *(2)*. Designers should use their own judgment in the selection of an appropriate design vehicle. Once a design vehicle is selected, the AASHTO Green Book *(2)* gives considerable guidance on radii and lane widths that are consistent with the characteristics of the design vehicle. (Note that federal and state legislation may require a route to be "accessible" for specified types of vehicles).

In terms of flexibility, designers and other stakeholders should be aware of the more stringent requirements governing intersections associated with the *Manual on Uniform Traffic Control Devices* (MUTCD). This document specifies practice regarding the design and placement of traffic-control devices, including traffic signals, stop and other regulatory signs, and warning signs. Many of the dimensions, treatments, etc., in the MUTCD are mandated.

3.8.3 Mitigating Nontraditional Intersection Design Treatments

Designers may occasionally be constrained with respect to the lane arrangements, geometry, or design vehicle that can be accommodated. Mitigation efforts may include placing roadside objects (lights, sign poles, signals, etc.) farther from the edge of pavement so large vehicles do not collide with them. The use of mountable or painted end treatments on raised barriers provides more room for encroachments.

Where desired turning lane arrangements cannot be developed, different traffic-control schemes may be used, including turn prohibitions, special signal phasing, or other measures. Whatever design and operating scheme is developed, the designer should verify that adequate intersection sight distance has been provided by the geometry and roadside design features.

3.9 Access Control

Control of access refers to the location and design of driveways or direct access to the street or roadway section. It also includes the provision for or restrictions associated with access to or across highway medians.

Access control is among the most useful tools the transportation agency has to maintain safe and efficient operations. Judicious use of median treatments, driveway permits, and driveway geometry can enhance the operation of the road without undue burden on landowners accessing their property. Achieving access control may mean acquiring the abutting property owner's right of access, limiting future driveways when large parcels are sold or developed, or directing or limiting certain turning movements through geometric restrictions.

Central to proper access control is the relationship of access to functional classification, shown in Figure 3-8. Designers working with communities should strive toward developing a highway system in which access needs are provided within the context of each road's function. For higher-classification facilities, the design team should focus on developing access solutions that relocate driveways from arterial streets to lower functional class streets or through frontage roads. For projects involving lower-classification roads and streets, designers should be more willing to compromise on access, within the constraints of good design practice, regarding the location of driveways relative to intersections, provision for sight distance at driveways, and appropriate traffic control.

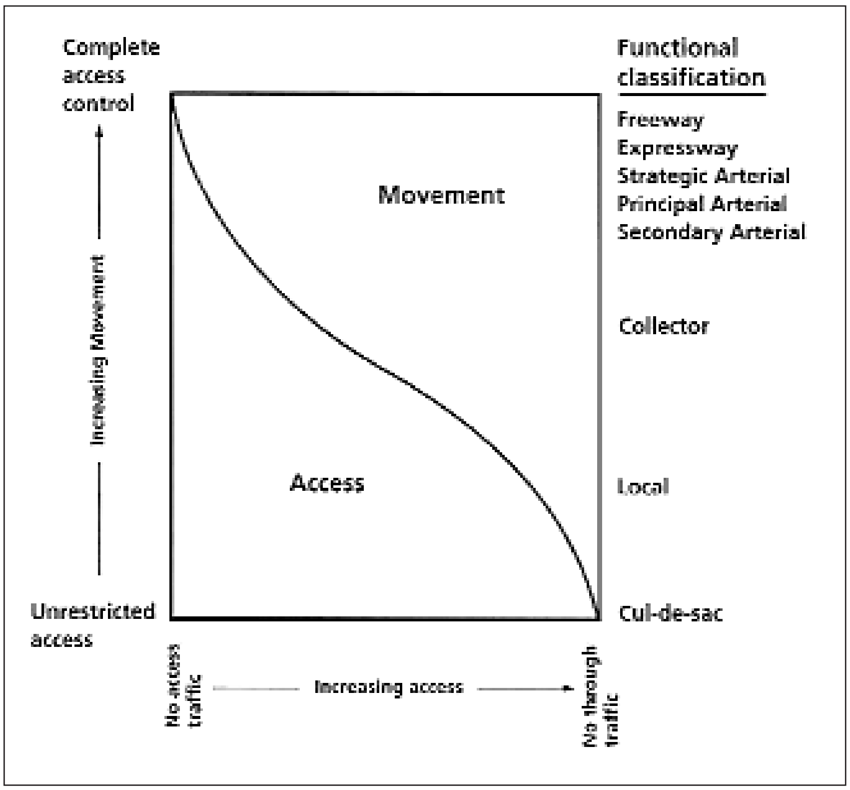


FIGURE 3-8
Relationship of Access Control to Functional Classification

3.9.1 Flexibility in the AASHTO Guidelines

The AASHTO Green Book *(2)* discusses techniques and design solutions for achieving access control, but includes no discussion mandating or requiring the establishment of such control. Most states have established policies and permit procedures that form the basis for project-specific design decisions.

3.10 Pedestrian and Bicycle Facilities

Walking and bicycling are significant modes of transportation. Pedestrians and bicyclists of all ages and capabilities use streets and highways in both urban and suburban areas. Clearly, bicyclists and pedestrians should be considered as an integral part of the nation's intermodal transportation systems. By improving the ability to move people and goods in the most efficient and safest means possible, a transportation agency can help a region realize its air quality, mobility, safety, and cost-effectiveness goals.

Despite the importance of walking and bicycling, many existing streets and highways and their rights-of-way do not adequately provide for these modes of travel. Designers responsible for a street or highway reconstruction or resurfacing project may be faced not only with design for motorized vehicles, but also with enhancing the movement of pedestrians and bicyclists within and across the right-of-way.

Unless specifically prohibited, bicycles and pedestrians should be considered in the design of any highway facility. This consideration may vary from use of highway shoulders to shared lane use for bicycles to separate facilities. AASHTO's *Guide for the Development of Bicycle Facilities (1)* provides guidelines and design criteria for bicycle facilities, while AASHTO's *Guide for the Planning, Design, and Operation of Pedestrian Facilities (5)* provides further guidance regarding pedestrians.

The incorporation of pedestrian and bicycle facilities should consider the type of highway, operating speeds, and levels of traffic volume. For example, paved paths specifically for walking and bicycling may not be needed on low-speed or low-volume roadways, or on highways where walking and bicycling are not permitted (such as freeways). However, on roadways where significant numbers of motor vehicles, pedestrians, and bicycles share the highway pavement, there is a potential degradation of safety, convenience, and travel efficiency as motor vehicle speeds and traffic volumes increase. Paved shoulders, bike lanes, or independent bike paths are often used for the safe accommodation of bicycle traffic on higher speed facilities and/or where a large volume of bicycle traffic is expected. With regard to pedestrian facilities, new requirements for public rights-of-way are expected to be finalized by the U.S. Access Board in 2005 and will also need to be followed.

In suburban and urban environments, a width within the right-of-way is usually available between the roadway and adjacent land uses. This border offers some degree of flexibility to the designer in the physical location of sidewalks and bike paths. The designer should evaluate the feasibility and acceptability of the various options for separate paths.

Ideally, where they are desired, pedestrian and bicycle facilities should be constructed outside the clear zone of high-speed, high-volume highways. Usually these paths operate as two-way traffic facilities alongside directional traffic lanes. Where this is not possible, traffic barriers may be appropriate to adequately protect bicyclists and/or pedestrians from high-speed vehicles. The designer should consider the barrier cost, the potential reduction in vehicle safety, and the potential improvement in bike/pedestrian safety when determining the appropriate safety measures. However, fixed objects, such as bollards or trees, should not be installed in high-speed areas as measures to protect pedestrians and bicyclists.

Curbing has little, if any, redirective capacity at medium and high speeds and consequently affords little, if any, protection for pedestrians. Where pedestrians are accommodated within high- and moderate-speed corridors, increased separation and even barrier protection may be a preferable alternative to curbs.

3.10.1 Flexibility in the AASHTO Guidelines

There is significant flexibility in the AASHTO guidelines regarding the provision for and/or design of pedestrian and bicycle facilities. Designers in some instances may choose not to provide separate facilities, or to do so in only one direction of travel or on one side of the roadway. Bicycle lanes or paths may be integral with the highway or on separate alignment, and may be combined with or separated from pedestrian facilities. Figure 3-9 illustrates one such flexible solution: conversion of a four-lane undivided roadway to a three-lane design (one lane in each direction with a two-way center left-turn lane) that also includes a bicycle lane.

FIGURE 3-9
Conversion of Four-Lane Roadway to Two-Lane Roadway with Center Turn Lane and Directional Bike Paths

The AASHTO guidelines emphasize the importance of designers identifying nonmotorized transportation needs and addressing these in a manner similar to that employed for traditional highway solutions.

3.11 Traffic Calming

There is increasing concern in many communities over the adverse effects of vehicular traffic. Traffic spillover from congested arterial streets to residential neighborhoods raises concerns over safety, noise, and degradation of the overall environment. Planners and engineers are increasingly confronted with demands by local residents and town councils to address such undesirable traffic impacts.

The term *traffic calming* refers to measures intended to reduce the undesirable effects of traffic. Such effects are generally two-fold: inappropriate (generally too high) speeds for a route or street, and inappropriate traffic (e.g., through traffic on a residential street). Traffic-calming techniques may apply on arterials, collectors, or local streets. It is important for designers and the community to fully understand the traffic problem that might be addressed by a traffic-calming solution. Effective traffic-calming techniques will differ depending on the nature of the identified problem and the location.

Traffic calming aimed at reducing speeds is primarily used in lower speed urban areas and in *speed transition* areas such as near the urbanized limits of small towns. In the latter instance, where a high-speed arterial or through route passes through a small town, it may be necessary to implement design and other traffic-control measures to encourage drivers to slow down as they pass through the town. Traffic-calming measures incorporating route diversion techniques and promoting nonmotorized transportation modes may apply where there are concerns about through traffic (often trucks) using local or residential streets.

Traffic-calming measures often incorporate the full range of geometric features (alignment, cross section, distance, and intersections). Flexible design practice in the urban environment requires an understanding and ability to properly consider and apply traffic-calming measures so they will have the intended effect.

3.11.1 Overview of Traffic Calming

Traffic-calming measures have been used successfully in Europe for many years. The number of successful traffic-calming programs in the United States is increasing, and reports of these successes are generating strong interest.

The Institute of Transportation Engineers (ITE) defines traffic calming as the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for nonmotorized street users. The terms are further defined as follows:

- **Reduce negative effects of motor vehicle use** refers to changing the design and the role of the street to reduce the negative social and environmental effects of motor vehicles on individuals (e.g., speed, intrusion, etc.), and on society in general (e.g., pollution, urban sprawl, etc.).

- **Alter driver behavior** addresses the self-enforcement aspect of traffic calming i.e., the lowering of speeds, the reduction of aggressive driving, and the increase in respect for nonmotorized street users.

- **Improve conditions for non motorized street users** refers to promoting walking and cycling, increasing safety, creating a feeling of safety, and improving aesthetics.

Traffic calming challenges the traditional design view of a roadway design, namely, that higher speeds are desirable and indicative of a high-quality design. While this may be true for higher-classification facilities, it may not be viewed as true by those who live along the highway or on residential or local streets. Designers should learn to adapt to the request by the public to provide a safe, *lower-speed* street that meets functional requirements.

3.11.2 Leading a Traffic-Calming Study

The challenge of the designer and the public is to recognize that traffic calming cannot solve all traffic problems and may not be appropriate on many highways or streets. Furthermore, the challenge to the designer is to understand local concerns and work to find design solutions that address them if traffic-calming measures are not believed appropriate.

3.11.2.1 Establish Purpose

The designer, working with the local community, should examine the project circumstances, establish the project objectives, and consider if traffic calming should be an alternative or an element of the solution. Traffic-calming techniques, when appropriately installed, can supplement law enforcement activities. However, such techniques cannot replace the need for or the obligation to provide normal law enforcement. In general, the designer should consider traffic-calming measures as a tool to address congestion, safety, and quality-of-life issues in response to one or more of the following:

1) A community, corridor, or area where a traffic-calming plan has been completed or agreed upon by a neighborhood group, the municipality, the county.

2) A project is scheduled for a village/main street, school zone, or other subarea, and scoping indicates that the inclusion of traffic calming would satisfy identified subarea needs such as a significant existing safety problem whose severity could reasonably be expected to be reduced by the application of traffic calming.

3) A community requests speed limit modifications, traffic-control devices, safety improvements, or other concerns that are not satisfied by more traditional measures and/or enforcement. Enforcement alone cannot be relied on to reduce speed. The physical environment, especially highway geometry, may need to change to alter the driver's perceived safe operating speed.

Traffic calming is not applicable to every project. Where the objective of traffic-calming conflicts with the primary intended function of the road, traffic calming may be counterproductive to the overall public good. In general, facilities that serve local traffic are best suited to traffic-calming measures. Measures that attempt to reduce the safe operating speed are not applicable on collectors and should not be used on arterials.

3.11.2.2 Offer Alternatives to Traffic Calming

Where traffic calming is requested for arterial highways or streets, the designer should be able to offer alternatives to the rejection of a traffic-calming plan. Careful attention should be paid to public concerns regarding pedestrian safety, excessive speeds, and the adverse effects of truck traffic.

Alternative treatments that may address these concerns, yet not degrade the arterial function, include channelization and the provision of pedestrian ambiance enhancing features.

3.11.3 Application of Traffic-Calming Techniques

Individual traffic-calming techniques are not new. Some techniques, such as pedestrian refuge islands and traffic circles, have been used since the days of horse drawn carriages. Many techniques have been used in one form or another with varying frequency on highways, streets, and/or private property. What is new is the interest in applying these techniques in combination, and improving the compatibility among all highway users. Combining techniques is especially effective in neighborhood traffic calming, which applies to residential neighborhoods, and on shopping or entertainment-oriented streets. In some cases, they can also be effective on main streets of cities, towns, and villages, and in school zones.

When considering the various traffic-calming techniques, the designer should strive to consider and balance the many conflicting needs between the highway users (motorists, pedestrians, bicyclists) and adjacent land owners, with safety being of paramount concern. Traffic-calming measures should be designed in accordance with all applicable designs, criteria, and guidelines. They should be consistently applied over an appropriate length of the facility or area, and should not be implemented in a way that "surprises" the motorist. There must also be sufficient street lighting so that traffic-calming measures are visible to the driver beyond the reach of headlights.

Designers unfamiliar with traffic-calming techniques, their applicability, and their effectiveness, should educate themselves prior to working with a community. Some techniques have been successful, others less so. While traffic calming has been embraced as a cure-all in some locales, designers should bring substantive information to a project on what works or does not work given the project's constraints. The burden is on the designer to explain how operating speeds will actually be reduced in response to the application of a particular traffic-calming measure.

Traffic-calming measures include 1) those that use physical restrictions to lower the speed at which a reasonable and prudent driver feels comfortable and 2) those that convey the clear message that priority is given to creating a pedestrian and resident-friendly setting, possibly with special accommodations for bicyclists. Measures in the former group include speed humps and tables (see Figure 3-10), lane constrictions (including neck-downs to a single lane), chicanes, tight curves, turning radius reductions, and sight distance limitations. Measures in the latter group (message or ambiance techniques) include aesthetic treatments such as landscaping with trees and other plants; use of special paving and/or markings; decorative benches, light poles, fountains, sculptures, and/or kiosks; accommodations such as sidewalks, pedestrian bulb-outs, mid-block crosswalks, and bicycle lane markings; and distinctive entrances (gateways) as demarcation for the traffic-calmed area.

FIGURE 3-10
Speed Table in Conjunction with Pedestrian Crossing on Local Street

3.11.3.1 Consider Route Diversion Effects

When the implementation of traffic calming causes drivers to divert to use alternate routes, increased volumes (and perhaps speeds) on those new routes may result. Traffic-calming projects that will result in significant diversions of traffic to alternate routes should be developed in accordance with the following:

1) Traffic-calming plans should not be developed without the opportunity for input from people who live or work along the alternate routes to which traffic may be diverted either by signing or by driver choice.

2) Capacity-reducing traffic-calming techniques should only be used on local streets or neighborhood streets to avoid otherwise serious congestion. Capacity-reducing techniques should not be used for other highway types unless a reasonable, logical alternative route is readily available, or is provided before the project. The alternate route should be clearly signed.

3) Area-wide traffic management/calming plans to ameliorate the potential impact of any traffic diversion as a consequence of the traffic-calming activities should be considered, particularly in urban settings.

4) Traffic calming should only be employed over limited lengths of a given collector or minor arterial that meet all other requirements for treatment. For local roads, it should only be used where it is important to give priority to residential area character or to nonmotorized users of the roadway.

3.11.3.2 Address Overall Public Safety

Drivers should be warned before they enter and when they drive through a traffic-calmed area. Isolated and unanticipated street narrowing, tight curves, or reduced sight distances could be potential concerns if encountered without warning.

When studying the limits of any traffic-calming project, the solution should consider the potential for motorists to speed up upon leaving the area. The downstream effect of increased speeds should be carefully considered, and appropriate design or traffic-control measures taken.

In addition to concerns for motorists' safety, other public safety concerns should be addressed. The most obvious of these are access for fire vehicles and response times for fire, ambulance, and police vehicles. An important consideration is how traffic calming may affect these emergency services.

3.11.3.3 Implementing Traffic-Calming Plans

Traffic-calming measures are still experimental in the United States. Designers should consider installing temporary, more forgiving traffic-calming measures such as pavement markings, temporary delineators, or channelizing devices on a trial basis, when appropriate, before installing the permanent measures, particularly in those situations where traffic calming may require significant driving adjustments. Temporary deployment can provide a transition to the permanent measures proposed, an insight into the effectiveness of the proposed calming measures, and offer the opportunity to make modifications before installing a permanent device. It also allows roadway users to adjust to changing conditions.

The trial period should be developed and implemented working closely with the locality. Trial measures should encompass all the affected highway mainline and side street approaches as deemed appropriate by agreement between the transportation agency and the locality. The trial period should be long enough to evaluate the effectiveness of the measures and acclimate highway users through the full range of traffic (commuter, tourism, commercial) and environmental (snow and ice control) conditions expected.

The use of forgiving, frangible, or crashworthy traffic-control devices, plantings, etc., for permanent traffic-calming measures is desirable. Design speed, vehicle traffic, pedestrian and bicycle volumes, project geometrics, and aesthetics are factors to be considered in determining the treatment to be used. Finally, traffic-calming plans, especially those that involve neighborhood traffic calming, require the complete cooperation and support of the affected local citizens if the plans are to be successful.

3.12 Developing and Documenting Safety Sensitive Solutions

It is the responsibility of the agency or group proposing the highway improvement to carefully consider all alternatives with all interested people, and then prepare a project scope that clearly defines what the highway design professional is to accomplish. The highway design professional's responsibility is to develop a full range of alternatives, work with the project team to evaluate these, and help select and refine the "best" plan (i.e., the one that best meets the project's purpose and need). As part of this process, the designer applies knowledge regarding each of the individual highway elements as described above.

Designers should always begin with full design criteria and guidelines as used by his/her agency and reflected in the AASHTO Green Book *(2)*. While strict adherence to design criteria does not guarantee a safe design, good design practice combined with the appropriate application of design criteria will most often produce a high-quality design that is accepted by the agency, motorists, and the community.

3.12.1 Overall Guidance

Designers should always strive to prepare solutions that incorporate full geometric design criteria. Design values published in the AASHTO Green Book *(2)* have evolved from much research and experience, and have stood the test of time. Flexible design solutions based on design criteria often demand creativity and the use of unique or innovative approaches.

In the context-sensitive environment, limitations, constraints, and competing values sometimes require designers to look beyond the full criteria or "tried and true" solutions for a workable solution. Information in this chapter should help designers make decisions about what dimensions or design approach may be tried with confidence. The following additional general guidance enhances this approach.

3.12.1.1 Avoid Combinations of Geometry Outside Typical Ranges

Designers may occasionally accept a design dimension outside the customary range for, say, lane width or curvature at a given location. They should strive, however, to avoid alternatives that simultaneously combine multiple dimensions outside traditional ranges. This is especially important for combinations known to cause safety problems (e.g., sharp curves on long down grades). Indeed, avoiding combinations of minimum geometry that meet criteria is good design practice.

3.12.1.2 Maintain a Reasonable Design Speed

Designers should not "solve" a sensitive design problem by arbitrarily lowering the nominal design speed without also undertaking proactive measures such as traffic calming to reduce speeds. Design speed is a factor in all of the major geometric elements. Lowering the design speed may result in the designer selecting an inappropriate design dimension or value, which otherwise would not have been required and may cause a safety or operational problem (refer to Chapter 1). Where lower speeds are sought through traffic calming, designers should commit to confirming the effectiveness of their solutions in reducing speeds.

3.12.1.3 Mitigate the Expected Operational Effects

Where an element, dimension, or approach is used that is outside the ranges found in the Green Book *(2)*, designers should understand the potential adverse effects and look to other design elements for mitigation. For example, if a designer decides to accept a narrow bridge width, every effort should be made to provide more than minimum stopping sight distance on the approach to the bridge, and to pay special attention to approach signing and delineation.

3.12.2 Demonstrating a Commitment to Mitigate Safety Concerns

In many cases where the context-sensitive solution cannot meet normal new-construction design criteria, additional safety enhancement measures can be built into the project to mitigate possible safety concerns. Examples of alternative safety mitigation measures that may be considered are shown in Table 3-3, some of which may require design exceptions.

While the installation of mitigation measures such as guardrail or crash cushions can be useful to reduce the potential severity of crashes with roadside obstacles, it must be remembered that such treatments may not "solve" the problem caused by other inadequacies; they simply reduce the overall severity of roadside crashes.

3.12.3 Documenting Design Exceptions

There is usually sufficient flexibility to operate within the parameters of the AASHTO Green Book *(2)*. Occasionally, there are instances where deviations from AASHTO Green Book *(2)* criteria are needed for a properly balanced design. *Design exceptions* provide the designer with the ability to prepare a design with reasonable modifications to the published minimum design parameters.

Design exceptions are a legitimate, acceptable part of the overall design process. Designers should not feel reluctant to request a design exception if they have fully investigated the alternatives and are confident in the expected operational and safety characteristics of the proposed design.

For example, design exceptions may be used for projects involving reconstruction of an existing roadway in which design options are limited due to unavailable right-of-way, or the presence of other highly-valued resources or land uses. Where a design exception is needed, it is important that designers and the public recognize the importance of striving to improve the design of the reconstructed road as compared to its existing condition, even if the *full criteria* solution is not feasible.

A critical aspect of the design process is the documentation of key design decisions. Many transportation agencies require the preparation of design reports as part of the overall project development process. Such reports are useful for projects that take years to complete, that involve many staff and different agencies, and for which other documentation such as Environmental Assessments are necessary.

The FHWA and many agencies require the review and approval of designs for which a geometric feature or dimension outside the traditional Green Book *(2)* values is proposed. Many of the design criteria previously outlined in Table 3-1 are considered of sufficient importance to require design exception requests.

TABLE 3-3
Alternative Safety Mitigation Measures

Feature	Alternative Safety Mitigation Measures
Narrow lanes or shoulders	Pavement edge lines Raised reflective markers Delineators
Steep sideslopes, roadside obstacles	Roadside object markers Slope flattening Rounded ditches Obstacle removal Breakaway safety hardware Guardrail or crash cushions
Narrow bridge	Approach guardrail Pavement edge lines Warning signs and/or object markers
Limited sight distance at hill crest	Warning signs Obstacle removal Shoulder widening Driveway relocation
Sharp horizontal curve	Warning signs Shoulder widening Improved superelevation Slope flattening Pavement anti-skid treatement Obstacle removal Guardrail or crash cushions
Locations with crash history	Upgrade intersection traffic control Warning signs Street lighting Pavement anti-skid treatement Speed controls Sight distance

A request for a design exception should include a description of the proposed design and an evaluation of the impacts of the reduced design values in terms of safety, capacity, and route compatibility; time to construction of ultimate improvement; environmental, historic and aesthetic considerations; and construction cost. It is useful to compare the design and its effects with that of a full-criteria approach to demonstrate the benefits of the recommendation.

Since most of the design parameters in the AASHTO guides are based on empirical data, significant deviations should be based on operational experience and an objective analysis by experienced designers. For projects involving the reconstruction of a corridor, reference should be made to the traffic volume, operations, and crash history of the site to support assurance that the exception will be acceptable.

The documentation of design exceptions provides the means for the designer to go on record regarding the recommended context-sensitive design solution. It also provides the necessary information to support the transportation agency's defense against potential future tort claims, as discussed in Chapter 4.

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chapter 4

Legal Liability and Highway Design

4.1 Introduction

For over three decades, exposure to tort liability has been an unwelcome reality for almost all state transportation agencies and their employees. Beginning with the loss or significant diminution of sovereign immunity in the 1960s and 1970s, followed by the insurance crisis of the 1980s, and with the ever increasing number and amounts of liability awards throughout the 1990s, sensitivity to tort liability has become a necessity. Because of the heightened awareness of liability exposure, design professionals, trained to adhere to accepted design criteria, have become understandably cautious about increased use of design exceptions and compromises in design criteria, and may have unresolved fears about utilizing the concept of Context-Sensitive Solutions (CSS).

The purpose of this chapter is not to give legal advice, but to provide a general discussion of the basic principles of tort liability as they relate to design issues, to resolve the fear that utilizing CSS will increase exposure to liability, and to establish confidence that tort liability should be considered but not be an impediment to the implementation of CSS. While this discussion is intended to encourage flexibility in using the range of design criteria found in the AASHTO Green Book or other state-adopted highway guidelines, it is not intended to endorse any deviation from them, except through authorized design exceptions. Due to the variations in statutory and case law from state to state, highway designers are cautioned to consult agency legal staff on the specifics of their own state law relative to the legal principles discussed here and the use of CSS in your jurisdiction.

4.2 Overview of Tort Liability

Tort law is a product of the English and American common law system, which establishes law by judicial decisions on a case-by-case basis. Under this system, a rule, once laid down, is to be followed as precedent until the courts find good reason to depart from it. The overriding emphasis is to make a conscious effort to direct the law along lines that will achieve a desirable social result for the present and the future. Perhaps more than any other branch of the law, torts are a battleground of social theory because the central idea is that liability must be based upon conduct that is socially unreasonable. It stands to reason that tort liability should mirror the economic, technological, ideological, and moral conditions that prevail in society. Such is not always the case. Courts seek to dispense contemporary justice by applying law that reflects interests balanced and counterbalanced over time. Legislatures and courts, over time, balance broad societal trends and incrementally shape the face of tort law. To some, this incremental balancing of interests must seem painfully slow. "The master ideas that drive tort doctrine—reasonableness, duty of care, and proximate cause—are as loose-jointed, context-sensitive, and openly relativistic as any principles to be found in law. They do not simply accommodate social change; they *invite* the law to adapt to it" *(22)*.

A very large part of the tort opinions try to strike a balance between the rights of the parties in litigation and the interest of the public at large. In this balancing process, the court is influenced by statutory law and by "public policy" *(15)*. Broadly speaking, public policy consists of the principles and standards regarded by the Congress, state legislatures, or by the courts as being of fundamental concern to the state and the whole society *(9)*. "A court may look to statutes not only as mandates on issues directly addressed but also as sources of 'establishment of policy [that] carries significance beyond the particular scope of each of the statutes involved'" *(16)*.

Based on the foregoing, we can predict that some courts, when considering liability issues involving CSS, will be open to an examination of the statutorily established public policy giving rise to CSS processes and objectives. This is because CSS clearly reflects the public policy objectives outlined in a range of national and state legislation on environmental and cultural resource protection. At the top of the list of such legislation is the National Environmental Policy Act of 1969, Public Law 91-190, in which Congress declared the national policy as follows:

> *The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances, and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.*

Arguably important will be the design-related provisions of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the National Highway System Designation Act of 1995 (NHS). ISTEA Section 1016(a) provides that:

> *If a proposed project . . . involves a historic facility or is located in an area of historic or scenic value, the Secretary may approve such project . . . if such project is designed to standards that allow for the preservation of such historic or scenic value and such project is designed with mitigation measures to allow preservation of such value and ensure safe use of the facility.*

NHS Section 304 provides that:

> *A design for new construction, reconstruction, resurfacing. . .restoration, or rehabilitation of a highway on the National Highway System (other than a highway also on the Interstate System) may take into account . . .* [in addition to safety, durability and economy of maintenance] *. . .*

A) *the constructed and natural environment of the area;*

B) *the environmental, scenic, aesthetic, historic, community, and preservation impacts of the activity; and*

C) *access for other modes of transportation.*

In addition, the Transportation Equity Act for the 21st Century (TEA-21) includes numerous provisions evidencing the continuing emphasis Congress places on environmental, scenic, aesthetic, historic, community, and preservation impacts being considered in the design of highway projects. For example, Section 1221 establishes The Transportation and Community and System Preservation Pilot program, providing a comprehensive initiative for research and grants to investigate the relationships between transportation and community and system preservation and private sector-based initiatives. Under this program, states, local governments, and metropolitan planning organizations are eligible for discretionary grants to plan and implement strategies that, among other things, improve the efficiency of the transportation system and reduce the environmental impacts of transportation. It is expected that this same Congressional emphasis will continue to be provided in future highway legislation.

The courts will also look to any state legislation intended to foster context-sensitive highway solutions, such as Connecticut Public Act No. 98-118 (C.G.S.A § 13a-13). Ideally, each state would enact legislation showing the intent of the legislature to authorize CSS decisions. In the absence of such state legislation, state officials at the policy level should consider delegating to or leaving open for lower-level design personnel the authority and discretion to make CSS policy decisions that involve social, economic, and political considerations such as the balancing of safety and mobility with the preservation of scenic, aesthetic, historic, and environmental resources. It seems clear that, based upon such state legislation and/or administrative issuances, the courts could be persuaded to find that when responsibly made CSS decisions are following such established public policy objectives, tort law policy should protect those decisions from liability. Consider whether your CSS process/decisions would meet this four-part test established by the Washington Supreme Court in *Evangelical United Brethren Church of Adna v. State of Washington (7)*:

1) *Does the challenged act, omission, or decision necessarily involve a basic governmental policy, program, or objective?*
2) *Is* [it] *. . . essential to the realization or accomplishment of that policy, program, or objective as opposed to one which would not change the course or direction of the policy, program, or objective?*
3) *Does* [it] *. . . require the exercise of basic policy evaluation, judgment, and expertise on the part of the governmental agency involved?*
4) *Does the governmental agency involved possess the requisite constitutional, statutory, or lawful authority and duty to do or make the challenged act, omission, or decision?*

4.3 Basic Principles of Tort Liability

Tort law consists of a body of common law principles that determines when a person suffering personal injuries and/or property damage may shift that loss to another member of society. Thus, a *tort* can be described as a civil wrong committed to the person or property of another for which a court of law will provide a remedy in money damages. The wrong considered to be a tort is often expressed as a breach or violation of a duty imposed by law. The duties imposed by law with which we are most familiar are the statutory rules of the road for operation of motor vehicles (e.g., duty to signal, duty to obey warning signs, duty to grant right-of-way, and the duty to observe the speed limit). A legally actionable duty may also arise from a failure to follow customary practices in industry, a deviation from professional criteria, or a mandatory "shall" duty imposed by a transportation agency's policy issuance on a particular feature of highway design, construction, or maintenance. The effect of assuming such a duty is demonstrated by a 1998 Missouri Court of Appeals decision in *Martin v. Missouri Highway and Transportation Department (MHTC) (17)*, which held that the MHTC "**assumed a duty** [emphasis added] to create safe 'clear zones' for motorists," by adopting the 1967 AASHO guidelines entitled *Highway Design and Operational Practices Related to Highway Safety* ["the Yellow Book"]. The Court stated that:

> *Under the standards established by AASHO and adopted by MHTC, and the authority granted over the right-of-way by statute, this duty includes the proper design, construction and maintenance of "clear areas." The evidence presented at trial sufficiently established that MHTC had a duty to maintain clear areas. Whether MHTC was negligent in the manner it did so is an issue properly left to the jury (17).*

Torts may be either intentional or unintentional, and an unintentional tort is synonymous with *negligence.* Only in rare circumstances would tort suits against transportation agencies or their employees allege anything but negligence as a basis for liability; so our primary concern, and the focus of our discussion, is with liability arising from negligent conduct. Negligence consists of the failure to do or the doing of that which an ordinary, reasonably prudent person would do or not do under the same or similar circumstances *(1)*. During a trial, the jury or sometimes the judge decides the issue of negligence. Quite often the legal definition of negligence given to jurors is phrased as *the failure to use ordinary care*. In effect, the court is asking the jury to determine a *standard of care* expected from the *ordinary person* or the person of *common prudence* and to decide whether the defendant fell below that standard of care, violating a duty imposed by law, thereby committing a negligent act. This process seeks to compensate injuries as they are understood in light of changing social and economic conditions. The law is in continuous development, adaptable to the conditions and needs of changing times and conditions. Ultimately the law must coincide with public opinion and public policy to be in the public interest.

Conduct that falls below the standard of care a person is legally required to exercise for his/her own safety and that contributes to the injury or damage suffered is called *contributory negligence.* Until recent years when the doctrine of comparative negligence was developed, a finding of contributory negligence would bar a plaintiff's recovery, even though the defendant's negligence had been established. Comparative negligence has now been adopted by most states and allows diminished damages based on the defendant's proportion of the negligence, as determined by the jury. While contributory negligence and/or comparative negligence are important in the trial defense of state transportation agencies, they always involve the issues of duty and standard of care. But a major defense acting as a bar to tort litigation and liability is *sovereign or discretionary immunity*, which, if initially upheld by the trial court at the outset of litigation, means that the issues of duty and standard of care are never reached.

4.4 Sovereign and Public Employee Immunity

The doctrine of Sovereign or Governmental Immunity in the United States is a common law concept originating in the English courts, originally applying to the King, but later extended to most governmental functions. Under this doctrine, several states in the United States have until recent years been immune from suit and liability, unless the state had expressly waived immunity in a given situation. This wall of defense began to erode in the late 1950s, influenced, in part, by passage of the Federal Tort Claims Act of 1946 (FTCA), which waived immunity for the federal government except for *discretionary functions.* In a 20-year period between 1957 and 1976, 29 state supreme courts took judicial action to abolish "large chunks" of sovereign immunity. State legislatures responded by enacting tort claims acts, sometimes restoring full immunity, but usually providing reduced immunity, like the FTCA. Following the insurance crisis in the mid-1980s, over 40 states enacted tort reform legislation designed to further limit the liability exposure of state agencies, many putting a cap on damage awards *(28)*. Categories of immunity into which state tort claims acts can be placed are as follows:

- Full retention of sovereign immunity.
- Technical retention of immunity from suit, but provision of an administrative claim procedure.
- Waiver of immunity in some limited class of cases.
- Abolishment of immunity in a substantial or general way.

A parallel but different legal concept of ancient lineage, both in the English and American common law, is the *doctrine of immunity of public* in the performance of *discretionary functions* (as opposed to *ministerial functions* or *operational functions*). The basis for public employee immunity is a policy of freeing public employees from fear of retaliation for unpopular decisions or being unduly intimidated in the discharge of their duties. Another reason is that without immunity, highly skilled employees would not accept public positions *(23)*. This doctrine was particularly important before states lost sovereign immunity because their employees were the only available defendants, but it still remains an important defense, particularly in those states, such as Wisconsin, retaining full sovereign immunity.

4.5 Discretionary Function Immunity

When the United States Congress enacted the FTCA in 1946, it made no attempt to define "governmental" activities, nor to exempt them from liability, as such. Instead, it worded the exception in terms of precluding judicial review for those governmental activities that are "discretionary" in nature. The statute exempts the United States from tort liability for:

> *Any claim based upon an act or omission of an employee of the Government, exercising due care, in the execution of a statute or regulation, whether or not such statute or regulation be valid, or* ***based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty*** [emphasis added] *on the part of a federal*

agency or an employee of the Government, whether or not the discretion involved be abused. (28 U.S.C. 2680(a))

The FTCA became the precursor of all state legislation embodying the discretionary function exception, with the state statutes either precisely duplicating, or following in reasonably close detail, the language of the federal statute *(30)*. Thus, more than half the states, by statute or common law judicial rulings, retain immunity for *discretionary functions*. Both federal and state decisions indicate a broad consensus with respect to the nature of the exception:

- The basic purpose of the discretionary function exception is to *ensure the separation of powers*.

- The cases in which judicial restraint is to be exercised in order to preserve the separation of powers are those that involve *policy decision making* by a coordinate branch of government.

- Although the word *policy* cannot be precisely defined, there is broad agreement that it includes within its umbrage *social, economic, and political considerations*.

Congress did not define the term *discretionary function*, nor have the state legislatures done so in state tort claims statutes exempting discretionary functions. It seems clear that the term has been used as nothing more than a clarifying provision to continue the long-standing common law rule of excluding discretionary activities of the government and its employees from tort liability. Thus, whether interpreting the FTCA, a state tort claims act, or simply applying the established common law rule, it is left to the courts to make the necessary distinction between discretionary and nondiscretionary actions of the government and its employees, as they have always done. The courts have not found this to be an easy task.

The standard dictionary definition of *discretionary* is "to have freedom to decide or choose, left to one's own judgment." Since judgment, choice, or discretion exists in virtually all human activity, how is a line to be drawn between governmental activities that are discretionary and those that are operational or ministerial? What judgments should be protected as policy decisions as distinguished from day-to-day engineering judgments or decisions carrying out established policy? How to answer these questions has been a major problem for the courts in attempting to interpret the discretionary function exception *(29)*. State courts are not in agreement on what constitutes exempted "discretionary functions." This variation from state to state underlies the necessity of consulting your agency attorney regarding your own state's legal precedent.

The first decision of the United States Supreme Court under the FTCA was *Dalehite v. United States (6)*, which upheld the government's claim of immunity based upon the discretionary function exception. The Court said: **"Where there is room for policy judgment and decision there is discretion."** The Court went on to add: **"The decisions . . . were all responsibly made at a planning rather than operational level"** [emphasis added]. Many courts, relying on this Supreme Court precedent, seized upon the planning/operational dichotomy language as an easy tool to decide when the discretionary function exception applied under state law, seemingly ignoring the other language of the Court. Thus, under this *planning/operational dichotomy* test, many courts began to focus on the level of government at which the decision was made as an easy way to distinguish exempt discretionary planning decisions from nonexempt operational decisions. This put the emphasis on who made the decision, rather than on whether the decision was actually a policy judgment. Later, United States Supreme Court decisions clarified the Court's intent, clearly establishing the principle that under the FTCA *discretionary function* exception was not confined to the policy or planning level and that it is the nature of the decision/conduct, rather than the status of the actor, that governs whether the exception applies *(27)*. Many state courts now agree *(20)*. Even though some state court decisions consider the status/level of the decision maker to be relevant *(21)*, more and more courts are now placing the primary focus on whether the decision sought to be exempted was *a balancing of policy considerations*, whatever the level *(13)*. The cases now demonstrate a strong trend toward recognizing the right of government officials at the policy level to delegate to or leave open for lower level officials the authority and discretion to make additional policy decisions which involve social, economic, and political considerations such as the balancing of safety and mobility with the preservation of scenic, aesthetic, historic, and environmental resources. This is an important trend supporting the practice of CSS, decreasing exposure to liability, because it expands "discretionary exemption" to include policy decisions made by lower level officials, such as design engineers, when authorized to make such policy decisions.

A recent federal decision in *Bowman v. United States (3)*, demonstrates a court's recognition of design decisions requiring the balancing of many factors, including highway safety:

> *National Park Service officials have more than safety in mind in determining the design and use of man-made objects such as guardrails and signs along the* [Blue Ridge] *Parkway. These decisions require balancing many factors: safety, aesthetics, environmental impact and available financial resources. In making each decision these factors must be weighed carefully in accordance with the policies of the National Park Service . . . What is obvious is that the decision* [not to place guardrail along an embankment] *was the result of a policy judgment. One can argue that another policy, which places greater emphasis upon safety, is more desirable. However, by the discretionary function exception, Congress intended to prevent courts from second-guessing federal policy . . . It is precisely this type of decision which Congress intended to shield from liability because 'where there is room for policy judgment and decision, there is discretion (6)*.'

Similarly, a 1996 decision by the Tennessee Supreme Court in *Helton v. Knox County, Tennessee (12)*, upheld the county's decision not to install standard guardrails despite a recommendation of state inspectors, because the decision, based upon "costs and concern for the preservation of this historic bridge," was a discretionary function that involves the weighing of public policy considerations.

4.6 Design Immunity

In the 1960 landmark New York decision in *Weiss v. Fote (32)*, the Court stated that to allow a jury to pass on the reasonableness of a plan or design would "place in inexpert hands what the Legislature has seen fit to entrust to experts." In a similar vein is the 1999 Supreme Court of Texas decision in *State of Texas v. Miguel (24)*, which held that the state DOT retained sovereign immunity about highway design decisions. The Court stated:

> *Whether a governmental activity is discretionary is a question of law. . .The state preserves its immunity for formulating policy because it is a discretionary act. . . Decisions about*

highway design and about what type of safety features to install are discretionary policy decisions (24).

Initially, for jurisdictions retaining discretionary function immunity, like Texas, the general rule was that all highway design decisions were protected discretionary functions *(31)*, but later Court decisions declined to give blanket exemption. Presently, there is a strong trend in the federal court decisions holding that design decisions involving policy considerations are exempt from liability as immune discretionary functions. For example, in *Aguehounde v. District of Columbia*, 666 A.2d 443, D.C. App. 1995, the Court stated:

If we were to accept [plaintiff's] argument, the District would be required to justify the policy underlying each of the myriad decisions involved in traffic design. Our case law suggests . . . we should ascertain whether the type of function at question is grounded in policy analysis . . . 'Discretionary conduct is not confined to policy or planning level . . . but on the nature of the actions taken and on whether they are susceptible to policy analysis' (25).

California and certain other states have enacted a specific design immunity statute. California's Government Code gives design immunity to both public entities and public employees in §830.6, which provides, in part:

Neither a public entity nor a public employee is liable under this chapter for an injury caused by the plan or design of a construction of, or an improvement to, public property where such plan or design has been approved in advance of construction or improvement by the legislative body of the public entity or by some other body or employee exercising discretionary authority to give such approval in conformity with standards previously so approved, if the trial court or appellate court determines that there is any substantial evidence upon the basis of which a) a reasonable public employee could have adopted the plan or design or the standards therefor or b) a reasonable legislative body or other body or employee could have approved the plan or design or the standards therefor . . .

Under this statutory scheme, a public entity is not liable for a dangerous condition of public property where it can show: 1) a causal relationship between the plan or design and the accident, 2) discretionary approval of the plan or design prior to construction or improvement, and 3) substantial evidence supporting the reasonableness of the design. In proving the reasonableness of the design, compliance with design criteria would usually prove sufficient, but where the design deviates from such criteria, documented approval of design exception, based on sound engineering, would be necessary *(11)*.

4.7 Absence of Decision Making

It needs to be noted that there are a significant number of courts now holding that to be entitled to design immunity the state must make a showing that the policy decision sought to be held exempt was a *conscious* balancing of policy factors. For example, in applying this test to a case where the discretionary immunity doctrine was at issue for alleged negligent design, the Washington Supreme Court in *Stewart v. State of Washington (26)* ruled against the state's claim of discretionary design immunity, stating:

There was no showing by the State that it considered the risks and advantages of these particular designs, that they were ***consciously balanced*** *against alternatives, taking into account safety, economics, adopted standards, recognized engineering practices and whatever else was appropriate.* [Emphasis added]

To the same effect is the 1990 decision in *Niver v. South Carolina DOT (18)*, denying the state immunity for a discretionary act, without some evidence of a discretionary decision:

. . . whether the Department is liable in this instance depends on whether its failure . . . resulted in fact from a discretionary decision. More precisely, the Department's immunity is contingent on proof that the Department, faced with alternatives, actually weighed competing considerations and made a ***conscious choice****. . . (33)* [Emphasis added].

Thus, *documentation* by the design engineer of the conscious decisions made in balancing the many policy factors can be critical in proving that an exempt "discretionary decision" was in fact made. Such proof was established to the Utah Supreme Court's satisfaction in its 1995 decision in *Keegan v. State of Utah DOT (14)*, where the Court held that the Utah DOT (UDOT) exercised "discretionary function" in deciding during surface overlay projects not to raise the median barrier. The evidence showed that the decision was based upon a comprehensive safety study report, including study of accident rates, involving a determination of not only the degree of safety that would be provided by various options considered, but also what degree of safety would be an appropriate goal given time and cost constraints. Additional evidence was the preparation by the project design engineer of a cost-benefits report, based upon the safety study. The Court found that:

UDOT's decision not to raise the concrete barrier during the surface overlay projects was not an operational decision . . . but rather involved a policy-based plan, approved by FHWA, which resulted from a considered weighing of the costs and benefits of certain safety and construction policies and which involved the exercise of UDOT's judgment and discretion.

4.8 Design Decisions, Negligence, and the Duty of Care

Notwithstanding the potential availability of discretionary immunity, design decisions are vulnerable to a challenge of negligence and trial on the merits in several circumstances:

- Where the state has waived sovereign immunity, but has not provided a statutory or common law exception to liability for discretionary functions such as design decisions.

- Where discretionary immunity is provided, but narrowly construed by the courts so as to exempt only planning and location decisions, but not design decisions *(4)*.

- Where discretionary immunity, while available to exempt certain design decisions, is not applicable in a particular instance because the alleged design defect resulted from an alleged violation of mandatory regulations or policies that precluded the exercise of discretion *(5)*.

- Where design immunity, although generally available, is held by the court to be inapplicable because the challenged design characteristic is so “inherently dangerous” that it demonstrates a failure to consider the safety of the public *(2)*.

When the defense of design immunity is not available to the state or the court has ruled against a state’s defense of discretionary immunity, for whatever reason, the case will go forward for trial on the merits on the issue of negligence. The questions that will be presented to the jury on a negligent design case are as follows:

- Did the state owe a legal duty to the plaintiff to design the highway in accordance with certain criteria?

- Did the state breach that duty by departing from those criteria, falling below the standard of care required (negligence)?

- Was the state’s negligence the proximate cause of the plaintiff’s injuries?

- What are the monetary damages to the plaintiff resulting from the state’s negligence (e.g., medical expense, lost wages, pain and suffering, etc.)?

These questions will be answered based upon the oral testimony and documentary evidence introduced during trial. A major battle in any tort litigation is over the issue of *duty*, the evidence that will be allowed to establish that duty, and the standard of care required to satisfy such duty. Where the defendant is a public transportation agency (or in some cases its employees) the plaintiff will seek to introduce into evidence the AASHTO Green Book, other state-adopted highway criteria, manuals, or guidelines in order to educate the jury about the traditional level of practice for design and to establish the applicable standard of care. Additionally, expert witnesses, relying on such written text, will provide opinions as to the accepted practices for design. In this regard, the following observations are noteworthy:

> *One of the most fruitful areas of inquiry for a plaintiff consists of the policies, guidelines and manuals of the public entity. These publications, often called “bibles” by engineers, carry the imprimatur of governmental authority and mandate. Design manuals contain the standards, warrants, policies and procedures for implementation of the design engineering aspects of a highway program. Because it has a direct impact on the driver, the design aspects of a highway facility suffer intense scrutiny when plaintiffs try to build a case against a transportation department. If a plaintiff can find a discrepancy between what a manual prescribes and what exists in the field, he is halfway home. His expert can then explain to a jury why the manual is correct and why variance from it increases the hazards to the driver and consequently is the cause of the accident. The closer a particular design manual approaches “gospel,” the more serious it is to deviate from it (10)*.

Depending upon the state jurisdiction, these manuals, particularly where language is expressed in mandatory terms, allow the plaintiff’s attorney to argue that a mandatory standard of care is involved. However, even if the language is not mandatory, the plaintiff’s attorney will argue its relevance on the issue of standard of care. It is in this evidentiary battle that documentation of design decisions becomes critical to the agency’s defense against alleged negligence. This documentation should establish that thorough and adequate study was done of this particular site/situation; that professional judgment was exercised to determine the relevant criteria, justifying any use of design exceptions; and that the process followed reflects a community consensus regarding purpose and need, with the features of improvement developed to address equally safety, mobility, and preservation of scenic, aesthetic, historic, and environmental resources. Such documentation will provide the tools for defense counsel to argue that *common prudence* and *ordinary care* was exercised by agency personnel and that the agency acted reasonably and is not guilty of negligence.

Adherence to accepted design practices, such as the AASHTO Green Book guidelines, does not automatically guarantee that reasonable care was exercised. By the same token, deviation from the guidelines through use of authorized design exceptions does not automatically establish negligence. The best defense is presentation of written evidence, prepared by the design engineer contemporaneously with design decisions, explaining the rationale of those decisions. The design engineer needs to explain in writing why the guidelines were not applicable to the circumstances of the project or could not be reasonably met. When such justification documentation thoroughly describes the physical and environmental factors that made the exception or the chosen design necessary, it is the best evidence to persuade a judge or jury that correct procedures were followed and appropriate decisions were made. The form and procedure for preparation of such documentation should be developed by the appropriate authorities, including agency counsel *(8)*.

4.9 Importance of Fully Evaluating and Documenting Design Decisions

In order to reduce exposure to losses due to liability claims, it is essential that the planning and design process be thoroughly documented. This documentation should demonstrate that the safety aspects of the roadway design were properly considered. If a new or innovative solution is proposed, reference to where it has been applied, how it has performed, and how the circumstances are similar or considered appropriate would be good information to include in project reports. If an exception to an applicable design value is required, documentation should explain the reasons for the exception and show that logical and orderly procedures were followed in obtaining it. Note that this requirement is really no different from best current practices. A thorough assessment of the safety implications of accepting the design value would be essential to good documentation.

When evaluating a proposed design exception, consideration must be given to its expected effect on the safety and operation of the roadway, and its compatibility with adjacent sections of road. Design exceptions should not be approved if it is believed they would result in measurably degrading the relative safety of the road when compared with existing conditions. Often, the best defense in this situation is to demonstrate that the cost-effectiveness of further upgrading a design element does not meet any reasonable criteria, or that unacceptable environmental and/or community impacts would result from further safety improvements. Part of this defense is evidence that special care was taken in determining that an exception was appropriate, and that other appropriate mitigation measures had been considered and, where useful, had been implemented. Finally, all of the above analysis and information would in most cases be of interest to stakeholders. The public supports designers in their efforts to provide safe solutions. The ability to substantively assess the safety tradeoffs increases public understanding as well as aids documentation of the decision.

In order to receive design immunity for planning and design activities, an agency must thoroughly document the design process in order to defend against challenges. Typically, information that should be included in requests for design exceptions includes items such as the following listed in *NCHRP Report 480: A Guide to Best Practices for Achieving Context Sensitive Solutions (19)*:

- Description of existing highway conditions and proposed improvement project.
- Thorough description of the nontraditional feature(s), providing specific data identifying the degree of deficiency.
- Crash data for at least the latest three-year period, indicating frequency, rate, and severity of crashes.
- Costs and adverse impacts that would result from meeting current design criteria.
- Safety enhancements that will be made by the project to mitigate the effects of the nontraditional feature.
- Discussion of the compatibility of the proposed improvement with adjacent roadway segments.

Many agencies have developed formal processes involving senior staff and chief engineers who are responsible for establishing design exception processes and reviewing and approving specific requests. Senior oversight of context-sensitive decision making and documentation to support it represents good risk management and quality management practices.

4.9.1 Responsibility for Decision Making

Although public involvement in the planning process is often an important part of context-sensitive design, design professionals cannot abrogate their duty to make reasonable and rational decisions. This point requires that the design professional thoroughly understand and then communicate safety issues and concerns to the public, particularly when a necessary but unpopular design decision needs to be made. (Communicating concerns about tort exposure to stakeholders, and linking such concerns to specific design decisions, is a legitimate and indeed important aspect of the design process. Any future claims paid by the agency would ultimately be paid by the taxpayers and system users. It is appropriate for the representatives of the design agency, in explaining their decision, to include any consideration of the long-term risk to the agency's resources stemming from a design decision.)

The context-sensitive design process requires that stakeholders be consulted and involved, and that the decision process be open and honest. It does not require, however, that decision making be simply a referendum or popularity contest. Likewise, decisions that rely on casual observations of traffic conditions, ad hoc contacts with local residents, and intuitive judgments are at legal risk. Decision making should be founded on well-recognized engineering principles and practices.

4.9.2 Risk Management

There are many reasons for the documentation of an agency's planning and design decision process, but one important reason, as previously discussed, is to be able to provide documents that prove that legally defensible decisions were made, should a tort action be filed. "Despite the best efforts of designers, crashes occur and tort claims are filed. An overriding concern of design agency staff (designers, quality managers, decision makers and risk managers) is not necessarily the avoidance of such claims, but rather the defense of a good and appropriate decision should a claim be made" *(19)*.

> *Context sensitive practices (consider alternatives, weigh tradeoffs, design using good industry practices, make and explain decisions openly, and document fully all aspects of the proj ect) will build a strong case for an agency's defense of tort claims. Of course, complete documentation and then document management become key aspects of risk management, as many claims may occur years after the decisions and construction, and defense of the agency's actions may be led by professionals who were not directly involved in the actual project execution. It is unfortunately the case that design agencies lose or settle claims not because their staff actions were inappropriate, but because the project files are incomplete or missing key documentation, and staff responsible for the project are no longer available to explain what was done and why (19).*

4.10 What Context-Sensitive Design Practices Will Reduce an Agency's Exposure to Successful Claims?

Context-sensitive solutions may cause designers to consider innovative approaches and be flexible in their design philosophy. Successful designers will not restrict themselves necessarily to what has been done before in their jurisdiction, but will determine what will fit and work well in a particular location. Experience with innovative design solutions successfully tried by other agencies may provide useful guidance. Designers may also consider design exceptions (i.e., the use of a design value outside the normal range of agency criteria) as a legitimate means of achieving an appropriate solution that addresses not only the needs of traffic, but also those of the environment and the community.

From the perspective of an agency operating with a large staff and many projects, and with the ongoing responsibility for maintaining a system, there are a number of actions that can be taken to minimize and manage risk in the CSS (or, for that matter, any) environment.

A transportation agency can adequately manage its exposure to tort liability on a systemwide basis by:

- Maintaining databases and processes that enable continual monitoring of system performance, including specifically safety performance.

- Establishing and following clear, well-thought out procedures for identifying, prioritizing, and treating known safety problems.

- Having well-trained professional/technical staff who understand design criteria and practices and the safety impacts of design decisions, and who carry this knowledge to projects.

• Establishing and following processes that bring to the proper staff special design problems requiring design exceptions or unusual solutions, so these can be given adequate consideration.

On a project-specific basis, management of risk entails the following practices:

• Careful, thoughtful evaluation of design alternatives
• Correction of known safety deficiencies
• Thorough documentation of the decision-making process
• Retention of documentation for retrieval in later years

Interestingly, all four of these practices are not only consistent with but considered essential to good context-sensitive design practices. Simply stated, a rational and orderly decision-making process must be followed if context-sensitive solutions are to be successfully defended against claims of negligence.

4.11 References

1. American Law Institute. *Restatement of the Law, 2d, Torts*. American Law Institute Publishers, St. Paul, MN, 1979, §283.

2. *American Law Reports*, West Publishing Company, St. Paul, MN, 45 ALR 3d 875, 888. For example, see *Missouri Highway and Transportation Commission v. Kansas City Cold Storage*, 948 S.W.2d 679, 682, Mo. App.W.D. 1997, where Court noted that “The Commission . . . is entitled to sovereign immunity [but] . . . two exceptions listed in the statute (motor vehicles and dangerous conditions) constitute ‘absolute’ waivers of immunity.”

3. *Bowman v. United States*, 820 F.2d 1393, 4th Cir. 1987. *See also*: *Autery v. U.S.*, 992 F.2d 1523, 1530, 11th Cir. 1993, at 1530, Court noting that “Generally, courts have held that decisions about safety measures to employ in national parks and how to execute them involve balancing the same considerations that inform all policy decisions regarding management of national parks: safety, aesthetics, environmental impacts, and available financial resources.”

4. *Breed v. Shaner*, 562 P.2d 436, Haw. Sup.Ct. 1977; see also: *Andrus v. State*, 541 P.2d 1117, 1120, Ut. Sup.Ct. 1975, alleged negligence in design of new highway for creating a “grade sag,” or depression, operating as a dangerous catch basin for runoff; held: “ . . . The decision to build the highway and specifying its general location were discretionary functions, but the preparing of plans and specifications and the supervision of the manner in which the work was carried out cannot be labeled discretionary functions.”

5. For example, in *C.J.W. v. State of Kansas*, 853 P.2d 4, 8, Ks. Sup.Ct. 1993, the Court stated that: “The discretionary function exception to the Kansas Tort Claims Act . . . is not applicable in those situations where a legal duty exists, either by case law or by statute, which the governmental agency is required to follow.”

6. *Dalehite v. United States*, 346 U.S. 15, 73 Sup.Ct. 956, 97 L.Ed. 1427 U.S. Sup.Ct. 1953.

7. *Evangelical United Brethren Church of Adna v. State of Washington*, 407 P.2d 440, 445, Wa. Sup.Ct. 1965.

8. FHWA. *Flexibility in Highway Design*. FHWA-PD-97. Federal Highway Administration, U.S. Department of Transportation, Washington, DC, 1997, p. 40.

9. Garner, B. A. *Black's Law Dictionary*. 7th ed. West Publishing Company, St. Paul, MN, 1999.

10. Gowan, B. C. Standards vs. Guidelines: Engineering Tools or Legal Weapons? Presentation for Session No. 322: "Flexible Geometric Design Philosophy Versus Rigid Geometric Design Standards" at 77th Annual Meeting of the Transportation Research Board, Washington, D.C., January 11–15, 1998; updated and presented at "Thinking Beyond the Pavement: A National Workshop on Integrating Highway Development with Communities and the Environment," sponsored by the Maryland State Highway Administration; Federal Highway Administration, U.S. Department of Transportation; and the American Association of State Highway and Transportation Officials, May 3–6, 1998, University of Maryland University College, College Park, Maryland.

11. Gowan, B. C. Standards vs. Guidelines, *supra*. For example, see *Higgins v. State of California*, 54 Cal. App. 4th 177 (1997), where the State met the standard of proof for design immunity.

12. *Helton v. Knox County, Tennessee*, 922 S.W.2d 877, 881, Tenn. Sup.Ct. 1996.

13. Jones, R. O. *Risk Management for Transportation Programs Employing Written Guidelines as Design and Performance Standards. NCHRP Legal Research Digest*, 38. Transportation Research Board, National Research Council, Washington, DC, August 1997, pp. 4–6. See also: Jones, R. O. *Discretionary Immunity and Gaubert.* Presentation at the 36th Annual Workshop on Transportation Law, Chicago, Illinois, July 21, 1997, Transportation Research Board.

14. *Keegan v. State of Utah DOT*, 896 P.2d 618, 626, Ut. Sup.Ct. 1995.

15. Keeton, W. P. *Prosser and Keeton on the Law of Torts*. 5th ed. West Publishing Company, St. Paul, MN, 1984, at 6, 15–16.

16. Keeton, W. P. *Prosser and Keeton on the Law of Torts*, *supra*, at 20, citing *Boston Housing Authority v. Hemingway*, 1973, 363 Mass. 184, 293 N.E.2d 831, 840, quoting *Moraque v. State Marine Lines, Inc*., 1970, 398 U.S. 375, 90 S.Ct. 1772, 26 L.Ed.2d 339. *See also: Moning v. Alfono* 1977 400 Mich 425, 254 NW2d 759, where, in adopting a judicial theory of negligent entrustment, the court imposed liability on suppliers for supplying slingshots directly to children, based upon statutes and legislative judgments of other states as "a source of common law."

17. *Martin v. Missouri Highway and Transportation Department,* 981 S.W. 2d 577, 582, Mo. App.W.D. 1998.

18. *Niver v. South Carolina DOT*, 395 S.E.2d 728, 730, S.C. Sup.Ct. 1990.

19. Neuman, T. R., M. Schwartz, L. Clark, and J. Bednar. *National Cooperative Highway Research Program Report 480: A Guide to Best Practices for Achieving Context Sensitive Solutions*. Transportation Research Board, National Research Council, Washington, DC, 2002, pp. 50–51, 88.

20. For example, see *Rick v. State of Louisiana*, *DOTD*, 630 So.2d 1271, 1276, La. Sup.Ct. 1994, which held: "Decisions at an operational level can be discretionary if based on policy. *U.S. v. Gaubert*, 499 U.S. 315, 111S.Ct. 1267, 113 L.Ed.2d 335, U.S. Sup.Ct. 1991." See also: *Shelton v. State of Tennessee,* 644 S.W.2d 427, 431, Tenn. Sup.Ct. 1992, where Court noted that "In *Goodman*, however, we recognized that our court, and many others, had misinterpreted Dalehite's scheme, thereby failing to recognize discretionary decisions at the 'operational' level. *Goodman,* 587 N.W.2d at 238" n.1, at 29.

21. *Rico v. State of Minnesota*, 472 N.W.2d 100, 105, Minn. Sup.Ct. 1991, adopting the view of Justice Scalia in *U.S. v. Gaubert*, that "the level at which the [operational] decision is made is often relevant to the discretionary function inquiry." See also: *Bowers v. City of Chattanooga*, 826 S.W.2d 427, 431, Tenn. Sup.Ct. 1992, where Court noted: "We caution that this [planning/operational] distinction serves only to aid in determining when discretionary immunity applies; [such] immunity attaches to all conduct properly involving the balancing of policy considerations . . . [A]n 'operational act' is entitled to immunity, where. . .the opera tional actor is properly charged with balancing policy considerations."

22. Schuck, P. H. *Tort Law and the Public Interest*, W. W. Norton & Company, New York, NY, 1990.

23. *Smith v. Cooper*, 475 P2d 78, Or. Sup.Ct. 1970.

24. *State of Texas v. Miguel*, 2 W.W.3d 249, 251, Tex. Sup.Ct. 1999.

25. *See also State of Texas v. Miguel*, *supra*, which held: "Decisions about highway design and about what type of safety features to install are discretionary policy decisions . . . entitled to sovereign immunity."

26. *Stewart v. State of Washington*, 597 P.2d 101, 106-107, Wa. Sup.Ct. 1979.

27. *United States v. Gaubert*, 499 U.S. 315, 111 S.Ct. 1267, 113 L.Ed.2d 335, U.S. Sup.Ct. 1991.

28. U.S. Department of Justice, *Report of the Tort Policy Working Group on the Causes, Extent, and Policy Implications of the Current Crisis in Insurance Availability and Affordability*, 30, U.S. Government Printing Office, Washington, DC, Feb. 1986.

29. Vance, J. C. Impact of the Discretionary Function Exception on Tort Liability of State Highway Departments, *NCHRP Legal Research Digest,* Vol. 6, Transportation Research Board, National Research Council, Washington, DC, June 1989, at 4. Vance notes the Court's statement in *Smith v. United States*, 375 F.2d 343, C.A. 5, 1967, to the effect that: "Most conscious acts of any person whether he works for the government or not, involves choice. Unless govern ment officials . . . make their choices by flipping coins, their acts involve discretion in making decisions."

30. Vance, J. C. Impact of the Discretionary Function Exception, *supra*, at 9. See also: *Olson v. City of Garrison*, 539 N.W.2d 663, N.D., 1995, where Court notes that tort claims act, NDCC § 32-12.1-03(3) at 665, "Apparently . . . comes directly from the language used in the [FTCA]."

31. Vance, J. C. Impact of the Discretionary Function Exception, *supra*, note 5, at 10, citing *Smith v. Cooper*, *supra*, note 6. See also: Annotation in *American Law Reports*, West Publishing Company, St. Paul, MN, 3d, § 3.

32. *Weiss v. Fote*, 200 NYS2d 409, 413, 167 NE2d 63, 66, N.Y. Sup.Ct. 1960. But see *Fisher v. State of New York*, 702 NYS2d 418, 419, N.Y.Sup.Ct A.D.3 2000, noting that "while the State enjoys qualified immunity with respect to matters involving traffic design engineering, it may be found negligent when the highway planning decision at issue evolved without adequate study or lacked a reasonable basis."

33. See also *Wooten v. South Carolina DOT*, 511 S.E.2d 355, S.C. Sup.Ct. 1999, suit alleging injuries by pedestrian caused by DOT's negligence in failing to allow adequate time for pedestrian to cross, held: "Discretionary immunity is contingent on proof the government entity, faced with alternatives, actually weighed competing considerations and made a conscious choice using accepted professional standards." See also: *McMurphy v. State of Vermont*, 787 A.2d 1043, 1046, Vt. Sup.Ct. 2000, alleged violation of MUTCD in designing intersection, held: Legislature did not intend to retain sovereign immunity from every claim alleging negligent highway design, but only for deliberate design decisions showing "purposeful" deviation from standards.

appendix A

U.S. Federal Regulations on Environmental Protection Affecting Highway Design

Statute/Regulatory Requirements	Comments
National Environmental Policy Act (NEPA), 1969	Sets forth broad national policy in relation to the environment and establishes implementing procedures through the Council on Environmental Quality
Council on Environmental Quality (CEQ) (40 CFR 1500–1508)	Requires the development of the appropriate environmental documents
Department of Transportation Act of 1966 (A provision of this act is known as Section 4(f) and codified as 49 U.S.C. 303)	Section 4(f): requires the Secretary of Transportation to consult with the Secretary of the Interior, HUD, and Agriculture, plus state agencies in developing transportation plans that include measures to maintain the natural beauty of the land.
Public Hearings, Federal Aid Highways Act (23 U.S.C. 128)	Provides for holding public hearings, or providing the opportunity for such hearings, for any federal aid project involving any city, town, or village either incorporated or unincorporated.
Metropolitan Planning, Federal Aid Highways Act (23 U.S.C. 134)	To the extent possible requires studies of regional economic impacts (like effects on development, tax revenues, and public expenditures, employment opportunities, etc.).
Land and Water Conservation Fund Act of 1965 (LAWCON) (16 U.S.C. 460l-4 et seq.)	Section 6(f): Requires that recreation land purchased or improved under the LAWCON Act cannot be used unless replacement land of equal value, use, and size can be supplied.
Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (42 U.S.C. 4601–4639)	Provides for the fair and equitable treatment of persons displaced from their homes, farms, or businesses by federal or federally assisted projects.
Farmland Protection Policy Act, U.S. Department of Agriculture (USDA) Soil Conservation Service (7 CFR Part 658)	Determines if any prime or unique farmlands will be converted to nonagricultural use and the relative value of such farmland.
Resource Conservation and Recovery Act (RCRA) (42 U.S.C. 6901) and Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (42 U.S.C. 9601)	Addresses the treatment, storage, and disposal of hazardous and toxic materials.

Statute/Regulatory Requirements	Comments
Clean Air Act of 1970 and Amendments of 1990, U.S. Environmental Protection Agency (EPA) (42 U.S.C. 7401)	Requires that highway construction impact studies and plans assess the effects of increasing traffic volumes on air quality.
FHWA Procedures for Abatement of Highway Traffic Noise and Construction Noise, 1997 (Federal Aid Policy Guide, Part 772)	Establishes a set of policies and procedures related to traffic noise that is to be applied to federal-aid projects.
Clean Water Act (33 U.S.C. 1251)	Section 402: Requires permits from the EPA; NPDES for point source and stormwater discharge. Section 404 (USACE): Requires a permit for discharge of dredged or fill materials into jurisdictional waters of the U.S., including wetlands.
Safe Drinking Water Act, Section 1424(e) (42 U.S.C. 300f)	Requires proposed actions that may impact areas that have been designated as principal or sole-source aquifers be coordinated with the EPA.
River and Harbor Act of 1899 (33 U.S.C. 403), U.S. Army Corps of Engineers (USACE)	Section 10: Requires a permit to place a structure in navigable water of the U.S. Section 13; modified by the Federal Water Pollution Control Act which established NPDES Permits.
Wild and Scenic Rivers Act, Protected under Section 4(f) (16 U.S.C. 1271–1287)	Provides for the protection and preservation of certain rivers and their immediate environments.
Floodplain Management, Executive Order 11988, 1977	Basis for assessment of flood hazards which may be related to highway improvements. Combines the need to protect lives and property with the need to restore and preserve natural and beneficial floodplain values.
Protection of Wetlands, Executive Order 11990, 1977	Directs federal agencies to avoid unnecessary alteration or destruction of wetlands, and requires implementation of actions to minimize the loss or degradation of wetlands affected by a project that received federal funding.
Federal Highway Administration Wetland Policy, 1977 (23 CFR 777, Mitigation of Impacts to Wetlands and Natural Habitat)	It is the FHWA's policy to prepare a formal wetland finding prior to the approval of any project involving new construction in wetlands and classified as an EIS or a FONSI.
National Historic Preservation Act (NHPA), 1966 (16 U.S.C. 470-470W-6)	Requirement to take into account the effect of the action on any district, site, building, structure or object that is included in or eligible for inclusion in the National Register.
National Register of Historic Places (36 CFR Part 800)	Establishes criteria for investigation of cultural resources, a property/site eligibility for addition to the National Register. A process to meet the requirements of section 106 of the National Historic Preservation Act.
Protection and Enhancement of the Cultural Environment, Executive Order 11593, Section 1(3), 1971	Requires that federal agencies, in consultation with the Council, establish procedures regarding the preservation and enhancement on non-federally owned historic and cultural properties in the execution of their plans and programs.

Statute/Regulatory Requirements	Comments
Archaeological and Historic Preservation Act, 1960 (16 U.S.C. 469)	Directs federal agencies to notify the Secretary of the Interior whenever they find a project that may cause the loss or destruction of significant scientific, prehistoric, or archaeological data.
Endangered Species Act, 1973 (50 CFR 402), Fish and Wildlife Service, Department of the Interior, National Marine Fisheries Service, Department of Commerce	Protects nationally designated threatened and endangered species.
Fish and Wildlife Coordination Act, 1958 (16 U.S.C. 661-667)	Ensures that wildlife conservation will receive equal consideration.
National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd), U.S. Fish and Wildlife Service (FWS)	Provides protection of wildlife refuges and ranges, game ranges, wildlife management areas, or waterfowl production areas as administered by the Secretary of the Interior through the U.S. Fish and Wildlife Service.
Impounding, Diverting or Controlling of Waters (16 U.S.C. 662(a))	Requires consultation with FWS on any federal action that involves a surface area of 10 acres or more of modification to a stream or body of water.
Highways, Standards (23 U.S.C. 109(n))	Section 682: National Energy Policy Act (1978) recognizes bicycles as a legitimate highway user, and that FHWA has a responsibility to provide for their transportation needs.
Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, Executive Order 12898, 1994	Requires that federal actions consider disproportionate impacts to low-income minority groups.
Essential Fish Habitat, 1996 (16 U.S.C. 1801)	1996 amendments to the Magnuson-Stevens Fishery Management and Conservation Act mandate that Federal Agencies identify and protect important marine and anadromous fish habitat.
Environmentally Beneficial Landscaping, Executive Memorandum, 1994	Environmentally beneficial landscaping entails utilizing techniques that complement and enhance the local environment and seek to minimize the adverse effect that the landscaping has on it. In particular, this means using regionally native plants and employing landscaping practices and technologies that conserve water and prevent pollution.
Invasive Species, Executive Order 13112, 1999	This order applies to all invasive species including plants, animals and microbes. It was enacted to prevent the introduction of invasive species into the United States, provide for their control, and minimize the economic, ecological and human health impacts that invasive species cause.
Migratory Bird Treaty Act, 1918 (16 U.S.C. 703–712)	Generally prohibits the taking, possession, transportation, sale, purchase, barter, importation, exportation, and banding or marking of migratory birds, and the taking of nests or eggs, except for scientific purposes.

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