Design Manual

M 22-01

Washington State Department of Transportation
Environmental and Engineering Programs
Design Office

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Foreword

This *Design Manual* is for use by Washington State Department of Transportation engineering personnel. It provides policies, procedures, and methods for developing and documenting the design of improvements to the transportation network in Washington. The *Design Manual* has been developed for state facilities and may not be appropriate for all county roads or city streets that are not state highways.

The manual supplements the engineering analyses and judgment that must be applied to improvement and preservation projects. It provides uniform procedures for documenting and implementing design decisions. When proposed designs meet the requirements contained in the *Design Manual*, little additional documentation is required. The Federal Highway Administration (FHWA) has agreed to approve designs that follow the guidance in the *Design Manual*; therefore following the guidance presented is mandatory for state highway projects.

The design environment changes rapidly, and often without warning to the practitioner. To track every change, and to make improvements based upon each change, is not feasible. The intent of this manual is to provide recommended values for critical dimensions. Flexibility is permitted to encourage independent design that is tailored to particular situations. When flexibility is applied, and critical dimensions of a proposed design do not meet the *Design Manual* criteria, additional documentation is required to record the decision- making process.

The addition of new or modified design criteria to the *Design Manual* through the revision process does not imply that existing features are deficient or inherently dangerous. Nor does it suggest or mandate immediate engineering review or initiation of new projects.

Cost-effective and environmentally conscious design is emphasized, and consideration of the use of the highway corridor by transit, pedestrians, and bicyclists is included. Designers are encouraged to view the highway corridor beyond the vehicular movement context. To accommodate multimodal use, the criteria provided for one mode is to be appropriately adapted, as needed, at individual locations.

The complexity of transportation design requires the designer to make fundamental trade-off decisions that balance competing considerations. Although weighing these considerations adds to the complexity of design, it accounts for the needs of a particular project and the relative priorities of various projects and programs. Improvements must necessarily be designed and prioritized in light of finite transportation funding.

Updating the *Design Manual* is a continuing process, and revisions are issued periodically. Questions, observations, and recommendations are invited. Page iii is provided to encourage comments and to assure their prompt delivery. For clarification of the content of the *Design Manual*, contact the Headquarters Design Office. The e-mail address is: DesignManual@wsdot.wa.gov .

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State Design Engineer

Contents

Division 3 Project Documentation

Division 4 Project Design Criteria

Division 5 Soils and Paving

Division 6 Geometrics

Division 7 Roadside Safety Elements

Division 8 Traffic Safety Elements

Division 9 Interchanges and Intersections

Division 10 Auxiliary Facilities

Division 11 Structures

Division 12 Hydraulics

Division 13 Roadside Development

Division 14 Right of Way and Access Control

Figures

100.01 Purpose

The Washington State Department of Transportation (WSDOT) has developed the *Design Manual* to reflect policy, outline a uniformity of methods and procedures, and communicate vital information to its employees and others who develop projects on state highways. When properly used, it will facilitate the development of a highway system consistent with the needs of the traveling public. WSDOT designers are required to comply with the *Design Manual*. The Federal Highway Administration (FHWA) has agreed to approve designs that follow guidance in the *Design Manual*; adherence to the guidance presented, therefore, is not optional for state highway projects.

The information, guidance, and references contained herein are not intended as a substitute for sound engineering judgment. It is recognized that some situations encountered are beyond the scope of this presentation, as the *Design Manual* is not a comprehensive textbook on highway engineering. Nor does it attempt to cover all the possible scenarios that Washington's highways present.

For design questions beyond the scope of the *Design Manual*, contact the Headquarters (HQ) Design Office.

100.02 Presentation and Revisions

The *Design Manual* is available in an up-to-date format on the Internet. It can be accessed through the WSDOT home page, the Design Policy page, or the Engineering Publications Online Library home page. Opening the manual on the Internet can take considerable time. However, it provides the ability to conduct a word search of the whole manual. Opening an individual chapter is faster, but a word search is limited to that chapter.

The *Design Manual* is also available on "Engineering Publications CD Library" (a CD-ROM). The CD is up-to-date as of the date of production. Hard-copy editions are available on a department cost-recovery basis (free to WSDOT employees).

The *Design Manual* is continually revised to reflect changing processes, procedures, regulations, and organizations. Feedback from users is encouraged to improve the manual for everyone. For example, material that is unclear to one user will most likely be unclear to others.

Engineering Publications maintains a list of people interested in receiving e-mail notification when a revision is being distributed. Comments may be submitted by any method that is convenient for the user. There is a Comment Form in the manual, as well as online at the Design Policy Internet page.

A Contents section is provided at the front of the *Design Manual* that lists all chapters, their major headings, and the last revision dates on the pages. There is also a list of all figures, with their page numbers and dates. The dates are provided to aid in determining whether a manual or page is up-to-date. By comparing a printed book or CD file to the manual on the Internet, the date in the footer of the Contents pages will indicate whether the latest revision is in place.

The *Design Manual* is divided into general divisions that contain specialized chapters and an index at the back of the manual.

Each chapter provides a list of the references that are the basis for the information in the chapter, including laws, administrative codes, manuals, and other publications. Each chapter provides definitions for the specialized vocabulary used in the chapter, particularly when a word or phrase has more than one dictionary meaning.

The index lists all significant chapter subheadings, other items selected by the chapters' authors and contributors, and many items suggested by users. Suggestions are helpful because one user's search might help other users later.

100.03 *Design Manual* Applications

The *Design Manual* guidance is provided to encourage uniform application of design details under normal conditions throughout the state. It also guides designers through the project development process used by WSDOT. The *Design Manual* is used by the department: to interpret current design principles, including American Association of State Highway and Transportation Officials (AASHTO) policy and federal and state laws; to develop projects to meet driver expectations; and to balance the benefits and costs of highway construction projects. This manual is designed to allow for flexibility in design for specific and unusual situations. For unusual circumstances, the *Design Manual* provides mechanisms for documenting the reasons for the choices made.

The *Design Manual* supplements engineering analysis and judgment; it is not intended as an engineering textbook. The manual is developed for use on state highways and it may not be suitable for projects on county roads or city streets.

100.04 How the *Design Manual* is to be Used

The WSDOT *Design Manual* is intended to be used for design of department-owned facilities, especially the transportation facilities associated with state highways as designated by the Revised Code of Washington (RCW) 47.17.

For state highway routes, all projects must be designed using the geometric control criteria (see Chapters 325 and Division Four) in the *Design Manual*. If WSDOT guidance is not used on a project, appropriate documentation and approvals are required. (See Chapters 325 and 330).

When WSDOT designs facilities to be turned over to local jurisdictions, those facilities are to be designed using appropriate local geometric design criteria.

When local jurisdictions design any element of state highway facilities, this manual must be used. Local jurisdictions are free to adopt this manual for their local criteria or to develop their own specialized guidance for facilities not on state highway routes.

100.05 The Project Development Process

The *Design Manual* addresses the project development process from programming through the Project Development Approval. The *Design Manual* is a comprehensive guide to the design of transportation projects; however, the full extent of project development is beyond the scope of the *Design Manual*. The following paragraphs provide a brief summary to assist the designer in understanding the relationship between planning, programming, and design at WSDOT.

Project development is a multi-disciplinary effort that develops the needs identified in the *Washington State Highway System Plan* (HSP) and subsequent planning studies in sufficient detail to produce a set of contract documents. This process bridges the gap from project concept to project construction. The project definition documents provide the framework for further development of the project scope, schedule and estimate, and record key decisions made early in the project development process. Final project design decisions are archived in the Design Decision Package (DDP). The contract documents provide sufficient detail to enable contractors to construct the project.

A global understanding of the overall project development process is important in order to eliminate corrective modifications or rework in the later stages of project implementation. Project modifications and rework are not only costly, they also impact delivery commitments made to the Legislature and the public. Integrating planning, program management, and project delivery are vital to efficient and successful delivery of transportation projects. These projects must have information and processes that flow seamlessly between the planning and the implementation phases of a project. A level of analysis guideline (a series of questions addressed to the design engineer) has been developed to address common areas where a lack of information has caused significant changes late in the design process. (See the web site: http://wwwi.wsdot.wa.gov/ppsc/pgmmgt/scoping/LevelAnalysis.pdf)

The HSP is the modal element of the *Washington Transportation Plan* (WTP) that addresses the state's highway system. The HSP, managed by the WSDOT HQ Systems Analysis and Program Development Office, includes a comprehensive assessment of existing and projected 20-year needs on the Washington State highway system. Freight, mobility, safety, bicycle, and pedestrian issues are among the 20-year needs. The HSP also lists potential solutions addressing these needs.

The HSP identifies four major programs that are used to manage the state-owned transportation system. These are:

- Maintenance Program (M)
- Operations Program (Q)
- Preservation Program (P)
- Improvement Program (I)

HQ Systems Analysis and Program Development staff begins programming the Preservation and Improvement programs for the highway construction program by sending out to the WSDOT regions the list of needs for each action strategy identified in the department's *Highway System Plan*. Each region takes the lists of needs and performs an engineering analysis on each need, in order, based on the programming instructions. They must develop a project alternative(s) consistent with the department's design matrices, estimate the cost to accomplish that work, and determine the resulting benefits (what performance change can be achieved).

Based on the resulting benefit to cost ratio (b/c), the projects are prioritized based on the highest to lowest ratio for each system plan strategy. Following this step, HQ Program Development develops different budget scenarios for the available investment dollars for the next 2- to 6-year period.

WSDOT has a responsibility to develop a 6-year highway construction program based on projected revenues (RCW 47.05 - Priority programming for highway development). This effort begins by using the Project Summary process to develop an accurate scope, accurate schedule, and accurate budget. Included in the Project Summary are:

- A project definition
- An Environmental Review Summary/Environmental Classification Summary
- A cost estimate
- A Design Decision Summary, when required for the project type

In addition, WSDOT develops a 10-year Capital Improvement and Preservation Program (CIPP) that includes a listing, cost estimate, and brief description of every capital improvement project in progress or to be in progress over the next 10-years. The CIPP is adopted by the Transportation Commission and submitted to the Governor and, ultimately, by the Governor to the Legislature. The CIPP is updated each biennium.

Program development staff in the regions work closely with region project development staff to identify projects where preliminary engineering funds are available to develop the contract documents. As these funds become available, the Project Development Engineers are notified, and a Project Engineer is identified to lead the project development process. At this point, the Project Engineer assembles a design team and goes to work on development of the project documents.

Design teams and managers are encouraged to use the WSDOT Project Management On-Line Guide to map out the direction and the expectations for the project. The guide is located at: http:www.wsdot.wa.gov/Projects/ProjectMgmt/Process.htm

The planning study recommendations are used to develop the Project Definition. Following the project definition and required hearings or public involvement, a set of Plans, Specifications and Estimates (PS&E) is completed and used to advertise the project for construction.

The key to maintaining consistency from the planning stage into project construction is to rely on good communication between the planning offices, program management, design engineers, support functions, and the construction office. In general, communication should be thought of as constant and bi-directional. There are always many opportunities throughout the life of a project for these communications to take place.

100.06 How the *Design Manual* is Organized

The *Design Manual* is divided into a series of divisions that address a portion of the project development and design process. The divisions are composed of chapters that address the general topic identified in the division in detail and are, in some cases, specific to a particular discipline.

Division One presents general background on the processes that precede project design. These include planning, managing project delivery, project development, and programming.

- Chapter 100–Manual Description: Informs the designer about content and resources within the *Design Manual*.
- Chapter 120–Planning: Informs the designer about resources that can provide critical information relating to the corridor in which the project resides, such as Corridor Studies and Route Development Plans.
- Chapter 141–Project Development Roles and Responsibilities for Projects with Structures: Presents the project development process used by WSDOT to determine the roles and responsibilities for projects with structures during the project development phase of a project.
- Chapter 150–Project Development Sequence: Describes the Project Development sequence from the *Washington Transportation Plan* (WTP) through the contract document, with emphasis on the Project Summary and Change Management process.

Division Two provides the designer with information about the public involvement and hearings process, the environmental documentation process, and the permit process.

- Chapter 210–Public Involvement and Hearings: Informs the designer about developing a public involvement plan that meets the specific needs of the project; the ingredients of an effective public involvement plan; and methods for public involvement.
- Chapter 220–Project Environmental Documentation: Provides the designer with elementary background on the environmental documentation process and the many requirements.
- Chapter 240–Environmental Permits and Approvals: Explains permits that may be required for highway and bridge projects.

Division Three provides designers with information on value engineering, design matrices, design documentation, and approvals.

- Chapter 315–Value Engineering: A systematic multi-disciplinary process study early in the project design to provide recommendations to improve scope, functional design, constructability, environmental impacts, or project cost. Value Engineering studies are required by federal law for high-cost, complex projects.
- Chapter 325–Design Matrix Procedures: Includes five figures that provide consistency across projects according to funding type and highway system. Each design matrix sets forth the level of development for a given type of need, which would be automatically approved by the department and FHWA. Deviating from the matrix requires approval. The Design Matrix figures assist the designer to apply the appropriate design level for the majority of improvement and preservation projects.
- Chapter 330–Design Documentation, Approval, and Process Review: Covers building the Project File (PF), and the Design Documentation Package (DDP). The Project File and Design Documentation Package record the recommendations

and decisions that lead to a project by preserving the documents from planning, scoping, programming, and design phases, including permits, approvals, contracts, utility relocation, right of way, advertisement, award, and construction for a project.

- Chapter 340–Minor Operational Enhancement Projects: Provides design matrices for low-cost, quick-fix projects that improve the operation of a state highway facility.

Division Four includes project design criteria for basic design, modified design, and full design that are part of the design matrices in Chapter 325.

- Chapter 410–Basic Design Level: Contains the required basic safety work and minor preservation and safety work included in the preservation of pavement structures and pavement service life, while maintaining safe operation of the highway.
- Chapter 430–Modified Design Level: Provides the design guidance that is unique to the Modified Design Level of preserving and improving existing roadway geometrics, safety and operational elements.
- Chapter 440–Full Design Level: Provides guidance for the highest level of highway design, to improve roadway geometrics, safety and operational elements. Full Design Level is used on new and reconstructed highways.

Division Five presents guidance for investigating soils, rock, and surfacing materials, estimating tables, and guidance and criteria for the use of geosynthetics.

- Chapter 510–Investigation of Soils, Rock, and Surfacing Materials: Describes the requirements for qualifying a materials source, geotechnical investigations, and the documentation to be included in the Project File.
- Chapter 520–Design of Pavement Structures: Provides estimating tables for the design of pavement structures.
- Chapter 530–Geosynthetics: Introduces the types and applications of geosynthetic drainage, earthwork, erosion control, and soil reinforcement materials.

Division Six covers an introduction to highway capacity; geometric plan elements; horizontal alignment; lane configurations and pavement transitions; geometric profile elements; vertical alignment; geometric cross sections; and sight distance.

- Chapter 610–Traffic Analysis: Provides the designer with a basic and limited introduction to highway capacity.
- Chapter 620–Geometric Plan Elements: Provides guidance on the design of horizontal alignment, lane configuration, and pavement transitions.
- Chapter 630–Geometric Profile Elements: Furnishes guidance for the design of vertical alignment.
- Chapter 640–Geometric Cross Section: Introduces the designer to roadway width, superelevation, and slope design.
- Chapter 641–Turning Roadways: Provides guidance for widening curves to make the operating conditions comparable to those on tangent sections.
- Chapter 642–Superelevation: Provides guidance on superelevating curves and ramps so that design speeds can be maintained.
- Chapter 650–Sight Distance: Addresses passing, stopping, and decision sight distance design elements.

Division Seven addresses design considerations for the area outside of the roadway, and includes clear zone, roadside hazards, safety mitigation, traffic barriers, and impact attenuator systems.

- Chapter 700–Roadside Safety: Presents clear zone design, roadside hazards to consider for mitigation, and some roadside safety features.
- Chapter 710–Traffic Barriers: Provides guidance for the design of traffic barriers based on the design levels identified in the Design Matrices.
- Chapter 720–Impact Attenuator Systems: Introduces the designer to permanent and work zone impact attenuator systems.

Division Eight introduces the designer to traffic safety elements such as work zone traffic control, signing, delineation, illumination, traffic control signals, and Intelligent Transportation Systems (ITS).

- Chapter 810–Work Zone Safety and Mobility: Addresses the planning, design, and preparation of highway improvement and preservation project plans for modification of traffic patterns during construction.
- Chapter 820–Signing: Presents the use of signing to regulate, warn, and guide motorists.
- Chapter 830–Delineation: Presents the use of pavement markings to designate safe traffic movement.
- Chapter 840–Illumination: Provides guidance on the use of illumination on state highway construction projects.
- Chapter 850–Traffic Control Signals: Offers the designer guidance in the use of power-operated traffic control devices that warn or direct traffic.
- Chapter 860–Intelligent Transportation Systems (ITS): Provides guidance on applying computer and communication technology to optimize the safety and efficiency of the highway system by providing motorists timely traffic condition information.

Division Nine addresses the design considerations of at-grade intersections, roundabouts, road approaches, railroad grade crossings, and traffic interchanges.

- Chapter 910–Intersections At-Grade: Provides guidance for designing intersections at-grade, including at-grade ramp terminals.
- Chapter 915–Roundabouts: Instructs the designer on the design of roundabouts.
- Chapter 920–Road Approaches: Informs the designer about the application and design of road approaches on state highways in unincorporated areas, and in incorporated areas where limited access rights have not been acquired.
- Chapter 930–Railroad Grade Crossings: Addresses the requirements associated with highways crossing railroads.
- Chapter 940–Traffic Interchanges: Provides guidance in the design of interchanges on Interstate highways, freeways, and other multilane divided routes.

Division Ten offers guidance on auxiliary lanes such as climbing lanes and passing lanes; bicycle facilities; pedestrian design considerations; safety rest areas and traveler services; weigh stations; high occupancy vehicle lanes; and transit benefit facilities.

- Chapter 1010–Auxiliary Lanes: Provides guidance on auxiliary facilities such as climbing lanes, passing lanes, slow vehicle turnouts, shoulder driving for slow vehicles, emergency escape ramps, and chain-up areas.
- Chapter 1020–Bicycle Facilities: Serves as a guide for selecting and designing useful and cost-effective bicycle facilities.
- Chapter 1025–Pedestrian Design Considerations: Supplies guidance for designing facilities that encourage safe and efficient pedestrian access.
- Chapter 1030–Safety Rest Areas and Traveler Services: Provides typical layouts for Safety Rest Areas.
- Chapter 1040–Weigh Sites: Provides guidance for the design of permanent, portable, and shoulder-sited weigh sites.
- Chapter 1050–High Occupancy Vehicle Facilities: Presents guidance on evaluating and designing high occupancy vehicle (HOV) facilities.
- Chapter 1060–Transit Benefit Facilities: Provides operational guidance and information for designing transit benefit facilities such as park-and-ride lots; transfer/transit centers; and bus stops and pullouts.

Division Eleven provides guidance for the design of structures for highway projects, including site data for structures, bridges, retaining walls, and noise walls.

- Chapter 1110–Site Data for Structures: Describes the information required by the WSDOT HQ Bridge and Structures Office to provide structural design services.
- Chapter 1120–Bridges: Provides basic design considerations for the development of a preliminary bridge plan and guidelines on basic bridge geometric features.
- Chapter 1130–Retaining Walls and Steep Reinforced Slopes: Provides design principles, requirements, and guidelines for retaining walls and steep reinforced slopes.
- Chapter 1140–Noise Barriers: Addresses the factors that are considered when designing a noise barrier.

Division Twelve addresses the issue of hydraulics, and serves as a guide to highway designers to identify and consider hydraulic-related factors that may impact the design.

- Chapter 1210–Hydraulic Design: Addresses hydraulic considerations for highway projects involving flood plains, stream crossing, channel changes, and ground water.

Division Thirteen provides guidance on the portion of state highways between the traveled way and the right of way boundary.

- Chapter 1300–Roadside Development: Presents guidance on managing the roadside environment, including the area between the traveled way and the right of way boundary, unpaved median strips, and auxiliary facilities such as rest areas, wetlands, and storm water treatment facilities.
- Chapter 1310–Contour Grading: Provides guidance for contour grading, which is an important element in achieving operational, environmental, and visual functions.
- Chapter 1320–Vegetation: Provides a discussion of the use of vegetation in the roadside environment and directs the designer to the Landscape Architect.
- Chapter 1330–Irrigation: Presents design considerations for irrigation on highway projects.
- Chapter 1350–Soil Bioengineering: Offers a discussion of bioengineering and design considerations for the use of bioengineering techniques on highway projects.

Division Fourteen provides guidance on right of way considerations; access point decision reports; limited and managed access; surveying and mapping; monumentation; and fencing.

- Chapter 1410–Right of Way Considerations: Explains the right of way and easement acquisition process.
- Chapter 1420–Access Control: Introduces the WSDOT Access Control program.
- Chapter 1425–Interchange Justification Report: Describes the process for access point revisions on state highways and explains the steps for producing an Interchange Justification Report.
- Chapter 1430–Limited Access: Provides clarification on limited, full, and modified access control.
- Chapter 1435–Managed Access: Explains the classes of managed access and the permitting process, and provides design considerations.
- Chapter 1440–Surveying and Mapping: Introduces the procedures within WSDOT for project surveying.
- Chapter 1450 Monumentation: Introduces monumentation requirements and procedures.
- Chapter 1460 Fencing: Introduces fencing, the purpose of fencing, the types of fencing, and fencing design criteria.

Chapter 120 Planning

120.01 General

Transportation planning is a decision making process, required by federal and state law that is used to solve complex, interrelated transportation and land use problems. Various transportation interests from affected jurisdictions including local, regional, and state governments, as well as businesses, transportation providers, and community groups typically identify transportation needs. The needs are then evaluated within the framework provided by local, regional, and state land use and transportation policies as well as state and federal laws. These needs are interpreted in terms of constructed or service strategies that would meet those needs and these strategies are then evaluated based on projected fiscal constraints.

120.02 References

Transportation Equity Act for the 21st Century (TEA-21) of 1998

Code of Federal Regulations (CFR)

23 CFR 450 subpart B, "Statewide Transportation Planning"

23 CFR 450 subpart C, "Metropolitan Transportation Planning and Programming"

40 CFR, "Clean Air Act," parts 51 and 93

United States Code (USC)

23 USC 134, "Metropolitan planning"

23 USC 135, "Statewide planning"

Revised Code of Washington (RCW)

RCW 35.58.2795, "Public transportation systems — Six-year transit plans."

RCW 35.77.010(2), "Perpetual advanced six-year plans for coordinated transportation program expenditures — Nonmotorized transportation — Railroad right-of-way"

RCW 36.70A, "Growth management — Planning by selected counties and cities"

RCW 36.81.121(2), "Perpetual advanced six-year plans for coordinated transportation program, expenditures — Nonmotorized transportation — Railroad right-of-way"

RCW 43.21C "State Environmental Protection Act"

RCW 47.05, "Priority Programming for Highway Development"

RCW 47.06, "State-Wide Transportation Planning"

RCW 47.06B, "Coordinating Special Needs Transportation"

RCW 47.38, "Roadside Areas - Safety Rest Areas"

RCW 47.39, "Scenic and Recreational Highway Act of 1967" and changes thereto

RCW 47.50, "Highway Access Management"

RCW 47.76.220, "State rail plan - Contents"

RCW 47.80, "Regional Transportation Planning Organizations"

RCW 70.94, "Washington Clean Air Act" (Includes Commute Trip Reduction Law)

Washington Administrative Code (WAC)

WAC 468-51 and 52, "Highway Access Management"

WAC 468-86, "RTPO Planning Standards and Guidelines"

Roadside Manual, M 25-30, WSDOT

120.03 Acronyms and Definitions

ACCT Agency Council on Coordinated Transportation

ARB Agency Request Budget

B/C Benefit/Cost

CFR *Code of Federal Regulations*

CIPP *Capital Improvement and Preservation Program*

CLB Current Law Budget

CMP Corridor Management Plan

CTR Commute Trip Reduction

FAST Freight Action Strategy for the Everett-Seattle-Tacoma Corridor

FGTS Freight and Goods Transportation System

FHWA Federal Highway Administration

FTA Federal Transit Administration

GMA Growth Management Act

HSP *State Highway System Plan*

HSS Highways of Statewide Significance

ISTEA Intermodal Surface Transportation Efficiency Act of 1991

LOS Level of Service

MTIP Metropolitan Transportation Improvement Program

MPO Metropolitan Planning Organization

PSRC Puget Sound Regional Council

RCW *Revised Code of Washington*

RDP *Route Development Plan*

RTID Regional Transportation Investment District

RTIP Regional Transportation Improvement Program

RTPO Regional Transportation Planning Organization

SEPA State Environmental Policy Act

SHSP *State Highway System Plan* also known as the **HSP**

STIP Statewide Transportation Improvement Program

TDM Transportation Demand Management

TEA-21 Transportation Equity Act for the 21stCentury of 1998

TIP Transportation Improvement Program

TPO Transportation Planning Office

UPO Central Puget Sound Urban Planning Office

USC *United States Code*

WAC *Washington Administrative Code*

WSDOT Washington State Department of Transportation

WTP *Washington's Transportation Plan*

120.04 Legislation and Policy Development

The Washington State Legislature requires the Washington State Department of Transportation (WSDOT) to plan, develop, maintain, and preserve the transportation network in accordance with all state laws and federal requirements. The Washington State Transportation Commission interprets these requirements through a set of policies that guide the process.

The Washington State Transportation Commission consists of seven members who are appointed by the Governor. This body serves as the board of directors for WSDOT and provides oversight to ensure that WSDOT delivers a high quality, multimodal transportation system that moves people and goods safely and efficiently. The Commission also develops plans and funding recommendations for Legislative approval.

The following are highlights of federal and state legal requirements that influence or direct planning activities conducted by WSDOT. These legal requirements must be satisfied for WSDOT to be eligible to receive or expend federal and state transportation funds.

(1) Federal Law: Transportation Equity Act (TEA-21)

The Transportation Equity Act (TEA-21), passed in 1998, authorizes highway safety, transit, and other surface transportation programs through the year 2004. TEA-21 continues the trend initiated in 1991 by the Intermodal Surface Transportation Efficiency Act (ISTEA). ISTEA brought closure to the federal Interstate highway construction era and established new methods for distributing federal transportation dollars.

TEA-21 acknowledges the importance of statewide and metropolitan transportation planning activities at the state and regional levels. Below is a list of mandatory federal planning requirements included in TEA-21.

(a) Statewide Planning. 23 USC 135 and 23 CFR 450 — subpart B outline the federal requirements for statewide planning by state departments of transportation.

(b) Metropolitan Planning. 23 USC 134 and 23 CFR 450 subpart C — outline the federal requirements for Metropolitan Planning Organizations (MPO).

Each urbanized area (an area determined by the US Census Bureau to have a population of 50,000 or more with a density of at least 500 per square mile) is required to have an MPO. The MPO must develop and obtain approval of a metropolitan transportation plan and transportation improvement program to receive and expend federal transportation capital or operating assistance. The 2000 census identified 13 urbanized areas in Washington; these areas have established eleven MPOs. (See ftp://ftp.wsdot.wa.gov/public/Cartography/RTPO/rtpompoSimple.jpg

They are:

- Benton-Franklin Council of Governments (BFCOG)
- Cowlitz – Wahkiakum Council of Governments (CWCOG)
- Lewis-Clark Valley Metropolitan Planning Organization (LCVMPO)
- Puget Sound Regional Council (PSRC)
- Skagit Metropolitan Planning Organization (Skagit MPO)
- Southwest Washington Regional Transportation Council (SWRTC)
- Spokane Regional Transportation Council (SRTC)
- Thurston Regional Planning Council (TRPC)
- Wenatchee Valley Transportation Council (WVTC)
- Whatcom County Council of Governments (WCCOG)
- Yakima Valley Conference of Governments (YVCOG)

MPOs cover the metropolitan areas prescribed by federal law and also serve as the lead agency for Regional Transportation Planning Organizations (RTPOs) as enabled by state law (RCW 47.80), that form to include the MPO area (in some cases RTPOs cover a larger area). MPOs with a population over 200,000 are also designated as Transportation Management Areas (TMA).

Each MPO has a transportation policy board consisting of local elected officials from cities and counties. These boards may also consist of representatives from ports, transit agencies, tribes, WSDOT, major employers, the public, and other local transportation interests. Typically, each MPO also has a technical committee composed of staff from local planning and public works departments, and WSDOT Regional staffs.

The results of this transportation planning process are transportation plans and programs that are consistent with, and implement local comprehensive plans. The MPO planning process provides for:

- A forum for gaining local consensus on regional transportation needs.
- The creation of a metropolitan transportation plan identifying future transportation facilities and services needed to support and implement local comprehensive plans.

- Targeted transportation studies used to develop the metropolitan transportation plan.
- A forum to decide how to allocate certain categories of transportation funds.
- The development of a three-year list of facilities and services (to be funded by member organizations) called the Metropolitan Transportation Improvement Program (MTIP).

Metropolitan transportation plans provide a significant building block for the development of *Washington's Transportation Plan* created by WSDOT.

(2) State Laws: Planning Mandates Shape Project Selection

The state of Washington has adopted several important laws affecting transportation planning at various levels. These laws provide the framework for transportation decision-making, ultimately guiding the programming, design, and construction of transportation facilities and services. The following is a partial list of the state laws that address transportation planning.

(a) Statewide Transportation Planning (RCW 47.06). This set of laws establishes that " . . . the state has an appropriate role in developing statewide transportation plans." RCW 47.06 specifies that state owned transportation facilities and services, as well as those transportation facilities and services of state interest, must be addressed in these plans and that these plans shall guide short-term investment decisions and the long-range vision for transportation system development.

(1) *Washington's Transportation Plan* (WTP). The WTP provides guidance for the development, maintenance, and operation of a comprehensive and balanced multimodal transportation system. The overall direction of the WTP, prepared pursuant to RCW 47.06, is provided by the Washington State Transportation Commission. The WTP provides the direction for investment decision-making at WSDOT for all modes of transportation.

The WTP includes the following subjects concerning all major transportation modes:

- Meeting the federal requirements identified in TEA-21.
- Critical factors affecting transportation.
- Important issues concerning each mode and strategies to solve problems or improve function.
- Plans for development and integration of the various modes of transportation.
- Major improvements in facilities and services to meet transportation needs.
- Financial resources required to implement the recommendations.

The WTP is a dynamic plan that is updated on a regular basis to address changing conditions. Information and recommendations for the WTP are received from WSDOT regions and Headquarters (HQ), Metropolitan Planning Organizations, Regional Transportation Planning Organizations, local governmental agencies, private transportation operators, and the public.

The WTP addresses transportation facilities owned and operated by the state, including state highways, Washington State Ferries, and state-owned airports. It also addresses facilities and services that the state does not own, but has interest in. These include public transportation, freight rail, intercity passenger rail, marine ports and navigation, nonmotorized transportation, and aviation.

(2) *State Highway System Plan* (SHSP or HSP). The *State Highway System Plan* is the highway component of the WTP. The HSP defines *Service Objectives*, *Action Strategies,* and costs to plan for, maintain, operate, preserve, and improve the state highway system for the next 20 years.

Because needs listed in the HSP exceed projected revenue, the Transportation Commission established a set of priorities for funding projects. (See the *State Highway System Plan*.) The Commission has adopted service objectives and action strategies as a way to establish a logical process for identifying and categorizing projects that will receive funding over the next 20 years. These service objectives and action strategies provide the framework for defining 20-years of needs on the state highway system. Work that does not fit any of the action strategies will not be authorized or considered in the development of, the Statewide Transportation Improvement Program (STIP) or any other budget proposal.

The HSP is updated every two years, in coordination with local plan updates, to reflect completed work and changing transportation needs, policies, and revenues.

(3) State Environmental Policy Act. The State Environmental Policy Act (SEPA) requires the environmental effects of state and local agency actions be evaluated per WAC 197-11. Certain categorical exemptions exist. Agencies are required to adopt these regulations by reference and may develop more specific regulations for their own agency to specify how SEPA will be implemented.

WSDOT adopted agency specific SEPA regulations in 1986. Per WAC 468-12-800 (3) the following transportation planning activities are categorically exempt under these rules:

"The development, adoption, and revision of transportation plans and six year construction programs and any other studies, plans and programs which lead to proposals which have not yet been approved, adopted or funded and which do not commit the WSDOT to proceed with the proposals."

It should be noted the local government Comprehensive Plans developed pursuant to the Growth Management Act (GMA) contain a transportation element and these Comprehensive Plans must include a SEPA review.

Typically, transportation planning does not require review under the National Environmental Policy ACT (NEPA) because there is no federal action in the development of state and local transportation plans.

(b) The Growth Management Act (RCW 36.70A). Enacted in March 1990, the state's Growth Management Act (GMA) requires cities and counties that meet certain population or growth-rate thresholds to adopt comprehensive plans. Jurisdictions that are required to or choose to plan under the GMA must also adopt and enforce ordinances that implement the policies adopted in the comprehensive plans. Under the GMA, comprehensive plans carry the force of law and require full public participation in their development.

A comprehensive plan is a series of coordinated policy statements and formal plans that direct growth. Comprehensive plans articulate how a community will be developed in the future. They include elements that address housing, utilities, capital facilities, economic development, land use, and transportation. GMA planning requires that the transportation element be consistent with and support the land use elements in comprehensive plans.

Continuous coordination and open discussion during the development of local comprehensive plans is key to developing valid plans that direct the growth of a community. Representatives from neighboring jurisdictions, special purpose districts, WSDOT, and others with an interest in future development must be involved at the beginning and throughout the planning process. This is to ensure that comprehensive plans are consistent with all other state and local plans.

Local comprehensive plans are important to WSDOT because they influence how state facilities not classified as Transportation Facilities of Statewide Significance, should be addressed, how state highways will be impacted by local land use, and how access requirements will be met or maintained.

WSDOT seeks to work in partnership with local governments as they develop comprehensive plans to help create a balance between the need for mobility and access, while emphasizing design components that improve or maintain the livability of communities. It is also the responsibility of WSDOT to review and comment on local comprehensive plans and amendments.

(c) Regional Transportation Planning Organizations (RTPOs) (RCW 47.80.020). Washington has two types of "regional" or "area wide" transportation planning organizations: MPO and RTPO. MPOs, which serve areas with urbanized populations over 50,000, were introduced in the discussion on federal laws in Section (1)(b). A Regional Transportation Planning Organization (RTPO) is a voluntary organization enabled under state law. In an area where an MPO exists, the MPO is required by state law to be the lead agency for the RTPO.

Although voluntary, cities, counties, ports, tribes, and transit agencies usually become members of the RTPO; their participation is their best way to influence local and statewide transportation planning.

RTPOs perform some functions similar to MPOs and, like MPOs, provide a forum for information exchange and collective decision making between local governments and WSDOT. WSDOT is represented on each RTPO technical advisory committee and on most RTPO Policy Boards.

Fourteen RTPOs exist in Washington State, covering all counties of the state except San Juan County. (See Figure 120-1.) Of the eleven MPOs listed in 120.04(1)(b), only Lewis-Clark Valley MPO is not the lead agency for an RTPO. In addition to the ten RTPOs with MPOs as lead agencies, there are the following RTPOs:

- Palouse RTPO (Asotin County is an Adjunct member)
- Peninsula RTPO
- QUADCO RTPO
- Northeastern Washington RTPO (N. E. W.)

(d) Transportation Facilities and Services of Statewide Significance (RCW 47.06.140). The Legislature has declared certain transportation facilities and services, which promote and maintain significant statewide travel and economic development, to be of statewide significance.

Transportation facilities and services of statewide significance (TFSSS) are considered essential state public facilities. (See RCW 36.70A.200.) Essential state public facilities cannot be precluded from operation or expansion by local comprehensive plans and development regulations. This means that the WSDOT interest in these facilities and services takes precedence over local interests in the planning process. These facilities must comply with local ordinances and permits.

Therefore, planning for TFSSS must be conducted with a statewide perspective in mind. WSDOT, in consultation with transportation providers and regulators, is responsible for development of a statewide, multimodal plan for these facilities and services. The balance between providing for the movement of people and goods and the needs of local communities is the main consideration.

Highways of Statewide Significance (HSS) are one category of transportation facilities and services of statewide significance. The HSS designation was established by the Washington State Transportation Commission, and approved by the Legislature, to identify significant state-owned transportation facilities and establish the following:

1. Standardized levels of service (LOS) for mobility on HSS routes
2. HSS routes receive a higher priority for WSDOT mobility improvement funding
3. HSS routes are specifically exempt from concurrency requirements (except in Island County) and
4. HSS routes will be the focus of Regional Transportation Improvement District funding (King, Pierce, and Snohomish Counties).

The HSS includes the Interstate highway system, interregional state principal arterials, and ferry connections that serve statewide travel.

WSDOT makes the final decision regarding the acceptable Level of Service (LOS) for highways of statewide significance. The MPOs and the RTPOs, in consultation with WSDOT, set the acceptable LOS on Regionally Significant state highways (Non-HSS).

For a list of Highways of Statewide Significance in Washington, see http://www.wsdot.wa.gov/ppsc/hsp/hss.htm.

(e) Functional Classification of Highways and Roadways (RCW 47.05.021). Functional classification is the grouping of highways, roads, and streets that serve similar functions into distinct systems or classes within the existing or future highway network. The objective of functional classification is to define the appropriate role (mobility versus access) of various highways in providing service and influencing development. Generally, the higher functional classification routes provide mobility between communities, have higher travel speeds, and serve longer distance travel. The lower functional classification routes focus on providing localized access to the land adjacent to the roadway. Functional classification is important in:

- Identifying routes for inclusion in the National Highway System.
- Providing the basis for administering the Surface Transportation Program.
- Determining design levels for a specific route.
- Planning.
- Establishing access control.
- Providing information for land use plans and decisions.
- Conducting needs assessments and cost allocation studies.
- Helping to determine the level of maintenance.
- Conducting the priority programming process.

All state highways are subdivided into three functional classifications. See Chapter 440, "Full Design Level," for definitions of the collector, minor arterial and principal arterial classifications.

(f) Freight and Goods Transportation System (FGTS). The FGTS has been established due to increasing interest in developing the most effective and efficient system for moving freight from suppliers to consumers. The FGTS is required by RCW 47.05.021 section 4, which states:

> "The transportation commission shall designate a freight and goods transportation system. This statewide system shall include state highways, county roads, and city streets. The commission, in cooperation with cities and counties, shall review and make recommendations to the legislature regarding policies governing weight restrictions and road closures which affect transportation of freight and goods."

The FGTS ranks state highways, county roads and city streets based on annual tonnage carried.

The Freight Mobility Strategic Investment Board (FMSIB) uses the FGTS to designate strategic freight corridors and is obligated to update the list of designated strategic corridors every two years (RCW 47.06A.020 (3)). WSDOT provides staff and logistical support to FMSIB, including updates to the FGTS.

(g) Access Control (RCW 47.50, WAC 468-51, and WAC 468-52). Access control is a program that combines traffic engineering and land use regulatory techniques. Access control balances the desire and need for access (from adjacent properties to streets and highways) with other elements such as safety, preservation of capacity, support for alternative transportation modes, and preservation and enhancement of communities.

There are two forms of access control within WSDOT: limited access control and managed access control. (See Chapters 1420, 1430, and 1435) For limited access control, WSDOT purchases the right to limit access to a highway. Managed access control is a regulatory program established by a state law that requires that access to state highways in unincorporated areas be managed by WSDOT to protect the public and preserve highway functionality. Cities also have authority to grant access to state highways with managed access within incorporated areas. WSDOT retains authority on state highways with limited access.

WSDOT has established the Master Plan for Limited Access Highways for access control that is consulted when planning transportation improvement strategies.

120.05 Planning at WSDOT

The role of planning at WSDOT is to identify transportation needs and facilitate the development and implementation of sound, innovative investments and strategies. Many groups within WSDOT conduct planning activities that directly or indirectly influence the design of transportation facilities.

These groups serve a variety of departmental purposes including advocating multi-modal strategies, providing technical assistance, and implementing a wide variety of programs, projects, and services.

The following is a list of the groups, involved in planning, with their responsibilities, and their effect on the design of transportation facilities.

(1) Transportation Planning Office

The Transportation Planning Office of the Strategic Planning and Programming Division in WSDOT Headquarters consists of three branches: the Systems Analysis and Program Development Branch, the Policy Development and Regional Coordination Branch, and the Central Puget Sound Urban Planning Office (UPO).

(a) Systems Analysis and Program Development Branch. The major responsibilities of the Systems Analysis and Program Development Branch are to:

- Coordinate planning activities and provide technical assistance to WSDOT regions.
- Oversee the development and programming of *Washington's Highway System Plan (HSP)*.
- Collect and process data, conduct studies, and develop travel forecasts.
- Coordinate project-planning activities and provide technical assistance to WSDOT regions.

(b) Policy Development and Regional Coordination Branch. The Policy Development and Regional Coordination Branch responsibilities include:

- Coordination of planning activities and technical assistance to WSDOT regions, the Central Puget Sound Urban Planning Office, eleven MPOs, and fourteen RTPOs.
- Management oversight of the MPOs to ensure fulfillment of federal metropolitan transportation planning regulations in 23 USC 134, and the RTPOs regarding state requirements in RCW 47.80, WAC 468-86, and the WSDOT Regional Planning Standards.
- Administration of federal and state planning grants for planning organizations.
- Development of the *Washington Transportation Plan* (WTP) in partnership with other WSDOT organizations, MPOs and RTPOs. See 120.04(2)(b) for a description of the WTP.

The responsibilities of the Central Puget Sound Urban Planning Office are discussed under Section 120.05(4).

(2) Public Transportation and Rail Division

The Public Transportation and Rail Division works to enhance mobility options by managing, coordinating, and advocating for rail, commuting options, and public transportation programs throughout the state. The division's mission is to improve transportation choices, connections, coordination, and efficiency. The division promotes freight rail programs and, in cooperation with Amtrak, passenger rail programs. The division also provides planning, project oversight, financial, and technical assistance to public transportation providers. Division staff oversees the state commute trip reduction program and provides technical assistance and grants to help reduce vehicle miles traveled by commuters in urban regions of the state.

Public Transportation and Rail Division's plans and programs add value to highway and roadway design decisions by emphasizing enhancement, improvement, and coordination of intermodal connections. It is recommended that these plans and programs be referenced during the design process to ensure coordination and efficiency.

(a) Public Transportation and Commute Options Office. Programs organized by the Public Transportation and Commute Options Office support passenger transportation systems and services through grants, technical assistance, research, and planning. The office works in partnership with local communities and governments to promote, improve, and expand and coordinate public transportation resources, and access to those resources, throughout the state. The major emphases in the Public Transportation program are:

- Implement projects and strategies identified in the *Public Transportation and Intercity Rail Passenger Plan for Washington State* and *Washington's Transportation Plan*.
- Identify, support, coordinate, and monitor the planning, capital, and operating funding needs of small urban and rural public transportation providers.
- Improve effectiveness and efficiency of public transportation through training, technical assistance, and coordination to all agencies engaged in public transportation including nonprofit agencies, and private for-profit bus and taxi companies.
- Establish mobility options in areas where public transportation is limited or does not exist.
- Develop, implement, and manage grant programs to enhance and sustain statewide mobility.
- Monitor compliance for safety, including the drug and alcohol programs of rural public transportation providers.
- Manage information and data for the efficient coordination of transportation programs and providers.
- Provide leadership and support for the Agency Council on Coordinated Transportation (ACCT). ACCT is an interagency team responsible for recommending policies and guidelines to promote institutional and operational structures that encourages the efficient coordination of transportation programs and providers.

(b) Rail Office. Intercity passenger rail and freight rail are the focus of this office. Passenger and freight rail services are an important part of our state transportation system. Moving people and goods by rail is often safer and more environmentally friendly than adding traffic to our already congested highways. Improvements to the state's rail system, whether funded by the private sector or the public sector, can help mitigate the impacts of our fast growing economy and population.

The *Intercity Rail Passenger Plan for Washington State* defines a passenger rail system that links major population centers throughout the state and provides the blueprint for needed improvements to these intercity rail systems. The plan emphasizes incrementally upgrading the Amtrak passenger rail system along the Pacific Northwest Rail Corridor in western Washington. The vision is to reduce travel times and provide better passenger rail service in the Pacific Northwest. A number of activities unrelated to passenger rail are continuously underway in the corridor, requiring extensive coordination among various agencies and private organizations. The corridor also serves some of the world's busiest ports. WSDOT is working with the Puget Sound Regional Council and other area agencies through the Freight Action Strategy for the Everett-Seattle-Tacoma Corridor (FAST Corridor) project to plan for the elimination of at-grade highway/railroad crossing conflicts and to improve port access.

The *Washington State Freight Rail Plan* fulfills a Federal Railroad Administration requirement that the states establish, update, and revise a rail plan. It also fulfills the Washington State Legislative directive (RCW 47.76.220) that WSDOT prepare and periodically revise a state rail plan that identifies, evaluates, and encourages essential rail services. The plan identifies the abandonment status of various rail lines, provides analysis of the various alternatives to these proposed abandonment's, and provides recommendations that are incorporated into *Washington's Transportation Plan*.

(c) Transportation Demand Management Office. The Transportation Demand Management (TDM) Office advocates for, creates, and develops effective solutions to capacity constraints within the state transportation system. TDM Office staff provides financial and technical support within WSDOT, and external transportation organizations, to help ensure that demand management can be implemented whenever such programs are appropriate and cost effective. Program support is provided in areas such as land use planning, TDM research, parking management, high capacity transportation planning, and policy development for the state's freeway high occupancy vehicle system.

The office also assists public and private employers, jurisdictions, and other interested parties with implementation of RCW 70.94.521 through 551. The goals of the commute trip reduction (CTR) statutes are to reduce air pollution, traffic congestion, and the consumption of fossil fuels. The TDM office provides financial and technical support to employers to meet their mandated CTR requirements.

The TDM Office provides leadership through developing policies and guidelines that help direct public and private investment in the state's transportation system. An essential function of the TDM Office is to develop and maintain a TDM Strategic Plan for WSDOT. This plan helps ensure that *Washington's Transportation Plan* and all other internal planning processes incorporate TDM activities. Regional and local TDM activities and planning functions are further supported by the TDM Office through coordination and implementation of statewide TDM programs, providing public information and marketing tools, and providing training opportunities. The office also administers local TDM grant programs and planning grants that generate commute efficiencies in certain urban areas of the state.

(3) Highways and Local Programs Division

Highways & Local Programs (H&LP) Division of the Washington State Department of Transportation (WSDOT), has been serving the local agencies of Washington State for over 60 years. H&LP is a statewide organization with Local Programs staff located in all six WSDOT regions and in Headquarters. Under WSDOT's stewardship agreement with the Federal Highways Administration (FHWA), H&LP serves as the steward of the local agency federal-aid program by administering and managing federal funds from project development through construction administration. H&LP provides assistance to cities, counties, ports, tribal governments, transit, and metropolitan and regional planning organizations in obtaining federal and state grant funds to build and improve local transportation systems. H&LP, on behalf of the Secretary of WSDOT, is responsible for preparing and submitting the Statewide Transportation Improvement Program (STIP) to FHWA, without which no federal project would be authorized. In addition, H&LP provides federal compliance oversight on federally funded projects, technical assistance and training, and promotes cooperative planning and partnerships between WSDOT and local agencies.

(4) WSDOT Regions and The Central Puget Sound Urban Planning Office (UPO)

The roles of planning at WSDOT regions and at the Central Puget Sound Urban Planning Office (UPO) are similar in many ways. What follows are descriptions of the roles of planning at WSDOT regions and the UPO.

(a) WSDOT Region Planning. Each WSDOT region has a Planning Office that has several roles, such as:

- Conducting and overseeing a variety of long-range planning studies.
- Coordinating and assisting planning organizations outside WSDOT.
- Assisting in development of prioritized plans.
- Administering internal WSDOT programs.
- Overseeing access control activities.
- Performing Development Services activities.

For the Olympic and Northwest Regions, many of these long-range planning functions are assigned to the Central Puget Sound Urban Planning Office (UPO).

Each Region Planning Office conducts long range planning studies such as Route Development Plans, Corridor Master Plans, and site-specific transportation alternatives and studies. These studies evaluate alternative solutions for both existing and projected transportation needs, initiate the long-range public involvement process, and ultimately provide the foundation for inclusion of identified improvement strategies into *Washington's Transportation Plan* (WTP) and the *State Highway System Plan* (HSP).

Each Region Planning Office coordinates with and assists the local Metropolitan Planning Organization (MPO) and Regional Transportation Planning Organizations (RTPO). In some cases, the Region Planning Office provides staff support for the local RTPO.

The region works with the Washington State Patrol to include their weigh site and other highway related needs in WSDOT projects.

Often, the Region Planning Office is responsible for administering internal WSDOT programs such as traffic modeling, the Travel Demand Management program (TDM), and responding to citizen concerns about pedestrian, bicycle, and other transportation related issues.

Development Services is the process of reviewing new developments affecting state highways, such as master planned communities, major subdivisions, and commercial projects. Developers provide mitigation for their impacts to the state highway system under the State Environmental Policy Act (SEPA) and Highway Access Management. The Development Services section works closely with the local lead agency during SEPA reviews and the permitting process to secure appropriate improvements to the state transportation system from developers.

The region's Planning Office also reviews and comments on local Comprehensive Plans so development regulations, local transportation elements, and WSDOT goals and interests are consistent.

(b) The Central Puget Sound Urban Planning Office. The Central Puget Sound Urban Planning Office (UPO), based in Seattle and part of the Strategic Planning and Programming Division, has a similar role to a region Planning Office yet the UPO role is more specialized. The UPO oversees long range planning efforts of WSDOT in the four-county Central Puget Sound area of King, Pierce, Snohomish, and Kitsap Counties. This is the same area covered by the MPO called the Puget Sound Regional Council (PSRC), located in Seattle. The four-county region is geographically split between WSDOT's Olympic and Northwest Regions. UPO also has the responsibility of coordinating plans developed by Washington State Ferries with the strategies contained in the *State Highway System Plan*.

The Central Puget Sound Urban Planning Office also participates in the review of documents mandated by the Growth Management Act (GMA). This includes the review of draft Comprehensive Plans as well as the Draft Environmental Impact Statements that provide supporting documentation to the Comprehensive Plans. The Central Puget Sound Urban Planning Office also provides staffing and logistical support for the Regional Transportation Investment District (RTID). The RTID, a regional transportation planning committee created by legislation, provides funding for major transportation projects in King, Pierce, and Snohomish counties.

Development Services responsibilities remain with the Northwest and Olympic Regions Planning Offices.

(5) Washington State Ferries Division

The *Long Range Ferry System Plan*, prepared by the Washington State Ferries Division, considers recent trends in ferry ridership, system costs, regional economy, and other system and site factors. It is recommended that designers contact the Washington State Ferries planning office during the design phase of any conceptual solution occurring near a ferry terminal or for a project that might add significant traffic to or around a ferry terminal.

(6) Aviation Division

The WSDOT Aviation Division:

- Provides general aviation airport aid, including an award-winning lighting program.
- Provides technical assistance for airspace and incompatible land use matters that may affect airport operations or compromise safety.
- Coordinates all air search, rescue, and air disaster relief.
- Administers pilot and aircraft registration.

This division is responsible for development of the *Washington State Airport System Plan.* The division also operates sixteen state airports strategically placed throughout the state.

120.06 Linking Transportation Plans

A main concern of the traveling public is that the transportation system allows them to move from point A to point B quickly, safely, and with the least possible inconvenience and expense. To fulfill the public's desire for a seamless transportation system, coordination of transportation planning efforts is essential.

(1) Coordination of Planning Efforts

Coordination of planning efforts between city, county, MPO, RTPO, public and private transportation providers, and state transportation plans is not only required by federal and state laws — it makes good business sense. Coordination of transportation planning is a cyclical process and begins as a bottom-up approach. Figure 120-1 is a diagram that explains the general relationships between the various transportation planning processes and organizations.

Cities and counties explore their needs and develop *comprehensive plans.* Among other components, each comprehensive plan contains a land use element and a transportation element, which must be consistent with each other. The transportation element (sometimes known as the *local transportation plan*) supports the land use element. The requirements in the Growth Management Act (see 120.04 (2)(d)) guide most of the comprehensive plans developed in the state of Washington.

MPOs and RTPOs coordinate and develop metropolitan and regional transportation plans. These plans cover multiple cities and, for RTPOs, encompass at least one county. The purpose of metropolitan transportation plans and regional transportation plans is to ensure that all the region's transportation needs are accurately captured in one document, to develop a financial strategy to address the unfunded needs, and to assure local plan consistency across jurisdictional boundaries.

Planning is undertaken to ensure consistent policy among all the various jurisdictions, whether state, regional, or local. It does not matter where the planning process begins because the process is both cyclic and iterative. If one component of a plan changes, it may or may not affect other components. If any one plan changes significantly, it can affect each of the other plans in the cycle. Early communication and coordination of conceptual solutions are critical to ensuring project delivery.

(2) Transportation Improvement Programs

Figure 120-2 shows the coordination of effort that produces consistent and comprehensive transportation plans and programs.

From these transportation plans, each town, city, county and public transportation provider develops a detailed list of projects that will be constructed in the ensuing three to six years. This detailed list of transportation projects is called the six year Regional Transportation Improvement Program also known as the Six-Year RTIP or the three-year Metropolitan Transportation Improvement Program (MTIP).

The six-year RTIP and the three-year MTIP must be financially constrained, meaning that the total cost of all projects cannot exceed the established revenue authority. Financially constraining the RTIP and the MTIP is one method used to ensure that the list of projects represents what the local agency intends to build in the near future to implement local transportation plans. Once each jurisdiction develops its individual TIP, the RTPO and the MPO compile these individual TIPs into a regional or metropolitan TIP.

Each RTPO/MPO completes a Regional or Metropolitan Improvement Program (RTIP or MTIP) at least once every two years (RCW 47.80.023). The RTIP/MTIPs must meet the requirements of federal and state laws regarding transportation improvement programs and plans. To achieve this, the RTIP/MTIP:

- Is developed cooperatively by local government agencies, public transit agencies, and the WSDOT Regions within each area.

- Includes all federally funded WSDOT Highway Construction Program projects.
- Includes all significant transportation projects, programs, and transportation demand management measures proposed to be implemented during each year of the next period.
- Identifies all significant projects, whether funded by state or federal funds.
- Includes all significant projects from the local transit development plans and comprehensive transportation programs required by RCW 35.58.2795, 35.77.010(2), and 36.81.121(2) for transit agencies, cities, towns, and counties.
- Includes all transportation projects funded by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA).
- Includes all federally funded public lands transportation projects.
- Includes all WSDOT projects regardless of funding source and clearly designates regionally significant projects as such.
- Complies with all state (RCW 70.94) and federal (40 CFR 51 & 93) Clean Air Act requirements (where applicable).
- Includes only projects consistent with local, regional, and metropolitan transportation plans.
- Includes a financial section outlining how the RTIP/MTIP is financially constrained, showing sources and amounts of funding reasonably expected to be received for each year of the ensuing six/three-year period, and includes an explanation of all assumptions supporting the expected levels of funding.

Funding agencies often give preference to jointly sponsored transportation projects. RTPOs and MPOs can develop jointly sponsored projects since they represent multiple agencies. Major projects backed by an RTPO or an MPO have a heightened chance of receiving funding.

(3) Development of the STIP

An important role of the WSDOT Highways and Local Programs Division is to collect all RTIP, MTIP, and HSP projects in appropriate years and assemble all of the state and federally funded projects, and the projects of regional significance, into the (three-year) Statewide Transportation Improvement Program (STIP).

Development of a new STIP every two years is required by federal law in order to expend federal transportation dollars. The state of Washington, however, develops a new STIP each year to enhance project flexibility and to ensure project delivery.

The Governor's approval of the MTIPs; plus the Federal Highway Administration's, and the Federal Transit Administration's approval of the STIP; are required prior to expenditure of federal funds.

120.07 Linking WSDOT Planning to Programming

Figure 120-3 is a flow chart describing the process conceptual solutions must go through to receive funding. This chart also describes the link between planning and program development. Project Definition is presented in Chapter 330, Design Matrices are in Chapter 325, and Environmental Documentation is in Chapter 220.

The role of WSDOT planning is to determine *what* facilities or services will be provided *where*. The role of WSDOT Systems Analysis and Program Development is to determine *when* the improvements will be provided. The WSDOT Systems Analysis and Program Development Branch prioritizes the projects that are selected from the *State Highway System Plan* component of *Washington's Transportation Plan*. (See 120.04(2)(b).)

(1) The Role of the Systems Analysis and Program Development Branch

Taking the HSP from the planning stage through the programming stage is one role of the Systems Analysis and Program Development Branch. The Systems Analysis and Program Development Branch and the Project Control and Reporting Office manage the statewide highway construction program including:

- Recommending subprogram funding levels.
- Developing project priorities.
- Preparing, executing, and monitoring the highway construction program.

One responsibility of the Systems Analysis and Program Development Branch is oversight of the *Programming Process*. The legislative authorization for this activity is in RCW 47.05, Priority Programming. The Programming Process describes how projects that have been identified in the HSP are prioritized.

(2) Subprogram Categories

Subprogram categories for the service objectives and action strategies have been established, by the Transportation Commission, within WSDOT's budget to allow decision makers to determine timing and the amount of money to invest in solving transportation needs. (See the HSP for the service objectives and action strategies.) The order of the needs within each subprogram category is usually prioritized based on benefit/cost methodology: however, some subprograms do not have a prioritization methodology attached to them (such as Economic Initiatives).

The Department may combine projects that are scheduled to be constructed within six-years of each other to eliminate projects at the same location just a few years apart.

Following completion of construction, WSDOT evaluates the effectiveness that the project had on the performance of the transportation system.

(3) WSDOT Budgets

WSDOT uses the *State Highway System Plan* component of the twenty-year *Washington's Transportation Plan* as the basis for prioritizing and programming to select projects for the Agency Request Budget (ARB) and Current Law Budget (CLB). To be selected, a project must already be included in the HSP.

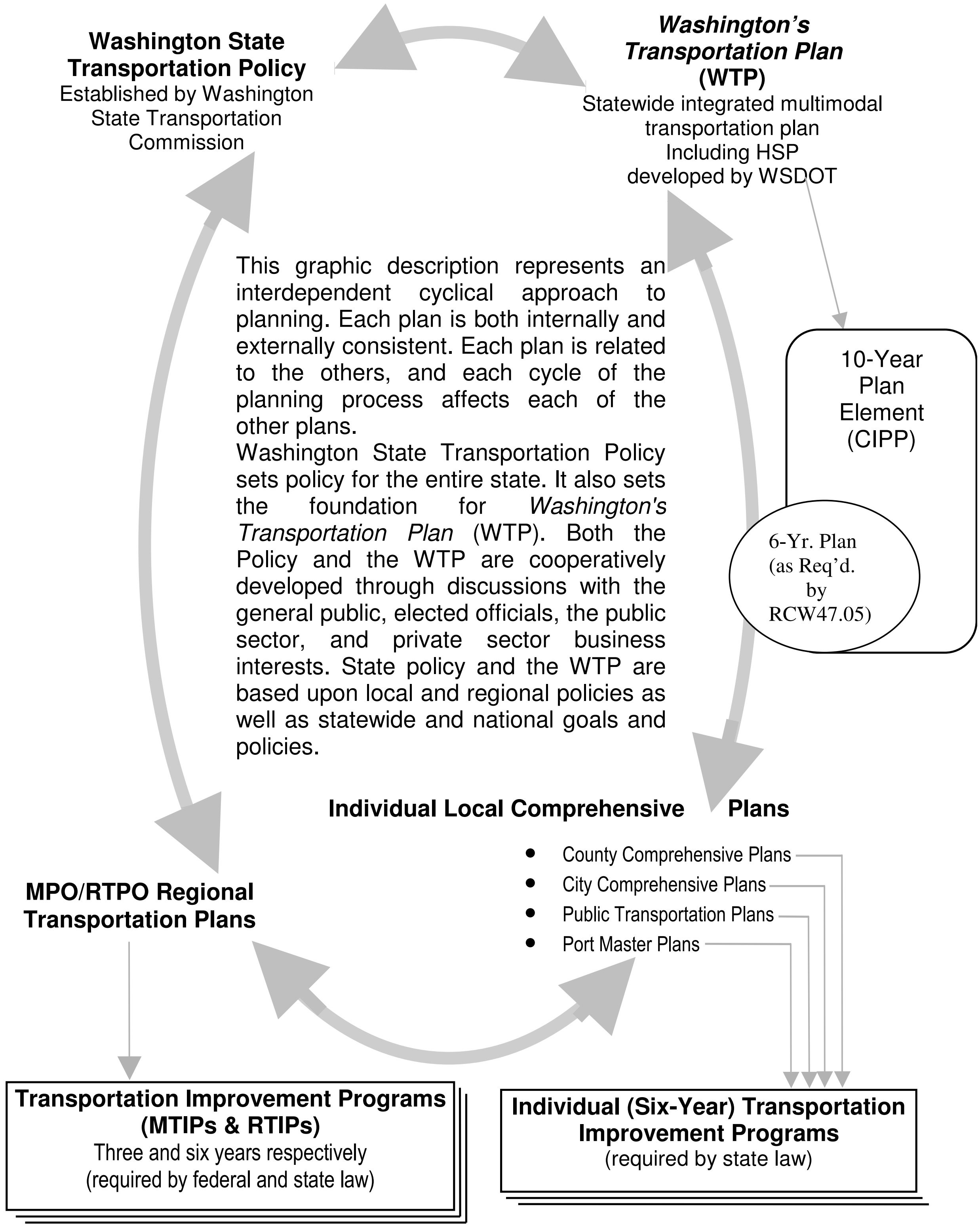
WSDOT operates on a two-year funding cycle. This is primarily because the state Legislature appropriates state transportation funds on a biennial basis. The Washington State Transportation Commission has developed a Six-Year Plan Element and the ten year Capital Improvement and Preservation Program (CIPP). The plans were developed to better implement the intent of federal and state laws influencing transportation and land use, to encourage a longer range perspective in the funding of transportation projects, and to be consistent with local and regional transportation planning processes. These plan elements will be used by the Commission to develop the two-year budget proposals.

When appropriated by the Legislature, WSDOT's two-year budget is forwarded to the appropriate RTPOs and MPOs for any needed revisions to the RTIPs and MTIPs.

(4) Key Points of Planning and Programming at WSDOT

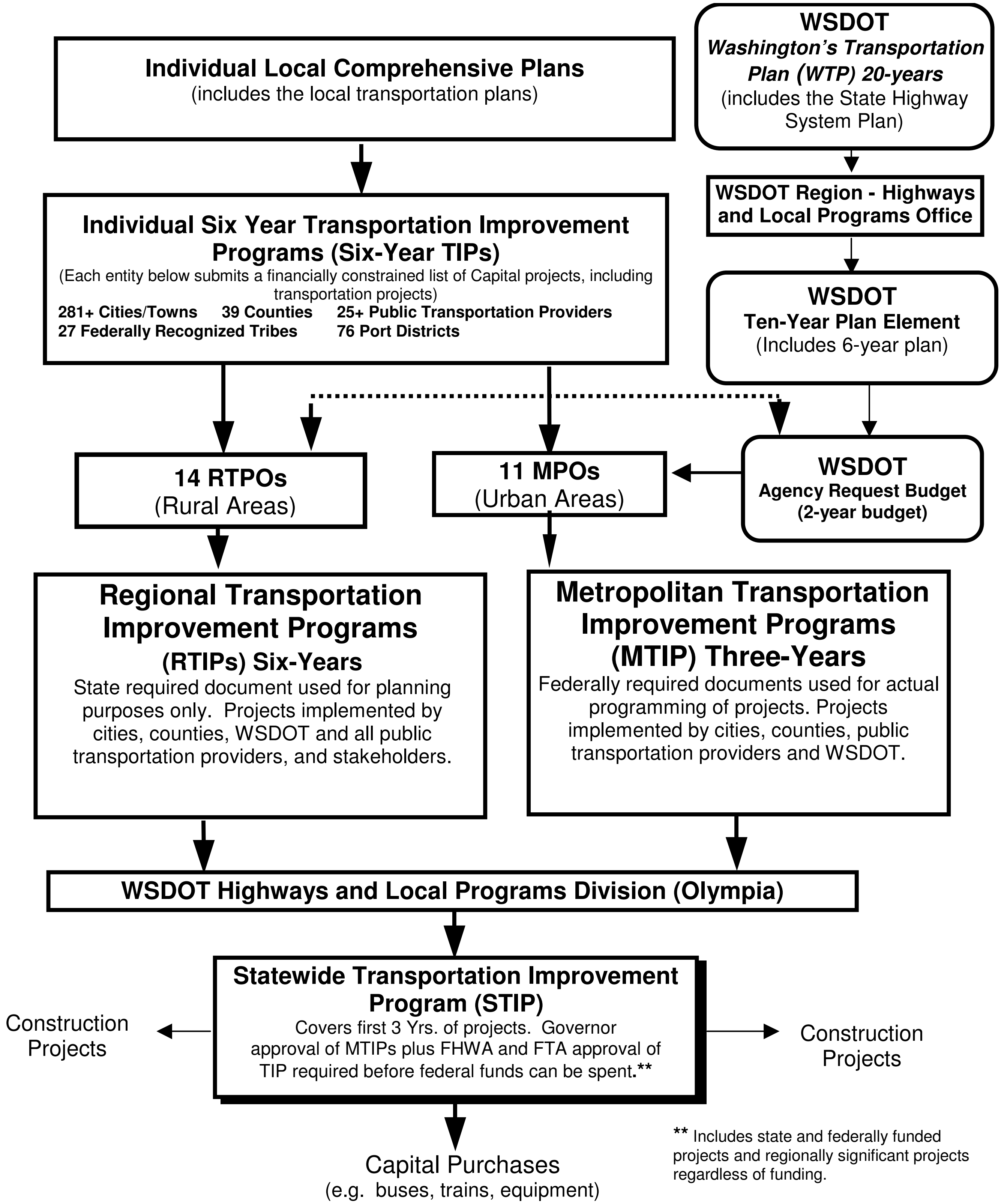
Below is a list of key points to remember about WSDOT's planning and programming process:

- Commission Policy sets the direction for *Washington's Transportation Plan* (WTP).
- Federal transportation laws and state transportation and land use laws guide solutions to address the needs for transportation facilities and services.
- The WTP is developed in partnership with MPOs and RTPOs and is tied to the land use plans of towns, cities, and counties.
- The region's Planning Offices have the main responsibility for meeting many of the state and federal planning requirements.
- The *State Highway System Plan* is a component of the WTP.
- The *State Highway System Plan* sets forth service objectives and action strategies to implement Commission policy.
- Conceptual solutions are prioritized within most budget categories based on benefit/cost analyses to obtain the greatest benefit at the least cost.
- Tradeoffs between project categories are made by policy choice through a multitiered process (WSDOT executives, Commission, and Legislature).
- An improvement strategy must be listed in the *State Highway System Plan* to be considered for project funding.

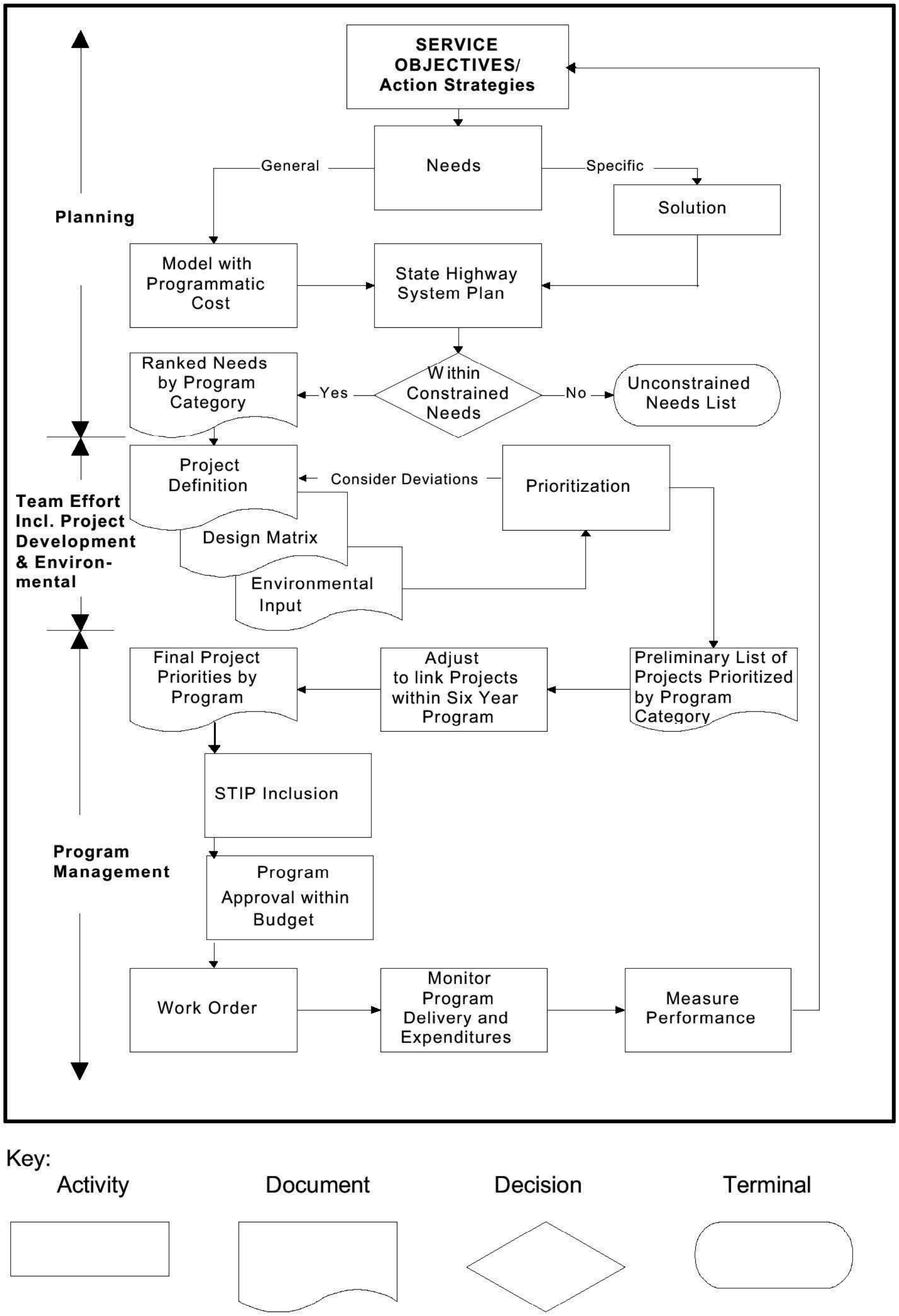


Relationship Between Transportation Plans and Planning Organizations

Figure 120-1



Transportation Improvement Programs
Figure 120-2



Linking Planning and Programming

Figure 120–3

Chapter 141 Project Development Roles and Responsibilities for Projects with Structures

141.01 General

This chapter presents the project development process used by Washington State Department of Transportation (WSDOT), the Regions and the Bridge and Structures Office together, to determine the roles and responsibilities for projects with structures during the project development phase of a project. This chapter complements the Project Management On-Line Guide which is located at:
http://www.wsdot.wa.gov/Projects/ProjectMgmt/Process.htm#PMOG

See Division 11 chapters and the *Bridge Design Manual* for design procedures.

The primary objective of this process is to provide a consistent means of selecting a bridge design team to perform all or part of the structural design work, whether it be a consultant or the WSDOT Bridge and Structures Office.

If the Local Agency will be requesting any services from WSDOT, the Local Agency will contact WSDOT's Local Program Engineer. The Local Program Engineer will help define the level of WSDOT's involvement in design and construction.

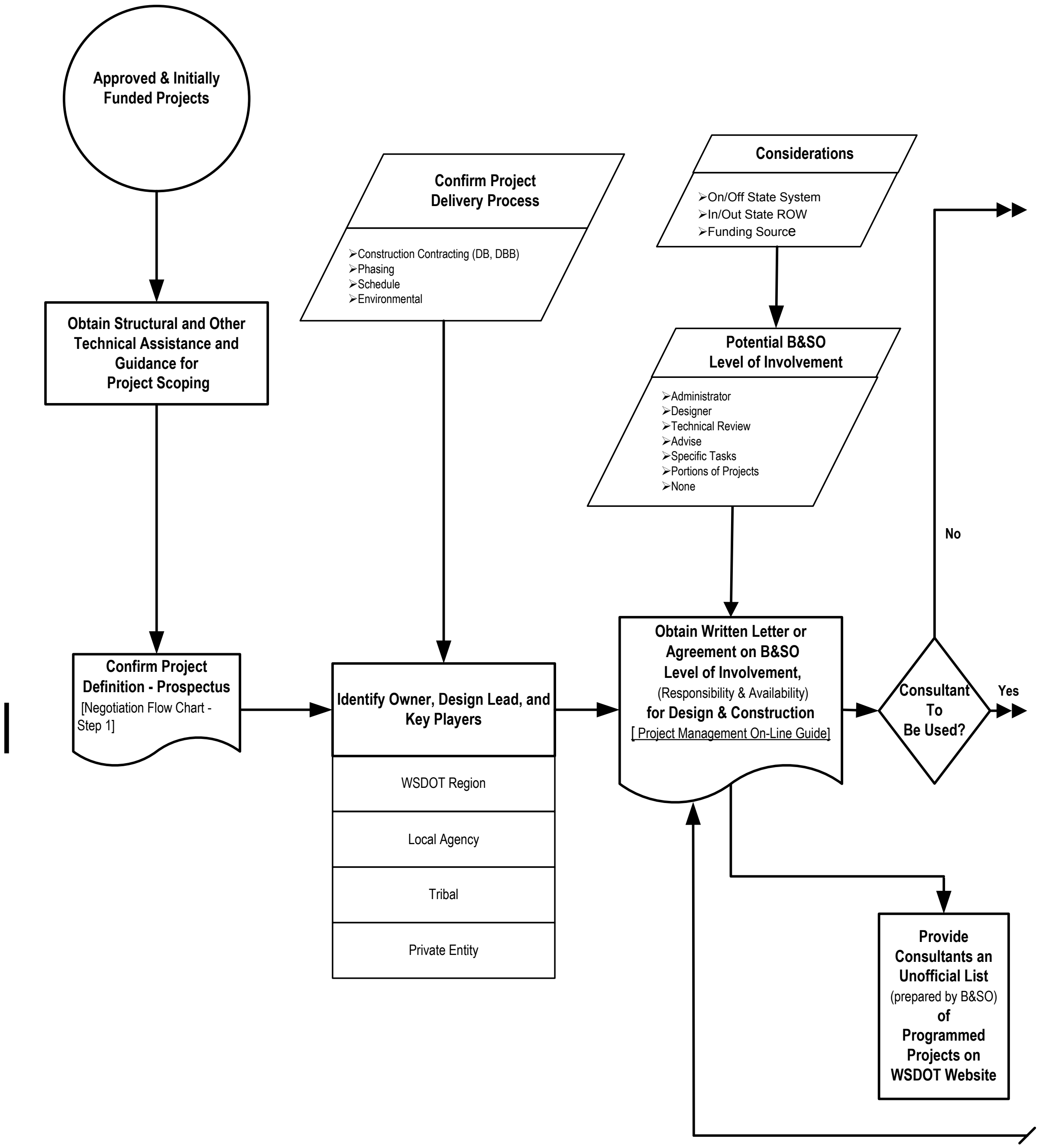
141.02 Procedures

The flow diagram, Figures 141-1a and 141-1b, begins at the left with the initial approval and funding of the project and ends at the right with the start of the project delivery process.

After a project is programmed, WSDOT is tasked with confirming the project scope and defining the structural team's level of involvement in design and construction. If a consultant is not used, all bridge design work will be performed by the Bridge and Structures Office. If a consultant is used, the WSDOT Region and Bridge and Structures Office will determine the level of involvement and responsibility for the design.

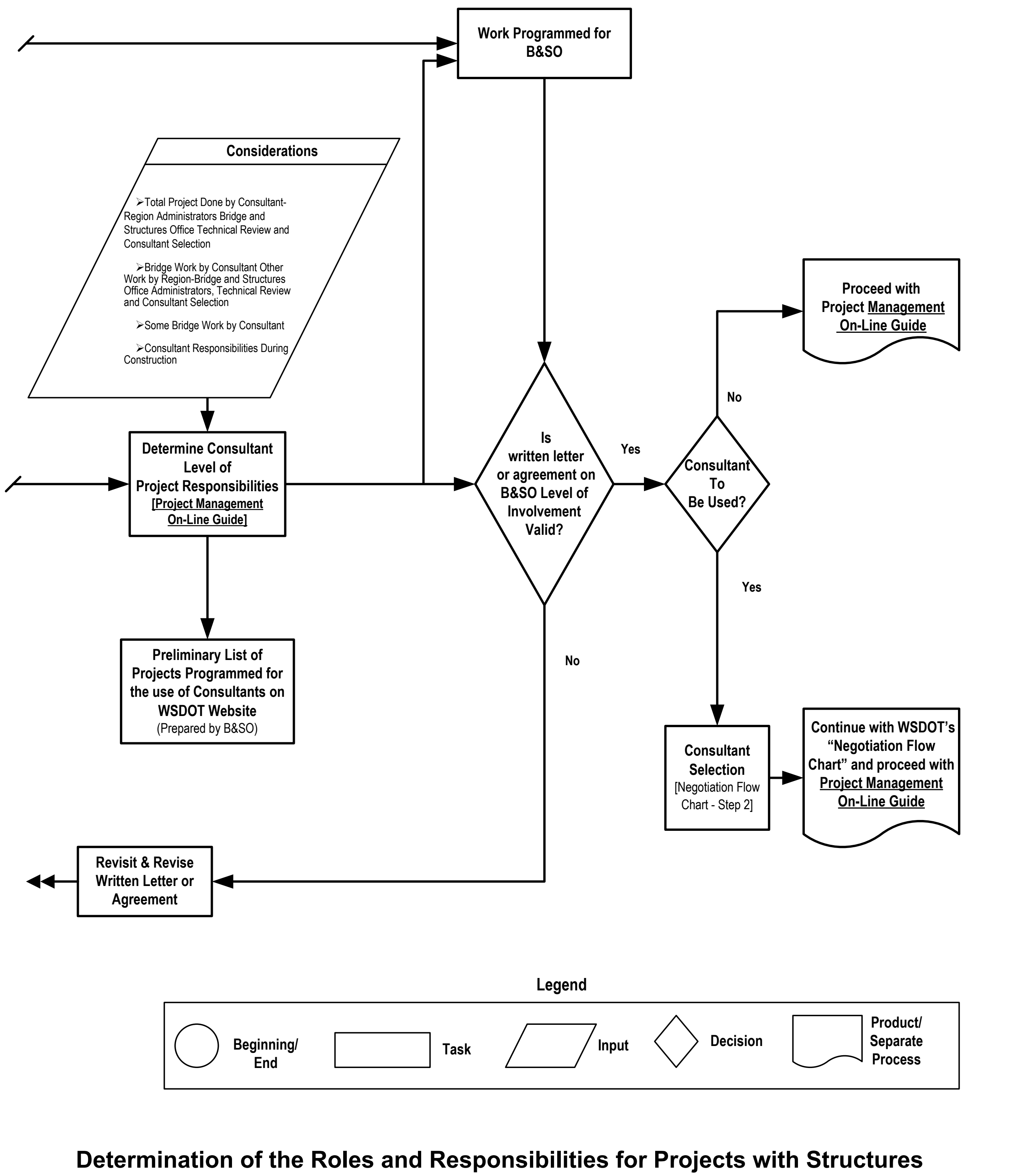
Agreements defining the level of involvement and responsibility will be developed and executed between the appropriate Regional office responsible for project development and the Bridge and Structures Office and the appropriate project delivery process will be implemented.

More information on this process and the desired outcomes is available on the Bridge and Structures Office's homepage at:



FHWA - Federal Highway Administration
WSDOT - Washington State Department of Transportation
DB - Design Build
DBB - Design Bid Build
B&SO - Bridge & Structures Office
ROW - Right of way

Determination of the Roles and Responsibilities for Projects with Structures (Project Development Phase)
Figure 141-1a



Determination of the Roles and Responsibilities for Projects with Structures (Project Development Phase)

Figure 141-1b

150.01 General

The purpose of Chapter 150 is to describe the project development sequence from the *Washington Transportation Plan* (WTP) through the contract document.

Projects go through a development process to ensure that all elements are considered, that local agencies and the public have an opportunity to comment on the department's proposed action, and that the final product successfully fulfills a transportation need. Changes in project scope, schedule, or budget are reviewed and approved using the Project Control and Reporting Process. Approved changes are reported in the department's quarterly performance report, known as the Gray Notebook.

150.02 References

Revised Code of Washington (RCW) 47.05

Programming and Operations Manual (http://wwwi.wsdot.wa.gov/ppsc/pgmmgt/manual/)

Environmental Procedures Manual – M 31-11, WSDOT

Plans Preparation Manual – M 22-31, WSDOT

*Construction Manua*l – M 41-01, WSDOT

Local Agency Guidelines (LAG) – M 36-63, WSDOThttp://wwwi.wsdot.wa.gov

150.03 Definitions

benefit cost (b/c) ratio A method for prioritizing highway improvement projects. The b/c ratio is determined by dividing measurable benefits by measurable costs for a specific time period; typically 20 years.

Capital Improvement and Preservation Program (CIPP) The Washington State Department of Transportation's (WSDOT's) plan to deliver the program of capital investments in transportation that have been funded in part or in whole by the state Legislature. The CIPP also serves as project documentation relating to the capital budget requests adopted by the Transportation Commission.

capital program management system (CPMS) A mainframe computer database used to develop and manage the highway and marine construction programs. It allows users to establish and maintain project data and is used to manage and deliver statewide construction programs. System screens allow the user to input and maintain project data, manage changes to approved projects, and generate reports to monitor program delivery. CPMS interfaces with the Transportation Information and Planning Support (TRIPS), Priority Array Tracking System (PATS), and Transportation Reporting and Accounting Information System (TRAINS) data bases.

carryforward – federal The apportionment balance, in each federal program, that will be available for the next federal fiscal year. Carryforward consists of the apportionment balance that accumulated and was not used in the three previous federal fiscal years. Unused apportionment is forfeited if it is older than three previous federal fiscal years.

carryforward – state The amount of funds necessary to complete project phases authorized in a previous biennium that will not be available to begin new projects or project phases in a subsequent biennium.

Federal Highway Administration (FHWA) The section of the United States Department of Transportation with jurisdiction over the use of federal transportation funds for state highway and local road and street improvements.

Federal Transit Administration (FTA) The section of the United States Department of Transportation with jurisdiction over the use of federal funds for financial assistance to develop new transit systems and improve, maintain, and operate existing systems.

Financial Information Retrieval System (FIRS) A computer application that allows the retrieval of accounting and work order information from the Transportation Reporting and Accounting Information System (TRAINS) data base at a "rolled-up" level. For further information, see: http://wwwi.wsdot.wa.gov/FASC/Accounting/firs.pdf.

Geographic Information System (GIS) A computerized geographic information system used to store data. Data may be used with GIS if the data includes the Accumulated Route Mile (ARM) or State Route Mile Post (SRMP). Global Positioning System (GPS) technology provides a means of collecting data and is an alternative to ARM and SRMP. WSDOT's primary desktop tool to view and analyze GIS data is ArcGIS software.

high accident corridor (HAC) A highway corridor one mile or greater in length where a five-year analysis of collision history indicates that the section has higher than average collision and severity factors.

high accident location (HAL) A highway section typically less than 0.25 mile in length where a two-year analysis of collision history indicates that the section has a significantly higher than average collision and severity rate.

highway construction program (HCP) The comprehensive two-year program and ten-year financial plan of highway improvement and preservation projects selected by priority.

Highway System Plan (HSP) A WSDOT planning document that addresses the state highway system element of the *Washington Transportation Plan* (WTP). The HSP defines the service objectives and the action strategies and costs to maintain, operate, preserve, and improve the state highway system for 20 years. It is the basis for the state highway element for the six-year plan and the biennial state highway construction program. It is periodically updated to reflect completed work, and changing transportation needs, policies, and revenues. It compares highway needs to revenues, describes the "financially constrained" costs of the highway programs, and provides details of conceptual solutions in the improvement program.

Metropolitan Planning Organization (MPO) A lead agency designated by the Governor to administer the federally-required transportation planning process in a metropolitan area with a population over 50,000. The MPO is responsible for the 20-year long-range plan and *Transportation Improvement Plan* (TIP).

National Highway System (NHS) A network of roadways designated by Congress that consists of all Interstate routes; a large percentage of urban and rural principal arterials; and strategic highways and highway connectors.

pedestrian accident location (PAL) A highway section typically less than 0.25 mile in length where a six-year analysis of accident history indicates that the section has had four accidents in a 0.1 mile segment.

Plans, Specifications, and Estimates (PS&E) The project development activity that follows project definition and culminates in the completion of contract-ready documents and the Engineer's Cost Estimate. These documents include final plans, specifications, and estimates.

preliminary engineering (PE) A term used to describe the effort needed to arrive at the conceptual solution to address a transportation need, including project establishment and route selection through the PS&E review.

priority array A collection of similar needs identified in the HSP, prioritized based on the methodology adopted by the department to meet the requirements of RCW 47.05.

Priority Array Tracking System (PATS) A centralized database that allows tracking of highway needs and their solutions. The system is designed to ensure that WSDOT addresses the highest ranked transportation needs. Deficiencies are tracked for each strategy in the HSP.

project control and reporting (PC&R) The Project Control and Reporting office is responsible for monitoring, tracking, and reporting the delivery of the Highway Capital Program in coordination with the Program Management Offices in each of the six WSDOT regions and the Urban Corridors Office.

project summary A document that comprises the project definition, design decisions, and environmental review summary. The document replaces the project prospectus, design report, and environmental database. The project summary ensures that the project scope addresses the need identified in the HSP.

Regional Transportation Planning Organization (RTPO) A planning organization authorized by the Legislature in 1990 as part of the Growth Management Act. The RTPO is a voluntary organization with representatives from state and local governments and is responsible for coordinating transportation planning activities within a region.

Statewide Transportation Improvement Program (STIP) A planning document that includes all federally funded projects and other regionally significant projects for a three-year period. The STIP is a compilation of all projects that are in the TIPs, developed by the regional planning organizations (MPOs and RTPOs). A new STIP must be developed every two years or less, and is approved jointly by the FHWA and FTA for compliance with statutory requirements and financial feasibility.

Surface Transportation Program (STP) A federal program established by Congress in 1991 that provides a source of federal funding for highway and bridge projects.

Transportation Improvement Program (TIP) A three-year transportation improvement strategy required from MPOs by Congress. It includes all projects in the three-year period expected to be financed by federal funds. All federally funded or regionally significant projects must be included in the TIP.

Transportation Information and Planning Support (TRIPS) A mainframe computer system designed to provide engineering, maintenance, planning, and accounting staff with highway inventory, traffic, and accident data.

Washington State Pavement Management System (WSPMS) A computer system that stores data about the condition of all the highways in the state. Information available includes the latest field review, and past contracts for every main line mile of state highway. Calculations are used to determine whether a given section of pavement is a "past due," "due," or "future due" preservation need.

Washington's Transportation Plan (WTP) A WSDOT planning document developed for the Transportation Commission in coordination with local governments, regional agencies, and private transportation providers. It addresses the future of transportation facilities owned and operated by the state and those that the state does not own, but in which it has an interest. It identifies significant transportation investments that are needed. These transportation needs are defined by service objectives and specific desired outcomes for each transportation mode.

150.04 Project Development Sequence

The project development sequence is composed of the following:

(1) Washington State Highway System Plan (HSP)

The HSP is the element of *Washington's Transportation Plan* that addresses the state's highway system. The HSP forecasts transportation needs, provides objectives and action strategies to improve and preserve the highway system, and serves as the basis for the department's capital investment strategies. (To view the *Highway System Plan,* see http://www.wsdot.wa.gov/ppsc/hsp/HSPPlan.htm)

(2) Highway Construction Program

In every odd-numbered year, the Washington State Legislature meets to consider and pass a transportation budget. One piece of this budget is funding for the highway construction program. In order to control expenditures and track budget dollars and commitments, the department groups capital projects into programs, subprograms, and categories based on the action strategies, objectives, and goals in the *Highway System Plan*. The department has identified three subprograms within the preservation program and six subprograms within the improvement program, four of which are discussed in the Improvement Program section.

(a) Prioritizing Project Needs and Solutions

Each category of work within the highway construction program has a set of needs that are identified by comparing a specific action strategy in the *Washington Transportation Plan* to the existing highway system. These needs are met by developing projects to program. The Legislature has directed the department to prioritize (select) projects for each category based on the benefits returned to the transportation user. State law in Priority Programming for State Highways (RCW 47.05) directs WSDOT to identify transportation needs, determine the benefit/cost (b/c) of the solutions, and prioritize the solutions based on the b/c.

(b) Background Information

WSDOT HQ Systems Analysis and Program Development begins the prioritization process for a category of work by identifying the potential benefit(s) associated with solving the need. There are not sufficient resources to analyze the benefits and costs of all needs in each category of the program each biennium, so a prioritization scheme is used to reduce the effort. Because the primary objective of the department's prioritization process is to provide the largest improvement for the least possible cost, needs in each category are ranked based on their potential to provide a benefit. The process includes these steps:

- The regions scope projects to address the needs in rank order. The biennial programming instructions provide guidance to the regions on how far down the ranked "needs lists" to go. To ensure a consistent approach to scoping a project, WSDOT has developed a set of design matrices. Each design matrix sets forth the level of development for a given type of need that would be automatically approved by the department and FHWA. (See Chapters 325 and 340.)
- The regions prepare a cost estimate for the approved scope of work and compare the cost to the potential benefit in order to determine which projects are the most beneficial to construct.

In order to minimize disruptions to the public and take advantage of cost savings, the department may adjust priorities by up to six years.

(c) Building the Program

The basic building blocks for the highway construction program are the project phases in the Capital Improvement and Preservation Program (CIPP). Carryforward project commitments represent job phases that will continue into the next biennium. The book building process starts with these carryforward projects. The regions need to review the carryforward projects and determine the potential for project delays and cost overruns in the current biennium that might affect the next biennium. Maintaining close coordination between the region, HQ Programming, the Project Development Engineer, and the Construction Engineer is necessary to ensure that projects under development and under construction are accomplished as planned.

Building on this foundation, new improvement project phase starts are added based on department policy and Transportation Commission direction. These new project starts represent needs that are identified in the *Highway System Plan*. The first step in adding new projects to the CIPP for the next biennium is to establish a funding target for each category of work within each subprogram. Once HQ has provided the target funding levels, the regions begin to assemble the highway construction program. It is important to remember that regions can't propose a project unless a need has been identified in the HSP.

After the new projects have been selected and the carryforward projects identified (and their planned expenditures and schedules verified), the program of projects is developed and the project data is input into CPMS for balancing to the target allocations for both dollars and workforce (FTEs). Project summaries are then developed. The program of projects is shared with region executives, and their input is incorporated. Adjustments are made to ensure that the program can be accomplished within the constraints of available workforce and facilities in the region.

(d) Roles and Responsibilities Within WSDOT for Delivering the Highway Construction Program

The WSDOT Budget Office, along with various offices in the Strategic Planning and Programming Division, share responsibility for developing a ten-year capital investment plan for the Commission, including a forecast of available revenue by fund source, and recommend investment levels based on the WTP. Program Development issues programming instructions, based on the preliminary budget targets, which assist the regions as they begin scoping highway projects.

Once a ten-year plan has been determined, and proposed projects scoped, Program Development finalizes a budget request, including a project list that is presented to the Commission for review and submittal to the Legislature. The Legislature sets funding levels for the different programs within the department that will deliver the project list for the funding amount identified in the scoping document.

WSDOT regions, working with support offices, such as Environmental, Utilities, Right of Way, and Construction, design and build the projects that deliver the transportation program.

(e) Categories of Work

The HSP presents the budgets for the Maintenance (M), Operations (Q), Preservation (P), and Improvement (I) programs. Strategies and conceptual solutions are limited to the P & I programs. Each of these programs are broken into sub-programs:

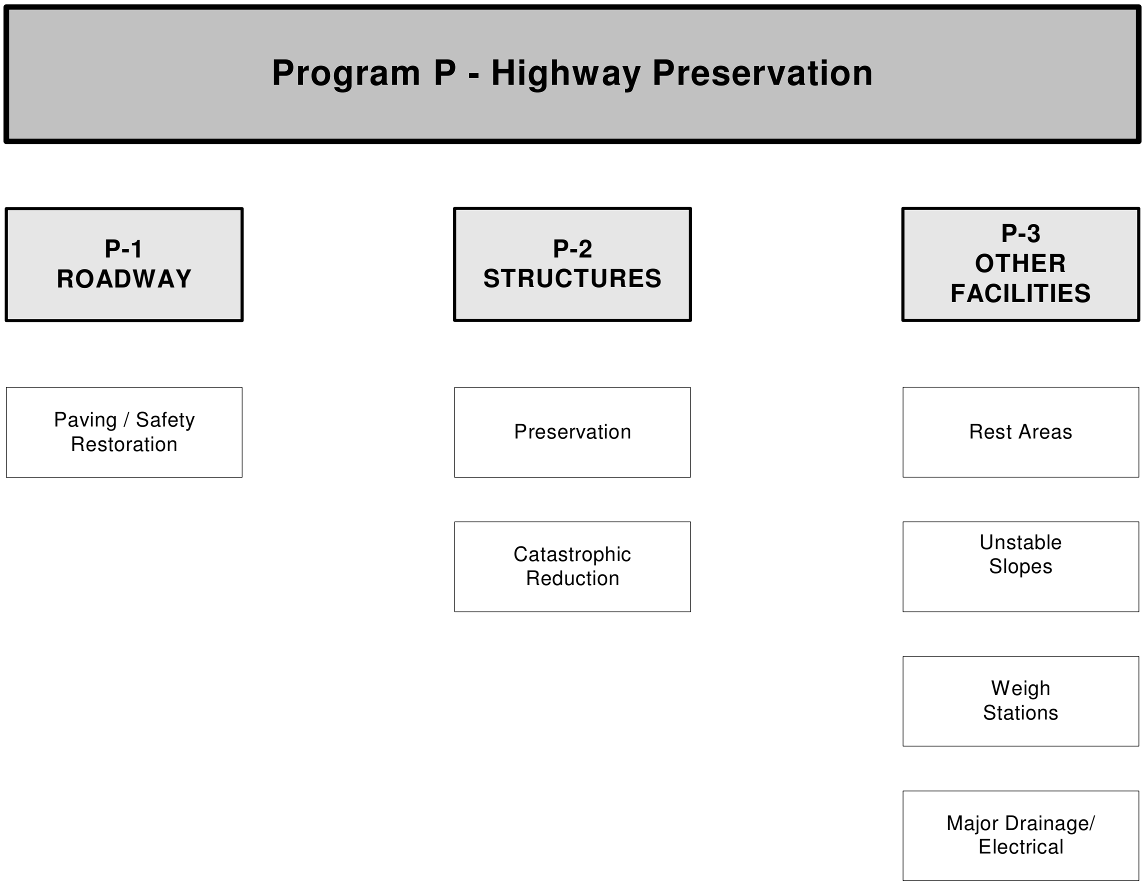


Figure Notes:

Preservation Program (P): Preserve the highway infrastructure cost to effectively protect the public investment.

- **P–1 Paving**
  Repave highways at regular intervals for lowest life cycle cost.
  Restore existing safety features.
- **P–2 Structures**
  Preserve existing structures for operational and structural integrity through rehabilitation or replacement of bridges or other structures.
  Reduce catastrophic failure from naturally occurring events.
- **P–3 Other Facilities**
  Refurbish rest areas to extend service life and improve safety.
  Stabilize known unstable slopes.
  Construct weigh stations to ensure enforcement across the entire highway system.
  Refurbish electrical systems, electronics, and mechanical systems to extend service life and improve safety.
  Rehabilitate or replace existing major drainage features to preserve operational and structural integrity.

Program Elements
Figure 150-1

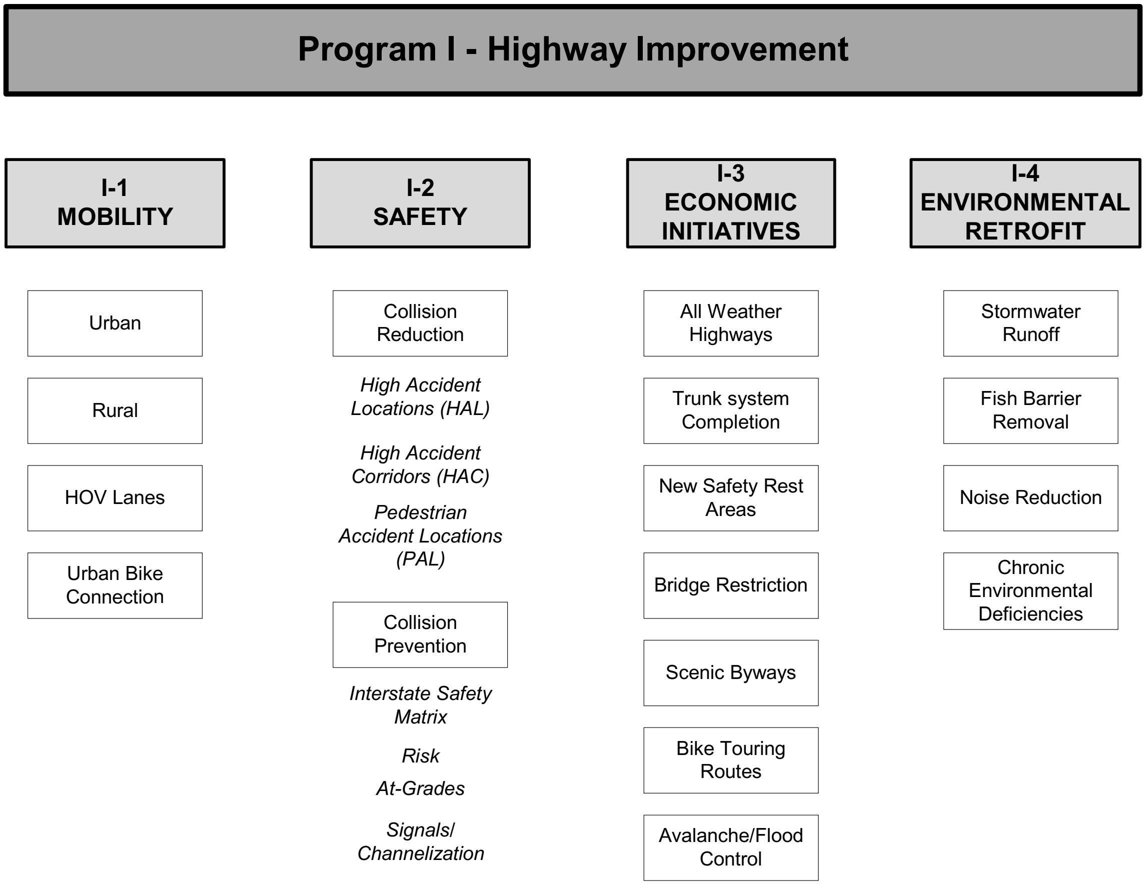


Figure Notes:

Improvement Program (I): Identifies deficiencies in the state highway system and develops solutions for those deficiencies through capital improvement projects.

- **I–1 Mobility**

  Mitigate congestion on urban highways when peak period level of service (LOS) falls below D (Congestion Index 10). For further information, see the *Highway System Plan*, http://www.wsdot.wa.gov/ppsc/hsp/HSPPlan.htm

  Provide uncongested conditions (LOS C-Congestion Index 6) on rural highways.

  Provide bicycle connections on state highways within urban growth areas.

  Complete the Freeway Core HOV Lane system in the Puget Sound region.

- **I–2 Safety**

  Collision Reduction needs include HALs, HACs, and PALs. Needs are ranked based on the societal cost of the accident history. If the Collision Reduction project is programmed within the next six years, regions may combine it with another project to minimize disruption to traffic.

  The needs in Collision Prevention consist of four types: Interstate safety matrix, risk (run off roadway), at-grade intersections, and signals and channelization.

  The needs are prioritized based on the cost benefit of reducing the potential societal cost of accidents, except as noted below.

  The needs in the Interstate safety matrix group are identified by the regions and include any design feature that does not meet the standard specified in the Interstate design matrices. This work is usually done at the same time other work is programmed, such as paving. The needs in the risk (run off roadway) group are identified by HQ Systems Analysis and Program Development, based on roadway and roadside data from the Transportation Data Office. The needs are ranked based on the potential cost of accidents as a result of the existing conditions.

Program Elements

Figure 150-2

At-grade intersections on multilaned, high-speed, access-controlled highways that have a history or the potential for serious accidents are identified by HQ Systems Analysis and Program Development.

The region identifies the needs in the signals and channelization group. Each region is responsible for preparing a prioritized list of needs for locations that meet traffic volume and signal warrants, as detailed in the WSDOT *Traffic Manual*.

Special safety initiative projects are narrowly focused, stand-alone risk reduction projects, such as cable median cross-over barriers and rumble strips.

- **I–3 Economic Initiatives**

All weather highway needs are identified as those sections of highway that are susceptible to damage by heavy loads when the roadway thaws after a freeze.

Trunk system completion needs include the state's T-1 freight corridors (highways that carry ten million tons or more of freight each year) identified by HQ Systems Analysis and Program Development and the Transportation Data Office. The Transportation Commission prioritizes these routes.

The Safety Rest Area Office in the HQ Maintenance and Operations Division works with the regions, specialty groups, and other government agencies to identify locations for new rest areas on state highways and to look for partnership opportunities.

The Restricted Bridges needs are made up of two types of work: low vertical clearance under-crossings on the Interstate (clearance less than 15 feet 6 inches) and load restricted bridges (licensed legal overloads). The Bridge Planning Section identifies these needs with the technical assistance of the Bridge Condition Section. The low vertical clearance structures on the Interstate have been given priority over the load-restricted structures.

The Highways and Local Programs Division and the Transportation Data Office have identified where 4-foot bike shoulders do not exist on the state's six rural bicycle-touring routes. The regions look for opportunities to solve these rural bike needs by combining them with programmed work in other categories. This approach minimizes traffic disruption and reduces contract costs.

HQ Systems Analysis and Program Development has identified roadway segments on T-1 freight corridors (highways that carry ten million tons or more of freight each year) where travelers have experienced delays due to avalanche and flood closures.

- **I–4 Environmental Retrofit**

Environmental Services (ES) surveys all storm water outfalls that flow into a water body. Each of these storm drains is identified as a need and is further rated from high to low.

Fish Barrier Removal needs are identified by the Washington State Department of Fish and Wildlife (WDFW). WDFW has surveyed culverts on the state's highway system and identified those that impede the migration of fish. The WDFW is conducting habitat surveys to determine the potential for migratory fish recovery and is prioritizing the culverts based on the results.

Since 1977, FHWA has funded a program for noise retrofit and made states responsible for mitigating noise-sensitive locations in conjunction with new construction projects. WSDOT's retrofit locations are prioritized based on a b/c ratio.

The Chronic Environmental Deficiency (CED) Program is a statewide program within WSDOT that works with WSDOT's regional staff to identify and fix locations along highways where recent, frequent, and chronic maintenance and/or repairs to the state transportation infrastructure (highway fills, toe slopes, sanding, etc.) are causing impacts to fish and/or fish habitat.

Program Elements
Figure 150-2 (continued)

(3) Project Summary

The project summary is developed in the region when a project is proposed for programming.

The project summary:

- defines the scope of work HQ Systems Analysis and Program Development and the region have agreed to.
- documents the design decisions made while determining the project scope.
- must be as complete and accurate as possible.
- establishes initial preliminary engineering, right of way, and construction cost estimate.
- documents the project delivery schedule.
- requires approval by HQ Systems Analysis and Program Development prior to beginning work on a project.
- documents the potential environmental impacts and permits that may be required.

The intent of this agreement is to identify the need that has generated the project and the proposed solution that will solve that need.

Regions are encouraged to place special emphasis on project scoping, estimating, and scheduling during program development to ensure program delivery stays within appropriated dollars and workforce. Resources available to the regions include the *Highway System Plan*; Route Development Plans; the Design Matrix; the *Roadside Classification Plan*; Environmental Workbench and other planning; and design and environmental documents to ensure that project scoping is consistent.

The environmental section of the project summary establishes the initial environmental classification and documentation required for the project. Environmental classification at the project summary stage has several benefits. It helps in understanding the impacts associated with a project and it helps to establish a realistic schedule and PE cost estimate. All projects require supporting State Environmental Policy Act (SEPA) documentation. National Environmental Policy Act (NEPA) documentation is also required for all projects that are eligible for federal funding.

Regions are encouraged to take full advantage of expertise available from the HQ Systems Analysis and Program Development Branch of the Strategic Planning and Programming Division, FHWA, the Environmental Office, and local agencies when scoping projects to ensure that all aspects are considered, and that the proposed solution is eligible for available funding. These resources can help the regions evaluate a project's impacts and provide the appropriate project direction.

HQ Systems Analysis and Program Development coordinates review of the project summary and forwards any comments to the regions for resolution prior to approval. Once all comments and outstanding issues are resolved, the project summary can be approved and copies distributed.

(4) Environmental Document

The Environmental Document is a statement identifying impacts to the natural and manmade environment as a result of a project. The statement may consist of one or two pages for categorically exempted projects, a SEPA checklist, or an environmental impact statement (EIS) for major projects. (See Chapter 220.)

(5) Design Documentation Package (DDP)

The DDP is a formal document of design considerations and conclusions reached in the development of a project. The Project File records various design recommendations that are reviewed within the department and, when approved, become the project design. (See Chapter 330.)

(6) Right of Way/Access Plans

Right of Way/Access Plans are the official state documents used to acquire real estate, property, and access rights. These plans determine rights of access from abutting property owners, interchange or intersection spacing, access points per mile, or other selective approaches to a highway facility. Right of way plans are used to obtain the "Order of Public Use and Necessity," which is the authority to acquire real property and property rights under eminent domain.

The establishment of access control is considered whenever major improvements, reconstruction, relocation, significant new rights of way, or new facilities are required. Projects not requiring right of way or other property interests skip this phase of project development. (See Chapters 1420, 1430, 1435 and the *Plans Preparation Manual*, M 22-31.)

(7) Contract Document

The contract Plans, Specifications, and Estimates (PS&E) are the final documents required for the advertisement of a construction contract. Contract plans must conform to the basic design features approved in the project summary, environmental documents, and the DDP. The plans and contract specifications must set forth the work in a clear and concise manner to avoid misinterpretation. A tool available to the designer to ensure that required items are addressed during the PS&E preparation is the "PS&E Review Checklist," available on the WSDOT intranet. Projects may go through PS&E preparation, but will not be advertised for construction until all previous phases are complete. (See the *Plans Preparation Manual,* M 22-31.)

210.01 General

It is the goal of the Washington State Department of Transportation (WSDOT) that decisions be made in the best overall public interest and that other agencies and the public be involved early enough to ensure that the decisions that are made are responsive to the public's interests.

Public involvement is used to place issues before the public; to gather, and assimilate comments; and to inform the public of the final decisions, construction schedules, and project results. As part of the public involvement activities, hearings are held when major decisions are being made. Other, less formal methods are also used because they are the best way to elicit comments and communicate proposals.

Current laws and regulations provide general guidelines that allow considerable flexibility. The environmental policies and procedures (SEPA and NEPA) are intended to ensure that environmental information is available to public officials, agencies, and citizens and that public input is considered before decisions are made.

The role of local elected officials in the project development process is emphasized, and consistency with community planning goals and objectives is required.

210.02 References

USC Title 23 — Highways, Sec. 128 Public Hearings

USC Title 23 — Highways, Sec. 771.111 Early coordination, public involvement, and project development

RCW 47.50, Highway Access Management

RCW 47.52, Limited Access Facilities

Design Manual Chapter 220 for environmental references

Improving the Effectiveness of Public Meetings and Hearings, FHWA Guidebook

Public Involvement Techniques for Transportation Decision-Making, FHWA September 1996

210.03 Definitions

hearing An assembly to which the public is invited — to attend and to be heard.

> **formal hearing** A hearing that is conducted by a moderator using a formal agenda, overseen by a hearing examiner, and recorded by a court reporter, as required by law.
>
> **informal hearing** A hearing that is recorded by a court reporter, as required by law. An open format hearing is an informal hearing. The hearing examiner and formal agenda are optional.
>
> **access hearing** A formal hearing that gives local public officials, owners of abutting property, and other interested citizens an opportunity to be heard concerning any plan that proposes the limitation of access to the highway system.
>
> **administrative appeal hearing** A formal process whereby a property owner may appeal the department's implementation of access management legislation. The appeal is heard by an Administrative Law Judge who renders a decision. See 210.11 for the administrative appeal hearing procedures. They differ from those for the other, more public, hearings.

combined hearing A hearing that is held when there are public benefits to be gained by any combination of the environmental, corridor, design, and access hearings.

corridor hearing A formal or informal hearing that presents the corridor alternatives to the public for review and comment before a commitment is made to any one route or location.

design hearing A formal or informal hearing that presents the design alternatives to the public for review and comment before a commitment is made to any one alternative.

environmental hearing A formal or informal hearing that ensures that social, economic, and environmental impacts have been considered.

court reporter A person with a license to write and issue official accounts of judicial or legislative proceedings.

findings and order A document containing the findings and conclusions of a limited access hearing that is approved by the Assistant Secretary for the Environmental and Engineering Service Center.

Hearing Coordinator The Access and Hearings Specialist within the Olympia Service Center (OSC), Design Office, Access and Hearings Unit, who is assigned the responsibility for coordination of all functions relating to hearings.

hearing examiner An Administrative Law Judge (ALJ) from the Office of Administrative Hearings, or a WSDOT designee, appointed to moderate a hearing.

NHS projects Projects on the National Highway System for which FHWA has delegated approval authority for design, contract administration, and construction to WSDOT. (See Chapter 330.)

opportunity for a hearing An advertised offer to hold a hearing if so requested.

resumé An official notification of action taken by WSDOT following adoption of a findings and order.

210.04 Public Involvement

Developing an effective public involvement program is a strategic effort that involves selecting techniques that will meet the unique needs of a given transportation plan, program, or project. An effective public involvement program:

- Informs the public of the need or proposed action.
- Informs the public about the process that will be used to make decisions.
- Ensures that the public has ready access to relevent and understandable information.
- Identifies and resolves issues early in the process.
- Gains public support.
- Assists the project development process.

Public involvement begins during the system planning phase when the public is given opportunities to help solve short and long term transportation problems.

The public involvement effort continues into the project definition phase when a project is proposed to fulfill an identified need. When the study area for a project is identified, the region frequently notifies the public that the department is initiating a project and invites them to participate in a project definition or environmental evaluation meeting.

The region develops a public involvement plan that identifies all the methods proposed for the project. Methods are selected to ensure that public opinion is considered throughout the planning, environmental, location, and design phases of the project. Follow-up activities sometimes continue through construction, and even after completion, to provide ongoing public outreach or notifications.

For simple projects, the region develops a public involvement plan for their own use and guidance. To inform the public, communicate the decision-making process, identify the issues, and possibly resolve concerns, the region communicates with the affected community through newspaper articles, fliers, community group presentations, open house meetings, or other methods. Public involvement on minor projects is not intended to be an open forum on the proposed design; however, public comments received during project development are evaluated and, if appropriate, included in the project.

It may become necessary to revise the public involvement plan as the project evolves, the community changes, or new issues arise.

(1) Public Involvement Plan

The regions develop the public involvement plans for WSDOT projects. For projects requiring an environmental impact statement (EIS), a public involvement plan and OSC approval are required as part of the preparation of the Study Plan. (See Chapter 220.) For all other projects, the region may consult the Access and Hearings Unit for assistance or concurrence.

The public involvement plan includes:

- List of proposed activities.
- Time schedule to do each task keyed to the environmental process schedule, if applicable.
- Methods to be used in considering comments in the decision-making process, including follow-up procedures.
- Personnel, time, and funds needed to carry out the plan.
- Identification of the project stakeholders as the *public* to be involved.

The *public* to be involved (affected directly or indirectly) might include any or all of the following:

- Staff and elected officials of local governments
- Other state and federal agencies and officials
- Indian tribes
- Adjacent property owners and tenants
- Adjacent billboard owners and clients
- Community groups; clubs, civic groups, churches
- Special interest groups
- Environmental Justice stakeholders (low income and minority groups)
- Service providers; emergency, utility
- Others expressing interest
- Others known to be affected
- The general public

The department recognizes the role of local, state, and federal staff and elected officials as active sponsors of proposed projects who might effectively assist in developing and implementing the public involvement plan. Early and continued contact with these resources is a key to the success of the project.

(2) Public Involvement Methods

Effective public involvement is flexible, innovative, multifaceted, and ongoing. There are many methods available to gain public participation. Any of the following methods might be appropriate to a project.

- Formal hearings (210.04(2)(a))
- Informal hearings (open format hearings) (210.04(2)(b))
- Public meetings and open house meetings (210.04(2)(c))
- Prehearing presentations
- Drop-in information centers or booths
- Advisory committee meetings
- Design workshops
- Meetings with public officials
- Individual (one-on-one) meetings
- Meetings with special interest groups
- Presentations at local group meetings
- Surveys and questionnaires/paper or electronic mail
- Hot lines
- Follow-up procedures (210.04(2)(d))

There are many communication tools available for use when announcing and holding public involvement events. See the following for lists of ideas.

- Notification techniques (210.04(2)(e))
- Handouts 210.04(2)(f)
- Graphics and Audio-Visual Aids 210.04(2)(g)

Agency representatives are conveying the department's image. They should be conscious of their roles, be well informed and confident, and communicate skillfully. When the event is well planned and the conductor is sensitive to the needs of the audience and objective about the needs of the project, meetings and hearings are usually productive efforts. See the FHWA publication *Public Involvement Techniques for Transportation Decision-Making.*

(a) **Formal Hearings.** The following are required of all formal hearings.

- Prehearing packet(210.05(5)(a))
- A hearing notice with a fixed time and date (210.05(2))
- Fixed agenda
- Hearing moderator (may be the hearing examiner)
- Hearing examiner
- Comment period
- Summary (210.05(6))

In addition to the oral comment period, people can write opinions on comment forms at the time of, or after, the hearing and submit them before the announced deadline.

See 210.06, 7, 8, and 9 for specifics related to the various types of hearings.

(b) **Informal Hearings (Open Format Hearings).**

An informal hearing must have the characteristics of a formal hearing listed in (a) above except for the fixed agenda. These events are usually scheduled for substantial portions of an afternoon or evening so people can drop in at their convenience and fully participate. People are directed to attend a presentation, visit the exhibits, and then submit their comments.

The following items are features of an open format hearing, which is the most common format for an informal hearing.

- In areas where people work in shifts, open format hearings can be scheduled to overlap the shift changes.
- Brief presentations about the project and hearing process, at preset times, are advertised in the hearing notice. They can be live, videotape, or computerized.
- Agency or technical staff are present to answer questions and provide details of the project.
- Information is presented buffet style and participants shop for information.
- Graphics, maps, photos, models, videos, and related documents are frequently used.
- People get information informally from exhibits, presentations, and staff.
- People have a chance to clarify their comments by reviewing materials and asking questions before commenting.
- People can comment formally before a court reporter, or they can write opinions on comment forms and submit them before the announced deadline.
- People are encouraged to give opinions, comments, and preferences to the examiner in the presence of a court reporter.

(c) **Public Meetings and Open House Meetings.** Meetings are less formal than hearings. Public meetings range from large informational and workshop meetings to small groups and one-on-one meetings with individuals. The region evaluates what is desired from a meeting, and how the input will be tracked, and then plans accordingly.

- Open house meetings are very effective for introducing a project to the public and stimulating the exchange of ideas.

- Small meetings are useful for gaining information from special interest groups, neighborhood groups, and advisory committees.
- Workshop formats, where large groups are organized into small discussion groups, serve to maximize participation of all attendees while discouraging domination by a few individuals.

(d) **Follow-Up Procedures.** Effective public involvement is an on-going two-way exchange and it may be necessary to provide follow-up information several times during a large project to maintain a continuing exchange of information with the community.

At significant stages, the region responds to input with general information about the project. Follow-up information conveys, as accurately as possible, how public input was used to develop the project. Follow-up for larger projects might include newsletters, reports, individual contacts, or other activities related to the public's contribution to the project.

Follow-up measures can continue through construction and after project completion. The construction schedule is useful information and project accomplishments (such as noise abatement) are of interest.

Follow-up for smaller projects or for specific comments might simply be timely responses to individual requests.

(e) **Notification Techniques.** For hearings, see 210.05 for requirements regarding advertising for hearing interest and hearing advertisements. For other public involvement methods, develop notification techniques to attract a cross-section of the public. Provide special notices to those directly affected. Design the notifications to catch the public's attention and encourage people to attend or become involved. Consider the following techniques:

- Handouts
- News Releases — TV or newspapers
- Display ads in newspapers
- Web sites
- Electronic mail
- Faxboards
- Fact sheets
- Billboards
- Project notebooks at public places
- Project display boards at public places
- Fliers
- Newsletters
- Posters
- Local bulletin board announcements
- Personal contacts
- Radio announcements — AM, FM, CB
- On-site tours.
- Project office located close to the project

(f) **Handouts.** A well designed and informative handout can serve as an ongoing link between the department and the public.

Handouts have no set format. Make them as clear, relevant, up-to-date, easily understood, and self-explanatory as possible. Use handouts in foreign languages when appropriate. The following are handout possibilities:

- Special project newspapers
- Pamphlets
- Brochures
- Booklets (large, complicated projects)
- Charts
- Tables
- Graphs
- Project maps (aerial photographs or line drawings)
- Project development schedules
- Reports
- Right-of-way brochures (or other general information)

- Questionnaires
- Surveys

(g) **Graphics and Audio-Visual Aids.** The department normally uses slide shows or graphic exhibits to present project information. These presentations are informal and responsive to questions and concerns. Consider the following presentation techniques:

- Slide, slide-tape presentation
- Videotape
- Models
- Maps — large, simple
- Artistic renderings
- Photomontage
- Aerial photographs
- Computer visualizations

210.05 Hearings

Environmental documents address the social, economic, and environmental effects as described in Chapter 220. The project environmental documentation is the first step in the hearing procedures sequence. Each step of the hearing procedures is dovetailed into the environmental process and is important in achieving the appropriate project documentation. Corridor and design hearings are not normally required for Environmental Assessment, SEPA Checklist, and categorically excluded projects, but the opportunity for an environmental hearing might be required. When environmental hearings are not required, an informational meeting may serve as a useful forum for public involvement in the environmental process.

For all projects, the region reviews the requirements for a hearing or notice of opportunity for a hearing during the early stages of project development and before completion of the draft environmental documents.

If a hearing or notice of opportunity for a hearing is required, see Figure 210-1 for a summary of the event and timing requirements.

(1) Hearing Requirements

A hearing or notice of opportunity for a hearing is required by federal and state law (USC Title 23 §771.111 and RCW 47.52) and by WSDOT policy if one or more of the following occurs. (When in doubt, consult the Hearing Coordinator.)

(a) **Corridor Hearing**

- The proposed route is on a new location.
- There will be substantial social, economic, or environmental impacts.
- There will be a significant change in the layout or function of connecting roads or streets.

(b) **Design Hearing**

- Acquisition of a significant amount of right of way will result in relocation of individuals, groups, or institutions.
- There will be substantial social, economic, or environmental impacts.
- There will be a significant change in the layout or function of connecting roads or streets or of the facility being improved.

(c) **Access Hearing**

- Access control is established or revised

(d) **Environmental Hearing**

- An EIS is required for the project or a hearing is requested for an EA.
- There will be substantial social, economic, or environmental impacts.
- There will be a significant adverse impact upon abutting real property.
- There is significant public interest or controversy regarding the project.
- Other agencies (Coast Guard or Corps of Engineers, for example) have hearing requirements that could be consolidated into one hearing process.

(c) **Follow-up Hearings**

A new hearing or the opportunity for a hearing is required for any previously held hearing when any one of the following occurs. (See USC 23, §771.111.)

- Corridor or design approvals have not been requested within three years after the date the last hearing was held or the opportunity for a hearing was afforded.
- An unusually long time elapsed since the last hearing or opportunity for a hearing.
- A substantial change occurs in the area affected by the proposal (due to unanticipated development, for example).
- A substantial change occurs in a proposal for which an opportunity for a hearing was previously advertised or a hearing was held.
- A significant social, economic, or environmental effect is identified that was not considered at earlier hearings.

(2) Hearing Notice

The OSC Access and Hearings Unit provides sample hearing notices to the regions upon request. These include items that are required by state and federal statutes. Some important elements of a notice are:

- To promote public understanding, the inclusion of a map or drawing is encouraged.
- For a notice of an opportunity for a hearing, include the procedures for requesting a hearing and the deadline, and note the existence of the relocation assistance program for persons or businesses displaced by the project.
- For a corridor, design, or combined corridor-design hearing or a notice of an opportunity for a hearing, announce the availability of the environmental document and where it may be obtained and/or reviewed.
- If there is involvement in wetlands, flood plains, prime and unique farmlands, Section 4(f) lands, or endangered species, include this information in the notice.
- Include information on any associated prehearing presentation (210.05(5)(d)).

Hearing notices and notices of opportunity for a hearing are advertised as described in 210.05(3) and Chapter 220. Hearing notices are also circulated as described in 210.05(5)(b)

(3) Advertise a Hearing or the Opportunity for a Hearing

To advertise a legal notice of a hearing or a notice of an opportunity to request a hearing, use the following procedure:

- The region transmits the proposed notice, and a list of the newspapers in which the notice will appear, to the OSC Hearing Coordinator for concurrence prior to advertisement.
- Upon receiving concurrence, the region advertises the notice.
- Advertisement must be published in a newspaper having general circulation in the vicinity of the proposed project or the impacted population and in any newspaper having a substantial circulation in the area concerned, such as foreign language newspapers and local newspapers.
- The advertisement may be in the legal notices section or, preferably, as a paid advertisement in a prominent location.
- Additional means (such as display ads, direct mail, fliers, posters, or telephoning) may also be used to better reach interested or affected groups or individuals.
- A copy of the published hearing notice is sent to the Hearing Coordinator at the time of the publication.
- For access and environmental hearings, the notice must be published at least 15 days prior to the hearing. The timing of additional publications is optional.
- For corridor and design hearings, the first-notice publication must occur at least 30 days before the date of the hearing. The second publication must be 5 to 12 days before the date of the hearing.

- In no case shall a first notice for a corridor or design hearing be advertised prior to public availability of the draft environmental document.
- For a notice of opportunity for a hearing, the notice must be published once each week for two weeks. The deadline for requesting a hearing must be at least 21 days after the first date of publication and at least 14 days after the second date of publication.

(4) No Hearing Interest

When the region is not aware of specific hearing interest, the region can satisfy project hearing requirements by advertising a notice of opportunity for a hearing.

If no requests are received for a corridor or design hearing, the region transmits a package (which contains the notice of opportunity for a hearing, the Affidavit of Publication of the hearing notice, and a letter stating that there were no requests for a hearing) to the OSC Access and Hearings Unit.

When a notice of opportunity for a hearing is used to fulfill the requirements for a limited access hearing and there are no requests for a hearing, the region must secure waivers from every abutting property owner and affected local agency.

- The region obtains sample waiver forms from the OSC Access and Hearings Unit.
- The Project Engineer must contact every affected property owner of record (not tenant) and local agency to explain the plan and project to them. This explanation must include access features, right of way take (if any), and the right to a hearing.
- The region transmits the original signed waivers to OSC Access and Hearings Unit for processing.
- The Access and Hearings Unit prepares a package for review and approval by the State Design Engineer. This package consists of the signed waivers and Affidavit of Publication of the access hearing notice of opportunity for a hearing along with a recommendation for approval of the right of way plan.

(5) Hearing Preparation

The Deputy State Design Engineer sets the hearing date. Final arrangements for the hearing date can be handled by telephone between the Hearing Coordinator and the region.

The region proposes a hearing date based on the following considerations:

- Convenient for community participation. Contact local community and government representatives to avoid conflict with local activities.
- When Commission members can attend if they so desire. Check with the Hearing Coordinator to avoid conflict with other commission business if possible.
- For corridor and design hearings, at least 30 days after circulation of the DEIS or the published notice of availability of any other environmental document.
- In most cases, more than 45 days after submittal of the prehearing packet.

The region makes other arrangements as follows:

- The location of the hearing hall is to be accessible from public transportation if possible, convenient for community participation, and accessible to the disabled.
- Arranges for a court reporter.
- Arranges for a the Hearing Coordinator to provide a hearing examiner for all access hearings and for other hearings if desired.
- Develops a hearing agenda for all access hearings and for other hearings if desired.
- If requested in response to the hearing notice, interpreters for the deaf, audio equipment for the hearing impaired, language interpreters, and Braille or taped information for people with visual impairments are required.

(a) **Prehearing Packet.** When it is determined that a hearing must be held, the region prepares a prehearing packet.

Include the following in the prehearing packet:

- Vicinity map
- Capsule project description
- Brief project history
- Public support or opposition to the project
- Plans for corridor and design alternatives with descriptions
- Hearing plans (access hearing only)
- News release
- Hearing notice tailored to the needs of the project. (For access hearing, indicate number of notices, plans, and Notices of Appearance needed for mailing.) See 210.05(2).
- List of legislators
- List of government agencies
- List of property owners (access hearing only)
- List of newspapers
- Hearing agenda if applicable
- Hearing arrangements, date, time, place
- Hearing format: formal or open format

Three copies of the prehearing packet are furnished to the OSC Access and Hearings Unit at least 45 days before the proposed hearing date. Concurrence with the prehearing packet takes about two weeks after receipt of the information. This assumes that all necessary information has been submitted to the Access and Hearings Unit.

(b) **Circulate Hearing Notice.** The Hearing Coordinator sends a copy of the notice of hearing to the Commission, the Attorney General's Office, the Public Affairs Office, and the FHWA (if applicable).

The region circulates copies of the hearing notice as follows:

- Send a copy of the hearing notice and a capsule description to the appropriate legislators and local officials about one week before the first publication of a hearing notice.
- Include in the cover letter to the news media a statement such as: "This material may have been released by a local legislator. If not, we will appreciate any coverage you care to give the project at any time prior to the hearing."
- Distribute the news release to all reasonable news media, as well as the newspapers that will carry the formal advertisement of the hearing notice, about 3 days before the first publication of a hearing notice.
- Advertise the hearing notice in the appropriate papers as described in 210.05(3) within a week of the mailing to the legislators.

(c) **Presentation of Material for Inspection and Copying.** The information outlined in the hearing notice, other engineering studies, and information that will be presented at the hearing is made available for inspection and copying throughout the period between the first advertisement and approval of the hearing summary or findings and order. The information need not be in final form, but must include every item that is included in the hearing presentation. The environmental document must also be available for public review.

The information presented for inspection and copying is made available in the general locality of the project. The region reviews the variables (locations of the regional office, the project office, the project site, and the interested individuals, and the probability of requests for review) and selects a mutually convenient site for the presentation of the information. The region keeps a record of who came in, when, and what data they reviewed and copied.

(d) **Hearing Briefing.** On controversial projects, the Hearing Coordinator arranges for a briefing (held before the hearing) for those interested in the project. Attendants include appropriate OSC, regional, and FHWA personnel, with special notice to the Secretary of Transportation. Regional personnel present the briefing.

(e) **Prehearing Presentations.** The region is encouraged to hold an informal presentation to the public for display and discussion of the project and plans. Holding this presentation on projects where local feeling runs high promotes rapport, brings out community reaction to the project, and identifies trouble spots prior to the hearing.

A prehearing presentation is informal, with ample opportunity for exchange of information between the department and the public. Prehearing presentations can be open house meetings, drop-in centers, workshops, or other formats that promote public participation.

The prehearing presentation is usually held approximately one week before the hearing for the more controversial projects. Other dates may be used depending on the desires of the region and the nature of the project.

Include notice of the date, time, and place in the hearing notice and ensure that the hearing notices are mailed in time to give adequate notice of the prehearing presentation.

(f) **The Hearing.** The hearing is moderated by the Regional Administrator or his designee. Normally, a hearing examiner is used when significant controversy or significant public involvement is anticipated. A hearing examiner is required for access hearings.

A word-for-word transcript of the proceedings is made by a court reporter.

Hearings are generally more informative and gain more public participation when an informal format is used so the public's views and opinions are openly sought in a casual and personal way. The open format hearing may be used for all hearings except access hearings. At least one court reporter is required to take testimony on a one-on-one basis. Use display tables and enough knowledgeable staff to answer specific questions about the project.

It is the responsibility of the hearing moderator and other department representatives to be responsive to all reasonable and appropriate questions, if possible. If a question or proposal is presented at the access hearing, which necessitates an answer at a later date, the region reserves an exhibit to respond to the comment. The hearing moderator must not allow any person to be harassed or subjected to unreasonable cross-examination.

(g) **Hearing Agenda Items.** For all access hearings and for other hearings, as desired, the region prepares a hearing agenda to ensure that all significant items are included. A hearing agenda includes:

1. Opening Statement:
   - Highway and project name
   - Purpose of hearing
   - Introduction of elected officials
   - Federal/State/County/City relationship
   - Statutory requirements being fulfilled by the hearing
   - Status of the project with regard to NEPA/SEPA documents
   - Description of information available for inspection and copying
   - For an environmental, corridor, design, or corridor-design hearing, statement that written statements and other exhibits can be submitted during the open record period following the hearing.
   - Statement that all who want to receive written notification of the department's action as a result of the hearing may add their names to the interest list or file a Notice of Appearance for access hearings.
   - Description of how the hearing will be conducted

2. Project History. Present a brief project history, including need for the project, public involvement program, hearing opportunities afforded, and hearings held.

3. Presentation of Plans. Develop alternatives studied to comparable levels of detail and present them equally. Include the no-action alternative. Refer to any supporting studies that are publicly available.

Advise if one corridor or design is preferred by the department for more detailed development. When a preferred alternative exists, stress that it is subject to revision and re-evaluation both during and after the hearing, based on public comments, additional studies, and other information that may become available.

4. Social, Economic, and Environmental Discussion. Discuss all social, economic, and environmental effects or summarize the major impacts and refer to the environmental document.

5. Statements, Plans, or Counter-Proposals from the Public. Accept public views or statements regarding the plans presented, the alternatives to those plans, and the social, economic, and environmental effects of any plan.

6. Relocation Assistance Program. Explain the relocation assistance program and relocation assistance payments available. The Relocation Assistance brochure must be available for free distribution at all hearings. Right of way and relocation personnel should be available.

If the project does not require any relocations, the relocation assistance discussion may be omitted. Make a simple statement to the effect that relocation assistance is provided when needed but that no relocation is required by the project under discussion. The brochure and personnel should still be available to the public at the hearing.

7. Acquisition. Discuss right of way acquisition, estimated cost, and construction schedules. Discuss current schedules of critical activities that may involve or affect the public.

8. Closing. Summarize the hearing and what will follow.

9. Adjournment. Adjourn a hearing with sincere gratitude for the public's valuable participation.

(6) Hearing Summary Contents

The hearing summary includes the following elements:

1. Transcript.

2. Copy of the Affidavit of Publication of the hearing notice.

3. Hearing material:

- Copies of the letters received before and after the hearing
- Copies or photographs of, or references to, every exhibit used in the hearing.

4. Summary and analysis of all oral and written comments. Include consideration of the social, economic, and environmental effect of these comments.

210.06 Environmental Hearing

Projects requiring an EIS must use an evaluation process (called *scoping* in the NEPA and SEPA requirements) to identify the significant issues and alternatives to be studied in the DEIS and must follow the public involvement plan included in the Study Plan for the project. After the project has been thoroughly discussed within the community through the environmental evaluation process and informal public involvement methods, a hearing is held to present and gather testimony. The hearing is timed to fall within the comment period of the draft EIS for the project.

Responses to comments on the DEIS must be addressed in the FEIS. See Chapter 220 for the approval process.

The environmental hearing summary includes the items outlined in 210.05(6) above.

210.07 Corridor Hearing

When a Corridor hearing is held, the region must provide enough design detail on the proposed alignment(s) within the corridor(s) so that an informed presentation can be made at the hearing. Justification must also be presented to abandon an existing corridor.

After the hearing, the region reviews the hearing transcript, responds to all questions or proposals submitted at or subsequent to the hearing, compiles a hearing summary, and transmits three copies (four copies for Interstate projects) to the Access and Hearings Unit. When appropriate, the hearing summary may be included in the final EIS.

The corridor hearing summary includes the items outlined in 210.05(6) above.

The Access and Hearings Unit prepares a package that contains the corridor summary and a formal document that identifies and describes the project, and forwards it to the Assistant Secretary for Environmental and Engineering Service Center for adoption.

Federal approval of a corridor on existing alignment is not required unless a substantial social, economic, or environmental impact is involved or unless the project substantially changes the layout or function of connecting roads or streets.

Submit the complete corridor hearing summary to the Access and Hearings Unit within approximately two months following the hearing if it is not part of an EIS.

210.08 Design Hearing

When a design hearing is held for an improvement on existing alignment, and no other corridors are being considered, sufficient data must be presented to clearly document the decision to retain the existing corridor.

(1) Design Hearing Summary

The design hearing summary includes the items outlined in 210.05(6) above.

Submit the complete hearing summary to the Access and Hearings Unit within approximately two months following the hearing.

If new studies or additional data are required subsequent to the hearing, the region compiles the data in coordination with the OSC Design Office.

(a) **NHS Projects.** After the hearing, the region reviews the hearing transcript, responds to all questions or proposals submitted at or subsequent to the hearing, compiles a hearing summary, and transmits three copies (four copies for Interstate projects) to the Access and Hearings Unit. When appropriate, the design hearing summary may be included in the final environmental document. The Access and Hearings Unit prepares a formal document that identifies and describes the project and submits it to the State Design Engineer for approval. One approved copy is returned to the region. The Hearing Coordinator notifies the region that adoption has occurred.

(b) **Interstate Projects.** Following the design hearing summary approval, the Deputy State Design Engineer submits the approved design hearing summary to FHWA for approval. If possible, this submittal is timed to coincide with the submittal of the Design Decision Summary to the FHWA.

(2) Public Notification of Action Taken

The region prepares a formal response to the individuals who had questions not answered at the hearing. The region keeps the public advised as to the eventual result of the hearing process (project adoption, revision to the plan, or project cancellation, for example). A region newsletter sent to those on the interest list is an effective method of notification.

210.09 Access Hearing

Access hearings are required by law (RCW 47.52) whenever limited access is established or revised on new or existing highways. Decisions concerning access hearings are made on a project by project basis by the State Design Engineer based on information that includes the recommendations submitted by the region. (See Chapters 1410, 1420, 1430, and 1435.) Access hearing procedures generally follow the procedures identified in 210.05.

Prior to the access hearing as per RCW 47.52.131, conferences with the local jurisdictions shall be held on the merits of the access report and the plans.

The following supplemental information applies only to access hearings and procedures for approval of the Findings and Order.

(1) Hearing Examiner

The OSC Access and Hearings Unit hires an Administrative Law Judge from the Office of Administrative Hearings to conduct the access hearing.

(2) Order of Hearing

The Order of Hearing officially establishes the hearing date. The Hearing Coordinator calendars the Order of Hearing on the same calendar as the access hearing plan. The Hearing Coordinator then notifies the region, the Attorney General's Office, and the hearing examiner of the official hearing date.

(3) Access Hearing Information to Abutters

The region prepares an information packet for mailing that must be mailed at least 15 days before the hearing (concurrent with advertisement of the hearing notice). If some of the access hearing packets are returned as undeliverable, the region must make every effort to locate the addressees.

The access hearing packet consists of:

- The Access Hearing Plan
- The Access Hearing Notice
- The Notice of Appearance

The region sends the access hearing packet to the following:

- The county and/or city
- The owners of property listed on the county tax rolls as abutting the section of highway, road, or street being considered at the hearing as a limited access facility.
- Local public officials and agencies who have requested a notice of hearing or who, by the nature of their function, interest, or responsibility, are interested in or affected by the proposal
- Every agency, organization, official, or individual on the interest list

And, if applicable, to the following:

- State resource, recreation, and planning agencies
- Tribal governments
- Appropriate representatives of the Department of Interior and the Department of Housing and Urban Development
- Other federal agencies
- Public advisory groups

The region prepares an Affidavit of Service by Mailing. This affidavit states that the access hearing packet was mailed at least 15 days prior to the hearing and that it will be entered into the record at the hearing.

(4) Access Hearing Plan

The region prepares an Access Hearing Plan to be used as an exhibit at the formal hearing and forwards it to the OSC Plans Engineer for review and approval about 45 days before the hearing. This can be a Phase 2 or Phase 2A plan. (See Chapter 1410.) The OSC Plans Engineer puts the Access Hearing Plan on the Deputy State Design Engineer's calendar for approval.

(5) Access Hearing Plan Revisions

The Access Hearing Plan cannot be revised after the Deputy State Design Engineer approves the plan without rescheduling the hearing. If significant revisions to the plan become necessary during the period between approval and the hearing, they can be made and must be entered into the record as a revised (red and green) plan at the hearing.

(6) Access Hearing Notice

The hearing notice must be published at least 15 calendar days before the hearing. This is a legal requirement and the hearing must be rescheduled if the advertising deadline is not met. Publication and notice requirements are the same as those required in 210.05 except that the statutory abutter mailing must be mailed after notification of the appropriate legislators.

(7) Notice of Appearance

The Hearing Coordinator transmits the Notice of Appearance to the region. Anyone wanting to receive a copy of the Findings and Order and the adopted Limited Access Plan must complete a Notice of Appearance form and return it to the department either at the hearing or by mail.

(8) Reproduction of Plans

The Hearing Coordinator submits the hearing plans for reproduction at least 24 days prior to the hearing. The reproduced plans are sent to the region, at least 17 days before the hearing, for mailing to the abutters at least 15 days before the hearing. (See 210.09(3) above.)

(9) Access Hearing Exhibits

The region retains the access hearing exhibits until preparation of the draft Findings and Order is complete. Then the region submits all the original hearing exhibits, and three copies, to the Access and Hearings Unit as part of the Findings and Order package (210.09(11)). Any exhibits submitted directly to OSC are sent to the region for inclusion with the region's submittal.

(10) Access Hearing Transcript

The court reporter furnishes the original access hearing transcript to the region. The region forwards the transcript to the hearing examiner, or presiding authority, for signature certifying that the transcript is complete. The signed original is returned to the region for inclusion in the Findings and Order package.

(11) Findings and Order

The Findings and Order is based entirely on the evidence in the hearing record. The region reviews a copy of the transcript and prepares a Findings and Order package. The package is sent to the Access and Hearings Unit.

A Findings and Order package contains:

- The draft Findings and Order
- Draft responses to comments (reserved exhibits)
- A draft Findings and Order Plan (as modified from the hearing plan)
- All access hearing exhibits (originals and 3 copies)
- The access hearing transcript (original and 3 copies)
- The Notice of Appearance forms
- A number indicating how many copies of the final Findings and Order Plan and text that the region will need for the mailing.

(12) Adoption of Findings and Order

The Assistant Secretary for Environmental and Engineering Service Center adopts the Findings and Order, or refers it to the Commission for adoption, based on the evidence introduced at the hearing and on any supplemental exhibits.

Following adoption of the Findings and Order, the OSC Plans Section makes the necessary revisions to the Access Hearing Plan, which then becomes the Findings and Order Plan.

The Access and Hearings Unit arranges for reproduction of the Findings and Order Plan and the Findings and Order text and transmits them to the region.

The region mails a copy of the Findings and Order Plan and the Findings and Order text to all parties filing a Notice of Appearance and to all local governmental officials. Subsequent to this mailing, the region prepares an Affidavit of Service by Mailing and transmits it to the Access and Hearings Unit.

At the time of mailing, but before publication of the resumé, the region notifies the appropriate legislators of the department's action.

(13) Resumé

The Access and Hearings Unit provides the resumé to the region. The region must publish the resumé once each week for two weeks not to begin until at least 10 days after the mailing of the Findings and Order.

(14) Final Establishment of Access Control

When the Findings and Order is adopted, the Findings and Order Plan becomes a Phase 4 plan. (See Chapter 1410.) The establishment of access control becomes final 30 days from the date the Findings and Order is mailed by the region as documented by the Affidavit of Service by Mailing.

An appeal from the county or city must be in the form of a written disapproval, and request for a hearing before a board of review, submitted to the Secretary of Transportation.

An appeal from abutting property owners must be filed in the Superior Court of the state of Washington, in the county where the limited access facility is to be located, and shall affect only those specific ownerships. The plan is final for all other ownerships.

210.10 Combined Hearings

When deciding whether to combine hearings, consider:

- Whether there is controversy.
- Whether alternative corridors are proposed.
- The nature of the environmental concerns.
- The benefits to the public of a combined hearing.

A combined hearing often alleviates the need to schedule separate hearings close together to cover the same material. A combined EIS-corridor-design hearing is desirable only when the timing for circulation of the draft environmental document is simultaneous with the timing for corridor and design hearings and all alternative designs are available for every alternative corridor.

210.11 Administrative Appeal Hearing

When implementing access management statutes, the region is required to use the public involvement process to communicate the principles and standards of access management to the abutting property owners, business owners, and emergency services providers that might access the affected properties.

The department, as applicable, applies the Highway Access Management statutes to control access to the state highway system in order to avoid congestion and functional deterioration of the system. (See Chapters 1420 and 1430.)

After the public involvement process, if a decision has been made to restrict or delete access to a specific property, the property owner may appeal the decision by requesting a hearing.

(1) Hearing Procedure

An administrative appeal hearing does not follow the hearing procedures described earlier in this chapter. The procedure is as follows:

- The department notifies the property owner, in writing, that an access management action has been taken. The letter explains the appeal process.
- The property owner may write a letter to the department requesting an administrative appeal hearing.
- OSC hires an Administrative Law Judge and sets the hearing date, time, and place.
- The department notifies the property owner of the date, time, and place (in writing).
- Testimony is given.
- The ALJ renders a decision.

(2) Further appeals.

- The property owner may appeal the ALJ's decision by writing the State Design Engineer.
- The State Design Engineer reviews the appeal and renders a decision (in writing, to the property owner).
- The property owner may appeal the State Design Engineer's decision to the Superior Court of the state of Washington.

210.12 Documentation

All documents generated by hearings are retained in Archives by the Office of the Secretary of State.

P65:DM

<table>
<tr><th>Min. From Hearing</th><th colspan="3">Sequence for a Hearing</th></tr>
<tr><td></td><td colspan="3">Determine need for a hearing or an opportunity for a hearing 210.05(1)</td></tr>
<tr><td></td><td colspan="3">Develop hearing notice 210.05(2) + exhibits, develop Access Hearing Plan 210.09(4)</td></tr>
<tr><td>45 days</td><td colspan="3">Send prehearing packet 210.05(5)(a), send Access Hearing Plan 210.09(4)</td></tr>
<tr><td></td><td colspan="3">Calendar Order of Hearing & Access Hearing Plan for access hearings 210.09(2)</td></tr>
<tr><td>30 days</td><td colspan="3">Draft EIS becomes available and its comment period begins for corridor and design hearings</td></tr>
<tr><td></td><td colspan="3">Send notice to legislators and local officials within a week of first ad 210.05(5)(b)</td></tr>
<tr><td></td><td colspan="3">Send letter with news release to media about 3 days before ad 210.05(5)(b)</td></tr>
<tr><th colspan="2">For Access Hearings</th><th colspan="2">For Corridor, Design, and Environmental Hearings</th></tr>
<tr><td>24 days</td><td>Reproduction of plans 210.09(8)</td><td>30 days
15 days</td><td>Advertise a hearing * 210.05(3)
Environmental hearing</td></tr>
<tr><td>15 days</td><td>Mail information packet 210.09(3) and advertise a hearing * 210.09(6)</td><td>5-12 days</td><td>Presentation of material to copy, hearing briefing, prehearing presentations 210.05(5)(c) - (e)</td></tr>
<tr><td></td><td>Confer with local jurisdictions 210.09</td><td></td><td>Second ad 210.05(3) for corridor and design hearings</td></tr>
<tr><td></td><td>Hearing 210.05(5)(f)</td><td></td><td>Hearing 210.05(5)(f)</td></tr>
<tr><td></td><td>Access Hearing Transcript 210.09(10)</td><td></td><td>Address comments</td></tr>
<tr><td></td><td>Final Access Hearing Plan 210.09(11)</td><td></td><td>Summary 210.05(6) within two months of the hearing</td></tr>
<tr><td></td><td>Findings and Order and Resumé 210.09(11) - (13)</td><td></td><td></td></tr>
</table>

*If the advertisement is for the opportunity for a hearing, the deadline for requests must be at least 21 days after the first ad. If there are no requests, see 210.05(4).

Sequence for a Hearing
Figure 210-1

Chapter 220 Project Environmental Documentation

220.01 Introduction

The term "environmental documentation" refers to the documents produced for a project to satisfy the requirements contained in the National Environmental Policy Act (NEPA) and the State Environmental Policy Act (SEPA). The *Environmental Procedures Manual,* M 31-11 provides detailed instructions on how to determine what level of documentation is required and how to prepare the documents. This section provides a summary of the relevant provisions in the *Environmental Procedures Manual*.

The purpose of the environmental document is to provide decision-makers, agencies, and the public with information on a project's environmental impacts, alternatives to the proposed action, and mitigation measures to reduce unavoidable impacts. Final environmental documents identify and evaluate the project to be constructed. Because projects vary in their level of environmental impacts, the rules on environmental documentation allow for different levels of documentation. As a project's impacts increase, so does the level of documentation.

The environmental office in each region and the Environmental Documentation Section of the WSDOT Headquarters (HQ) Environmental Services Office routinely provide environmental documentation assistance to designers and project engineers.

220.02 References

United States Code (USC) 42 USC Chapter 55 National Environmental Policy Act of 1969 (NEPA)

Code of Federal Regulation (CFR) 23 CFR 771 Environmental Impact and Related Procedures

23 CFR 771.135 Section 4(f) (49 U.S.C. 303). Policy on Lands, Wildlife and Waterfowl Refuges, and Historic Sites

36 CFR 800: PART 800-Protection of Historic and Cultural Properties

40 CFR Parts 1500 – 1508 Council for Environmental Quality Regulations for Implementing NEPA

Revised Code of Washington (RCW) 43.21C State Environmental Policy Act (SEPA)

Washington Administrative Code (WAC) 197-11 SEPA Rules

Washington Administrative Code (WAC) 468-12 WSDOT SEPA Rules

Environmental Procedures Manual, M 31-11, WSDOT

220.03 Definitions / Acronyms

Categorical Exclusion (CE) (NEPA) or Categorical Exemption (CE) (SEPA) Actions that do not individually or cumulatively have a significant effect on the environment.

DCE Documented Categorical Exclusion (NEPA)

Determination of Non-significance (DNS) (SEPA) The written decision by the Region Administrator that a proposal will not have a significant impact and no EIS is required.

Determination of Significance (DS) (SEPA) A written decision by the Region Administrator that a proposal could have a significant adverse impact and that an EIS is required.

Environmental Assessment (EA) (NEPA) A document prepared for federally funded, permitted or licensed projects that are not categorical exclusions (CE) but do not appear to be of sufficient magnitude to require an EIS. The EA provides enough analysis to determine if an EIS or a FONSI should be prepared.

Environmental Classification Summary (ECS) A form used to evaluate and classify projects for the construction program. The ECS supports a decision of a documented CE.

Environmental Impact Statement (EIS) A detailed written statement of a proposed course of action, project alternatives and the possible impacts of the proposal.

Environmental Review Summary (ERS) Part of the project summary document, it identifies environmental permits and approvals. The ERS is prepared in the region and is required for Design Approval.

Finding Of No Significant Impact (FONSI) (NEPA) A federal document indicating that a proposal will not significantly affect the environment and that an EIS is not required.

NEPA National Environmental Policy Act

ROD Record Of Decision

SEPA State Environmental Policy Act

220.04 Determining the Environmental Document

The Environmental Review Summary (ERS) provides the first indication of what form the environmental documentation will take. The ERS is prepared as part of the Project Summary. Project Summaries are prepared during the scoping phase of all projects in the construction program. The Project Summary includes three components:

- Project Definition
- Design Decisions Summary
- Environmental Review Summary

The ERS form is found in the Project Summary database in each regional office. The *Environmental Procedures Manual* has detailed instructions on how to prepare the ERS. The process for classifying projects and determining the environmental document is similar for NEPA and SEPA and generally is as follows:

- Once the project has been sufficiently developed to assess any environmental impacts, the region completes the ERS based on the best information available at the scoping phase of development.
- The Regional Environmental Manager then concurs with the classification by signing the ERS and returns the completed form to the region Design Office for inclusion in the Project Summary package.
- For NEPA, if a project has been determined to be a Categorical Exclusion (CE) the NEPA environmental review process is considered complete. If it is determined that a Documented Categorical Exclusion (DCE), Environmental Assessment (EA), or Environmental Impact Statement (EIS) is required, the region evaluates the project schedule and arranges for preparation of the appropriate document.
- For SEPA, the signing and submittal of the ERS completes the environmental classification process. On projects that are categorized as exempt from SEPA, the environmental process is complete, unless the project requires consultation under the Endangered Species Act. On projects that do not meet the criteria for a SEPA Categorical Exemption (WAC 197-11-800 and WAC 468-12) and require a SEPA checklist (WAC 197-11-960) or an EIS, those documents are prepared as necessary prior to Project Development Approval.

The ERS allows environmental staff to consider at this early stage potential impacts and mitigations, and required permits. For many projects, the WSDOT Environmental GIS Workbench coupled with a site visit provide sufficient information to fill out the ERS. (See the *Environmental Procedures Manual*.)

For most WSDOT projects, the Federal Highway Administration (FHWA) is the lead agency for NEPA. Other federal lead agencies on WSDOT projects are the Federal Aviation Administration, Federal Rail Administration, and the Federal Transit Administration (FTA).

220.05 Identifying the Project Classification

Based on the environmental considerations identified during preparation of the ERS, WSDOT projects are classified for NEPA/SEPA purposes to determine the type of environmental documentation that will be required. Projects with a federal nexus (using federal funds, involving federal lands, or requiring federal approvals or permits) are subject to NEPA and SEPA. Projects that are state funded only, with no federal nexus including federal permits, follow SEPA guidelines. Since many WSDOT projects are prepared with the intent of obtaining federal funding, NEPA guidelines are usually followed. The *Environmental Procedures Manual* provides detailed definitions of the classes of projects and lists types of work typically found in each class; FHWA/federal agency concurrence requirements; and procedures for classifying and, if necessary, reclassifying the type of environmental documentation for projects.

Projects subject to NEPA are classified as either Class I, II, or III. Class I projects require preparation of an EIS because the action is likely to have significant adverse environmental impacts. Class II projects are Categorical Exclusions or Documented Categorical Exclusions that meet the definitions contained in 40 CFR 1508.4 and 23 CFR 771.117. These are actions that are not likely to cause significant adverse environmental impacts. Class III projects require an Environmental Assessment (EA) because the significance of the impact on the environment is not clearly established.

SEPA has a similar, but not identical system. SEPA recognizes projects that are categorically exempt, projects that require an EIS, and projects that do not. WSDOT projects that are CEs under NEPA (Class II) may not be categorically exempt under SEPA.

If the project is not exempt under SEPA, WSDOT must issue a threshold determination and then prepare a SEPA Checklist or EIS. The threshold determination may be a determination of non-significance (DNS) or a determination of significance (DS) requiring an EIS. WSDOT may adopt a NEPA EA FONSI to satisfy the requirements for a DNS.

220.06 Environmental Impact Statements – Class I Projects

Class I projects are actions that are likely to have significant impact on the environment because of their effects on land use, planned growth, development patterns, traffic volumes, travel patterns, transportation services, natural resources, or because they are apt to create substantial public controversy. An EIS may follow an EA if significant impacts are discovered during preparation of an EA. The *Environmental Procedures Manual* has details on EIS documents and procedures. WSDOT typically prepares a joint NEPA/SEPA EIS to satisfy both statutes.

Examples of projects that usually require an EIS, as referenced in 23 CFR 771.115, are:

- New controlled-access freeway
- Highway projects of four or more lanes on a new location
- New construction or extension of fixed rail transit facilities (e.g., rapid rail, light rail, commuter rail, automated guideway transit)
- New construction or extension of a separate roadway for buses or high-occupancy vehicles not located within an existing highway facility
- Construction of a new ferry terminal or large-scale changes to existing terminal facilities

Although examples are given, it is important to remember that it is the size and significance of the potential impacts that determines the need for an EIS, not the size of the project. “Significance” is not always clearly defined but is generally determined by the impact’s “context” and “intensity.” Having a significant impact in just one area is sufficient to warrant preparation of an EIS.

Only about three percent of WSDOT's projects go through the EIS process. Typically these are the larger, more complicated projects often in urban areas or involving new right of way and important natural or cultural resources. The process takes from two to five years or longer depending on the issues and stakeholders. EISs are expensive because of the amount of information produced, the level of design required, the frequency of redesign to address issues that are discovered, and the higher level of agency and public involvement. WSDOT is preparing an 'EIS Reader-Friendly Tool Kit' to simplify the content of EISs and to improve them as a communication tool to inform the public and decision-makers. Both federal and state initiatives exist to streamline the EIS process and reduce the costs.

220.07 Categorical Exclusions – Class II Projects

The FHWA NEPA Regulations identify project types that qualify as CEs (see 23 CFR 771.117). In general, CEs are actions that, based on past experience with similar projects, do not have significant environmental impacts. CEs are subject to reevaluation by FHWA where there are unusual circumstances, such as new environmental impacts; controversy on environmental grounds; unforeseen impacts to cultural, historic or recreational resources (Section 4(f) or Section 106); or inconsistencies with federal, state, or local laws.

CEs are defined further by two subcategories: CEs not requiring FHWA concurrence and Documented Categorical Exclusions (DCE). Projects defined as CEs not requiring FHWA concurrence must meet the requirements of the Memorandum of Understanding Between WSDOT and FHWA on Programmatic Categorical Exclusion Approvals, signed May 25, 1999 (see *Environmental Procedures Manual*). This may include preparation of a Biological Assessment (BA) to document effects to endangered and threatened species. If a "no effects" determination is the outcome of the BA, then the only NEPA documentation required is a signed ERS that is included in the Project Summary package sent to HQ Systems Analysis and Program Development. No other NEPA documentation or approval by FHWA is required.

For DCEs, additional environmental documentation is required and FHWA approval must be obtained before the Project File can be approved. All environmental documentation must be completed before finalizing the PS&E package and going to ad. The ERS is then renamed the Environmental Classification Summary (ECS), signed by the WSDOT Regional Environmental Manager, and sent with federal permits and/or documentation to FHWA for approval.

After obligation of project design funds, detailed environmental studies for CE documentation may be required for DCE projects to determine the environmental, economic, and social impacts. WSDOT then finalizes the ECS and submits it to FHWA for final approval.

220.08 Environmental Assessment – Class III Projects

Under NEPA, when the significance of the impact of a proposed project on the environment is not clearly established, an Environmental Assessment (EA) is prepared to determine the extent of environmental impact and to determine whether an EIS is needed. WSDOT may adopt the EA to satisfy requirements for a SEPA DNS, but the EA will not satisfy the EIS requirement under SEPA. No EIS is required when the EA supports a NEPA Finding of No Significant Impact (FONSI). Issuance of a FONSI (normally by the FHWA) is the final step in the EA process. (See Section 411.04 of the *Environmental Procedures Manual* for details on EA documentation and procedure.)

220.09 Reevaluations

Both NEPA and SEPA allow for reevaluating the project classification or environmental document. In general, reevaluations are required when there are substantial changes to the scope of a project, such that the project is likely to have significant adverse environmental impacts, or if there is new information that increases the likelihood that a project will have significant adverse environmental impacts. Reevaluations are also required if project construction has not begun within 5 years of completing the NEPA process.

As FHWA must concur with the NEPA classification, any major change in a project classification for a project involving federal funds requires the processing of a revised ECS form. Minor changes may be handled informally, if FHWA concurs.

For SEPA, when the scope of a project is changed, a revised ERS is normally required with some exceptions. As part of that revision process, the environmental classification needs to be reassessed. The decision on whether or not to revise the ERS is made by the regional Environmental Office in coordination with the region Program Management Office. For many minor scope changes, a new ERS is not required. A note to the file or a follow-up memo is then prepared to document the revision.

In some cases, new circumstances may cause a change in the environmental classification but not a change in scope. A note to the file or a follow-up memo documents any changes in classification.

220.10 Commitment File

As an initial part of project development, the region establishes a project commitment file. Establishment of this file generally coincides with preparation of the environmental document or might be at later stages as required. The file consists of proposed mitigating measures, commitments made to resource or other agencies with permitting authority, and other documented commitments made on the project. Also included in the file are design and environmental commitments. Other commitments types (ROW, Maintenance, etc.) may be added at the region's discretion.

The region continues to maintain the commitment file as a project progresses through its development process. Whenever commitments are made, they are incorporated into project documents and transferred from one phase of the project to the next. Commitments are normally included or identified in the following documents or actions:

- Environmental documents and consultations
- Design Documentation Package (DDP)
- Environmental permits
- MOUs/ Letters to stakeholders
- Right of way plans
- Access plans
- Findings and order from access hearings
- Contract document
- Preconstruction conference
- Change orders
- End of project report
- Maintenance

To organize and track commitments made during the development and implementation of a project, WSDOT has established a Commitment Tracking System (CTS). This system provides easy access and retrieval of commitment information. Reports from the system establish the commitment record for the project file. When a commitment is made, log it in the CTS. The entry requires sufficient detail necessary to document the commitment, including references to correspondence, agreement numbers, etc. A commitment may be revised when WSDOT and the organization or individual involved agree to the revision.

When commitments are completed, the CTS is updated with the date the commitment was finished and appropriate comments. Commitments requiring ongoing maintenance need to be formally passed off to Maintenance and Operations for incorporation into the Maintenance Program.

220.11 Documentation

A list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) is on the following website: http://www.wsdot.gov/eesc/design/projectdev/

Chapter 240 Environmental Permits and Approvals

240.01 Introduction

Washington State Department of Transportation (WSDOT) projects are subject to a variety of federal, state, and local environmental permits and approvals. The *Environmental Procedures Manual,* M 31-11, provides detailed guidance on the applicability of each permit and approval. Because the facts of each project vary and the environmental regulations are complex, reliance on either the *Design Manual* or the *Environmental Procedures Manual* is insufficient. Region and Headquarters (HQ) environmental staff should be consulted.

240.02 Permits and Approvals

The Environmental Review Summary (ERS) prepared as part of the Project Summary identifies some of the most common environmental permits that might be required based on the information known at that stage. As the project design develops, additional permits and approvals can be identified. Conducting project site visits for engineering and environmental features may reduce project delays due to late discoveries. Coordination with region and HQ environmental staff is recommended.

Figures 240-1a through 1e provide a comprehensive list of the environmental permits and approvals required by WSDOT projects. For each permit or approval, the responsible agency is identified, the conditions that trigger the permit are listed, the relevant sections of the *Environmental Procedures Manual* are provided, and the statutory authority is cited.

The conditions that trigger a permit or approval are discussed in detail in the *Environmental Procedures Manual*. The permit triggers are subject to interpretation and change as new regulations are developed or court decisions are rendered that alter their applicability. Determining which permits and approvals apply and how they apply is dependent on the facts of each project. Consult environmental staff at each stage of the project design to review the permits and approvals that might be required based on the project design.

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
National Environmental Policy Act (NEPA)	FHWA and WSDOT	Activities that require federal permits, approvals, or funding trigger NEPA procedural and documentation requirements.	320, 410-480	42 USC 4321 23 CFR 771 40 CFR 1500-1508
State Environmental Policy Act (SEPA)	Ecology	Any activity not categorically exempt triggers SEPA procedural and documentation requirements.	410-480	RCW 43.21C WAC 197-11, WAC 468-12
Corps of Engineers Section 404 Individual Permits (Uses Joint Aquatic Resource Permits Application [JARPA])	COE	Any discharging, dredging, or placing of fill material in waters of the U.S. and adjacent wetlands	431, 432, 437, 452, 510	Section 404 of the Clean Water Act (CWA); 33 USC 1344, 33 CFR 330.5 and 330.6
Corps of Engineers Section 404 Nationwide Permits (NWP) (Uses JARPA)	COE	NWP information is presented in a 2002 special public notice issued by the COE. A total of 44 NWPs for a range of activities in waters of the US are described in the public notice.	431, 432, 437, 452, 510	Section 404 of the CWA; 33 USC 1344, 33 CFR 330.5 and 330.6
Water Quality 401 Certification (Uses JARPA)	Ecology Headquarters, Shorelands and Environmental Assistance Program, Coordination Section; US EPA on Tribal and Federal land	Any activity requiring a federal permit for discharging into waters must receive certification from the state that the discharge complies with that state's water quality standards.	431, 432, 437, 452, 453	33 USC 1341, 33 CFR 320.4; RCW 90.48, WAC 173-225
Coastal Zone Management (CZM) Certification (Uses JARPA)	Ecology Headquarters, Shorelands and Environmental Assistance Program	Any activity requiring a federal permit/license must certify that the activity will comply with the State's Coastal Zone Management Program (Shoreline Management Act).	431, 432, 437, 452, 520	16 USC 1456, 33 CFR 320.3, RCW 90.58
Coast Guard Section 9 Bridge Permit (Uses JARPA)	U.S. Coast Guard	Any work on bridges and causeways in navigable waters or waters that are susceptible to improvement for transporting interstate or foreign commerce, or waters that are used by boats 21 feet or more in length.	431, 432, 452, 453	Section 9 of the Rivers and Harbors Act; 33 USC 401; 33 CFR 114 and 115; Federal Aid Highway Act of 1987. Section 123(b)
Corps of Engineers Section 10 Permit (Uses JARPA)	COE	Any obstruction, alteration, or improvement of any navigable water, including rechanneling, piers, wharfs, dolphins, bulkheads, and buoys.	431, 432, 452	Section 10 of the Rivers and Harbors Act; 33 USC 401; 33 CFR 330.5 and 330.6
Threatened and Endangered Species	USFWS and NMFS	Projects affecting critical habitat of species listed under the ESA may be subject to water quality and wetland permits listed in Section 431.06 and Section 437.06.	436, 447, 510, 520	16 USC 1531-1543

Permits and Approvals
Figure 240-1a

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
Historic Preservations Act - Section 106	OAHP SHPO	Potential impacts to historic or archaeological properties trigger Section 106 procedural and documentation requirements.	411, 456	16 USC 470 Sec.106 36 CFR 800 RCW 43.51.750
Land and Water Conservations Act - Section 6(f)	FHWA and Affected Agency (WSDOT)	Use of lands purchased with LWCA funds triggers Section 6(f) procedural and documentation requirements.	411, 455	LWCA, 16 USC
U.S. Dept of Transportation Act - Section 4(f)	FHWA and Affected Agency (WSDOT)	Use of park and recreation lands, wildlife and waterfowl refuges, and historic sites of national, state, or local significance triggers Section 4(f) procedural and documentation requirements.	411, 455	49 USC 1651 Sec. 4 (f) 23 CFR 138
Wild and Scenic Rivers	FHWA and Affected Agency	No specific permits are required for projects in wild and/or scenic river corridors, but water quality permits may apply.	453	16 USC 1271
Farmland Conversion	NRCS Counties/Cities	NRCS Form AD1006 approval may be required if project entails conversion of farmlands. Local grading permits may also be required.	454	7 USC 4201 7 CFR 650
Airport/Highway Clearance	FAA (Federal)	Airspace intrusion by a highway facility (i.e. proposed construction in the vicinity of public use or military airports) may require FAA notification.	460	FHPM 6-1-1-2 FAA Regs. Part .77
(NPDES Municipal Stormwater Discharge General Permit	Ecology	WSDOT projects that discharge stormwater. There are four geographical areas covered by separate general permits that are based on watershed boundaries: Island, Snohomish, South Puget Sound, and Cedar/Green.	431, 433	33 USC 1342, RCW 90.48, WAC 173-226
NPDES Stormwater Construction Permit	Ecology	WSDOT construction activities disturbing more than 5 acres.	431, 433	33 USC 1342, RCW 90.48, WAC 173-226
NPDES Sand and Gravel General Permit	Ecology	Discharges of process water and stormwater associated with sand and gravel operations and rock quarries.	431, 433	33 USC 1342, RCW 90.48; WAC 173-226
NPDES Stormwater Industrial Permit	Ecology	Ferry-related activities that discharge stormwater to waters of the state.	431, 433	33 USC 1342, RCW 90.48; WAC 173-226
Underground Injection Control	Ecology	Injection well that may contaminate drinking water.	433	40 CFR 144 RCW 43-21A.44 , WAC 173-218

Permits and Approvals
Figure 240-1b

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
Hazardous Waste Tracking Form	Ecology	A WAD tracking number from Ecology is required for transport, storage, or disposal of dangerous waste.	447	WAC 173-303
Water Quality Permit. Use of Herbicides to Control Noxious Weeds on WSDOT Properties and Projects within the State of Washington	Ecology, Environmental Coordination Section, Federal Permit Manager for WSDOT	Application of herbicides to waters of the state at WSDOT-owned or –managed sites to control noxious weeds.	431	RCW 90.48.445, and WAC 173-201A-110
Administrative Order # DE99WQ-003. WSDOT Use of Herbicides to Control Non-noxious Weeds on WSDOT Properties and Projects within the State of Washington	Ecology, Environmental Coordination Section, Federal Permit Manager for WSDOT	Approved methods of application must be followed and careful record keeping must be documented. WDFW must be consulted for identification of salmonid bearing waters and special seasonal timing restrictions. Restrictions and public notice requirements are placed on herbicide application within 0.5 mile of areas of potential public use.	431	RCW 90.48, and WAC 173-201A-110
Water Right Permit	Ecology, Water Resources Program	Any withdrawal of surface or groundwater for a WSDOT activity or project.	431, 433	RCW 90.03; 90.44; 90.54
State Waste Discharge (SWD) Permit	Ecology	Any activity that will discharge or dispose of municipal and industrial wastewater into groundwaters of the state, or discharge industrial wastewater to a NPDES-permitted wastewater treatment plant. SWD permits are different from NPDES permits because NPDES permits regulate discharges directly to water or stormwater systems.	433	RCW 90.48; WAC 173-226
Water System Project Approvals	Washington State Department of Health or County/City Department of Health	Any project in which there are two or more water service connections for human consumption and domestic use.	431, 433	RCW 43.20A; WAC 246-290 through 293
Hydraulic Project Approval (HPA)	WDFW	Any project that will use, cross, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state. Regulated activities include culvert work, stream realignment, and bridge replacement.	431, 432, 436, 447, 452, 453, 510, 520	RCW 75.20.100; WAC 220-110;

Permits and Approvals
Figure 240-1c

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
Fish Habitat Enhancement Project Application	WDFW	Streamlined process for projects designed to enhance fish habitat. Application is in addition to JARPA.	436	
Aquatic Resource Use Authorization (Uses JARPA)	DNR	Included in JARPA.	436, 437, 520	RCW 79.90 WAC 332-30
Easements	DNR	Any activity that fills, crosses over, bridges, or is on the beds of navigable waters of the state.	436, 437, 520	RCW 47.12
Monument Removal	DNR	Removal or destruction of a monument.	451	
Operating Permit for Surface Mining	DNR, USFS, BLM	Surface mining (pit and quarry sites); more than 3 acres disturbed at one time or pit walls more than 30 feet high and steeper than 1:1; pit site reclamation (WDNR). Borrow pits on federal land may require a permit or easement from the land-management agency.	420, 510	RCW 78.44
Forest Practices Application	DNR	Road construction, pits, pesticide use, and other specified activities on public or private forest land (i.e., land capable of supporting merchantable timber).	455	RCW 76.09 WAC 222
Shoreline Substantial Development Permit (Uses JARPA)	Counties or Cities	Qualified activities within shoreline jurisdiction – lakes/reservoirs 20 acres or greater, streams with 20 cfs annual flow, marine water, and all areas landward for 200 feet of OHWM.	431, 432, 437, 452, 520	RCW 90.48, WAC 173-10 through 173-28
Flood Plain Development Permit (Uses JARPA)	Counties or Cities	Any structure or activity that may adversely affect the flood regime of a stream within the flood zone.	432	RCW 86.16; WAC 173-158
Critical Areas Ordinance (Uses JARPA)	Counties and Cities	Any activity involving critical areas as regulated by the local jurisdiction. Critical areas include wetlands, critical recharge areas to aquifers, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas.	420, 431, 436, 437, 451, 520	RCW 36.70A

Permits and Approvals
Figure 240-1d

Permit or Approval	Responsible Agency	Conditions Requiring	Environmental Procedures	Statutory Authority
Clearing, Grading, and Building Permits	Counties / Cities	Clearing and grading of land for development with impacts outside WSDOT right of way (includes connecting streets, frontage roads, etc.). Construction of any building for human habitation.	420, 451, 454, 460, 520	RCW 36.21.080
Temporary Air Pollution	Ecology, Local Clean Air Agencies, Fire Protection Agencies	Pollutants above allowed levels for temporary periods; includes building demolition and brush burning. Regulations may limit the type, size, or timing of brush burning.	425	RCW 70.94
New Source Construction	Ecology, Local Clean Air Agencies	Air pollution from a point source (e.g., asphalt plants, rock crushers).	425	RCW 70.94.152
Noise Variance	Counties / Cities	Construction and maintenance activities during nighttime hours may require a variance from local noise ordinances. Daytime noise from construction is usually exempt.	446	WAC 173-60
Archaeological Resources Protection Permit	Tribes Federal Landowners, (e.g. BLM, COE, NPS)	Excavation or removal of archaeological resources from tribal or federal land.	456	43 CFR 7.6 – 7.11

BLM – Bureau of Land Management
CFR – Code of Federal Regulations
COE – Corps of Engineers
CWA – Clean Water Act
CZMA – Coastal Zone Management Act
DNR – Department of Natural Resources
DOE – Department of Ecology
EPA – Environmental Protection Agency
ESA – Endangered Species Act
FERC – Federal Energy Regulatory Commission
LWCA – Land and Water Conservation Act
NMFS – National Marine Fisheries Service
NPDES – National Pollution Discharge Elimination System
NPS – National Park Service
NRCS – Natural Resources Conservation Service
OAHP – Office of Archaeology and Historic Preservation
OHWM – Ordinary High Water Mark
RCW – Revised Code of Washington
SHPO – State Historic Preservation Officer
USFS – U.S. Forest Service
USFWS – U.S. Fish and Wildlife Service
WAC – Washington Administrative Code
WAD – EPA, Washington State waste ID tracking number
WDFW – Washington State Department of Fish and Wildlife

Permits and Approvals
Figure 240-1e

240.03 Project Types and Permits

Understanding and anticipating what permits and approvals may be required for a particular project type will assist the designer in project delivery. This section provides information on what project types are likely to trigger which permits. The purpose of this section is to inform designers of the potential for permits and does not substitute for the information developed in the Environmental Review Summary prepared during the Project Summary or more specific permit information developed during design. The intent is to provide a familiar and reasonably quick method for gauging the relative complexity of the permit process. Designers are encouraged to use the expertise in the region environmental office and the HQ Environmental Services Office.

To make the evaluation familiar, this chapter uses the design matrices developed in Chapter 325, as a template. The project types and definitions are found in Chapter 325 with the exception of some additional project types for bridge work. These additional bridge projects are defined below. Rather than identify levels of design for each project type, the matrices identify permits and approvals. While every project is unique to some degree, there are common facts associated with project types that allow for a level of predictability. As the project type gets more complex, the predictability of which environmental permits and approvals may be triggered decreases.

Figures 240-2 through 240-7b use the predictability about project types and combine that with assumptions on environmental conditions to generate probabilities about required permits and approvals. The probabilities cannot be substituted for a fact-based analysis of the project and the applicability of any particular environmental permit or approval. Contact region or HQ environmental staff before decisions are made about whether a permit or approval applies. Coordination with the HQ Bridge and Structures Office and the HQ Environmental Services Office is recommended for bridge projects.

The probabilities for needing a permit are divided into low, medium, and high. A low probability generally means that the thresholds for triggering an environmental permit or approval may not be reached under the assumptions behind the project type. A medium probability means that there is the potential to trigger the application of the permit or approval. A high probability means that there is a likelihood of triggering the permit or approval.

The assumptions underlying the project types and probabilities are shown as endnotes following the matrices (Figures 7a – 7c). Some general assumptions were made regarding the project types; for main line projects on the Interstate, National Highway System main line (except Interstate), or non-National Highway System, all bridgework is assumed to be over water. For interchange projects on the Interstate and non-Interstate, all bridgework is assumed to be over roads. (See Chapter 325.)

The environmental permits and approvals selected for inclusion in the matrices represent the ones that are most frequently triggered. The other permits and approvals listed in Figure 240-1a through 1e are more limited in their application and often require very specific fact situations. They are discussed in more detail in the *Environmental Procedures Manual*.

The additional bridge projects are as follows:

- **Bridge Replacement (Obsolete, Structural):** Projects to replace or rehabilitate state-owned bridges when continued maintenance and preservation strategies can no longer accommodate safe, continuous movement of people and goods. Includes new or replacement bridge (on or over, main line, interchange ramp, or water body), and repair or replacement of reinforced concrete, steel, and/or timber bridges. Obsolete replacement typically includes bridges that have a narrow width or low vertical clearance or a restrictive waterway opening. Structural replacement is a replacement of a bridge that has a structural deficiency in a superstructure or substructure element.

- **Existing Bridge Widening:** Widening an existing bridge for an existing highway.
- **Bridge Deck Rehabilitation:** Structures preservation projects that repair delaminated concrete bridge deck and add a protective overlay that will provide a sound, smooth surface; prevent further corrosion of the reinforcing steel; and preserve operational and structural capacity. The goal is to ensure safe, long-lasting riding surfaces on all reinforced concrete bridges.
- **Bridge Scour Countermeasures:** Measures undertaken to reduce the risk of bridge foundation scour damage and stream bank erosive forces that increase the potential of bridge collapse due to flooding and long-term waterway changes. The goal is to maintain the structural integrity of the roadway prism and highway structures. Bridge scour repair can include repair to the streambed around a bridge column or repairs to stream banks near a bridge. This category typically involves an in-depth engineering and environmental review for site and/or reach processes. Extensive documentation and permitting are typically needed. Early and close coordination with the permit agency representatives through Regional environmental staff is essential. Close coordination with the HQ Bridge Preservation Office, Hydraulics Branch, and Environmental Services Office (watershed, permit program) are useful to ensure a one-WSDOT project approach is established early in the design phase.
- **Steel Bridge Painting:** Measures undertaken to preserve the load-carrying capacity of steel bridges by maintaining properly functioning paint systems to provide protection against corrosion. These measures include high-pressure washing and spot abrasive blasting to prepare steel surfaces for painting. This category typically involves discharge of wastewater into waters of the state and the decisions surrounding the need for full or partial containment of the wash water and blast media used for preparing the steel surfaces. Early and close coordination with the Bridge Management Engineer is necessary. A thorough review of the Standard Specifications current Water Quality Implementing Agreement (WQIA), and available Programmatic Permits, such as the General Hydraulic Project Approval (GHPA) and National Pollution Discharge Elimination System (NPDES) permits, is also recommended. Early project scoping for determination of wildlife usage is another factor for early coordination with all departments.
- **Bridge Seismic Retrofit:** Seismic retrofit of a bridge element (typically bridge columns). Measures undertaken to reduce the vulnerability of existing Washington State-owned bridges in the high to moderate seismic risk areas to earthquake damage that could cause collapse, excessive repair costs, or lengthy closures to traffic. This includes Phase 1 repairs (prevent span separation), Phase 2 repairs (retrofit single-column supports) and Final Phase (retrofit multiple-column supports).
- **Special Bridge Repair (Electrical/ Mechanical Retrofit):** Rehabilitating a major portion of an existing bridge to include electrical and mechanical repairs, such as for a movable bridge, a bridge over navigable water, or sign support structures.
- **Other Bridge Structures:** Major repair or replacement of Sign Bridges, Cantilever Sign Supports, Bridge Mounted Sign Supports, Tunnels, and High Mast Luminaire Poles.
- **New Special Structures:** Measures taken to build a new floating, movable, suspension, or cable stayed bridge for new or existing roadway.

⇩ Project Type Permit or Approval(***) ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)(1)	Water Quality 401 Certification	Coastal Zone Management (CZM) Certification	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit	Section 9 Bridge Permit	Section 10 Permit	Section 106	Section 4(f) 6(f)	Critical/Sensitive Areas Ordinances	Noise Variance
(1-1) Preventive Maintenance																			
Pavement Restoration																			
(1-2) Diamond Grinding	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(1-3) Milling with HMA Inlays	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(1-4) Nonstructural Overlay	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
Pavement Rehab./Resurf.																			
(1-5) HMA Structural Overlays	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(1-6) PCCP Overlays	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(1-7) Dowel Bar Retrofit	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
Bridge Rehabilitation																			
(1-8) Bridge Widening	M	M	M	M	M	H	H	M	L	L	L	L	L	M	M	M	L	M	L**
(1-8a) Existing Bridge Replacement	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	H	M	M	M
(1-8b) Bridge Deck Rehabilitation	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	M
(1-8c) Bridge Scour Countermeasures	M	H	H	H	H	H	H	L	M	L	L	L	L	M	M	M	L	H	L
(1-8d) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	L*	L	M	L	L	L	L	M**
(1-8e) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
(1-8f) Special Bridge Repair	L	M	M	M	M	M	L	L	L	L	L	L	L	M	L	L	L	L	M
Safety																			
(1-9) Median Barrier	L	M	M	L	L	L	L	L	L	H	M	L	L	L	L	L	L	L	L
(1-10) Guardrail Upgrades	L	M	M	L	L	L	M	L	L	H	M	L	L	L	L	L	L	L	L
(1-11) Bridge Rail Upgrades	L	L	L	H	L	L	H	L	L	H	L	L	L	L	L	M	L	L	L
Reconstruction																			
(1-12) New/Reconstruction	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	H	M	M	M

(See endnotes for explanation of matrices)

Project Environmental Matrix 1
Permit Probabilities for Interstate Routes (Main Line)
Figure 240-2

⇩ Project Type / Permit or Approval ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)	Water Quality 401 Certification	Coastal Zone Management (CZM) Certification	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit	Section 9 Bridge Permit	Section 10 Permit	Section 106	Section 4(f) 6(f)	Critical/Sensitive Areas Ordinances	Noise Permit
(2-1) Preventive Maintenance																			
Pavement Restoration																			
(2-2) Diamond Grinding	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(2-3) Milling with HMA Inlays	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(2-4) Nonstructural Overlay	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
Pavement Rehab./Resurf.																			
(2-5) HMA Structural Overlays	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(2-6) PCCP Overlays	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(2-7) Dowel Bar Retrofit	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
Bridge Rehabilitation																			
(2-8) Bridge Deck Rehabilitation	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	M**
(2-8a) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	H	L	M	L	L	L	L	L
(2-8b) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
Safety																			
(2-9) Guard Rail Upgrades	L	M	M	L	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(2-10) Bridge Rail Upgrades	L	L	L	M	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
Reconstruction																			
(2-11) New/Reconstruction	M/H	H	H	H	H	H	H	M	L	H	H	L	L	L	L	H	M	M	M

Project Environmental Matrix 2
Permit Probabilitiy for Interstate Interchange Areas
Figure 240-3

⇩ Project Type / Permit or Approval ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)	Water Quality 401 Certification	Coastal Zone Management (CZM) Certification[2]	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit[3]	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit[4]	Section 9 Bridge Permit[5]	Section 10 Permit[6]	Section 106	Section 4(f) 6(F)	Critical/Sensitive Areas Ordinances[7]	Noise Permit
Preservation																			
Roadway																			
(3-1) Non-Interstate Freeway	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(3-2) HMA/PCCP/BST Overlays	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(3-3) Replace HMA w/ PCCP at I/S	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
Structures																			
(3-4) Bridge Replacement	H	H	H	H	H		H	H	M	H	H	L	L	M	M	M	M	M	L
(3-5) Bridge Deck Rehab.	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	M
(3-5a) Bridge Scour	M	H	H	H	H	H	H	L	M	L	L	L	L	M	M	M	L	H	L
(3-5b) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	H	L	M	L	L	L	L	L
(3-5c) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
(3-5d) Special Bridge Repair	L	M	M	M	M	M	L	L	L	L	L	L	L	M	L	L	L	L	M
Improvements																			
(3-6) Non-Interstate Freeway	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M**
(3-7) Urban	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M**
(3-8) Rural	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-9) HOV	M	M	M	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	M
(3-10) Bike/Ped. Connectivity	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
Safety																			
(3-11) Non-Interstate Freeway	L	L	L	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-12) Intersection	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(3-13) Corridor	L	L	L	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-14) Median Barrier	L	M	M	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(3-15) Guardrail Upgrades	L	M	M	L	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(3-16) Bridge Rail Upgrades	L	L	L	M	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(3-17) Risk: Roadside	L	H	H	L	L	L	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-18) Risk: Sight Distance	L	L	L	L	L	L	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-19) Risk: Roadway Width	L	H	H	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(3-20) Risk: Realignment	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
Economic Development																			
(3-21) Freight and Goods (Frost Free)	M	H	H	M	M	M	M	M	L	H	H	L	L	L	L	M	M	M	M
(3-22) Four-Lane Trunk System	M	H	H	M	M	M	M	M	M	H	H	L	L	L	L	H	H	H	M
(3-23) Rest Areas (New)	M	H	H	L	M	M	M	L	L	H	H	L	M	L	L	H	H	H	L
(3-24) Bridge Restrictions	M	H	H	H	M	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(3-25) Bike Routes (Shldrs)	L	M	M	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L

Project Environmemtal Matrix 3
Permit Probability for NHS Routes Non-Interstate (Main Line)
Figure 240-4

⇩ Project Type Permit or Approval ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)	Water Quality 401 Certification(1)	Coastal Zone Management (CZM) Certification(2)	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit(4)	Section 9 Bridge Permit(5)	Section 10 Permit	Section 106	Section 4(f) 6(F)	Critical/Sensitive Areas Ordinances(7)	Noise Permit
Preservation																			
Roadway																			
(4-1) Non-Interstate Freeway	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
(4-2) HMA/PCCP/BST	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	M
Overlays Ramps	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	
Structures																			
(4-3) Bridge Replacement	M	H	H	M	L	L	M	M	L	H	H	L	L	L	L	M	L	L	M
(4-4) Bridge Deck Rehab.	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	L
(4-5) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	H	L	M	L	L	L	L	L
(4-6) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
Improvements																			
Mobility																			
(4-6) Non-Interstate Freeway	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M**
(4-7) Urban	M/H	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M**
(4-7) Rural	M	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-8) HOV By Pass	M	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	M
(4-9) Bike/Ped. Connectivity	M	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
Safety																			
(4-10) Non-Interstate Freeway	L	L	L	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-11) At Grade	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(4-12) Intersection	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(4-13) Guardrail Upgrades	L	M	M	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(4-14) Bridge Rail Upgrades	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(4-15) Risk: Roadside	L	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-16) Risk: Sight Distance	L	L	L	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-17) Risk: Roadway Width	L	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
(4-18) Risk: Realignment	M	H	H	L	L	L	L	M	L	H	M	L	L	L	L	M	L	L	L
Economic Development																			
(4-19) Four-Lane Trunk System	M	H	H	M	M	M	M	M	M	H	H	L	L	L	L	H	H	H	M

Project Environmental Matrix 4
Interchange Areas, NHS (Except Interstate) and Non-NHS
Figure 240-5

⇩ Project Type Permit or Approval ⇨	Section 404 Individual Permits	Section 404 Nationwide Permits (NWP)	Water Quality 401 Certification[1]	Coastal Zone Management (CZM) Certification[2]	Threatened and Endangered Species	Hydraulic Project Approval (HPA)	Shoreline Substantial Development Permit	Flood Plain Development Permit	Aquatic Resource Use Authorization	NPDES Municipal Stormwater Permit	NPDES Stormwater Construction Permit	NPDES Industrial Discharge Permit	State Waste Discharge (SWD) Permit[4]	Section 9 Bridge Permit[5]	Section 10 Permit	Section 106	Section 4(f) 6(F)	Critical/Sensitive Areas Ordinances[7]	Noise Permit
Roadway																			
(5-1) HMA/PCCP	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(5-2) BST	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(5-3) BST Routes/Basic Safety	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(5-4) Replace HMA with PCCP at I/S	L	L	L	L	L	L	M	L	L	H	L	L	L	L	L	L	L	L	
Structures																			
(5-5) Bridge Replacement	H	H	H	H	H	H	H	H	M	H	H	L	L	M	M	M	M	M	M
(5-6) Bridge Repl. (Multilane)	H	H	H	H	H	H	H	H	M	H	H	L	L	M	M	M	M	M	M
(5-7) Bridge Deck Rehab	M	L	L	H	M	M	H	L	L	H	L	L	L	M	L	M	L	L	M
(5-7a) Bridge Scour Countermeasures	M	H	H	H	H	H	H	L	M	L	L	L	L	M	M	M	L	H	L
(5-7b) Steel Bridge Painting	L	L	H	H	M	H	L	L	L	L	L	H	L	M	L	L	L	L	L
(5-7c) Bridge Seismic Retrofit	L	M	M	M	M	H	L	L	L	L	L	L	L	M	L	L	L	L	L
(5-7d) Special Bridge Repair	L	M	M	M	M	M	L	L	L	L	L	L	L	M	L	L	L	L	M
Improvements																			
(5-8) Non-Interstate Freeway	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M	M**
(5-9) Urban	H	H	H	M/H	H	H	M	M	H	H	L	L	L	L	M	M	M	M	M**
(5-10) Rural	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-11) HOV	M	M	M	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	M
(5-12) Bike/Ped. Connectivity	M	M	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
Safety																			
(5-13) Non-Interstate Freeway	L	L	L	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-14) Intersection	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(5-15) Corridor	L	L	L	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-16) Median Barrier	L	M	M	L	L	L	L	L	L	H	M	L	L	L	L	M	L	L	L
(5-17) Guardrail Upgrades	L	M	M	L	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(5-18) Bridge Rail Upgrades	L	L	L	M	L	L	M	L	L	H	M	L	L	L	L	M	L	L	L
(5-19) Risk: Roadside	L	H	H	L	L	L	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-20) Risk: Sight Distance	L	L	L	L	L	L	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-21) Risk: Roadway Width	L	H	H	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L
(5-22) Risk: Realignment	M	H	H	L	M	M	M	M	L	H	M	L	L	L	L	M	L	L	L
Economic Development																			
(5-23) Freight and Goods (Frost Free)	M	H	H	M	M	M	M	M	L	H	H	L	L	L	L	M	M	M	M
(5-24) Rest Areas (New)	M	H	H	M	M	M	M	L	L	H	H	L	M	L	L	H	H	H	L
(5-25) Bridge Restrictions	M	H	H	H	M	L	M	L	L	H	L	L	L	L	L	L	L	L	M
(5-26) Bike Routes (Shldrs)	L	M	M	L	L	M	M	M	L	H	M	L	L	L	L	M	L	L	L

Project Environmental Matrix 5
Non-NHS Routes (Main Line)
Figure 240-6

NOTES

For Figures 240-2 through 240-6.

For main line projects on the Interstate, National Highway System main line (except Interstate), or non-National Highway System, all bridgework is assumed to be over water. For interchange projects on the Interstate and non-Interstate, all bridgework is assumed to be over roads. (See Chapter 325.)

NEPA/SEPA Endnotes

(*) Programmatic permits may apply

(**) Night work may require variance

(***) NEPA/SEPA compliance is required on all projects. The level of documentation will correspond to the complexity of the project and the potential environmental impacts anticipated. (See region or HQ environmental staff.)

Section 404 IP Endnotes

L= Low probability assumes the work is covered by an NWP.

M= Medium probability assumes the potential for impacts beyond the thresholds for an NWP.

H= High probability assumes a likelihood for impacts beyond the thresholds for an NWP.

Section 404 NWP Endnotes

L= Low probability assumes no work and/or fill below the OHWM or wetlands in waters of the US.

M= Medium probability assumes potential for work and/or fill below the OHWM in waters of the US and/or minimal wetland fill.

H= High probability assumes likelihood for work and/or fill in waters of the U.S. below the OHWM or wetland fills below 1/3 acre (tidal) or 1/2 acre (non-tidal).

Section 401 Endnotes

(1) Parallels probability of Section 404 IP/NWP. Includes reference to Corps/Ecology/Tribes Regional General Conditions.

CZM Endnotes

(2) Parallels probability of Section 401 within 15 coastal counties only and involving waters of the state subject to Shoreline Management Act.

ESA Endnotes

L= Low probability assumes either applicable programmatic BA or individual BA and No Effect Determination.

M= Medium probability assumes either applicable programmatic or individual BA and Not Likely to Adversely Effect Determination.

H= High probability assumes either applicable programmatic or individual BA and adverse effect determination (Biological Opinion).

HPA Endnotes

L= Low probability assumes no work within or over waters of the state subject to HPA.

M= Medium probability assumes potential for limited work within or over waters of the state.

H= High probability assumes likelihood for work within or over waters of the state.

Shoreline Endnotes

L= Low probability assumes no work within shorelines of the state.

M= Medium probability assumes potential for work within shorelines of the state.

H= High probability assumes likelihood for work within shorelines of the state.

Endnotes for Project Environmental Matrices

Figure 240-7a

Floodplain Endnotes

L= Low probability assumes no fill in the 100-year floodplain.

M= Medium probability assumes potential for fill in the 100-year floodplain.

H= High probability assumes likelihood for fill in the 100-year floodplain.

Aquatic Resource Use Authorization Endnotes (DNR)

L= Low probability assumes no new structures or use of aquatic lands. (“Use” is subject to interpretation by DNR.)

M= Medium probability assumes potential for new structures or use of aquatic lands.

H= High probability assumes likelihood for new structures or use of aquatic lands. May need to define USE and include Easement over Navigable Water.

Section 402 NPDES Municipal Stormwater General Permit Endnotes

(3) Applies to construction, operation, and maintenance activities in four watersheds - Island/ Snohomish, Cedar/Green, South Puget Sound, and Columbia Gorge.

L= Low probability assumes project exempt from NPDES Municipal Stormwater Permit.

H= High probability assumes project subject to NPDES Municipal Stormwater Permit.

Section 402 NPDES Stormwater Construction General Permit Endnotes

L= Low probability assumes ground disturbance of less that one acre.

M= Medium probability assumes ground disturbance of one acre or more.

H= High probability assumes likelihood of ground disturbance of one acre or more.

Section 402 NPDES Industrial Discharge General Permit Endnotes

L= Low probability assumes no bridge or ferry terminal washing over waters of the state.

M= Medium probability assumes potential for bridge or ferry terminal washing over waters of the state.

H= High probability assumes likelihood for bridge or ferry terminal washing over waters of the state.

State Waste Discharge Permit Endnotes

(4) Applies to discharges of commercial or industrial wastewater into waters of the state - does not cover stormwater discharges under NPDES program.

L= Low probability assumes SWD permit does not apply.

M= Medium probability assumes potential for SWD permit.

Section 9 Bridge Permit Endnotes

(5) Applies to work on bridges across navigable waters of the U.S.

L= Low probability assumes no bridgework.

M= Medium probability assumes potential for work on a bridge across navigable water.

H= High probability assumes likelihood for work on a bridge across navigable water.

Section 10 Permit Endnotes

(6) Applies to obstruction, alteration, or improvement of navigable waters of the U.S.

L= Low probability assumes no obstructions, alterations, or improvements to navigable waters.

M= Medium probability assumes potential for obstructions, alterations, or improvements to navigable waters.

H= High probability assumes likelihood for obstructions, alterations, or improvements to navigable waters.

Endnotes for Project Environmental Matrices

Figure 240-7b

Section 106 Endnotes

L= Low probability assumes no federal nexus and/or activities exempted per the statewide Programmatic Agreement on Section 106 signed by FHWA, WSDOT, OAHP and ACHP.

M= Medium probability assumes a federal nexus; therefore, Section 106 federal regulations apply.

H= High probability assumes a federal nexus and/or the likelihood for discovery of historic or culturally significant artifacts. See 36 CFR part 800, *Environmental Procedures Manual*, (Current DOT Policy and the Section 106 Programmatic Agreement).

Section 4(f)/6(f) Endnotes

L= Low probability assumes no use of or acquisition of new right-of-way.

M= Medium probability assumes potential use of or acquiring of new right of way.

H= High probability assumes likelihood for use of or acquiring of new right of way.
Review Triggers: http://www.wsdot.wa.gov/environment/compliance/Section4f_guidance.htm

Critical/Sensitive Areas Endnotes

(7) The mechanism for critical/sensitive areas review varies by jurisdiction.

L= Low probability assumes no work inside or outside of right of way in critical/sensitive areas.

M= Medium probability assumes potential for work inside or outside of right of way in critical/sensitive areas.

H= High probability assumes likelihood for work inside or outside of right of way in critical/sensitive areas.

Noise Variance Endnotes

L= Low probability assumes no night work.

M= Medium probability assumes potential for night work.

H= High probability assumes likelihood for night work.

Endnotes for Project Environmental Matrices

Figure 240-7c

240.04 Design Process and Permit Interaction

Environmental permits require information prepared during the design phase to demonstrate compliance with environmental rules, regulations, and policies. To avoid delays in project delivery, it is necessary for the designer to understand and anticipate this exchange of information. The timing of this exchange often affects design schedules, while the permit requirements can affect the design itself. In complex cases, the negotiations over permit conditions can result in iterative designs as issues are raised and resolved.

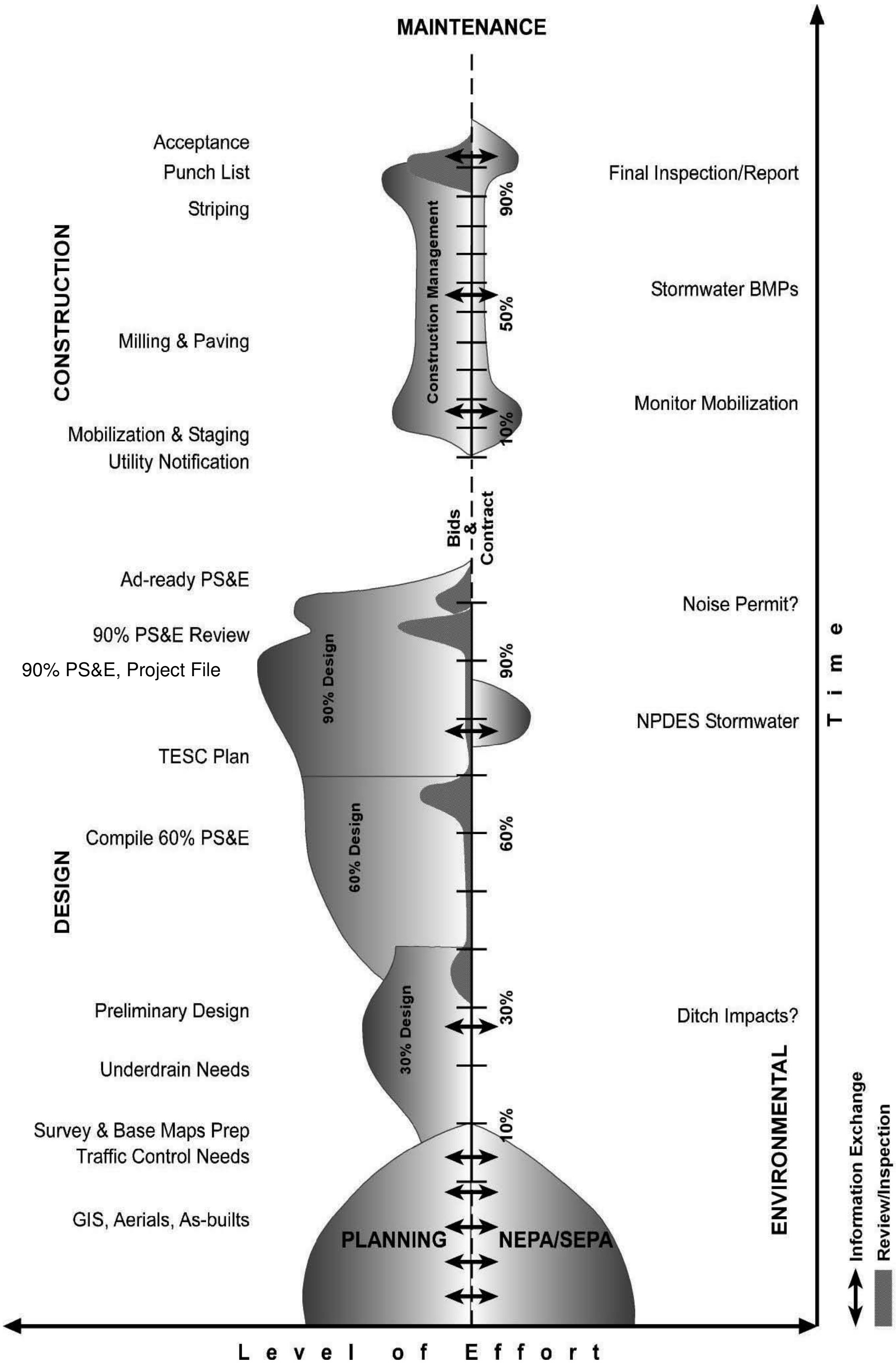
The permit process begins well in advance of the actual permit application. For some permits, WSDOT has already negotiated permit conditions through the use of programmatic and general permits. These permits typically apply to repetitive, relatively simple projects and the permit conditions apply regardless of the actual facts of the project type. For complex projects, the negotiations with permit agencies often begin during the environmental documentation phase for compliance with NEPA and SEPA. The mitigation measures developed for the NEPA/SEPA documents are captured as permit conditions on the subsequent permits.

For many other project types, the permit process begins during the design phase. This section illustrates the interaction between design and permitting for two relatively uncomplicated projects. Figures 240-8 and 240-9 illustrate project timelines for two project types and the interaction of typical permits for those project types. The project types are an overlay project and a channelization project. The figures illustrate the level of effort over time for both design components and environmental permits.

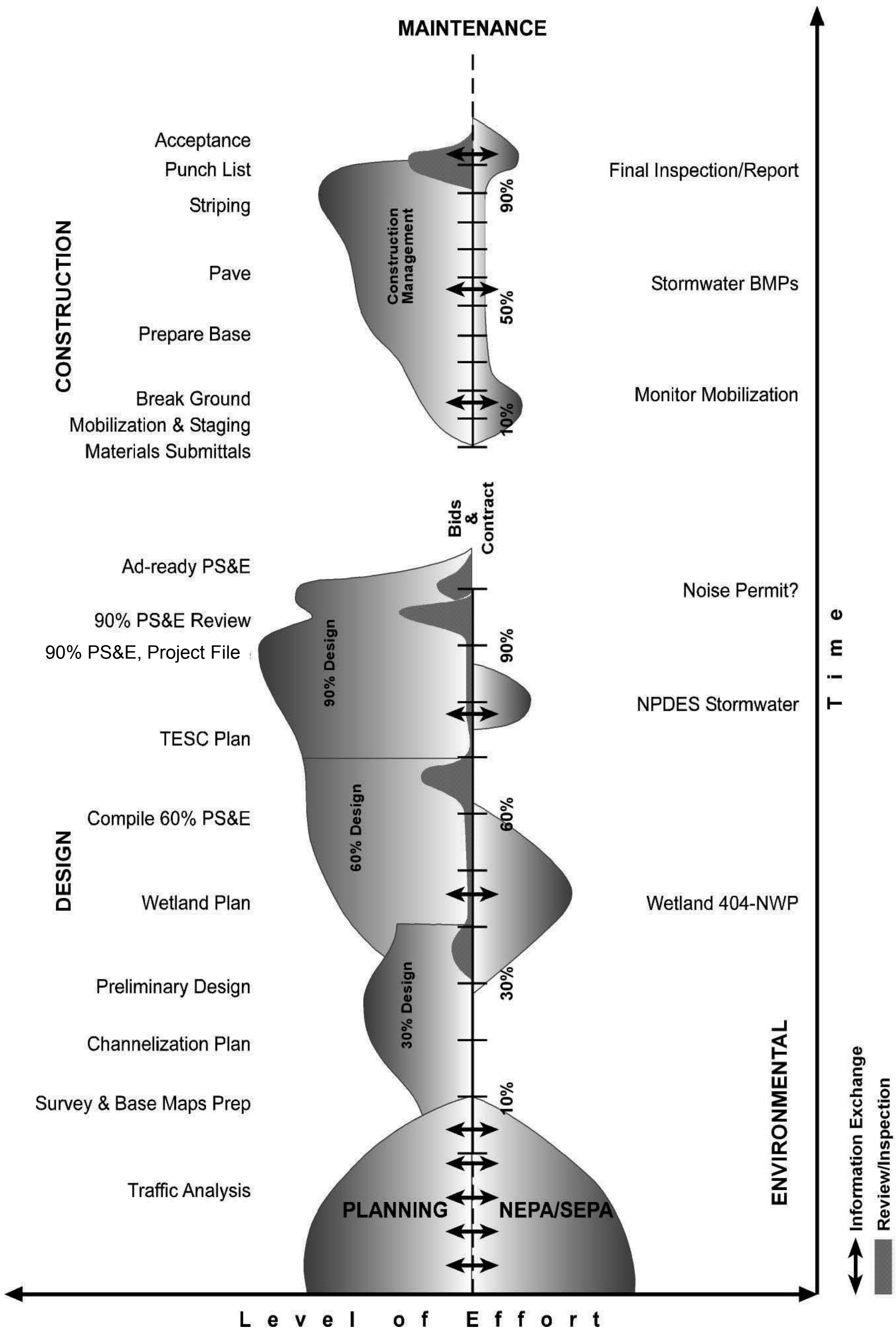
The overlay project assumes that only an NPDES Municipal Stormwater General Permit is required. Compliance with this permit is through application of WSDOT's *Highway Runoff Manual,* M 31-16 and the implementation of WSDOT's 1997 *Stormwater Management Plan*. The possibility for a noise variance exists because of the potential for night work.

The channelization project assumes minor amounts of new right of way are required. Because roadside ditches are often at the edge of the right of way, it was assumed that the potential for impacting wetlands exists. Usually the amount of fill is minor and the project may qualify for a Corps of Engineers Section 404 Nationwide Permit. A wetland mitigation plan is required to meet permit requirements, and the plan's elements have the potential to affect design, including stormwater facilities.

The interaction of design and permitting increases in complexity as the project type becomes more complex. More detailed analysis of environmental permits and their requirements is available in the *Environmental Procedures Manual* and through consultation with region and HQ environmental staff.



Environmental Interrelationship: HMA/PCCP/BST Main Line Overlay
Figure 240-8



Environmental Interrelationship: Safety Corridor Channelization Main Line
Figure 240-9

Chapter 315 Value Engineering

315.01 General

Value Engineering is a systematic process designed to focus on the major issues of a complex project or process. It uses a multi-disciplined team to develop recommendations for the important decisions that must be made. The primary objective of a Value Engineering study is *Value Improvement.*

For projects, the value improvements might be improvements in scope definition, functional design, constructibility, coordination (both internal and external), or the schedule for project development. Other possible value improvements are reduced environmental impact, reduced public (traffic) inconvenience, or reduced project cost. The Value Engineering process incorporates, to the extent possible, the values of the design engineer, construction engineer, maintenance engineer, contractor, state and federal approval agencies, local agencies, other stakeholders, and the public. Important design decisions are formulated from the recommendations of the Value Engineering team.

315.02 References

CFR 23 Part 627 Value Engineering

Value Engineering for Highways, Study Workbook, U. S. Department of Transportation, FHWA

Introduction To Value Engineering Principles and Practices, Transportation Partnership in Engineering Education Development (TRANSPEED), University of Washington.

315.03 Definitions

***Value Engineering* (VE)** A systematic application of recognized techniques by a multi-disiplined team to identify the function of a product or service, establish a worth for that function, generate alternatives through the use of creative thinking, and provide the needed functions to accomplish the original purpose; thus assuring the lowest life cycle cost without sacrificing safety, necessary quality, or environmental attributes. Value Engineering is sometimes referred to as Value Analysis (VA) or Value Management (VM).

project The portion of a transportation facility that WSDOT proposes to construct, reconstruct, or improve, as described in the *State Highway System Plan* or applicable environmental documents. A project may consist of several contracts or phases over several years that are studied together as one *project*.

315.04 Procedure

The VE process uses the Eight-Phase Job Plan in Figure 315-1. Only the phases 1 and 7 are discussed in this chapter. A detailed discussion of phases 2 through 6 can be found in the VE training manual entitled *Introduction To Value Engineering Principles and Practices*.

(1) Selection Phase

(a) **Project Selection**

Projects for VE studies may be selected from any of the categories identified in the Highway Construction Program, including *Preservation* or *Improvement* projects, depending on the size and/or complexity of the project. In addition to the cost, other issues adding to the complexity of the project design are considered in the selection process. These complexities include: critical constraints, difficult technical issues, expensive solutions, external influences, and complicated functional requirements.

A VE study is required for any federally funded NHS project with an estimated cost of $25 million or more (CFR 23 Part 627). Other types of projects that usually provide the highest potential for value improvement have a preliminary estimate exceeding $5 million and include one or more of the following:

- Projects with alternative solutions that vary the scope and cost
- New alignment or bypass sections
- Capacity improvements that widen an existing highway
- Major structures
- Interchanges on multilane facilities
- Projects with extensive or expensive environmental or geotechnical requirements
- Materials that are difficult to acquire or require special efforts
- Inferior materials sources
- Major reconstruction
- Projects requiring major traffic control
- Projects with multiple stages

(b) Statewide VE Study Plan

On a biennial basis, the state VE manager coordinates with the region VE coordinators to prepare the Two-Year VE Study Plan with specific projects scheduled by quarter. The VE Study Plan is the basis for determining the projected VE program needs, including team members, team leaders, and training. The Statewide VE Study Plan is a working document and close coordination is necessary between HQ and the regions to keep it current.

The regional VE coordinator:

- Identifies potential projects for VE studies from the Project Summaries and the available planning documents for future work.
- Makes recommendations for the VE study timing.
- Presents a list of the identified projects to regional management to prioritize into a regional Two-Year VE Study Plan. (VE studies other than projects are also included in the plan.)

The State Design Engineer:

- Reviews the regional Two-Year VE Study Plan regarding the content and schedule of the plan.

The state VE Manager:

- Incorporates the regional Two-Year VE Study Plans and the HQ Study Plans to create the Statewide VE Study Plan.

(c) VE Study Timing

Selecting the project at the appropriate stage of development (the timing of the study) is very important to the success of the VE program. Value can be added by performing a VE study any time during project development; however, the WSDOT VE program identifies three windows of opportunity for performing a VE study.

1. **Problem Definition Stage**

   As soon as preliminary engineering information is available and the specific deficiencies or "drivers" are identified, the project scope and preliminary cost are under consideration. This is the best time to consider the various alternatives or design solutions and there is the highest potential that the related recommendations of the VE team can be implemented. At the conclusion of the VE study, the project scope, preliminary cost, and major design decisions can be based on the recommendations.

   When conducting a study in the problem definition stage, the VE study focuses on issues affecting project "drivers." This stage often provides an opportunity for building consensus with stakeholders.

2. **Conceptual Design Stage**

   At the conceptual design stage, the project scope and preliminary cost have already been established and the major design decisions have been made. Some PS&E activities might have begun and coordination has been initiated with the various service units that will be involved with the design. At this stage, the established project scope, preliminary cost, and schedule will define the limits of the VE study. There is still opportunity for a VE study to focus on the technical issues for each of the specific design elements.

3. **30 % Development Stage**

At the 30% stage, most of the important project decisions have been made and the opportunity to affect the project design is limited. The VE study focuses on constructibility, construction sequencing, staging, traffic control elements, and any significant design issues that have been identified during design development.

(d) **Study Preparation**

To initiate a VE study, the project manager submits a Request for Value Engineering Study form (shown in Figure 315-2) to the region VE coordinator at least one month before the proposed study date.

The regional VE coordinator then works with the state VE Manager to determine the team leader and team members.

The design team prepares a study package that includes project information for each of the team members. A list of potential items is shown in Figure 315-3.

The region provides a facility and the equipment for the study (Figure 315-3).

(e) **Team Leader**

The quality of the VE study is dependent on the skills of the VE team leader. This individual guides the team efforts and is responsible for its actions during the study. The best VE team leader is knowledgeable and proficient in transportation design and construction, and in the VE study process for transportation projects.

For best results, the team leader should be certified by the Society of American Value Engineers (SAVE) as a Certified Value Specialist (CVS) or as a Value Methodology Practitioner (VMP).

Team leadership can be supplied from within the region or from other regions, HQ, consultants, or other qualified leaders outside the department. The state VE Manager coordinates with the regional VE coordinator to select the team leader. A statewide pool of qualified team leaders is maintained by the state VE Manager.

(f) **Team Members**

The VE team is usually composed of five to eight persons with diverse backgrounds that are relevant to the specific study. The team members may be selected from the regions, HQ, other state and federal agencies, local agencies, and the private sector.

The team members are selected on the basis of the kinds of expertise needed to address the major functional areas and critical high-cost issues of the study. All team members must be committed to the time required for the study. For best results, the team members have had VE training before participating in a VE study.

(g) **VE Study Requirements**

The time required to conduct a VE study varies with the complexity and size of the project, but typically ranges from three to five days.

The VE study Final Report and Workbook include a narrative description of project input information, background and history, constraints and drivers, VE team focus areas, and a discussion of the team speculation, evaluation, and recommendations. All of the team's evaluation documentation (including sketches, calculations, analyses, and rationale for recommendations) is included in the Workbook as part of the Final Report. Include a copy of the Final Report and Workbook in the Project File. The number of copies of the Final Report and Workbook is specified by the project manager.

(2) Implementation Phase

The VE team's recommendations are included in the Final Report and Workbook. The project manager reviews and evaluates the recommendations and prepares a VE Decision Document. This document has a specific response for each of the VE team recommendations and a summary statement containing the managers' decisions and schedule for implementation regarding further project development.

The VE Decision Document also includes estimated costs or savings of the recommendations, as well as the estimated cost to implement the recommendations. A copy of this document is sent to the state VE Manager so the results can be included in the annual VE report to FHWA.

The VE Decision Document is submitted to the State Design Engineer and a copy becomes a vital element in the design file for the project. Project development then continues based on the decisions developed from the preliminary engineering and the VE study recommendations (barring participation agreements funded by other agencies, utilities, developers, and so forth).

315.05 Documentation

The documents required to be preserved in the Design Documentation Package (DDP) or the Project File (PF) is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev

1. Selection Phase 315.04(1)	Select the right projects, timing, team, and project processes and elements.
2. Investigation Phase	Investigate the background information, technical input reports, field data, function analysis, and team focus and objectives.
3. Speculation Phase	Be creative and brainstorm alternative proposals and solutions.
4. Evaluation Phase	Analyze design alternatives, technical processes, life cycle costs, documentation of logic, and rationale.
5. Development Phase	Develop technical and economic supporting data to prove the feasibility of the desirable concepts. Develop team recommendations. Recommend long-term as well as interim solutions.
6. Presentation Phase	Present the recommendations of the VE team in an oral presentation, and in a written report and workbook.
7. Implementation Phase 315.04(2)	Evaluate the recommendations. Prepare an implementation plan (VE Decision Document) including the response of the managers and a schedule for accomplishing the decisions based on the recommendations.
8. Audit Phase	Maintain a records system to track the results and accomplishments of the VE program on a statewide basis. Compile appropriate statistical analyses as requested.

Steps 2-6 are performed during the study, see *Introduction To Value Engineering Principles and Practices* for procedures during these steps.

Eight-Phase Job Plan for VE Studies

Figure 315-1

Project Title:					
SR No.	MP	to	MP	Length	Subprogram
PIN			WIN		
Assigned Project Engineer					
Proposed Advertising Date					
Estimated Right of Way Costs			Estimated Construction Costs		
Design Speed			Projected ADT		
Route Conditions/Geometry: Adjacent Segments Overall Route					
Major Project Elements					
Environmental Issues					
Construction Issues					
Suggested Value Team Composition:					
	Architecture		Hydraulics		
	Bridge		Landscape Architecture		
	Construction		Maintenance		
	Design		Planning/Programming		
	Environmental		Traffic		
	Other ______________		Real Estate Services		
Region Contact Person			Dates requested for VE study		

Request for Value Engineering Study
Figure 315-2

Project-Related Input* (Study Package)	Study-Related Facilities and Equipment
Design File	Room w/large table
Quantities	Phone
Estimates	Photo/Video log access/SRView
R/W Plans	Van for Field Trip **
Geotechnical Reports	Easel(s)
Plan Sheets	Large Tablet Paper (2x2 squares)
Environmental Documents	Colored Marking Pens
X-sections and Profiles	Masking and Clear Adhesive Tape
Land Use Maps	Workbook(s)
Contour Maps	Polaroid Camera
Quadrant Maps	Design Manual
Accident Data	"Green Book"
Traffic Data	Standard Plans
Up-to-Date Large-Scale Aerial Photographs	Standard Specifications
Vicinity Map	M.P. Log
Hydraulics Report	Bridge List
Aerial Photos	WSDOT Phone Book
Existing As-Built Plans	Scales and Straight Edge
	Red Book - Field Tables
	Unit Bid Prices
	Calculators
	Scissors

* Not all information listed may be available to the team depending on the stage of the project.
** If field trip is not possible, provide video of project.

VE Study Team Tools
Figure 315-3

325.01 General

This *Design Manual* provides guidance for three levels of design for highway projects: the basic, modified, and full design levels. The design matrices in this chapter are used to identify the design level(s) for a project and the associated processes for allowing design variances. The matrices address the majority of preservation and improvement projects and focus on those design elements that are of greatest concern in project development.

The design matrices are five tables that are identified by route type. Two of the matrices apply to Interstate highways. The other three matrices apply to non-Interstate highways and address preservation and improvement projects.

A design matrix is used to determine the design level for the Design Elements of a project. Apply the appropriate design levels and document the design decisions as required by this chapter and Chapter 330.

325.02 Selecting a Design Matrix

Selection of a design matrix is based on highway system (Interstate, NHS excluding Interstate, and non-NHS) and location (main line, interchange). (See Figure 325-1.)

Highway System	Location	
	Main Line	**Interchange Area**
Interstate	Matrix 1	Matrix 2
NHS(1)	Matrix 3	Matrix 4
Non-NHS	Matrix 5	Matrix 4

(1) Except Interstate.

Design Matrix Selection Guide
Figure 325-1

The **Interstate System** (Matrices 1 and 2) is a network of routes selected by the state and the FHWA under terms of the federal aid acts. These routes are principal arterials that are the most important to the economic welfare and defense of the United States. They connect, as directly as practicable:

- Principal metropolitan areas and cities.
- Industrial centers.
- International border crossings.

The Interstate System also includes important routes into, through, and around urban areas, serves the national defense, and, where possible, connects with routes of continental importance. It serves international and interstate travel and military movements.

The Interstate System is represented on the list of NHS highways, Figures 325-2a and 2b, with the letter "I" before the route number.

The **National Highway System (NHS)** (Matrices 3 and 4) is an interconnected system of principal arterial routes and highways (including toll facilities) that serve:

- Major population centers.
- International border crossings.
- Industrial centers.
- Ports.
- Airports.
- Public transportation facilities.
- Other intermodal transportation facilities.
- Other major travel destinations.

The NHS includes the Interstate System and the Strategic Highway Corridor Network (STRAHNET) and its highway connectors to major military installations (Interstate and non-Interstate).

The NHS meets national defense requirements and serves international, interstate, and interregional travel.

See Figures 325-2a and 2b.

The **Non-NHS** highways (Matrices 4 and 5) are state routes that form a network of highways that supplement the NHS system by providing for freight mobility and, mainly, regional and interregional travel. Non-NHS highways are not shown on Figures 325-2a and 2b. They are shown on WSDOT's (free) Official State Highway Map of Washington.

325.03 Using a Design Matrix

The design matrices are shown in Figures 325-3 through 325-7. Follow *Design Manual* guidance for all projects except as noted in the design matrices and elsewhere as applicable. The definitions presented in this chapter are meant to provide clarification for terminology used in the *Design Manual*. There is no assurance that these terms are used consistently in references outside of the *Design Manual*.

(1) Project Type

For project types not listed in the design matrices (such as unstable slopes), consult the Headquarters Design Office for guidance.

In the design matrices, row selection is based on Project Type. The Project Summary defines and describes the project. (Project Summary is discussed in Chapter 330.) For NHS and non-NHS routes (Matrices 3, 4, and 5), the project's program/subprogram might be sufficient information for identifying Project Type. See the *Programming Manual* for details about funding programs and subprograms.

The various sources of funds for these subprograms carry eligibility requirements that the designers and Project Development must identify and monitor throughout project development — this is especially important to ensure accuracy when writing agreements and to avoid delaying advertisement for bids if the Project Type changes.

Some projects involve work from several subprograms. In such cases, identify the various limits of the project that apply to each subprogram. Where the project limits overlap, apply the higher design level to the overlapping portion.

Project Types (in alphabetical order) are:

At Grade projects are safety improvements on NHS highways (45 mph or greater) to build grade separation facilities that replace the existing intersections.

Bike Routes (Shldrs) are main line economic development improvements to provide a statewide network of rural bicycle touring routes with shoulders a minimum of four feet wide.

Bike/Ped. Connectivity projects are mobility improvements to provide bicycle/pedestrian connections, along or across state highways within urban growth areas, to complete local networks.

Bridge Deck Rehabilitation projects are structures preservation, which repair delaminated bridge decks and add protective overlays that will provide a sound, smooth surface; prevent further corrosion of the reinforcing steel; and preserve operational and structural integrity.

Bridge Rail Upgrades are safety improvements to update older bridge rails to improve strength and redirectional capabilities.

Bridge Repl. (Multilane) projects are non-NHS main line structures preservation that replace bridges on multilane highways to improve operational and structural capacity.

Bridge Replacement projects are NHS and two-lane non-NHS (main line and interchange) structures preservation that replace bridges to improve operational and structural capacity.

Bridge Restrictions projects are main line economic development improvements that remove vertical or load capacity restrictions to benefit the movement of commerce.

BST projects are non-NHS roadway preservation to do bituminous surface treatment (BST) work only, to protect the public investment.

BST Routes/Basic Safety projects are non-NHS roadway preservation to resurface highways at regular intervals and restore existing safety features to protect the public investment.

Corridor projects are main line improvements to reduce and prevent collisions (vehicular, nonmotorized, and pedestrian) within available resources.

Diamond Grinding is grinding a concrete pavement, using gang mounted diamond saw blades, to remove surface wear or joint faulting.

Dowel Bar Retrofit is reestablishing the load transfer efficiencies of the existing concrete joints and transverse cracks by cutting slots, placement of epoxy coated dowel bars, and placement of high-early strength, nonshrink concrete.

Four-Lane Trunk System projects are NHS economic development improvements to complete contiguous four-lane limited access facilities on a trunk system consisting of all Freight and Goods Transportation Routes (FGTS) with a classification of 10,000,000 tons/year.

Freight & Goods (Frost Free) projects are main line economic development improvements to reduce delay from weather related closures on high priority freight and goods highways.

Guardrail Upgrades are safety improvement projects limited to the specified roadside Design Elements. These projects focus on W beam with 12'-6" spacing and on guardrail systems with concrete posts. The length of need is examined and minor adjustments are made. Removal is an option if guardrail is no longer needed. For Interstate main line, address length of need as specified in Chapter 710. For non-interstate routes, additional length of more than 5% of the existing length is beyond the intent of this program. In these instances, consider funding in accordance with priority programming instructions, and if the length of need is not met, document to the Design Documentation Package (DDP), that the length of need is not addressed because it is beyond the intent of this program.

HMA/PCCP projects are non-NHS roadway preservation to resurface highways at regular intervals and restore existing safety features to protect the public investment.

HMA/PCCP/BST Overlays are NHS main line roadway preservation projects that resurface the existing surfaces at regular intervals to protect the public investment.

HMA/PCCP/BST Overlays Ramps are NHS and non-NHS ramp roadway preservation projects that resurface the existing surfaces at regular intervals and restore existing safety features to protect the public investment.

HMA Structural Overlays is a hot mix asphalt overlay that is placed to increase the load carrying ability of the pavement structure. Structural overlay thickness is greater than 0.15 ft.

HOV Bypass projects are NHS and non-NHS ramp mobility improvements to improve mobility within congested highway corridors by providing HOV bypass lanes on freeway ramps. Congested highway corridors have high congestion index values as described in the *Highway System Plan* (footnote in text for Improvement/Mobility).

HOV projects are main line mobility improvements completing the freeway Core HOV lane system in the Puget Sound region, and providing level of service C on HOV lanes (including business access transit lanes), within congested highway corridors.

Intersection projects are safety improvements to reduce and prevent collisions, to increase the safety of highways, and to improve pedestrian safety within available resources.

Median Barrier projects are limited safety improvement projects – mainly new median barrier with a focus on cable barrier to reduce median crossover accidents.

Milling with HMA Inlays is removal of a specified thickness of the existing HMA pavement, typically from the traveled lanes, and then overlaying with HMA at the same specified thickness.

New/Reconstruction includes the following types of work:

- Capacity changes: add a through lane, convert a general purpose (GP) lane to a special purpose lane (such as an HOV lane), or convert a high occupancy vehicle (HOV) lane to GP.
- Other lane changes: add or eliminate a collector-distributor or auxiliary lane. (A rural truck climbing lane that, for its entire length, meets the warrants in Chapter 1010 is not considered new/reconstruction.)
- Pavement reconstruction: full depth PCCP or HMA replacement.
- New interchange.
- Changes in interchange type such as diamond to directional or adding a ramp.
- New or replacement bridge (on or over, main line or interchange ramp).

Non-Interstate Freeway (mobility) projects, on non-NHS and NHS interchanges and on NHS main line, are mobility improvements on multilane divided highways, with limited access control, within congested highway corridors.

Non-Interstate Freeway (roadway preservation) projects, on non-NHS and NHS interchanges and on NHS main line, are roadway preservation to overlay or inlay with HMA/PCCP/BST on multilane divided highways, with limited access control, to minimize long-term costs and restore existing safety features.

Non-Interstate Freeway (safety) are NHS and non-NHS (main line and interchanges) safety improvements on multilane divided highways, with limited access control, to increase the safety within available resources.

Nonstructural Overlay is an HMA pavement overlay that is placed to minimize the aging effects and minor surface irregularities of the existing HMA pavement structure. The existing HMA pavement structure is not showing extensive signs of fatigue (longitudinal or alligator cracking in the wheel paths). Nonstructural overlays are less than or equal to 0.15 ft thick, and frequently less than 0.12 ft thick.

PCCP Overlays are Portland cement concrete pavement overlay of an existing PCCP or HMA surface.

Preventive Maintenance includes roadway work such as pavement patching; restoration of drainage system; panel replacement; joint and shoulder repair; and bridge work such as crack sealing, joint repair, slope stabilization, seismic retrofit, scour countermeasures, and painting. Preventive maintenance projects must not degrade any existing safety or geometric aspects of the facility. Any elements that will be reconstructed as part of a preventative maintenance project are to be addressed in accordance with Full Design Level.

Replace HMA w/ PCCP at I/S (intersections) projects are NHS and non-NHS main line roadway preservation that restores existing safety features and replaces existing HMA intersection pavement that has reached the point of lowest lifecycle cost (11-15 years old) with PCCP that has about a 40 year life cycle.

Rest Areas (New) projects are NHS and non-NHS main line economic development and safety improvements to provide rest areas every 60 miles, and some RV dump stations.

Risk, Realignment projects are improvements intended to improve alignment at specific locations where the Risk program has identified a high probability of collisions/accidents.

Risk, Roadside projects are improvements intended to mitigate roadside conditions at specific locations where the Risk program has identified a high probability of vehicular encroachment.

Risk, Roadway Width projects are improvements intended to adjust the roadway width at specific locations where the Risk program has identified a high probability of a vehicle leaving its lane of travel.

Risk, Sight Distance projects are improvements intended to improve sight distance at specific locations where the Risk program has identified a high probability of collisions/accidents.

Rural projects are mobility improvements providing uncongested level of service on rural highways within congested highway corridors. (See HOV Bypass above for cross reference regarding “congested.”)

Urban (Multilane) projects are non-NHS mobility improvements within congested urban multilane highway corridors. (See HOV Bypass above for cross reference regarding “congested.”)

Urban projects are NHS and two-lane non-NHS (main line and interchange) mobility improvements within congested urban highway corridors. (See HOV Bypass above for cross reference regarding “congested.”)

(2) Design Elements

The column headings on a design matrix are **Design Elements.** Not all potential design elements have been included in the matrices.

The Design Elements that are included are based on the following thirteen FHWA controlling design criteria: design speed, lane width, shoulder width, bridge width, structural capacity, horizontal alignment, vertical alignment, grade, stopping sight distance, cross slope, superelevation, vertical clearance, and horizontal clearance. For the column headings, some of these controlling criteria have been combined (for example, design speed is part of horizontal and vertical alignment).

If using a design element that is not on the assigned matrix, use full design level as found elsewhere in this manual.

If using a design element that is not covered in this manual, use an approved manual or guidance on the subject and document the decision and the basis for the decision.

The following elements are shown on the design matrices. If the full design level applies, see the chapters listed below. If basic design level applies, see Chapter 410. If the modified design level applies, see Chapter 430.

Horizontal Alignment is the horizontal attributes of the roadway including horizontal curvature, superelevation, and stopping sight distance; all based on design speed. (See Chapter 620 for horizontal alignment, Chapter 642 for superelevation, Chapter 650 for stopping sight distance, and Chapters 440 or 940 for design speed.)

Vertical Alignment is the vertical attributes of the roadway including vertical curvature, profile grades, and stopping sight distance; all based on design speed. (See Chapter 630 for vertical alignment, Chapters 430, 440, 630, and 940 for grades, Chapters 430 and 650 for stopping sight distance, and Chapter 430, 440, or 940 for design speed.)

Lane Width is defined in Chapter 440. (See also Chapters 430, 640, 641, and 940.)

Shoulder Width is defined in Chapter 440. (See also Chapters 430, 640, and 940.) Also see Chapter 710 for shy distance requirements when barrier is present.

Lane Transitions (pavement transitions) are the rate and length of transition of changes in width of lanes. (See Chapter 620.)

On/Off Connection is the widened portion of pavement at the end of a ramp connecting to a main lane of a freeway. (See Chapter 940.)

Median Width is the distance between inside edge lines. (See Chapters 440 and 640.)

Cross Slope, Lane is the rate of elevation change across a lane. This element includes the algebraic difference in cross slope between adjacent lanes. (See Chapter 430 and Traveled Way Cross Slope in 640.)

Cross Slope, Shoulder is the rate of elevation change across a shoulder. (See Chapters 430 and 640.)

Fill/Ditch Slope is the downward slope from edge of shoulder to bottom of ditch or catch. (See Chapters 430 and 640.)

Access is the means of entering or leaving a public road, street, or highway with respect to abutting private property or another public road, street, or highway. (See Chapter 1420.)

Clear Zone is the total roadside border area, starting at the edge of the traveled way, available for use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a nonrecoverable slope, and/or a clear run-out area. (The median is part of a clear zone.) (See Chapter 700.)

Signing, Delineation, Illumination are signs, guide posts, pavement markings, and lighting. (See Chapter 820 for signing and 1120 for bridge signs, Chapter 830 for delineation, and Chapter 840 for illumination.)

Vertical Clearance - see Chapter 1120.

Basic Safety is the list of safety items in Chapter 410.

Bicycle and Pedestrian See Chapter 1020, Bicycle Facilities, and Chapter 1025, Pedestrian Design Considerations, for definitions.

Bridges: Lane Width is the width of a lane on a structure. (See Chapters 430, 440, 640, 641, 940, and 1120.)

Bridges: Shoulder Width is the distance between the edge of traveled way and the face of curb or barrier, whichever is less. (See Chapters 430, 440, 640, 940, and 1120.) Also see Chapter 710 for shy distance requirements.

Bridges/Roadway: Vertical Clearance is the minimum height between the roadway, including shoulder, and an overhead obstruction. (See Chapter 1120.)

Bridges: Structural Capacity is the load bearing ability of a structure. (See Chapter 1120.)

Intersections/Ramp Terminals: Turn Radii See Chapter 910 for definition.

Intersections/Ramp Terminals: Angle See Chapter 910 for definition.

Intersections/Ramp Terminals: Intersection Sight Distance See Chapters 910 and 940 for definitions.

Barriers: Terminals and Transition Sections — **Terminals** are crashworthy end treatments for longitudinal barriers that are designed to reduce the potential for spearing, vaulting, rolling, or excessive deceleration of impacting vehicles from either direction of travel. Impact attenuators are considered terminals. Beam guardrail terminals include anchorage. — **Transition Sections** are sections of barriers used to produce a gradual stiffening of a flexible or semirigid barrier as it connects to a more rigid barrier or fixed object. (See Chapters 700, 710, and 720.)

Barriers: Standard Run are guardrail and other barriers as found in the *Standard Plans for Road Bridge and Municipal Construction* excluding terminals, transitions, attenuators, and bridge rails. (See Chapter 710.)

Barriers: Bridge Rail is barrier on a bridge excluding transitions. (See Chapter 710.)

(3) Design Level

In the non-Interstate matrices, design levels are noted in the cells by B, M, F, and sometimes with a number corresponding to a footnote on the matrix. For Improvement type projects full design level applies to all design elements except as noted in the design matrices and in other chapters as applicable. In the Interstate matrices, only full design level applies.

The design levels of basic, modified, and full (B, M, and F) were used to develop the design matrices. Each design level is based on the investment intended for the highway system and Project Type. (For example, the investment is higher for an Interstate overlay than for an overlay on a non-NHS route.)

A **blank cell** on a design matrix row signifies that the Design Element will not be addressed because it is beyond the scope of the typical project. In rare instances, a Design Element with a blank cell may be included if that element is linked to the original need that generated the project and is identified in the Project Summary or a Project Control Form.

Basic design level (B) preserves pavement structures, extends pavement service life, and maintains safe operations of the highway. See Chapter 410 for design guidance.

Modified design level (M) preserves and improves existing roadway geometrics, safety, and operational elements. See Chapter 430 for design guidance. Use full design level for design elements or portions of design elements that are not covered in Chapter 430.

Full design level (F) improves roadway geometrics, safety, and operational elements. See Chapter 440 and other applicable *Design Manual* chapters for design guidance.

(4) Design Variances

Types of design variances are design exceptions (DE), evaluate upgrades (EU), and deviations. See Chapter 330 concerning the Design Variance Inventory System (DVIS).

A **design exception (DE)** in a matrix cell indicates that WSDOT has determined that the Design Element is usually outside the scope of the Project Type. Therefore, an existing condition that does not meet or exceed the design level specified in the matrix may remain in place unless a need has been identified in the *Highway System Plan* and prioritized in accordance with the programming process. See Chapter 330 regarding documentation.

An **evaluate upgrade (EU)** in a matrix cell indicates that WSDOT has determined that the Design Element is an item of work that is to be considered for inclusion in the project. For an existing element that does not meet or exceed the specified design level, an analysis is required to determine the impacts and cost effectiveness of including the element in the project. The EU analysis must support the decision regarding whether or not to upgrade that element. See Chapter 330 regarding documentation.

A **deviation** is required when an existing or proposed Design Element differs from the specified design level for the project and neither DE nor EU processing is indicated. See Chapter 330 regarding documentation.

DE or EU with /F or /M in a cell means that the Design Element is to be analyzed with respect to the specified design level. For instance, a DE/F is analyzed with respect to full design level and might be recorded as having an existing Design Element that does not meet or exceed current full design level. An EU/M is analyzed to decide whether or not to upgrade any existing Design Element that does not meet or exceed current modified design level.

(5) Terminology in Notes

F/M Full for freeways/Modified for nonfreeway uses the word **freeway** to mean a divided highway facility that has a minimum of two lanes in each direction, for the exclusive use of traffic, and with full control of access. For matrix cells with an F/M designation, analyze freeway routes at full design level and nonfreeway routes at modified design level.

The **HAL, HAC, and PAL** mentioned in note (1) on Design Matrices 3, 4, and 5 are high accident locations (HAL), high accident corridors (HAC), and pedestrian accident locations (PAL).

The **Access Control Tracking System** mentioned in note (3) on Design Matrices 3, 4, and 5 is a list that is available on the web at http://www.wsdot.wa.gov/eesc/design/access/ under the RELATED SITES heading. See Chapter 1420 for access control basics and 1430 and 1435 for limited and managed access, respectively.

The **corridor or project analysis** mentioned in notes (2) and (4) on Design Matrices 3, 4, and 5 is the justification needed to support a change in design level from the indicated design level. The first step is to check for recommendations for future improvements in an approved Route Development Plan. If none are available, an analysis can be based on route continuity and other existing features. See Chapter 330 regarding documentation.

Note **(21) Analyses required** appears only on Design Elements for Risk projects on Design Matrices 3, 4, and 5. These Design Elements are to be evaluated using benefit/cost (B/C) to compare and rank each occurrence of the Design Elements. The B/C evaluation supports engineering decisions regarding which proposed solutions are included in a Risk project.

Most components of a Risk project will have a B/C of 1.0 or greater. Proposed solutions with a B/C ratio less than 1.0 may be included in the project based on engineering judgment of their significant contribution to corridor continuity. Risk program size, purpose and need, or project prioritization may lead to instances where design elements with a ratio greater than 1.0 are excluded from a project. The analysis, design decisions and program funding decisions are to be documented in the Design Documentation Package. Decisions regarding which design elements to include in a project are authorized at the WSDOT region level.

State Route	NHS Route Description	Beginning SR MP	Begin ARM	Ending SR MP	End ARM
US 2	I-5 to Idaho State Line	0.00	0.00	334.51	326.64
US 2 Couplet	Everett Couplet	0.00	0.00	1.64	0.87
US 2 Couplet	Brown Street Couplet	287.45	0.00	288.08	0.63
US 2 Couplet	Division Street Couplet	289.19	0.00	290.72	1.53
SR 3	US 101 to SR 104	0.00	0.00	60.02	59.81
SR 4	US 101 to I-5	0.00	0.00	62.28	62.27
I-5	Oregon State Line to Canadian Border	0.00	0.00	276.56	276.62
SR 8	US 12 to US 101	0.00	0.00	20.67	20.67
SR 9	SR 546 to Canadian Border	93.61	93.52	98.17	98.08
SR 9 Spur	Sumas Spur	98.00	0.00	98.25	0.24
SR 11	I-5 to Alaskan Ferry Terminal	19.93	19.93	21.28	21.28
US 12	US 101 to Idaho State Line	0.00	0.00	434.19	430.76
US 12 Couplet	Aberdeen Couplet	0.33	0.00	0.68	0.35
SR 14	I-5 to US 97	0.00	0.00	101.02	100.93
SR 14 Spur	Maryhill Spur	100.66	0.00	101.05	0.39
SR 16	I-5 to SR 3	0.00	0.00	29.19	27.01
SR 16 Spur	SR 16 to SR 3	28.74	0.00	29.13	0.39
SR 17	US 395 to I-90	7.43	0.00	50.89	43.40
SR 18	So. Federal Way Park & Ride to I-5	2.20B	0.00	0.00	0.53
SR 18	I-5 to I-90	0.00	0.53	27.91	28.41
SR 20	US 101 to I-5	0.00	0.00	59.54	59.49
SR 20 Spur	SR 20 to San Juan Ferry	47.89	0.00	55.67	7.78
SR 22	US 97 to I-82	0.70	0.00	4.00	3.31
SR 26	I-90 to US 195	0.00	0.00	133.53	133.61
SR 26 Spur	SR 26 to US 195	133.44	0.00	133.51	0.07
SR 28	US 2 to SR 281	0.00B	0.00	29.77	33.91
I-82	I-90 to Oregon State Line	0.00	0.00	132.60	132.57
I-90	I-5 to Idaho State Line	1.94	0.00	299.82	297.52
I-90 Reverse Lane	Reversible lane	1.99	0.00	9.44	7.45
SR 96	McCollum Park and Ride to I-5	0.00	0.00	0.52	0.52
US 97	Oregon State Line to SR 22	0.00B	0.00	61.44	61.30
US 97	I-90 to Canadian Border	133.90	118.80	336.48	321.62
US 97 Couplet	Maryhill Couplet	2.59	0.00	2.68	0.09
US 97 Spur	US 97 to US 2 (Orondo)	213.36	0.00	213.62	0.26
US 97 Y	SR 970 to US 97				
SR 99	188th to SeaTac Airport	18.35	14.70	18.77	15.12
SR 99	SR 509 to SR 104	26.04	22.40	43.60	39.84
US 101	Oregon State Line to SR 401	0.00	0.00	0.46	0.46
US 101	SR 4 to I-5	28.89	28.89	367.41	365.78
US 101 Couplet	Aberdeen Couplet	87.49	0.00	91.66	4.17
US 101 Couplet	Port Angeles Couplet	249.65	0.00	251.32	1.67
SR 104	US 101 to I-5	0.20	0.00	29.67	29.14
SR 109	Pacific Beach Access	0.00	0.00	30.25	30.29
SR 125	Oregon State Line to US 12	0.00	0.00	6.09	6.08
SR 125 Spur	SR 125 to US 12	6.09	0.00	6.76	0.67
SR 127	US 12 to SR 26	0.03	0.00	27.05	27.05
SR 128	US 12 to Idaho State Line	0.00	0.00	2.30	2.30

NHS Highways in Washington
Figure 325-2a

State Route	NHS Route Description	Beginning SR MP	Begin ARM	Ending SR MP	End ARM
SR 166	Naval Fuel Depot	0.02	0.00	3.40	3.38
SR 167	I-5 to I-405	0.00	0.00	27.28	28.60
I-182	I-82 to US 395	0.00	0.00	15.19	15.19
US 195	Idaho State Line to I-90	0.00B	0.00	95.99	93.37
US 195 Spur	US 195 to Idaho State Line	0.06	0.00	0.60	0.54
I-205	Oregon State Line to I-5	26.59	0.00	37.16	10.57
SR 240	Hanford Access	30.63	28.86	34.87	33.10
SR 270	US 195 to Idaho	0.00	0.00	9.89	9.89
SR 270	Pullman Couplet	2.67	0.00	2.90	0.23
SR 270	US 195 Y Connection	0.00	0.00	0.38	0.38
SR 281	SR 28 to I-90	0.00	0.00	10.55	10.55
SR 281 Spur	SR 281 to I-90	2.65	0.00	4.34	1.69
SR 303	SR 3 to SR 304	0.00B	0.00	8.73	8.89
SR 304	SR 16 to Bremerton Ferry	0.00	0.00	3.51	3.24
SR 305	SR 3 to Winslow Ferry	0.02	0.00	13.52	13.50
SR 307	SR 305 to SR 104	0.00	0.00	5.25	5.25
SR 310	SR 3 to SR 304	0.00	0.00	1.84	1.84
US 395	Congressional High Priority Route	13.05	13.05	270.26	275.09
SR 401	US 101 to SR 4	0.00	0.00	12.13	12.13
I-405	I-5 to I-5	0.00	0.00	30.32	30.30
SR 432	SR 4 to I-5	0.00	0.00	10.33	10.32
SR 433	Oregon State Line to SR 432	0.00	0.00	0.94	0.94
SR 500	I-5 to SR 503	0.00	0.00	5.96	5.96
SR 501	I-5 to Port of Vancouver	0.00	0.00	3.83	3.42
SR 502	I-5 to SR 503	0.00B	0.00	7.56	7.58
SR 503	SR 500 to SR 502	0.00	0.00	8.09	8.09
SR 509	SR 99 to 12th Place S	24.35B	26.13	29.83	33.11
SR 509	Pacific Ave. to Marine View Drive	0.22	1.44	3.20	4.42
SR 512	I-5 to SR 167	0.00	0.00	12.06	12.06
SR 513	Sandpoint Naval Air Station	0.00	0.00	3.35	3.35
SR 516	I-5 to SR 167	2.03	2.02	4.72	4.99
SR 518	I-5 to SR 509	0.00	0.00	3.81	3.42
SR 519	I-5 to Seattle Ferry Terminal	0.00	0.00	1.14	1.14
SR 520	I-5 to SR 202	0.00	0.00	12.83	12.82
SR 522	I-5 to US 2	0.00	0.00	24.68	24.68
SR 524	Lynnwood Park and Ride to I-5	4.64	4.76	5.20	5.32
SR 524 Spur	Cedar Way Spur - Lynnwood Park and Ride to I-5	4.64	0.00	5.14	0.50
SR 525	I-5 to SR 20	0.00	0.00	30.49	30.72
SR 526	SR 525 to I-5	0.00	0.00	4.52	4.52
SR 529	Everett Homeport	0.00	0.00	2.20	2.20
SR 539	I-5 to Canadian Border	0.00	0.00	15.16	15.16
SR 543	I-5 to Canadian Border	0.00	0.00	1.09	1.09
SR 546	SR 539 to SR 9	0.00	0.00	8.02	8.02
I-705	I-5 to Schuster Parkway	0.00	0.00	1.50	1.50
SR 970	I-90 to US 97	0.00	0.00	10.31	10.31
SR 970 Y	Y connection to US 97	0.00	0.00	0.10	0.10

NHS Highways in Washington
Figure 325-2b

⇩ Project Type																Bridges			Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width (13)	On/Off Conn.	Median Width	Cross Slope Lane	Cross Slope Shldr	Fill/Ditch Slopes	Clear Zone	Sign. (10)	Delini. (9)	Illumin.	Vert. Clear. (11)	Bike & Ped.	Lane Width	Shldr Width	Structural Capacity	Term. & Trans. Section (12)	Std Run	Bridge Rail (14)(19)
(1-1) Preventive Maintenance																					
Pavement Restoration																					
(1-2) Diamond Grinding										EU	EU	F		DE					F	EU	F
(1-3) Milling with HMA Inlays									EU	F	EU	F		DE					F	EU	F
(1-4) Nonstructural Overlay				DE			EU	EU	EU	F	EU	F		EU					F	F	F
Pavement Rehab./Resurf.																					
(1-5) HMA Structural Overlays	EU	DE	F	F	F(17)	DE	F	EU	F	F	EU	F	F	F		F	DE		F	F	F
(1-6) PCCP Overlays	EU	DE	F	F	F(17)	DE	F	EU	F	F	EU	F	F	F		F	DE		F	F	F
(1-7) Dowel Bar Retrofit	EU	DE	F	F	F(17)	DE	DE		F	F	EU	F	F	DE			DE		F	F	F
Bridge Rehabilitation																					
(1-8) Bridge Deck Rehabilitation												F		F		F	DE	(11)	F(6)	F(22)	F
Safety																					
(1-9) Median Barrier				DE															F(20)	F(20)	
(1-10) Guardrail Upgrades				DE						F									F	F(23)	
(1-11) Bridge Rail Upgrades																			F	F(22)	F
Reconstruction (16)																					
(1-12) New/Reconstruction	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

☐ Not Applicable
F Full design level. See Chapter 440.
DE Design Exception to full design level.
EU Evaluate Upgrade to full design level.

(6) Applies only to bridge end terminals and transition sections.
(9) Continuous shoulder rumble strips required in rural areas. See Chapter 700.
(10) See Chapter 820.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(13) See Chapters 440 and 640.
(14) Includes crossroad bridge rail. See Chapter 710.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(17) DE for existing acceleration/deceleration lanes when length meets posted freeway speed and no significant accidents. See Chapter 940.
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(20) Applies to median elements only.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.

Design Matrix 1
Interstate Routes (Main Line)
Figure 325-3

⇩ Project Type / Design Elements ⇨	Ramps and Collector Distributors: Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	On/Off Conn.	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Limited Access	Clear Zone	Sign., Del., Illumin. (9)(10)	Vertical Clear. (11)	Bike & Ped.	Ramp Terminals: Turn Radii	Angle	I/S Sight Dist.	Barriers: Term. & Trans. Section (12)	Std Run	Bridge Rail (14)(19)	Cross Road: Lane Width	Shldr Width	Fill/ Ditch Slopes	Limited Access	Clear Zone	Sign., Del., Illumin. (10)	Vert. Clear. (11)	Ped. & Bike	Barriers: Term. & Trans. Section (12)	Std Run	Bridge Rail (14)(19)
(2-1) Preventive Maintenance																															
Pavement Restoration																															
(2-2) Diamond Grinding											EU	F(15)						F	EU	F					EU	F(15)			F	EU	F
(2-3) Milling with HMA Inlays									EU		F	F(15)	F	M				F	F	F			EU		F	F(15)		M	F	F	F
(2-4) Nonstructural Overlay							EU	EU	EU		F	F(15)	F	M				F	F	F			EU		F	F(15)		M	F	F	F
Pavement Rehab./Resurf.																															
(2-5) HMA Structural Overlays	EU	DE	F	F	F	F(17)	F	EU	F	F	F	F(15)	F	M	F	F	F	F	F	F	DE	DE	DE	F	F	F(15)	F	M	F	F	F
(2-6) PCCP Overlays	EU	DE	F	F	F	F(17)	F	EU	F	F	F	F(15)	F	M	F	F	F	F	F	F	DE	DE	DE	F	F	F(15)	F	M	F	F	F
(2-7) Dowel Bar Retrofit	DE		DE	DE	F	F(17)	DE		F	F	F	F(15)	DE		F	F	F	F	F	F				F		F(15)			F	F	F
Bridge Rehabilitation																															
(2-8) Bridge Deck Rehabilitation													F	M				F(6)	F(22)	F							F	M	F(6)	F(22)	F
Safety																															
(2-9) Intersection			F	F	F				F	F	F	F		M	F	F	F	F	F	F			F	F	F	F	F	M	F	F	F
(2-10) Guardrail Upgrades				DE							F							F	F(23)										F	F(23)	
(2-11) Bridge Rail Upgrades																		F	F(22)	F									F	F(22)	F
Reconstruction (16)																															
(2-12) New/Reconstruction	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

☐ Not Applicable
F Full design level. See Chapter 440.
M Modified design level. See Chapter 430.
DE Design Exception to full design level.
EU Evaluate Upgrade to full design level.

(6) Applies only to bridge end terminals and transition sections.
(9) Continuous shoulder rumble strips required in rural areas. See Chapter 700.
(10) See Chapter 820.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(14) Includes crossroad bridge rail. See Chapter 710.
(15) EU for signing and illumination.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(17) DE for existing acceleration/deceleration lanes when length meets posted freeway speed and no significant accidents. See Chapter 940.
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.

Design Matrix 2
Interstate Interchange Areas
Figure 325-4

⇩ Project Type																Bridges (11)				Intersections			Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	On/Off Conn.	Median Width	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Access (3)	Clear Zone (18)	Sign., Del., Illumin.	Basic Safety	Bike & Ped.	Lane Width	Shldr Width	Vertical Clear-ance	Structural Capacity	Turn Radii	Angle	I/S Sight Dist.	Term. & Trans. Section (12)	Std Run	Bridge Rail (14)(19)
Preservation																									
Roadway																									
(3-1) Non-Interstate Freeway	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F		B	B		DE/F	DE/F	F					F	B	F
(3-2) HMA/PCCP/BST Overlays	DE/M	DE/M	DE/M	DE/M	DE/F	DE/F	DE/M	DE/M	DE/M	DE/M			B	B	M	DE/M	DE/M	F				B	F	B	F
(3-3) Replace HMA w/ PCCP at I/S	DE/M	DE/M	EU/M	EU/M	DE/F		DE/M	EU/M	DE/M	DE/M			B	B	M	DE/M	DE/M	F				B	F	B	F
Structures																									
(3-4) Bridge Replacement	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)		F	F		F	F(2)	F(2)	F	F	F(2)	F(2)	F	F	F	F
(3-5) Bridge Deck Rehab.													B	B	M			F					F(6)	F(22)	F
Improvements (16)																									
Mobility																									
(3-6) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	F	F
(3-7) Urban	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F (2)	F	F	F (2)	F (2)	F	F	F	F
(3-8) Rural	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F (2)	F	F	F (2)	F (2)	F	F	F	F
(3-9) HOV	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F (2)	F	F	F (2)	F (2)	F	F	F	F
(3-10) Bike/Ped. Connectivity	(5)	(5)	(5)	(5)	(5)			(5)	(5)	(5)	(5)	(5)	(5)		F	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Safety																									
(3-11) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F		F	F	F	F	F	F
(3-12) Intersection (1)			F(2)	F(2)	F					F (2)	F	F	F		M					F	F	F	F	F	F
(3-13) Corridor (1)(24)	M(4)	M(4)	M(4)	M(4)	F	F(17)	M(4)	M(4)	M(4)	M(4)	F	F	F		F	M(4)	M(4)	F		M(4)	M(4)	F	F	F	F
(3-14) Median Barrier				DE/F																			F(20)	F(20)	
(3-15) Guardrail Upgrades				DE/F																			F	F(23)	
(3-16) Bridge Rail Upgrades																							F	F(22)	F
(3-17) Risk: Roadside										F	EU/F	F	F										F	F	F
(3-18) Risk: Sight Distance	F/M(21)	F/M(21)	F/M(21)	F/M(21)						F/M(21)	F(21)	F(21)	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
(3-19) Risk: Roadway Width			F/M(21)	F/M(21)	F(21)	F(21)	F/M(21)	F/M(21)	F/M(21)	F/M(21)	F	F	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
(3-20) Risk: Realignment	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F		F(2)	F(2)	F(2)	F	F	F
Economic Development																									
(3-21) Freight & Goods (Frost Free)(8)	F(2)	F(2)	F(2)	F(2)	F	F (2)	F(2)	F(2)	F(2)	F(2)	EU/F	F	B		EU/F(26)	DE/F	DE/F	F	F	EU/F	EU/F	EU/F	F	F	F
(3-22) Four-Lane Trunk System	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	F	F
(3-23) Rest Areas (New)	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F		F	F	F	F	F	F
(3-24) Bridge Restrictions	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F(2)		F	F		EU/F(26)	F(2)	F(2)	F	F	F(2)	F(2)	F	F	F	F
(3-25) Bike Routes (Shldrs)			EU/M	(7)	EU/F				EU/M	EU/M			B	B	F	EU/M	EU/M	F				B	F	B	EU/F

☐ Not Applicable
F Full design level. See Chapter 440.
M Modified design level. See Chapter 430.
B Basic design level. See Chapter 410.
F/M Full for freeways/Modified for nonfreeway
DE Design Exception
EU Evaluate Upgrade

(1) Collision Reduction (HAL, HAC, PAL), or Collision Prevention (At-Grade Removal, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in the matrix.
(2) Modified design level may apply based on a corridor or project analysis. See 325.03(5).
(3) If designated as L/A acquired in the Access Control Tracking System, limited access requirements apply. If not, managed access applies. See 325.03(5).
(4) Full design level may apply based on a corridor or project analysis. See 325.03(5).
(5) For bike/pedestrian design see Chapters 1020 and 1025.
(6) Applies only to bridge end terminals and transition sections.
(7) 4 ft minimum shoulders.
(8) If all weather structure can be achieved with spot digouts and overlay, modified design level applies to NHS highways and basic design level applies to non-NHS highways.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(14) Includes crossroad bridge rail. See Chapter 710.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(17) DE for existing acceleration/deceleration lanes when length meets posted freeway speed and no significant accidents. See Chapter 940.
(18) On managed access highways within the limits of incorporated cities and towns, City and County Design Standards apply to areas outside the curb or outside the paved shoulder where no curb exists.
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(20) Applies to median elements only.
(21) Analyses required. See 325.03(5) for details.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.
(24) Apply Full design level to projects that realign or reconstruct significant portions of the alignment.
(26) Sidewalk ramps must be addressed for ADA compliance. See Chapter 1025.

Design Matrix 3
Main Line NHS Routes (Except Interstate)
Figure 325-5

Design Matrix 4
Interchange Areas, NHS (Except Interstate) and Non-NHS
Figure 325-6

Ramps and Collector Distributors

⇩ Project Type / Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	On/Off Conn.	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Access (3)	Clear Zone	Sign, Del., Illumin.	Basic Safety	Bike & Ped.	Ramp Terminals: Turn Radii	Ramp Terminals: Angle	Ramp Terminals: I/S Sight Dist.	Barriers: Term. & Trans. Section (12)	Barriers: Std Run	Barriers: Bridge Rail (14)(19)
Preservation																				
Roadway																				
(4-1) Non-Interstate Freeway	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F		B	B	M	DE/F	DE/F	DE/F	F	B	F
(4-2) HMA/PCCP/BST Overlays Ramps												B	B	M			B	F	B	F
Structures																				
(4-3) Bridge Replacement	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F	F	F
(4-4) Bridge Deck Rehab.												B	B	M				F(6)	F(22)	F
Improvements (16)																				
Mobility																				
(4-5) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F
(4-6) Urban	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F	F	F	F
(4-7) Rural	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F	F	F	F
(4-8) HOV By Pass	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F	F	F	F
(4-9) Bike/Ped. Connectivity	(5)	(5)	(5)	(5)	(5)		(5)	(5)	(5)	(5)	(5)	(5)		F	(5)	(5)	(5)	(5)	(5)	(5)
Safety																				
(4-10) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F		M	F	F	F	F	F	F
(4-11) At Grade (1)(25)	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F	F	F	F
(4-12) Intersection (1)			F(2)	F(2)	F				F(2)	F	F	F		M	F	F	F	F	F	F
(4-13) Guardrail Upgrades				DE/F														F	F(23)	
(4-14) Bridge Rail Upgrades																				
(4-15) Risk: Roadside									F	EU/F	F	F								
(4-16) Risk: Sight Distance	F/M(21)	F/M(21)	F/M(21)	F/M(21)					F/M(21)	F(21)	F(21)	F		F	F/M(21)	F/M(21)	F	F	F	F
(4-17) Risk: Roadway Width			F/M(21)	F/M(21)	F	F(21)	F/M(21)	F/M(21)	F/M(21)	F	F	F		F	F/M(21)	F/M(21)	F	F	F	F
(4-18) Risk: Realignment	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F/M(21)	F/M(21)	F	F	F	F
Economic Development																				
(4-19) Four-Lane Trunk System	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F

Cross Road

⇩ Project Type / Design Elements ⇨	Lane Width	Shldr Width	Fill/ Ditch Slopes	Access (3)	Clear Zone	Sign., Del., Illumin.	Basic Safety	Vert. Clear. (11)	Ped. & Bike	Barriers: Term. & Trans. Section (12)	Barriers: Std . Run	Barriers: Bridge Rail (14)(19)
Preservation												
Roadway												
(4-1) Non-Interstate Freeway	DE/F	DE/F	DE/F			B	B	F	M	F	B	F
(4-2) HMA/PCCP/BST Overlays Ramps						B	B	F	M	F	B	F
Structures												
(4-3) Bridge Replacement	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-4) Bridge Deck Rehab.						B	B	F	M	F(6)	F(22)	F
Improvements (16)												
Mobility												
(4-5) Non-Interstate Freeway	F	F	F	F	F	F		F	F	F	F	F
(4-6) Urban	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-7) Rural	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-8) HOV By Pass	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-9) Bike/Ped. Connectivity	(5)	(5)	(5)			(5)		(5)	F	(5)	(5)	(5)
Safety												
(4-10) Non-Interstate Freeway	F	F	F	F	F	F		F	M	F	F	F
(4-11) At Grade (1)(25)	F(2)	F(2)	F(2)	F	F	F		F	F	F	F	F
(4-12) Intersection (1)			F(2)	F	F	F		F	M	F	F	F
(4-13) Guardrail Upgrades										F	F(23)	
(4-14) Bridge Rail Upgrades										F	F(22)	F
(4-15) Risk: Roadside			F	EU/F	F	F				F	F	F
(4-16) Risk: Sight Distance			F/M(21)	F(21)	F(21)			F(21)	F			
(4-17) Risk: Roadway Width	F/M(21)	F/M(21)	F/M(21)	F	F			F(21)	F	F	F	F
(4-18) Risk: Realignment	F(2)	F(2)	F(2)	F	F			F(21)	F	F	F	F
Economic Development												
(4-19) Four-Lane Trunk System	F	F	F	F	F	F		F		F	F	F

☐ Not Applicable
F Full design level. See Chapter 440.
M Modified design level. See Chapter 430.
B Basic design level. See Chapter 410.
F/M Full for freeways/Modified for nonfreeway
DE Design Exception
EU Evaluate Upgrade

(1) Collision Reduction (HAL, HAC, PAL), or Collision Prevention (At-Grade Removal, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in the matrix.
(2) Modified design level may apply based on a corridor or project analysis. See 325.03(5).
(3) If designated as L/A acquired in the Access Control Tracking System, limited access requirements apply. If not, managed access applies. See 325.03(5).
(4) Full design level may apply based on a corridor or project analysis. See 325.03(5).
(5) For bike/pedestrian design see Chapters 1020 and 1025.
(6) Applies only to bridge end terminals and transition sections.
(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(14) Includes crossroad bridge rail. See Chapter 710.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(21) Analyses required. See 325.03(5) for details.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.
(25) For main line, use the Project Type row for Safety, Non-Interstate Freeway on Matrix 3 for NHS and on Matrix 5 for non-NHS.

⇩ Project Type														Bridges (11)				Intersections			Barriers		
Design Elements ⇨	Horiz. Align.	Vert. Align.	Lane Width	Shldr Width	Lane Tran-sition	Median Width	Cross Slope Lane	Cross Slope Shldr	Fill/ Ditch Slopes	Access (3)	Clear Zone (18)	Sign, Del., Illumin.	Basic Safety	Bike & Ped.	Lane Width	Shldr Width	Vertical Clear.	Structural Capacity	Turn Radii	Angle	I/S Sight Dist.	Term. & Trans. Section (12)	Std Run	Bridge Rail (19)
Preservation																								
Roadway																								
(5-1) HMA/PCCP												B	B	M			F				B	F	B	F
(5-2) BST																								
(5-3) BST Routes/Basic Safety												B	B								B	F	B	F
(5-4) Replace HMA with PCCP at I/S			EU/M	EU/M		DE/M	EU/M					B	B	M			F					F	B	F
Structures																								
(5-5) Bridge Replacement	M	F	M	M	F		M	M	M		F	F		F	F(2)	F(2)	F	F	M	M	F	F	F	F
(5-6) Bridge Repl. (Multilane)	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	F(2)		F	F		F	F(2)	F(2)	F	F	F(2)	F(2)	F	F	F	F
(5-7) Bridge Deck Rehab												B	B	M								F(6)	F(22)	F
Improvements (16)																								
Mobility																								
(5-8) Urban (Multilane)	F(2)	F(2)	F(2)	F(2)	F	F(2)	F(2)	F(2)	(2)	F	F	F		F	F(2)	F(2)	F	F	EU/F	EU/F	F	F	F	F
(5-9) Urban	M	M	M	M	F		M	M	M	F	F	F		F	M	M	F	F	EU/M	EU/M	F	F	F	F
(5-10) Rural	M	M	M	M	F	M	M	M	M	F	F	F		F	M	M	F	F	EU/M	EU/M	F	F	F	F
(5-11) HOV	M	M	M	M	F	M	M	M	M	F	F	F		F	M	M	F	F	EU/M	EU/M	F	F	F	F
(5-12) Bike/Ped. Connectivity	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)		F	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Safety																								
(5-13) Non-Interstate Freeway	F(2)	F(2)	F(2)	F(2)	F(2)	F(2)	F(2)	F(2)	F(2)	F	F	F		F	F(2)	F(2)	F		F(2)	F(2)	F	F	F	F
(5-14) Intersection (1)			M(4)	M(4)	F				M(4)	F	F	F		M					M(4)	M(4)	F	F	F	F
(5-15) Corridor (1)	M(4)	M(4)	M(4)	M(4)	F	M(4)	M(4)	M (4)	M(4)	F	F	F		M	M(4)	M(4)	F		M(4)	M(4)	F	F	F	F
(5-16) Median Barrier				DE/F																		F(20)	F(20)	
(5-17) Guardrail Upgrades				DE/F																		F	F(23)	
(5-18) Bridge Rail Upgrades																						F	F(22)	F
(5-19) Risk: Roadside									M(4)	EU/F	F	F										F	F	F
(5-20) Risk: Sight Distance	F/M(21)	F/M(21)	F/M(21)	F/M(21)					F/M(21)	F(21)	F(21)	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
(5-21) Risk: Roadway Width			F/M(21)	F/M(21)	F	F/M(21)	F/M(21)	F/M(21)	F/M(21)	F	F	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
(5-22) Risk: Realignment	F/M	F/M	F/M	F/M	F	F/M	F(2)	F(2)	F/M	F	F	F		F	F(21)	F(21)	F(21)		F/M(21)	F/M(21)	F(21)	F	F	F
Economic Development																								
(5-23) Freight & Goods (Frost Free) (8)	EU/M	EU/M	EU/M	EU/M	EU/F	EU/M	M	M	EU/M		F	B	B	EU/F(26)	DE/M	DE/M	F		EU/M	EU/M	EU/F	F	B	F
(5-24) Rest Areas (New)	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F			F	F	F	F	F	F
(5-25) Bridge Restrictions	M	F	M	M	F	M	M	M	M		F	F		EU/F(26)	M	M	F	F	M	M	F	F	F	F
(5-26) Bike Routes (Shldrs)			EU/M	(7)	EU/F			EU/M	EU/M			B	B	F	EU/M	EU/M					B	F	B	EU/F

☐ Not Applicable
F Full design level. See Chapter 440.
M Modified design level. See Chapter 430.
F/M Full for freeways/Modified for nonfreeway
B Basic design level. See Chapter 410.
DE Design Exception
EU Evaluate Upgrade

(1) Collision Reduction (HAL, HAC, PAL), or Collision Prevention (At Grade Removal, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in the matrix.
(2) Modified design level may apply based on a corridor or project analysis. See 325.03(5).
(3) If designated as L/A acquired in the Access Control Tracking System, limited access requirements apply. If not, managed access applies. See 325.03(5).
(4) Full design level may apply based on a corridor or project analysis. See 325.03(5).
(5) For bike/pedestrian design see Chapters 1020 and 1025.
(6) Applies only to bridge end terminals and transition sections.
(7) 4 ft minimum shoulders.
(8) If all weather structure can be achieved with spot digouts and overlay, modified design level applies to NHS highways and basic design level applies to non-NHS highways.

(11) See Chapter 1120.
(12) Impact attenuators are considered as terminals.
(16) For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 325.03(2).
(18) On managed access highways within the limits of incorporated cities and towns, City and County Design Standards apply to areas outside the curb or outside the paved shoulder where no curb exists.
(19) The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.
(20) Applies to median elements only.
(21) Analyses required. See 325.03(5) for details.
(22) Upgrade barrier, if necessary, within 200 ft of the end of the bridge.
(23) See description of Guardrail Upgrades Project Type, 325.03(1) regarding length of need.
(26) Sidewalk ramps must be addressed for ADA compliance. See Chapter 1025.

Design Matrix 5
Main Line Non-NHS Routes
Figure 325-7

Chapter 330 Design Documentation, Approval, and Process Review

330.01 General

The Project File (PF) contains the documentation for planning, scoping, programming, design, approvals, contract assembly, utility relocation, needed right of way, advertisement, award, construction, and maintenance review comments for a project. A Project File is completed for all projects and is retained by the region office responsible for the project. Responsibility for the project may pass from one office to another during the life of a project, and the Project File follows the project as it moves from office to office. Portions of the Project File that are not designated as components of the Design Documentation Package (DDP) may be purged when retention of the construction records is no longer necessary.

The Design Documentation Package is a part of the Project File. It documents and justifies design decisions and the design process that was followed. The Design Documentation Package is retained in a permanent, retrievable file for a period of 75 years, in accordance with Washington State Department of Transportation (WSDOT) records retention policy.

For operational changes and developer projects, design documentation is required and is retained by the region office responsible for the project, in accordance with WSDOT records retention policy. All participants in the design process must provide the appropriate documentation for their decisions.

330.02 References

Federal/State Laws and Codes

Code of Federal Regulations (CFR) 23 CFR 635.111 "Tied bids"

23 CFR 635.411 "Material or product selection"

Revised Code of Washington (RCW) 47.28.030, Contracts – State forces – Monetary limits – Small businesses, minority, and women contractors – Rules

RCW 47.28.035, Cost of project, defined

Washington Federal-Aid Stewardship Agreement, as implemented in the design matrices (Chapter 325)

Design Guidance

Advertisement and Award Manual, M 27-02, WSDOT

Directional Documents Index, WSDOT, at: http://wwwi.wsdot.wa.gov/docs/

Executive Order E 1010.00, "Certification of Documents by Licensed Professionals," WSDOT

Hydraulics Manual, M 23-03, WSDOT

Master Plan for Limited Access Highways, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Roadside Classification Plan, M 25-31, WSDOT

Route Development Plan, WSDOT

Washington State Highway System Plan, WSDOT

Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

330.03 Definitions

Design Approval Documented approval of the design criteria, which becomes part of the Design Documentation Package. This approval is an endorsement of the design criteria by the designated representative of the approving organization, as shown in Figures 330-2a and 2b.

design exception (DE) Preauthorization to omit correction of an existing design element for various types of projects, as designated in the design matrices. (See Chapter 325.) A DE designation indicates that the design element is normally outside the scope of the project type. (See Figure 330-1.)

design variance A recorded decision to differ from the design level specified in the *Design Manual*, such as an Evaluate Upgrade (EU) not upgraded, a DE, or a deviation. EUs leading to an upgrade are documented but are not considered to be variances. A project or corridor analysis may also constitute a design variance if that analysis leads to a decision to use a design level or design classification that differs from what the *Design Manual* specifies for the project type.

Design Variance Inventory (DVI) A list of design elements that will not be improved in accordance with the *Design Manual* criteria designated for the project.

Design Variance Inventory System (DVIS) A database application developed to generate the DVI form. The DVIS also provides query functions, giving designers an opportunity to search for previously granted variances. The DVIS application can be accessed at: http://www.wsdot.wa.gov/eesc/design/projectdev/

deviation A documented decision granting approval at project-specific locations to differ from the design level specified in the *Design Manual*. (See Figures 325-3 through 7 and Figure 330-1.)

environmental documents:

- ***NEPA*** National Environmental Policy Act
- ***SEPA*** [Washington] State Environmental Policy Act
- ***CE*** NEPA: Categorical Exclusion
- ***CE*** SEPA: Categorical Exception
- ***EA*** Environmental Assessment
- ***ECS*** Environmental Classification Summary
- ***EIS*** Environmental Impact Statement
- ***ERS*** Environmental Review Summary
- ***FONSI*** Finding Of No Significant Impact
- ***ROD*** Record of Decision

evaluate upgrade (EU) A decision-making process to determine whether or not to correct an existing design element as designated in the design matrices. Documentation is required. (See Figure 330-1.)

FHWA Federal Highway Administration.

HQ The Washington State Department of Transportation Headquarters organization.

Project Control Form A form used to document and approve revisions to project scope, schedule, or budget, from a previously approved Project Definition (see Project Summary).

Project Development Approval Final approval of all project development documents by the designated representative of the approving organization prior to the advertisement of a capital transportation project. (See Figures 330-2a and 2b.)

Project File (PF) A file containing all documentation and data for all activities related to a project. (See 330.01 and 330.04.)

- ***Design Documentation Package (DDP)*** The portion of the Project File, including Project Development Approval, that will be retained long term in accordance with WSDOT document retention policies. Depending on the scope of the project, it contains the Project Summary and some or all of the other documents discussed in this chapter. Common components are listed in Figure 330-5. Technical reports and calculations are part of the Project File, but are not designated as components of the DDP. Include estimates and justifications for decisions made in the DDP. (See 330.04(2).) The DDP explains how and why the design was chosen, and documents approvals. (See 330.01.)

Project Summary A set of electronic documents consisting of the Design Decisions Summary (DDS), the Environmental Review Summary (ERS), and the Project Definition (PD). The Project Summary is part of the design documentation required to obtain Design Approval and is ultimately part of the design documentation required for Project Development Approval. (See 330.06.)

- ***Design Decisions Summary (DDS)*** An electronic document that records major design decisions regarding roadway geometrics, roadway and roadside features, and other issues that influence the project scope and budget.
- ***Environmental Review Summary (ERS)*** An electronic document that records the environmental requirements and considerations for a specific project.
- ***Project Definition (PD)*** An electronic document that records the purpose and need of the project, along with program level and design constraints.

scoping phase The first phase of project development for a specific project. It follows identification of the need for a project and precedes detailed project design. It is the process of identifying the work to be done and developing a cost estimate for completing the design and construction. The Project Summary, engineering and construction estimates, and several technical reports (geotechnical, surfacing, bridge condition, etc.) are developed during this phase.

330.04 Design Documentation

(1) Purpose

Design documentation records the evaluations and decisions by the various disciplines that result in design recommendations. Design assumptions and decisions made prior to and during the scoping phase are included. Changes that occur throughout project development are documented. Required justifications and approvals are also included.

The DDP identifies the purpose and need of the project and documents how the project addresses the purpose and need. The "Project Design Documentation Check List" has been developed as a tool to assist in generating the contents of the DDP and the PF. The use of this tool is optional and can be found at:
http://www.wsdot.wa.gov/eesc/design/projectdev/

(2) Design Documents

The DDP portion of the PF preserves the decision documents generated during the design process. In each package, a summary (list) of the documents is recommended.

The design documents commonly included in the PF and DDP for all but the simplest projects are listed in Figure 330-5.

Documentation is not required for components not related to the project.

The DVI is *required* for all projects on the National Highway System (NHS) having design variances; it is recommended for all projects having design variances. The DVI lists all EU not upgraded to the applicable design level, DE, and deviations as indicated by the design matrices. Record variances resulting from a project or corridor analysis in the DVI. Use the DVIS database application to record and manage design variances. The DVIS is available at:
http://www.wsdot.wa.gov/eesc/design/projectdev/

The ERS and the PD are required for most projects. Exceptions will be identified by the Project Control and Reporting Office.

The DDS is not required for the following project types unless they involve reconstructing the lanes, shoulders, or fill slopes. Since these and some other project types are not included in the design matrices, evaluate them with respect to modified design level (M) for non-NHS routes and full design level (F) for NHS routes. Include in the evaluation only those design elements specifically impacted by the project. Although the following list illustrates some of the project types that do not require a DDS, the list is not intended to be a complete accounting of all such projects. Consult with the HQ Project Control and Reporting Office for projects not included in the list.

- Bridge painting
- Crushing and stockpiling
- Pit site reclamation
- Lane marker replacement
- Guidepost replacement
- Signal rephasing
- Signal upgrade
- Seismic retrofit
- Bridge joint repair
- Navigation light replacement
- Signing upgrade
- Illumination upgrade
- Rumble strips
- Electrical upgrades
- Major drainage
- Bridge scour
- Fish passage
- Other projects as approved by the HQ Design Office

(3) Certification of Documents by Licensed Professionals

All original technical documents must bear the certification of the responsible licensee. (See Executive Order E 1010.00.)

(4) Design Exception (DE), Evaluate Upgrade (EU), and Deviation Documentation

In special cases, projects may need to address design elements, which are shown as blank cells in a design matrix. (See Figure 330-1.) These special cases must be coordinated with the appropriate Assistant State Design Engineer (ASDE) and the HQ Project Control and Reporting Office. When this is necessary, document the reasons for inclusion of that work in your project.

When the design matrices specify a DE for a design element, the DE documentation must specify the matrix and row, the design element, and the limits of the exception. When a DVI is required for the project, the DE locations must be recorded in the inventory.

The EU process determines if an item of work will or will not be done, through analysis of factors such as benefit/cost, route continuity, accident reduction potential, environmental impact, and economic development. Document all EU decisions to the DDP using the list in Figure 330-6 as a guide for the content. The cost of the improvement must always be considered when making EU decisions. EU examples on the Internet can serve as models for development of EU documentation. The appropriate approval authority for EUs is designated in Figures 330-2a and 2b.

Deviation requests are stand-alone documents requiring enough information and project description for an approving authority to make an informed decision of approval or denial. Documentation of a deviation must contain justification and must be approved at the appropriate administrative level, as shown in Figures 330-2a and 2b. Submit the request as early as possible because known deviations are to be approved prior to Project Development Approval or Intersection/Interchange Plan approval.

When applying for deviation approval, it is necessary to provide two explanations. The first identifies the design element and explains why the design level specified in the design matrices was not or cannot be used. The second provides the justification for the design that is proposed. Justification for a deviation must be supported by at least two of the following:

- Accident history and accident analysis
- Benefit/cost analysis
- Engineering judgment
- Environmental issues
- Route continuity

Engineering judgment includes a reference to another publication, with an explanation of why that reference is applicable to the situation encountered on the project.

If the element meets current AASHTO guidance adopted by FHWA, such as *A Policy on Geometric Design of Highways and Streets*, but not the *Design Manual* criteria, it is a deviation from the *Design Manual* that does not require

Matrix Cell Content	Project corrects design elements that do not conform to specified design level	Document to file[1]	Record in DVIS[2]
Blank cell in design matrix		No[3]	No
Cell Entry			
Full (F), Modified (M), or Basic (B) (with no DE or EU qualifiers)	Yes	No	No
	No[4]	Yes[5]	Yes
Design Exception (DE)	Yes[3]	DDP	No
	No	DDP	Yes
Evaluate Upgrade (EU)[5]	Yes	DDP	No
	No	DDP	Yes

DDP = Document to Design Documentation Package

Notes:
[1] See 330.04(3).
[2] See 330.04(2).
[3] Document to the DDP if the element is included in the project as identified in the Project Summary or Project Control Form.
[4] Nonconformance with specified design level (see Chapter 325) requires an approved deviation.
[5] Requires supporting justification. See 330.04(4).

Design Matrix Documentation Requirements
Figure 330-1

approval by FHWA or the HQ Design Office. However, it only requires documentation and justification in the DDP to support the use of the AASHTO guidance. The following documentation is required:

- Identify the design element
- Explain why the design level specified in the design matrices was not used
- Explain which AASHTO guidance was used (including the title of the AASHTO guidance, the publication date, and the chapter and page number of the guidance)

Deviation approval is at the appropriate administrative level, as shown in Figures 330-2a and 2b.

Reference a corridor or project analysis as supporting justification for design deviations dealing with route continuity issues. (See Chapter 325.)

Once a deviation is approved, it applies to that project only. When a new project is programmed at the same location, the subject design element must be reevaluated and either (1) the subject design element is rebuilt to conform with the applicable design level, or (2) a new deviation is developed, approved, and preserved in the DDP for the new project. Check the DVIS for help in identifying previously granted deviations.

A change in a design level resulting from an approved *Route Development Plan* or a corridor or project analysis, as specified in design matrix notes, is documented similar to a deviation. Design elements that do not comply with the design level specified in an approved corridor or project analysis are documented as deviations.

To prepare a deviation request, use the list in Figure 330-7 as a general guide for the sequence of the content. The list is not all-inclusive of potential content and it might include suggested topics that do not apply to a particular project. Design deviation examples can be found at: http://www.wsdot.wa.gov/eesc/design/projectdev/

330.05 Project Development

In general, the region initiates the development of a specific project by preparing the Project Summary. Some project types may be initiated by other WSDOT groups such as the HQ Bridge and Structures Office or the HQ Traffic Office, rather than the region. The project coordination with other disciplines (such as Real Estate Services, Roadside and Site Development, Utilities, and Environmental) is started in the project scoping phase and continues throughout the project's development. The region coordinates with state and federal resource agencies and local governments to provide and obtain information to assist in developing the project.

The project is developed in accordance with all applicable Directives, Instructional Letters, Supplements, and manuals; the *Master Plan for Limited Access Highways*; the *Washington State Highway System Plan*; the *Route Development Plan*; the Washington Federal-Aid Stewardship Agreement, as implemented in the design matrices (see Chapter 325); and the Project Summary.

The region develops and maintains documentation for each project. The Project File includes documentation of project work including planning; scoping; public involvement; environmental action; design decisions; right of way acquisition; Plans, Specifications, and Estimates (PS&E) development; project advertisement; and construction. Refer to the *Plans Preparation Manual* for PS&E documentation.

All projects involving FHWA action require NEPA clearance. Environmental action is determined through the ECS form. The environmental approval levels are shown in Figures 330-3a and 3b.

Upon receipt of the ECS approval for projects requiring an EA or EIS under NEPA, the region proceeds with environmental documentation, including public involvement, appropriate for the magnitude and type of the project. (See Chapter 210.)

Design approval and approval of Right of Way Plans are required prior to acquiring property. If federal funds are used to purchase the property, then NEPA clearance is also required.

The ASDEs work with the regions on project development and conduct process reviews on projects as described in 330.10.

330.06 Scoping Phase

Development of the project scope is the initial phase of project development. This effort is prompted by the *Washington State Highway System Plan*. The project scoping phase consists of determining a project description, schedule, and cost estimate. The intent is to make design decisions early in the project development process that focus the scope of the project. During the project scoping phase, the Project Summary documents are produced.

(1) Project Summary

The Project Summary provides information on the results of the scoping phase; links the project to the *Washington State Highway System Plan* and the *Capital Improvement and Preservation Program* (CIPP); and documents the design decisions, the environmental classification, and agency coordination. The Project Summary is developed and approved before the project is funded for design and construction, and consists of ERS, DDS, and PD documents, which are electronic forms. Specific online instructions for filling them out are contained in the Project Summary database.

(a) **Environmental Review Summary (ERS).** Lists the environmental permits and approvals that will be required, environmental classifications, and environmental considerations. This form lists requirements by environmental and permitting agencies. If there is a change in the PD or DDS, the information in the ERS must be reviewed and revised to match the rest of the Project Summary. The ERS is prepared during the scoping phase and is approved by the region. During final design and permitting, revisions may need to be made to the ERS and be reapproved by the region.

(b) **Design Decisions Summary (DDS).** Provides the design matrix used to develop the project, and the roadway geometrics, design deviations, EUs, other roadway features, roadside restoration, and any design decisions made during the scoping of a project. The information contained in this form is compiled from various databases of departmental information, field data collection, and evaluations made in development of the PD and the ERS. Design decisions may be revised throughout the project development process based on continuing evaluations.

The DDS is approved by the appropriate ASDE for new construction and reconstruction projects on the Interstate System before submittal to FHWA. (See 330.07.) The regional design authority approves the DDS for all other types of projects. To approve the Design Decisions Summary, the region must be confident that there will be no significant change in the PD or estimated cost. However, if there is a change to the PD or a significant change in the cost estimate, the DDS is to be revised or supplemented and reapproved. Significant cost changes require a Project Control Form to be submitted and approved by the appropriate designee.

(c) **Project Definition (PD).** Identifies the various disciplines and design elements that will be encountered in project development. The PD states the purpose and need for the project, the program categories, and the recommendations for project phasing. This information determines the level of documentation and evaluation that is needed for Project Development Approval. The PD is completed early in the scoping phase to provide a basis for full development of the ERS, DDS, schedule, and estimate. If circumstances necessitate a change to an approved PD, process a Project Control Form for approval by the appropriate designee, revise the original PD form, and obtain approval of the revisions.

330.07 FHWA Approval

For all NHS projects, the level of FHWA oversight varies according to the type of project, the agency doing the work, and the funding source as shown in Figures 330-2a and 2b. Oversight and funding do not affect the level of design documentation required for a project.

An FHWA determination of engineering and operational acceptance is required for any new or revised access point (including interchanges, temporary access breaks, and locked gate access points) on the Interstate System, regardless of funding. (See Chapter 1425.)

Documents for projects requiring FHWA review, Design Approval, and Project Development Approval are submitted through the HQ Design Office. Include applicable project documents as specified in Figure 330-5.

330.08 Design Approval

When the Project Summary documents are complete, and the region is confident that the proposed design adequately addresses the purpose and need for the project, a Design Approval may be entered into the PF. Approval levels for design and PS&E documents are presented in Figures 330-2a through 330-4.

The following items must be provided for Design Approval:

- A one- or two-page reader-friendly memo that describes the project
- Project Summary documents
- Corridor or project analysis
- Design Criteria worksheets at: http://www.wsdot.wa.gov/EESC/Design/projectdev/default.htm
- Design Variances Inventory (for known variances)
- Channelization plans, Intersection plans, or Interchange plans (if applicable)
- Alignment plans and profiles (if project significantly modifies either the existing vertical or horizontal alignment)
- Current cost estimate with a confidence level

330.09 Project Development Approval

When all project development documents are complete and approved, Project Development Approval is granted by the approval authority designated in Figures 330-2a and 2b. The Project Development Approval becomes part of the DDP. (See 330.04 and Figure 330-5 for design documents that may lead to Project Development Approval.) Figures 330-2a through 330-4 provide approval levels for project design and PS&E documents.

The following items must be approved prior to Project Development Approval:

- Required environmental documents
- Design Approval documents (and any supplements)
- Design Variance Inventory (as required)
- Cost estimate
- Stamped cover sheet (project description)

Review new design policy for projects to be advertised more than three years after Project Development Approval, redesign as appropriate, and update the DDP and the Project Development Approval to reflect the revisions. For an overview of design policy changes, consult the Detailed Chronology of Design Policy Changes Affecting Shelved Projects at:
http://www.wsdot.wa.gov/eesc/design/policy/designpolicy.htm

330.10 Process Review

The process review is done to provide reasonable assurance that projects are prepared in compliance with established policies and procedures and that adequate records exist to show compliance with state and federal requirements. Process reviews are conducted by WSDOT, FHWA, or a combination of both.

The design and PS&E process review is performed in each region at least once each year by the HQ Project Development Branch. The documents used in the review process are (1) the Design Documentation Checklist, (2) the PS&E Review Checklist, and (3) the PS&E Review Summary. These are generic forms used for all project reviews. Copies of these working documents are available for reference when assembling project documentation. The HQ Design Office, Project Development Branch, maintains current copies at:
http://www.wsdot.wa.gov/eesc/design/projectdev/

Each project selected for review is examined completely and systematically beginning with the scoping phase (including planning documents) and continuing through contract plans and, when available, construction records and change orders. Projects are normally selected after contract award. For projects having major traffic design elements, the HQ Maintenance and Operations Programs' Traffic Operations personnel are involved in the review. The WSDOT process reviews may be held in conjunction with FHWA process reviews.

The HQ Project Development Branch schedules the process review and coordinates it with the region and FHWA.

A process review follows this general agenda:

1. Review team meets with regional personnel to discuss the object of the review.
2. Review team reviews the design and PS&E documents, and the construction documents and change orders (if available) using the checklists.
3. Review team meets with regional personnel to ask questions and clarify issues of concern.
4. Review team meets with regional personnel to discuss findings.
5. Review team submits a draft report to the region for comments and input.
6. If the review of a project shows a serious discrepancy, the region's design authority is asked to report the steps that will be taken to correct the deficiency.
7. The process review summary forms are completed.
8. The summary forms and checklists are evaluated by the State Design Engineer.
9. The findings and recommendations of the State Design Engineer are forwarded to the regional design authority for action and/or information within 30 days of the review.

Project Design	FHWA Oversight Level	Deviation and Corridor/Project Approval[a][b]	EU Approval[b]	Design Approval and Project Development Approval
Interstate				
New/Reconstruction[c] • Federal funds • No federal funds	 (d) (e)	FHWA	Region	FHWA*
Intelligent Transportation Systems (ITS) over $1 million	(f)	HQ Design	Region	HQ Design
All Other[g] • Federal funds • State funds • Local agency funds	 (f) (f) (e)	HQ Design	Region	Region
National Highway System (NHS)				
Managed access highway outside incorporated cities and towns or inside unincorporated cities and towns, or limited access highway	(f)	HQ Design	Region	Region
Managed access highway within incorporated cities and towns[h] • Inside curb or EPS[i] • Outside curb or EPS	 (f) (f)	HQ Design HQ H&LP	Region N/A	Region City/Town

FHWA = Federal Highway Administration
HQ = WSDOT Headquarters
H&LP = WSDOT Highways and Local Programs Office
EPS = Edge of paved shoulder where curbs do not exist

Notes:
(a) These approval levels also apply to deviation processing for local agency work on a state highway.
(b) See 330.04(4).
(c) For definition, see Chapter 325.
(d) Requires FHWA review and approval (full oversight) of design and PS&E submitted by HQ Design Office.
(e) To determine the appropriate oversight level, FHWA reviews the Project Summary (or other programming document) submitted by HQ Design Office, or by WSDOT Highways and Local Programs through the HQ Design Office.
(f) FHWA oversight is accomplished by process review. (See 330.10.)
(g) Reduction of through lane or shoulder widths (regardless of funding) requires FHWA review and approval of the proposal.
(h) Applies to the area within the incorporated limits of cities and towns.
(i) Includes raised medians.
* FHWA will accept design criteria prior to NEPA approval, but will not approve the design until NEPA is complete.

Design Approval Level
Figure 330-2a

Project Design	FHWA Oversight Level	Deviation and Corridor/Project Approval[a][b]	EU Approval[b]	Design Approval and Project Development Approval
Non-National Highway System (Non-NHS)				
Improvement project on managed access highway outside incorporated cities and towns or within unincorporated cities and towns, or on limited access highway (Matrix lines 5-8 through 5-26)	N/A	HQ Design	Region	Region
Improvement project on managed access highway within incorporated cities and towns[h] • Inside curb or EPS[i] • Outside curb or EPS (Matrix lines 5-8 through 5-26)	 N/A N/A	 HQ Design HQ H&LP	 Region N/A	 Region City/Town
Preservation project on managed access highway outside incorporated cities and towns or within unincorporated cities and towns, or on limited access highway[j] (Matrix lines 5-1 through 5-7)	N/A	Region[k]	Region	Region
Preservation project on managed access highway within incorporated cities and towns[h][j] • Inside curb or EPS[i] • Outside curb or EPS (Matrix lines 5-1 through 5-7)	 N/A N/A	 Region HQ H&LP	 Region N/A	 Region City/Town

FHWA = Federal Highway Administration
HQ = WSDOT Headquarters
H&LP = WSDOT Highways and Local Programs Office
EPS = Edge of paved shoulder where curbs do not exist

Notes:
(a) These approval levels also apply to deviation processing for local agency work on a state highway.
(b) See 330.04(4).
(h) Applies to the area within the incorporated limits of cities and towns.
(i) Includes raised medians.
(j) For Bridge Replacement projects in the preservation program, follow the approval level specified for improvement projects.
(k) For guidance on access deviations, see Chapters 1430 & 1435.

Design Approval Level
Figure 330-2b

Item	Approval Authority		
	Region	HQ	FHWA
Program Development			
Work Order Authorization		X	X[1]
Public Hearings			
Corridor Hearing Summary		X[2]	
Design Summary		X[3]	
Access Hearing Plan		X[4]	
Access Findings and Order		X[5]	
Environmental by Classification			
Summary (ECS) NEPA			X
Class I NEPA (EIS)		[7]	X
Class I SEPA (EIS)		X	
Class II NEPA – Programmatic Categorical Exclusion (CE)*	X		
Class II NEPA – Documented Categorical Exclusion (CE)	[6]		X
Class II SEPA – Categorical Exemption (CE)	X		
Class III NEPA – Environmental Assessment (EA)		[7]	X
SEPA Check List	X		
Design			
Design Deviations	[8]	[8]	[8]
Experimental Features		X	X[9]
Environmental Review Summary	X		
Final Design Decisions Summary	X	X[3]	
Final Project Definition		X[10]	
Interchange Justification Report		[7]	X
Non-Interstate Interchange Justification Report		X	
Interchange Plans	X[11]	X[9][11]	
Intersection Plans	X[11]	X[9][11]	
Right of Way Plans	[12]	X	
Monumentation Map	X		
Materials Source Report		X[13]	
Pavement Determination Report		X[13]	
Roundabout Geometric Design	X[11]	X[11]	
Design Approval	[8]	[8]	[8]
Project Development Approval	[8]	[8]	[8]

Approvals
Figure 330-3a

Item	Approval Authority		
	Region	HQ	FHWA
Design			
Resurfacing Report		X[13]	
Signal Permits	X[14]		
Geotechnical Report		X[13]	
Tied Bids	X[15]		X[9][15]
Bridge Design Plans (Bridge Layout)	X	X	
Hydraulic Report	X[16][17]	X[16][17]	
Preliminary Signalization Plans		X[6]	
Rest Area Plans		X	
Roadside Restoration Plans	X[18]	X[19]	
Structures Requiring TS&L's		X	X
Planting Plans	X[18]	X[19]	
Grading Plans	X[18]	X[19]	
Continuous Illumination – Main Line		X[20]	
Project Control Form	X[21]	X[21]	
Work Zone Transportation Management Plan/Traffic Control Plan	X[22]		

X Normal procedure * If on the preapproved list

Notes:
[1] Federal-aid projects only.
[2] Environmental and Engineering Programs Director approval.
[3] State Design Engineer approval.
[4] Right of Way Plans Engineer approval.
[5] Refer to Chapter 210 for approval requirements.
[6] Final review & concurrence required at the region prior to submittal to approving authority.
[7] Final review & concurrence required at HQ prior to submittal to approving authority.
[8] Refer to Figures 330-2a & 2b for Design Approval and Project Development Approval levels.
[9] Applies to new/reconstruction projects on Interstate routes.
[10] HQ Project Control & Reporting approval.
[11] Include channelization details.
[12] Certified by the responsible professional licensee.
[13] Submit to HQ Materials Laboratory for review and approval.
[14] Approved by region's Administrator or Designee.
[15] See 23 CFR 635.111.
[16] For additional guidance, see the *Hydraulics Manual*, M 23-03.
[17] Region to submit Hydraulic Report. Refer to *Hydraulics Manual*.
[18] Applies only to regions with a Landscape Architect.
[19] Applies only to regions without a Landscape Architect.
[20] Approved by State Traffic Engineer.
[21] Consult HQ Project Control & Reporting for clarification on approval authority.
[22] Region Traffic Engineer.

Approvals
Figure 330-3b

Item	New/ Reconstruction (Interstate only)	NHS and Non-NHS
DBE/training goals* **	(a)	(a)
Right of way certification for federal-aid projects	FHWA(b)	FHWA(b)
Right of way certification for state-funded projects	Region(b)	Region(b)
Railroad agreements	(c)	(c)
Work performed for public or private entities*	[1][2]	Region[1][2]
State force work*	FHWA[3](d)	Region[3](d)
Use of state-furnished stockpiled materials*	FHWA[4]	Region[4]
Stockpiling materials for future projects*	FHWA[4]	Region[4]
Work order authorization	[5](d)	[5](d)
Ultimate reclamation plan approval through DNR	Region	Region
Proprietary item use*	FHWA[4]	[4](c)
Mandatory material sources and/or waste sites*	FHWA[4]	Region[4]
Nonstandard bid item use*	Region	Region
Incentive provisions	FHWA	(e)
Nonstandard time for completion liquidated damages*	FHWA(e)	(e)
Interim liquidated damages*	(f)	(f)

Notes:

[1] This work requires a written agreement.
[2] Region approval subject to $250,000 limitation.
[3] Use of state forces is subject to $60,000 limitation and $100,000 in an emergency situation, as stipulated in RCWs 47.28.030 and 47.28.035.
[4] Applies only to federal-aid projects; however, document for all projects.
[5] Prior FHWA funding approval required for federal-aid projects.

Regional or Headquarters approval authority:

(a) Office of Equal Opportunity
(b) Real Estate Services Office
(c) Design Office
(d) Project Control & Reporting Office
(e) Construction Office
(f) Transportation Data Office

References:

**Plans Preparation Manual*
***Advertisement and Award Manual*

PS&E Process Approvals

Figure 330-4

Document[1]	Required for FHWA Oversight
Project Definition	X
Design Decisions Summary	X
Environmental Review Summary	X
Design Variance Inventory (and supporting information for DEs, EUs not upgraded, and deviations)[2]	X
Cost Estimate	X
SEPA & NEPA documentation	X
Design Clear Zone Inventory (see Chapter 700)	X
Interchange plans, profiles, roadway sections	X
Interchange Justification Report (if requesting new or revised access points)	X
Corridor or project analysis (see Chapter 325)	X
Traffic projections and analysis	
Accident analysis	
Right of way plans	
Work zone traffic control strategy	
Record of Survey or Monumentation Map	
Documentation of decisions to differ from WSDOT design guidance	
Documentation of decisions for project components for which there is no WSDOT design guidance	
Paths and Trails Calculations[3]	

Notes:
(1) See Design Documentation Checklist for a complete list.
(2) Required for NHS highways; recommended for all highways.
(3) See *Plans Preparation Manual*.

Common Components of Design Documentation Package
Figure 330-5

1. **Design element upgraded to the level indicated in the matrix**
   (a) Design element information
      - Design element
      - Location
      - Matrix number and row

   (b) Cost estimate[(1)]

   (c) B/C ratio[(2)]

   (d) Summary of the justification for the upgrade[(3)]

2. **Design element not upgraded to the level indicated in the matrix**
   (a) Design element information
      - Design element
      - Location
      - Matrix number and row

   (b) Existing Conditions
      - Description
      - Accident Summary
      - Advantages and disadvantages of leaving the existing condition unchanged

   (c) Design Using the *Design Manual* criteria
      - Description
      - Cost estimate[(1)]
      - B/C ratio[(2)]
      - Advantages and disadvantages of upgrading to the level indicated in the matrix

   (d) Selected Design, if different from existing but less than the level indicated in the matrix
      - Description
      - Cost estimate[(1)]
      - B/C ratio[(2)]
      - Advantages and disadvantages of the selected design

   (e) Summary of the justification for the selected design[(3)]

Notes:

(1) An estimate of the approximate total additional cost for the proposed design. Estimate may be based on experience and engineering judgment.

(2) Include only when B/C is part of the justification. An approximate value based on engineering judgment may be used.

(3) A brief (one or two sentence) explanation of why the proposed design was selected.

Evaluate Upgrade (EU) Documentation Content List

Figure 330-6

1. **Overview**
   (a) The safety or improvement need that the project is to meet
   (b) Description of the project as a whole
   (c) Highway classification and applicable design matrix number and row
   (d) Funding sources
   (e) Evidence of deviations approved for previous projects (same location)
2. **Design Alternatives in Question**
   (a) Existing Conditions and Design Data
      - Location in question
      - Rural, urban, or developing
      - Route development plan
      - Environmental issues
      - Right of way issues
      - Number of lanes and existing geometrics
      - Present and 20-year projected ADT
      - Design speed, posted speed, and operating speed
      - Percentage of trucks
      - Terrain Designation
      - Managed Access or Limited Access

   (b) Accident Summary and Analysis
   (c) Design Using the *Design Manual* Criteria
      - Description
      - Cost estimate
      - B/C ratio
      - Advantages and disadvantages
      - Reasons for considering other designs

   (d) Other Alternatives (may include "No-build" alternative)
      - Description
      - Cost estimate
      - B/C ratio
      - Advantages and disadvantages
      - Reasons for rejection

   (e) Selected Design Requiring Justification or Documentation to File
      - Description
      - Cost estimate
      - B/C ratio
      - Advantages and disadvantages
3. **Concurrences, Approvals, and Professional Seals**

Deviation Request Content List
Figure 330-7

Chapter 340 — Minor Operational Enhancement Projects

340.01 General

This chapter complements Chapter 325 by providing guidance for development of minor operational enhancement projects. Do not use this chapter to develop preservation or improvement projects. Refer to Chapter 325 for guidance in development of preservation and improvement projects and also for projects initiated by local agencies or developers. The minor operational enhancement matrices contained in this chapter identify the design level(s) for a project, the associated approval level, and the documentation requirements for the most common minor operational enhancement projects and focus on the various elements of greatest concern during project development.

Minor enhancement projects are categorized as low-cost enhancements, to improve the operational safety and efficiency of the highway system. These enhancements are most often installed by state forces through work orders, but may be accomplished through: a stand-alone state contract funded entirely through the Q Program, a Q Program funded bid item within a larger improvement project, a change order to an existing state contract, or agreements with local agencies. An important characteristic of these projects is the ability to quickly develop and implement them without a cumbersome approval process. Balanced with that is a need to apply consistency in design policies and guidelines in the development and approval processes. Therefore, the intent of this chapter is to clarify the design guidelines and documentation requirements for minor operational enhancement projects without unduly impeding the process.

The objective of the Q Program is to maximize highway transportation system safety and efficiency through a statewide program focused on the WSDOT business function for "Traffic Operations." It is the smallest of the four major highway programs that comprise the Highway System Plan (i.e. Improvement, Maintenance, Preservation, and Traffic Operations). Elements within the Q Program include: Q1 – Traffic Operations Program Management, Q2 – Traffic Operations Program Operations, and Q3 - Special Advanced Technology Projects. This chapter is intended to guide the development of projects in the Low Cost Enhancements subcategory within the Q2 program. Large capital improvement projects developed for the Q3 subprogram are beyond the scope and intent of this chapter. Normally, these projects are developed using *Design Manual* guidelines for Preservation and Improvement Program projects. Consult the Headquarters Traffic Office for guidance when designing Q3 subprogram projects.

The minor operational enhancement matrices consisting of three tables are identified by route type. One of the matrices applies to Interstate and NHS freeways, one applies to NHS Non-freeway routes, and the third matrix applies to non-NHS routes.

340.02 References

Revised Code of Washington (RCW) 47.28.030, Contracts — State forces — Monetary limits —Small businesses, minority, and women contractors — Rules.

Chart of Accounts, M 13-02, WSDOT

340.03 Definitions

The **National Highway System (NHS)** See Chapter 325 for definition and a list of specific routes on the NHS.

The term **freeway** applies to multilane, divided highways with full access control.

The **minor operational enhancement projects** usually originate from the Q2 component of the Q Program and are quick responses to implement low cost improvements.

Projects are typically narrow in scope, and focus on improvements to traffic operations, and modifications to traffic control devices. Guidance on the type of work included in the Q subprograms is in the *Chart of Accounts* (M 13-02).

(1) Project Types

Regulatory projects include actions undertaken to manage or regulate traffic conflict, movements, and use of the roadway. Potential projects in this category include revisions to speed limits, parking restrictions, turn restrictions, truck restrictions, signal operations, unsignalized intersection control, intersection lane use control, ramp meters, no passing zones, crosswalks, special traffic control schemes, and lane use restrictions.

Driver guidance projects are actions to improve driver guidance, clarify options, or reduce hazard in the roadway setting. Potential projects include revisions to, informational signs, warning signs, lighting and supplemental illumination, supplemental delineation, glare screen, signals, roadside guidance, and intelligent transportation systems (ITS).

Pavement widening projects are expansion of the roadway surface for vehicular use and may involve earthwork, drainage, and paving elements. Consult with the regional bicycle/pedestrian coordinator to ensure that the concerns of bicyclists and pedestrians are given adequate consideration. These projects are considered alterations of the roadway and must address Americans with Disabilities Act (ADA) accessibility for pedestrians. See Chapter 1025 for guidance on pedestrian facilities. Potential projects are:

- Turn lane — Addition of a new channelized turn bay at an intersection.
- Pullout — Pavement widening to provide auxiliary highway uses including transit stops, Washington State Patrol (WSP) enforcement pullouts, snow chain-up areas, and maintenance vehicle turnouts.
- Expansion — Widen at intersection corners, lengthen existing channelized turn bay, widening shoulders, and flattening approach taper. This type of work is not anticipated for main line sections on Interstate freeways.
- Median crossover — Restricted-use median crossover on separated highways for emergency or maintenance use. See Chapter 960 for design of median crossovers.

Rechannelize existing pavement projects alter the use of the roadway without additional widening. These projects may add, delete, or modify channelization features, and may include reduction of existing shoulder or lane widths. Consult with the regional bicycle/pedestrian coordinator to ensure that the concerns of bicyclists and pedestrians are given adequate consideration. Projects that change the traffic configuration by reducing shoulders to add turn lanes are considered an alteration of the existing roadway and have the same requirements for preservation projects as it relates to pedestrian facilities for ADA accessibility. See Chapter 1025 for guidance on pedestrian facilities.

Potential projects are:

- Pavement markings — Develop added storage, additional lanes, or altered lane alignment. This work may modify tapers or radii, modify painted islands, channelize bicycle lanes, preferential-use lanes or shoulders.
- Raised channelization — New or altered raised curbing to channelization islands to enhance guidance, curtail violation or misuse, or introduce access control.
- Left-Turn Channelization (2-Lane Highways) – Restriping two-lane highways with a minimum pavement width of 39 feet, to provide left-turn channelization at existing intersections. Restripe to provide a minimum of 11-foot lanes and 3-foot shoulders. Ensure that the pavement is structurally adequate for the anticipated traffic loads. Within this configuration at T-Intersections, a reduced

length refuge lane may be provided for traffic entering the main line from the intersecting roadway. See Figure 340-6 for minimum dimensional characteristics of the refuge lane.

Nonmotorized facilities projects add adjacent roadside features for bicycle or pedestrian use. Involve the regional bicycle/pedestrian coordinator in the project development process.

Potential projects are:

- Sidewalk — Installation of sidewalks, which might involve preserving existing shoulder, or converting some portion of existing shoulder for use as a new sidewalk.
- Walkway — Adds to the existing roadway's overall width to provide a wider walkable shoulder.
- Separated Trails — Class 1 separated bike lane or pedestrian paths on independent alignment or parallel to the highway.
- Spot Improvement — Installation of ADA sidewalk curb cuts, new pedestrian landings, sidewalk bulbouts at intersections, or new or revised trailhead features.

Roadside projects are modifications to roadside features for safety purposes. Potential projects are:

- Cross section — Altering roadway cross sections to address clear zone hazard or sight distance concern such as slope flattening, recontouring a ditch, closing a ditch with culvert, or removal of hazard.
- Protection — Installation of hazard protection for clear zone mitigation including guardrail, barrier, and impact attenuator.
- New object — Placement of new hardware or fixed object within clear zone unable to meet breakaway criteria.

(2) Design Elements

The following elements are shown on the minor operational enhancement matrices. If full design level applies see the chapters listed below. If modified design level applies, see Chapter 430.

Sight Distance refers to any combination of horizontal and vertical stopping sight distance, decision sight distance, passing sight distance, and intersection sight distance. See Chapters 650 and 910 for definitions and guidance.

Lane Width See Chapter 325 for definition.

Lane Transition See Chapter 325 for definition.

Shoulder Width See Chapter 325 for definition.

Fill/Ditch Slope See Chapter 325 for definition.

Clear Zone See Chapter 325 for definition.

Ramp Sight Distance refers to any combination of horizontal and vertical stopping sight distance, decision sight distance, and intersection sight distance. See Chapters 650 and 910 for definitions and guidance.

Ramp Lane Width is the lane width for ramp alignments. See Lane Width definition in Chapter 325.

Ramp Lane Transition is the lane transition applied to a ramp alignment. See definition for Lane Transition in Chapter 325. Also see Chapter 940.

Ramp Shoulder Width is the shoulder width for a ramp alignment. See Shoulder Width definition in Chapter 325.

Ramp Fill/Ditch Slopes is the fill/ditch slope along a ramp alignment. See Fill/Ditch Slope definition in Chapter 325.

Ramp Clear Zone is the clear zone along a ramp alignment. See Clear Zone definition in Chapter 325.

Ramp Terminals or Intersection Turn Radii See Chapter 910 for definition.

Ramp Terminals or Intersection Angle See Chapter 910 for definition.

Ramp Terminals or Intersection Sight Distance See Chapter 910 for definition.

Pedestrian and Bike refers to the facilities along a route for accommodation of pedestrians and/or bicycles. See Chapter 1020 for bicycles and Chapter 1025 for pedestrians.

Crossroads at Ramps Lane Width is the lane width on a crossing alignment intersected by a ramp. See Lane Width definition in Chapter 325.

Crossroads at Ramps Shoulder Width is the shoulder width on a crossing alignment intersected by a ramp. See Shoulder Width definition in Chapter 325.

Crossroads at Ramps Pedestrian and Bike refers to the facilities on a crossing alignment intersected by a ramp, for accommodation of pedestrians and/or bicycles. See Pedestrian and Bike definition.

Crossroads at Ramps Fill/Ditch Slopes is the fill/ditch slope along a crossroad intersected by a ramp. See Fill/Ditch Slope definition in Chapter 325.

Crossroads at Ramps Clear Zone is the clear zone along a crossroad intersected by a ramp. See Clear Zone definition in Chapter 325.

Barriers Terminal and Transition Section See Chapter 325 for definition.

Barriers Standard Run See Chapter 325 for definition.

340.04 Minor Operational Enhancement Matrix Procedures

During project definition and design, the following steps are used to select and apply the appropriate minor operational enhancement matrix. Each step is further explained in this chapter.

- *Select a minor operational enhancement matrix* by identifying the route: Interstate/NHS Freeway, NHS non-freeway, or non-NHS.
- Within the minor operational enhancement matrix, *select the row* by the type of work.
- Use the minor operational enhancement matrix to *determine the documentation and approval levels for the various design elements* in the project. Apply the appropriate design levels and document the design decisions as required by this chapter and Chapter 330.

340.05 Selecting a Minor Operational Enhancement Matrix

Selection of a minor operational enhancement matrix is based on highway system (Interstate/NHS Freeway, NHS non-freeway, non-NHS). (See Figure 340-1.) Figures 325-2a and 2b provide a list of the NHS and the Interstate routes in Washington. The minor operational enhancement matrices are shown in Figures 340-2 through 340-4. Follow *Design Manual* guidance for all projects except as noted in the minor operational enhancement matrices.

Route	Project	
	Freeway	Non-freeway
Interstate	Matrix 1	
NHS	Matrix 1	Matrix 2
Non-NHS	Matrix 1	Matrix 3

Minor Operational Enhancement Matrix Selection Guide
Figure 340-1

340.06 Project Type

Row selection in the design matrices is based on project type or type of work. See 340.03(1). For projects not listed in the matrices, consult the Headquarters Traffic Office and the Headquarters Design Office.

Some projects might include work from several project types. In such cases, identify the design and approval level for each project element. In all cases, select the higher design level and approval level where overlaps are found.

340.07 Using a Minor Operational Enhancement Matrix

The column headings on a minor operational enhancement matrix are design elements. They are based on the following thirteen Federal Highway Administration (FHWA) controlling design criteria: design speed, lane width, shoulder width, bridge width, structural capacity, horizontal alignment, vertical alignment, grade, stopping sight distance, cross slope, superelevation, vertical clearance, and horizontal clearance. For the column headings, some of the controlling criteria are combined (for example design speed is part of horizontal and vertical alignment).

Unlike the design matrices described in Chapter 325, designers using a minor operational enhancement matrix are not required to inventory deficiencies for elements not improved by the minor enhancement project. Similarly, they are not required to justify existing deficiencies not addressed by minor enhancement projects. In the case where improvements to existing features surpass the existing condition but do not meet the design guidelines, Basic Documentation plus Supplemental Coordination (BD+) is required. See 340.09(1).

A **blank cell** on a minor operational enhancement matrix signifies that the design element is beyond the scope of the project and need not be addressed.

For work on ramps on Interstate or NHS freeway routes, there is a requirement to provide assurance of no adverse effect to main line flow. Provide FHWA a copy of the documentation providing assurance or process a deviation through FHWA if there is an adverse effect.

(1) Design Level

The minor operational enhancement matrices specify the appropriate design level for the various project elements. The design levels specified are Full and Modified.

Full design level (F) improves roadway geometrics, safety, and operational elements. See Chapter 440 and other applicable chapters for design guidance. Use the current traffic volume with Chapter 440 to evaluate design class for Q Program projects.

Modified design level (M) preserves and improves existing roadway geometrics, safety, and operational elements. See Chapter 430.

Design levels specified in a matrix cell are supplemented with notations for design variances.

(2) Design Variances

Design variances are information packages that justify the introduction of features that are not in accordance with design guidelines. Variances specified in minor operational enhancement project cells include: Design Justification, Level 2, Level 3, or Level 4. See 340.09 for details on documentation requirements.

340.08 Project Approval

Project approval for minor operational enhancement projects authorizes expenditures for the project. The State and/or Region's Traffic Engineer have the responsibility and authority to authorize all expenditures for Q2 Low Cost Enhancements. Delegation of design and/or expenditure approval authority for Q Program funded projects must be identified in writing from the appropriate Traffic Engineer to the person receiving the delegated authority. Such written delegation must identify the specific conditions for which approval authority has been delegated. Project Development Approval authority for PS&E contracts cannot be delegated.

Mechanisms for project expenditure approval vary with the types of projects and the costs involved.

- **Minor-cost projects** are projects normally implemented by state forces directed through maintenance task orders, within the monetary limits established in RCW 47.28.030. Expenditure authority is granted by initialing the work order.
- **Mid-range projects** include: all contract change orders, local agency agreements, or Q Program bid items included in an Improvement or Preservation project, regardless of cost. Maintenance task orders exceeding the monetary limits established in RCW 47.28.030 are included in this category. Expenditure authority is granted by initialing the task order, change order, or agreement memo.
- **PS&E contracts** are stand-alone contracts funded through the Q Program for minor operational enhancement projects. A Design Summary/Approval memorandum must be prepared and signed by the region's Traffic Engineer to approve a project in this category. Figures 340-5a and 340-5b provide a template for the approval memo.

Project development decisions and approvals for "Regulatory" and for "Driver Guidance" projects reside within region or Headquarters Traffic Offices. Projects impacting roadway geometric features in the "Pavement Widening," "Rechannelizing Existing Pavement," "Non-motorized Facilities" or "Roadside" categories are developed jointly by the region's Traffic Office and the region's Project Development Office. Depending on the route type, the approval authority may involve the Assistant State Design Engineer and the FHWA.

340.09 Documentation

The minor operational enhancement matrices include a column that specifies the documentation levels for each project type listed. The documentation levels are categorized as Basic Documentation (BD) and Basic Documentation plus Supplemental Coordination (BD+).

In all cases, the documentation must outline the rationale for the project and include backup information sufficient to support the design decisions. Document the roadway configuration prior to implementation of a minor operational enhancement project. Documentation is to be retained in a permanent retrievable file at a central location in each region.

(1) Projects

Basic Documentation (BD) level applies to regulatory or driver guidance projects. Documentation consists of an unstructured compilation of materials sufficient to validate the designer's decisions. Materials may include: meeting notes, printed e-mails, record of phone conversations, copies of memos, correspondence, and backup data such as level of service modeling, accident data, and design drawings.

A single narrative outlining the decision-making process from start to finish is not required, provided that the materials retained in the file can be traced to a decision consistent with the project design. This level of documentation includes a requirement for inputting the project information into the TRaffic ACtion Tracking System (TRACTS) database at the conclusion of the project.

Basic Documentation plus Supplemental Coordination (BD+) level applies to all projects except regulatory or driver guidance projects. A more comprehensive evaluation of options and constraints is required for this documentation level. Documentation includes basic documentation with additional information describing coordination efforts with other WSDOT groups having a stake in the project. Document the coordination efforts with the following disciplines: Environmental, Hydraulics, Local Agencies and WSDOT Local Programs, Maintenance, Materials, Program Management, Real Estate Services, Urban Corridors, Utilities, and the general public. This level of documentation also includes a requirement for inputting the project information into the TRACTS database at the conclusion of the project.

(2) Design Deviations

Design Justification (DJ) is a written narrative summarizing the rationale for introduction of a feature that varies from the applicable *Design Manual* guidelines. Include in the narrative sufficient information to describe the problem, the constraints, and the trade-offs at a level of detail that provides a defendable professional judgment. DJs are not intended to have the same level of formality as the Level 2, 3, and 4 deviations. DJs may use written memos, e-mails, or documented discussions with the approving traffic authority. The region's Traffic Engineer has responsibility for approving Design Justifications. The DJ documentation must include the name and date of the approving authority. At the time the work order is approved, the region's Project Development Engineer and the Assistant State Design Engineer are to be sent informational copies of the Design Justification, to provide them an opportunity to communicate their concerns. Comment on the informational copy is not mandatory and progress toward project implementation does not wait on a response.

Level 2 documentation serves to justify a deviation to the specified design guidance. Within the document, summarize the project, the design guidelines, the proposed elements that vary from design guidelines, alternatives analyzed, constraints and impacts of each alternative, and the recommended alternative. Level 2 documentation requires joint approval of the region's Traffic Engineer and region's Project

Development Engineer. At the time the work order is approved, the Assistant State Design engineer is to be sent an informational copy of the Level 2 documentation to provide an opportunity to communicate concerns. Comment on the informational copy is not mandatory, and progress toward project implementation does not wait on a response.

Level 3 documentation requirements include the level 2 requirements, however the approval process is through the region's Traffic Engineer, and region's Project Development Engineer with final approval from the Assistant State Design Engineer.

Level 4 documentation requirements include the level 3 requirements, however the approval process is through region's Traffic Engineer, region's Project Development Engineer, and the Assistant State Design Engineer with final approval from the Federal Highway Administration on Interstate routes.

Level 2, 3, and 4 design deviation requests are intended to be stand-alone documentation describing the project, design criteria, proposed element(s), why the desired design level was not or can not be used, alternatives evaluated, and a request for approval. Include funding source(s), type of route, project limits, design classification, posted speed, current ADT, and percent truck traffic in the project description. Justification for the design deviation can include project costs, but must be supported by at least two of the following:

- Accident history or potential.
- Engineering judgment.
- Environmental issues.
- Route continuity (consistency with adjoining route sections).
- The project is an interim solution (covering a 4 to 6 year time horizon).

⇩ Project Type	Main Line						Ramps (1)						Ramp Terminals or Intersections			Crossroads at Ramps					Barriers All		Doc. Level
Design Elements ⇨	Sight Dist.	Lane Width	Lane Tran-sition	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Sight Dist.	Lane Width	Lane Tran-sition	Shldr Width	Fill/ Ditch Slopes	Clear Zone	Turn Radii	Angle	Sight Dist.	Lane Width	Shldr Width	Ped & Bike	Fill/ Ditch Slopes	Clear Zone	Term. & Trans. Section	(2) Std Run	
Regulatory - (Traffic Office Authority)																							**BD**
Driver Guidance - (Traffic Office Authority)																							**BD**
Pavement Widening																							
(1-1Q) Turn Lane								**F/DJ**	**F/DJ**	**F/DJ**			**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(1-2Q) Pullout							**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**M/DJ**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(1-3Q) Expansion	**F/3**	**F/4**	**F/3**	**F/4**	**F/3**	**F/3**		**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**	**M/DJ**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(1-4Q) Median Crossover	**F/3**	**F/4**	**F/3**	**F/4**	**F/3**	**F/3**															**F/3**	**F/3**	**BD+**
Rechannelize Existing Pavement																							
(1-5Q) Pavement Markings	**F/3**	**F/4**	**F/3**	**F/4**		**F/3**	**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**		**F/DJ**	**F/3**	**F/3**	**BD+**
(1-6Q) Raised Channelization							**F/DJ**	**F/DJ**	**F/DJ**	**F/DJ**		**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**		**F/DJ**	**F/3**	**F/3**	**BD+**
(1-7Q) Left-Turn Channelization 2-Lane Hwys (3)																**DJ**	**DJ**	**M**					
Nonmotorized Facilities																							
(1-8Q) Sidewalk/Walkway													**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(1-9Q) Separated Trails																		**F/DJ**			**F/3**	**F/3**	**BD+**
(1-10Q) Spot Improvement													**M/DJ**	**M/DJ**	**F/DJ**	**M/DJ**	**M/DJ**	**F/DJ**		**F/DJ**			**BD+**
Roadside																							
(1-11Q) Cross Section	**F/3**				**F/3**	**F/3**	**F/DJ**				**F/DJ**	**F/DJ**			**F/DJ**				**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(1-12Q) Protection	**F/3**			**F/4**	**F/3**	**F/3**	**F/DJ**			**F/DJ**	**F/DJ**	**F/DJ**			**F/DJ**		**M/DJ**		**M/DJ**	**F/DJ**	**F/3**	**F/3**	**BD+**
(1-13Q) New Object	**F/3**					**F/3**	**F/DJ**					**F/DJ**			**F/DJ**					**F/DJ**	**F/3**	**F/3**	**BD+**

□ Not Applicable
F Full design level
M Modified design level. See Chapter 430.
DJ Design Justification required and Project Approval by region Traffic, with notification to Headquarters Design.
2 Deviation approval through the region's Traffic and Project Development Engineers, with notification to Headquarters Design.
3 Deviation approval through level 2 and the Assistant State Design Engineer.
4 Deviation approval through level 3, and FHWA on Interstate routes.
BD Basic Documentation required.
BD+ Basic Documentation plus supplemental coordination required.

If a project impacts any design element, the impacted elements are addressed.
Elements not impacted, are not addressed.

For items not meeting the design level provided in the matrix, justification or deviation is required and is processed through the designated approval level, DJ, 2, 3, or 4

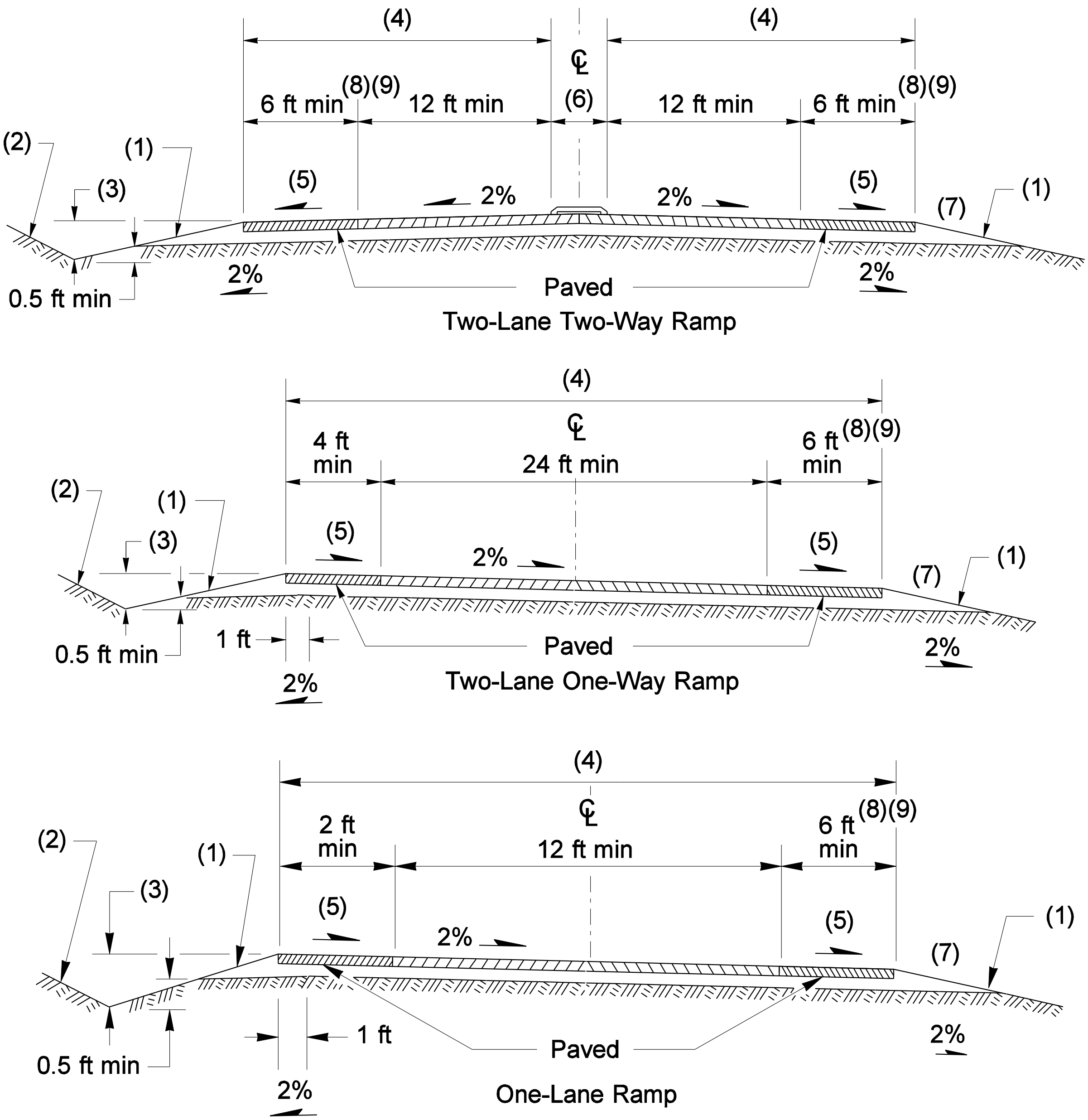
For at-grade intersections on NHS routes, apply Matrix 2.

(1) Documentation must provide assurance of no adverse effect to main line flow.
Otherwise process a deviation through level 4

(2) If existing shoulder width is decreased below minimum values, when placing new guardrail or concrete barrier, a deviation request justifying the proposal is required.

(3) Where existing pavement width is 39 feet or greater.

Minor Operational Enhancement Matrix 1
Interstate & NHS Freeway Routes
Figure 340-2



Notes:

(1) See Fill and Ditch Slope Selection Table on Figure 430-13.
(2) See Cut Slope Selection Table on Figure 430-13
(3) Minimum ditch depth is 2 feet for design speeds over 40 mph and 1.5 feet for design speeds at and under 40 mph.
(4) See 430.04(2)(b) and Figure 430-6 for minimum ramp width.
(5) See Chapter 640 for shoulder slope requirements.
(6) The median width of a two-lane two-way ramp shall not be less than that required for traffic control devices and their required shy distances.
(7) Widen and round embankments steeper than 4H:1V.
(8) Existing 6 feet may remain. When the roadway is to be widened, 8 feet is preferred.
(9) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced by up to 4 inches.

Ramp Roadway Sections, Modified Design Level
Figure 430-14

Date Placeholder

TO: (Specify) Region Traffic Engineer[1]

THRU:

FROM:

SUBJECT:

Design Approved By:

____

(Specify) Region Traffic Engineer[1]

____

Date

General Information

SR ___________ is a (*NHS or Non-NHS*) route, and classified as a (*Urban or Rural*) (*Interstate, Principal Arterial, Minor Arterial, Collector or Urban Managed Access Roadway*) in ___________ County. The posted speed limit is ____ mph. The ADT is, ___________ with ________ percent trucks. The project is within a (*full, partial, or modified limited access control, or Class 1 - 5 managed access controlled*) area.

Project Initiation

How did the project get started? Accident history, constituent call, e-mail, or letter?

Existing Geometrics

What is out there today? Lane, shoulder, sidewalk widths? Turn pockets, etc.?

Project Description

How did you come to the design decision being proposed? What does it resolve for the situation at hand? What options have you looked at? Why were other options not selected?

Proposed Geometrics

What will be out there when you are through? Lane, shoulder, sidewalk widths? Turn pockets, etc.?

[1] For example "Eastern Region Traffic Engineer"

Q Project Design Summary/Approval Template

Figure 340-5a

Resurfacing

If pavement is involved what does the resurfacing report say to use?

Pavement Marking/Traffic Control Devices

What happens with the pavement markings? Signing? Illumination? Signals? Etc.?

Environmental Approval

Did you check with the Environmental Services Office? Are there any issues or permits that need to be addressed? Hydraulics?

Deviations

Are there any deviations? Describe briefly what features are deviated and the date of approval.

Permits

Are there any permits or easements needed? Construction permits? Noise variances? Utility relocations? Detours? Signal? Others?

Project Cost and Schedule

How much do you anticipate spending? When is the project scheduled for advertisement? When do you anticipate the project will be completed?

Sole Source Justification

Some traffic items are sole source and require justification. Have you completed the process?

Work Zone Traffic Control

What happens to traffic, pedestrians, and bicyclists during construction? Is a lane taken or reduced in width? Night work? Shoulder work? Duration? Does Washington State Patrol (WSP) need to be involved?

Local Agency Coordination

Do we need to coordinate with, or notify the city or county? WSP?

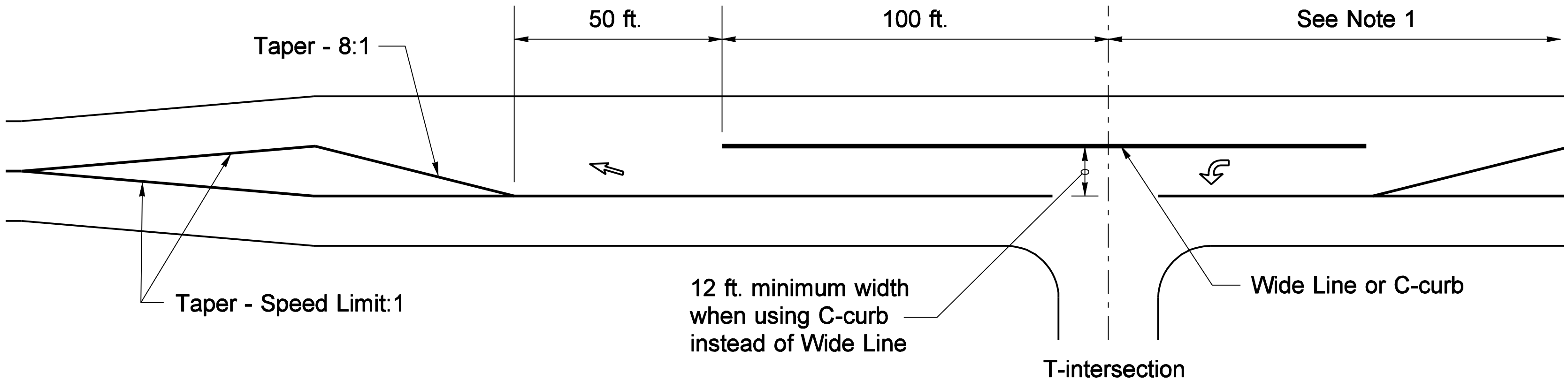
We are requesting approval for the Subject project. This project was designed in accordance with Q Program guidelines for Minor Operational Enhancements, Matrix ___________ *note matrix title and project type line.*

Typist's Initials Placeholder

Attachments: Channelization Plan?
Permits?
Deviations?

cc: Headquarters Design 47329

Q Project Design Summary/Approval Template (continued)
Figure 340-5b



Notes:

1. See Chapter 910 for left-turn channelization.

Refuge Lane for T-Intersections on 2-Lane Highways
Figure 340-6

410.01 General

Basic design level (B) preserves pavement structures, extends pavement service life, and maintains safe operations of the highway.
The basic design level includes restoring the roadway for safe operations and, where needed, may include safety enhancement. Flexibility is provided so that other conditions can be enhanced while remaining within the scope of pavement preservation work.

The required safety items of work listed below may be programmed under a separate project from the paving project as long as there is some benefit to the delay, the safety features remain functional, and the work is completed within two years after the completion of the paving project. If some of the required items are separated from the paving project, maintain a separate documentation file that addresses the separation of work during the two-year time period.

For bituminous surface treatment projects on non-NHS routes, the separation of required safety items is not limited to the two years stated above. The safety work can be accomplished separately using a corridor-by-corridor approach.

410.02 Required Basic Safety Items of Work

For basic design level (B), the following items of work are required:

- Install and replace delineation in accordance with Chapter 830
- Install and replace rumble strips in accordance with the matrices and Chapter 700
- Adjust existing features that are affected by resurfacing, such as monuments, catch basins, and access covers
- Adjust guardrail height in accordance with Chapter 710
- Replace deficient signing, as needed, using current standards. This does not include replacement of sign bridges or cantilever supports
- Relocate, protect, or provide breakaway features for sign supports, luminaires, and WSDOT electrical service poles inside the design clear zone
- Restore sight distance at public road intersections and the inside of curves through low cost measures if they are available such as removal or relocation of signs and other obstructions, and cutting of vegetative matter
- Upgrade nonstandard bridge rail in accordance with the matrices and Chapter 710
- Upgrade barrier terminals and bridge end protection, including transitions, in accordance with Chapter 710
- Restore the cross slope to 1.5 percent when the existing cross slope is flatter than 1.5 percent and, in the engineer's judgment, the steeper slope is needed to solve highway runoff problems in areas of intense rainfall

410.03 Minor Safety and Minor Preservation Work

Consider the following items, where appropriate, within the limits of a pavement preservation project:

- Spot safety enhancements. These are modifications to isolated roadway or roadside features that, in the engineer's judgment, reduce potential accident frequency or severity
- When recommended by the region Traffic Engineer, additional or improved channelization to address intersection related accident concerns, where sufficient pavement width and structural adequacy exist or can be obtained. With justification, channelization improvements may be implemented, with lane and shoulder widths no less than the

design criteria specified in the “Rechannelize Existing Pavement” projects presented in Chapter 340. Consider the impacts to all roadways users. Consider illumination of these improvements. Document decisions when full illumination is not provided, including an analysis of the frequency and severity of nighttime accidents.

- Roadside safety hardware (such as guardrail, signposts, impact attenuators)
- Addressing Location 1 Utility Objects in accordance with the *Utilities Accommodation Policy*, M 22-86

Consider the following items when restoration, replacement, or completion is necessary to assure that an existing system can function as intended:

- Right of way fencing
- Drainage
- Illumination
- Electrical
- Pedestrian and bicycle use

Examples of the above include, but are not limited to, the following: installing short sections of fence needed to control access, replacing grates that are a hazard to bicycles, upgrading electrical system components that require excessive maintenance, and beveling culverts.

Chapter 430 Modified Design Level

430.01 General

Modified design level (M) preserves and improves existing roadway geometrics, safety, and operational elements. This chapter provides the design that is unique to the modified design level.

The modified design level design criteria have been developed to apply to all applicable functional classes. As a result, for the lower volumes and urban highways modified design level design criteria might exceed full level design criteria. In these cases, full level design criteria may be used.

Projects developed to correct a deficiency, must address all design elements contributing to that deficiency, even when those elements meet modified design level design criteria

Design elements that do not have modified design level guidance include:

- Lane Transitions, Chapter 620
- On and off connections, Chapter 940
- Access control, Chapter 1420
- Clear zone, Chapter 700
- Signing, delineation, and illumination, Chapters 820, 830, and 840
- Basic safety, Chapter 410
- Structural capacity, Chapter 1120
- Vertical clearance, Chapter 1120
- Intersection sight distance, Chapter 910
- Traffic Barriers, Chapter 710

430.02 Design Speed

When applying modified design level to a project, select a design speed for use in the design process that reflects the character of the terrain and the type of highway. The desirable design speed for modified design level is given in Figure 430-1. The minimum design speed is not less than the posted speed, or the proposed posted speed. (See Chapter 440 for additional information on design speed.) Document which speed was used, include any supporting studies and data.

Route Type	Posted Speed	Desirable Design Speed
Freeways	All	10 mph over the posted speed
non-Freeways	45 mph or less	Not less than the posted speed
	Over 45 mph	5 mph over posted speed

Desirable Design Speed
Figure 430-1

When the posted speed exceeds the design speed for existing geometric features that are to remain in place (curve radius, superelevation, sight distance, or other elements that the design speed controls) one of two choices must be made:

- When appropriate, work with the region Traffic Office to lower the posted speed to be consistent with the existing design speeds for the geometric features on the facility.
- A corridor analysis can be completed in order to leave the posted speed unchanged and identify all design elements that do not meet the criteria for the existing posted speed. Identify each appropriate location for cautionary signing (including road approach sight distance) and work with the region Traffic Office to install the cautionary signing as provided for in the MUTCD (either by contract or region sign personnel). Consult with and obtain guidance from Region Project Develpment leadership prior to progressing with the corridor analysis and the design.

430.03 Alignment

(1) Horizontal Alignment

Consideration of horizontal alignment for modified design level is normally limited to curves. Curve design is controlled by the design speed [430.02], superelevation [430.03(4)], and stopping sight distance [430.03(3)].

Identify major modifications to horizontal alignment in the Project Summary. Total removal of pavement and reconstruction of the subgrade are examples of major modifications.

(2) Vertical Alignment

Vertical alignment consists of a series of profile grades connected by vertical curves.

(a) ***Vertical curves.*** Stopping sight distance controls crest vertical curves. Figure 430-8 gives the minimum curve length for crest vertical curves to remain in place for modified design level stopping sight distance. See 430.03(3) for additional information on modified design level stopping sight distance.

When modified design level is being applied, existing sag vertical curves are not normally addressed.

When either a crest or a sag vertical curve is to be reconstructed, use full design level design criteria (see Chapters 630 and 650).

(b) ***Profile Grades.*** When applying modified design level, profile grades generally are not flattened. However, corrective action may be justified for combinations of steep grades and restricted horizontal or vertical curvature. Identify major modifications to vertical alignment in the Project Summary. Total removal of pavement and reconstruction of the subgrade are examples of major modifications. When changing the profile grade, see Chapter 440 for the maximum grade for the functional class of the route.

(3) Stopping Sight Distance

Stopping sight distance is a controlling factor for both vertical and horizontal alignment. A 2-foot object height is used for modified design level stopping sight distance evaluation. Figure 430-2 gives the minimum stopping sight distances allowed to remain in place.

Design Speed (mph)	Design Stopping Sight Distance (ft)
40 or less	155
45	200
50	250
55	305
60	360
65	425
70	495
75	570
80	645

Stopping Sight Distance, Modified Design Level
Figure 430-2

(a) ***Stopping Sight Distance for Horizontal Curves.*** For modified design level, use the existing lateral clearance to the sight obstruction and the curve radius to compare the existing condition to Figure 430-9a. When reconstructing a horizontal curve, apply full design level criteria for sight distance. (See Chapter 650.)

For Figure 430-9a, an obstruction is any object with a height of greater than 2.75 feet above the roadway surface on the inside of a curve. Examples of possible obstructions are median barrier, guardrail, bridges, walls, cut slopes, wooded areas, and buildings. Objects between 2.75 feet and 2.00 feet above the roadway surface within the M distance might be a sight obstruction, depending on the distance from the roadway. See Figure 430-9b for guidance on determining if an object between 2.75 feet and 2.00 feet above the roadway surface is a sight obstruction.

(b) ***Stopping Sight Distance for Vertical Curves.*** For existing crest vertical curves use the algebraic difference in grades and the length of curve to compare the existing condition to the stopping sight distance requirements from Figure 430-2. Use the equations in Figure 430-3 or use Figure 430-8 to evaluate the existing curve.

When a crest vertical curve is lengthened, the minimum sight distance is increased; however, the length of the roadway that has the minimum sight distance is also increased. This results in a questionable benefit when the new sight distance is less than for full design level. Therefore, when the existing roadway is reconstructed to improve stopping sight distance, apply full design level criteria. (See Chapter 650.)

When s is less than L:

$$L = \frac{As^2}{2158}$$

When s is greater than L:

$$L = 2s - \frac{2158}{A}$$

Where:
- L = Length of vertical curve, ft
- s = Sight distance, ft (Figure 430-2)
- A = Absolute value of the algebraic difference in grades, %

Minimum Crest Vertical Curve Length, Modified Design Level
Figure 430-3

(4) Superelevation

Evaluate existing superelevation using the equation in Figure 430-4. When the existing superelevation equals or exceeds the value from the equation, the modified design level design criteria is met.

When modifying the superelevation of an existing curve where the existing pavement is to remain in place, use the equation in Figure 430-4 to determine the required superelevation.

For curves on realigned roadways or where the roadway is to be rebuilt, provide full design level superelevation (See Chapter 642).

$$e = \left(\frac{6.69V^2}{R}\right) - f$$

Where:
- R = Existing curve radius in ft.
- V = Design speed in mph from 430.02.
- e = Superelevation rate in %.
- f = Side friction factor from Figure 430-5.

Minimum Superelevation, Modified Design Level
Figure 430-4

Design Speed (mph)	Side Friction Factor (f)
15	17.5
20	17
25	16.5
30	16
35	15.5
40	15
45	14.5
50	14
55	13
60	12
65	11
70	10
75	9
80	8

Side Friction Factor
Figure 430-5

430.04 Roadway Widths

Review route continuity and roadway widths. Select widths on the tangents to be consistent throughout a given section of the route. Make any changes where the route characteristics change. The design of a project must not decrease the existing roadway width.

(1) Lane and Shoulder Width

Lane and shoulder widths are shown in Figures 430-10 and 11. Consider joint use with other modes of transportation in shoulder design.

Minimum ramp lane and shoulder widths are shown on Figure 430-14. Use full design level lane and shoulder widths (See Chapter 940) for new and rebuilt ramps.

(2) Turning Roadway Widths

It might be necessary to widen the roadway on curves to accommodate large vehicles. The proposed roadway width for a curve shall not be less than that of the adjacent tangent sections.

Widening of the total roadway width of a curve by less than 2-feet is not required for existing two-lane roadways that are to remain in place.

(a) ***The two-lane two-way roadway*** width of a curve may not be less than that shown in Figure 430-12a or, if the internal angle (delta) is less than 90 degrees, Figure 430-12b. The minimum total roadway width from Figure 430-12a or 12b may include the shoulder. When the shoulder is included, full-depth pavement is required.

(b) ***One-way roadway and Ramp*** widths on a curve are shown in Figure 430-6 for existing roadways that are to remain in place. Use full design level width (See Chapters 641 and 940) for new and rebuilt ramps.

(3) Median Width

Minimum median widths are given in Figure 430-10.

430.05 Cross Slope

On all tangent sections, the normal cross slopes of the traveled way are 2 percent.

If a longitudinal contiguous section of pavement is to be removed or is on a reconstructed alignment, or if a top course is to be placed over existing pavement, design the restored pavement cross slope to full design level criteria (See Chapter 640).

The algebraic difference in cross slopes is an operational factor during a passing maneuver on a two-lane two-way roadway. Its influence increases when increased traffic volumes decrease the number and size of available passing opportunities.

A somewhat steeper cross slope may be necessary to facilitate pavement drainage in areas of intense rainfall, even though this might be less desirable from the operational point of view. In such areas, the design cross slopes may be increased to 2.5 percent with an algebraic difference of 5 percent.

For existing pavements, cross slopes within a range of 1 to 3 percent may remain if there are no operational or drainage problems and — on a two-lane two-way roadway — the following conditions are met:

- The algebraic difference is not greater than 4 percent where the ADT is greater than 2,000.
- The algebraic difference is not greater than 5 percent where the ADT is 2,000 or less.
- The algebraic difference is not greater than 6 percent and the road is striped or signed for no passing.

Curve Radius (ft)	One-Lane(1)	Two-Lane(2)
Tangent to 1,001	20	24
500	21	25
400	21	25
300	22	25
200	22	26
150	23	26
100	25	28
75	27	29
50	30	31

(1) Includes the shoulder width.
(2) Add shoulder widths from Figure 430-10 for highways and 10 ft for ramps.

One-Way Roadway and Ramp Turning Roadway Widths, Modified Design Level
Figure 430-6

For a two-lane two-way roadway, provide an algebraic difference to meet the appropriate conditions stated above, except when facilitating drainage in areas of intense rainfall. When applying modified design level to a road with bituminous surface treatment (BST), cross slope correction is not required on the basis of algebraic differences alone.

To maintain or restore curb height, consider lowering the existing pavement level and correcting cross slope by grinding before an asphalt overlay. The cross slope of the shoulder may be steepened to maximize curb height and minimize other related impacts. The shoulder may be up to 6 percent with a rollover between the traveled way and the shoulder of no more than 8 percent. See Chapter 640 for additional information.

430.06 Side Slopes

(1) Fill/Ditch Slopes

Foreslopes (fill slopes and ditch inslopes) and cut slopes are designed as shown in the Fill and Ditch Slope Selection Table on Figure 430-13 for modified design level main line roadway sections. After the foreslope has been determined, use the guidance in Chapter 700 to determine the need for a traffic barrier.

When a crossroad or road approach has steep foreslopes, there is the possibility that an errant vehicle might become airborne. Therefore, flatten crossroad and road approach foreslopes to 6H:1V where practical and at least to 4H:1V. Provide smooth transitions between the main line foreslopes and the crossroad or road approach foreslopes. Where possible, move the crossroad or road approach drainage away from the main line. This can locate the pipe outside the design clear zone and reduce the length of pipe required.

(2) Cut Slopes

Existing stable backslopes (cut slopes) are to remain undisturbed unless disturbed by other work. When changes are required to a cut slope, design them as shown in the Cut Slope Selection Table on Figure 430-13.

430.07 Bike and Pedestrian

Sidewalk ramps must be addressed for Americans with Disabilities Act of 1990 (ADA) compliance on projects that include hot mix asphalt (HMA) or Portland cement concrete pavement (PCCP) overlays or inlays. Evaluate existing sidewalk ramps for compliance. Construct ADA compliant sidewalk ramps as required.

On Interstate Pavement Rehab./Resurface projects (See Chapter 325) that include HMA or PCCP overlays, or inlays on ramps or crossroads, sidewalk ramps must be addressed for ADA compliance. Other bicycle or pedestrian elements are design exceptions on HMA or PCCP overlays or inlays on Interstate ramps or crossroads.

Projects that widen the roadway, or change the traffic configuration by reducing the shoulders to add turn lanes are considered alterations of the roadway. Such alterations include a requirement to address ADA compliance for sidewalk ramps.

See Chapter 1025 for guidance on pedestrian facilities.

430.08 Bridges

Design all new and replacement bridges to full design level (See Chapter 440) unless a corridor or project analysis justifies the use of modified design level lane and shoulder widths. Evaluate bridges to remain in place using Figures 430-10 and 11. Whenever possible, continue the roadway lane widths across the bridge and adjust the shoulder widths.

Consider joint use with other modes of transportation in lane and shoulder design. See Chapters 1020, 1025, 1050, and 1060.

430.09 Intersections

Except as given below, design intersections to meet the requirements in Chapter 910.

(1) Turn Radii

The intersection turn radii (or right-turn corners) are controlled by the design vehicle. Figure 430-7 is a guide for determining the design vehicle for modified design level. Perform a field review to determine intersection type, types of vehicles that use the intersection, and adequacy of the existing geometrics. When the crossroad is a city street or county road, consider the requirements of the city or county when selecting a design vehicle.

Design right turn corners to meet the requirements of Chapter 910 using the design vehicle selected from Figure 430-7 or from the field review.

(2) Angle

The allowable angle between any two respective legs is between 60° and 120°. When realignment is required to meet this angle requirement, consider realigning to an angle between 75°and 105°.

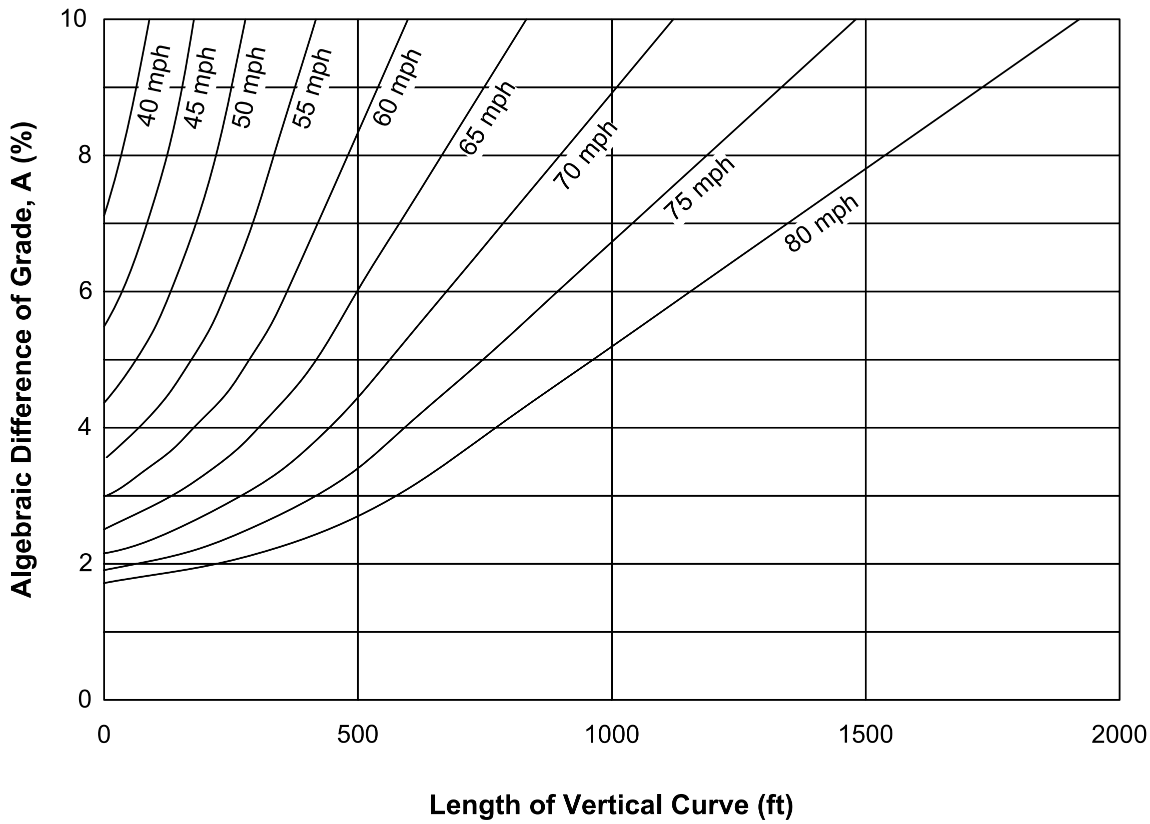
Intersection Type	Design Vehicle
Junction of Major Truck Routes	WB-67
Junction of State Routes	WB-40
Ramp Terminals	WB-40
Other Rural	SU(1)
Urban Industrial	SU(1)
Urban Commercial	P(1)
Residential	P(1)

(1) When the intersection is on a transit or school bus route, use the BUS design vehicle. See Chapter 1060 for additional guidance for transit facilities and for the BUS turning path templates.

Design Vehicles, Modified Design Level
Figure 430-7

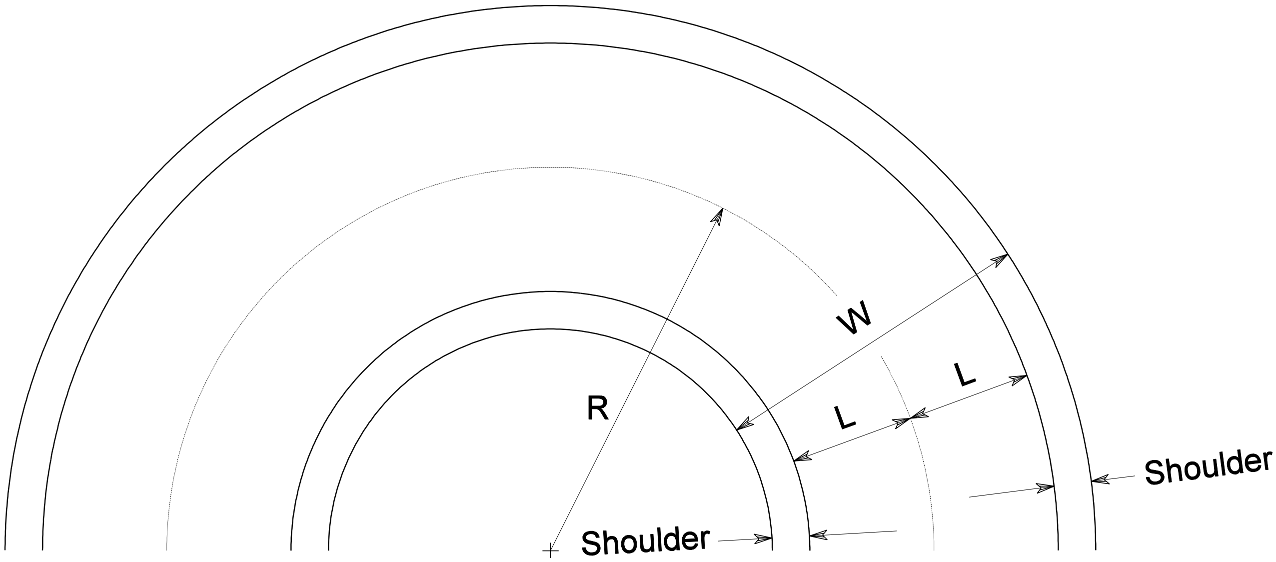
430.10 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

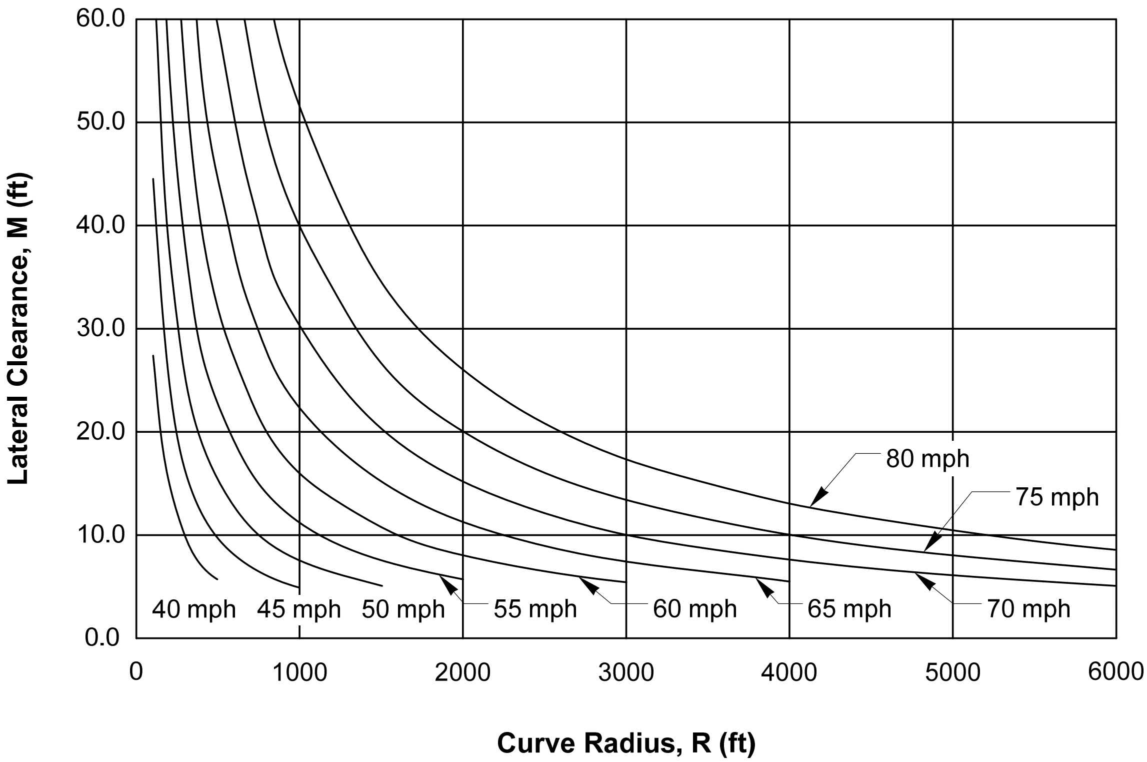


When the intersection of the algebraic difference of grade with the length of vertical curve is below the selected design speed line, modified design level design criteria is met.

Evaluation for Stopping Sight Distance for Crest Vertical Curves, Modified Design Level
Figure 430-8

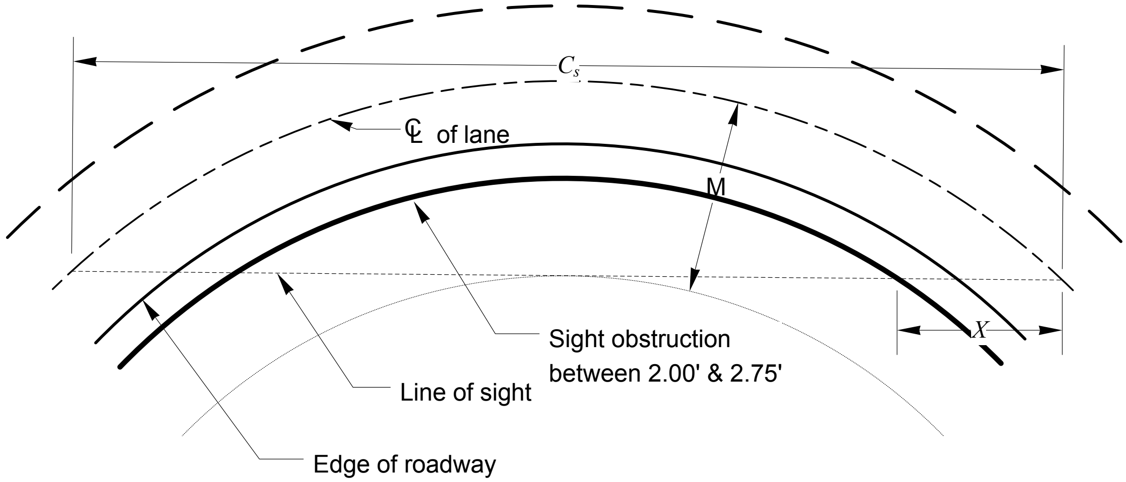


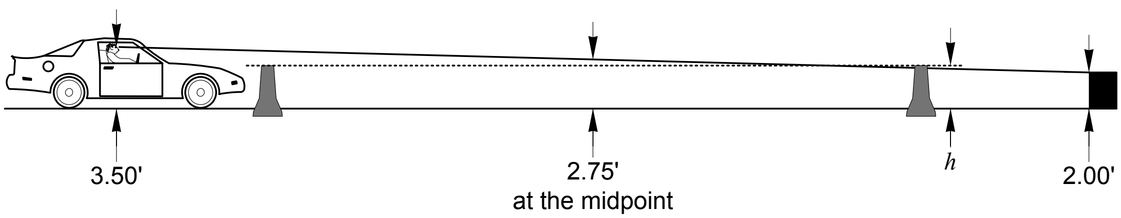
M is the distance in feet from the center line of the inside lane to the obstruction. Obstruction is a cut slope or other object 2.75 ft or more above the inside lane. Objects between 2.75 ft and 2.00 ft above the roadway surface within the M distance might be a sight obstruction, depending on the distance from the roadway. See Figure 430-9b.



When the intersection of the lateral clearance (M) with the curve radius (R) falls above the curve for the selected design speed, modified design criteria is met.

Evaluation for Stopping Sight Distance for Horizontal Curves,
Modified Design Level
Figure 430-9a





When $h \le \left(2 + \frac{1.5X}{C_s}\right)$ modified design criteria is met.

Where:

M = Lateral clearance for sight distance (ft) See Figure 430-9a

C_S = Stopping sight distance chord (ft)

X = Distance from the sight obstruction to the end of the sight distance chord (ft)

h = Height of sight obstruction above the inside lane.

Evaluation for Stopping Sight Distance Obstruction for Horizontal Curves, Modified Design Level

Figure 430-9b

	Multilane Divided				Multilane Undivided			
	Trucks Under 10%		Trucks 10% and Over		Trucks Under 10%		Trucks 10% and Over	
Design Class	MDL-1	MDL-2	MDL-3	MDL-4	MDL-5	MDL-6	MDL-7	MDL-8
Current ADT (1)	Under 4000	Over 4000	Under 4000	Over 4000	Under 4000	Over 4000	Under 4000	Over 4000
Design Speed	See Figure 430-1							
Traffic Lanes Number Width	 4 or more 11 ft	 4 or more 11 ft	 4 or more 11 ft	 4 or more 12 ft	 4 or more 11 ft	 4 or more 11 ft	 4 or more 11 ft	 4 or more 12 ft
Parking Lanes Urban	None	None	None	None	8 ft	8 ft (2)	8 ft	8 ft (2)
Median Width Rural Urban	 Existing Existing	 Existing Existing	 Existing Existing	 Existing Existing	 2 ft 2 ft	 4 ft 2 ft	 4 ft 2 ft	 4 ft 2 ft
Shoulder Width (15) Right (3) Left (4)	 4 ft 2 ft	 6 ft 2 ft	 4 ft 2 ft	 6 ft 2 ft	 4 ft	 6 ft (5)	 4 ft	 6 ft (5)
Minimum Width for Bridges to Remain in Place (6) (7) (8)	24 ft (9)	26 ft (9)	24 ft (9)	26 ft (10)	48 ft (9)	50 ft (9) (11)	50 ft (9) (11)	54 ft (10) (11)
Minimum Width for Rehabilitation of Bridges to Remain in Place (6) (8) (12)	28 ft (9)	30 ft (9)	28 ft (9)	32 ft (10)	54 ft (9)	60 ft (9) (11) (13)	56 ft (9) (11)	64 ft (10) (11) (13)
Minimum Width for Replacement Bridges	Full Design Level Applies (14)							
Access Control	See Chapters 1430 and 1435 and the Master Plan for Limited Access Highways, or WAC 468-52 and the region's Highway Access Management Classification Report							

Notes:

(1) If current ADT is approaching a borderline condition, consider designing for the higher classification.
(2) Parking restricted when ADT is over 15,000.
(3) When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 feet. In urban areas, see Chapter 440. On a route identified as a local, state, or regional significant bicycle route the minimum shoulder width is 4 feet (See Chapter 1020).
(4) When a curb section is used, the minimum shoulder width from the edge of traveled way to the face of the curb is 1 foot on the left.
(5) May be reduced by 2 feet under urban conditions.
(6) Width is the clear distance between curbs or rails, whichever is less.
(7) Use these widths when a bridge within the project limits requires deck treatment or thrie beam retrofit only.
(8) For median widths 25 feet or less, see Chapter 1120.
(9) Add 11 feet for each additional lane.
(10) Add 12 feet for each additional lane.
(11) Includes a 4-foot median, which may be reduced by 2 feet under urban conditions.
(12) Use these widths when a bridge within the project limits requires any work beyond the treatment of the deck such as bridge rail replacement, deck replacement, or widening.
(13) Includes 6-foot shoulders — may be reduced by 2 feet on each side under urban conditions.
(14) Modified design level lane and shoulder widths may be used when justified with a corridor or project analysis.
(15) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced by up to 4 inches.

Multilane Highways and Bridges, Modified Design Level
Figure 430-10

	Two-Lane Highways					
	Trucks Under 10%			Trucks 10% and Over		
Design Class	MDL-9	MDL-10	MDL-11	MDL-12	MDL-13	MDL-14
Current ADT (1)	Under 1000	1000-4000	Over 4000	Under 1000	1000-4000	Over 4000
Design Speed	See Figure 430-1					
Traffic Lane Width (2)	11 ft	11 ft	11 ft	11 ft	11 ft	12 ft
Parking Lanes Urban	8 ft	8 ft	8 ft (3)	8 ft	8 ft	8 ft (3)
Shoulder Width (4)	2 ft	3 ft (5)	4 ft	2 ft	3 ft (5)	4 ft
Minimum Width for Bridges to Remain in Place (6)(7)	22 ft (8)	24 ft	28 ft	22 ft (8)	24 ft	28 ft
Minimum Width for Rehabilitation of Bridges to Remain in Place (7)(9)	28 ft (10)	32 ft	32 ft	28 ft (10)	32 ft	32 ft
Minimum Width for Replacement Bridges	Full Design Level Applies (11)					
Access Control	See Chapters 1430 and 1435 and the Master Plan for Limited Access Highways, or WAC 468-52 and the region's Highway Management Classification Report.					

Notes:

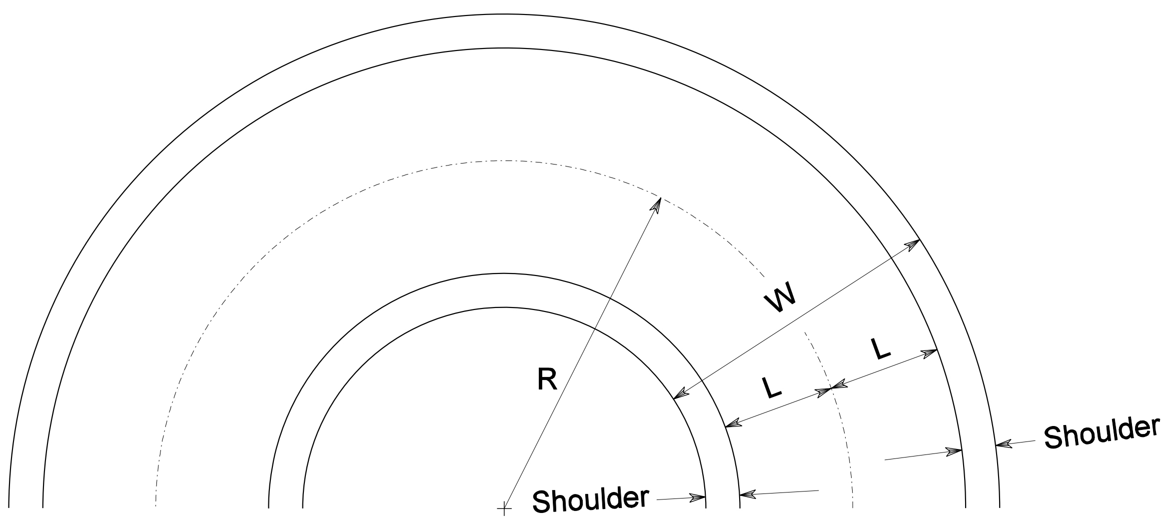
(1) If current ADT is approaching a borderline condition, consider designing for the higher classification.
(2) See Figures 430-12a and 12b for turning roadways.
(3) Parking restriction recommended when ADT exceeds 7,500.
(4) When a curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 feet. In urban areas, see Chapter 440. On a route identified as a local, state, or regional significant bicycle route the minimum shoulder width is 4 feet (See Chapter 1020).
(5) For design speeds of 50 mph or less on roads of 2,000 ADT or less, width may be reduced by 1 foot, with justification.
(6) Use these widths when a bridge within the project limits requires deck treatment or thrie beam retrofit only.
(7) Width is the clear distance between curbs or rails, whichever is less.
(8) 20 feet when ADT 250 or less.
(9) Use these widths when a bridge within the project limits requires any work beyond the treatment of the deck such as bridge rail replacement, deck replacement, or widening.
(10) 26 feet when ADT 250 or less.
(11) Modified design level lane and shoulder widths may be used when justified with a corridor or project analysis.

Two-Lane Highways and Bridges,
Modified Design Level
Figure 430-11

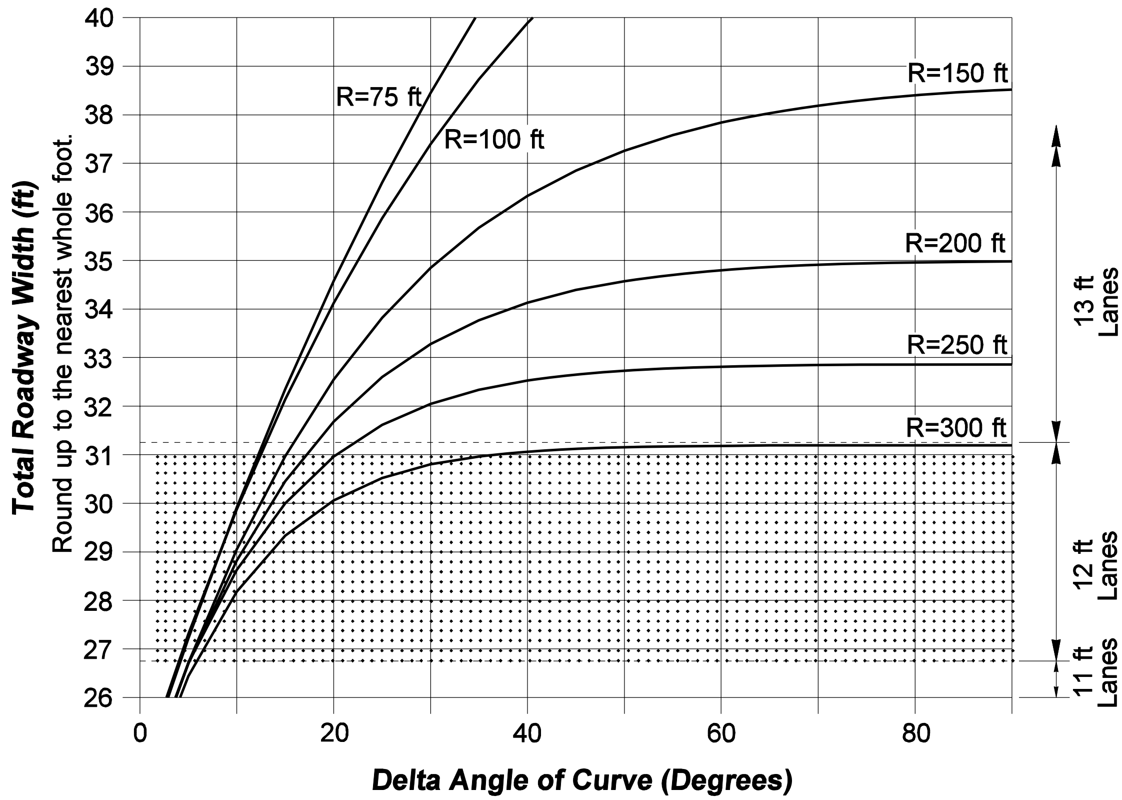
Radius of Center Line R (ft)	Minimum Total Roadway Width W (ft)	Minimum Lane Width L (ft)
Tangent	26	11
900	26	11
800	27	12
700	27	12
600	28	12
500	28	12
400	29	12
350	30	12
300	31	12
250	33	13
200	35	13
150	39	13

Note:

Also see minimums from Figure 430-11. If the minimum total roadway width is greater than the sum of the shoulders and lane widths, apply the extra width to the inside of the curve.



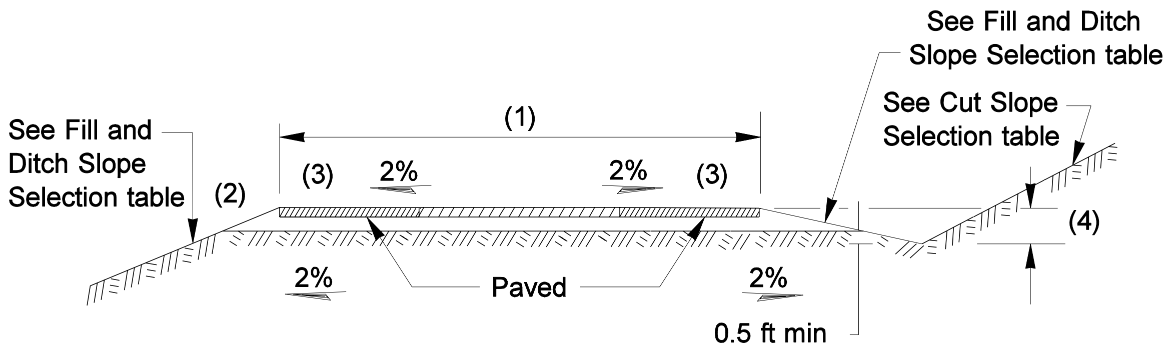
Minimum Total Roadway Widths for Two-Lane Two-Way Highway Curves, Modified Design Level
Figure 430-12a



Notes:

May be used when the internal angle (delta) is less than 90 degrees.
If result is less than the total roadway width from Figure 430-11, use the greater.

Minimum Total Roadway Widths for Two-Lane Two-Way Highway Curves, Modified Design Level
Figure 430-12b



Height of Cut (ft)	Slope not Steeper than (5)
0 - 5	4H:1V
5 - 20	3H:1V
over 20	2H:1V

Cut Slope Selection Table

Height of Fill/Depth of Ditch (ft)	Slope not Steeper than
0 - 20	4H:1V
20 - 30	3H:1V
over 30	2H:1V(6)(7)

Fill and Ditch Slope Selection Table

Notes:

(1) See Figures 430-10 and 11 for minimum roadway widths and Figures 430-12a and 12b for turning roadway widths.

(2) Widen and round embankments steeper than 4H:1V.

(3) See Chapter 640 for shoulder slope requirements.

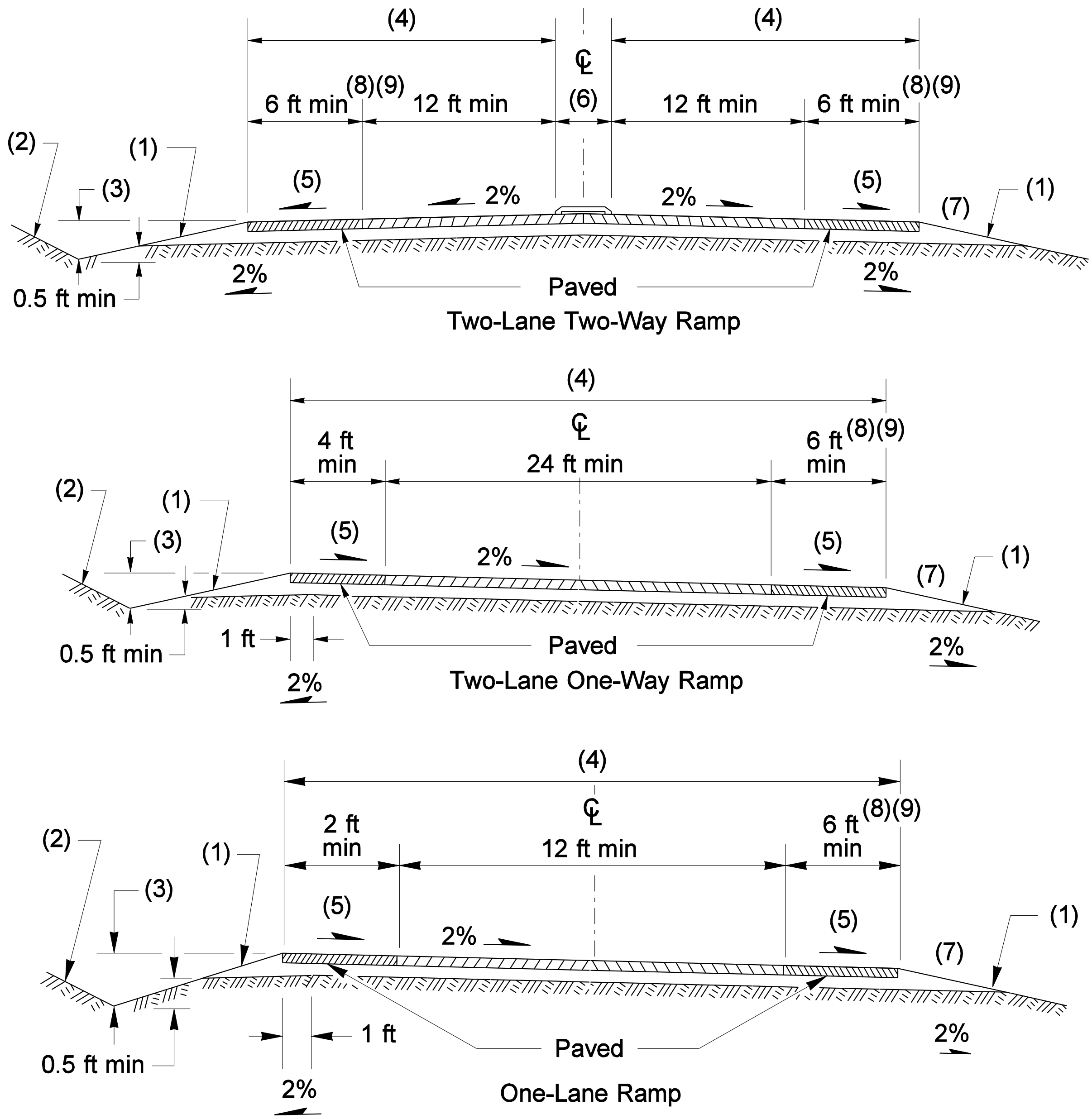
(4) Minimum ditch depth is 2 feet for design speeds over 40 mph and 1.5 feet for design speeds 40 mph or less.

(5) Or as recommended by the soils or geothechnical report. Refer to Chapter 700 for clear zone and barrier requirements

(6) Where practical, provide flatter slopes for the greater fill heights and ditch depths.

(7) Fill slopes up to 1 1/2H:1V may be used where favorable soil conditions exist. Refer to Chapter 640 for additional details and Chapter 700 for clear zone and barrier requirements.

Main Line Roadway Sections,
Modified Design Level
Figure 430-13



Notes:

(1) See Fill and Ditch Slope Selection Table on Figure 430-13.
(2) See Cut Slope Selection Table on Figure 430-13
(3) Minimum ditch depth is 2 feet for design speeds over 40 mph and 1.5 feet for design speeds at and under 40 mph.
(4) See 430.04(2)(b) and Figure 430-6 for minimum ramp width.
(5) See Chapter 640 for shoulder slope requirements.
(6) The median width of a two-lane two-way ramp shall not be less than that required for traffic control devices and their required shy distances.
(7) Widen and round embankments steeper than 4H:1V.
(8) Existing 6 feet may remain. When the roadway is to be widened, 8 feet is preferred.
(9) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced by up to 4 inches.

Ramp Roadway Sections, Modified Design Level
Figure 430-14

440.01 General

Full design level is the highest level of design and is used on new and reconstructed highways. These projects are designed to provide optimum mobility, safety, and efficiency of traffic movement. The overall objective is to move the greatest number of vehicles, at the highest allowable speed, and at optimum safety. Major design controls are functional classification, terrain classification, urban or rural surroundings, traffic volume, traffic character and composition, design speed, and access control.

440.02 References

Revised Code of Washington (RCW) 46.61.575, Additional parking regulations

RCW 47.05.021, Functional classification of highways.

RCW 47.24, City Streets as Part of State Highways

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT.

Plans Preparation Manual, WSDOT, M 22-31

Local Agency Guidelines (LAG), M 36-63, WSDOT

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

A Policy on Design Standards - Interstate System, 1991, AASHTO

440.03 Definitions

auxiliary lane The portion of the roadway adjoining the through lanes for parking, speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through-traffic movement.

bikeway Any trail, path, part of a highway or shoulder, sidewalk, or any other traveled way specifically signed and/or marked for bicycle travel.

collector system Routes that primarily serve the more important intercounty, intracounty, and intraurban travel corridors, collect traffic from the system of local access roads and convey it to the arterial system, and on which, regardless of traffic volume, the predominant travel distances are shorter than on arterial routes (RCW 47.05.021).

design speed The speed used to determine the various geometric design features of the roadway.

divided multilane A roadway with 2 or more through lanes in each direction and a median that physically or legally prohibits left-turns, except at designated locations.

freeway A divided highway that has a minimum of two lanes in each direction, for the exclusive use of traffic, and with full control of access.

frontage road An auxiliary road that is a local road or street located on the side of a highway for service to abutting property and adjacent areas and for control of access.

functional classification The grouping of streets and highways according to the character of the service they are intended to provide.

high pavement type Portland cement concrete pavement or hot mix asphalt pavement on treated base.

incorporated city or town A city or town operating under either Title 35 or 35A RCW.

intermediate pavement type Hot Mix asphalt pavement on an untreated base.

Interstate System A network of routes selected by the state and the FHWA under terms of the federal aid acts as being the most important to the development of a national system. The Interstate System is part of the principal arterial system.

lane A strip of roadway used for a single line of vehicles.

lane width The lateral design width for a single lane, striped as shown in the Standard Plans and Standard Specifications. The width of an existing lane is measured from the edge of traveled way to the center of the lane line or between the centers of adjacent lane lines.

limited access highway All highways where the rights of direct access to or from abutting lands have been acquired from the abutting landowners.

low pavement type Bituminous surface treatment (BST).

managed access highway All highways where the rights of direct access to or from abutting lands have not been acquired from the abutting landowners.

median The portion of a highway separating the traveled ways for traffic in opposite directions.

minor arterial system A rural network of arterial routes linking cities and other activity centers that generate long distance travel and, with appropriate extensions into and through urban areas, form an integrated network providing interstate and interregional service (RCW 47.05.021).

National Highway System **(NHS)** An interconnected system of principal arterial routes that serves interstate and interregional travel; meets national defense requirements; and serves major population centers, international border crossings, ports, airports, public transportation facilities, other intermodal transportation facilities, and other major travel destinations. The Interstate System is a part of the NHS.

operating speed The speed at which drivers are observed operating their vehicles during free-flow conditions. The 85th percentile of the distribution of observed speeds is most frequently used.

outer separation The area between the outside edge of traveled way for through traffic and the nearest edge of traveled way of a frontage road or C-D road.

posted speed The maximum legal speed as posted on a section of highway using regulatory signs.

principal arterial system A connected network of rural arterial routes with appropriate extensions into and through urban areas, including all routes designated as part of the Interstate System, that serve corridor movements having travel characteristics indicative of substantial statewide and interstate travel (RCW 47.05.021).

roadway The portion of a highway, including shoulders, for vehicular use.

rural area An area that meets none of the conditions to be an urban area.

shoulder The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and use by pedestrians and bicycles.

shoulder width The lateral width of the shoulder, measured from the edge of traveled way to the edge of the roadway or face of curb.

suburban area A term for the area at the boundary of an urban area. Suburban settings may combine higher speeds common in rural areas with activities that are more similar to urban settings. Separate design values are not given for suburban areas, classify suburban areas as either urban or rural as best fits the existing or design year conditions.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

two-way left-turn lanes (TWLTL) A lane, located between opposing lanes of traffic, to be used by vehicles making left turns from either direction, either from or onto the roadway.

undivided multilane A roadway with 2 or more through lanes in each direction on which left-turns are not controlled.

urban area An area defined by one or more of the following:

- An area including and adjacent to a municipality or other urban place having a population of five thousand or more, as determined by the latest available published official Federal census, decennial or special, within boundaries to be fixed by a State highway department, subject to the approval of the FHWA.
- Within the limits of an incorporated city or town
- Characterized by intensive use of the land for the location of structures and receiving such urban services as sewer, water, and other public utilities and services normally associated with an incorporated city or town.
- With not more than twenty-five percent undeveloped land.

urbanized area An urban area with a population of 50,000 or more.

usable shoulder The width of the shoulder that can be used by a vehicle for stopping.

440.04 Functional Classification

As provided in RCW 47.05.021, the state highway system is divided and classified according to the character and volume of traffic carried by the routes and distinguished by specific geometric design criteria. The functional classifications used on highways, from highest to lowest classification, are Interstate, principal arterial, minor arterial, and collector. The higher functional classes give more priority to through traffic and less to local access.

The criteria used to determine the functional classification consider the following:

- Urban population centers inside and outside the state stratified and ranked according to size.
- Important traffic generating economic activities, including but not limited to recreation, agriculture, government, business, and industry.
- Feasibility of the route, including availability of alternate routes inside and outside the state.
- Directness of travel and distance between points of economic importance.
- Length of trips.
- Character and volume of traffic.
- Preferential consideration for multiple service which shall include public transportation.
- Reasonable spacing depending upon population density.
- System continuity.

440.05 Terrain Classification

To provide a general basis of reference between terrain and geometric design, three classifications of terrain have been established.

Level. Level to moderately rolling. This terrain offers few or no obstacles to the construction of a highway having continuously unrestricted horizontal and vertical alignment.

Rolling. Hills and foothills. Slopes rise and fall gently but occasional steep slopes might offer some restriction to horizontal and vertical alignment.

Mountainous. Rugged foothills, high steep drainage divides, and mountain ranges.

Terrain classification pertains to the general character of the specific route corridor. Roads in valleys or passes of mountainous areas might have all the characteristics of roads traversing level or rolling terrain and are usually classified as level or rolling rather than mountainous.

440.06 Geometric Design Data

(1) State Highway System

For projects designed to full design level, all highways in rural areas and limited access highways in urban areas the geometric design data is controlled by the functional class (Figures 440-4 through 7b). The urban managed access highway design class (Figure 440-8) may be used on managed access highways in urban areas, regardless of the functional class.

(2) State Highways as City Streets

When a state highway within an incorporated city or town is a portion of a city street, the design features must be developed in cooperation with the local agency. For facilities on the NHS, use the *Design Manual* criteria as the minimum for the functional class of the route. For facilities not on the NHS, the *Local Agency Guidelines* may be used as the minimum design criteria; however, the use of *Design Manual* criteria is encouraged where feasible. On managed access highways within the limits of incorporated cities and towns, the cities or towns have full responsibility for design elements outside of curb, or outside the paved shoulder where no curb exists, using the *Local Agency Guidelines.*

(3) City Streets and County Roads

Plan and design facilities that cities or counties will be requested to accept as city streets or county roads according to the applicable design criteria shown in:

- WAC 468-18-040.
- *Local Agency Guidelines*.
- The standards of the local agency that will be requested to accept the facility.

440.07 Design Speed

Vertical and horizontal alignment, sight distance, and superelevation will vary appreciably with design speed. Such features as traveled way width, shoulder width, and lateral clearances are usually not affected. See Chapters 620, 630, 642, and 650 for the relationships between design speed, geometric plan elements, geometric profile elements, superelevation, and sight distance.

The choice of a design speed is influenced principally by functional classification, posted speed, operating speed, terrain classification, traffic volumes, accident history, access control, and economic factors. However, a geometric design that adequately allows for future improvement is the major criterion, rather than strictly economics. Categorizing a highway by a terrain classification often results in arbitrary reductions of the design speed when, in fact, the terrain would allow a higher design speed without materially affecting the cost of construction. Savings in vehicle operation and other costs alone might be sufficient to offset the increased cost of right of way and construction.

It is important to consider the geometric conditions of adjacent sections. Maintain a uniform design speed for a significant segment of highway.

For all rural highways and limited access highways in urban areas, the design speed is given for each design class in Figures 440-4 through 7b.

When terrain or existing development limit the ability to achieve the design speed for the functional class, use a corridor analysis to determine the appropriate design speed. The desirable design speed is not less than given in Figure 440-1. Do not select a design speed less than the posted speed.

Route Type	Posted speed	Desirable Design Speed
Freeways	All	10 mph over the posted speed
non-Freeways	45 mph or less	Not less than the posted speed.
	Over 45 mph	5 mph over the posted speed

Desirable Design Speed
Figure 440-1

On urban highways, that have obvious "street-like" characteristics, operationally and physically, the design speed is less critical to the operation of the facility. Closely spaced intersections and other operational constraints usually limit vehicular speeds more than the design speed.

For managed access facilities in urban areas, select a design speed based on Figure 440-1. In cases where the 440-1 design speed does not fit the conditions, use a corridor analysis to select a design speed. Select a design speed not less than the posted speed and logical with respect to topography, operating speed (or anticipated operating speed for new alignment), adjacent land use, design traffic volume, accident history, access control, and the functional classification. Consider both year of construction and design year. Maintain continuity throughout the corridor, with changes at logical points, such as a change in roadside development.

440.08 Traffic Lanes

Lane width and condition have a great influence on safety and comfort. The minimum lane width is based on the highway design class, terrain type, and whether it is in a rural or urban area. Lanes 12 ft wide provide desirable clearance between large vehicles where traffic volumes are high and a high number of large vehicles are expected. The added cost for lanes 12 ft wide is offset, to some extent, by the reduction in shoulder maintenance cost due to the lessening of wheel load concentrations at the edge of the lane.

Highway capacity is also affected by the width of the lanes. With narrow lanes, drivers must operate their vehicles closer (laterally) to each other than they normally desire. To compensate for this, drivers increase the headway, resulting in reduced capacity.

Figures 440-4 through 440-7a give the minimum lane width for the various design classes for use on all rural highways and urban limited access highways. Figure 440-8 gives the minimum lane widths for urban managed access highways.

The roadway on a curve may need to be widened to make the operating conditions comparable to those on tangents. See Chapter 641 for guidance on width requirements on turning roadways.

440.09 Shoulders

The shoulder width is controlled by the functional classification of the roadway, the traffic volume, and the function the shoulder is to serve.

The more important shoulder functions and the associated minimum widths are given in Figure 440-2.

Shoulder Function	Minimum Shoulder Width
Stopping out of the traffic lanes	8 ft
Minimum lateral clearance	2 ft (1)
Pedestrian or bicycle use	4 ft (2)
Large vehicle off tracking on curves.	See Chapters 641 & 910
Maintenance operations.	Varies (3)
Law enforcement	8 ft (4)
Bus stops.	See Chapter 1060.
Slow vehicles turnouts and shoulder driving.	See Chapter 1010
Ferry holding	8 ft (5)
For use as a lane during reconstruction of the through lanes.	8 ft
Structural support	2 ft
Improve sight distance in cut sections.	See Chapter 650
Improve capacity.	See Chapter 610

(1) See Chapters 700 and 710.
(2) Minimum usable shoulder width for bicycles. For additional information, see Chapter 1020 for bicycle and Chapter 1025 for pedestrians.
(3) 10 ft usable width to park a maintenance truck out of the through lane; 12 ft, 14 ft clearance is preferred, for equipment with outriggers to work out of traffic.
(4) See Chapters 1040 and 1050 for additional information.
(5) Minimum usable shoulder width, 10 ft preferred.

Minimum Shoulder Width
Figure 440-2

Contact the region maintenance office to determine the shoulder width for maintenance operations. When shoulder widths wider than called for in Figures 440-4 through 8 are requested, compare the added cost of the wider shoulders to the added benefits to maintenance operations and other benefits that may be derived. When the maintenance office requests a shoulder width different than for the design class, justify the width selected.

Shoulders also:

- Provide space to escape potential accidents or to reduce their severity.
- Provide a sense of openness, contributing to driver ease and freedom from strain.
- Reduce seepage adjacent to the traveled way by discharging storm water farther away.

Minimum shoulder widths for use on all rural highways and urban limited access highways are based on functional classification and traffic volume, see Figures 440-4 through 7b. Figure 440-8 gives the minimum shoulder widths for urban managed access highways without curb.

When curbing with a height less than 24 inches is present on urban managed access highways, provide the minimum shoulder widths shown in Figure 440-3. (See 440.11 for information on curb.)

Lane Width	Posted Speed			
	>45 mph	≤45 mph	>45 mph	≤45 mph
	On Left		**On Right** (3)	
12 ft or wider	4 ft	(1)(2)	4 ft	2 ft
11 ft	4 ft	(1)(2)	4 ft	3 ft (4)

Notes:

(1) When mountable curb is used on routes with a posted speed of 35 mph or less, shoulder width is desirable but, with justification, curb may be placed at the edge of traveled way.

(2) 1 ft for curbs with a height of 8 in or less.
2 ft for curbs or barriers with a height between 8 in and 24 in.

(3) When the route has been identified as a local, state, or regional significant bike route, the minimum shoulder width is 4 ft or as indicated in Chapter 1020 for signed bike lanes.

(4) When bikes are not a consideration, may be reduced to 2 ft with justification.

(5) Measured from the edge of traveled way to the face of the curb.

Shoulder Width for Curbed Sections (5)
Figure 440-3

When traffic barrier with a height of 2 ft or greater is used adjacent to the roadway, the minimum shoulder width from the edge of traveled way to the face of the traffic barrier is 4 ft. Additional width for traffic barrier is not normally required on urban managed access highways.

Where there are no sidewalks the minimum shoulder width is 4 ft. Shoulder widths less than 4 ft will require wheelchairs using the roadway to encroach on the through lane. See Chapter 1025 for additional information and requirements on pedestrians and accessible routes.

The usable shoulder width is less than the constructed shoulder width when vertical features (such as traffic barrier or walls) are at the edge of the shoulder. This is because drivers tend to shy away from the vertical feature. See Chapter 710 for the required widening.

Shoulders on the left between 4 ft and 8 ft are undesirable. Shoulders in this width range might appear to a driver to be wide enough to stop out of the through traffic, when it is not. To prevent the problems that can arise from this, when the shoulder width and any added clearance result in a width in this range, consider increasing the width to 8 ft.

Provide a minimum clearance to roadside objects so that the shoulders do not require narrowing. At existing bridge piers and abutments, shoulders less than full width to a minimum of 2 ft may be used with design exception documentation. See Chapter 700 for design clear zone and safety treatment requirements.

For routes identified as local, state, or regional significant bicycle routes, provide a minimum 4 ft shoulder. Maintain system continuity for the bicycle route, regardless of jurisdiction and functional class. See Chapter 1020 for additional information on bicycle facilities.

Shoulder widths greater than 10 ft may encourage use as a travel lane. Therefore, use shoulders wider than this only where required to meet one of the listed functions.

440.10 Medians

Medians are either restrictive or nonrestrictive. Restrictive medians limit left-turns, physically or legally, to defined locations. Nonrestrictive medians allow left-turns at any point along the route. Consider restrictive medians on multilane limited access highways and multilane managed access highways when the DHV is over 2000.

The primary functions of a median are to:

- Separate opposing traffic.
- Provide for recovery of out-of-control vehicles.
- Reduce head-on accidents.

- Provide an area for emergency parking.
- Allow space for left turn lanes.
- Minimize headlight glare.
- Allow for future widening.
- Control access.

For maximum efficiency, make medians highly visible both night and day. Medians may be depressed, raised, or flush with the through lanes.

The width of a median is measured from edge of traveled way to edge of traveled way and includes the shoulders. The minimum median width for each design class is given in Figures 440-4 through 440-8. When selecting a median width, consider future needs such as wider left shoulders when widening from four to six lanes.

A two-way left-turn lane (TWLTL) may be used as a nonrestrictive median for an undivided managed access highway. (See Figure 440-8.) The desirable width of a TWLTL is 13 ft with a minimum width of 11 ft. For more information on traffic volume limits for TWLTLs on managed access highways, see Chapter 1435. See Chapter 910 for additional information on TWLTL design.

A common form of restrictive median on managed access highways in urban areas is the raised median. The width of a raised median can be minimized by using a dual-faced cement concrete traffic curb, a precast traffic curb, or an extruded curb. For more information on traffic volume limits for restrictive medians on managed access highways, see Chapter 1435.

At locations where the median will be used to allow vehicles to make a u-turn, consider increasing the width to meet the needs of the vehicles making the u-turn. See Chapter 910 for information on u-turn locations.

When the median is to be landscaped or where rigid objects are to be placed in the median, see Chapter 700 for traffic barrier and clear zone requirements. When the median will include a turn-lane lane, see Chapter 910 for left-turn lane design.

440.11 Curbs

(1) General

Curbs are divided into vertical curbs and sloped curbs. Vertical curbs have a face batter not flatter than 1H:3V. Sloped curbs have a sloping face that is more readily traversed.

Curbs can also be classified as mountable. Mountable curbs are sloped curb with a height of 6 in or less, preferably 4 in or less. When the face slope is steeper than 1H:1V, the height of a mountable curb is limited to 4 in or less.

Where curbing is to be provided, ensure that surface water that collects at the curb will drain and not pond or flow across the roadway.

When an overlay will reduce the height of a vertical curb, evaluate grinding to maintain curb height, or replacing the curb, versus the need to maintain the height of the curb.

Curbs can hamper snow removal operations. The area Maintenance Superintendent's review and approval is required for the use of curbing in areas of heavy snowfall.

For curbs at traffic islands, see Chapter 910.

(2) Curb Usage

Curbing is used for the following purposes:

- control drainage
- delineate the roadway edge
- delineate pedestrian walkways
- delineate islands
- reduce right of way
- assist in access control
- inhibit mid-block left turns

Avoid using curbs if the same objective can be attained with pavement markings.

In general, curbs are not used on facilities with a posted speed greater than 40 mph. The exceptions are for predominantly urban or rapidly developing areas where sidewalks are provided or where traffic movements are to be restricted. Justify the use of curb when the posted speed is greater than 40 mph.

(a) Vertical curbs with a height of 6 inches or more are required for:

- inhibiting or at least discouraging vehicles from leaving the roadway.
- walkway and pedestrian refuge separations.
- raised islands on which a traffic signal, or traffic signal hardware, is located.

When an overlay is planned, do not reduce the height of the curb to less than 4 inches.

(b) Consider vertical curbs with a height of 6 inches or more:

- to inhibit mid-block left turns.
- for divisional and channelizing islands.
- for landscaped islands.

(c) Provide mountable curbs where a curb is needed but higher vertical curb is not justified.

440.12 Parking

In urban areas and rural communities, land use might require parking along the highway. In general, on-street parking decreases capacity, increases accidents, and impedes traffic flow. Therefore, it is desirable to prohibit parking.

Although design data for parking lanes are included on Figures 440-5a through 8, consider them only in cooperation with the municipality involved. The lane widths given are the minimum for parking, provide wider widths when practical.

Angle parking is not permitted on any state route without approval by WSDOT (RCW 46.61.575). This approval is delegated to the State Traffic Engineer. Angle parking approval is to be requested through the HQ Design Office. Provide an engineering study, approved by the region's Traffic Engineer, with the request that shows the parking will not unduly reduce safety and that the roadway is of sufficient width that the parking will not interfere with the normal movement of traffic.

440.13 Pavement Type

The pavement types given in Figures 440-4 through 7a are the recommended for each design class. (See Chapter 520 for information on pavement type selection). When a roadway is to be widened and the existing pavement will remain, the new pavement type may be the same as the existing without a pavement type determination.

440.14 Structure Width

Provide a clear width between curbs on a structure not less than the approach roadway width (lanes plus shoulders). The structure widths given in Figures 440-4 through 8 are the minimum structure width for each design class.

Additional width for barriers is not normally added to the roadway width on structures. When a structure is in a run of roadside barrier with the added width, consider adding the width on shorter structures to prevent narrowing the roadway.

440.15 Right of Way Width

Right of way width must be sufficient to accommodate all roadway elements and required appurtenances necessary for the current design and known future improvements. To allow for construction and maintenance activities, provide 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See Chapter 640 and the Standard Plans for slope treatment information.

The right of way widths given in Figures 440-4 through 7b, are desirable minimums for new alignment requiring purchase of new right of way. See Chapter 1410 for additional information and consideration on right of way acquisition.

440.16 Grades

Grades can have a pronounced effect on the operating characteristics of the vehicles negotiating them. Generally, passenger cars can readily negotiate grades as steep as 5% without appreciable loss of speed from that maintained on level highways. Trucks, however, travel at the average speed of passenger cars on the level but display up to a 5% increase in speed on downgrades and a 7% or more decrease in speed on upgrades (depending on length and steepness of the grade as well as weight to horsepower ratio).

The maximum grades for the various functional classes and terrain conditions are shown in Figures 440-4 through 7a. For the effects of these grades on the design of a roadway see Chapters 630 and 1010.

440.17 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

	Divided Multilane	
Design Class	I-1	
Design Year	(1)	
Access Control (2)	Full	
Separate Cross Traffic		
Highways	All	
Railroads	All	
Design Speed (mph)		
Rural	80 (3)	
Urbanized	70 (4)	
Traffic Lanes		
Number	4 or more divided	
Width (ft)	12	
Median Width (ft)	4 lane	6 lanes or more
Rural — Minimum (5)	40	50
Urban — Minimum	16	22
Shoulder Width (ft)(14)		
Right of Traffic	10 (6)	10 (6)
Left of Traffic	4	10 (6)(7)
Pavement Type (8)	High	
Right of Way (9)		
Rural — Width (ft)	63 from edge of traveled way	
Urban — Width (ft)	As required (10)	
Structures Width (ft) (11)	Full roadway width each direction (12)	

	Design Speed (mph)						
Type of Terrain	50	55	60	65	70	75	80
Level	4	4	3	3	3	3	3
Rolling	5	5	4	4	4	4	4
Mountainous	6	6	6	5	5	5	5
Grades (%) (13)							

Interstate Notes:

(1) The design year is 20 years after the year the construction is scheduled to begin.

(2) See Chapter 1430 for access control requirements.

(3) 80 mph is the desirable design speed; with a corridor analysis, the design speed may be reduced to 60 mph in mountainous terrain and 70 mph in rolling terrain. Do not select a design speed that is less than the posted speed.

(4) 70 mph is the desirable design speed, with a corridor analysis the design speed may be reduced to 50 mph. Do not select a design speed that is less than the posted speed.

(5) Independent alignment and grade is desirable in all rural areas and where terrain and development permits in urban areas.

(6) 12 ft shoulders are desirable when the truck DDHV is 250 or greater.

(7) For existing 6-lane roadways, existing 6 ft left shoulders may remain with design exception documentation, when they are not being reconstructed, and no other widening is required.

(8) See Chapter 520 for Pavement Type Determination.

(9) Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See 440.15.

(10) In urban areas, make right of way widths not less than those required for necessary cross section elements.

(11) See Chapter 1120 for minimum vertical clearance.

(12) For median widths 26 ft or less, address bridge(s) in accordance with Chapter 1120.

(13) Grades 1% steeper may be provided in urban areas and mountainous terrain with critical right of way controls.

(14) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Interstate

Figure 440-4

Design Class	Divided Multilane				Two-Lane						Undivided Multilane	
	P-1		P-2		P-3		P-4		P-5		P-6 (1)	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
DHV in Design Year (2) NHS Non NHS	Over 1,500		Over 700		Over 201 (3) Over 301		61-200 (4) 101-300		60 and under 100 and Under		Over 700	
Access Control	Full (5)		Partial (5)		(5)		(5)		(5)		(5)	
Separate Cross Traffic Highways Railroads (6)	 All All		 Where Justified All		 Where Justified All (7)		 Where Justified Where Justified (8)		 Where Justified Where Justified (8)		 Where Justified Where Justified (8)	
Design Speed (mph) (9) Minimum (10)	80 60 (11)		70 50 (12)		70 50	60 40 (12)	70 50	60 40 (12)	60 40	60 30 (12)	70 40	60 30 (12)
Traffic Lanes Number Width (ft)	 4 or more divided 12		 4 or 6 divided 12		 2 12		 2 12		 2 12		 4 12	 4 or 6 11 (13)
Shoulder Width (ft) <u>(30)</u> Right of Traffic Left of Traffic	 10 (14) Variable (15)(16)		 10 Variable (15)(16)		8		6		4		8	8(17)
Median Width (ft) 4 lane 6 or more lanes	 40 (18) 48 (18)	 16 22	 60 60	 16 22							 4 4	 2 (19) 2 (19)
Parking Lanes Width (ft) — Minimum	None		None		None		None	10	None	10	None	10 (20)
Pavement Type (21)	High				High or intermediate							
Right of Way (22) —Width (ft)	(23)	(24)	(23)	(24)	120	80	120	80	100	80	150	80
Structures Width (ft) (25)	Full roadway width (26)				40		40		32		Full roadway width	
Other Design Considerations-Urban					(27)		(27)		(27)		(27)	

Type of Terrain	Rural — Design Speed (mph)									Urban — Design Speed (mph)						
	40	45	50	55	60	65	70	75	80	30	35	40	45	50	55	60 (28)
Level	5	5	4	4	3	3	3	3	3	8	7	7	6	6	5	5
Rolling	6	6	5	5	4	4	4	4	4	9	8	8	7	7	6	6
Mountainous	8	7	7	6	6	5	5	5	5	11	10	10	9	9	8	8
Grades (%) (29)																

Geometric Design Data, Principal Arterial
Figure 440-5a

Principal Arterial Notes:

(1) Justify the selection of a P-6 design class on limited access highways.

(2) The design year is 20 years after the year the construction is scheduled to begin.

(3) Where DHV exceeds 700, consider four lanes. When the volume/capacity ratio is equal to or exceeds 0.75, consider the needs for a future four-lane facility. When considering truck climbing lanes on a P-3 design class highway, perform an investigation to determine if a P-2 design class highway is justified.

(4) When considering a multilane highway, perform an investigation to determine if a truck climbing lane or passing lane will satisfy the need. See Chapter 1010.

(5) See Chapters 1430 and 1435 and the Master Plan for Limited Access Highways for access control requirements. Contact the HQ Design Office Access & Hearings Unit for additional information.

(6) Contact the Rail Office of the Public Transportation and Rail Division for input on the needs for the railroad.

(7) All main line and major-spur railroad tracks will be separated. Consider allowing at-grade crossings at minor-spur railroad tracks.

(8) Criteria for railroad grade separations are not clearly definable. Evaluate each site regarding the hazard potential. Provide justification for railroad grade separations.

(9) These are the design speeds for level and rolling terrain in rural areas. They are the preferred design speeds for mountainous terrain and urban areas. Higher design speeds may be selected, with justification.

(10) These design speeds may be selected in mountainous terrain, with a corridor analysis. Do not select a design speed that is less than the posted speed.

(11) In urbanized areas, with a corridor analysis, 50 mph may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

(12) In urban areas, with a corridor analysis these values may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

(13) 12 ft lanes are required when the truck DDHV is 150 or greater.

(14) 12 ft shoulders are desirable when the truck DDHV is 250 or greater.

(15) Minimum left shoulder width is to be as follows: four lanes — 4 ft: six or more lanes — 10 ft. Consider 12 ft shoulders on facilities with 6 or more lanes and a truck DDHV of 250 or greater.

(16) For existing 6-lane roadways, existing 6 ft left shoulders may remain with design exception documentation, when they are not being reconstructed, and no other widening is required.

(17) When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft.

(18) On freeways or expressways requiring less than eight lanes within the 20-year design period, provide sufficient median or lateral clearance and right of way to permit addition of a lane in each direction if required by traffic increase after the 20-year period.

(19) When signing is required in the median of a six-lane section, the minimum width is 6 ft. If barrier is to be installed at a future date, an 8 ft minimum median is required.

(20) Restrict parking when DHV is over 1500.

(21) See Chapter 520 for Pavement Type Determination.

(22) Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See 440.15.

(23) 63 ft from edge of traveled way.

(24) Make right of way widths not less than those required for necessary cross section elements.

(25) See Chapter 1120 for the minimum vertical clearance.

(26) For median widths 26 ft or less, address bridges in accordance with Chapter 1120.

(27) For bicycle requirements, see Chapter 1020. For pedestrian and sidewalk requirements, see Chapter 1025. Curb requirements are in 440.11. Lateral clearances from the face of curb to obstruction are in Chapter 700.

(28) For grades at design speeds greater than 60 mph in urban areas, use rural criteria.

(29) Grades 1% steeper may be used in urban areas and mountainous terrain with critical right of way controls.

(30) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Principal Arterial
Figure 440-5b

Design Class		Divided Multilane		Two-Lane						Undivided Multilane	
		M-1		M-2		M-3		M-4		M-5 (1)	
		Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
DHV in Design Year (2)	NHS	Over 700		Over 201 (3)		61-200 (4)		60 and Under		Over 700	
	Non NHS			Over 401		201-400		200 and Under			
Access Control		Partial (5)		(5)		(5)		(5)		(5)	
Separate Cross Traffic											
Highways		Where Justified		Where Justified		Where Justified		Where Justified		Where Justified	
Railroads (6)		All		All (7)		Where Justified (8)		Where Justified (8)		Where Justified (8)	
Design Speed (mph) (9)		70		70	60	70	60	60	60	70	60
Minimum (10)(11)		50		50	40	50	40	40	30	40	30
Traffic Lanes											
Number		4 or 6 divided		2		2		2		4	4 or 6
Width (ft)		12		12		12		12		12	11 (12)
Shoulder Width (ft) (27)											
Right of Traffic		10		8		6		4		8	8 (15)
Left of Traffic		Variable (13)(14)									
Median Width (ft)											
4 lane		60	16							4	2 (16)
6 lane		60	22								
Parking Lanes Width (ft) — Minimum		None		None		None	10	None	10	None	10 (17)
Pavement Type (18)		High		As required						High or Intermediate	
Right of Way (19) —Width (ft)		(20)	(21)	120	80	120	80	100	80	150	80
Structures (ft) (22)		Full Roadway Width (23)		40		40		32		Full Roadway Width	
Other Design Considerations-Urban				(24)		(24)		(24)		(24)	

Type of Terrain	Rural — Design Speed (mph)									Urban — Design Speed (mph)						
	40	45	50	55	60	65	70	75	80	30	35	40	45	50	55	60 (25)
Level	5	5	4	4	3	3	3	3	3	8	7	7	6	6	5	5
Rolling	6	6	5	5	4	4	4	4	4	9	8	8	7	7	6	6
Mountainous	8	7	7	6	6	5	5	5	5	11	10	10	9	9	8	8
Grades (%)(26)																

Geometric Design Data, Minor Arterial
Figure 440-6a

Minor Arterial Notes:

(1) Justify the selection of an M-5 design class on limited access highways.

(2) The design year is 20 years after the year the construction is scheduled to begin.

(3) Where DHV exceeds 700, consider four lanes. When the volume/capacity ratio is equal to or exceeds 0.75, consider the needs for a future four-lane facility. When considering truck climbing lanes on an M-2 design class highway, perform an investigation to determine if an M-1 design class highway is justified.

(4) When considering a multilane highway, perform an investigation to determine if a truck climbing lane or passing lane will satisfy the need. See Chapter 1010.

(5) See Chapters 1430 and 1435 and the Master Plan for Limited Access Highways for access control requirements. Contact the HQ Design Office Access & Hearings Unit for additional information.

(6) Contact the Rail Office of the Public Transportation and Rail Division for input on the needs for the railroad.

(7) All main line and major-spur railroad tracks will be separated. Consider allowing at-grade crossings at minor-spur railroad tracks.

(8) Criteria for railroad grade separations are not clearly definable. Evaluate each site regarding the hazard potential. Provide justification for railroad grade separations.

(9) These are the design speeds for level and rolling terrain in rural areas. They are the preferred design speeds for mountainous terrain and urban areas. Higher design speeds may be selected, with justification.

(10) In urban areas, with a corridor analysis these values may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

(11) These design speeds may be selected in mountainous terrain, with a corridor analysis. Do not select a design speed that is less than the posted speed.

(12) When the truck DDHV is 150 or greater, consider 12 ft lanes.

(13) The minimum left shoulder width is 4 ft for four lanes and 10 ft for six or more lanes.

(14) For existing 6-lane roadways, existing 6 ft left shoulders may remain with design exception documentation, when they are not being reconstructed,and no other widening is required.

(15) When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft.

(16) When signing is required in the median of a six-lane section, the minimum width is 6 ft. If barrier is to be installed at a future date, an 8 ft minimum median is required.

(17) Restrict parking when DHV is over 1500.

(18) <u>See Chapter 520 for</u> Pavement Type Determination.

(19) Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See 440.15.

(20) 63 ft from edge of traveled way

(21) Make right of way widths not less than those required for necessary cross section elements.

(22) See Chapter 1120 for the minimum vertical clearance.

(23) For median widths 26 ft or less, address bridges in accordance with Chapter 1120.

(24) For bicycle requirements, see Chapter 1020. For pedestrian and sidewalk requirements see Chapter 1025. Curb requirements are in 440.11. Lateral clearances from the face of curb to obstruction are in Chapter 700.

(25) For grades at design speeds greater than 60 mph in urban areas, use rural criteria.

(26) Grades 1% steeper may be used in urban areas and mountainous terrain with critical right of way controls.

(27) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Minor Arterial
Figure 440-6b

Design Class	Undivided Multilane		Two-Lane					
	C-1		C-2		C-3		C-4	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
DHV in Design Year (1) NHS Non NHS	Over 900		Over 301 (2) Over 501		201-300 (3) 301-500		200 and under 300 and Under	
Access Control	(4)		(4)		(4)		(4)	
Separate Cross Traffic Highways Railroads (5)	Where Justified Where Justified (6)		Where Justified All (6)		Where Justified Where Justified (6)		Where Justified Where Justified (6)	
Design Speed (mph) (7) Minimum (8)(9)	70 40	60 30	70 50	60 40	70 50	60 40	60 40	60 30
Traffic Lanes Number Width (ft)	4 12	4 or 6 11 (10)	2 12		2 12		2 12	
Shoulder Width (ft) (19)	8	8 (11)	8		6		4	
Median Width — Minimum (ft)	4	2 (12)						
Parking Lanes Width (ft) — Minimum	None	10	None		None	10	None	10
Pavement Type (13)	High or Intermediate		As required					
Right of Way (ft) (14)	150	80	120	80	120	80	100	80
Structures Width (ft) (15)	Full Roadway Width		40		40		32	
Other Design Considerations — Urban	(16)		(16)		(16)		(16)	

Type of Terrain	Rural — Design Speed (mph)										Urban — Design Speed (mph)								
	25	30	35	40	45	50	55	60	65	70	20	25	30	35	40	45	50	55	60(17)
Level	7	7	7	7	7	6	6	5	5	4	9	9	9	9	9	8	7	7	6
Rolling	10	9	9	8	8	7	7	6	6	5	12	12	11	10	10	9	8	8	7
Mountainous	11	10	10	10	10	9	9	8	8	6	14	13	12	12	12	11	10	10	9
Grades (%) (18)																			

Geometric Design Data, Collector

Figure 440-7a

Collector Notes:

(1) The design year is 20 years after the year the construction is scheduled to begin.

(2) Where DHV exceeds 900, consider four lanes. When the volume/capacity ratio is equal to or exceeds 0.85, consider the needs for a future four-lane facility. When considering truck climbing lanes on a C-2 design class highway, perform an investigation to determine if a C-1 design class highway is justified.

(3) When considering a multilane highway, perform an investigation to determine if a truck climbing lane or passing lane will satisfy the need. See Chapter 1010.

(4) See Chapters 1430 and 1435 and the Master Plan for Limited Access Highways for access control requirements. Contact the HQ Design Office Access & Hearings Unit for additional information.

(5) Contact the Rail Office of the Public Transportation and Rail Division for input on the needs for the railroad.

(6) Criteria for railroad grade separations are not clearly definable. Evaluate each site regarding the hazard potential. Provide justification for railroad grade separations.

(7) These are the design speeds for level and rolling terrain in rural areas. They are the preferred design speeds for mountainous terrain and urban areas. Higher design speeds may be selected, with justification. Do not select a design speed that is less than the posted speed.

(8) In urban areas, with a corridor analysis these values may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

(9) These design speeds may be selected in mountainous terrain, with a corridor analysis. Do not select a design speed that is less than the posted speed.

(10) Consider 12 ft lanes when the truck DHV is 200 or greater.

(11) When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft.

(12) When signing is required in the median of a six-lane section, the minimum width is 6 ft median. If barrier is to be installed at a future date, an 8 ft minimum median is required.

(13) <u>See Chapter 520 for</u> Pavement Type Determination.

(14) Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut. See 440.15.

(15) See Chapter 1120 for the minimum vertical clearance.

(16) For bicycle requirements, see Chapter 1020. For pedestrian and sidewalk requirements see Chapter 1025. Curb requirements are in 440.11. Lateral clearances from the face of curb to obstruction are in with Chapter 700.

(17) For grades at design speeds greater than 60 mph in urban areas, use rural criteria.

(18) Grades 1% steeper may be used in urban areas and mountainous terrain with critical right of way controls.

(19) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Collector
Figure 440-7b

Design Class	Divided Multilane		Undivided Multilane		Two-Lane	
	UM/A-1	UM/A-2	UM/A-3	UM/A-4	UM/A-5	UM/A-6
DHV in Design Year (1)	Over 700	Over 700	700 – 2,500	Over 700	All	All
Design Speed (mph)	Greater than 45	45 or less	35 to 45	30 or less	Greater than 45	45 or less
Access	(2)	(2)	(2)	(2)	(2)	(2)
Traffic Lanes						
Number	4 or more	4 or more	4 or more	4 or more	2	2
Width (ft) NHS	12 (3)(4)	12 (3)	12 (3)	12 (3)	12 (3)(6)	12 (3)
Non NHS	11 (4)	11 (5)	11 (5)	11 (5)	11 (6)	11 (7)
Shoulder Width (ft) (8)						
Right of Traffic (19)	10	10	8	8	8 (9)	4
Left of Traffic	4	4				
Median Width (ft)	10 (10)	3 (10)(11)	(12)	(12)		
Parking Lane Width (ft)	None	10 (13)	10 (13)	8 (14)	10 (15)	8 (14)
Structures Width (ft) (16)	Full roadway width (17)		Full roadway width		32	30
Other Design Considerations	(18)	(18)	(18)	(18)	(18)	(18)

Urban Managed Access Highways Notes:

(1) The design year is 20 years after the year the construction is scheduled to begin.
(2) The urban managed access highway design is only used on managed access highways. See Chapter 1435.
(3) May be reduced to 11 ft with justification.
(4) Provide 12 ft lanes when truck DDHV is 200 or greater.
(5) Consider 12 ft lanes when truck DDHV is 200 or greater.
(6) Provide 12 ft lanes when truck DHV is 100 or greater.
(7) Consider 12 ft lanes when truck DHV is 100 or greater.
(8) See Figure 440-3 when curb section is used.
(9) When DHV is 200 or less, may be reduced to 4 ft.
(10) 12 ft desirable. At left-turn lanes, the minimum median width is 12 ft to accommodate the turn lane.
(11) The minimum median width is 10 ft when median barrier is used.
(12) 2 ft is desirable. When a TWLTL is present 13 ft is desirable, 11 ft is minimum.
(13) Prohibit parking when DHV is over 1500.
(14) 10 ft desirable.
(15) Prohibit parking when DHV is over 500.
(16) See Chapter 1120 for minimum vertical clearance.
(17) See Chapter 1120 for median requirements.
(18) For bicycle requirements, see Chapter 1020. For pedestrian and sidewalk requirements, see Chapter 1025. Lateral clearances from the face of curb to obstruction are in with Chapter 700. For railroad and other roadway grade separation, maximum grade, and pavement type for the functional class, see Figures 440-5a through 7b. Make right of way widths not less than required for necessary cross section elements.
(19) When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced up to 4 inches.

Geometric Design Data, Urban Managed Access Highways
Figure 440-8

Chapter 510 Investigation of Soils, Rock, and Surfacing Materials

510.01 General

It is the responsibility of the Washington State Department of Transportation (WSDOT) to understand the characteristics of the soil and rock materials that support or are adjacent to the transportation facility to ensure that the facility, when designed, will be adequate to safely carry the estimated traffic. It is also the responsibility of WSDOT to ensure the quality and quantity of all borrow materials used in the construction of transportation facilities.

The following information serves as guidance in the above areas. Where a project consists of a surface overlay of an existing highway, requirements as set forth in *WSDOT Pavement Guide for Design, Evaluation and Rehabilitation* are used.

To identify the extent and estimated cost for a project, it is necessary to obtain and use an adequate base data. In recognition of this need, preliminary soils investigation work begins during project definition. This allows early investigative work and provides necessary data in a timely manner for use in project definition and design. More detailed subsurface investigation follows during the project design and plan, specification, and estimate (PS&E) phases.

It is essential to get the region's Materials Engineer (RME) and the Headquarters (HQ) Geotechnical Services Division involved in the project design as soon as possible once the need for geotechnical work is identified. See 510.04(3) for time-estimate information. Furthermore, if major changes occur as the project is developed, inform the RME and HQ Geotechnical Services Division as soon as possible so that the geotechnical design can be adapted to the changes without significant delay to the project.

510.02 References

Construction Manual, M 41-01, WSDOT

Hydraulics Manual, M 23-03, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

WSDOT Pavement Guide Interactive

510.03 Materials Sources

(1) General

The region's Project Development Engineer (RPDE) determines when a materials source is needed. The region's Materials Engineer (RME) determines the best materials source for the project. (See Figure 510-1.) It is preferred that existing approved materials source sites be used when there are suitable sites available. When there are no approved sites available, the RME conducts a site investigation. The HQ Geotechnical Services Division provides assistance upon request.

The RME selects sources for gravel base, borrow excavation and gravel borrow, crushed surfacing materials, mineral and concrete aggregates, riprap, and filler only after careful investigation of:

- The site. (Consider the adequacy of the work area.)
- The quality of the material.
- The quantity of the material. (Consider the needs of the immediate project and the needs to support future maintenance and construction work in the area.)

- Reclamation requirements.
- Aesthetic considerations.
- Economic factors.
- Ability to preserve or enhance the visual quality of the highway and local surroundings.

Once the materials source investigation and laboratory testing have been completed the RME prepares a materials source report. The materials source report summarizes the site geology, site investigation (including boring and test pit logs), source description, quality and quantity of material available, and other aspects of the materials sources that are relevant.

(2) Materials Source Approval

The RME submits the materials source report to the HQ Geotechnical Services Division for review and approval.

The HQ Materials Office and the HQ Design Office must approve each pit or quarry site before it is purchased, leased, or acquired on a royalty basis. Until the approval process is complete, the project cannot be advertised for bids. Local and state permits are required for materials sources. To avoid delay in advertising the project, begin the site investigations and permitting process in the early stages of project definition.

510.04 Geotechnical Investigation, Design, and Reporting

(1) General

A geotechnical investigation is conducted on all projects that involve significant grading quantities, unstable ground, or foundations for structures in a manner that preserves the safety of the public who use the facility, as well as preserving the economic investment by the state of Washington. Geotechnical engineering must be conducted by engineers or engineering geologists who possess adequate geotechnical training and experience, and must be conducted in accordance with regionally or nationally accepted geotechnical practice. Where required by law, geotechnical engineering must be performed by, or under the direct supervision of, a person licensed to perform such work in the state of Washington.

(2) Key Contacts for Initiating Geotechnical Work

In general, the RME functions as the clearing house for all geotechnical work, with the exception of structural projects and Washington State Ferries (WSF) projects. The RME takes the lead in conducting the geotechnical work if the geotechnical work required is such that the ground is stable and relatively firm, bedrock is not involved, and the design of the project geotechnical elements does not require specialized geotechnical design expertise. If this is not the case, the RME asks for the involvement and services of the HQ Geotechnical Services Division. They respond to and provide recommendations directly to the region's project design office (or the HQ Facilities Office in the case of Facilities projects), but always keeping the RME "in the loop."

For structural projects (bridges and tunnels, for example), the HQ Bridge and Structures Office works directly with the HQ Geotechnical Services Division.

For WSF projects, the Terminal Engineering Office works directly with the RME or the HQ Geotechnical Services Division, depending on the nature of the project.

For walls and noise walls, see Chapters 1130 and 1140, respectively. For geosynthetic design, see Chapter 530.

(3) Scheduling Considerations for Geotechnical Work

The region's Design Office, HQ Bridge and Structures Office, WSF, and the HQ Facilities Office are responsible for identifying the potential need for geotechnical work, and requesting time and budget estimates from the RME or the HQ Geotechnical Services Division, as early as practical to prevent delays to the project.

Once the geotechnical design request and the site data are received by the RME or the HQ Geotechnical Services Division, it can take anywhere from two to six months, or more, to complete the geotechnical design, depending on the complexity of the project, whether or not test holes are needed, current workload, the need to give the work to consultants, and how long it takes to obtain environmental permits and rights of entry (ROE).

If a consultant must be used, the minimum time required to complete a design (for even a simple project) is typically 2.5 months.

In true emergency situations (a highway blocked by a landslide or a collapsed bridge, for example), it is possible to get geotechnical design work completed (in house or by consultants) more rapidly to at least provide a design for temporary mitigation.

Consider all of these factors when deciding how soon to initiate the geotechnical work for a project but, in general, the sooner, the better.

(4) Site Data and Permits Needed to Initiate Geotechnical Work

To initiate geotechnical work on a project during the design and PS&E phases, provide the following information:

(a) Project description.

(b) Plan sheets showing the following:

- Station and location of cuts, fills, walls, bridges, retention/detention ponds, or other geotechnical features to be designed.
- Existing utilities (as-built plans are acceptable).
- Right of way limits.
- Wetlands.
- Drainage features.
- Existing structures.
- Other features or constraints that could affect the geotechnical design or investigation.

(c) Electronic files, or cross sections every 50 ft to 65 ft or as appropriate, to define existing and new ground line above and below the wall, cut, fill, and other pertinent information.

- Show stationing.
- Show locations of existing utilities, right of way lines, wetlands, and other constraints.
- Show locations of existing structures that might contribute load to the cut or fill.

(d) Right of entry agreements and permits required for geotechnical investigation.

(e) Due date and work order number.

(f) Contact person.

When the alignment and any constraints as noted above are staked, the stationing on the plans and in the field must be in the same units. Physical surveys are preferred to photogrammetric surveys to ensure adequate accuracy of the site data.

Permits and agreements to be supplied by the region might include:

- HPA
- Shoreline permits
- Tribal lands and waters
- Railroad easement and right of way
- City, county, or local agency use permits
- Sensitive area ordinance permits

The region's project office is also responsible for providing the stations, offsets, and elevations of test holes to the nearest 1 ft once the test holes have been drilled. Provide test hole locations using state plane coordinates as well, if available.

(5) Overview of Geotechnical Design Objectives for the Various Project Stages

(a) **Project Definition.** The project design office uses the geotechnical investigation results obtained during the project definition phase to develop the project delivery cost and schedule. Geotechnical recommendations provided for this phase will be at the conceptual/feasibility level. The investigation for this phase usually consists of a visual project walk-through and a review of the existing records, geologic maps, and so forth.

For projects of significant geotechnical scope and complexity, and if soil borings are not available at critical locations within the project, some soil borings might be drilled at this time. Potential geotechnical hazards (earthquake faults, liquefaction, landslides, rockfall, soft ground, for example) are identified during project definition, and conceptual hazard avoidance or mitigation plans are developed. Future geotechnical design services needed in terms of time and cost, including the need for special permits to perform the geotechnical exploration (critical areas ordinances), are determined at this time.

(b) **Project Design.** Once the roadway geometry is established, detailed design of cut and fill slopes, adequate to establish the right of way needs, is accomplished. Once approximate wall locations and heights are known, preliminary design of walls is performed to establish feasibility, primarily to establish right of way needs (as is true for slopes) and likely wall types. A similar level of design is applied to hydraulic structures, and to determine overall construction staging and constructibility requirements to address the geotechnical issues at the site. Conceptual and/or more detailed preliminary bridge foundation design is conducted during this phase if it was not conducted during project definition. Before the end of this phase, the geotechnical data necessary to allow future completion of the PS&E level design work is gathered (final geometric data, test hole data, and so forth.).

(c) **PS&E Development.** Final design of all geotechnical project features is accomplished. Recommendations for these designs, as well as special provisions and plan details to incorporate the geotechnical design recommendations in the PS&E, are provided in the geotechnical report. Minor geotechnical features such as signal/sign foundations and small detention/retention ponds are likely to be addressed at this stage, as the project details become clearer. Detailed recommendations for the constructibility of the project geotechnical features are also provided.

(6) Earthwork

(a) **Project Definition.** The project designer contacts and meets with the RME, and the HQ Geotechnical Services Division as needed, at the project site to conduct a field review to help identify the geotechnical issues for the project.

In general, if soil/rock conditions are poor and/or large cuts or fills are anticipated, the RME requests that the HQ Geotechnical Services Division participate in the field review and reporting efforts.

The designer provides a description and location of the proposed earthwork to the RME.

- For widening of existing facilities, the anticipated width, length, and location of the widening, relative to the current facility, are provided.
- For realignments, the approximate new location proposed for the facility is provided.
- Locations in terms of length can be by mile post or stations.

A brief conceptual level report is provided to the designer that summarizes the results of the investigation.

(b) **Project Design.** Geotechnical data necessary to allow completion of the PS&E level design is compiled during the design phase. This includes soils borings, testing, and final geometric data. Detailed design of cut and fill slopes can be done once the roadway geometry is established and geotechnical data is available. The purpose of this design effort is to determine the maximum stable cut or fill slope and, for fills, potential for short and long term settlement. Also, the usability of the cut materials and the type of borrow needed for the project, if any, is evaluated. Evaluate the use of soil bioengineering as an option for building steeper slopes or to prevent surface erosion. See the Chapter 1350 "Soil Bioengineering," for more information.

The designer requests a geotechnical report from the RME. The site data indicated in 510.04(4), as applicable, is provided. It is important that the request for the geotechnical report be made as early in the design phase as practical. Cost and schedule requirements to generate the report are project specific and can vary widely. The time required to obtain permits and rights of entry must be considered when establishing schedule requirements.

The RME, in conjunction with the HQ Geotechnical Services Division, provides the following information as part of the geotechnical report (as applicable):

1. General description of the regional and site geology

2. Summary of the investigation

3. Boring logs
4. Laboratory tests and results
5. Soil/rock unit descriptions
6. Ground water conditions
7. Embankment design recommendations
   - The slope required for stability
   - Estimated amount and rate of settlement
   - Stability and settlement mitigation requirements
   - Construction staging requirements
   - Effects of site constraints
   - Monitoring needs
   - Material and compaction requirements
   - Subgrade preparation
8. Cut design recommendations
   - The slope required for stability
   - Stability mitigation requirements (deep seated stability and erosion)
   - Identification of seepage areas and how to mitigate them
   - Effects of site constraints
   - Monitoring requirements
   - Usability of excavated cut material, including gradation, moisture conditions and need for aeration, and shrink/swell characteristics

The recommendations include the background regarding analysis approach and any agreements with the region or other customers regarding the definition of acceptable level of risk.

The project office uses the report to finalize design decisions for the project. To meet slope stability requirements, additional right of way might be required or a wall might be needed. Wall design is covered in Chapter 1130. Construction timing might require importing material rather than using cut materials. The report is used to address this and other constructibility issues. The report is also used to proceed with completion of the project PS&E design.

(c) **PS&E Development.** Adequate geotechnical design information to complete the PS&E is typically received during project design. Additional geotechnical work might be needed when right of way cannot be acquired, restrictions are included in permits, or other requirements are added that result in changes in the design.

Special provisions and plan details, if not received as part of the report provided during project design, are developed with the assistance of the RME or the HQ Geotechnical Services Division. The project designer uses this information, as well as the design phase report, to complete the PS&E documents. Both the region's Materials Section and the HQ Geotechnical Services Division can review the contract plans before the PS&E review process begins, if requested. Otherwise, they will review the contract plans during the normal PS&E review process.

(7) Hydraulic Structures and Environmental Mitigation

(a) **Project Definition.** The designer provides a description and location of the proposed hydraulic/environmental improvements and other pertinent site information, and discusses the extent of the hydraulics and environmental improvements, with both the RME and the HQ Hydraulics Branch, to identify the geotechnical issues to be investigated. At this stage, only the identification and feasibility of the proposed hydraulic structures or environmental mitigation are investigated. The cost and schedule requirements for the geotechnical investigation are also determined at this time.

Examples of hydraulic structures include, but are not limited to, large culverts, pipe arches, underground detention vaults, and fish passage structures. Examples of environmental mitigation include, but are not limited to, detention/retention ponds and wetland creation.

(b) **Project Design.** The designer requests a geotechnical report from the RME. The site data indicated in 510.04(4), as applicable, is provided along with the following information:

- Pertinent field observations (such as unstable slopes, existing soft soils or boulders, or erosion around and damage to existing culverts or other drainage structures).
- Jurisdictional requirements for geotechnical design of berms/dams.

It is important that the request for the geotechnical report be made as early in the design phase as practical. Cost and schedule requirements to generate the report are project specific and can vary widely. The time required to obtain permits and rights of entry must be considered when establishing schedule requirements.

The RME, with support from the HQ Geotechnical Services Division as needed, provides the following information, when requested and where applicable, as part of the project geotechnical report:

- Soil boring logs.
- Soil pH and resistivity.
- Water table elevation.
- Soil infiltration rates (highest rate for assessing spill containment/aquifer protection and long-term rate for determining pond capacity).
- Bearing capacity and settlement for hydraulic structure foundations.
- Slope stability for ponds.
- Retention berm/dam design.
- Potential for and amount of differential settlement along culverts and pipe arches and the estimated time required for settlement to occur.
- Soil pressures and properties (primarily for underground detention vaults).
- Erosion potential.
- Geosynthetic design per Chapter 530.
- Recommendations for mitigation of the effect of soft or unstable soil on the hydraulic structures.
- Recommendations for construction.

Note that retaining walls that are part of a pond, fish passage, and the like, are designed per Chapter 1130.

The project designer uses the geotechnical information to:

- Finalize design decisions.
- Evaluate and mitigate environmental issues.
- Proceed with completion of the PS&E design (includes determining the most cost effective hydraulic structure/pond to meet the desired objectives, locating and sizing ponds and foundations for hydraulic structures, structural design, mitigating the effects of settlement, satisfying local jurisdictional requirements for design, and so forth).

(c) **PS&E Development.** During PS&E development, the designer uses the information provided in the geotechnical report as follows:

- Select pipe materials in accordance with corrosion, resistivity, and abrasion guidelines in the *Hydraulics Manual*.
- Consider and include construction recommendations.

Additional design and specification guidance and support from the RME or the HQ Geotechnical Services Division are sought as needed. Both sections provide careful review of the contract plans before the PS&E review process begins, if requested. Otherwise, they will review the contract plans during the normal PS&E review process.

(8) Signals, Sign Bridges, Cantilever Signs, and Luminaire Foundations

(a) **Project Definition and Design.** Geotechnical information is usually not required for signals, sign bridges, cantilever signs, and luminaires during project definition.

The region's Traffic Office contacts the RME for conceptual foundation recommendations. The conceptual recommendations are based on existing information in the area, and identify if Standard Plan foundations are feasible or if special design foundations are required. If good soils are anticipated or the foundations will be placed in fill, Standard Plan foundations can be assumed. If special design foundations are required, additional time and money can be included in the project to accommodate increased field exploration for foundation design, HQ Geotechnical Services Division involvement, and structural design by the HQ Bridge and Structures Office.

(b) **PS&E Development.** Foundation recommendations are made by either the RME or the HQ Geotechnical Services Division. The recommendations provide all necessary geotechnical information to complete the PS&E.

The region's Traffic Office (or region's Project Engineer in some cases) is responsible for delivering the following project information to the region's Materials Engineer:

- Plan sheet showing the location of the structures (station and offset) and the planned structure type.
- Applicable values for: XYZ, strain pole class, sign bridge span length, luminaire height, variable message sign weight, wind load, CCTV pole height, and known utility information in the area.

The RME provides the following information to the requester if Standard Plan foundation types can be used:

- Allowable lateral bearing capacity of the soil.
- Results of all field explorations.
- Groundwater elevation.
- Foundation constructibility.

The region uses this information to complete the plan sheets and prepare any special provisions. If utilities are identified during the field investigation that could conflict with the foundations, the region's project office pursues moving or accommodating the utility. Accommodation could require special foundation designs.

If special designs are required, the RME notifies the requester that special designs are required and forwards the information received from the region to the HQ Geotechnical Services Division. The HQ Geotechnical Services Division provides the HQ Bridge and Structures Office with the necessary geotechnical recommendations to complete the foundation designs. The region coordinates with the HQ Bridge and Structures Office to ensure that they have all the information necessary to complete the design. Depending on the structure type and complexity, the HQ Bridge and Structures Office might produce the plan sheets and special provisions for the foundations, or they might provide the region with information so that the region can complete the plan sheets and special provisions.

(9) Buildings, Park and Ride Lots, Rest Areas, and Communication Towers

In general, the RME functions as the clearing house for the geotechnical work to be conducted in each of the phases for technical review of the work if the work is performed by consultants, or for getting the work done in-house. For sites and designs that are more geotechnically complex, the RME contacts the HQ Geotechnical Services Division for assistance.

Detailed geotechnical investigation guidance is provided in Facilities Operating Procedure 9-18, "Site Development." In summary, this guidance addresses the following phases of design:

(a) **Site Selection.** Conceptual geotechnical investigation (based on historical data and minimal subsurface investigation) of several alternative sites is performed in which the geotechnical feasibility of each site for the intended use is evaluated, allowing the sites to be ranked. In this phase, geological hazards (landslides, rockfall, compressible soils, liquefaction, and so forth) are identified, and geotechnical data adequate to determine a preliminary cost to develop and build on the site is gathered.

(b) **Schematic Design.** For the selected site, the best locations for structures, utilities, and other elements of the project are determined based on site constraints and ground conditions. In this phase, the site is characterized more thoroughly than in the site selection phase, but subsurface exploration is not structure specific.

(c) **Design Development.** The final locations of each of the project structures, utilities, and other project elements determined from the schematic design phase are identified. Once these final locations are available, a geotechnical investigation adequate to complete the final design of each of the project elements (structure foundations, detention/retention facilities, utilities, parking lots, roadways, site grading, and so forth) is conducted. From this investigation and design, the final PS&E is developed.

(10) Retaining Walls, Reinforced Slopes, and Noise Walls

(a) **Project Definition.** The designer provides a description and location of the proposed walls or reinforced slopes, including the potential size of the proposed structures and other pertinent site information, to the RME. At this stage, only the identification and feasibility of the proposed walls or reinforced slopes are investigated. A field review may also be conducted at this time as part of the investigation effort. In general, if soil/rock conditions are poor and/or large walls or reinforced slopes are anticipated, the RME requests that the HQ Geotechnical Services Division participate in the field review and reporting efforts. The cost and schedule requirements for the geotechnical investigation are also determined at this time.

A brief conceptual level report that summarizes the results of the investigation may be provided to the designer at this time, depending on the complexity of the geotechnical issues.

(b) **Project Design and PS&E Development**. Geotechnical data necessary to allow completion of the PS&E level design for walls and reinforced slopes are compiled during the design and PS&E development phases. This includes soils borings, testing, and final geometric data. Detailed design of walls and reinforced slopes can be done once the roadway geometry is established and geotechnical data are available. The purpose of this design effort is to determine the wall and slope geometry needed for stability, noise wall and retaining wall foundation requirements, and the potential for short- and long-term settlement.

The designer requests a geotechnical report from the RME for retaining walls, noise walls, and reinforced slopes that are not part of the bridge preliminary plan. For walls that are part of the bridge preliminary plan, the HQ Bridge and Structures Office requests the geotechnical report for the walls from the HQ Geotechnical Services Division. For both cases, see Chapter 1130 for the detailed design process for retaining walls and reinforced slopes and Chapter 1140 for the detailed design process for noise walls. It is important that requests for a geotechnical report be made as early in the design phase as practical. The time required to obtain permits and rights of entry must be considered when establishing schedule requirements.

For retaining walls and reinforced slopes, the site data to be provided with the request for a geotechnical report are as indicated in Chapter 1130. Also supply right of entry agreements and permits required for the geotechnical investigation. The site data indicated in 510.04(4), as applicable, are provided for noise walls.

The RME or the HQ Geotechnical Services Division (see Chapter 1130 or 1140 for specific responsibilities for design), provides the following information as part of the geotechnical report (as applicable):

1. General description of the regional and site geology
2. Summary of the investigation
3. Boring logs
4. Laboratory tests and results
5. Soil/rock unit descriptions
6. Ground water conditions
7. Retaining wall/reinforced slope and noise wall recommendations
    - Recommended geometry for stability
    - Stability and settlement mitigation requirements, if needed
    - Foundation type and capacity
    - Estimated amount and rate of settlement

- Design soil parameters
- Construction staging requirements
- Effects of site constraints
- Monitoring needs
- Material and compaction requirements
- Subgrade preparation

The recommendations may also include the background regarding analysis approach and any agreements with the region or other customers regarding the definition of acceptable level of risk. Additional details and design issues to be considered in the geotechnical report are as provided in Chapter 1130 for retaining walls and reinforced slopes and in Chapter 1140 for noise walls. The project designer uses this information for final wall/reinforced slope selection and to complete the PS&E.

For final PS&E preparation, special provisions and plan details (if not received as part of the report provided during project design) are developed with the assistance of the region Materials Section or the HQ Geotechnical Services Division. Both the region Materials Section and the HQ Geotechnical Services Division can review the contract plans before the PS&E review process begins, if requested. Otherwise, they will review the contract plans during the normal PS&E review process.

(11) Unstable Slopes

Unstable slope mitigation includes the stabilization of known landslides and rockfall that occur on slopes adjacent to the WSDOT transportation system, and that have been programmed under the P3 unstable slope program.

(a) **Project Definition.** The region's project office provides a description and location of the proposed unstable slope mitigation work to the RME. Location of the proposed work can be mile post limits or stationing. The region's project designer meets at the project site with the RME and HQ Geotechnical Services Division to conduct a field review, discuss project requirements, and identify geotechnical issues associated with the unstable slope project. The RME requests that the HQ Geotechnical Services Division participate in the field review and project definition reporting.

The level of work in the project definition phase for unstable slopes is conceptual in nature, not final design. The geotechnical investigation generally consists of a field review, a more detailed assessment of the unstable slope, review of the conceptual mitigation developed during the programming phase of the project, and proposed modification (if any) to the original conceptual level unstable slope mitigation. The design phase geotechnical services cost and schedule, including any required permits, are determined at this time. A brief conceptual level report is provided to the project designer that summarizes the results of the project definition investigation.

(b) **Project Design.** Geotechnical information and field data necessary to complete the unstable slope mitigation design is compiled during this design phase. This work includes, depending on the nature of the unstable slope problem, test borings, rock structure mapping, geotechnical field instrumentation, laboratory testing, and slope stability analysis. The purpose of this design effort is to determine the most appropriate method(s) to stabilize the known unstable slope.

The designer requests a geotechnical report from the HQ Geotechnical Services Division through the RME. The site data indicated in 510.04(4), as applicable, is provided along with the following information:

- Plan sheet showing the station and location of the proposed unstable slope mitigation project.
- If requested, Digital Terrain Model (DTM) files necessary to define the on-ground topography of the project site. The limits of the DTM will have been defined during the project definition phase.

It is important that the request for the geotechnical report be made as early in the design phase as practical. Cost and schedule requirements to generate the report are project specific and can vary widely. Unstable slope design investigations might require geotechnical monitoring of ground movement and ground water over an extended period of time to develop the required field information for the unstable slope mitigation design. The time required to obtain rights of entry and other permits, as well as the long-term monitoring data, must be considered when establishing schedule requirements for the geotechnical report.

The HQ Geotechnical Services Division provides the following information as part of the project geotechnical report (as applicable):

- General site description and summary of site geology.
- Summary of the field investigation.
- Boring logs.
- Laboratory tests and results.
- Geotechnical field instrumentation results.
- Summary of the engineering geology of the site including geologic units encountered.
- Unstable slope design analysis and mitigation recommendations.
- Constructibility issues associated with the unstable slope mitigation.
- Appropriate special provisions for inclusion in the contact plans.

The region's project design office uses the geotechnical report to finalize the design decisions for the project and the completion of the PS&E design.

(c) **PS&E Development.** Adequate geotechnical design information to complete the PS&E is typically obtained during the project design phase. Additional geotechnical work might be needed when right of way cannot be acquired, restrictions are included in permits, or other requirements are added that result in changes to the design.

Special provisions, special project elements, and design details (if not received as part of the design phase geotechnical report) are developed with the assistance of the RME and the HQ Geotechnical Services Division. The region's project designer uses this information in conjunction with the design phase geotechnical report to complete the PS&E document. The RME and the HQ Geotechnical Services Division can review the contract plans before the PS&E review begins, if requested. Otherwise, they will review the contract plans during the normal PS&E review process.

(12) Rockslope Design

(a) **Project Definition.** The region's project office provides a description and location of the proposed rock excavation work to the RME. For widening of existing rock cuts, the anticipated width and length of the proposed cut in relationship to the existing cut are provided. For new alignments, the approximate location and depth of the cut are provided. Location of the proposed cut(s) can be mile post limits or stationing. The project designer meets at the project site with the RME and the HQ Geotechnical Services Division to conduct a field review, discusses project requirements, and identify any geotechnical issues associated with the proposed rock cuts. The RME requests that the HQ Geotechnical Services Division participate in the field review and project definition reporting.

The level of rock slope design work for the project definition phase is conceptual in nature. The geotechnical investigation generally consists of the field review, review of existing records, an assessment of existing rockslope stability, and preliminary geologic structure mapping. The focus of this investigation is to assess the feasibility of the rock cuts for the proposed widening or realignment, not final design. A brief conceptual level report that summarizes the result of the project definition investigation is provided to the project designer.

(b) **Project Design.** Detailed rockslope design is done once the roadway geometrics have been established. The rockslope design cannot be finalized until the roadway geometrics have been finalized. Geotechnical information and field data necessary to complete the rockslope design are compiled during this design phase. This work includes rock structure mapping, test borings, laboratory testing, and slope stability analysis. The purpose of this design effort is to determine the maximum stable cut slope angle, and any additional rockslope stabilization measures that could be required.

The designer requests a geotechnical report from the HQ Geotechnical Services Division through the RME. The site data indicated in 510.04(4), as applicable, is provided.

It is important that the request for the geotechnical report be made as early in the design phase as practical. Cost and schedule requirements to generate the report are project specific and can vary widely. The time required to obtain permits and rights of entry must be considered when establishing schedule requirements.

The HQ Geotechnical Services Division provides the following information as part of the project geotechnical report (as applicable):

1. General site description and summary of site geology.

2. Summary of the field investigation.

3. Boring logs.

4. Laboratory tests and results.

5. Rock units encountered within the project limits.

6. Rock slope design analysis and recommendations.

- Type of rockslope design analysis conducted and limitation of the analysis. Also included will be any agreements with the region and other customers regarding the definition of acceptable risk
- The slope(s) required for stability
- Additional slope stabilization requirements (rock bolts, rock dowels, and so forth.)
- Rockslope ditch criteria (See Chapter 640)
- Assessment of rippability
- Blasting requirements including limitations on peak ground vibrations and air blast over-pressure, if required
- Usability of the excavated material including estimates of shrink and swell
- Constructibility issues associated with the rock excavation

The project office uses the geotechnical report to finalize the design decisions for the project, and the completion of the PS&E design for the rockslope elements of the project.

(c) **PS&E Development.** Adequate geotechnical design information to complete the PS&E is typically obtained during the project design phase. Additional geotechnical work might be needed when right of way cannot be acquired, restrictions are included in permits, or other requirements are added that result in change to the design.

Special provisions, special blasting requirements, and plans details, if not received as part of the design phase geotechnical report, are developed with the assistance of the RME or the HQ Geotechnical Services Division. The project designer uses this information in conjunction with the design phase geotechnical report to complete the PS&E documents. The RME and the HQ Geotechnical Services Division review the contract plans before the PS&E review begins, if requested. Otherwise, they will review the contract plans during the normal PS&E review process.

(13) Bridge Foundations

(a) **Project Definition.** The HQ Geotechnical Services Division supports the project definition process to develop reasonably accurate estimates of bridge substructure costs. For major projects and for projects that are located in areas with little or no existing geotechnical information, a field review is recommended. The region's office responsible for project definition coordinates field reviews. Subsurface exploration (drilling) is usually not required at this time, but might be needed if cost estimates cannot be prepared within an acceptable range of certainty.

The HQ Bridge and Structures Office, once they have received the necessary site data from the region's project office, is responsible for delivering the following project information to the HQ Geotechnical Services Division:

- Alternative alignments and/or locations of bridge structures.
- A preliminary estimate of channelization (structure width).

- Known environmental constraints.

The Bridge and Structures and region offices can expect to receive the following from the HQ Geotechnical Services Division:

- Summary or copies of existing geotechnical information.
- Identification of geotechnical hazards (slides, liquefiable soils, soft soil deposits, and so forth.).
- Identification of permits that might be required for subsurface exploration (drilling).
- Conceptual foundation types and depths.
- If requested, an estimated cost and time to complete a geotechnical foundation report.

The HQ Bridge and Structures Office uses this information to refine preliminary bridge costs. The region's project office uses the estimated cost and time to complete a geotechnical foundation report to develop the project delivery cost and schedule.

(b) **Project Design.** The HQ Geotechnical Services Division assists the HQ Bridge and Structures Office with preparation of the bridge Preliminary Plan. Geotechnical information gathered for project definition will normally be adequate for this phase, as test holes for the final bridge design cannot be drilled until accurate pier location information is available. For selected major projects, a type, size, and location (TS&L) report might be prepared which usually requires some subsurface exploration to provide a more detailed, though not final, estimate of foundation requirements.

The HQ Bridge and Structures Office is responsible for delivering the following project information, based on bridge site data received from the region's project office, to the HQ Geotechnical Services Division:

- Anticipated pier locations
- Approach fill heights
- For TS&L, alternate locations/alignments/ structure types

The HQ Bridge and Structures Office can expect to receive:

- Conceptual foundation types, depths and capacities
- Permissible slopes for bridge approaches
- For TS&L, a summary of site geology and subsurface conditions, and more detailed preliminary foundation design parameters and needs
- If applicable or requested, erosion or scour potential

The HQ Bridge and Structures Office uses this information to complete the bridge preliminary plan. The region's project office confirms right of way needs for approach embankments. For TS&L, the geotechnical information provided is used for cost estimating and preferred alternate selection. The preliminary plans are used by the HQ Geotechnical Services Division to develop the site subsurface exploration plan.

(c) **PS&E Development.** During this phase, or as soon as a 95 percent preliminary plan is available, subsurface exploration (drilling) is performed and a geotechnical foundation report is prepared to provide all necessary geotechnical recommendations needed to complete the bridge PS&E.

The HQ Bridge and Structures Office is responsible for delivering the following project information to the HQ Geotechnical Services Division:

- 95 percent preliminary plans (concurrent with distribution for region approval)
- Estimated foundation loads and allowable settlement criteria for the structure, when requested

The HQ Bridge and Structures Office can expect to receive:

- Bridge geotechnical foundation report

The HQ Bridge and Structures Office uses this information to complete the bridge PS&E. The region's project office reviews the geotechnical foundation report for construction considerations and recommendations that might affect region items, estimates, staging, construction schedule, or other items.

Upon receipt of the structure PS&E review set, the HQ Geotechnical Services Division provides the HQ Bridge and Structures Office with a Summary of Geotechnical Conditions for inclusion in Appendix B of the contract.

(14) Geosynthetics

See Chapter 530 for geosynthetic design guidance.

(15) Washington State Ferries Projects

(a) **Project Design.** The HQ Geotechnical Services Division assists the Washington State Ferries (WSF) division with determining the geotechnical feasibility of all offshore facilities, terminal facility foundations, and bulkhead walls. For upland retaining walls and grading, utility trenches, and pavement design, the RME assists WSF with determining geotechnical feasibility.

In addition to the site data identified in Section 510.04(4), as applicable, the following information is supplied by WSF to the HQ Geotechnical Services Division or the RME, as appropriate, with the request for the project geotechnical report::

- A plan showing anticipated structure locations as well as existing structures.
- Relevant historical data for the site.
- A plan showing utility trench locations.
- Anticipated utility trench depths.
- Proposed roadway profiles.

WSF can expect to receive:

- Results of any borings or laboratory tests conducted.
- A description of geotechnical site conditions.
- Conceptual foundation types, depths and capacities.
- Conceptual wall types.
- Assessment of constructibility issues that affect feasibility.
- Surfacing depths and/or pavement repair and drainage schemes.
- If applicable or requested, erosion or scour potential.

WSF uses this information to complete the project design report, design decisions, and estimated project budget and schedule.

WSF is responsible for obtaining any necessary permits or right of entry agreements needed to access structure locations for the purpose of subsurface exploration (for example, test hole drilling). The time required for obtaining permits and rights of entry must be considered when developing project schedules. Possible permits and agreements might include but are not limited to:

- City, county, or local agency use permits.
- Sensitive area ordinance permits.

(b) **PS&E Development**

Subsurface exploration (drilling) is performed and a geotechnical foundation report is prepared to provide all necessary geotechnical recommendations needed to complete the PS&E.

The designer requests a geotechnical report from the HQ Geotechnical Services Division or the RME, as appropriate. The site data indicated in 510.04(4), as applicable, is provided along with the following information:

- A plan showing final structure locations as well as existing structures.
- Proposed structure loadings.

WSF can expect to receive:

- Results of any borings or laboratory tests conducted.
- A description of geotechnical site conditions.
- Final foundation types, depths, and capacities.
- Final wall types and geotechnical designs/parameters for each wall.
- Assessment of constructibility issues to be considered in foundation selection and when assembling the PS&E.
- Pile driving information - driving resistance and estimated overdrive.

- Surfacing depths and/or pavement repair and drainage schemes.

WSF uses this information to complete the PS&E.

Upon receipt of the WSF PS&E review set, the HQ Geotechnical Services Division provides WSF with a Summary of Geotechnical Conditions for inclusion in Appendix B of the Contract. A Final Geotechnical Project Documentation package is assembled by the HQ Geotechnical Services Division and sent to WSF or the Plans Branch, as appropriate, for reproduction and sale to prospective bidders.

510.05 Use of Geotechnical Consultants

The HQ Geotechnical Services Division or the RME assists in developing the geotechnical scope and estimate for the project, so that the consultant contract is appropriate. (Consultant Services assists in this process.) A team meeting between the consultant team, the region or Washington State Ferries (depending on whose project it is), and the HQ Geotechnical Services Division/RME is conducted early in the project to develop technical communication lines and relationships. Good proactive communication between all members of the project team is crucial to the success of the project due to the complex supplier-client relationships.

510.06 Geotechnical Work by Others

Geotechnical design work conducted for the design of structures or other engineering works by other agencies or private developers within the right of way is subject to the same geotechnical engineering requirements as for engineering works performed by WSDOT. Therefore, the provisions contained within this chapter also apply in principle to such work. All geotechnical work conducted for engineering works within the WSDOT right of way or that otherwise directly impacts WSDOT facilities must be reviewed and approved by the HQ Geotechnical Services Division or the RME.

510.07 Surfacing Report

Detailed criteria and methods that govern pavement rehabilitation can be found in WSDOT Pavement Guide Interactive. The RME provides the surfacing report to the region's project office. This report provides recommended pavement types, surfacing depths, pavement drainage recommendations, and pavement repair recommendations.

510.08 Documentation

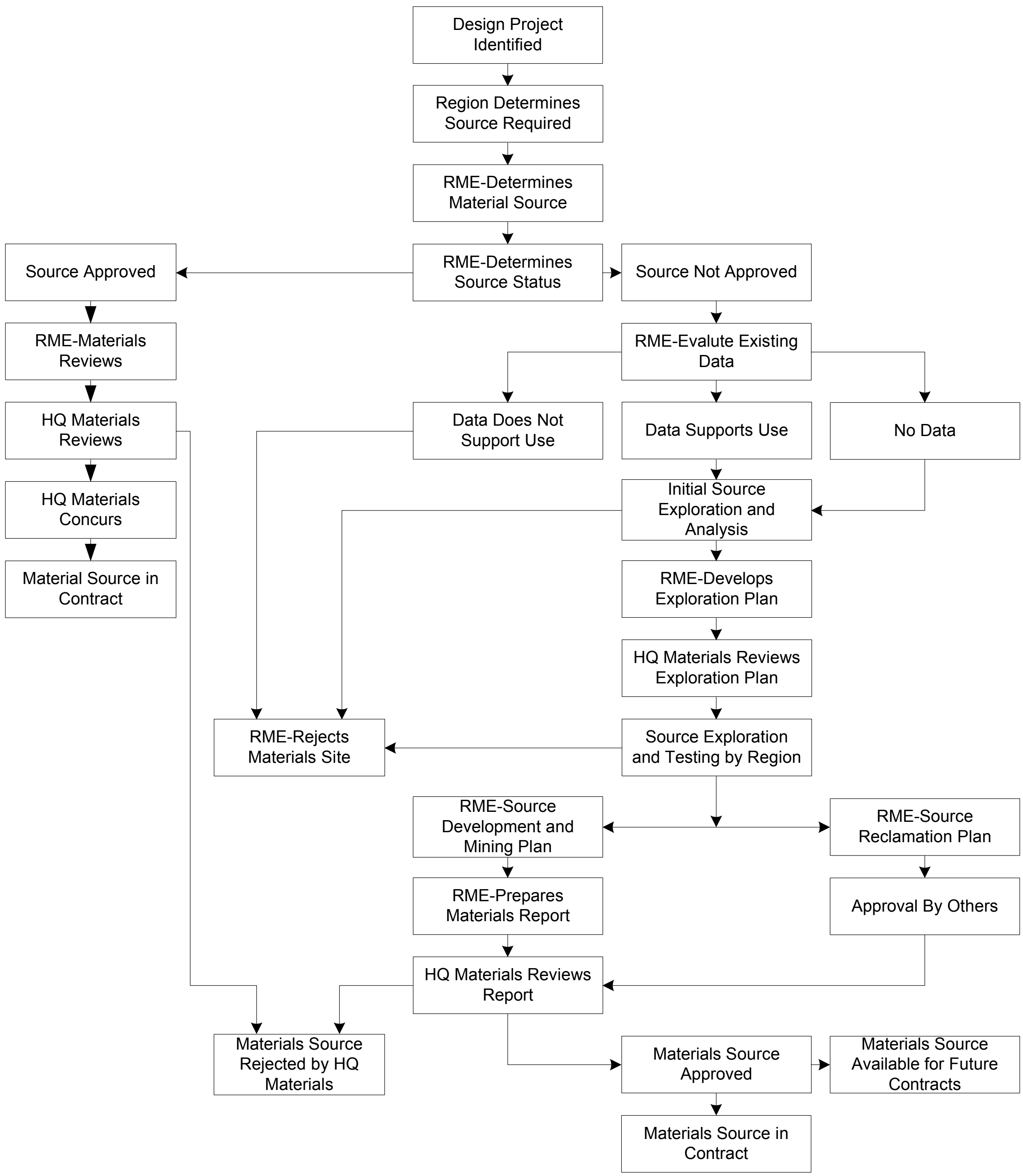
(1) Design Documentation

A list of documents that are required to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

(2) Final Geotechnical Project Documentation and Geotechnical Information Included as Part of the Construction Contract

Once a project PS&E is near completion, all of the geotechnical design memorandums and reports are compiled together to form the Final Geotechnical Project Documentation, to be published for the use of prospective bidders. The detailed process for this is located in the *Plans Preparation Manual*.

Geotechnical information included as part of the contract generally consists of the final project boring logs, and, as appropriate for the project, a Summary of Geotechnical Conditions. Both of these items are provided by the HQ Geotechnical Services Division.



Material Source Development Plan
Figure 510-1

520.01 Introduction

Detailed criteria and methods that govern pavement design are in the following:

WSDOT Pavement Guide – Interactive issued only on CD ROM.

Pavement Type Selection Protocol (PTSP) including the Dowel Bar Type Selection Protocol (DBTSP) located online at: http://www.wsdot.wa.gov/biz/mats/

520.02 Estimating Tables

Figures 520-1 through 520-5h are to be used when detailed estimates are required. They are for pavement sections, shoulder sections, stockpiles, and asphalt distribution. Prime coats and fog seal are in Figure 520-2a.

Type of Material	Unit Dry Weight			
	Truck Measure		Compacted on Roadway	
	lb/cy	T/cy	lb/cy	T/cy
Ballast	3100	1.55	3900	1.95
Crushed Surfacing Top Course	2850	1.43	3700	1.85
Crushed Surfacing Base Course	2950	1.48	3700	1.85
Screened Gravel Surfacing			3700	1.85
**Gravel Base			3400 – 3800	1.70 – 1.90
Shoulder Ballast			2800	1.40
Maintenance Sand 3/8” – 0	2900	1.45		
Mineral Aggregate 2” – 1”	2600	1.30		
Mineral Aggregate 1 3/4” – 3/4”	2600	1.30		
Mineral Aggregate 1 1/2” – 3/4”	2550	1.28		
Mineral Aggregate 1” – 3/4”	2500	1.25		
Mineral Aggregate 3/4” – 1/2”	2400	1.20		
Mineral Aggregate 1 1/4” – 1/4’”	2600	1.30		
Mineral Aggregate 1” – 1/4”	2600	1.30		
Mineral Aggregate 7/8” – 1/4”	2550	1.28		
Mineral Aggregate 3/4” – 1/4”	2500	1.25		
Mineral Aggregate 5/8” – 1/4”	2650	1.33		
Mineral Aggregate 1/2” – 1/4” or #4	2600	1.30		
Mineral Aggregate 1/4” or #4 – 0	2900	1.45		
Concrete Aggr. No. 2 (1 1/4” - #4)	3000	1.50		
Concrete Sand (Fine Aggregate)	2900	1.45		
Crushed Cover Stone	2850	1.43		

** 3,700 lb/cy (1.85 tons/cy) is recommended as the most suitable factor; however, if the grading approaches the coarseness of ballast, the factor would approach 3,800 lb/cy (1.90 tons/cy), and if the grading contains more than 45% sand, the factor would decrease, approaching 3,400 lb/cy (1.70 tons/cy) for material that is essentially all sand.

General Notes:

Weights shown are dry weights and corrections are required for water contents.

The tabulated weights for the materials are reasonably close; however, apply corrections in the following order:

For specific gravity:

$$\text{Wt.} = \frac{\text{tabular wt. x specific gravity on surface report}}{2.65}$$

For water content:

Wt. = tabular wt. x (1 + free water % in decimals)

If they are to be stockpiled, increase required quantities by 10 percent to allow for waste.

Direct attention to the inclusion of crushed surfacing top course material that may be required for keystone when estimating quantities for projects having ballast course.

Estimating – Miscellaneous Tables

Figure 520-1

General Data [1, 2, 3]							
Hot Mix Asphalt Pavement							
Complete Mix							
Class of Mix	Depth (ft)	Spread per sy		sy per ton	Tons/Mile Width (ft)		
		lb	ton		10	11	12
HMA	0.10	137	0.0685	14.60	402	442	482

Prime Coats and Fog Seal															
Asphalt							Aggregate								
Application	Type of Asphalt[4]	Application gal[5] per sy	Tons[5] per sy	Tons/Mile Width (ft)			Application lb per sy	Tons/Mile Width (ft)			cy per sy	cy/Mile Width (ft)			
				10	11	12		10	11	12		10	11	12	
Prime Coat	MC-250	0.25	0.001004	5.9	6.5	7.1	30	88	97	106	0.0105	62	68	74	
Fog Seal	CSS-1	0.04	0.000167	1.0	1.1	1.2									

Specific Data [1 2 3]														
Hot Mix Asphalt Paving Quantities (tons/mile)*														
Width (ft)	Depth of Pavement (ft)													
	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
4	161	241	321	402	482	563	643	723	804	884	964	1045	1125	1206
6	241	362	482	603	723	844	964	1085	1206	1326	1447	1567	1688	1808
8	321	482	643	804	964	1125	1286	1447	1607	1768	1929	2090	2250	2411
10	402	603	804	1005	1206	1407	1607	1808	2009	2210	2411	2612	2813	3014
11	442	663	884	1105	1326	1547	1768	1989	2210	2431	2652	2873	3094	3315
12	482	723	964	1206	1447	1688	1929	2170	2411	2652	2893	3135	3376	3617
22	884	1326	1768	2210	2652	3094	3536	3978	4421	4863	5305	5747	6189	6631
24	964	1447	1929	2411	2893	3376	3858	4340	4822	5305	5787	6269	6751	7234
* Based on 137 lbs/sy of 0.10 ft compacted depth = 2.05 tons/cy														

1 The specific gravity of the aggregate will affect the weight of aggregate in the completed mix.

2 The percentage of fine mineral in the coarse aggregate will affect the ratio of coarse to fine. If the coarse aggregate produced contains an excessive amount of fines (1/4” to 0), increase the percentage of coarse aggregate and decrease the fines accordingly.

3 Quantities shown do not provide for widening, waste from stockpile, or thickened edges.

4 The column “Type of Asphalt” is shown for the purpose of conversion to proper weights for the asphalt being used and does not imply that the particular grade shown is required for the respective treatment.

5 Quantities shown are retained (residual) asphalt.

Estimating – Hot Mix Asphalt Pavement and Asphalt Distribution Tables

Figure 520-2a

Asphalt Distribution (tons/mile) [1]																						
Asphalt Grade	Gal/ ton @ 60° F	Width (ft)	Rate of Application (Gal./cy)																			
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
SC, MC, RC 70	253	10	1.16	2.32	3.48	4.64	5.80	6.96	8.12	9.28	10.46	11.59	12.79	13.91	15.07	16.23	17.39	18.55	19.71	20.87	22.03	23.19
		11	1.28	2.55	3.83	5.10	6.38	7.65	8.93	10.20	11.48	12.75	14.03	15.30	16.58	17.86	19.13	20.41	21.68	22.96	24.23	25.51
		12	1.39	2.78	4.17	5.57	6.96	8.35	9.74	11.13	12.52	13.91	15.30	16.70	18.09	19.48	20.87	22.26	23.65	25.04	26.43	27.83
SC,MC,RC 250	249	10	1.18	2.36	3.53	4.71	5.89	7.07	8.25	9.42	10.60	11.78	12.96	14.14	15.31	16.49	17.67	18.85	20.03	21.20	22.38	23.56
		11	1.30	2.59	3.89	5.18	6.48	7.78	9.07	10.37	11.66	12.96	14.25	15.55	16.85	18.14	19.44	20.73	22.03	23.33	24.62	25.92
		12	1.41	2.83	4.24	5.65	7.07	8.48	9.90	11.31	12.72	14.14	15.55	16.96	18.38	19.79	21.20	22.62	24.03	25.45	26.86	28.27
SC,MC,RC 800	245	10	1.20	2.39	3.59	4.79	5.99	7.18	8.38	9.58	10.78	11.97	13.17	14.37	15.56	16.76	17.96	19.16	20.35	21.55	22.75	23.95
		11	1.30	2.63	3.95	5.27	6.59	7.90	9.22	10.54	11.85	13.17	14.49	15.80	17.12	18.44	19.79	21.07	22.39	23.71	25.02	26.34
		12	1.44	2.87	4.31	5.75	7.18	8.62	10.06	11.49	12.93	14.37	15.80	17.24	18.68	20.11	21.55	22.99	24.42	25.86	27.30	28.73
SC,MC,RC 3000	241	10	1.22	2.44	3.66	4.87	6.09	7.31	8.53	9.75	10.97	12.19	13.41	14.62	15.84	17.06	18.28	19.50	20.72	21.94	23.15	24.37
		11	1.34	2.68	4.02	5.36	6.69	8.03	9.37	10.71	12.05	13.39	14.73	16.07	17.41	18.74	20.08	21.42	22.76	24.10	25.44	26.78
		12	1.46	2.92	4.38	5.84	7.30	8.76	10.22	11.68	13.15	14.61	16.07	17.53	18.99	20.45	21.91	23.37	24.83	26.29	27.75	29.21
Paving Asphalt 200-300 PEN.	239	10	1.23	2.45	3.68	4.91	6.14	7.36	8.59	9.82	11.05	12.27	13.50	14.73	15.96	17.18	18.41	19.64	20.86	22.09	23.32	24.55
		11	1.35	2.70	4.05	5.40	6.75	8.10	9.45	10.80	12.15	13.50	14.85	16.20	17.55	18.90	20.25	21.60	22.95	24.30	25.65	27.00
		12	1.47	2.95	4.42	5.89	7.36	8.84	10.31	11.78	13.26	14.73	16.20	17.67	19.15	20.62	22.09	23.56	25.04	26.51	27.98	29.46
Emulsified Asphalt	240	10	1.22	2.44	3.67	4.89	6.11	7.33	8.56	9.77	11.00	12.22	13.44	14.67	15.89	17.11	18.33	19.56	20.78	22.00	23.22	24.44
		11	1.34	2.67	4.03	5.38	6.72	8.07	9.41	10.76	12.10	13.45	14.79	16.13	17.48	18.82	20.17	21.51	22.86	24.20	25.54	26.89
		12	1.47	2.93	4.40	5.87	7.33	8.80	10.27	11.73	13.20	14.67	16.13	17.60	19.07	20.53	22.00	23.47	24.93	26.40	27.87	29.33

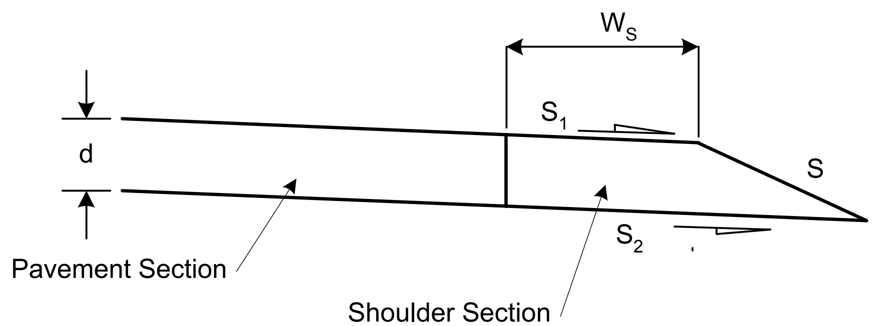
1 Quantities of asphalt shown are based on 60° F temperature. Recompute to the application temperature for the particular grade.

Estimating –Asphalt Distribution Tables
Figure 520-2b

Bituminous Surface Treatment [1]																		
Class of Mix	Type of Application	Average Application		Mineral Aggregate						Average Spread	Asphalt [2, 4, 5]						Basic [3]
				10 ft		11 ft		12 ft			10 ft		11 ft		12 ft		Asphalt Used
		lb/sy	cy/sy	T/mi	cy/mi	T/mi	cy/mi	T/mi	cy/mi	gal/sy	gal/mi	T/mi	gal/mi	T/mi	gal/mi	T/mi	
	Prime Coat									0.48	2787	11.2	3065	12.3	3344	13.4	MC-250
	Crushed Screenings 3/4" – 1/2"	35	0.0146	103	86	113	94	123	103								
	Tack Coat									0.43	2493	10.4	2743	11.4	2992	12.5	CRS-2
	Crushed Screenings 1/2" – 1/4"	28	0.0106	81	62	89	68	97	74								
	Crushed Screenings 1/4" – 0"	5	0.0017	15	10	16	11	18	12								
	Totals	68	0.0269	199	158	218	173	238	189	0.91	5280	21.6	5808	23.7	6336	25.9	
B	Seal Coat									0.50	2933	12.2	3227	13.4	3520	14.7	CRS-2
B	Crushed Screenings 5/8" – 1/4"	33	0.0123	95	72	105	79	114	86								
B	Crushed Screenings 1/4" – 0"	5	0.0017	15	10	16	11	18	12								
B	Totals	38	0.0140	110	82	121	90	132	98	0.50	2933	12.2	3227	13.4	3520	14.7	
C	Seal Coat									0.45	2640	11.0	2904	12.1	3168	13.2	CRS-2
C	Crushed Screenings 1/2" – 1/4"	28	0.0106	81	62	89	68	97	74								
C	Crushed Screenings 1/4" – 0"	5	0.0017	15	10	16	11	18	12								
C	Totals	33	0.0123	96	72	105	79	115	86	0.45	2640	11.0	2904	12.1	3168	13.2	
D	Seal Coat									0.43	2493	10.4	2743	11.4	2992	12.5	CRS-2
D	Crushed Screenings 3/8" - #10	25	0.0088	73	51	81	57	88	62								
Preseal for B, C & D	Preseal									0.18	1027	4.3	1129	4.7	1232	5.1	CRS-2
Preseal for B, C & D	Crushed Screenings 1/4" – 0"	12	0.0040	34	23	37	26	40	28								

1 Quantities shown do not provide for widening, waste from stockpile, or thickened edges.
2 Quantities of asphalt shown are based on 60°F temperature. Recompute to the application temperature for the particular grade.
3 The column "Basic Asphalt Used" is shown for the purpose of conversion to proper weights for the asphalt being used and does not imply that the particular grade shown is required for the respective treatment.
4 For cutbacks, decrease asphalt by 25 percent.
5 For stress absorbing membrane (rubberized asphalt), increase asphalt by 25 percent.

Estimating – Bituminous Surface Treatment
Figure 520-3



W_S = Shoulder Width – (Varies 4 ft, 6 ft, 8 ft, 10 ft, 12 ft)

d = Depth of Section – (Varies 0.05 ft to 2 ft)

S = Side Slope (H:V) – (Varies 2:1, 3:1, 4:1, and 6:1)

S_1 = Top Shoulder Slope – (Varies –0.02 ft/ft or –0.05 ft/ft)

S_2 = Bottom Shoulder Slope – (Varies –0.02 ft/ft or –0.05 ft/ft)

Formula for Shoulder Section		
Tons/mile = (A)(K) K=(5280/27)(1.85 tons/cy) $A = \frac{[d + W_S(1/S - S_1)]^2 S}{2(1 - SS_2)} - \frac{W_S^2}{2}(1/S - S_1)$		
Case 1	$S_1 = S_2 = -0.02$ ft/ft	$A = \frac{[d + W_S(1/S - 0.02)]^2 S}{2(1 - 0.02S)} - \frac{W_S^2}{2}(1/S - 0.02)$
Case 2	$S_1 = -0.02$ ft/ft, $S_2 = -0.05$ ft/ft	$A = \frac{[d + W_S(1/S - 0.02)]^2 S}{2(1 - 0.05S)} - \frac{W_S^2}{2}(1/S - 0.02)$
Case 3	$S_1 = -0.05$ ft/ft, $S_2 = -0.02$ ft/ft	$A = \frac{[d + W_S(1/S - 0.05)]^2 S}{2(1 - 0.02S)} - \frac{W_S^2}{2}(1/S - 0.05)$ *
Case 4	$S_1 = S_2 = -0.05$ ft/ft	$A = \frac{[d + W_S(1/S - 0.05)]^2 S}{2(1 - 0.05S)} - \frac{W_S^2}{2}(1/S - 0.05)$
*Limit: Positive Values of A only when $d = W_S(0.03)$		

EXAMPLE: Shoulder Section

Given –		Shoulder Width 8 ft	
	Top Course	0.25 ft	
	Base Course	0.80 ft	
	Total Depth	1.05 ft	
	Side Slope	3:1	
	Shoulder Slope	-0.05	
	Subgrade Slope	-0.02	
Depth	1.05 ft (Case 3) =		3070 tons/mile
Top Course	0.25 ft (Case 4) =		763 tons/mile
Base Course	=		2307 tons/mile

Top Course = 763 tons/mile

Base Course = 2307 tons/mile

Estimating – Base and Surfacing Typical Section Formulae and Example

Figure 520-4

Shoulder Section												
Shldr. Width W_s(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
4	2	1	73	148	226	304	385	468	553	639	728	818
		2	171	251	333	417	504	592	682	774	869	965
		3	N/A	N/A	131	205	281	360	440	522	605	691
		4	73	149	226	306	387	470	556	643	733	824
	3	1	74	150	230	313	398	486	577	671	768	868
		2	178	262	350	442	536	634	734	838	945	1056
		3	N/A	N/A	131	206	285	366	450	537	627	720
		4	74	151	231	315	402	492	585	681	780	883
	4	1	74	153	235	321	411	505	603	705	810	920
		2	185	275	370	469	572	681	793	910	1032	1158
		3	N/A	N/A	131	208	288	373	461	554	650	750
		4	75	154	237	326	418	516	617	724	834	950
	6	1	75	157	245	339	439	545	658	776	901	1032
		2	204	307	417	535	661	794	936	1085	1242	1406
		3	N/A	N/A	131	210	296	387	485	589	699	815
		4	76	160	252	351	459	574	696	827	965	1111
6	2	1	109	221	334	449	566	685	806	929	1053	1180
		2	325	444	565	688	812	939	1068	1199	1332	1467
		3	N/A	N/A	N/A	239	349	461	575	691	809	929
		4	110	221	335	450	568	687	809	933	1058	1186
	3	1	110	223	339	457	579	703	830	961	1094	1230
		2	338	462	590	722	856	994	1134	1278	1426	1576
		3	N/A	N/A	N/A	239	350	464	581	701	824	949
		4	110	223	340	460	583	709	838	970	1106	1245
	4	1	110	225	343	466	592	722	856	994	1136	1282
		2	352	483	619	760	905	1055	1209	1368	1531	1699
		3	N/A	N/A	N/A	239	351	467	587	711	839	971
		4	111	226	346	470	599	733	871	1013	1160	1311
	6	1	112	229	353	483	620	762	911	1066	1227	1394
		2	386	534	690	853	1025	1204	1391	1585	1788	1998
		3	N/A	N/A	N/A	239	353	474	600	733	871	1016
		4	112	233	360	496	640	791	950	1116	1291	1473
8	2	1	146	293	443	594	747	902	1059	1218	1379	1541
		2	526	683	843	1004	1167	1333	1500	1670	1841	2015
		3	N/A	N/A	N/A	N/A	376	522	670	820	972	1125
		4	146	293	443	595	749	904	1062	1222	1384	1548
	3	1	146	295	447	602	760	920	1084	1250	1419	1591
		2	546	711	879	1050	1224	1402	1583	1766	1954	2144
		3	N/A	N/A	N/A	N/A	376	523	673	825	981	1139
		4	146	296	448	604	763	926	1091	1260	1432	1607
	4	1	147	297	452	610	773	939	1109	1284	1462	1644
		2	568	741	919	1101	1288	1479	1675	1875	2080	2290
		3	N/A	N/A	N/A	N/A	376	524	675	831	990	1153
		4	147	298	454	615	780	950	1124	1302	1486	1673
	6	1	148	302	462	628	801	979	1164	1355	1552	1755
		2	622	816	1017	1226	1443	1668	1900	2140	2388	2643
		3	N/A	N/A	N/A	N/A	376	525	681	842	1009	1183
		4	149	305	469	641	820	1008	1203	1406	1616	1835

Estimating - Base and Surfacing Quantities

Figure 520-5a

Shoulder Section												
Shldr. Width W_s(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
4	2	1	910	1004	1100	1198	1297	1399	1502	1608	1715	1824
		2	1063	1163	1266	1370	1476	1585	1695	1807	1922	2038
		3	779	868	960	1053	1148	1245	1344	1445	1548	1652
		4	918	1013	1110	1210	1311	1415	1520	1628	1738	1849
	3	1	971	1076	1185	1296	1410	1527	1647	1770	1896	2024
		2	1169	1286	1406	1529	1655	1785	1918	2053	2193	2335
		3	816	914	1016	1120	1228	1338	1451	1567	1686	1807
		4	989	1098	1210	1326	1444	1566	1691	1820	1951	2086
	4	1	1034	1151	1273	1398	1528	1661	1798	1939	2085	2234
		2	1289	1424	1564	1708	1857	2010	2168	2330	2497	2668
		3	855	963	1075	1191	1311	1435	1562	1694	1830	1969
		4	1070	1194	1323	1456	1594	1737	1884	2035	2191	2352
	6	1	1169	1312	1462	1617	1779	1947	2121	2301	2488	2680
		2	1579	1759	1947	2142	2346	2557	2776	3002	3237	3479
		3	937	1066	1200	1341	1488	1641	1800	1966	2138	2315
		4	1265	1426	1596	1773	1957	2150	2350	2558	2774	2998
6	2	1	1308	1438	1570	1704	1840	1978	2117	2259	2402	2548
		2	1603	1742	1883	2026	2171	2318	2467	2618	2771	2926
		3	1050	1174	1299	1426	1555	1686	1819	1954	2090	2229
		4	1315	1447	1581	1716	1854	1994	2135	2279	2425	2573
	3	1	1369	1510	1655	1802	1953	2106	2262	2421	2583	2748
		2	1729	1886	2046	2209	2376	2545	2718	2894	3073	3255
		3	1078	1209	1343	1480	1620	1763	1909	2058	2209	2363
		4	1387	1532	1681	1832	1987	2145	2306	2471	2638	2809
	4	1	1432	1586	1743	1905	2070	2240	2413	2591	2772	2957
		2	1871	2048	2229	2415	2606	2801	3000	3204	3412	3625
		3	1106	1246	1389	1537	1688	1843	2003	2166	2333	2504
		4	1467	1628	1793	1963	2137	2315	2499	2686	2878	3075
	6	1	1567	1746	1932	2124	2322	2526	2736	2953	3175	3404
		2	2215	2441	2674	2916	3164	3421	3685	3957	4237	4525
		3	1167	1325	1488	1658	1833	2015	2203	2398	2598	2805
		4	1663	1861	2066	2279	2500	2729	2965	3209	3461	3721
8	2	1	1706	1872	2040	2211	2383	2557	2732	2910	3090	3271
		2	2190	2367	2547	2728	2912	3097	3285	3475	3666	3860
		3	1281	1438	1597	1758	1921	2086	2253	2422	2592	2765
		4	1713	1881	2051	2223	2397	2573	2751	2930	3112	3296
	3	1	1766	1944	2125	2309	2495	2685	2877	3072	3271	3472
		2	2338	2534	2734	2937	3144	3353	3566	3782	4001	4223
		3	1300	1464	1631	1801	1974	2149	2328	2509	2693	2880
		4	1785	1966	2151	2339	2530	2724	2921	3122	3326	3533
	4	1	1830	2020	2214	2411	2613	2819	3028	3242	3459	3681
		2	2504	2722	2945	3172	3404	3641	3882	4128	4378	4632
		3	1320	1491	1666	1845	2028	2215	2405	2600	2799	3001
		4	1865	2062	2263	2469	2679	2894	3114	3337	3566	3799
	6	1	1965	2181	2402	2630	2864	3105	3351	3604	3863	4128
		2	2907	3178	3457	3743	4038	4340	4650	4967	5292	5626
		3	1363	1549	1741	1940	2144	2355	2572	2795	3024	3259
		4	2061	2295	2536	2786	3043	3308	3580	3861	4149	4445

Estimating - Base and Surfacing Quantities
Figure 520-5b

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
10	2	1	182	366	551	739	928	1119	1312	1507	1704	1903
		2	773	969	1167	1367	1569	1773	1979	2187	2397	2609
		3	N/A	N/A	N/A	N/A	N/A	543	724	908	1094	1281
		4	182	366	552	740	930	1122	1315	1511	1709	1909
	3	1	182	368	556	747	941	1137	1337	1539	1745	1953
		2	802	1007	1215	1426	1640	1858	2079	2303	2530	2760
		3	N/A	N/A	N/A	N/A	N/A	543	725	910	1098	1289
		4	182	368	557	749	944	1143	1344	1549	1757	1968
	4	1	183	370	560	755	954	1156	1363	1573	1787	2006
		2	834	1049	1268	1492	1721	1954	2191	2433	2679	2930
		3	N/A	N/A	N/A	N/A	N/A	543	726	912	1103	1298
		4	183	371	563	760	961	1167	1377	1592	1811	2035
	6	1	184	374	570	773	982	1196	1417	1644	1878	2117
		2	913	1153	1399	1654	1916	2186	2464	2750	3043	3344
		3	N/A	N/A	N/A	N/A	N/A	543	727	917	1113	1316
		4	185	377	578	786	1001	1225	1456	1695	1942	2197
12	2	1	218	438	660	883	1109	1336	1566	1797	2030	2265
		2	1066	1301	1537	1776	2016	2259	2504	2750	2999	3249
		3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	956	1175	1397
		4	218	438	660	884	1110	1339	1569	1801	2035	2271
	3	1	219	440	664	891	1121	1354	1590	1829	2071	2315
		2	1106	1351	1599	1850	2104	2362	2623	2887	3154	3424
		3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	956	1177	1401
		4	219	441	666	894	1125	1360	1598	1839	2083	2330
	4	1	219	442	669	900	1134	1373	1616	1862	2113	2367
		2	1151	1407	1668	1933	2203	2478	2757	3040	3328	3621
		3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	956	1179	1405
		4	219	443	672	904	1142	1384	1630	1881	2137	2397
	6	1	220	446	679	918	1162	1413	1671	1934	2203	2479
		2	1259	1544	1836	2136	2444	2759	3083	3414	3752	4099
		3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	957	1182	1413
		4	221	450	686	930	1182	1442	1709	1985	2268	2558

Pavement Section										
Width W_P (ft)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
11	199	398	597	796	995	1194	1393	1592	1791	1990
12	217	434	651	868	1085	1302	1519	1737	1954	2171
22	398	796	1194	1592	1990	2388	2786	3184	3582	3980
24	434	868	1302	1737	2171	2605	3039	3473	3907	4341

*Tabulated quantities are based on compacted weight of 1.85 tons/yd^3

Estimating - Base and Surfacing Quantities

Figure 520-5c

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
10	2	1	2104	2306	2511	2717	2925	3135	3347	3561	3777	3995
		2	2823	3039	3257	3477	3699	3923	4149	4378	4608	4840
		3	1471	1662	1855	2050	2247	2446	2646	2849	3053	3260
		4	2111	2315	2521	2729	2939	3151	3366	3582	3800	4020
	3	1	2164	2378	2595	2815	3038	3264	3492	3724	3958	4195
		2	2994	3230	3470	3714	3960	4209	4462	4718	4977	5239
		3	1483	1680	1880	2082	2288	2496	2707	2921	3138	3358
		4	2183	2401	2621	2845	3072	3303	3536	3773	4013	4256
	4	1	2228	2454	2684	2918	3156	3398	3643	3893	4147	4404
		2	3186	3446	3710	3980	4253	4531	4814	5101	5393	5689
		3	1496	1699	1905	2116	2330	2548	2770	2996	3227	3460
		4	2263	2496	2734	2976	3222	3473	3729	3989	4253	4522
	6	1	2363	2615	2873	3137	3407	3684	3966	4255	4550	4851
		2	3653	3969	4294	4626	4965	5313	5668	6031	6402	6781
		3	1524	1739	1960	2187	2420	2660	2906	3157	3415	3679
		4	2459	2729	3007	3292	3585	3887	4195	4512	4836	5168
12	2	1	2502	2740	2981	3224	3468	3714	3962	4212	4464	4718
		2	3502	3757	4013	4272	4533	4795	5060	5327	5596	5866
		3	1620	1845	2072	2301	2532	2765	2999	3236	3474	3714
		4	2509	2750	2992	3236	3482	3730	3981	4233	4487	4743
	3	1	2562	2813	3066	3322	3581	3843	4107	4375	4645	4919
		2	3698	3975	4255	4538	4824	5114	5406	5702	6001	6304
		3	1627	1857	2089	2324	2562	2803	3047	3294	3544	3796
		4	2581	2835	3092	3352	3615	3882	4151	4424	4700	4980
	4	1	2626	2888	3154	3424	3698	3976	4258	4544	4834	5128
		2	3918	4220	4526	4837	5152	5472	5796	6125	6458	6796
		3	1635	1869	2107	2348	2594	2844	3098	3355	3617	3882
		4	2661	2930	3204	3482	3765	4052	4344	4640	4941	5246
	6	1	2761	3049	3343	3643	3950	4262	4581	4906	5237	5575
		2	4453	4815	5185	5562	5948	6341	6742	7150	7566	7991
		3	1651	1894	2144	2400	2662	2930	3205	3485	3772	4065
		4	2857	3163	3477	3799	4128	4465	4810	5163	5524	5892

Pavement Section										
Width W_P (ft)	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
11	2189	2388	2587	2786	2985	3184	3383	3582	3781	3980
12	2388	2605	2822	3039	3256	3473	3690	3907	4124	4341
22	4378	4775	5173	5571	5969	6367	6765	7163	7561	7959
24	4775	5210	5644	6078	6512	6946	7380	7814	8249	8683

*Tabulated quantities are based on compacted weight of 1.85 tons/yd^3

Estimating - Base and Surfacing Quantities
Figure 520-5d

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
4	2	1	1935	2048	2163	2279	2398	2518	2640	2765	2891	3019
		2	2157	2277	2399	2524	2650	2779	2909	3042	3176	3312
		3	1759	1867	1977	2089	2203	2319	2437	2557	2678	2802
		4	1963	2078	2196	2315	2437	2561	2686	2814	2943	3075
	3	1	2156	2290	2428	2568	2711	2857	3006	3157	3312	3470
		2	2480	2629	2781	2936	3094	3255	3420	3588	3759	3933
		3	1932	2059	2190	2323	2459	2598	2740	2885	3033	3183
		4	2223	2364	2509	2656	2806	2960	3117	3277	3441	3607
	4	1	2387	2543	2704	2869	3038	3210	3387	3567	3752	3940
		2	2844	3025	3210	3399	3593	3792	3995	4202	4415	4631
		3	2113	2260	2412	2567	2726	2890	3057	3228	3403	3582
		4	2517	2686	2860	3039	3222	3410	3602	3799	4000	4206
	6	1	2879	3084	3295	3513	3736	3966	4201	4443	4691	4946
		2	3729	3986	4252	4525	4806	5094	5391	5695	6007	6327
		3	2499	2689	2886	3088	3297	3512	3733	3960	4193	4433
		4	3229	3468	3715	3969	4232	4502	4779	5065	5358	5659
6	2	1	2695	2844	2995	3147	3302	3459	3617	3778	3940	4104
		2	3083	3242	3403	3566	3731	3898	4067	4238	4411	4586
		3	2369	2511	2655	2802	2949	3099	3251	3404	3560	3717
		4	2722	2874	3028	3184	3341	3501	3663	3827	3993	4160
	3	1	2916	3086	3260	3436	3615	3798	3983	4170	4361	4555
		2	3440	3629	3821	4016	4214	4416	4620	4828	5039	5253
		3	2521	2681	2844	3010	3179	3351	3525	3703	3883	4067
		4	2983	3160	3341	3524	3711	3901	4094	4290	4490	4692
	4	1	3146	3339	3536	3737	3942	4151	4364	4580	4801	5026
		2	3843	4065	4291	4523	4758	4998	5243	5492	5746	6004
		3	2679	2858	3041	3228	3418	3613	3812	4014	4221	4431
		4	3276	3482	3692	3907	4127	4350	4579	4812	5049	5291
	6	1	3639	3880	4127	4381	4640	4906	5178	5456	5741	6031
		2	4820	5123	5434	5753	6079	6413	6755	7105	7462	7827
		3	3017	3236	3461	3693	3930	4174	4423	4679	4941	5210
		4	3989	4264	4547	4837	5136	5442	5756	6078	6407	6745
8	2	1	3454	3640	3827	4016	4207	4399	4594	4791	4989	5189
		2	4055	4253	4452	4654	4858	5063	5271	5480	5692	5906
		3	2939	3115	3293	3473	3655	3839	4024	4212	4401	4592
		4	3482	3670	3860	4052	4246	4442	4640	4840	5042	5246
	3	1	3675	3882	4092	4304	4520	4738	4959	5183	5410	5640
		2	4449	4677	4909	5144	5382	5624	5869	6116	6367	6622
		3	3070	3263	3459	3658	3859	4064	4271	4481	4695	4911
		4	3743	3956	4173	4392	4615	4841	5071	5303	5539	5778
	4	1	3906	4135	4368	4606	4847	5092	5341	5593	5850	6111
		2	4891	5155	5423	5696	5973	6255	6541	6832	7127	7427
		3	3208	3418	3632	3851	4073	4299	4529	4763	5001	5243
		4	4036	4278	4524	4775	5031	5291	5556	5825	6098	6376
	6	1	4399	4676	4959	5249	5545	5847	6155	6469	6790	7116
		2	5966	6315	6671	7035	7407	7787	8174	8569	8972	9383
		3	3501	3749	4002	4262	4529	4801	5079	5364	5655	5952
		4	4748	5060	5379	5706	6040	6383	6733	7091	7456	7830

Estimating - Base and Surfacing Quantities

Figure 520-5e

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile* Surfacing Depth (ft) 1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
4	2	1	3148	3280	3414	3549	3687	3826	3967	4110	4255	4402
		2	3451	3591	3734	3878	4025	4173	4324	4477	4631	4788
		3	2927	3054	3183	3314	3447	3582	3718	3857	3997	4139
		4	3209	3344	3482	3622	3763	3907	4053	4201	4350	4502
	3	1	3630	3793	3959	4129	4300	4475	4653	4834	5017	5203
		2	4110	4291	4475	4662	4852	5045	5242	5441	5644	5850
		3	3337	3493	3652	3814	3979	4147	4318	4492	4668	4848
		4	3777	3950	4126	4305	4488	4673	4862	5054	5250	5448
	4	1	4133	4329	4529	4733	4941	5153	5369	5589	5812	6040
		2	4852	5078	5308	5543	5782	6026	6274	6527	6784	7046
		3	3764	3951	4142	4337	4535	4738	4944	5155	5369	5587
		4	4416	4631	4850	5074	5302	5535	5773	6015	6261	6512
	6	1	5206	5473	5745	6024	6310	6601	6898	7202	7512	7828
		2	6654	6989	7332	7683	8041	8407	8781	9163	9552	9950
		3	4678	4930	5188	5452	5722	5999	6282	6570	6865	7166
		4	5968	6285	6609	6941	7281	7628	7984	8347	8718	9096
6	2	1	4270	4438	4608	4779	4953	5128	5306	5485	5666	5849
		2	4763	4942	5123	5306	5491	5678	5868	6059	6252	6447
		3	3876	4038	4201	4365	4532	4701	4871	5044	5218	5394
		4	4330	4502	4676	4852	5030	5210	5391	5575	5761	5949
	3	1	4752	4951	5153	5359	5567	5778	5992	6208	6428	6651
		2	5471	5691	5915	6142	6372	6605	6842	7082	7325	7571
		3	4253	4442	4634	4829	5026	5227	5430	5637	5846	6058
		4	4898	5107	5320	5535	5754	5976	6201	6429	6660	6895
	4	1	5254	5486	5723	5963	6207	6455	6707	6963	7223	7487
		2	6267	6534	6806	7082	7363	7648	7938	8233	8532	8835
		3	4645	4864	5086	5312	5542	5776	6014	6256	6501	6751
		4	5537	5788	6044	6304	6569	6838	7111	7389	7672	7959
	6	1	6328	6630	6939	7254	7576	7903	8237	8577	8923	9275
		2	8200	8581	8969	9365	9769	10181	10600	11028	11463	11905
		3	5484	5765	6051	6344	6643	6949	7260	7578	7901	8231
		4	7090	7442	7803	8171	8547	8931	9322	9721	10128	10543
8	2	1	5391	5595	5801	6009	6219	6431	6644	6859	7077	7296
		2	6121	6339	6559	6780	7004	7230	7457	7687	7919	8153
		3	4785	4980	5177	5376	5577	5779	5984	6190	6398	6608
		4	5452	5660	5870	6082	6296	6512	6730	6950	7172	7396
	3	1	5873	6109	6347	6589	6833	7080	7330	7583	7839	8098
		2	6879	7140	7403	7670	7940	8214	8490	8770	9053	9339
		3	5129	5351	5576	5803	6034	6267	6503	6743	6985	7229
		4	6020	6265	6514	6765	7020	7278	7539	7804	8071	8342
	4	1	6376	6644	6917	7193	7473	7758	8046	8338	8634	8934
		2	7731	8040	8354	8671	8994	9321	9652	9988	10329	10674
		3	5488	5738	5992	6249	6511	6776	7046	7319	7596	7877
		4	6659	6946	7238	7534	7835	8140	8450	8764	9083	9406
	6	1	7449	7788	8133	8485	8842	9206	9575	9951	10333	10722
		2	9801	10227	10661	11103	11552	12009	12474	12947	13427	13915
		3	6255	6565	6880	7202	7530	7864	8204	8550	8903	9262
		4	8211	8600	8997	9401	9813	10233	10661	11096	11539	11990

Estimating - Base and Surfacing Quantities

Figure 520-5f

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
10	2	1	4214	4436	4659	4884	5111	5340	5571	5804	6038	6275
		2	5074	5310	5548	5788	6031	6275	6521	6769	7019	7272
		3	3468	3678	3890	4104	4320	4537	4757	4978	5201	5427
		4	4242	4466	4692	4920	5150	5382	5617	5853	6091	6331
	3	1	4435	4678	4924	5173	5424	5679	5936	6196	6460	6726
		2	5505	5774	6045	6320	6599	6880	7165	7453	7744	8038
		3	3581	3806	4035	4266	4501	4738	4978	5221	5467	5715
		4	4503	4752	5005	5261	5520	5782	6048	6316	6588	6863
	4	1	4666	4931	5201	5474	5751	6032	6317	6606	6899	7196
		2	5990	6295	6605	6919	7238	7561	7889	8221	8558	8900
		3	3698	3940	4186	4436	4689	4947	5208	5474	5743	6017
		4	4796	5074	5357	5644	5935	6232	6532	6838	7147	7462
	6	1	5158	5472	5792	6117	6449	6787	7132	7482	7839	8202
		2	7167	7561	7963	8373	8790	9215	9648	10088	10537	10993
		3	3950	4226	4509	4798	5093	5394	5701	6015	6334	6660
		4	5508	5856	6211	6574	6945	7323	7710	8104	8506	8915
12	2	1	4974	5231	5491	5752	6015	6281	6548	6816	7087	7360
		2	6139	6414	6691	6969	7250	7533	7818	8104	8393	8684
		3	3956	4200	4446	4694	4944	5195	5449	5704	5961	6220
		4	5002	5262	5524	5788	6055	6323	6593	6866	7140	7416
	3	1	5195	5474	5756	6041	6329	6619	6913	7209	7509	7811
		2	6609	6918	7230	7545	7863	8184	8509	8837	9168	9502
		3	4052	4310	4571	4836	5103	5372	5645	5921	6199	6481
		4	5262	5548	5837	6129	6424	6723	7024	7329	7637	7948
	4	1	5425	5727	6033	6342	6656	6973	7294	7619	7948	8282
		2	7138	7485	7836	8192	8553	8917	9287	9661	10039	10422
		3	4151	4425	4702	4983	5268	5557	5850	6147	6448	6753
		4	5556	5870	6189	6512	6840	7172	7509	7851	8197	8547
	6	1	5918	6268	6624	6986	7354	7728	8109	8495	8888	9287
		2	8422	8862	9309	9764	10227	10698	11176	11662	12156	12657
		3	4364	4669	4981	5298	5622	5952	6288	6630	6979	7333
		4	6268	6652	7043	7442	7849	8264	8687	9117	9555	10001
Pavement Section												
Width W_P (ft)			1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
11			4179	4378	4576	4775	4974	5173	5372	5571	5770	5969
12			4558	4775	4993	5210	5427	5644	5861	6078	6295	6512
22			8357	8755	9153	9551	9949	10347	10745	11143	11541	11939
24			9117	9551	9985	10419	10853	11287	11722	12156	12590	13024
*Tabulated quantities are based on compacted weight of 1.85 tons/yd^3												

Estimating - Base and Surfacing Quantities

Figure 520-5g

Shoulder Section												
Shldr. Width W_S(ft)	Side Slope S:1	Case	Quantity in tons per mile*									
			Surfacing Depth (ft)									
			1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
10	2	1	6513	6753	6995	7239	7485	7733	7983	8234	8488	8743
		2	7526	7782	8041	8301	8563	8827	9094	9362	9632	9905
		3	5654	5883	6113	6346	6581	6817	7056	7296	7538	7782
		4	6573	6818	7064	7312	7562	7814	8069	8325	8583	8843
	3	1	6995	7266	7541	7819	8099	8382	8669	8958	9250	9545
		2	8335	8636	8940	9247	9557	9870	10187	10506	10829	11156
		3	5967	6221	6479	6739	7002	7268	7537	7809	8084	8361
		4	7141	7423	7707	7995	8286	8581	8878	9179	9482	9789
	4	1	7497	7802	8111	8423	8740	9060	9385	9713	10045	10381
		2	9246	9596	9951	10311	10675	11043	11416	11794	12176	12563
		3	6294	6575	6860	7149	7442	7739	8040	8344	8653	8966
		4	7780	8104	8432	8764	9101	9442	9788	10139	10494	10853
	6	1	8571	8946	9327	9715	10108	10508	10914	11326	11744	12169
		2	11457	11928	12408	12895	13390	13892	14403	14921	15447	15980
		3	6992	7330	7674	8025	8382	8744	9113	9488	9870	10257
		4	9333	9758	10191	10631	11079	11536	11999	12471	12950	13437
12	2	1	7634	7911	8189	8469	8751	9035	9321	9609	9899	10190
		2	8977	9272	9569	9868	10168	10471	10776	11083	11392	11703
		3	6481	6744	7009	7276	7544	7814	8087	8361	8637	8915
		4	7695	7975	8258	8542	8828	9117	9407	9700	9994	10291
	3	1	8116	8424	8735	9049	9365	9685	10007	10333	10661	10992
		2	9840	10180	10524	10871	11221	11575	11931	12291	12654	13020
		3	6765	7052	7342	7635	7931	8230	8532	8836	9144	9454
		4	8263	8581	8901	9225	9553	9883	10216	10553	10893	11236
	4	1	8619	8960	9304	9653	10006	10363	10723	11088	11456	11829
		2	10810	11202	11599	12000	12405	12816	13230	13650	14073	14502
		3	7061	7374	7691	8011	8335	8664	8996	9332	9672	10017
		4	8902	9262	9626	9994	10367	10745	11127	11514	11905	12300
	6	1	9692	10103	10521	10945	11374	11810	12253	12701	13155	13616
		2	13167	13684	14209	14741	15282	15830	16386	16949	17521	18100
		3	7694	8061	8434	8813	9199	9590	9988	10392	10802	11218
		4	10454	10915	11384	11861	12346	12838	13338	13846	14361	14885
Pavement Section												
Width W_P (ft)			1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
11			6168	6367	6566	6765	6964	7163	7362	7561	7760	7959
12			6729	6946	7163	7380	7597	7814	8031	8249	8466	8683
22			12337	12735	13133	13530	13928	14326	14724	14122	15520	15918
24			13458	13892	14326	14761	15195	15629	16063	16497	16931	17365

*Tabulated quantities are based on compacted weight of 1.85 tons/yd^3

Estimating - Base and Surfacing Quantities

Figure 520-5h

530.01 General

Geosynthetics include a variety of manufactured products that are used in drainage, earthwork, erosion control, and soil reinforcement applications.

Several geosynthetic applications are addressed in the *Standard Specifications for Road, Bridge, and Municipal Construction* (Standard Specifications). These applications are as follows:

- Low survivability underground drainage
- Moderate survivability underground drainage
- Separation
- Soil stabilization
- Moderate survivability permanent erosion control
- High survivability permanent erosion control
- Ditch lining
- Temporary silt fence

The Standard Specifications address geosynthetic properties as well as installation requirements and are not site specific. Geosynthetic properties provided in the Standard Specifications are based on the range of soil conditions likely to be encountered in the state of Washington for the applications defined. Other applications, such as prefabricated edge drains, pond liners, and geotextile retaining walls, are currently handled by special provision.

Design responsibilities are discussed in 530.05 below and illustrated in Figures 530-4 and 5.

This chapter does not address applications where geosynthetics are used to help establish vegetation through temporary prevention of erosion (vegetation mats).

530.02 References

Highway Runoff Manual, M 31-15, WSDOT

Hydraulics Manual, M 23-03, WSDOT

Pavement Guide for Design, Evaluation and Rehabilitation, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

530.03 Geosynthetic Types and Characteristics

Geosynthetics include woven and nonwoven geotextiles, geogrids, geonets, geomembranes, and geocomposites. Terms used in the past for these construction materials include *fabrics*, *filter fabric*, or *filter cloth* which are for the most part synonymous with the newer term *geotextile*.

Photographs of the various types of geosynthetics are provided in Figure 530-6.

Woven geotextiles consist of slit polymer tapes, monofilament fibers, fibrillated yarns, or multifilament yarns simply woven into a mat. Woven geotextiles generally have relatively high strength and stiffness and, except for the monofilament wovens, relatively poor drainage characteristics.

Nonwoven geotextiles consist of a sheet of continuous or staple fibers entangled randomly into a felt in the case of needle-punched nonwovens, and pressed and melted together at the fiber contact points in the case of heat-bonded nonwovens. Nonwoven geotextiles tend to have low to medium strength and stiffness with high elongation at failure, and relatively good drainage characteristics. The high elongation characteristic gives them superior ability to deform around stones and sticks.

Geogrids consist of a polymer grid mat constructed either of coated yarns or punched and stretched polymer sheet and usually have high strength and stiffness. They are used primarily for soil reinforcement.

Geonets are similar to geogrids but are typically lighter weight, weaker, and have smaller mesh openings. They are used in light reinforcement applications or are combined with drainage geotextiles to form a drainage structure.

Geomembranes consist of impervious polymer sheets that are typically used to line ponds or landfills, or in some cases are placed over moisture sensitive swelling clays to control moisture.

Geocomposites include prefabricated edge drains, wall drains, and sheet drains, that consist typically of a cuspated or dimpled polyethylene drainage core wrapped in a geotextile. The geotextile wrap keeps the core clean so that water can freely flow through the drainage core. The drainage core acts as a conduit. Prefabricated edge drains are used in place of shallow geotextile wrapped trench drains at the edges of the roadway to provide subgrade and base drainage. Wall drains and sheet drains are typically placed between the back of the wall and the soil to drain the soil retained by the wall.

530.04 Geosynthetic Function Definitions and Applications

The function of the geosynthetic varies with the application. See Figure 530-7 for pictorial representations of the various applications. The geosynthetic must be designed with its function(s) in the given application in mind. Typical geosynthetic functions include filtration, drainage, separation, reinforcement, and erosion control. Definitions of these functions and examples of applications where these functions are dominant are as follows:

Geosynthetic filtration is defined as the passage of water through the geosynthetic relatively unimpeded (permeability or permittivity) without allowing passage of soil through the geosynthetic (retention). This is the primary function of geotextiles in underground drainage applications.

Drainage is defined as the carrying of water in the plane of the geosynthetic as a conduit (transmissivity). This is a primary function of geocomposite drains and in some cases thick nonwoven needle-punched geotextiles placed in underground drainage applications where water must be transported away from a given location by the geosynthetic itself.

Separation is defined as the prevention of the mixing of two dissimilar materials. This is a primary function of geotextiles placed between a fine-grained subgrade and a granular base course beneath a roadway.

Reinforcement is defined as the strengthening of a soil mass by the inclusion of elements (geosynthetics) that have tensile strength. This is the primary function of high strength geotextiles and geogrids in geosynthetic reinforced wall or slope applications, or in roadways placed over very soft subgrade soils that are inadequate to support the weight of the construction equipment or even the embankment itself.

Geosynthetic erosion control is defined as the minimizing of surficial soil particle movement due to the flow of water over the surface of bare soil or due to the disturbance of soil caused by construction activities under or near bodies of water. This is the primary function of geotextiles used as silt fences or placed beneath riprap or other stones on soil slopes. Silt fences keep eroded soil particles on the construction site, whereas geotextiles placed beneath riprap or other stones on soil slopes prevent erosion from taking place at all. In general, the permanent erosion control methods described in this chapter are only used where more natural means (such as the use of biodegradable vegetation mats to establish vegetation to prevent erosion) are not feasible.

These functions control some of the geosynthetic properties, such as apparent opening size (AOS) and permittivity, and in some cases load-strain characteristics.

The application will also affect the geosynthetic installation conditions. These installation conditions influence the remaining geosynthetic properties needed, based on the *survivability* level required.

Geosynthetic survivability is defined as the ability of the geosynthetic to resist installation conditions without significant damage, such that the geosynthetic can function as intended. Survivability affects the strength properties of the geosynthetic required.

530.05 Design Approach for Geosynthetics

Four questions must be answered to complete a geosynthetic design:

- Is a geosynthetic really needed?
- What geosynthetic properties will ensure that the geosynthetic functions as intended?
- Where should the geosynthetic be located?
- Will maintenance of the geosynthetic, or the structure of which it is a part, be needed? And, if so, how will it be maintained?

The site conditions and purpose for the geotextile are reviewed to determine whether or not a geotextile is needed.

- For most drainage, separation, soil stabilization, permanent erosion control, and silt fence applications, if a geotextile is needed the geotextile properties in the Standard Specifications can be used.
- In some situations where soil conditions are especially troublesome or in critical or high risk applications, a project specific design may be needed.
- The location of the geosynthetic will depend on how it is intended to function. (See Figure 530-7 for examples.)
- Consider the flow path of any ground water or surface water when locating the geotextile as well as selecting the geotextile to be used. For example, in permanent erosion control applications, water may flow to the geotextile from the existing ground as well as from the surface through wave action, stream flow, or overland sheet flow. For saturated fine sandy or silty subgrades, water must be able to flow from the subgrade through the geotextile soil stabilization layer during the pumping action caused by traffic loads.

Background information and the answers to each of these questions, or at least guidance to obtaining the answers to these questions, are provided for each Standard Specification application as follows:

(1) Underground Drainage, Low and Moderate Survivability

Geotextile used for underground drainage must provide filtration to allow water to reach the drain aggregate without allowing the aggregate to be contaminated by finer soil particles.

Geotextile filtration properties are a function of the soil type. For underground drainage applications, if the subgrade soil is relatively clean gravel or coarse sand, a geotextile is probably not required. At issue is whether or not there are enough fines in the surrounding soil to eventually clog the drain rock or drain pipe if unrestricted flow toward the drain is allowed.

To approximately match the geotextile filtration properties to various soil types, specifications for three classes of Construction Geotextile for Underground Drainage are available in the Standard Specifications. For underground drainage applications, use the gradation of the soil, specifically the percent by weight passing the #200 sieve, to select the drainage geotextile class required. Base selection of the appropriate class of geotextile on the following table:

Percent Passing the #200 Sieve	Geotextile Class
Less than 15%	A
15% to 50%	B
Greater than 50%	C

Selection Criteria for Geotextile Class
Figure 530-1

Obtain soil samples for geotextile underdrain design every 300 ft along the roadway alignment, using hand holes, and at major soil type transitions. This may be spread to every 1,000 ft if the soil conditions appear to be uniform. Use existing soil data where feasible instead of taking new soil samples.

If soil conditions vary widely along the alignment where underground drainage geotextile is anticipated, different classes of drainage geotextile may be required for specific sections of a continuous system.

Strength properties for the underground drainage geotextile depend on the survivability level required to resist installation stresses.

Low survivability designates that the installation stresses placed on the geotextile will be relatively low, requiring only moderate geotextile strength to resist potentially damaging installation conditions. Examples of low survivability level underground drainage applications include:

- Trench drains
- Drains placed behind walls or other structures to drain the backfill
- A geotextile filter sheet placed behind a gabion wall to prevent fines from being washed through the gabion wall face. Trench depths, or the height of the geotextile filter sheet behind gabion walls, must be less than or equal to 6 ft for the low survivability level.

In moderate survivability applications, significant installation stresses may occur, requiring higher geotextile strength. Examples of the moderate survivability application include:

- Trench drains with a depth of greater than 6 ft
- A geotextile filter sheet behind a gabion wall with a height greater than 6 ft
- Any area drain

An area drain is defined as a geotextile placed over or under a horizontal to moderately sloping (1.5H:1V or flatter slope) layer of drainage aggregate. Examples of area drains include:

- Drainage layers over cut-and-cover tunnels
- Rock buttress drainage
- Permeable base beneath highway pavement (see the *Pavement Guide for Design, Evaluation and Rehabilitation* for additional information on permeable bases)
- A parking lot drainage layer

Note that pipe wrapping (the geotextile is wrapped around the surface of the pipe) is not included as an underground drainage application.

Locate the geotextile such that it will function as intended. For example, if the objective is to keep the drainage aggregate surrounding a drain pipe clean, locate the geotextile such that it completely separates the drainage aggregate from more silty surrounding soils, which may include native soils as well as relatively silty roadway base or fill materials.

Consider the flow path of any ground water or surface water when locating the geotextile.

The flow path from the geotextile, as part of the ground water drainage, is typically directed to a surface water conveyance system. Design of surface water conveyance is guided by the *Hydraulics Manual*. The surface water conveyance must be low enough to prevent backflow and charging of the ground water drainage; typically by matching inverts of ground water drainage to crowns of surface water conveyance pipes. A 1 ft allowance is usually applied when connecting to open water or ditches.

(2) Separation

Geotextile used for separation must prevent penetration of relatively fine grained subgrade soil into the ballast or other roadway or parking lot surfacing material to prevent contamination of the surfacing material (the separation function). This application may also apply to situations other than beneath roadway or parking lot surfacing where it is not necessary for water to drain through the geotextile unimpeded (filtration), but where separation of two dissimilar materials is required.

Separation geotextile should only be used in roadway applications where the subgrade is workable such that it can be prepared and compacted as required in Section 2-06.3 of the Standard Specifications, but without removal and replacement of the subgrade soil with granular material. Such removal and replacement defeats the purpose of the geotextile separator.

Separation geotextile placed beneath roadway surfacing is feasible if the subgrade resilient modulus is greater than 5,800 psi and if a saturated fine sandy, silty, or clayey subgrade is not likely to be present. Note that the feasibility of separation geotextile may be dependent on the time of year and weather conditions expected when the geotextile is to be installed.

For separation applications, a geotextile is not needed if the subgrade is dense and granular (silty sands and gravels), but is not saturated fine sands. In general, a separation geotextile is not needed if the subgrade resilient modulus is greater than 15,000 psi.

(3) Soil Stabilization

Geotextile used for soil stabilization must function as a separator, a filtration layer, and to a minor extent as a reinforcement layer. This application is similar to the separation application, except that the subgrade is anticipated to be softer and wetter than in the separation application.

Soil stabilization geotextile is used in roadway applications if the subgrade is too soft and wet to be prepared and compacted as required in Section 2-06.3 of the Standard Specifications. Soil stabilization geotextile is placed directly on the soft subgrade material, even if some overexcavation of the subgrade is performed. Backfill to replace the overexcavated subgrade is not placed below the geotextile soil stabilization layer, as this would defeat the purpose of the geotextile.

The need for soil stabilization geotextile should be anticipated if the subgrade resilient modulus is less than or equal to 5,800 psi, or if a saturated fine sandy, silty, or clayey subgrade is likely to be present.

Consider the flow path of any ground water or surface water when locating the soil stabilization geotextile and when selecting the geotextile to be used. For saturated fine sandy or silty subgrades, water must be able to flow from the subgrade through the geotextile soil stabilization layer during the pumping action caused by traffic loads.

Even if the subgrade is not anticipated to be saturated based on available data, if the subgrade is silty or clayey and it is anticipated that the geotextile will be installed during prolonged wet weather, a soil stabilization geotextile may still be needed.

Soil stabilization geotextile should not be used for roadway fills greater than 5 ft in height or if extremely soft and wet silt, clay, or peat is anticipated at the subgrade level. (Such deposits may be encountered in wetlands, for example.) In such cases the reinforcement function becomes more dominant, requiring that a site-specific design be performed.

(4) Permanent Erosion Control, Moderate and High Survivability

The primary function of geotextile used for permanent erosion control is to protect the soil beneath it from erosion due to water flowing over the protected soil.

The need for a permanent erosion control geotextile depends on the type and magnitude of water flow over the soil being considered for protection, the soil type in terms of its erodability, and the type and amount of vegetative cover present. (See the *Highway Runoff Manual.*)

The source of flowing water could be streams, man-made channels, wave action, or runoff. Water may also flow from the soil behind the geotextile depending on the ground water level.

If ground water cannot escape through the geotextile, an erosion control system failure termed *ballooning* (resulting from water pressure buildup behind the geotextile) or soil piping could occur. Therefore, the geotextile must have good filtration characteristics.

Three classes of permanent erosion control geotextile are available to approximately match geotextile filtration characteristics to the soil. In order to select the drainage geotextile class, determine the gradation of the soil, specifically the percent by weight passing the #200 sieve. Base selection of the appropriate class of geotextile using Figure 530-1.

A minimal amount of soil sampling and testing is needed to determine the geotextile class required. Permanent erosion control geotextile generally does not extend along the roadway alignment for significant distances as does underground drainage geotextile. One soil sample per permanent erosion control location is sufficient. If multiple erosion control locations are anticipated along a roadway alignment, soil sampling requirements for underground drainage can be applied.

If soil conditions vary widely along the alignment where permanent erosion control geotextile is anticipated, different classes of erosion control geotextile may be required for specific sections of a continuous system.

Examples of the permanent erosion control application are the placement of geotextile beneath riprap or gabions along drainage channels, shorelines, waterways, around bridge piers, and under slope protection for highway cut or fill slopes.

If a moderate survivability geotextile is to be used, the geotextile must be protected by a 12 in aggregate cushion and be placed on slopes of 2H:1V or flatter to keep installation stresses to a relatively low level. Large stones can cause significant damage to a moderate survivability geotextile if the geotextile is not protected in this manner. If these conditions are not met, then a high survivability erosion control geotextile must be used.

(5) Ditch Lining

The primary function of the geotextile in a ditch lining application is to protect the soil beneath it from erosion.

This ditch lining application is limited to man-made ditches less than 16 ft wide at the top with side slopes of 2H:1V or flatter. (If the ditch does not meet these requirements, then permanent erosion control, moderate or high survivability geotextile must be used.) It is assumed that only quarry spall sized stones or smaller will be placed on the geotextile so only a moderate survivability geotextile will be required.

Filtration is not a significant function in this application. Since the ditch is relatively shallow, it is expected that the main water source will be the water carried by the ditch, and little water will pass through the geotextile.

Another application with a similar geotextile function is the placement of geotextile below culvert outlets to prevent erosion at the outlet.

(6) Temporary Silt Fence

The primary function of geotextile used in a temporary silt fence is to prevent eroded material from being transported away from the construction site by runoff water. The silt fence acts primarily as a temporary dam and secondarily as a filter.

In some cases, depending on the topography, the silt fence may also function as a barrier to direct flow to low areas at the bottom of swales where the water can be collected and temporarily ponded. It is desirable to avoid the barrier function as much as possible, as silt fences are best suited to intercepting sheet flow rather than concentrated flows as would occur in swales or intermittent drainage channels.

To function as intended, the silt fence should have a low enough permeability to allow the water to be temporarily retained behind the fence allowing suspended soil particles in the water to settle to the ground. If the retention time is too long, or if the flow rate of water is too high, the silt fence could be overtopped thus allowing silt laden water to escape. Therefore, a minimal amount of water must be able to flow through the fence at all times.

Temporary water ponding is considered the primary method of silt removal and the filtration capabilities of the fence are the second line of defense. However, removal of silt sized particles from the water directly by the geotextile creates severe filtration conditions for the geotextile, forcing the geotextile to either blind or allow the fines to pipe through the geotextile. (Blinding is the coating of the geotextile surface with soil particles such that the openings are effectively plugged.) If the geotextile openings (AOS) are designed to be small enough to capture most of the suspended soil particles, the geotextile will likely blind, reducing the permeability enough to allow water to overtop the fence. Therefore, it is best to allow some geotextile openings that are large enough to allow the silt sized particles to easily pass through. Even if some silt particles pass through the fence, the water flow rate below the fence will be decreased and the volume of silt laden water passing through the geotextile is likely to be relatively small and the water is partially filtered.

The geotextile apparent opening size (AOS) and permittivity are typically used to specify the filtration performance of geotextiles. The geotextile function in silt fence applications is more complex than this and AOS and permittivity do not relate directly to how well a silt fence will perform. However, nominal values of AOS and permittivity can be specified such that the types of geotextile products known to perform satisfactorily in this application are selected. Such values are provided in the Standard Specifications.

The source of load on the geotextile is from silt buildup at the fence and water ponding. The amount of strength required to resist this load depends on whether or not the geotextile is supported with a wire or polymer grid mesh between the fence posts. Obviously, unsupported geotextile must have greater strength than supported geotextile. If the strength of the geotextile or its support system is inadequate, the silt fence could fail. Furthermore, unsupported geotextile must have enough stiffness such that it does not deform excessively and allow silt laden water to go over the top of the fence.

The need for a silt fence can be anticipated where construction activities will disturb and expose soil that could erode. The ground surface is considered disturbed if vegetative cover is at least partially removed over a significant area by construction activities. Consider whether or not silt laden runoff water from the disturbed area can reach an environmentally sensitive area or a man-made storm water system. If the exposed soil is a clean sand or gravel or if a significant zone of heavy vegetative cover separates the exposed soil from the environmentally sensitive area, a silt fence may not even be needed. Obtain assistance from the Olympia Service Center (OSC) Hydraulics Section for help in determining whether or not a silt fence is needed in such situations.

The feasibility of a geotextile silt fence depends on the magnitude of water flow to the fence, the steepness of the slope behind the fence and whether or not flow is concentrated at the fence. If the silt fence is not feasible, alternative erosion control methods may be required. (See the *Highway Runoff Manual*.)

Consider all feasible erosion control options in terms of potential effectiveness and economy before making the final decision to use a silt fence. Select the best option for the site conditions, including site geometry and contours, soil type, and rainfall potential. Consider silt fences for temporary erosion control in disturbed areas in the following circumstances:

- Fully covering disturbed areas temporarily with polyethylene sheeting or other temporary covering is not feasible or practical.
- Permanent ground cover for disturbed areas is not yet established.
- Runoff water reaches the silt fence primarily as sheet flow rather than as concentrated flows, with the exception of some ditch and swale applications.
- Slopes above the silt fence are not steeper than 1.5H:1V.
- The sheet flow length (length of slope contributing runoff water to the silt fence) is not too long.

Maximum sheet flow lengths allowed for silt fences are provided in the following table which is based on the typical 2-year 24-hour design storm for Washington resulting in a 24-hour rainfall of 3 in.

Slope	Sheet Flow Length
1.5H:1V	100 ft
2H:1V	115 ft
4H:1V	150 ft
6H:1V	200 ft

Maximum Sheet Flow Lengths for Silt Fences
Figure 530-2

The sheet flow length represents the area contributing runoff water from precipitation. The sheet flow length is defined in Figure 530-8. The sheet flow lengths provided in Figure 530-2 were determined assuming a bare soil condition, with the soil classified as a silt. These are worst case assumptions because less runoff would be expected for sand or gravel soils or if some vegetation is present.

The sheet flow length is usually equal to or greater than the disturbed soil slope length. However, undisturbed sloping ground above the disturbed slope area may also contribute runoff to the silt fence area. The length of undisturbed sloping ground above the disturbed slope to included in the total contributing slope length depends on the amount and type of vegetation present, the slope steepness, and the degree of development above the slope.

If unsure whether the proposed silt fence meets the requirements in Figure 530-2, contact the OSC Hydraulics Section for assistance.

Average or Ditch Swale Grade	Ditch or Swale Storage Length	Allowable Contributing Area per Foot of Ditch or Swale Storage Width
16%	13 ft	200 ft^2
10%	20 ft	250 ft^2
5%	40 ft	300 ft^2
4%	50 ft	400 ft^2
3%	65 ft	500 ft^2
2%	100 ft	600 ft^2
1%	200 ft	1,000 ft^2

Maximum Contributing Area for Ditch and Swale Applications
Figure 530-3

Temporary silt fences may also be used in ditch or swale applications. If the area contributing runoff to the fence exceeds the value determined from Figure 530-3, hydraulic overload will occur. The ditch or swale storage length and width are defined in Figure 530-9. The assumptions used in the development of Figure 530-3 are the same as those used for Figure 530-2 in terms of the design storm and ground conditions.

As an example, if a site has a 13-ft wide ditch with an average slope of 2%, the fence can be located such that 7,800 ft^2 of area drain to it. If it appears that the area draining to the fence will be larger than the allowable, it may be possible to divide the contributing area into smaller areas and add a silt fence for each smaller area as shown in Figure 530-10.

The minimum storage length for the ditch behind each silt fence must be maintained. If this is not possible, it may be necessary to use an alternate erosion control structure as described in the *Highway Runoff Manual* or to develop a special silt fence design.

Figure 530-3 was developed with the assumption that water will be able to pond to a depth of at least 2 ft behind the fence. If this is not the case (the ditch or swale depth is less than 2 ft), the table cannot be used. Furthermore, the ditch depth must be greater than the height of the silt fence at its lowest point within the ditch. Otherwise, there will not be enough storage available behind the fence and water will circumvent the fence by flowing around it.

Locate silt fences on contour as much as possible. At the ends of the fence turn it up hill such that it captures the runoff water and prevents water from flowing around the end of the fence. This is illustrated in Figure 530-11.

Silt fences are designed to capture up to a 2 ft depth of water behind the fence. Therefore, the ground line at the ends of the fence must be at least 2 ft above the ground line at the lowest part of the fence. This 2 ft requirement applies to ditches as well as to general slope erosion control.

If the fence must cross contours (except for the ends of the fence) use gravel check dams placed perpendicular to the back of the fence to minimize concentrated flow and erosion along the back of the fence. (See Figure 530-12.)

- The gravel check dams are approximately 1 ft high at the back of the fence and be continued perpendicular to the fence at the same elevation until the top of the dam intercepts the ground surface behind the fence.
- Locate the gravel check dams every 10 ft along the fence.
- In general, the slope of the fence line is not be steeper than 3H:1V.
- For the gravel check dams, use Crushed Surfacing Base Course Section 9-03.9(3)), Gravel Backfill for Walls Section 9-03.12(2), or Shoulder Ballast Section 9-03.9(2)).

If the silt fence application is considered critical (such as when the fence is placed immediately adjacent to environmentally sensitive areas such as streams, lakes, or wetlands) place a second silt fence below the first silt fence to capture any silt that passes through the first fence and/or place straw bails behind the silt fence. Locate silt fences at least 7 ft from an environmentally sensitive area. Where this is impossible, and a silt fence must be used, a special design may be necessary.

Temporary silt fences are sometimes used to completely encircle underground drainage inlets or other similar features to prevent silt from entering the drainage system. This is acceptable, but the silt fence functions primarily as a barrier, and not as a ponding or filtering mechanism, unless the drainage inlet is in a depression that is large enough to allow water to pond behind the silt fence.

- If the drainage inlet and silt fence are not in a large enough depression, silt laden water will simply be directed around the fence and must be captured by another fence or sedimentation pond downslope.
- If the depression is deep, locate the silt fence no more than 2 ft below the top of the depression to prevent overtopping. A site-specific design may be needed if the silt fence is located deeper than 2 ft within the depression.

It may be necessary to relocate silt fences during the course of a construction project as cuts and fills are built or as disturbed areas change. An erosion control/silt fence plan that accounts for the anticipated construction stages (and eventual removal) should be developed. Do not assume that one silt fence location can routinely be used for the entire life of the contract. Periodically check the locations in the field during the construction project and field-adjust the silt fence locations as necessary to ensure that the silt fence functions as intended.

(7) Standard Specification Geotextile Application Identification in the Plans

Identify the geotextile in the contract plan detail in a way that ties it to the appropriate Standard Specification application. For example:

- If a geotextile is to be used to line an underground trench drain 3 ft in depth and the native soil has less than 15% passing the #200 sieve, identify the geotextile on the plan sheet as “Construction Geotextile for Underground Drainage, Low Survivability, Class A.”

- If the geotextile is to be placed beneath riprap on a slope without a cushion layer between the geotextile and the riprap and the native soil contains 35% passing the #200 sieve, identify the geotextile on the plan sheet as “Construction Geotextile for Permanent Erosion Control, High Survivability, Class B.”
- If the geotextile is to be placed between the roadway base course and a moist silt subgrade with a resilient modulus of 6,500 psi, and the roadway is planned to be constructed during the dry summer and early fall months, identify the geotextile on the plan sheet as “Construction Geotextile for Separation.”

(8) Site-Specific Designs (All Applications)

A site-specific design is required:

- For all reinforcement applications
- For applications not covered by the Standard Specifications

Consider a site-specific design:

- For high risk applications
- For exceptionally large geotextile projects: if the geotextile quantity in a single application is over 35,000 yd^2, or over 85,000 yd^2 for the separation application
- For severe or unusual soil or ground water conditions
- If the soil in the vicinity of the proposed geotextile location consists of alternate thin layers of silt or clay with potentially water-bearing sand layers on the order of 1 to 3 in in thickness or less
- If the soil is known through past experience to be problematic for geosynthetic drains
- For drains in native soil behind structures except drains contained within granular backfill
- For drains designed to stabilize unstable slopes
- For drains designed to mitigate frost heave

In such cases, obtain assistance from the OSC Materials Laboratory Geotechnical Branch. To initiate the special design provide a plan and cross-section showing:

- The geosynthetic structure to be designed
- Its relative location to other adjacent structures that it could potentially affect
- Its intended purpose
- Any soil data in the vicinity

Consider a site-specific design for temporary silt fences:

- If silt fence must be used in intermittent streams or where a significant portion of the silt fence functions as a barrier that directs flow to the lower portions of the silt fence
- If the fence must be located on steep slopes
- In situations not meeting the requirements in Figures 530-2 and 3
- If the 2 year, 24 hour design storm for the site is greater than the 3 in assumed for the development of Figures 530-2 and 3
- Where concentrated flow is anticipated
- If closer than 7 ft from an environmentally sensitive area
- If more than 2 ft depth of storage is needed

For a site-specific temporary silt fence design, obtain assistance from the OSC Hydraulics Section. To initiate the design, send the following information to the OSC Hydraulics Section and a copy to the OSC Materials Laboratory Geotechnical Branch:

- Plan sheets showing proposed silt fence locations and grading contours
- Estimate of the area contributing runoff to each silt fence, including percentage and general type of vegetative cover within the contributing area
- Any available site soil information

For all site-specific designs of applications not covered by the Standard Specifications, complete plans and special provisions are needed. In general, for site-specific designs of Standard Specification applications, only a minor modification of the appropriate geotextile property table will be needed.

530.06 Design Responsibility

The design responsibility and process for geotextile design are illustrated in Figures 530-4 and 5. The Regional Project Development Office, in particular the Regional Project Manager, is responsible to initiate and develop all Standard Specification geotextile designs, except for roadway separation and soil stabilization applications, which are initiated and developed by the Regional Materials Laboratory.

The Regional Materials Laboratory assists the Regional Project Manager with Standard Specifications underground drainage and permanent erosion control designs.

The Regional Environmental Design Section assists with Standard Specifications, permanent erosion control, and temporary silt fence designs.

Once the Regional Project Manager or Materials Laboratory has determined that a geotextile is appropriate, development of a Standard Specification geotextile design includes the development of plan details showing the plan location and cross-section of the geotextile installation. Standard details for geotextiles as provided in the *Plans Preparation Manual* may be used or modified to adapt to the specific project situation. Note that only minimum dimensions for drains are provided in these standard details.

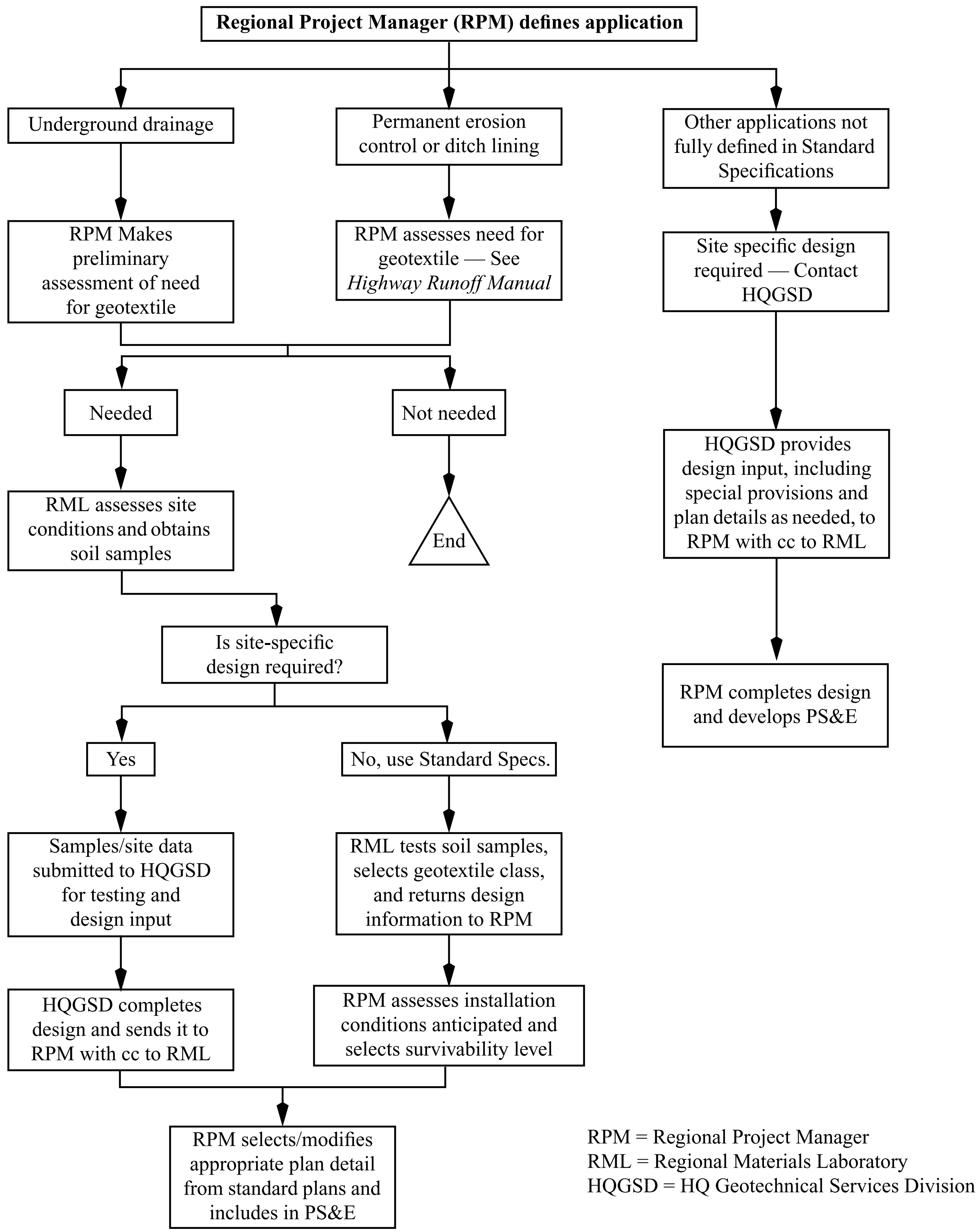
Site-specific geosynthetic designs and applications not addressed by the Standard Specifications are designed by the region with the assistance of the HQ Materials Laboratory Geotechnical Services Division or the HQ Hydraulics Branch as described in 530.05.

Design assistance by the HQ Geotechnical Services Division or HQ Hydraulics Branch for site-specific design of Standard Specifications applications includes determination of geosynthetic properties and other advice as needed to complete the geosynthetic plans and any special provisions required.

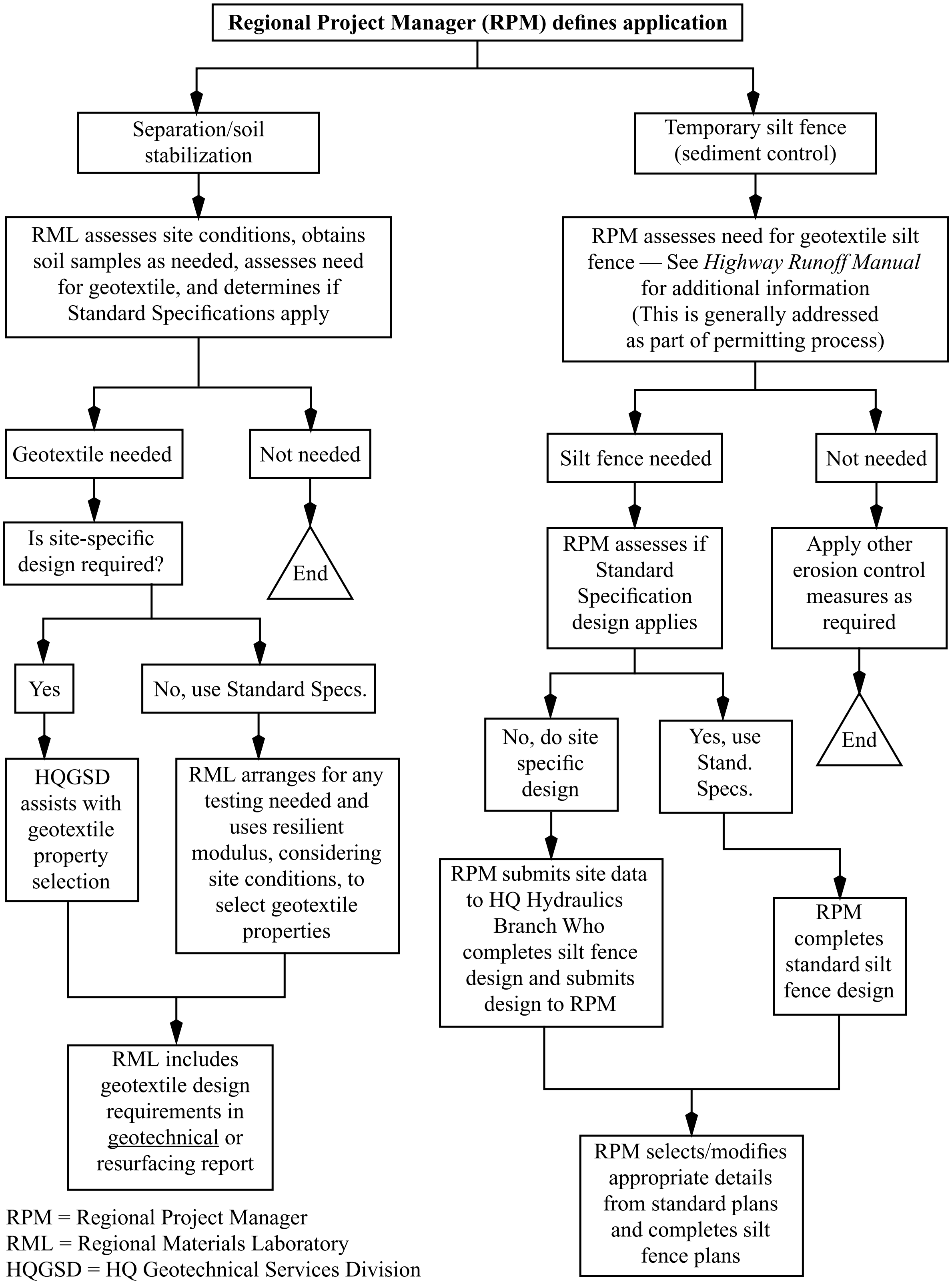
The HQ Geotechnical Services Division is fully responsible to develop and complete the geosynthetic design, plan details that can be used to develop the contract plan sheets, and special provisions for geosynthetic reinforced walls, slopes, and embankments; deep trench drains for landslide stabilization; and other applications that are an integral part of an HQ geotechnical design. The Regional Project Manager incorporates the plan details and special provisions into the PS&E.

530.07 Documentation

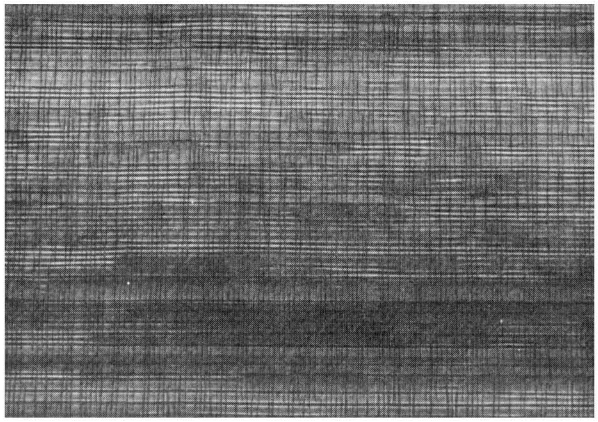
A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/



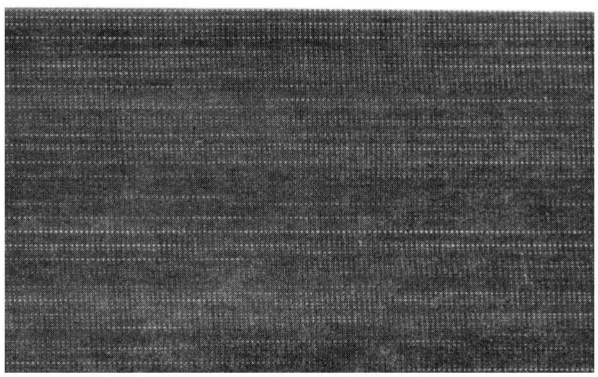
Design Process for Drainage and Erosion Control Geotextiles and Nonstandard Applications
Figure 530-4



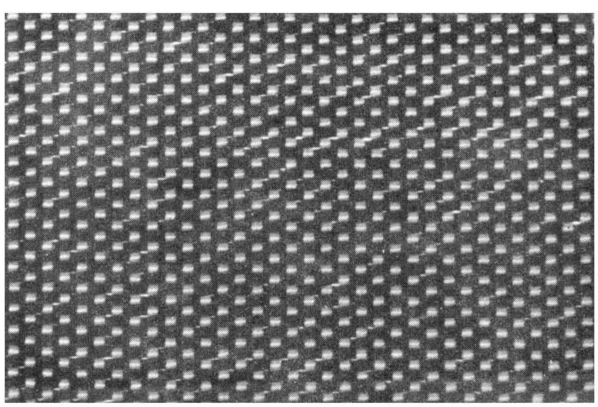
Design Process for Separation, Soil Stabilization, and Silt Fence
Figure 530-5



Slit Film Woven Geotextile

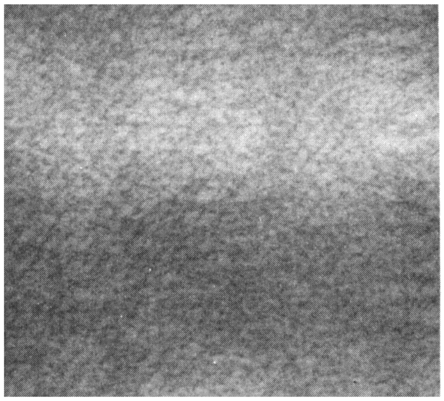


Monofilament Woven Geotextile

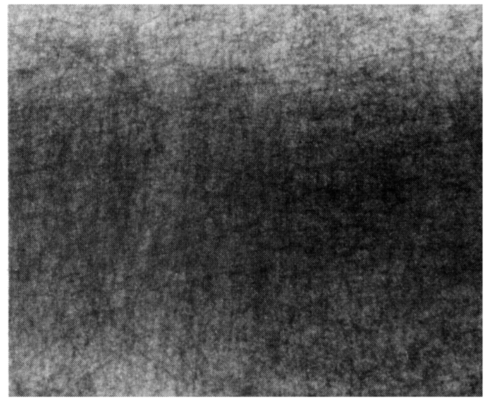


Multifilament Woven Geotextile

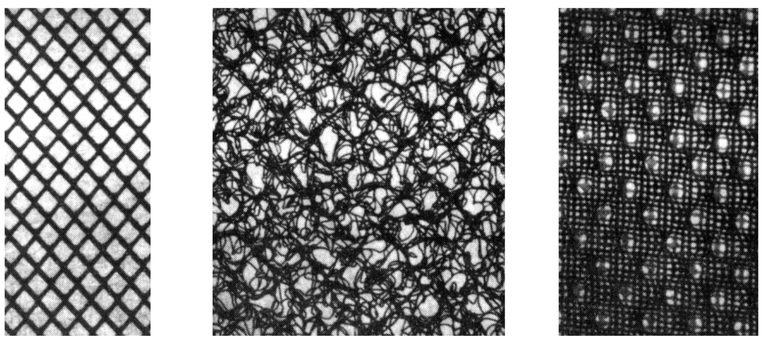
Examples of Various Geosynthetics
Figure 530-6a



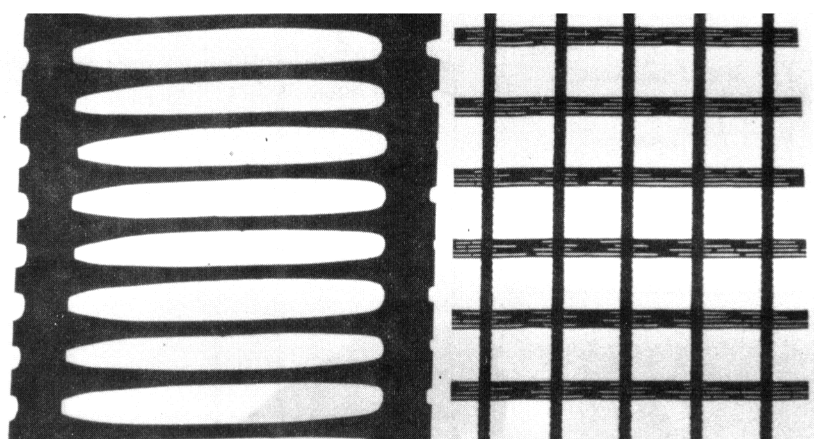
Needle Punched Nonwoven Geotextile



Heat Bonded Nonwoven Geotextile

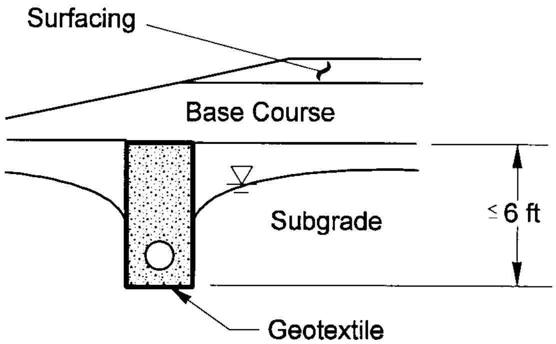


Geocomposite Drains (Geotextile With Core)

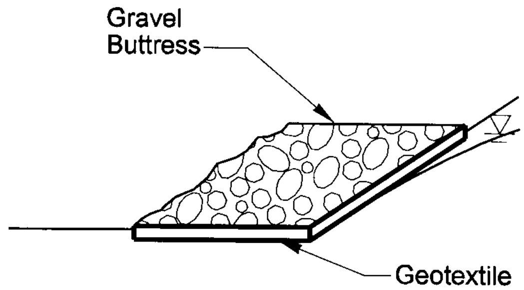


Extruded and Woven Geogrids

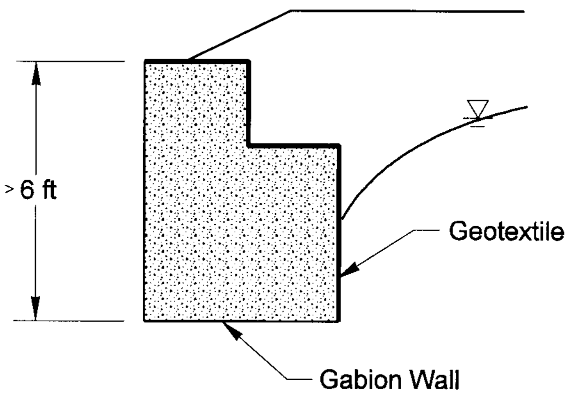
Examples of Various Geosynthetics
Figure 530-6b



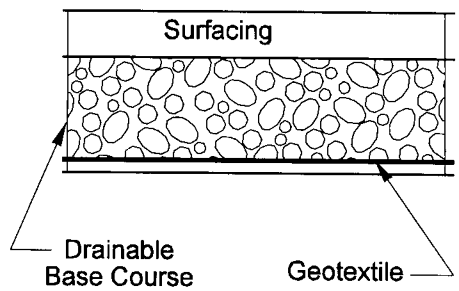
a. Underground drainage, low survivability (roadway trench drain)



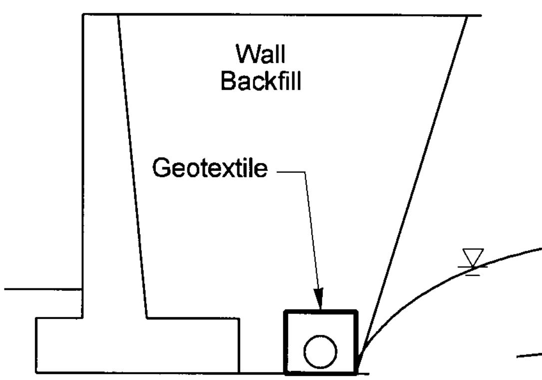
b. Underground drainage, moderate survivability (area drain beneath buttress)



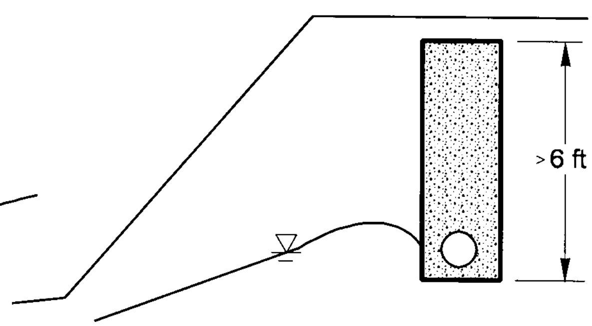
c. Underground drainage, moderate survivability (geotextile sheet drain)



d. Underground drainage, moderate survivability (area drain beneath parking lot or roadway)



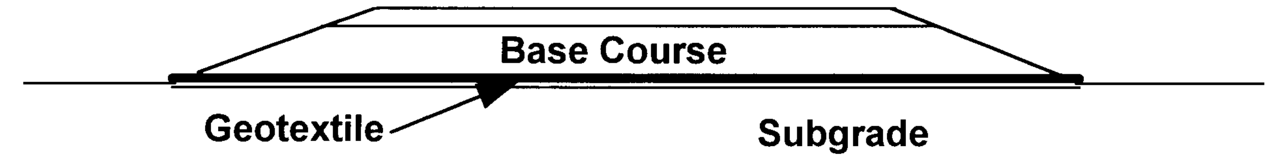
e. Underground drainage, low survivability (wrapped drain behind foundation)



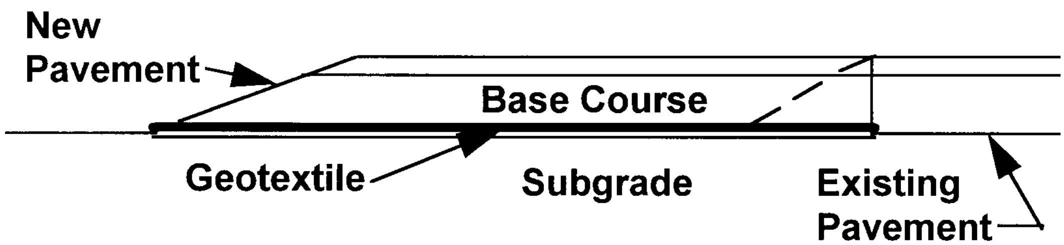
f. Underground drainage, moderate survivability (deep trench drain for slope stabilization)

Geotextile Application Examples

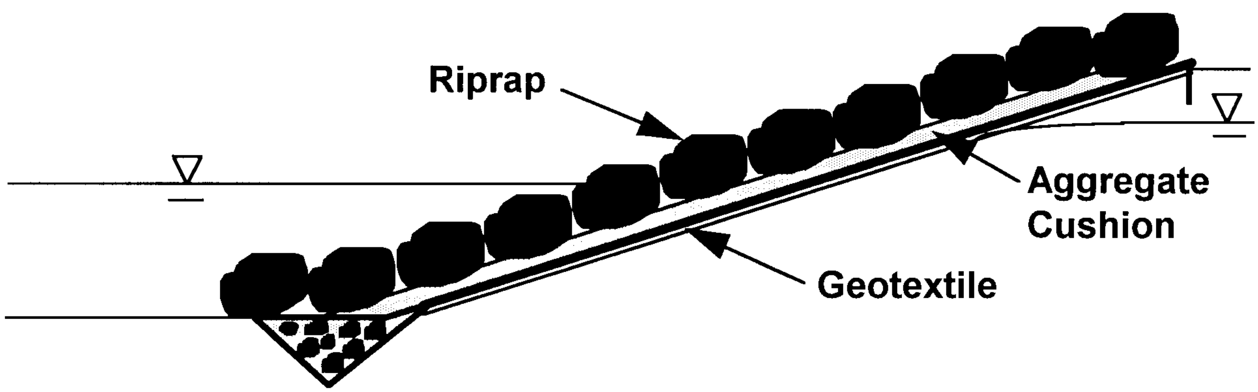
Figure 530-7a



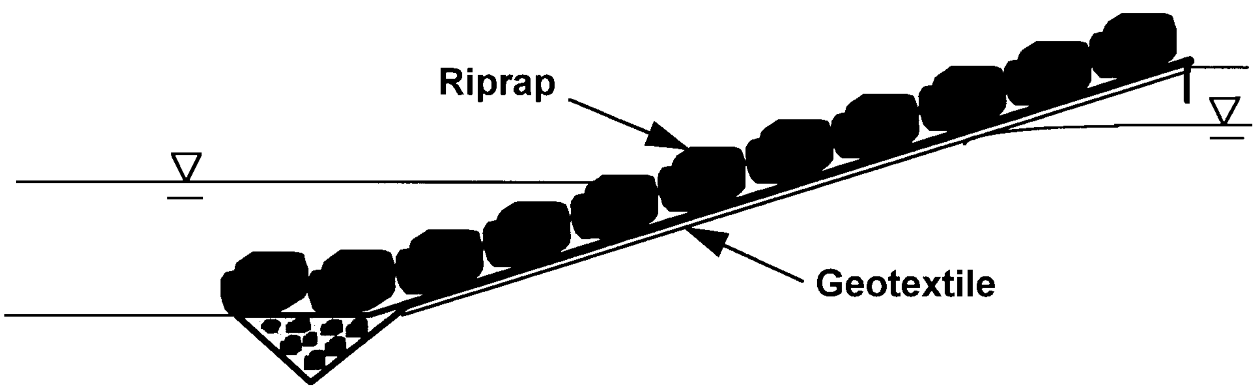
g. Separation or soil stabilization for new roadway (depends on subgrade condition)



h. Separation or soil stabilization for widened roadway (depends on subgrade condition)

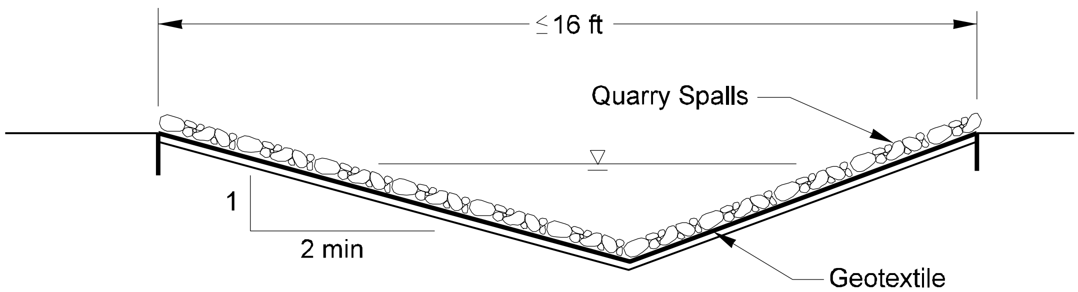


i. Permanent erosion control, moderate survivability

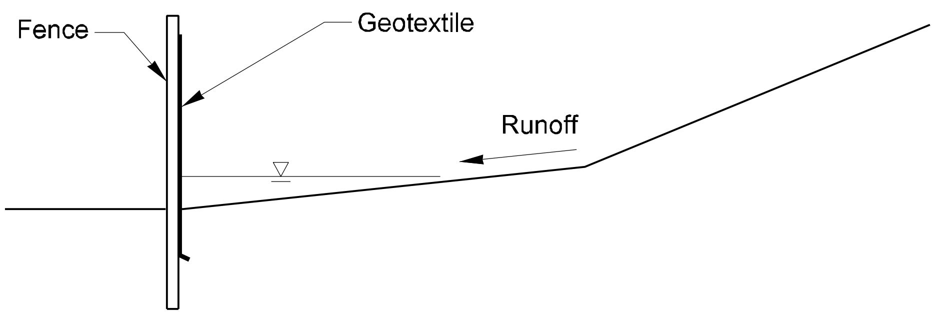


j. Permanent erosion control, high survivability

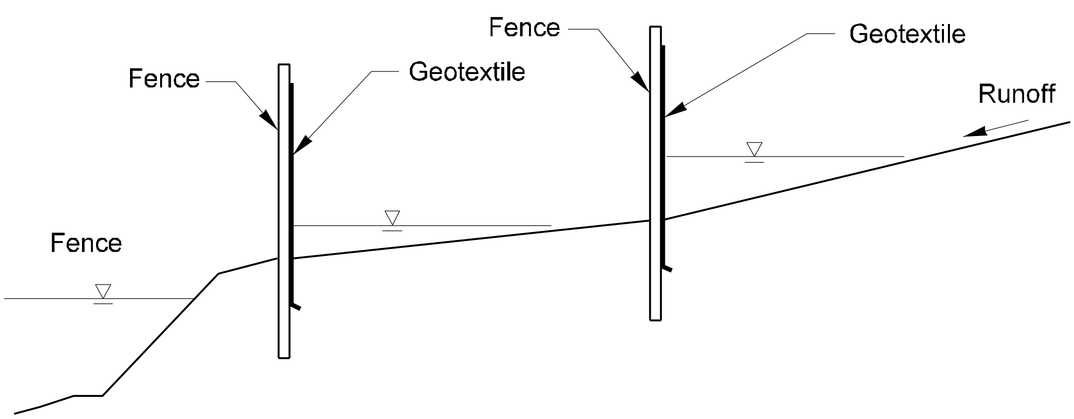
Geotextile Application Examples
Figure 530-7b



k. Ditch lining

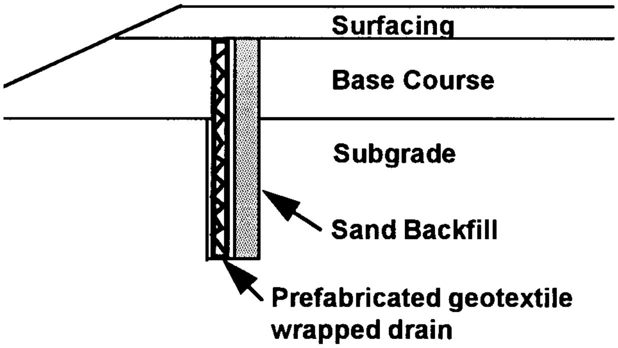


l. Silt fence not immediately adjacent to enviromentally sensitive area

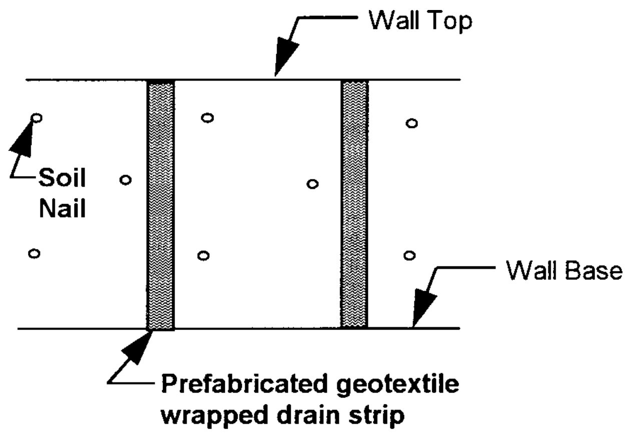


m. Silt fence immediately adjacent to enviromentally sensitive area

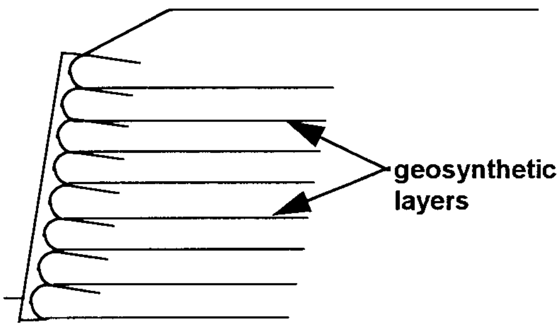
Geotextile Application Examples
Figure 530-7c



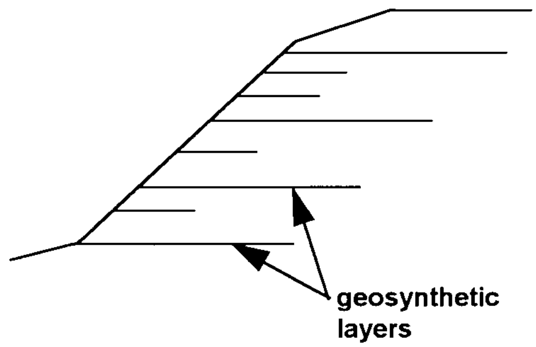
n. Prefabricated edge drain for roadway



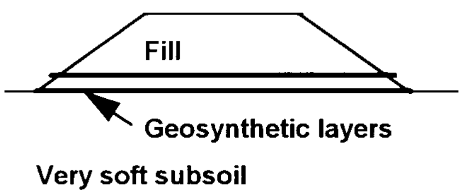
o. Prefabricated drain strip behind wall face



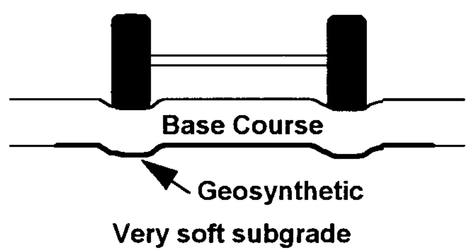
p. Geosynthetic wall



q. Geosynthetic reinforced slope

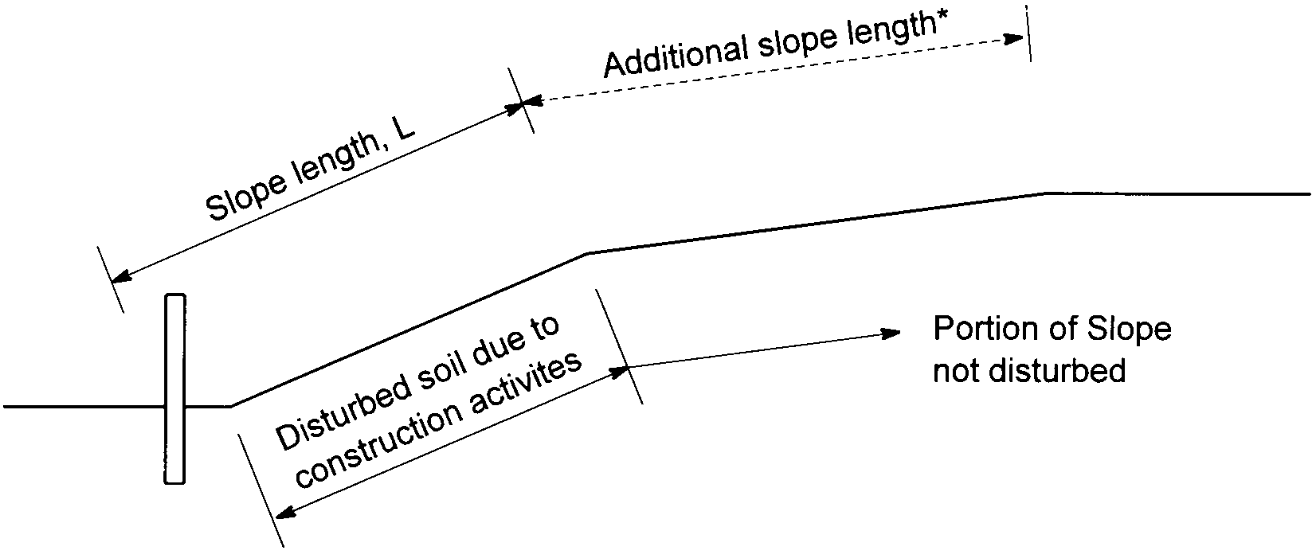


r. Geosynthetic reinforced embankment



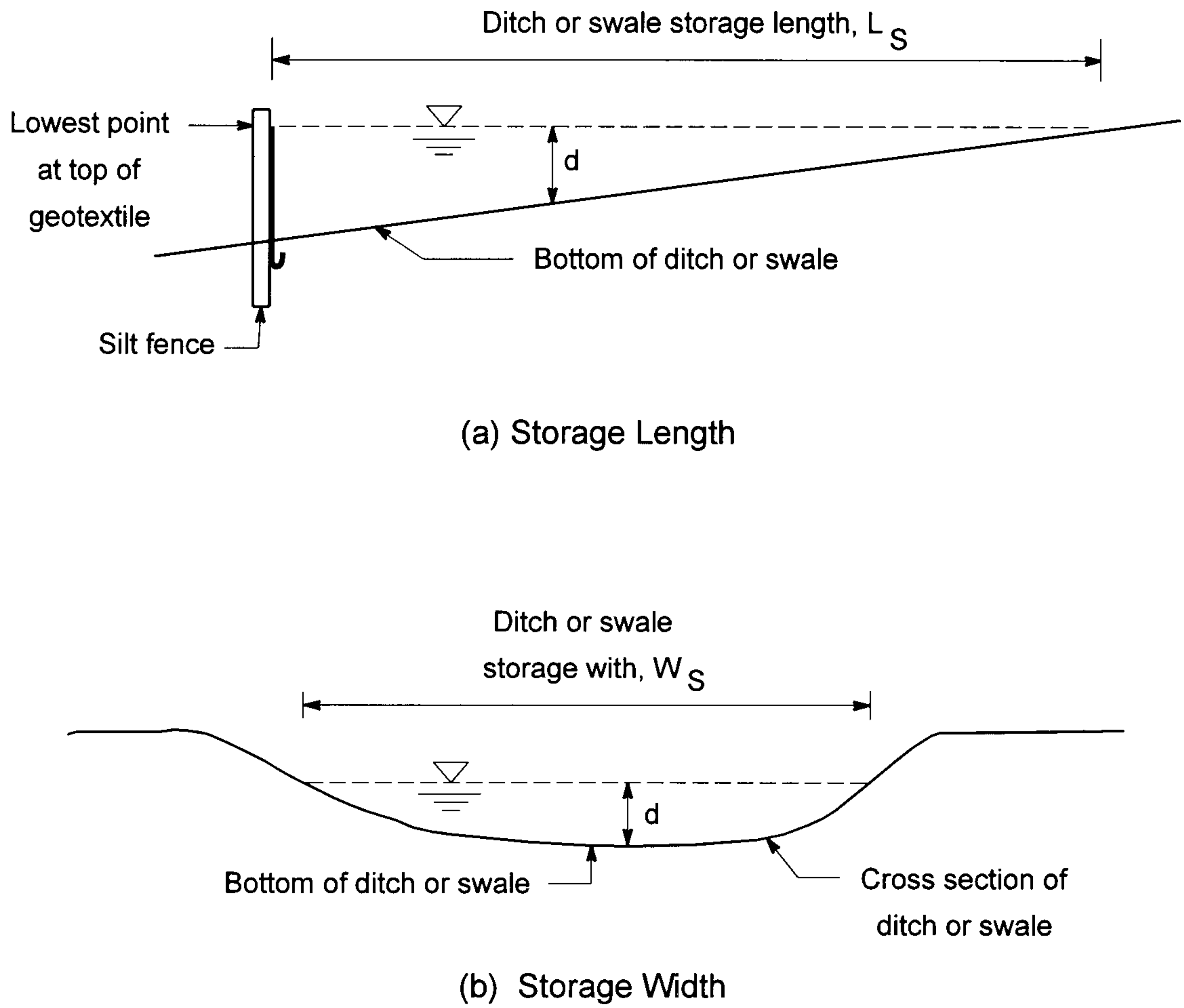
s. Geosynthetic subgrade reinforcement for temporary roads

Geotextile Application Examples
Figure 530-7d

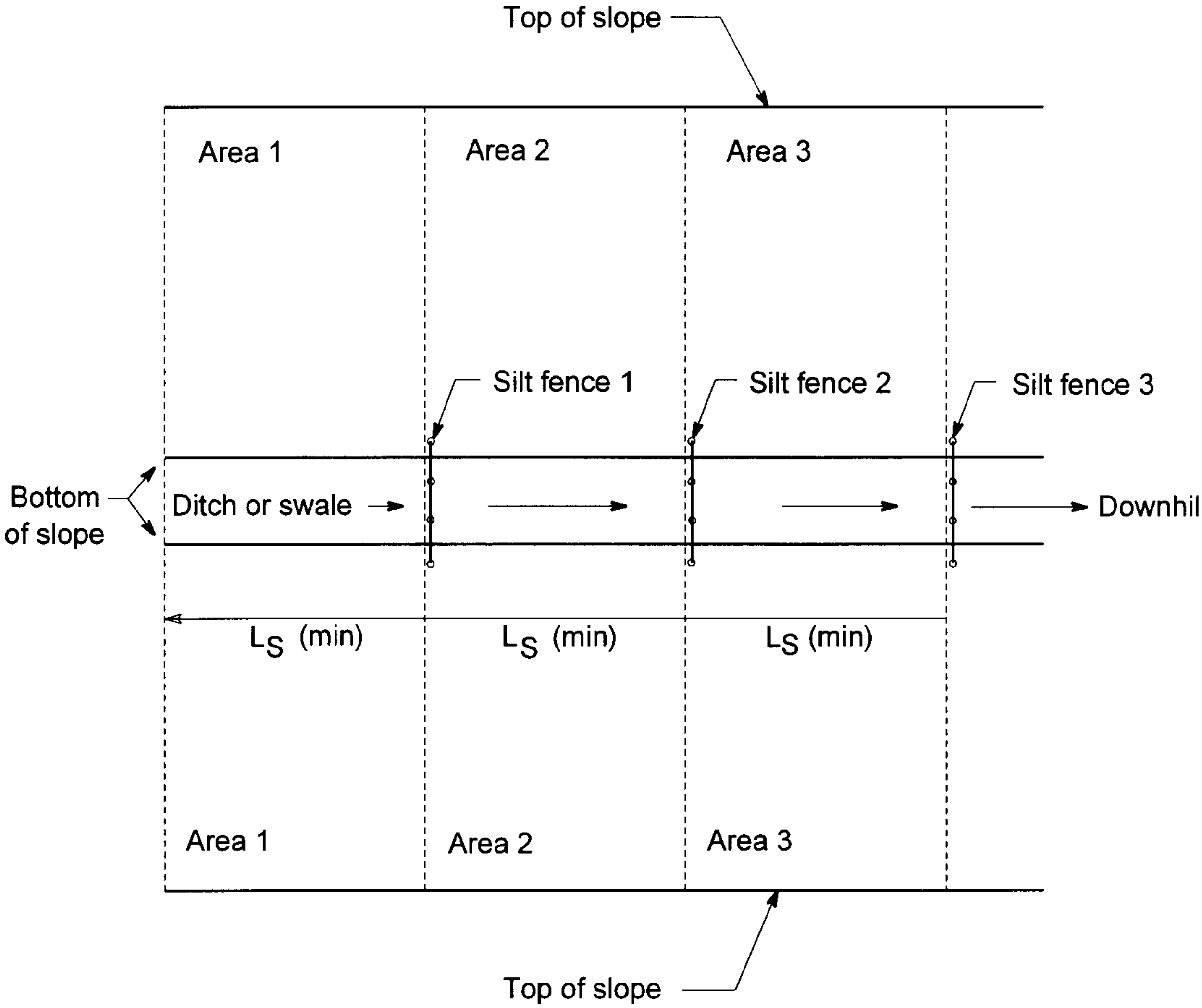


*May need to be included as part of slope length depending on vegetative cover, slope steepness, and degree of development above slope.

Definition of Slope Length
Figure 530-8

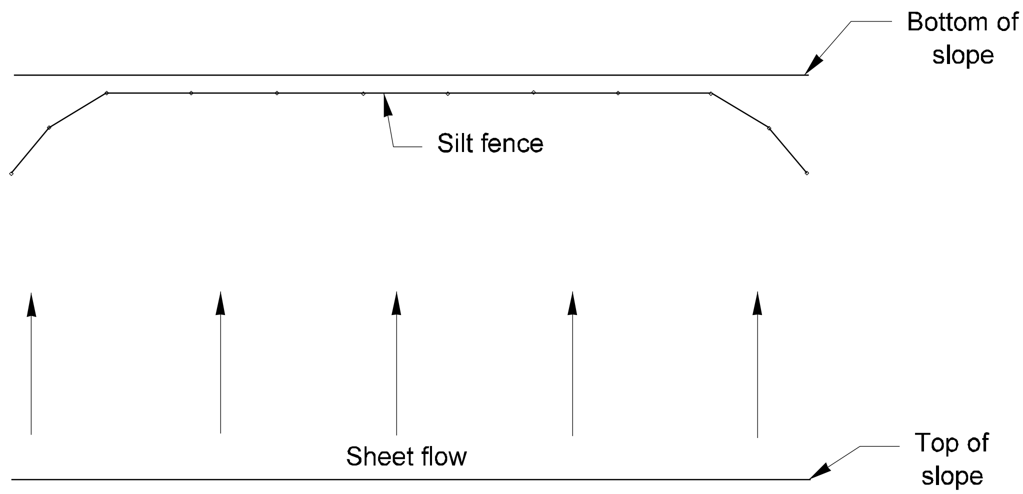


Definition of Ditch or Swale Storage Length and Width
Figure 530-9

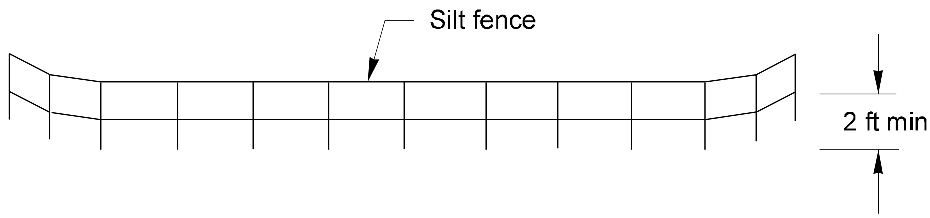


Method to keep contributing area to ditch or swale within allowable limits if contributing area too large based on Figure 530-3.

Silt Fences for Large Contributing Area
Figure 530-10



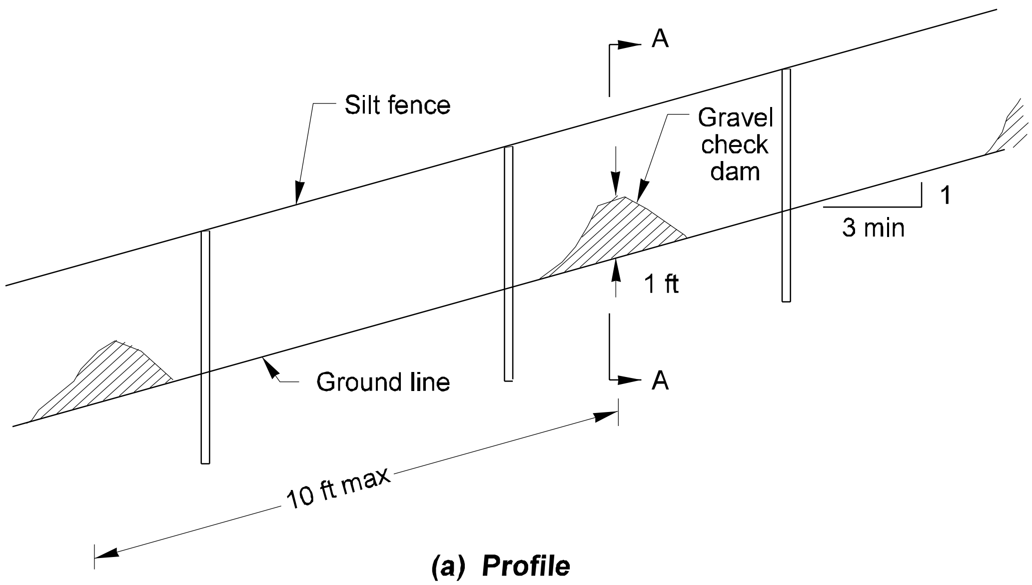
(a) Silt Fence Plan



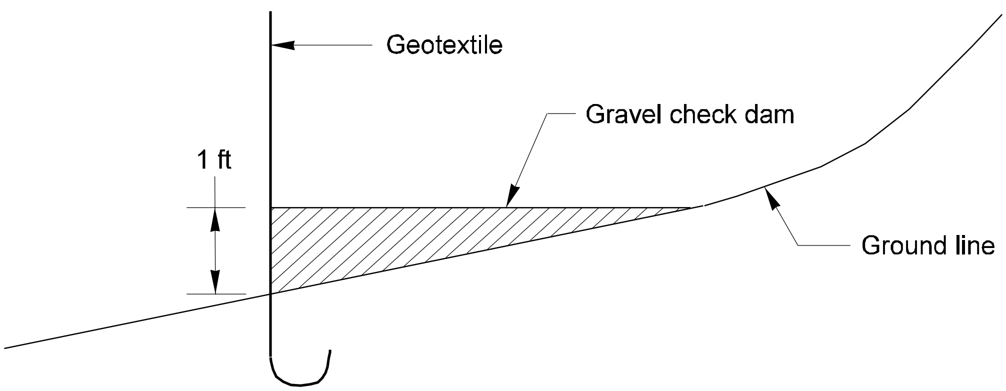
(b) Silt Fence Profile

Silt fence plan and profile illustrating how to insure silt fence will capture runoff water and not allow water to run around ends of fence.

Silt Fence End Treatment
Figure 530-11



(a) Profile



(b) Cross-Section A-A

Gravel Check Dams for Silt Fences
Figure 530-12

610.01 General

It is the Washington State Department of Transportation's (WSDOT's) responsibility to provide for an interconnected transportation system to ensure the mobility of people and goods. In order to achieve these objectives, traffic engineers determine whether the proposed improvements will satisfy future needs by comparing the forecast directional hourly volume with the traffic-handling capacity of an improved facility. Project traffic forecasts and capacity are used to establish the number of through lanes, the length of auxiliary lanes, signal timing, right of way requirements, and other characteristics, so that the facility can operate at an acceptable level of service through the design year.

This chapter provides guidance and general requirements for traffic analyses. Specific requirements for a traffic analysis depend on a variety of factors. These include:

- Project proponents (federal, state, local, and private sector).
- Lead agency.
- Legal requirements (laws, regulations, procedures, and contractual obligations).
- Purpose of the traffic analysis.

Along with these factors, examine capacity and safety needs, look at project benefits and costs, determine development impacts, and identify mitigation requirements.

This *Design Manual* does not cover capacity analysis; see the latest version of the *Highway Capacity Manual* (HCM).

610.02 References

Laws – Federal and state laws and codes that may pertain to this chapter include:

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, Federal Highway Administration (FHWA), National Advisory Committee on Uniform Traffic Control Devices, including the "Washington State Modifications to the MUTCD," Chapter 468-95 Washington Administrative Code (WAC), MUTCD http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Revised Code of Washington (RCW), Chapter 43.21C, the State Environmental Policy Act (SEPA)

The National Environmental Policy Act (NEPA) of 1969

Design Guidance – Design guidance included by reference within the text includes:

Highway Capacity Manual (HCM), latest edition, Transportation Research Board, National Research Council

Roadway Delineation Practices Handbook, FHWA report, Washington, DC, 1994

Sign Fabrication Manual, M 55-05, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

"Trip Generation," Institute of Transportation Engineers (ITE)

Supporting Information – Other resources used or referenced in this chapter include:

NCHRP Synthesis 306, *Long-Term Pavement Practices*, Transportation Research Board

Development Services Manual, 3007.00, WSDOT

Traffic Manual, M51-02, WSDOT

610.03 Design Year

Roadway geometric design must consider projected traffic for the opening year and the design year. The design year for new construction and reconstruction projects is given in Chapter 440. However, the design year for developer projects is often (but not always) the horizon year or build-out year. One early task for the traffic analyst is to determine the correct design year.

610.04 Definitions

annual average daily traffic (AADT) The total volume of traffic passing a point or segment of a highway facility in both directions for one year divided by the number of days in the year.

average daily traffic (ADT) The total volume during a given time period (in whole days): greater than one day and less than one year, divided by the number of days in that time period.

capacity The maximum sustainable flow rate at which vehicles or persons can reasonably be expected to traverse a point or uniform segment of a lane or roadway during a specified time period under given roadway, geometric, traffic, environmental, and control conditions. Capacity is usually expressed as vehicles per hour (vph), passenger cars per hour (pcph), or persons per hour (pph).

capture trips Trips that do not enter or leave the traveled ways of a project's boundary within a mixed-use development.

design hourly volume (DHV) Computed by taking the annual average daily traffic times the K-factor. It can only be accurately determined in locations where there is a permanent traffic recording device active 365 days of the year. It correlates to the peak hour (see peak hour definition), but it is not equivalent. In some circumstances, it is necessary to use the peak hour data instead of DHV because peak hour can be collected using portable traffic recorders.

directional design hour volume (DDHV) The traffic volume for the design hour in the peak direction of flow, in vehicles per hour. For example, if during the design hour, 60% of the vehicles traveled eastbound and 40% traveled westbound, then the DDHV for the eastbound direction would be the DHV x 0.60.

K-factor The proportion of AADT occurring in the analysis hour is referred to as the K-factor, expressed as a decimal fraction (commonly called "K," "K30," or "K100"). The K30 is the thirtieth (K100 is the one-hundredth) highest peak hour divided by the annual average daily traffic. Normally, the K30 or K100 will be in the range of 0.09 to 0.10 for urban and rural areas. Average design hour factors are available on the web in the Transportation Data Office's Annual Peak Hour Report.

lead agency The public agency that has the principal responsibility for carrying out or approving a project.

level of service (LOS) A qualitative measure describing operational conditions within a traffic stream, based on service measures such as speed, travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. Six levels of service are defined for each type of facility that has analysis procedures available. Letters designate each level, from A to F, with LOS A representing the best operating conditions and LOS F the worst. Each level of service represents a range of operating conditions and the driver's perception of those conditions. Safety is not included in the measures that establish service levels.

"pass-by" trips Pass-by trips are made as intermediate stops between an origin and a primary trip destination (for example, home to work, home to shopping).

peak hour The 60-minute interval that contains the largest volume of traffic during a given time period. If a traffic count covers consecutive days, the peak hour can be an average of the highest hour across all of the days. An A.M. peak is simply the highest hour from the A.M., and the P.M. peak is the highest from the P.M. Peak hour correlates to the DHV, but is not the same. However, it is close enough on items such as intersection plans for approval to be considered equivalent.

project Activities directly undertaken by government, financed by government, or requiring a permit or other approval from government.

"select zone" analysis A traffic model run, where the related project trips are distributed and assigned along a populated highway network. This analysis isolates the anticipated impact on the state highway network created by the project.

610.05 Travel Forecasting (Transportation Modeling)

While regional models are available in most urban areas, they may not be the best tool for reviewing developments. Most regional models are macroscopic in nature and do not do a good job of identifying intersection-level development impacts without further refinement of the model. The task of refining the model can be substantial and is not warranted in many instances. The region makes the determination whether a model or a trend line analysis can be used to take into account historical growth rates and background projects. This decision would be based on numerous factors including the type, scale, and location of the development. The regional model is generally more appropriate for larger projects that generate a substantial number of new trips. The Traffic Impact Analysis (TIA) clearly describes the methodology and process used in developing the forecast in support of the analysis of a proposed project.

610.06 Traffic Analysis

The level of service (LOS) for operating state highway facilities is based upon measures of effectiveness (MOEs), per the latest version of the *Highway Capacity Manual*.

These MOEs (see Figure 610-1) describe the measures best suited for analyzing state highway facilities, such as freeway segments, signalized intersections, on- or off-ramps, and others. Depending on the facility, WSDOT LOS thresholds are LOS C and LOS D on state highway facilities. The LOS threshold for developer projects is set differently. Refer to Chapter 4 of the *Developer Services Manual*.

(1) Trip Generation Thresholds

The following criteria are used as the starting point for determining when a TIA is needed:

- When a project changes local circulation networks that impact a state highway facility involving direct access to the state highway facility; includes a nonstandard highway geometric design feature, and others.
- The potential risk for a traffic incident is significantly increased due to congestion-related collisions, nonstandard sight distance considerations, increases in traffic conflict points, and others.
- When a project affects state highway facilities experiencing significant delay; LOS "C" in rural areas or "D" in urban areas.

Note: A traffic analysis can be as simple as providing a traffic count or as complex as a microscopic simulation. The appropriate level of analysis is determined by the specifics of a project, the prevailing highway conditions, and the forecasted traffic. For developer projects, different thresholds may be used depending on local agency codes or interagency agreements (or both) between WSDOT and local agencies. For more information, refer to Chapter 4 of the *Development Services Manual.*

TYPE OF FACILITY	MEASURE OF EFFECTIVENESS (MOE)
Basic Freeway Segments	Density (pc/mi/ln)
Ramps	Density (pc/mi/ln)
Ramp Terminals	Delay (sec/veh)
Multilane Highways	Density (pc/mi/ln)
Two-Lane Highways	Percent-Time-Spent Following Average Travel Speed (mi/hr)
Signalized Intersections	Control Delay Per Vehicle (sec/veh)
Unsignalized Intersections	Average Control Delay Per Vehicle (sec/veh)
Urban Streets	Average Travel Speed (mi/hr)

Measures of Effectiveness by Facility Type
Figure 610-1

(2) Updating an Existing Traffic Impact Analysis

A TIA may require updating when the amount or character of traffic is significantly different from an earlier analysis. Generally, a TIA requires updating every two years. A TIA might require updating sooner in rapidly developing areas and not as often in slowly developing areas. In these cases, consultation with WSDOT is strongly recommended.

610.07 Scope of Traffic Impact Analysis

Consultation between the lead agency, WSDOT, and those preparing the TIA is recommended before commencing work on the analysis to establish the appropriate scope. At a minimum, the TIA includes the following elements:

(1) Boundaries of the Traffic Impact Analysis

Boundaries are all state highway facilities impacted in accordance with the criteria in 610.06. Traffic impacts of local streets and roads can impact intersections on state highway facilities. In these cases, include an analysis of adjacent local facilities, (driveways, intersections, and interchanges), upstream and downstream of the intersection with the state highway in the TIA. A "lesser analysis" may include obtaining traffic counts, preparing signal warrants, or a focused TIA. For developer projects, the boundaries (such as the city limits) may be determined by the local agency.

(2) Traffic Analysis Scenarios

WSDOT is interested in the effects of plan updates and amendments, as well as the effects of specific project entitlements (including, but not limited to, site plans, conditional use permits, subdivisions, and rezoning) that have the potential to impact a state highway facility. The complexity and/or magnitude of the impacts of a project normally dictate the scenarios necessary to analyze the project. Consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to determine the appropriate scenarios for the analysis and why they should be addressed.

(a) When only a plan amendment or update is being sought in a TIA, the following scenarios are required:

1. Existing Conditions – Current year traffic volumes and peak hour LOS analysis of affected state highway facilities.
2. Proposed Project Only With Select Zone Analysis – Trip generation, distribution, and assignment in the year the project is anticipated to complete construction.
3. Plan Build-Out Only – Trip assignment and peak hour LOS analysis. Include current land uses and other pending plan amendments/anticipated developments.
4. Plan Build-Out Plus Proposed Project – Trip assignment and peak hour LOS analysis. Include proposed project and other pending plan amendments.

(b) When a plan amendment is not proposed and a proposed project is seeking specific entitlements (such as site plans, conditional-use permits, subdivisions, rezoning, and others), the following scenarios are required to be analyzed in the TIAs:

1. Existing Conditions – Current year traffic volumes and peak hour LOS analysis of affected state highway facilities.
2. Proposed Project Only – Trip generation, distribution, and assignment in the year the project is anticipated to complete construction.
3. Cumulative Conditions (Existing Conditions Plus Other Approved and Pending Projects Without Proposed Project) – Trip assignment and peak hour LOS analysis in the year the project is anticipated to complete construction.
4. Cumulative Conditions Plus Proposed Project (Existing Conditions Plus Other Approved and Pending Projects Plus Proposed Project) – Trip assignment and peak hour LOS analysis in the year the project is anticipated to complete construction.
5. Cumulative Conditions Plus Proposed Phases (Interim Years) – Trip assignment and peak hour LOS analysis in the years the project construction phases are anticipated to be completed.

(c) In cases where the circulation element of the plan is not consistent with the land use element or the plan is outdated and not representative of current or future forecasted conditions, all scenarios from 610.07(2)(a) and (b) are to be utilized, with the exception of the duplication of (b)1 and (b)2.

610.08 Traffic Data

Prior to any fieldwork, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to reach consensus on the data and assumptions necessary for the study. The following elements are a starting point in that consideration:

(1) Trip Generation

For trip generation forecasts, use the latest edition of the Institute of Transportation Engineers' (ITE) publication, "Trip Generation." Local trip generation rates are also acceptable if appropriate validation is provided to support them.

(a) **Trip Generation Rates** – When the land use has a limited number of studies to support the trip generation rates or when the Coefficient of Determination (R2) is below 0.75, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended.

(b) **Pass-by Trips** – Pass-by trips are only considered for retail-oriented development. Reductions greater than 15% require consultation and acceptance by WSDOT. Include the justification for exceeding a 15% reduction in the TIA.

(c) **Captured Trips** – Captured trip reductions greater than 5% require consultation and acceptance by WSDOT. Include the justification for exceeding a 5% reduction in the TIA.

(d) **Transportation Demand Management (TDM)** – Consultation between the lead agency and WSDOT is essential before applying trip reduction for TDM strategies. Note: Reasonable reductions to trip generation rates are considered when adjacent state highway volumes are sufficient (at least 5,000 ADT) to support reductions for the land use.

(2) Traffic Counts

Prior to field traffic counts, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to determine the level of detail (location, signal timing, travel speeds, turning movements, and so forth) required at each traffic count site. All state highway facilities within the boundaries of the TIA are to be considered. Common rules for counting vehicular traffic include, but are not limited to, the following:

(a) Conduct vehicle counts to include at least one contiguous 24-hour period on Tuesdays, Wednesdays, or Thursdays during weeks not containing a holiday and in favorable weather conditions.

(b) Conduct vehicle counts during the appropriate peak hours (see peak hour discussion below).

(c) Consider seasonal and weekend variations in traffic where appropriate (recreational routes, tourist seasons, harvest season, and others).

(3) Peak Hours

To eliminate unnecessary analysis, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended during the early planning stages of a project. In general, the TIA includes a morning (A.M.) and an evening (P.M.) peak hour analysis. Other peak hours (such as 11:30 A.M. to 1:30 P.M., weekends, and holidays) might also be required to determine the significance of the traffic impacts generated by a project.

(4) Accidents

The following should be included in any discussion of the subject of accidents:

(a) A listing of the location's 3-year accident history. (For direct access points and/or intersections, the list covers an area 0.1 mile to either side of the main line or crossroad intersection).

(b) A collision diagram illustrating the 3-year accident history at each location where the number of accidents at the location has been 15 or more in the last 3 years.

(c) The predominant accident types and their locations, any accident patterns, and an assessment of and mitigation for the development's traffic safety impacts.

Also, include in the discussion the following:

1. Sight distance and any other pertinent roadway geometrics
2. Driver expectancy and accident potential (if necessary)
3. Special signing and illumination needs (if necessary)

610.09 Traffic Impact Analysis Methodologies

Typically, the traffic analysis methodologies for the facility types indicated below are used by WSDOT and will be accepted without prior consultation. When a state highway has saturated flows, the use of a microsimulation model is encouraged for the analysis (note, however, that the microsimulation model must be calibrated and validated for reliable results). Other analysis methods may be accepted; however, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to agree on the data necessary for the analysis. The methodologies include:

A. Freeway Segments – *Highway Capacity Manual (*HCM), operational analysis

B. Weaving Areas – WSDOT *Design Manual* (DM), (HCM), operational analysis

C. Ramps and Ramp Junctions – HCM, operational analysis or WSDOT DM, WSDOT Ramp Metering Guidelines (most recent edition)

D. Multilane Highways – HCM, operational analysis

E. Two-Lane Highways – HCM, operational analysis

F. Signalized Intersections – HCM, Highway Capacity Software,** operational analysis, Synchro

G. Unsignalized Intersections – HCM, (MUTCD), and WSDOT *Design Manual*, Chapter 850.05, for signal warrants if a signal is being considered

H. Transit – HCM, operational analysis

I. Pedestrians – HCM

J. Bicycles – HCM

K. WSDOT Criteria/Warrants – MUTCD (stop signs), WSDOT *Traffic Manual* (school crossings), WSDOT *Design Manual*, Chapter 840 (freeway lighting, conventional highway lighting)

L. Channelization – WSDOT *Design Manual*

M. Roundabouts – WSDOT *Design Manual*

**Note: WSDOT does not officially advocate the use of any special software. However, consistency with the HCM is advocated in most (but not all) cases. The WSDOT local development review units utilize the software mentioned above. If different software or analytical techniques are used for the TIA, then consultation between the lead agency, WSDOT, and those preparing the TIA is recommended.

Challenge results that are significantly different than those produced with the analytical techniques above. The procedures in the *Highway Capacity Manual* do not explicitly address operations of closely spaced signalized intersections. Under such conditions, several unique characteristics must be considered, including spill-back potential from the downstream intersection to the upstream intersection; effects of downstream queues on upstream saturation flow rates; and unusual platoon dispersion or compression between intersections. An example of such closely spaced operations is signalized ramp terminals at urban interchanges. Queue interactions between closely spaced intersections can seriously distort the procedures in the HCM.

610.10 Traffic Analysis Software

For applications that fall outside the limits of the HCM software, WSDOT makes use of the following software:

(1) TRANSYT-7F

TRANSYT-7F is a traffic signal timing optimization software package for traffic networks, arterial streets, or single intersections having complex or simple conditions.

TRANSYT-7F capabilities other than signal timing programs include:

- Lane-by-lane analysis
- Direct CORSIM optimization
- Multicycle and multiperiod optimization
- Detailed simulation of existing conditions
- Detailed analysis of traffic-actuated control
- Hill-climb and genetic algorithm optimization
- Optimization based on a wide variety of objective functions
- Optimization of cycle length, phasing sequence, splits, and offsets
- Explicit simulation of platoon dispersion, queue spillback, and spillover
- Full flexibility in modeling unusual lane configurations and timing plans

(2) *Traffic*ware – Syn*chro*

Synchro is a software application for optimizing traffic signal timing and performing capacity analyses. The software optimizes splits, offsets, and cycle lengths for individual intersections, an arterial, or a complete network. Synchro performs capacity analyses using both the Intersection Capacity Utilization (ICU) and HCM methods. Synchro provides detailed time space diagrams that can show vehicle paths or bandwidths. Synchro can be used for creating data files for SimTraffic and other third party traffic software packages. SimTraffic models signalized and unsignalized intersections, and freeway sections with cars, trucks, pedestrians, and buses.

Synchro capabilities other than signal timing programs include:

- Lane-by-lane analysis
- Direct CORSIM optimization
- Multicycle and multiperiod optimization
- Detailed simulation of existing conditions
- Detailed analysis of traffic-actuated control
- Hill-climb and genetic algorithm optimization
- Optimization based on a wide variety of objective functions
- Optimization of cycle length, phasing sequence, splits, and offsets
- Explicit simulation of platoon dispersion, queue spillback, and spillover
- Full flexibility in modeling unusual lane configurations and timing plans

(3) aaSIDRA

aaSIDRA is a software product that can analyze signalized and unsignalized intersections, including roundabouts in one package. It is a microanalytical traffic evaluation tool that employs lane-by-lane and vehicle drive cycle models.

aaSIDRA can perform signal timing optimization for actuated and pretimed (fixed-time) signals, with signal phasing schemes from the simplest to the most sophisticated.

aaSIDRA, or aaTraffic SIDRA (Signalized & unsignalized Intersection Design and Research Aid) software is for use as an aid for designing and evaluating of the following intersection types:

- Signalized intersections (fixed-time, pretimed, and actuated)
- Roundabouts
- Two-way stop sign control
- All-way stop sign control
- Yield sign control

(4) PTV America – Vissim

Vissim is a microscopic, behavior-based multi-purpose traffic simulation program, for signal systems, freeway systems, or combined signal and freeway systems having complex or simple conditions.

The program offers a wide variety of urban and highway applications, integrating public and private transportation. Even complex traffic conditions are visualized at an unprecedented level of detail providing realistic traffic models.

Vissim capabilities include:

- Dynamic Vehicle Assignment
- Land use traffic impact studies and access management studies
- Freeway and surface street interchanges
- Signal timing, coordination, and pre-emption
- Freeway weaving sections, lane adds and lane drops
- Bus stations, bus routes, carpools, and taxis
- Ramp metering and HOV lanes
- Unsignalized intersections and signal warrants
- Incident detection and management
- Queuing studies involving turn pockets and queue blockage
- Toll plazas and truck weigh stations
- Origin-destination traffic flow patterns
- Verification and validation of other software
- Surrogate for field data collection
- Public presentation and demonstration

(5) TSIS – Corsim

TSIS is a traffic simulation software package for signal systems, freeway systems, or combined signal and freeway systems having complex or simple conditions. Its strength lies in its ability to simulate traffic conditions at a level of detail beyond other simulation programs.

TSIS capabilities include:

- Land use traffic impact studies and access management studies
- Freeway and surface street interchanges
- Signal timing, coordination, and pre-emption
- Freeway weaving sections, lane adds, and lane drops
- Bus stations, bus routes, carpools, and taxis
- Ramp metering and HOV lanes
- Unsignalized intersections and signal warrants
- Incident detection and management
- Queuing studies involving turn pockets and queue blockage
- Toll plazas and truck weigh stations
- Origin-destination traffic flow patterns
- Verification and validation of other software
- Surrogate for field data collection
- Public presentation and demonstration

Use the most current version of Traffic Analysis Software. Current software licenses may be obtained from the Traffic Analysis Engineer at the HQ Traffic Office: (360) 705-7297.

610.11 Mitigation Measures

Consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to reach consensus on the mitigation measures and who will be responsible. Mitigation measures must be included in the TIA, to determine if a project's impacts can be eliminated or reduced to a level of insignificance. Eliminating or reducing impacts to a level of insignificance is the standard pursuant to SEPA and NEPA. The lead agency is responsible for administering the SEPA review process and has the principal authority for approving a local development proposal or land use change. WSDOT, as a lead agency, is responsible for reviewing the TIA for impacts that pertain to state highway facilities. However, the authority vested in the lead agency under SEPA does not take precedence over other authorities in law.

If the mitigation measures require work in the state highway right of way, an encroachment permit from WSDOT is required. This work is also subject to WSDOT standards and specifications. Consultation between the lead agency, WSDOT, and those preparing the TIA early in the planning process is strongly recommended to expedite the review of local development proposals and to reduce conflicts and misunderstandings in both the local agency SEPA review process as well as the WSDOT encroachment permit process.

Additional mitigation recommendations necessary to help relieve impacts include the following:

- (a) Satisfy local agency guidelines and interlocal agreements
- (b) Correct any LOS deficiencies as per interlocal guidelines
- (c) Donation of right of way/frontage improvements/channelization changes
- (d) Installation of a traffic signal (warrant analysis per MUTCD is required)
- (e) Include current/future state projects (Sunshine Report)
- (f) Clear zone if widening the state highway
- (g) Any proposed changes to state highway channelization require submittal of a complete channelization plan, per channelization plan checklist, for state review and approval
- (h) Possible restrictions of turning movements
- (i) Sight distance
- (j) Traffic mitigation payment (pro-rata share contribution) to a programmed WSDOT project (see Chapter 4 of the *Development Services Manual)*

610.12 Traffic Impact Analysis Report

The minimum contents of a TIA report are listed below. The amount of text required under each element will vary depending upon the scale of the project.

I. EXECUTIVE SUMMARY

II. TABLE OF CONTENTS

- A. List of Figures (Maps)
- B. List of Tables

III. INTRODUCTION

- A. Description of the proposed project
- B. Location of the project
- C. Site plan including all access to state highways (site plan, map)
- D. Circulation network including all access to state highways (vicinity map)
- E. Land use and zoning
- F. Phasing plan including proposed dates of project (phase) completion
- G. Project sponsor and contact person(s)
- H. References to other traffic impact studies

IV. TRAFFIC ANALYSIS

A. Clearly stated assumptions

B. Existing and projected traffic volumes (including turning movements), facility geometry (including storage lengths), and traffic controls (including signal phasing and multisignal progression where appropriate), (figure/s)

C. Project trip generation (including references) (tables)

D. Project-generated trip distribution and assignment (figure/s)

E. LOS and warrant analyses—existing conditions, cumulative conditions, and full-build of plan conditions with and without project

V. CONCLUSIONS AND RECOMMENDATIONS

A. LOS and appropriate MOE quantities of impacted facilities with and without mitigation measures

B. Mitigation phasing plan including dates of proposed mitigation measures

C. Define responsibilities for implementing mitigation measures

D. Cost estimates for mitigation measures and financing plan

VI. APPENDICES

A. Description of traffic data and how data was collected

B. Description of methodologies and assumptions used in analyses

C. Worksheets used in analyses (for example, signal warrant, LOS, traffic count information)

620.01 General

This chapter provides guidance on the design of horizontal alignment, frontage roads, number of lanes, the arrangement of the lanes, and pavement transitions. See the following chapters for additional information:

Chapter	Subject
430	All roadway width requirements for modified design level
440	Lane and shoulder width requirements for full design level
440	Shoulder width requirements at curbs
641	Open highway and ramp lane widths on turning roadways for full design level
642	Superelevation rate and transitions
650	Sight distance
910	Requirements for islands
940	Ramp lane and shoulder requirements

620.02 References

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

Utilities Manual M 22-87, WSDOT

Plans Preparation Manual M 22-31, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Right of Way Manual M 26-01, WSDOT

Local Agency Guidelines (LAG), M 36-63, WSDOT

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

620.03 Definitions

auxiliary lane The portion of the roadway adjoining the traveled way for parking, speed change, turning, storage for turning, weaving, truck climbing, passing, and other purposes supplementary to through-traffic movement.

basic number of lanes The minimum number of general purpose lanes designated and maintained over a significant length of highway.

frontage road An auxiliary road that is a local road or street located on the side of a highway for service to abutting property and adjacent areas and for control of access.

outer separation The area between the outside edge of traveled way for through traffic and the nearest edge of traveled way of a frontage road or collector/distributor road.

turning roadway A curve on an open highway, a curve on a ramp, or a connecting roadway between two intersecting legs of an intersection.

620.04 Horizontal Alignment

(1) General

Horizontal and vertical alignments (Chapter 630) are the primary controlling elements for highway design. It is important to coordinate these two elements with design speed, drainage, intersection design, and aesthetic principles in the early stages of design.

Figures 620-2a through 2c show desirable and undesirable alignment examples for use with the following considerations:

(a) Make the highway alignment as direct as practical and still blend with the topography while considering developed and undeveloped properties, community boundaries, and environmental concerns.

(b) Make highway alignment consistent by:

- Using gentle curves at the end of long tangents.
- Using a transition area of moderate curvature between the large radius curves of rural areas and the small radius curves of populated areas.
- Making horizontal curves visible to approaching traffic.

(c) Avoid minimum radii and short curves unless:

- Restrictive conditions are present and are not readily or economically avoidable.
- On two-lane highways, minimum radii will result in tangent sections long enough for needed passing.

(d) Avoid any abrupt change in alignment. Design reverse curves with an intervening tangent long enough for complete superelevation transition for both curves. See Chapter 642 for more information on superelevation transitions.

(e) Avoid the use of curves in the same direction connected by short tangents (broken back curves); substitute a single larger curve.

(f) Avoid compound curves on open highway alignment if a simple curve can be obtained. When compound curves are used, make the shorter radius at least two-thirds the longer radius. Make the total arc length of a compound curve not less than 500 ft.

(g) On divided multilane highways, take advantage of independent alignment to produce a flowing alignment along natural terrain.

(h) The preferred locations for bridges, interchanges, intersections, and temporary connections are on tangent sections in clear view of drivers.

(i) On two-lane, two-way highways, strive for as much passing sight distance as possible. (See Chapter 650.)

(2) Horizontal Curve Radii

Design speed is the governing element of horizontal curves. For guidance regarding design speed selection see Chapter 440 for full design level, Chapter 430 for modified design level, and Chapter 940 for ramps.

Use the following factors to determine the radius for a curve:

- Stopping sight distance where sight obstructions are on the inside of a curve. Median barriers, bridges, walls, cut slopes, wooded areas, buildings, and guardrails are examples of sight obstructions. See Chapter 650 to check for adequate stopping sight distance for the selected design speed.
- Superelevation is the rotation or banking of the roadway cross section to overcome part of the centrifugal force that acts on a vehicle traversing a curve. Design information on the relationship between design speed, radius of curve, and superelevation is in Chapter 642.
- Coordinate vertical and horizontal alignment. (see Chapter 630.)

Spiral curves, although no longer used on new highway construction or major realignment, still exist on Washington highways. Spirals were used to transition between tangents and circular curves with the horizontal curvature rate increasing from tangent to the central curve and decreasing from curve to tangent. Spirals do not pose an operational concern and may remain in place. See the "Green Book" for information on spirals.

(3) Horizontal Curve Length

A curve is not required for small deflection angles. Figure 620-1 gives the maximum allowable angle without a curve. See Chapter 910 for guidance on angle points or short radii curves in the vicinity of intersections at grade.

Design Speed (mph)	Maximum Angle Without Curve
25	2º17’
30	1º55’
35	1º38’
40	1º26’
45	1º16’
50	1º09’
55	1º03’
60	0º57’
65	0º53’
70	0º49’
75	0º46’
80	0º43’

Maximum Angle Without Curve
Figure 620-1

To avoid the appearance of a kink in the road, the desirable length of curve for deflection angles larger than given in Figure 620-1 is at least 500 ft long.

620.05 Distribution Facilities

(1) General

In addition to the main highway under consideration, other facilities can be provided to distribute traffic to and from the highway and to fulfill access requirements. Highway flexibility can be augmented by:

- Frontage roads
- Collector distributor roads
- On and off connections
- Parallel arterial routes with connections between them and the main highway
- Loop highways around large metropolitan areas

A city or county may be asked to accept a proposed distribution facility as a city street or county road. Plan and design these facilities according to the applicable design values as city streets or county roads. (See Chapter 440.)

(2) Frontage Roads

Frontage roads constructed as part of highway development may serve any of the following purposes:

- To reestablish continuity of an existing road severed by the highway.
- To provide service connections to adjacent property that would otherwise be isolated as a result of construction of the highway.
- To control access to the highway.
- To maintain circulation of traffic on each side of the highway.
- To segregate local traffic from the higher speed through traffic and intercept driveways of residences and commercial establishments along the highway.
- To relieve congestion on the arterial highway during periods of high use or in emergency situations.

Frontage roads are generally not permanent state facilities. They are usually turned back to the local jurisdiction. Plan and design frontage roads as city streets or county roads. (See Chapter 440.) Initiate coordination with the local agency that will be the recipient of the facility early in the planning process, and carry through design and construction. See Chapter 1430 for additional guidance on frontage roads and turnbacks.

Outer separations function as buffers between the through traffic on the highway and the local traffic on the frontage road. The width is governed by requirements for grading, signing, barriers, aesthetics, headlight glare, and ramps. Where possible, make the separation wide enough to allow for development on both sides of the frontage road. Wider separations also move the intersection with the frontage road and a cross road farther from the intersection with the through roadway. It also can reduce the amount of limited access control rights to be acquired. (See Chapter 1430.)

Where two-way frontage roads are provided, a driver on the highway must contend with approaching traffic on the right (opposing frontage road traffic) as well as opposing traffic on the left. Make the outer separation wide enough to minimize the effects of approaching traffic, particularly the headlight glare. See Chapter 700 for information on headlight glare considerations. With one-way same-direction frontage roads, the outer separation need not be as wide as with two-way frontage roads.

Wide separations lend themselves to landscape treatment and can enhance the appearance of both the highway and the adjoining property.

A substantial width of outer separation is particularly advantageous at intersections with cross streets. The wider separation reduces conflicts with pedestrians and bicycles.

Where ramp connections are provided between the through roadway and the frontage road, the minimum outer separation width will depend on design requirements for the ramp termini.

620.06 Number of Lanes and Arrangement

(1) General

The basic number of lanes is designated and maintained over a length of highway. The total number of lanes is the basic number of lanes plus any auxiliary lanes required to meet:

- Level of service (volume-capacity).
- Lane balance.
- Flexibility of operation.

(2) Basic Number of Lanes

Keep the basic number of lanes constant over a highway route, or a significant portion thereof, regardless of changes in traffic volume. See Chapter 440 for the minimum number of lanes for each functional class of highway.

Change the basic number of lanes only for general changes in traffic volume over a substantial length of the route. The recommended location for a reduction in the basic number of lanes is on a tangent section between interchanges or intersections.

To accommodate high traffic volumes for short distances, such as between adjacent interchanges, use auxiliary lanes. When consecutive sections between interchanges require auxiliary lanes, consider increasing the basic number of lanes through the entire length.

(3) Auxiliary Lanes

Auxiliary lanes are added to the basic number of lanes to allow additional traffic movements on short segments. These added lanes are based primarily on volume-to-capacity relationships (Chapter 610).

To ensure efficient operation of auxiliary lanes see the following:

910	Left and right turn lanes and storage for turning
940	Weaving and auxiliary lanes associated with interchanges
1010	Truck climbing and passing lanes

620.07 Pavement Transitions

(1) Lane Transitions

(a) **For lane width changes** that create an angle point in an adjacent lane, the maximum angle is given in Figure 620-1. When a lane width change does not create an angle point in an adjacent lane, a 25:1 taper is sufficient.

(b) To **reduce the number of lanes**, a transition is required. The following guidelines apply:

- Locate transitions where decision sight distance exists, preferably on a tangent section and on the approach side of any crest vertical curve (except the end of climbing lanes which are transitioned in accordance with Chapter 1010).
- Supplement the transition with traffic control devices.
- Reduce the number of lanes by dropping only one at a time from the right side in the direction of travel. (When dropping a lane on the left side, an approved deviation is required.) See the MUTCD when more than one lane in a single direction must be dropped.

- Use the following formula to determine the minimum length of the lane transition for high speed conditions (45 mph or more):

  $L = VT$

  Where:

  L = length of transition (ft)
  V = design speed (mph)
  T = tangential offset width (ft)

- Use the following formula to determine the minimum length of the lane transition for low speed conditions (less than 45 mph):

  $$L = \frac{TV^2}{60}$$

  Where:

  L = length of transition (ft)
  V = design speed (mph)
  T = tangential offset width (ft)

(c) **To increase the number of lanes**, a tangential rate of change in the range of 1:4 to 1:15 is sufficient. Aesthetics are the main consideration.

(d) **For turning roadway** widening width transitions, see Chapter 641.

(2) Median Width Transitions

Whenever two abutting sections have different median widths, use long, smooth transitions (L = VT or flatter). When horizontal curves are present, this can be accomplished by providing the transition throughout the length of the curve. When required on a tangent section, the transition may be applied about the center line or on either side of the median based on whether or not the abutting existing section is programmed for the wider median in the future. To satisfy aesthetic requirements, make the transition length as long as feasible.

620.08 Procedures

When the project will realign the roadway, develop horizontal alignment plans for inclusion in the PS&E. Show the following as needed to maintain clarity and provide necessary information:

- Horizontal alignment details (tangent bearing, curve radius, and superelevation rate)
- Stationing
- Number of lanes
- Intersections, road approaches, railroad crossings, and interchanges (Chapters 910, 920, 930, and 940)
- Existing roadways and features affecting or affected by the project

See the *Plans Preparation Manual* for additional plan requirements.

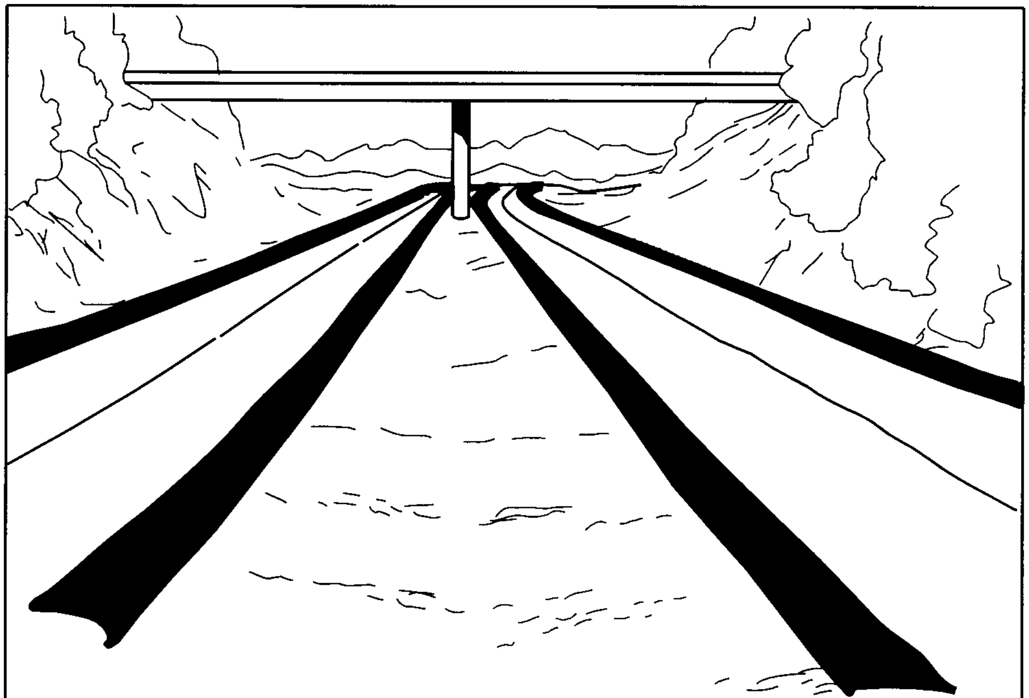
Justify any realignment of the roadway. Include the reasons for the realignment, profile considerations, alternatives considered, and the reasons the selected alignment was chosen.

When the project will change the number of lanes, include a capacity analysis supporting the number selected (Chapter 610) with the justification for the number of lanes.

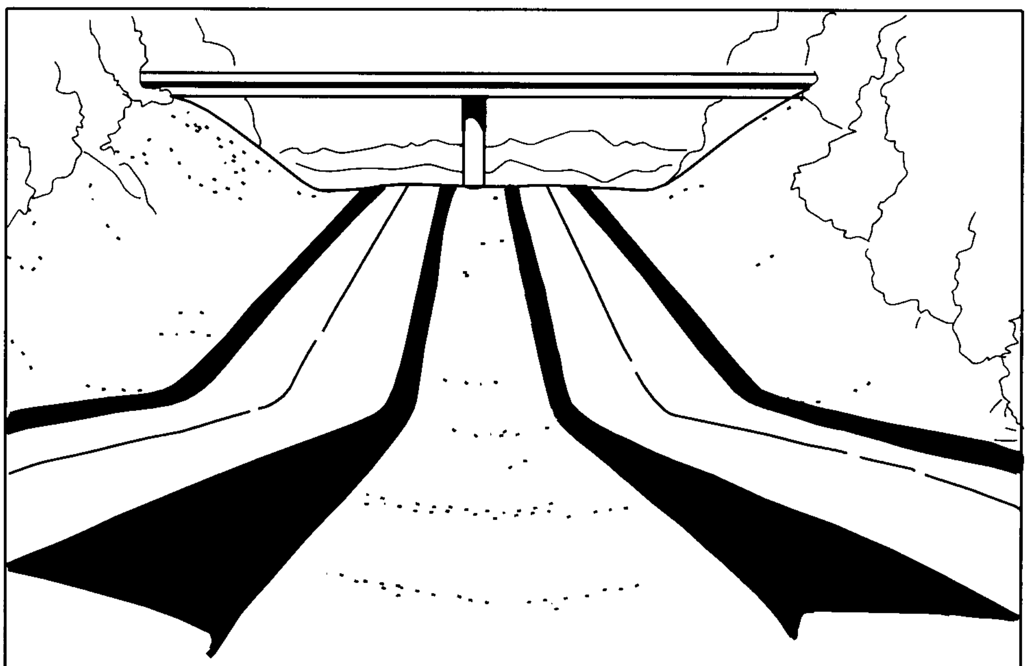
Include with the justification for a frontage road any traffic analyses performed, the social, environmental, and economic considerations, the options considered, and the reasons for the final decision.

620.09 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

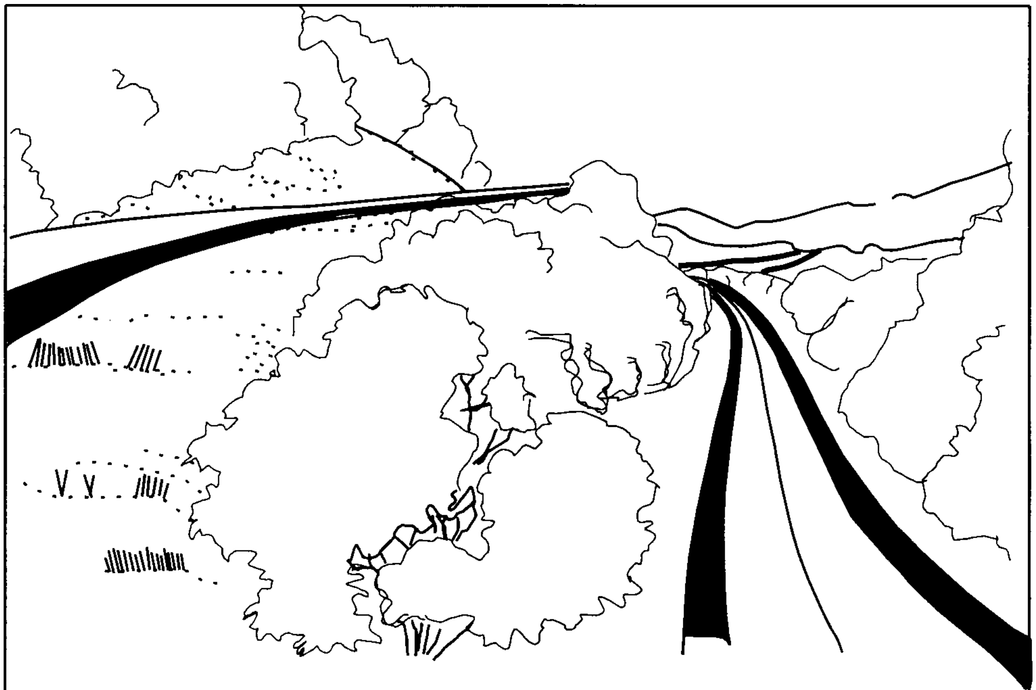


Desirable - Vertical Curves Lengthened

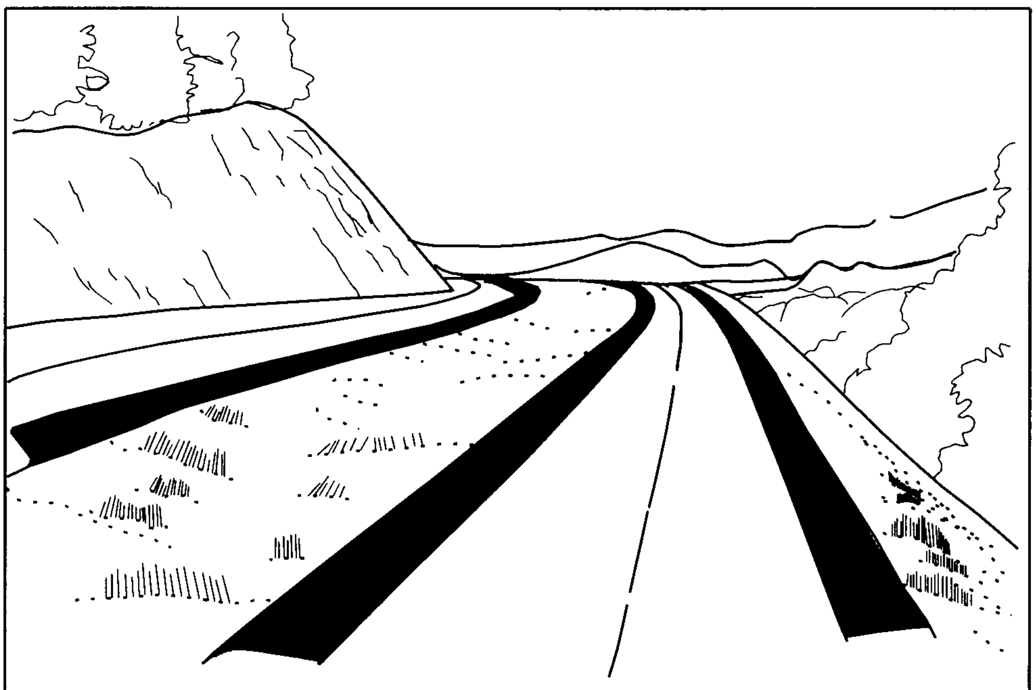


Undesirable - Minimum Vertical Curves Used

Alignment Examples
Figure 620-2a

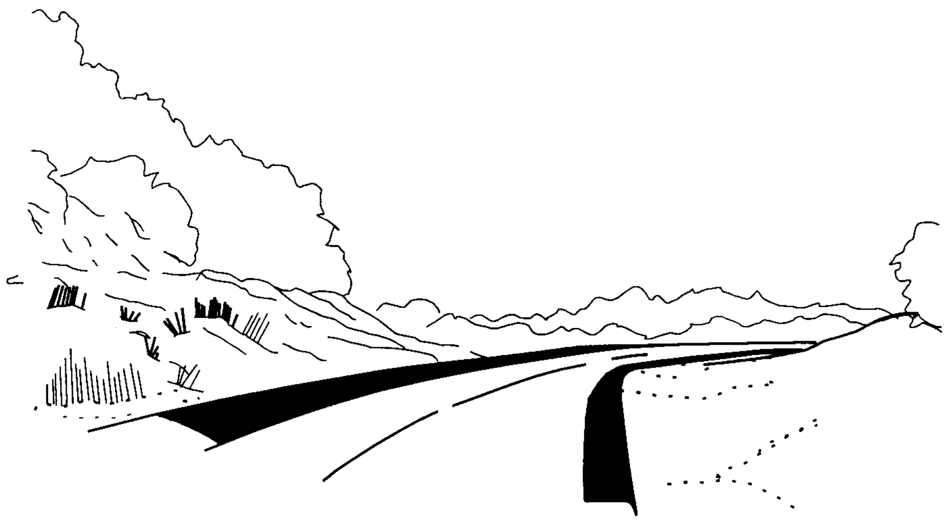


Desirable - Consistency with Topography

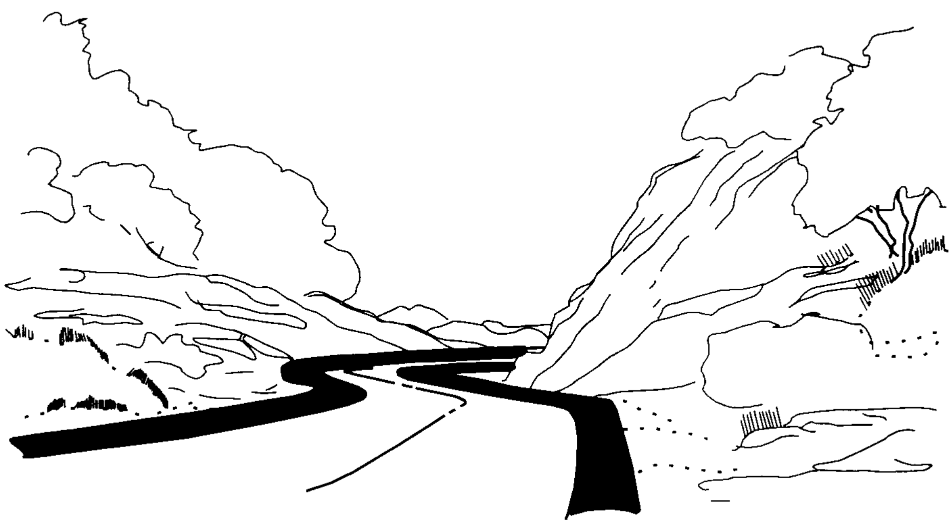


Undersirable - Heavy Cuts and Fills

Alignment Examples
Figure 620-2b



Desirable - Daylighting and a Simple Curve



Undesirable - Short Curve Reversals

Alignment Examples
Figure 620-2c

630.01 General

Vertical alignment (roadway profile) consists of a series of gradients connected by vertical curves. It is mainly controlled by:

- Topography
- Class of highway
- Horizontal alignment
- Safety
- Sight distance
- Construction costs
- Drainage
- Adjacent land use
- Vehicular characteristics
- Aesthetics

This chapter provides guidance for the design of vertical alignment. See the following chapters for additional information:

Chapter	Subject
440	Maximum grade for each functional class
620	Horizontal alignment
650	Sight distance
910	Grades at intersections
940	Maximum grade for ramps

630.02 References

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

Plans Preparation Manual, M 22-31, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Local Agency Guidelines (LAG), M 36-63, WSDOT

A Policy on Geometric Design of Highways and Streets, (Green Book), 2001, AASHTO

630.03 Vertical Alignment

(1) Design Controls

The following are general controls for developing vertical alignment (also see Figures 630-2a through 2c):

- Use a smooth grade line with gradual changes, consistent with the class of highway and character of terrain. Avoid numerous breaks and short grades.
- Avoid "roller coaster" or "hidden dip" profiles by use of gradual grades made possible by heavier cuts and fills or by introducing some horizontal curvature in conjunction with the vertical curvature.
- Avoid grades that will affect truck speeds and, therefore, traffic operations.
- Avoid broken back grade lines with short tangents between two vertical curves.
- Use long vertical curves to flatten grades near the top of long steep grades.
- Where at-grade intersections occur on roadways with moderate to steep grades, it is desirable to flatten or reduce the grade through the intersection.

- Establish the subgrade at least 1 ft above the high water table (real or potential) or as recommended by the region Materials Engineer. Consider the low side of superelevated roadways.
- When a vertical curve takes place partly or wholly in a horizontal curve, coordinate the two as discussed in 630.04.

(2) Minimum Length of Vertical Curves

The minimum length of a vertical curve is controlled by design speed, the requirements for stopping sight distance, and the change in grade. Make the length of a vertical curve, in feet, not less than three times the design speed, in miles per hour. See Chapter 650 to design vertical curves to meet stopping sight distance requirements. For aesthetics, the desirable length of a vertical curve is two to three times the length required for stopping sight distance.

Sag vertical curves may have a length less than required for stopping sight distance when all three of the following are provided:

- An evaluate upgrade to justify the length reduction.
- Continuous illumination.
- Design for the comfort of the vehicle occupants. For comfort use:

$$L = \frac{AV^2}{46.5}$$

where: L = Curve length ft
A = Change in grade %
V = Design speed mph

The sag vertical curve lengths designed for comfort are about 50% of those required for sight distance.

(3) Maximum Grades

Analyze grades for their effect on traffic operation because they may result in undesirable truck speeds. Maximum grades are controlled by functional class of the highway, terrain type, and design speed (Chapters 440 and 940).

(4) Minimum Grades

Minimum grades are used to meet drainage requirements. Avoid selecting a "roller coaster" or "hidden dip" profile merely to accommodate drainage.

Minimum ditch gradients of 0.3% on paved materials and 0.5% on earth can be obtained independently of roadway grade. Medians, long sag vertical curves, and relatively flat terrain are examples of areas where independent ditch design may be justified. A closed drainage system may be needed as part of an independent ditch design.

(5) Length of Grade

The desirable maximum length of grade is the maximum length on an upgrade at which a loaded truck will operate without a 10 mph reduction. Figure 630-1 gives the desirable maximum length for a given percent of grade. When grades longer than the desirable maximum are unavoidable, consider an auxiliary climbing lane (Chapter 1010). For grades that are not at a constant percent, use the average.

When long steep downgrades are unavoidable, consider an emergency escape ramp (Chapter 1010).

(6) Alignment on Structures

Where practical, avoid high skew, vertical curvature, horizontal curvature, and superelevation on structures, but do not sacrifice safe roadway alignment to achieve this.

630.04 Coordination of Vertical and Horizontal Alignments

Do not design horizontal and vertical alignment independently. Coordinate them to obtain safety, uniform speed, pleasing appearance, and efficient traffic operation. Coordination can be achieved by plotting the location of the horizontal curves on the working profile to help visualize the highway in three dimensions. Perspective plots will also give a view of the proposed alignment. Figures 630-2a and 2b show sketches of desirable and undesirable coordination of horizontal and vertical alignment.

Guides for the coordination of the vertical and horizontal alignment are as follows:

- Balance curvature and grades. Using steep grades to achieve long tangents and flat curves, or excessive curvature to achieve flat grades, are both poor designs.
- Vertical curvature superimposed on horizontal curvature generally results in a more pleasing facility. Successive changes in profile not in combination with horizontal curvature may result in a series of dips not visible to the driver.
- Do not begin or end a horizontal curve at or near the top of a crest vertical curve. This condition can be unsafe, especially at night, if the driver does not recognize the beginning or ending of the horizontal curve. Safety is improved if the horizontal curve leads the vertical curve, that is, the horizontal curve is made longer than the vertical curve in both directions.
- To maintain drainage, design vertical and horizontal curves so that the flat profile of a vertical curve will not be located near the flat cross slope of the superelevation transition.
- Do not introduce a sharp horizontal curve at or near the low point of a pronounced sag vertical curve. The road ahead is foreshortened and any horizontal curve that is not flat assumes an undesirably distorted appearance. Further, vehicular speeds, particularly of trucks, often are high at the bottom of grades and erratic operation may result, especially at night.
- On two-lane roads, the need for safe passing sections (at frequent intervals and for an appreciable percentage of the length of the roadway) often supersedes the general desirability for combination of horizontal and vertical alignment. Work toward long tangent sections to secure sufficient passing sight distance.

For grades longer than indicated, consider an auxiliary climbing lane (Chapter 1010).

Grade Length
Figure 630-1

- On divided highways, consider variation in width of median and the use of independent alignments to derive the design and operational advantages of one-way roadways.
- Make horizontal curvature and profile as flat as feasible at intersections where sight distance along both roads is important and vehicles may have to slow or stop.
- In residential areas, design the alignment to minimize nuisance factors to the neighborhood. Generally, a depressed facility makes a highway less visible and less noisy to adjacent residents. Minor horizontal adjustments can sometimes be made to increase the buffer zone between the highway and clusters of homes.
- Design the alignment to enhance attractive scenic views of the natural and manmade environment, such as rivers, rock formations, parks, and outstanding buildings.

When superelevation transition within the limits of a vertical curve is necessary, plot profiles of the edges of pavement to ensure smooth transitions.

630.05 Airport Clearance

For proposed highway construction or alteration in the vicinity of a public or military airport, early contact by the region with the airport authorities is required so that advance planning and design work can proceed within the required FAA regulations (Chapter 240).

630.06 Railroad Crossings

When a highway crosses a railroad at grade, design the highway grade so that a low-hung vehicle will not damage the rails or get hung up on the tracks. Figure 630-3 gives guidance on designing highway grades at railroad crossings. For more information on railroad-highway crossings, see Chapter 930.

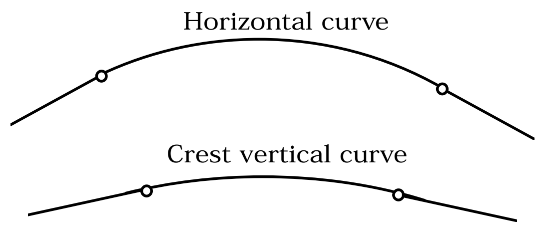
630.07 Procedures

When the project will modify the vertical alignment, develop vertical alignment plans for inclusion in the PS&E to a scale suitable for showing vertical alignment for all proposed roadways including ground line, grades, vertical curves, and superelevation. See the *Plans Preparation Manual* for additional requirements.

When justifying any modification to the vertical alignment, include the reasons for the change, alternatives considered (if any) and why the selected alternative was chosen. When the profile is a result of new horizontal alignment, consider vertical and horizontal alignments together and document the profile with the horizontal alignment justification.

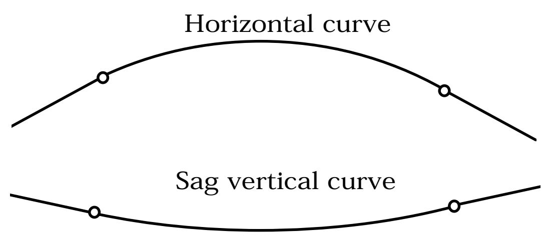
630.08 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http//www.wsdot.wa.gov/eesc/design/projectdev/



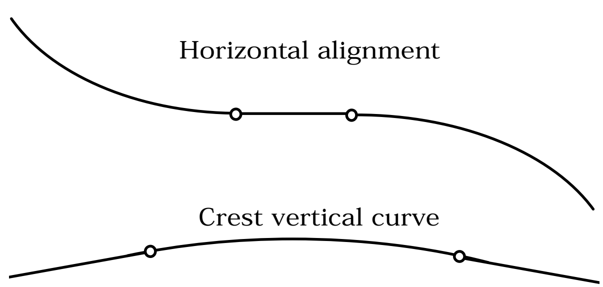
Coinciding Horizontal and Crest Vertical Curves.

When horizontal and crest vertical curves coincide, a satisfactory appearance results.



Coinciding Horizontal and Sag Vertical Curves

When horizontal and sag vertical curves coincide, a satisfactory appearance results.



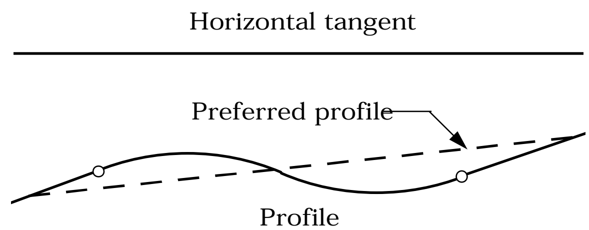
Short Tangent on a Crest Between Two Horizontal Curves

This combination is deficient for several reasons:

- The curve reversal is on a crest making the second curve less visible.
- The tangent is too short for the superelevation transition.
- The flat area of the superelevation transition will be near the flat grade in the crest.

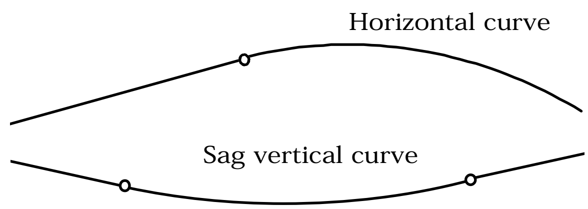
Coordination of Horizontal and Vertical Alignments

Figure 630-2a



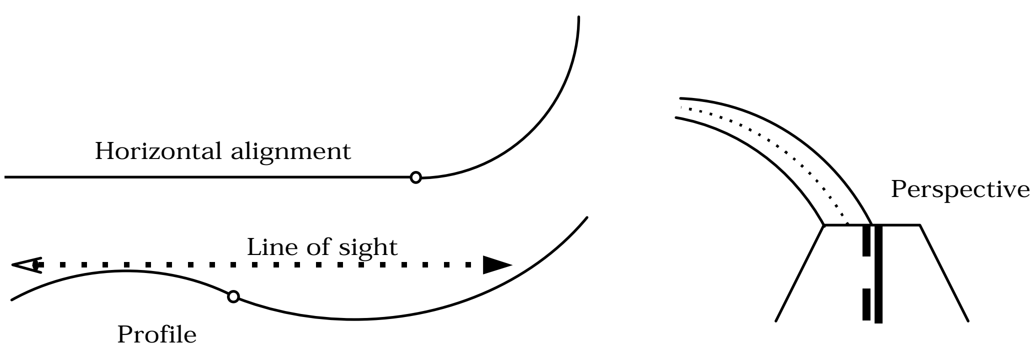
Profile with Tangent Alignment

Avoid designing dips on an otherwise long uniform grade.



Sharp Angle Appearance

This combination presents a poor appearance. The horizontal curve looks like a sharp angle.

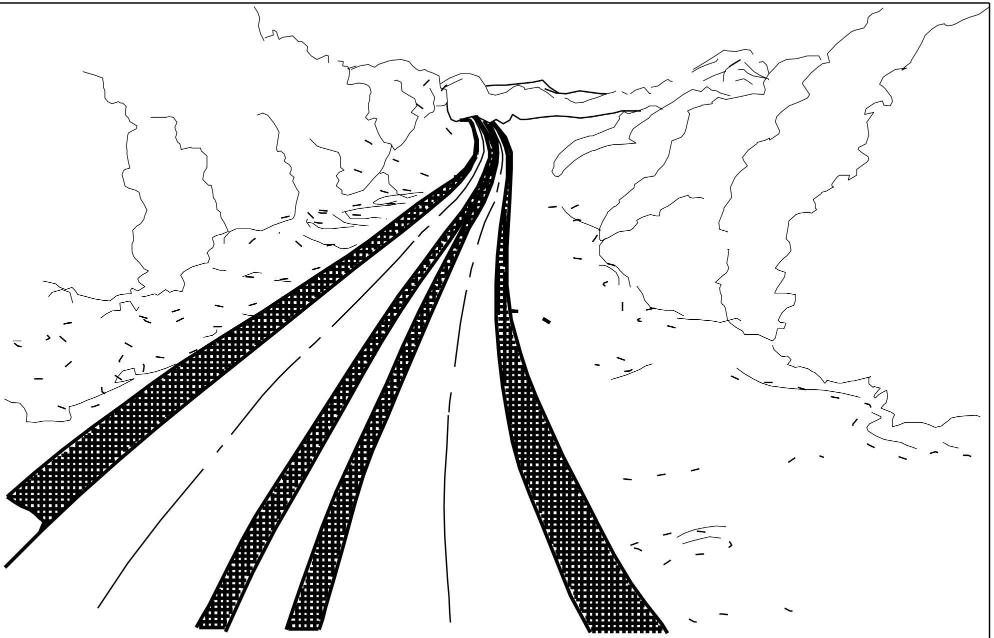


Disjointed Effect

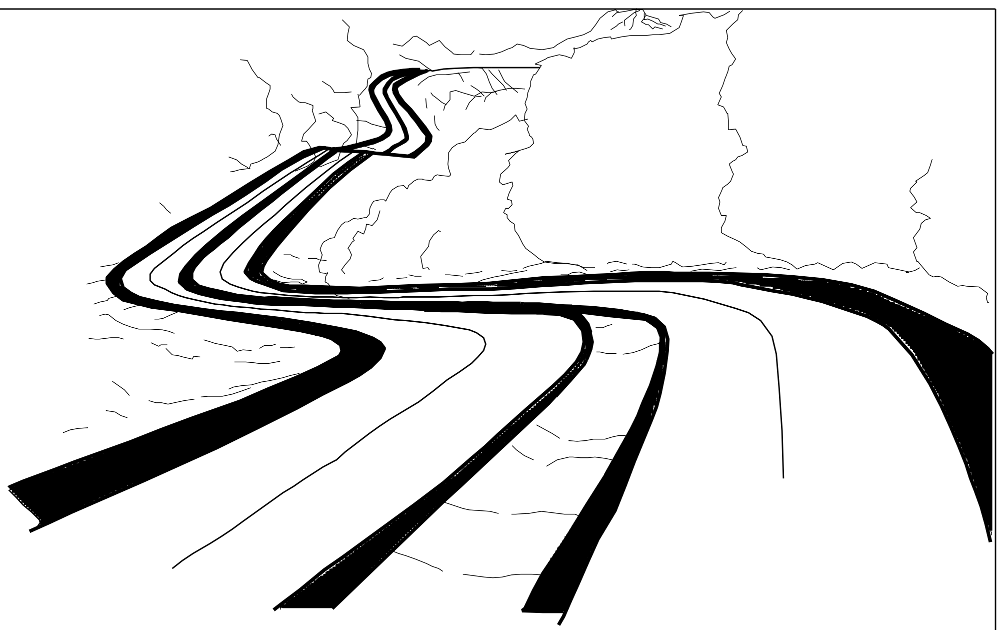
A disjointed effect occurs when the beginning of a horizontal curve is hidden by an intervening crest while the continuation of the curve is visible in the distance beyond the intervening crest.

Coordination of Horizontal and Vertical Alignments

Figure 630-2b

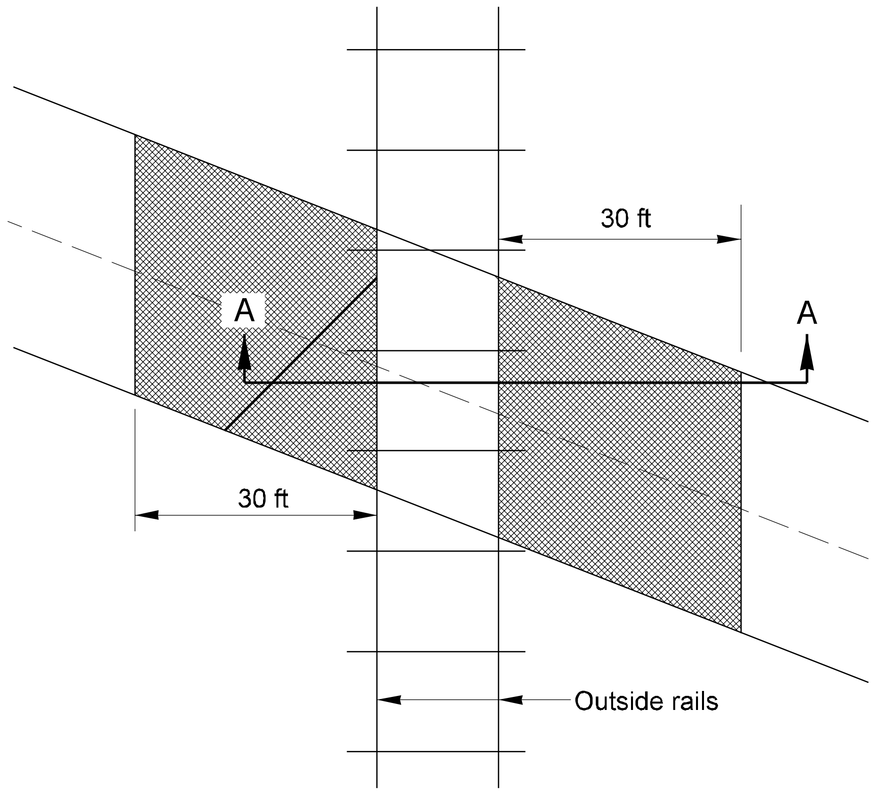


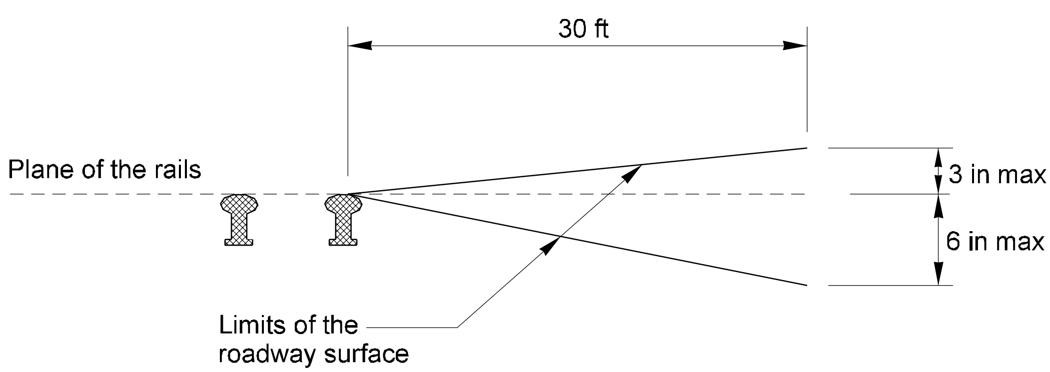
Desirable Coordination of Vertical and Horizontal
Curves and the Use of Flowing Alignment



Undesirable - Vertical and Horizontal Curves
Not Coordinated and Using Minimums

Coordination of Horizontal and Vertical Alignments
Figure 630-2c





Detail A-A

Grading at Railroad Crossings
Figure 630-3

640.01 General

Geometric cross sections for state highways are governed by functional classification criteria, traffic volume, and whether the highway is in a rural or an urban area. (See Chapter 440 for information on functional class.)

High Occupancy Vehicle (HOV) lanes must be considered when continuous through lanes are to be added within the limits of an urban area with a population over 200,000. (See Chapter 1050.)

When a state highway within an incorporated city or town is a portion of a city street, the design features must be developed in cooperation with the local agency. (See Chapter 440 for guidance on geometric design data when a state highway within an incorporated city or town is a portion of a city street.)

For additional information, see the following chapters:

Chapter	Subject
430	Roadway widths and cross slopes for modified design level
440	Minimum lane and shoulder widths for full design level
440	Shoulder widths at curbs
510	Geotechnical investigation
520	Pavement type
641	Turning roadway width
642	Superelevation
910	Requirements for islands
940	Lane and shoulder widths for ramps
960	Median crossovers

640.02 References

Design Guidance

Highway Runoff Manual, M 31-16, WSDOT

Local Agency Guidelines (LAG), M 36-63, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

640.03 Definitions

auxiliary lane The portion of the roadway adjoining the through lanes for parking, speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through-traffic movement.

divided multilane A roadway with two or more through lanes in each direction and a median that physically or legally prohibits left turns, except at designated locations.

freeway A divided highway that has a minimum of two lanes in each direction, for the exclusive use of traffic, and with full control of access.

high pavement type Portland cement concrete pavement or hot mix asphalt (HMA) pavement on a treated base.

intermediate pavement type Hot mix asphalt pavement on an untreated base.

lane A strip of roadway used for a single line of vehicles.

lane width The lateral design width for a single lane, striped as shown in the Standard Plans and the Standard Specifications.

low pavement type Bituminous surface treatment (BST).

median The portion of a highway separating the traveled ways for traffic in opposite directions.

outer separation The area between the outside edge of the traveled way for through traffic and the nearest edge of the traveled way of a frontage road or a collector-distributor road.

roadway The portion of a highway, including shoulders, for vehicular use.

rural design area An area that meets none of the conditions to be an urban design area.

shoulder The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and use by pedestrians.

shoulder width The lateral width of the shoulder, measured from the outside edge of the outside lane to the edge of the roadway.

superelevation The rotation of the roadway cross section in such a manner as to overcome part of the centrifugal force that acts on a vehicle traversing a curve.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

turning roadway A curve on an open highway, a ramp, or the connecting portion of the roadway between two intersecting legs of an intersection.

undivided multilane A roadway with two or more through lanes in each direction on which left turns are not controlled.

urban area An area designated by the Washington State Department of Transportation (WSDOT) in cooperation with the Transportation Improvement Board and regional transportation planning organizations, subject to the approval of the FHWA.

urban design area An area where urban design criteria is appropriate, that is defined by one or more of the following:

- An urban area.
- An area within the limits of an incorporated city or town.
- An area characterized by intensive use of the land for the location of structures, that receives such urban services as sewer, water, and other public utilities, as well as services normally associated with an incorporated city or town. This may include an urban growth area defined under the Growth Management Act (see Chapter 36.70A RCW, Growth management – planning by selected counties and cities), but outside the city limits.
- An area with not more than 25% undeveloped land.

640.04 Roadways

The cross sections shown in Figures 640-1, 2, 3, 4a, and 4b represent minimum values for full design level. (See Chapter 440 for additional design information for full design level and Chapter 430 for cross sections and design information for modified design level.)

(1) Traveled Way Cross Slope

The cross slope on tangents and curves is a main element in roadway design. The cross slope or crown on tangent sections and large radius curves is complicated by two contradicting controls. Reasonably steep cross slopes are desirable to aid in water runoff and to minimize ponding as a result of pavement imperfections and unequal settlement. However, steep cross slopes are undesirable on tangents because of the tendency for vehicles to drift to the low side of the roadway. Steeper cross slopes are noticeable in steering, and they increase susceptibility to sliding to the side on icy or wet pavements.

A 2% cross slope is normally used for tangents and large radius curves on high and intermediate pavement types. With justification and a hydraulic analysis, cross slopes between 1.5% and 2.5% are acceptable. Do not design cross slopes flatter than 1.5%.

On low pavement types, the cross slope may be increased to 3% to allow for reduced construction control and greater settlement.

Superelevation on curves is a function of the design speed and the radius of the curve. (See Chapter 642 for guidance on superelevation design.)

(2) Turning Roadways

The roadway on a curve may need to be widened to make the operating conditions comparable to those on tangents. There are two main reasons to do this. One is the offtracking of vehicles, such as trucks and buses. The other is the increased difficulty drivers have in keeping their vehicles in the center of the lane. (See Chapter 641 for width requirements on turning roadways.)

To maintain the desired design speed, highway and ramp curves are usually superelevated to overcome part of the centrifugal force that acts on a vehicle. (See Chapter 642 for superelevation requirements.)

(3) Shoulders

Pave the shoulders of all highways where high or intermediate pavement types are used. Where low pavement type is used, treat the roadway full width.

Shoulder cross slopes are normally the same as the cross slopes for adjacent lanes. With justification, shoulder slopes may be increased to 6%. On the high side of a roadway with a plane section, such as a turning roadway in superelevation, the shoulder may slope in the opposite direction from the adjacent lane. The maximum difference in slopes between the lane and the shoulder is 8%. Examples of locations where it may be desirable to have a shoulder slope different than the adjacent lane are:

- Where curbing is used.
- Where shoulder surface is bituminous, gravel, or crushed rock.
- Where overlays are planned and it is desirable to maintain the grade at the edge of the shoulder.
- On divided highways with depressed medians where it is desirable to drain the runoff into the median.
- On the high side of the superelevation on curves where it is desirable to drain stormwater or meltwater away from the roadway.

When extruded curb is used, see the Standard Plans for required widening. Widening is normally required when traffic barrier is installed. (See Chapter 710.)

It is preferred that curb not be used on high-speed facilities (design speed above 45 miles per hour). In some areas, curb may be needed to control runoff water until ground cover is attained to prevent erosion. Plan for the removal of the curb when the ground cover becomes adequate. Arrange for curb removal with regional maintenance as part of the future maintenance plans. When curb is used in conjunction with guardrail, see Chapter 710 for guidance.

Figures 640-5a and 5b represent shoulder details and requirements.

640.05 Medians and Outer Separations

(1) Purpose

The main function of a median is to separate opposing traffic lanes. The main function of an outer separation is to separate the main roadway from a frontage road. Medians and outer separations also provide space for:

- Drainage facilities.
- Undercrossing bridge piers.
- Vehicle storage space for crossing and left-turn movements at intersections.
- Headlight glare screens, including planted or natural foliage.
- Visual separation of opposing traffic.
- Safety refuge areas for errant or disabled vehicles.
- Storage space for snow and water from traffic lanes.
- Increased safety, comfort, and ease of operations.
- Access control.
- Enforcement.

(2) Design

Figures 640-6a through 6c give minimum design requirements for medians. (See Chapters 430 and 440 for minimum median widths.) Median widths in excess of the minimums are highly desirable. When the horizontal and vertical alignments of the two roadways of a divided highway are independent of one another, determine median side slopes in conformance with Figure 640-1. Independent horizontal and vertical alignment, rather than parallel alignment, is desirable.

No attempt has been made to cover all the various grading techniques that are possible on wide, variable-width medians. Considerable latitude in treatment is intended, provided the requirements of minimum geometrics, safety, and aesthetics are met or exceeded. Unnecessary clearing, grubbing, and grading are undesirable within wide medians. Give preference to selective thinning and limited reshaping of the natural ground. For median clear zone requirements, see Chapter 700, and for slopes into the face of traffic barriers, see Chapter 710.

In areas where land is expensive, make an economic comparison of wide medians to narrow medians with their barrier requirements. Consider right of way, construction, maintenance, and accident costs. The widths of medians need not be uniform. Make the transition between median widths as long as feasible. (See Chapter 620 for minimum taper lengths.)

When using concrete barriers in depressed medians or on curves, provide for surface drainage on both sides of the barrier. The transverse notches in the base of precast concrete barrier are not intended to be used as a drainage feature, but rather as pick-up points when placing the sections.

640.06 Roadsides

(1) Side Slopes

When designing side slopes, fit the slope selected for any cut or fill into the existing terrain to give a smooth transitional blend from the construction to the existing landscape. Slopes flatter than recommended are desirable, especially within the Design Clear Zone. Slopes not steeper than 4H:1V, with smooth transitions where the slope changes, will provide a reasonable opportunity to recover control of an errant vehicle. Where mowing is contemplated, slopes must not be steeper than 3H:1V. If there will be continuous traffic barrier on a fill slope, and mowing is not contemplated, the slope may be steeper than 3H:1V.

Where unusual geological features or soil conditions exist, treatment of the slopes will depend upon results of a review of the location by the region's Materials Engineer.

With justification, fill slopes steeper than shown in the Fill and Ditch Slope Selection tables in Figures 640-1, 2, 3, and 4b may be used when traffic barrier is installed. Do not install traffic barrier unless a hazard requiring mitigation is present. The steepest slope is determined by the soil conditions. Where favorable soil conditions exist, higher fill slopes may be as steep as 1½H:1V. (See Chapter 700 for clear zone and barrier requirements.)

The Cut Slope Selection tables in Figures 640-1, 2, 3, and 4b are for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable cut slopes just to meet the slopes given in the Cut Slope Selection tables. When an existing slope is to be revised, document the reason for the change.

If borrow is required, consider obtaining it by flattening cut slopes uniformly on one or both sides of the highway. Where considering wasting excess material on an existing embankment slope, consult the region's Materials Engineer to verify that the foundation soil will support the additional material.

In all cases, provide for adequate drainage from the roadway surface and adequate drainage in ditches. (See 640.06(4) for drainage ditches in embankment areas details.)

At locations where vegetated filter areas or detention facilities will be established to improve highway runoff water quality, provide appropriate slope, space, and soil conditions for that purpose. (See the *Highway Runoff Manual* for design criteria and additional guidance.)

Except under guardrail installations, it is desirable to plant and establish low-growing vegetation on all nonpaved roadsides. This type of treatment relies on the placement of a lift of compost or topsoil over base course material in the roadway cross section. Consult with the Area Maintenance Superintendent and the region's Landscape Architect to determine the appropriate configuration of the roadway cross section and soil and plant specifications.

Slope treatment, as shown in the Standard Plans, is required at the top of all roadway cut slopes, except for cuts in solid rock. Unless Class B slope treatment is called for, Class A slope treatment is used. Call for Class B slope treatment where space is limited, such as where right of way is restricted.

(2) Roadway Sections in Rock Cuts

Typical sections for rock cuts, illustrated in Figures 640-7a and 7b, are guides for the design and construction of roadways through rock cuts. Changes in slope or fallout area are recommended when justified. Base the selection of the appropriate sections on an engineering study and the recommendations of the region's Materials Engineer and Landscape Architect. Headquarters (HQ) Materials Lab concurrence is required.

There are two basic design treatments applicable to rock excavation (see Figures 640-7a and 7b). Design A applies to most rock cuts. Design B is a talus slope treatment.

(a) **Design A.** This design is shown in stage development to aid the designer in selecting an appropriate section for site conditions in regard to backslope, probable rockfall, hardness of rock, and so on.

The following guidelines apply to the various stages shown in Figure 640-7a:

- Stage 1 is used where the anticipated quantity of rockfall is small, adequate fallout width can be provided, and the rock slope is ½H:1V or steeper. Controlled blasting is recommended in conjunction with Stage 1 construction.
- Stage 2 is used when a "rocks in the road" problem exists or is anticipated. Consider it on flat slopes where rocks are apt to roll rather than fall.
- Stage 3 represents the full implementation of all protection and safety measures applicable to rock control. Use it only when extreme rockfall conditions exist.

  Show Stage 3 as the ultimate stage for future construction on the Plans, Specifications, and Estimates (PS&E) if there is any possibility that it will be needed.

The use of Stage 2 or 3 alternatives (concrete barrier) is based on the designer's analysis of the particular site. Considerations include maintenance, size and amount of rockfall, probable velocities, availability of materials, ditch capacity, adjacent traffic volumes, distance from traveled lane, and impact severity. Incorporate removable sections in the barrier at approximately 200-foot intervals. Appropriate terminal treatment is required. (See Chapter 710.)

Occasionally the existing ground above the top of the cut is on a slope approximating the design cut slope. The height (H) is to include the existing slope or that portion that can logically be considered part of the cut. The cut slope selected for a project must be that required to effect stability of the existing material.

Benches may be used to increase slope stability; however, the use of benches may alter the design requirements for the sections given in Figure 640-7a.

The necessity for benches, as well as their width and vertical spacing, is established only after an evaluation of slope stability. Make benches at least 20 feet wide. Provide access for maintenance equipment to the lowest bench, and to the higher benches if feasible. Greater traffic benefits in the form of added safety, increased horizontal sight distance on curves, and other desirable attributes may be realized from widening a cut rather than benching.

(b) **Design B**. A talus slope treatment is shown in Figure 640-7b. The rock protection fence is placed at any one of the three positions shown, but not in more than one position at a particular location. The exact placement of the rock protection fence in talus slope areas requires considerable judgment and should be determined only after consultation with the region's Materials Engineer.

- **Fence position a** is used when the cliff generates boulders less than 0.25 yd^3 in size, and the length of the slope is greater than 350 feet.
- **Fence position b** is the preferred location for most applications.

- **Fence position c** is used when the cliff generates boulders greater than 0.25 yd^3 in size, regardless of the length of the slope. On short slopes, this may require placing the fence less than 100 feet from the base of the cliff.
- Use of gabions may be considered instead of the rock protection shown in fence position a. However, gabion treatment is considered similar to a wall and therefore requires appropriate face and end protection for safety. (See Chapters 710 and 1130.)

Use of the alternate shoulder barrier is based on the designer's analysis of the particular site. Considerations similar to those given for Design A alternatives apply.

Rock protection treatments other than those described above may be required for cut slopes that have relatively uniform spalling surfaces (consult with the region's Materials Engineer).

(3) Stepped Slopes

Stepped slopes are a construction method intended to promote early establishment of vegetative cover on the slopes. They consist of a series of small horizontal steps or terraces on the face of the cut slope. Soil conditions dictate the feasibility and necessity of stepped slopes. They are to be considered only on the recommendation of the region's Materials Engineer. (See Chapter 510.) Consult the region's landscape personnel for appropriate design and vegetative materials to be used. (See Figure 640-8 for stepped slope design details.)

(4) Drainage Ditches in Embankment Areas

Where it is necessary to locate a drainage ditch adjacent to the toe of a roadway embankment, consider the stability of the embankment. A drainage ditch placed immediately adjacent to the toe of an embankment slope has the effect of increasing the height of the embankment by the depth of the ditch. In cases where the foundation soil is weak, the extra height could result in an embankment failure. As a general rule, the weaker the foundation and the higher the embankment, the farther the ditch should be from the embankment. Consult the region's Materials Engineer for the proper ditch location.

When topographic restrictions exist, consider an enclosed drainage system with appropriate inlets and outlets. Do not steepen slopes to provide lateral clearance from toe of slope to ditch location, thereby necessitating traffic barriers or other protective devices.

Maintenance operations are also facilitated by adequate width between the toe of the slope and an adjacent drainage ditch. Where this type of facility is anticipated, provide sufficient right of way for access to the facility and place the drainage ditch near the right of way line.

Provide for disposition of the drainage collected by ditches in regard to siltation of adjacent property, embankment erosion, and other undesirable effects. This may also apply to top of cut slope ditches.

(5) Bridge End Slopes

Bridge end slopes are determined by several factors, including location, fill height, depth of cut, soil stability, and horizontal and vertical alignment. Close coordination between the HQ Bridge and Structures Office and the region is necessary to ensure proper slope treatment. (See Chapter 1120.)

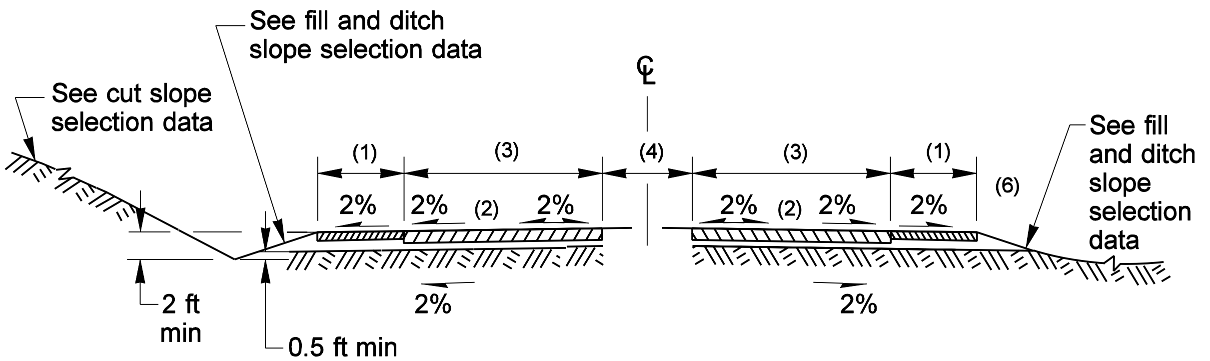
Early in the bridge plan development, determine preliminary bridge geometrics, end slope rates, and toe of slope treatments. Figure 640-9a provides guidelines for use of slope rates and toe of slope treatments for overcrossings. Figure 640-9b shows toe of slope treatments to be used on the various toe conditions.

640.07 Roadway Sections

Provide a typical roadway section for inclusion in the PS&E for each general type used on the main roadway, ramps, detours, and frontage or other roads. (See the *Plans Preparation Manual* for requirements.)

640.08 Documentation

A list of the documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/



Design Class I-1, P-1, P-2, M-1, $U_{M/A}$-1, $U_{M/A}$-2

Height of fill/depth of ditch (ft)	Slope not steeper than (5)
10	6H:1V
10 – 20	4H:1V
20 – 30	3H:1V (6)
over 30	2H:1V (6)(8)

Fill and Ditch Slope Selection

Height of cut (ft)*	Slope not steeper than
0 – 5	6H:1V
5 – 20	3H:1V
over 20	2H:1V (7)
* From bottom of ditch	

Cut Slope Selection (9)

Notes:

(1) For shoulder details, see Figures 640-5a and 5b. For minimum shoulder width, see Chapters 430 and 440.

(2) Generally, the crown slope will be as follows:
- Four-lane highway – Slope all lanes away from the median (plane section).
- Six-lane highway – Slope all lanes away from the median unless high rainfall intensities would indicate otherwise.
- Eight-lane highway – Slope two of the four directional lanes to the right and two to the left unless low rainfall intensities indicate that all four lanes could be sloped away from the median.

(3) For minimum number and width of lanes, see Chapters 430 and 440. For turning roadway width, see Chapter 641.

(4) For median details, see Figures 640-6a through 6c. For minimum median width, see Chapters 430 and 440.

(5) Where practicable, consider flatter slopes for the greater fill heights and ditch depths.

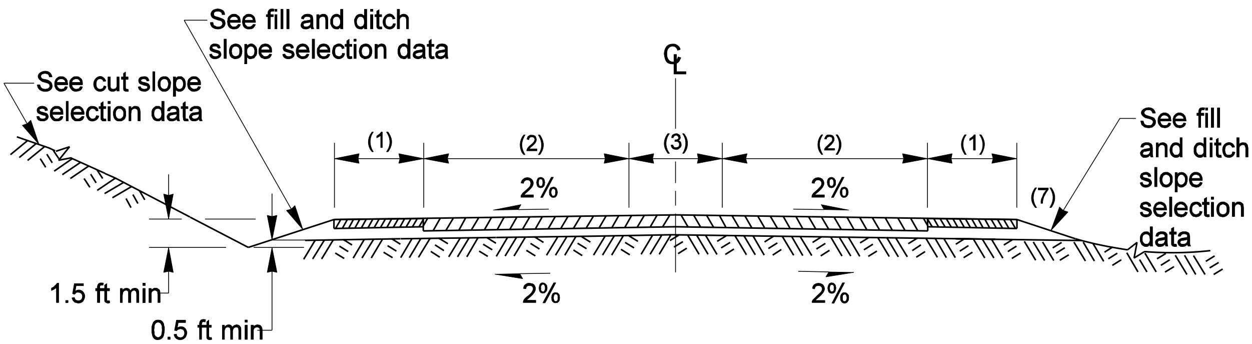
(6) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640-5b.

(7) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. (See Chapter 700 for clear zone and barrier requirements.)

(8) Fill slopes as steep as 1½H:1V may be used where favorable soil conditions exist. (See Chapter 700 for clear zone and barrier requirements.)

(9) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

Divided Highway Roadway Sections
Figure 640-1



Design Class P-6, M-5, C-1, $U_{M/A}$-3, $U_{M/A}$-4

Height of fill/depth of ditch (ft)	Slope not steeper than (4)
0 – 5	6H:1V
5 – 20	4H:1V
20 – 30	3H:1V (7)
over 30	2H:1V (6)(7)

Fill and Ditch Slope Selection

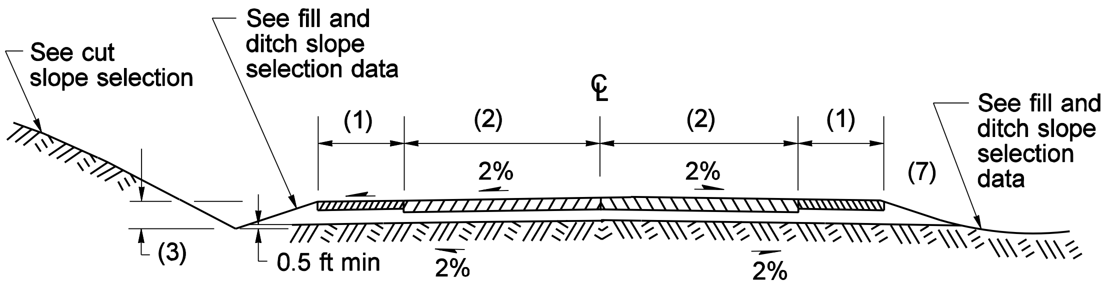
Height of cut (ft)*	Slope not steeper than
0 – 5	4H:1V
over 5	2H:1V (5)
* From bottom of ditch	

Cut Slope Selection (8)

Notes:

(1) For shoulder details, see Figures 640-5a and 5b. For minimum shoulder width, see Chapters 430 and 440.
(2) For minimum number and width of lanes, see Chapters 430 and 440. For turning roadway width, see Chapter 641.
(3) For minimum median width, see Chapters 430 and 440. For width when median is a two-way left-turn lane, see Chapter 910.
(4) Where practicable, consider flatter slopes for the greater fill heights and ditch depths.
(5) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. (See Chapter 700 for clear zone and barrier requirements.)
(6) Fill slopes up to 1½H:1V may be used where favorable soil conditions exist. (See Chapter 700 for clear zone and barrier requirements.)
(7) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640-5b.
(8) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

Undivided Multilane Highway Roadway Sections
Figure 640-2



Design Class P-3, P-4, P-5. M-2, M-3, M-4, C-2, C-3, C-4, $U_{M/A}$-^{5}, $U_{M/A}$-^{6}

Design Class of highway	P-3, P-4, M-2, C-2, $U_{M/A}{}^5$	P-5, M-3, M-4, C-3, C-4, $U_{M/A}{}^6$
Height of fill/ depth of ditch (ft)	Slope not steeper than (4)	
0 – 10	6H:1V	4H:1V
10 – 20	4H:1V	4H:1V
20 – 30	3H:1V (7)	3H:1V (7)
over 30	2H:1V (5)(7)	2H:1V (5)(7)

Fill and Ditch Slope Selection

Design Class of highway	P-3, P-4, M-2, C-2, $U_{M/A}{}^5$	P-5, M-3, M-4, C-3, C-4, $U_{M/A}{}^6$
Height of cut (ft)*	Slope not steeper than	
0 – 5	6H:1V	4H:1V
5 – 20	3H:1V	2H:1V (6)
over 20	2H:1V (6)	2H:1V (6)
* From bottom of ditch		

Cut Slope Selection (8)

Notes:

(1) For shoulder details, see Figures 640-5a and 5b. For minimum shoulder width, see Chapters 430 and 440.

(2) For minimum width of lanes, see Chapters 430 and 440. For turning roadway width, see Chapter 641.

(3) The minimum ditch depth is 2 feet for Design Class P3 and 1.5 feet for Design Classes P-4, P-5, M-2, M-3, M-4, C-2, C-3, C-4, UM/A-5, and UM/A-6.

(4) Where practicable, consider flatter slopes for the greater fill heights.

(5) Fill slopes up to 1½H:1V may be used where favorable soil conditions exist. (See Chapter 700 for clear zone and barrier requirements.)

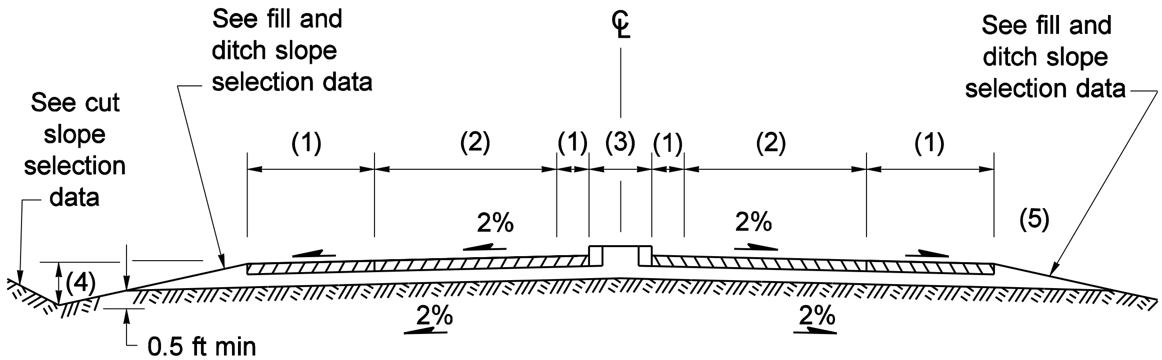
(6) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. (See Chapter 700 for clear zone and barrier requirements.)

(7) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640-5b.

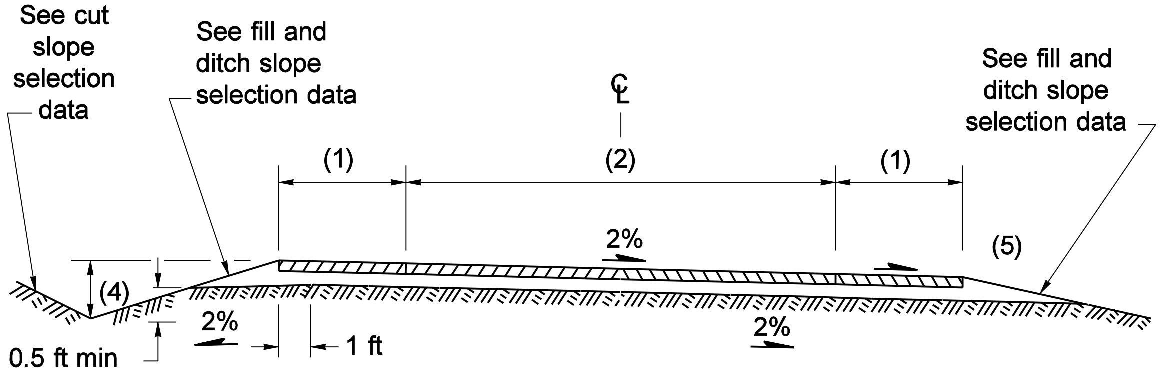
(8) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

Two-Lane Highway Roadway Sections

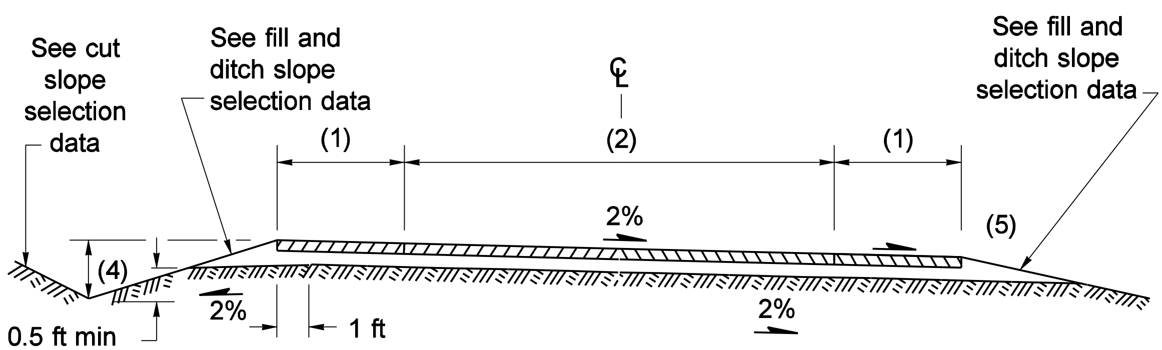
Figure 640-3



Two-Lane Two-Way Ramp



Two-Lane One-Way Ramp



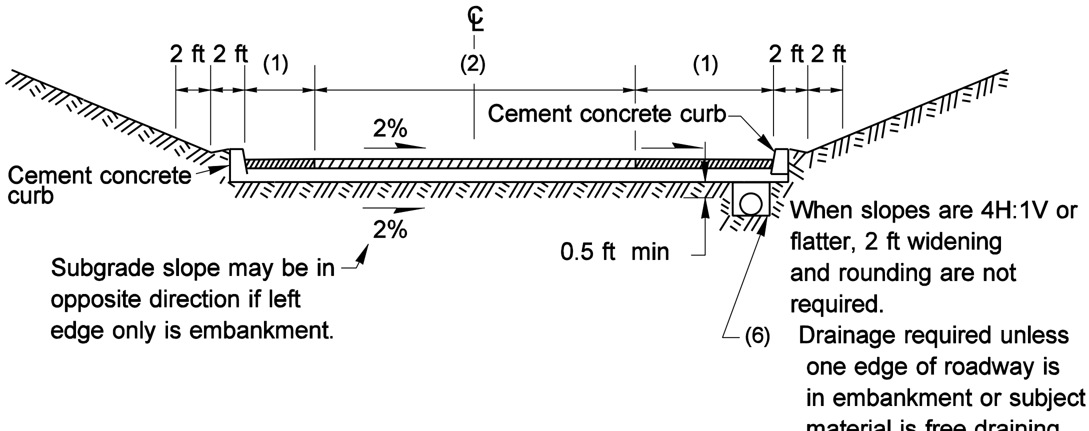
One-Lane Ramp

Note:

For notes, dimensions, and slope selection tables, see Figure 640-4b.

Ramp Roadway Sections

Figure 640-4a



Special Design

This special design section is to be used only when restrictions (high right of way costs or physical features that are difficult or costly to correct) require its consideration.

Height of fill/depth of ditch (ft)	Slope not steeper than (7)
0 – 10	6H:1V
10 – 20	4H:1V
20 – 30	3H:1V (5)
over 30	2H:1V (5) (9)

Fill and Ditch Slope Selection

Height of cut (ft)*	Slope not steeper than
0 – 5	6H:1V
5 – 20	3H:1V
over 20	2H:1V (8)
* From bottom of ditch	

Cut Slope Selection (10)

Notes:

(1) For shoulder details, see Figures 640-5a and 5b. For minimum shoulder widths, see Chapter 940.

(2) For minimum ramp lane widths, see Chapter 940. For turning roadway width, see Chapter 641. For two-way ramps, treat each direction as a separate one-way roadway.

(3) The minimum median width of a two-lane two-way ramp is not less than that required for traffic control devices and their respective clearances.

(4) Minimum ditch depth is 2 feet for design speeds over 40 mph and 1.5 feet for design speeds of 40 mph or less. Rounding may be varied to fit drainage requirements when minimum ditch depth is 2 feet.

(5) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640-5b.

(6) Method of drainage pickup to be determined by the designer.

(7) Where practicable, consider flatter slopes for the greater fill heights and ditch depths.

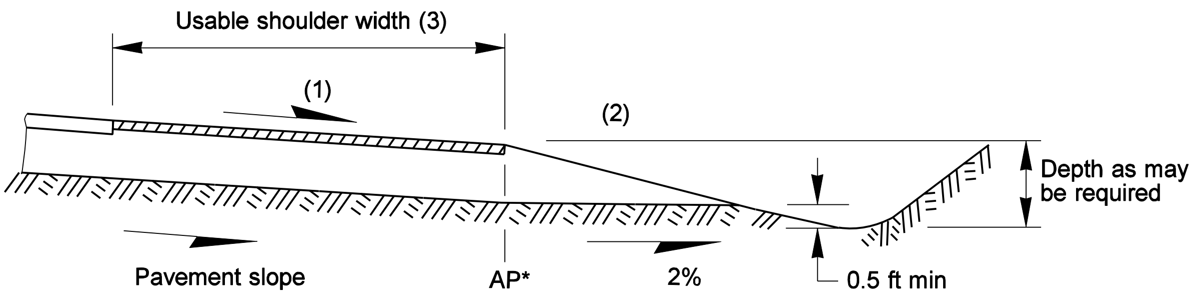
(8) Cut slopes steeper than 2H:1V may be used where favorable soil conditions exist or stepped construction is used. (See Chapter 700 for clear zone and barrier requirements.)

(9) Fill slopes as steep as 1½H:1V may be used where favorable soil conditions exist. (See Chapter 700 for clear zone and barrier requirements.)

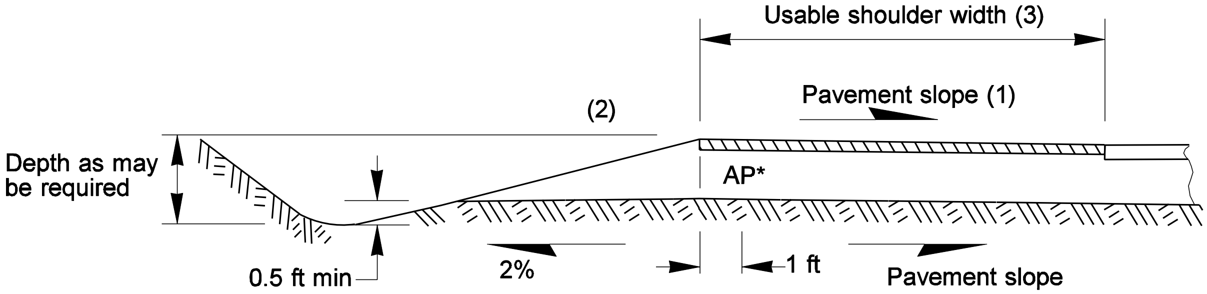
(10) The Cut Slope Selection table is for preliminary estimates or where no other information is available. Design the final slope as recommended in the geotechnical report. Do not disturb existing stable slopes just to meet the slopes given in this table.

Ramp Roadway Sections

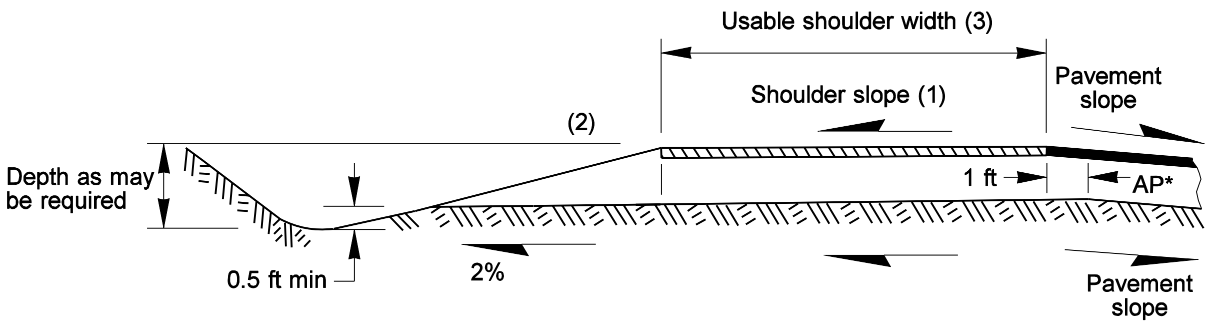
Figure 640-4b



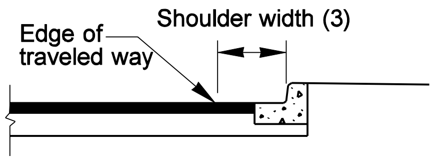
Shoulder Design <u>o</u>n <u>t</u>he Low Side <u>o</u>f <u>t</u>he Roadway <u>f</u>or Cross Slopes Greater Than 2%.



**Shoulder Design <u>o</u>n <u>t</u>he High Side <u>o</u>f <u>t</u>he Roadway <u>o</u>n Curves <u>a</u>nd Divided Roadways<u>.</u>
Shoulder Slopes <u>W</u>ith Roadway.**



**Shoulder Design <u>o</u>n <u>t</u>he High Side <u>o</u>f <u>t</u>he Roadway <u>o</u>n Curves <u>a</u>nd Divided Roadways<u>.</u>
Shoulder Slopes Away <u>F</u>rom Roadway.**



Shoulder Design <u>W</u>ith Curb (5)(6).

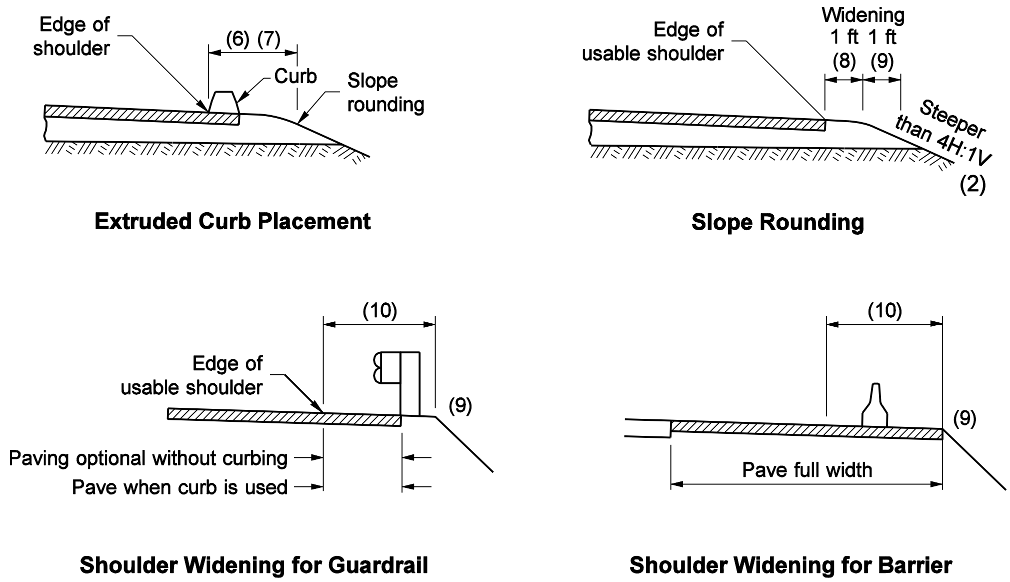
*AP = angle point in the subgrade.

<u>**Note:**</u>

For notes, see Figure 640-5b.

Shoulder Details

Figure 640-5a

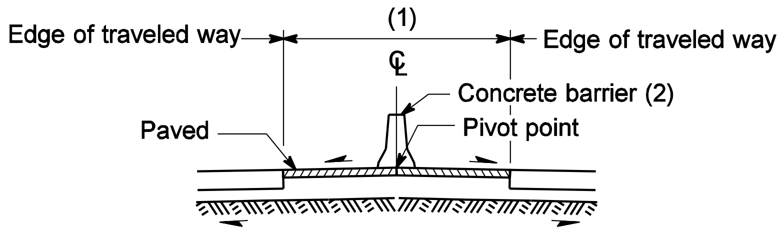


Notes:

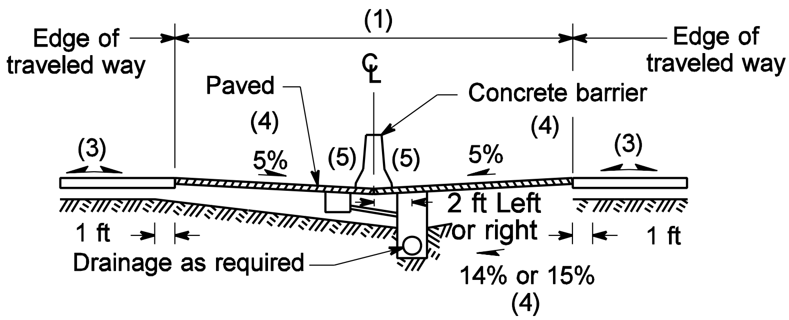
(1) Shoulder cross slopes are normally the same as the cross slopes for adjacent lanes. (See 640.04(3) in the text for examples, additional information, and requirements of locations where it may be desirable to have a shoulder cross slope different than the adjacent lane.)
(2) Widening and slope rounding outside the usable shoulder is required when foreslope is steeper than 4H:1V.
(3) For minimum shoulder width, see Chapters 430, 440, and 940.
(4) On divided multilane highways, see Figures 640-6a through 6c for additional details and requirements for median shoulders.
(5) For additional requirements for sidewalks, see Chapter 1025.
(6) It is preferred that curb not be used on high-speed facilities (posted speed >40 mph).
(7) Paved shoulders are required wherever extruded curb is placed. Use curb only where necessary to control drainage from roadway runoff. (See the Standard Plans for additional details and dimensions.)
(8) When rounding is required, use it uniformly on all ramps and crossroads, as well as the main roadway. End rounding on the crossroad just beyond the ramp terminals and at a similar location where only a grade separation is involved.
(9) When widening beyond the edge of usable shoulder is required for curb, barrier, or other purposes, additional widening for slope rounding is not required.
(10) For required widening for guardrail and concrete barrier, see Chapter 710.

Shoulder Details

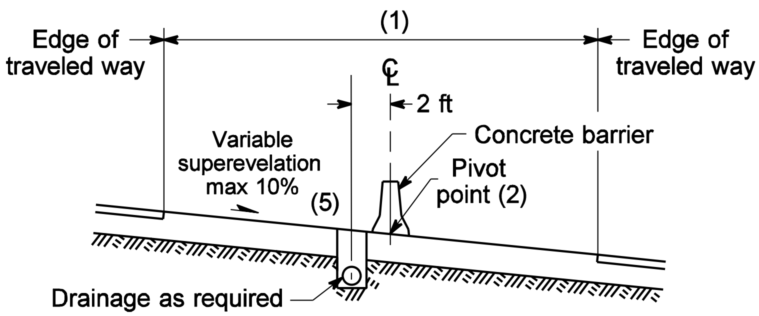
Figure 640-5b



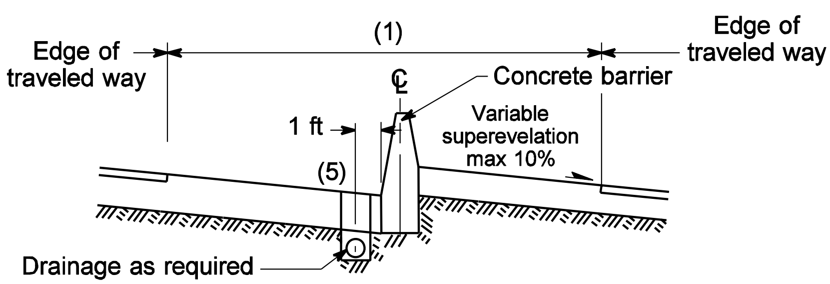
Design A Crowned Median



Design B Depressed Median



Alternate Design 1 Treatment on Curves



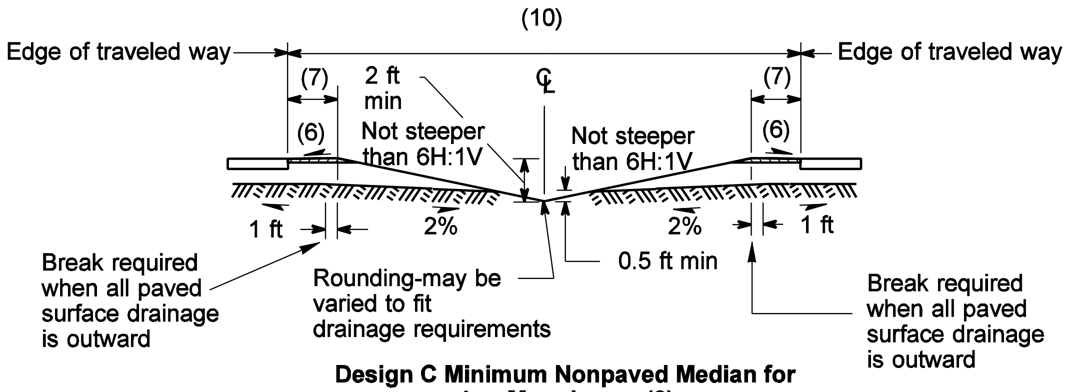
Alternate Design 2 No Fixed Pivot Point (2)

Note:

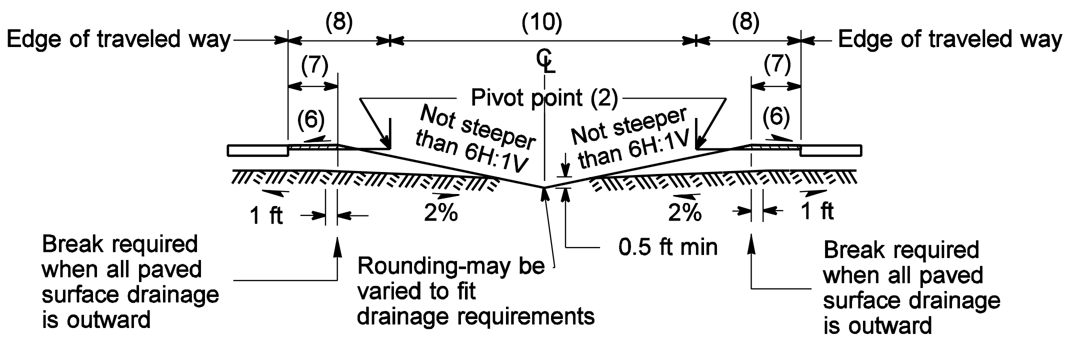
For notes, see Figure 640-6c.

Divided Highway Median Sections

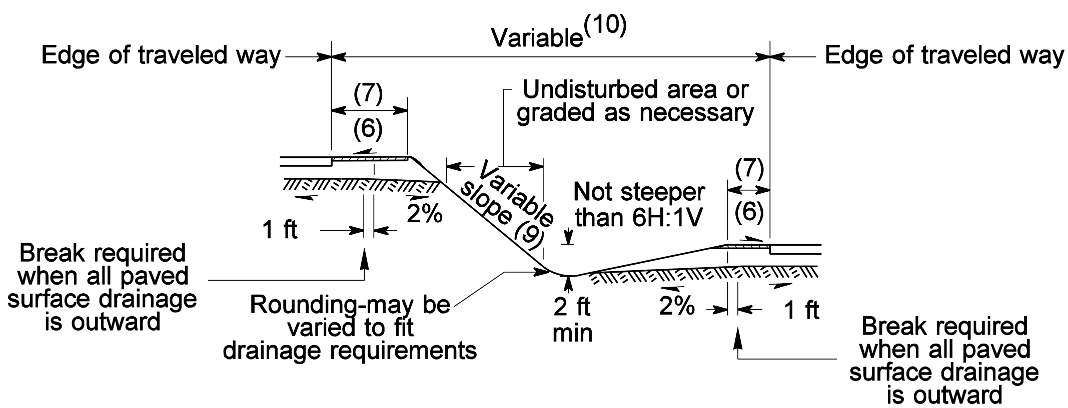
Figure 640-6a



Design C Minimum Nonpaved Median for 4 or More Lanes (2)



Design D Minimum for 4 or More Lanes with Future Lanes in Median



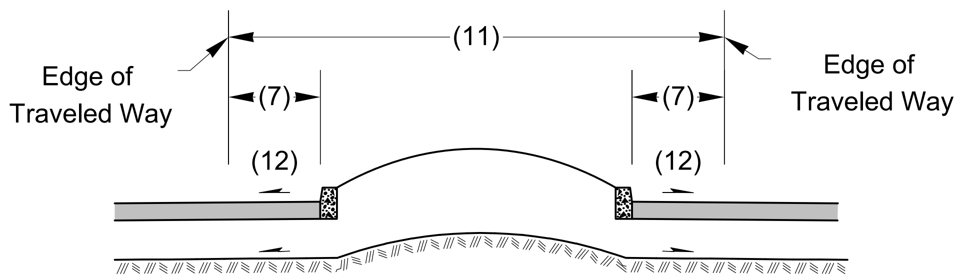
Design E Minimum for 4 or More Lanes with Independent Alignment

Note:

For notes, see Figure 640-6c.

Divided Highway Median Sections

Figure 640-6b

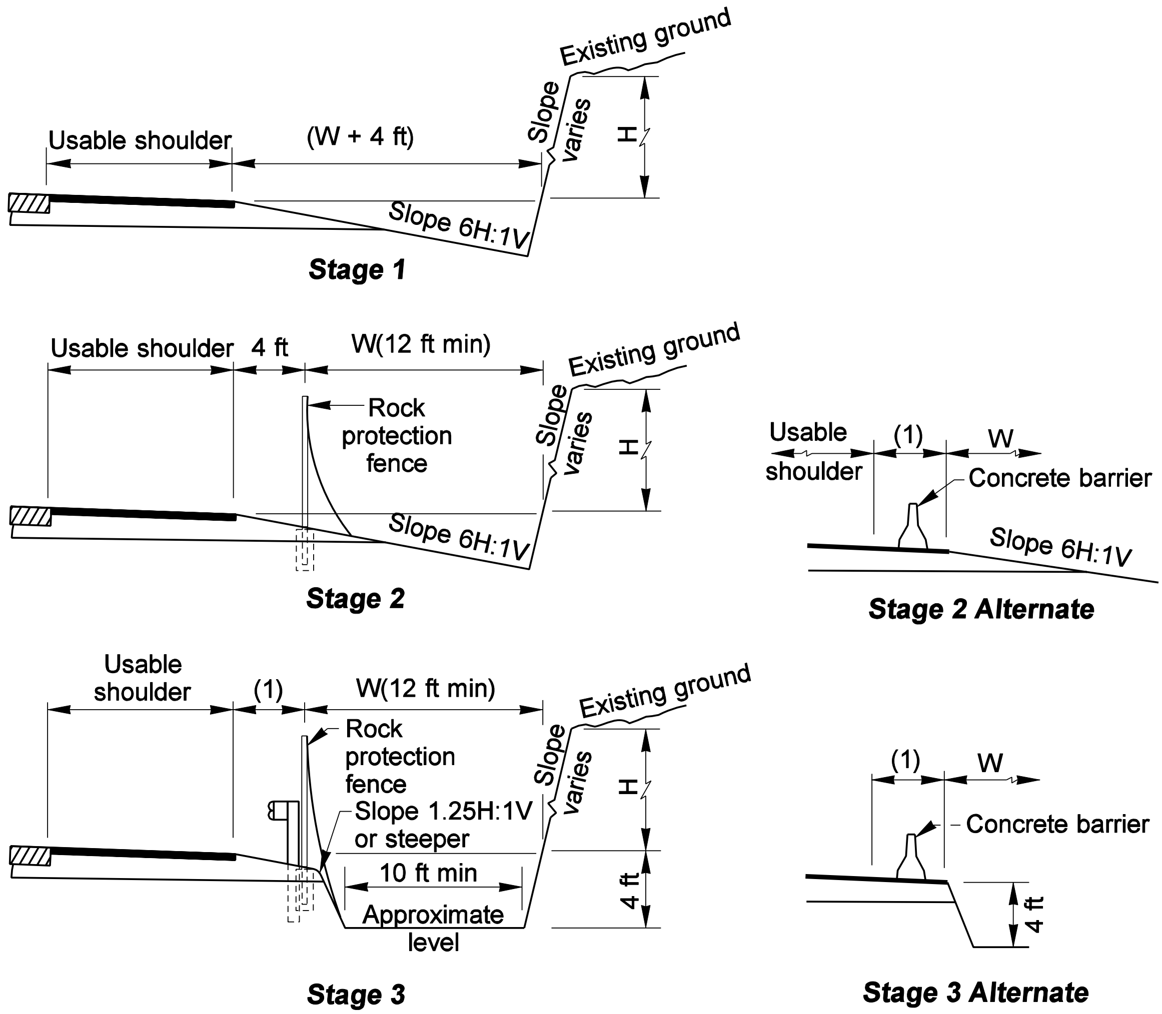


Design F Raised Median (13)

Notes:

(1) For minimum median width, see Chapters 430 and 440.
(2) Locate the pivot point to best suit the requirements of vertical clearances, drainage, and aesthetics.
(3) Pavement slopes generally shall be in a direction away from the median. A crowned roadway section may be used in conjunction with the depressed median where conditions justify. (See Figure 640 1 for additional crown information.)
(4) Design B may be used uniformly on both tangents and horizontal curves. Use alternate designs 1 or 2 when the "rollover" between the shoulder and the inside lane on the high side of a superelevated curve exceeds 8%. Provide suitable transitions at each end of the curve for the various conditions encountered in applying the alternate to the basic median design.
(5) Method of drainage pickup to be determined by the designer.
(6) Median shoulders normally slope in the same direction and rate as the adjacent through lane. (See 640.04(3) for examples, additional information, and requirements of locations where it may be desirable to have a shoulder cross slope different than the adjacent lane.)
(7) For minimum shoulder width, see Chapters 430 and 440.
(8) Future lane (see Chapter 440 for minimum width).
(9) Widen and round foreslopes steeper than 4H:1V, as shown in Figure 640 5b.
(10) Designs C, D, and E are rural median designs. (See Chapter 440 for minimum rural median widths.) Rural median designs may be used in urban areas when minimum rural median widths can be achieved.
(11) For minimum median width, see Chapter 440. Raised medians may be paved or landscaped. For clear zone and barrier requirements when fixed objects or trees are in the median, see Chapter 700.
(12) Lane and shoulders normally slope away from raised medians. When they slope toward the median, provide for drainage.
(13) The desirable maximum design speed for a raised median is 45 mph. When the design speed is above 45 mph, Design A or Design B is preferred.

Divided Highway Median Sections
Figure 640-6c



Rock Slope	H (ft)	W (ft)
Near Vertical	20-30	12
	30 – 60	15
	> 60	20
0.25H:1V through 0.50H:1V	20-30	12
	30-60	15
	60-100	20
	>100	25

Notes:

Cut heights less than 20 feet shall be treated as a normal roadway, unless otherwise determined by the region's Materials Engineer.

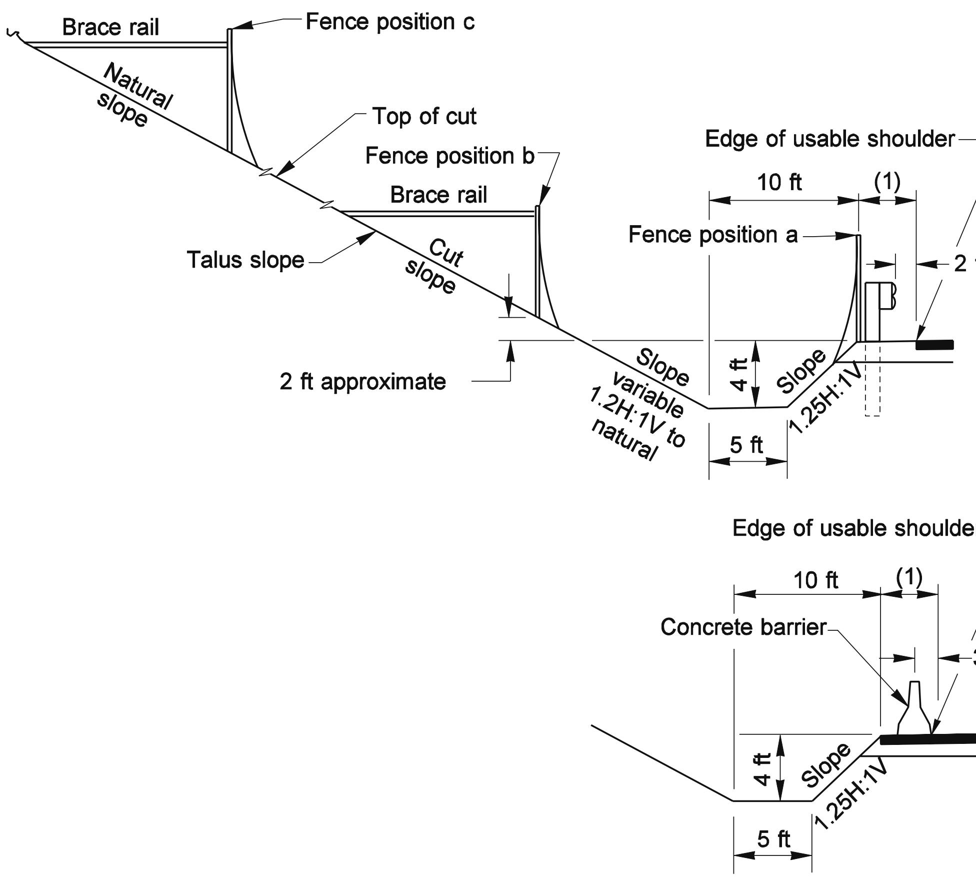
Stage 2 and 3 Alternates may be used when site conditions dictate.

Fence may be used in conjunction with the Stage 3 Alternate. (See Chapter 700 for clear zone requirements.)

(1) For required widening for guardrail and concrete barrier, see Chapter 710.

Roadway Sections in Rock Cuts, Design A

Figure 640-7a



Shoulder Barrier Alternate

Notes:

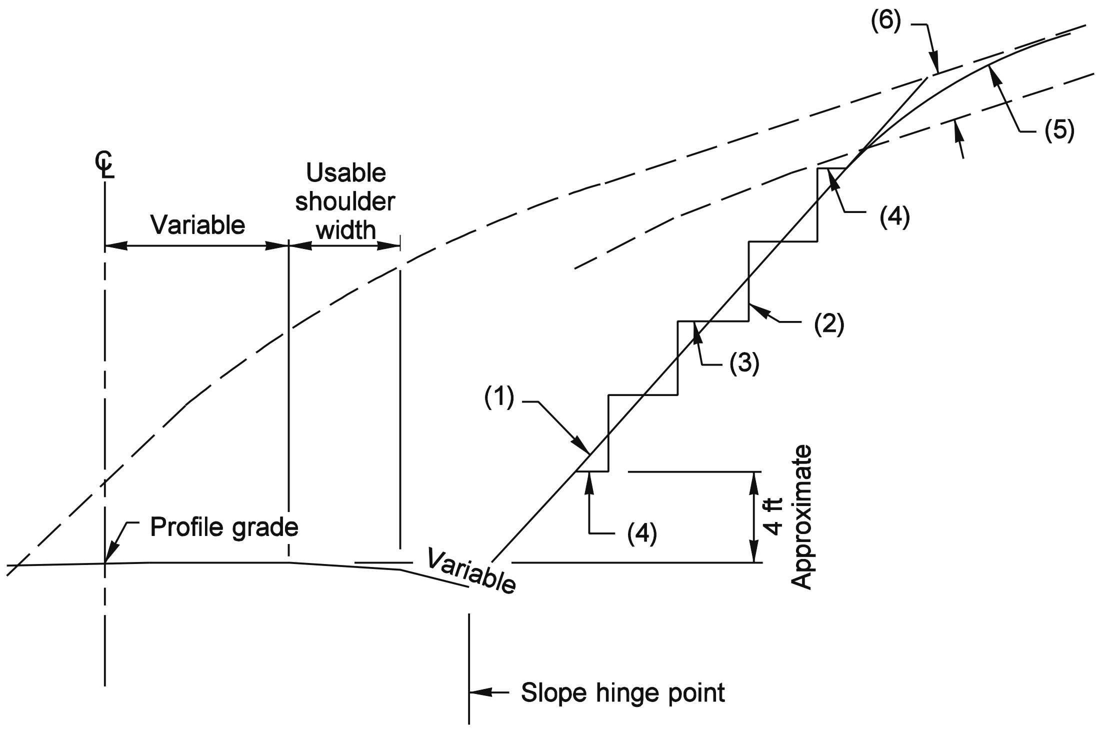
Ordinarily, place fence within a zone of 100 feet to 200 feet maximum from base of cliff, measured along the slope.

Rock protection fence may be used in conjunction with the Shoulder Barrier Alternate when site conditions dictate.

(1) For required widening for guardrail and concrete barrier, see Chapter 710.

Roadway Sections in Rock Cuts, Design B

Figure 640-7b



Notes:

(1) Staked slope line – Maximum slope 1H:1V.
(2) Step rise – Height variable 1 foot to 2 feet.
(3) Step tread – Width = staked slope ratio x step rise.
(4) Step termini – Width ½ step tread width.
(5) Slope rounding.
(6) Overburden area – Variable slope ratio.

Roadway Sections With Stepped Slopes

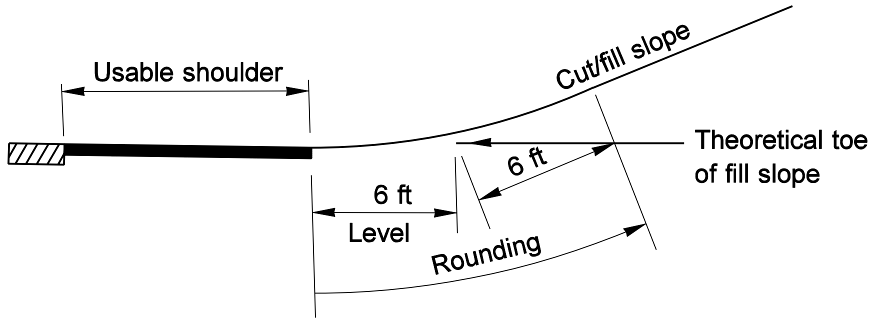
Figure 640-8

Bridge End Condition	Toe of Slope End Slope Rate		Lower Roadway Treatment (1)		Slope Rate
End Piers on Fill	Height	Rate	Posted speed of lower roadway	Treatment	
	≤ 35 ft > 35 ft	1¾H:1V 2H:1V (2)	> 50 mph ≤ 50 mph	Rounding No rounding	
End Piers in Cut	Match lower roadway slope.(3)		No rounding, toe at centerline of the lower roadway ditch.		(4)
Lower Roadway in Cut	Match lower roadway slope.(3)		No rounding, toe at centerline of the lower roadway ditch.		(4)
Ends in Partial Cut and Fill	When the cut depth is > 5 ft and length is > 100 ft, match cut slope of the lower roadway.		When the cut depth is > 5 ft and length is > 100 ft, no rounding, toe at centerline of the lower roadway ditch.		(4)
	When the cut depth is ≤ 5 ft or the length is ≤ 100 ft, it is designer's choice.		When the cut depth is ≤ 5 ft or the length is ≤ 100 ft, it is designer's choice.		(4)

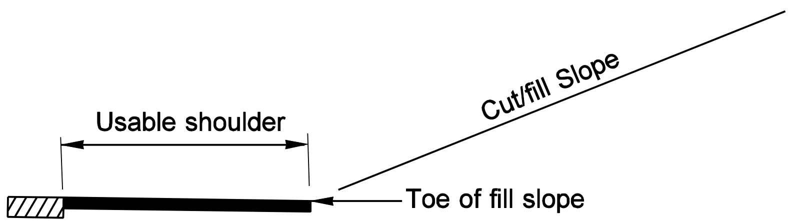
Notes:

(1) See Figure 640-9b.
(2) Slope may be 1¾H:1V in special cases.
(3) In interchange areas, continuity may require variations.
(4) See 640.06.

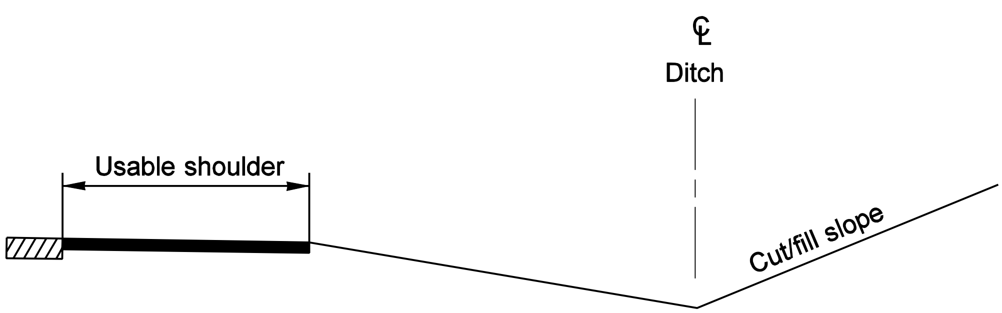
Bridge End Slopes
Figure 640-9a



Rounding



No Rounding



Toe at ℄ of Roadway Ditch

Bridge End Slopes
Figure 640-9b

641.01 General

The roadway on a curve may need to be widened to make the operating conditions comparable to those on tangents. There are two main reasons to do this. One is the offtracking of vehicles, such as trucks and buses. The other is the increased difficulty drivers have in keeping their vehicles in the center of the lane.

For additional information, see the following chapters:

Chapter	Subject
430	Roadway widths and cross slopes for modified design level
440	Minimum lane and shoulder widths for full design level
642	Superelevation
940	Lane and shoulder widths for ramps

641.02 References

Design Guidance

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

641.03 Definitions

divided multilane A roadway with two or more through lanes in each direction and a median that physically or legally prohibits left turns, except at designated locations.

lane A strip of roadway used for a single line of vehicles.

lane width The lateral design width for a single lane, striped as shown in the Standard Plans and the Standard Specifications.

roadway The portion of a highway, including shoulders, for vehicular use.

shoulder The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and use by pedestrians.

shoulder width The lateral width of the shoulder, measured from the outside edge of the outside lane to the edge of the roadway.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

turning roadway A curve on an open highway, a ramp, or the connecting portion of the roadway between two intersecting legs of an intersection.

undivided multilane A roadway with two or more through lanes in each direction on which left turns are not controlled.

641.04 Turning Roadway Widths

(1) Two-Lane Two-Way Roadways

Figure 641-1a shows the traveled way width W for two-lane two-way roadways. For values of R between those given, interpolate W and round up to the next foot.

Minimum traveled way width W based on the delta angle of the curve, shown in Figure 641-1b, may be used. Document the reasons for using the minimum width. Round W to the nearest foot.

Widths given in Figures 641-1a and 1b are for facilities with 12-foot lanes. When 11-foot lanes are called for, width W may be reduced by 2 feet.

(2) Two-Lane One-Way Roadways

Figure 641-2a shows the traveled way width W for two-lane one-way turning roadways, including two lane ramps and four-lane highways. For values of R between those given, interpolate W and round up to the next foot. Treat each direction of travel on four-lane facilities as a one-way roadway.

Minimum traveled way width W based on the delta angle of the curve, shown in Figure 641-2b, may be used. Document the reasons for using the minimum width. Round W to the nearest foot.

Widths given in Figures 641-2a and 2b are for facilities with 12-foot lanes. When 11-foot lanes are called for, width W may be reduced by 2 feet.

To keep widths to a minimum, traveled way widths for Figures 641-2a and 2b were calculated using the WB-40 design vehicle. When volumes are high for trucks larger than the WB-40 and other traffic, consider using the widths from Figures 641-1a and 1b.

(3) One-Lane Roadways

Figure 641-3a shows the traveled way width W for one-lane turning roadways, including one-lane ramps. For values of R between those given, interpolate W and round up to the next foot.

Minimum width W, based on the delta angle of the curve for one-lane roadways shown in Figure 641-3b using the radius to the outer edge of the traveled way and Figure 641-3c using the radius on the inner edge of the traveled way, may be used. Document the reasons for using the minimum width. Round W to the nearest foot.

Build shoulder pavements at full depth for one-lane roadways. To keep widths to a minimum, traveled way widths were calculated using the WB-40 design vehicle, which may force larger vehicles to encroach on the shoulders. This also helps to maintain the integrity of the roadway structure during partial roadway closures.

(4) Other Roadways

For roadways where the traveled way is more than two lanes in any direction, for each lane in addition to two, add the lane width for the highway functional class from Chapter 440 to the width from 641.04(2).

For three-lane ramps with HOV lanes, see Chapter 1050.

(5) Total Roadway Width

Full design shoulder widths for the highway functional class or ramp are added to the traveled way width to determine the total roadway width.

Small amounts of widening will add cost with little benefit. When the required traveled way widening is less than 0.5 feet per lane, it may be disregarded. If the total roadway width deficiency is less than 2 feet on existing roadways that are to remain in place, correction is not normally required.

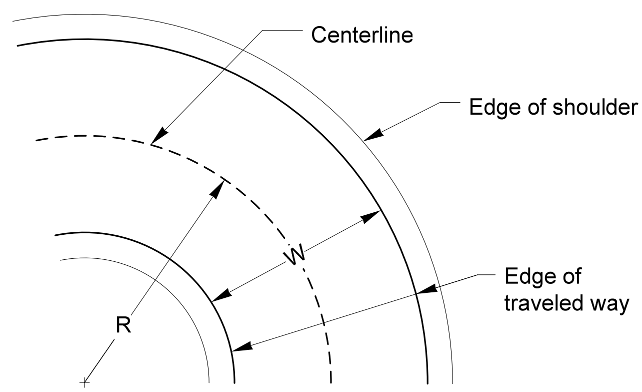
When widening the traveled way:

- Widening may be constructed on the inside of the traveled way or divided equally between the inside and outside. Do not construct widening only on the outside of a curve.
- Place final marked lane lines, and any longitudinal joints, at equal spacing between the edges of the widened traveled way.
- Provide widening throughout the curve length.
- For widening on the inside, make transitions on a tangent where possible.
- For widening on the outside, develop the widening by extending the tangent. This avoids the appearance of a reverse curve that a taper would create.
- For widening of 6 feet or less, use a 1:25 taper. For widths greater than 6 feet, use a 1:15 taper.

641.05 Documentation

A list of the documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

Radius on Centerline of Traveled Way (ft)	Design Traveled Way Width (W)(ft)(1)
3000 to tangent	24
2999	25
2000	26
1000	27
800	28
600	29
500	30
400	31
350	32
300	33
250	35
200	37
150	41

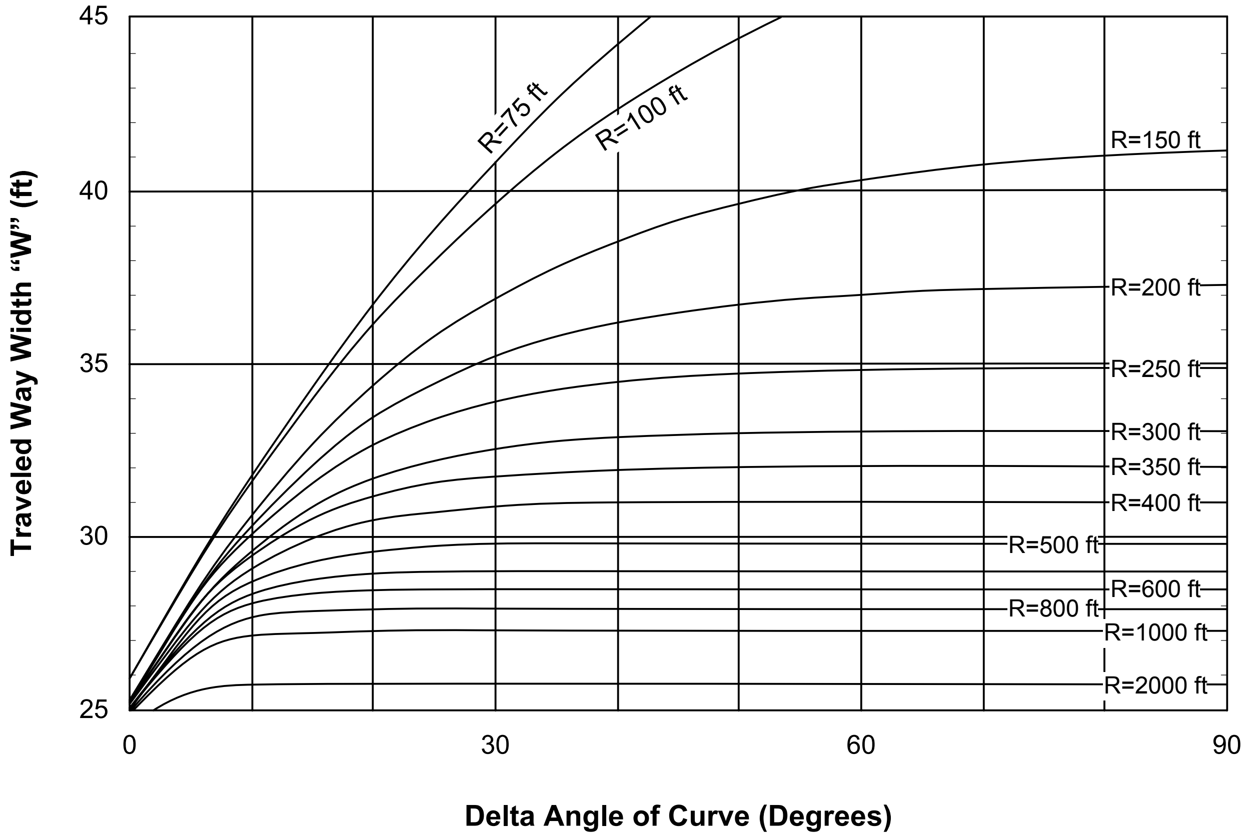


Note:

(1) Width (W) is for facilities with 12-foot lanes. When 11-foot lanes are called for, width may be reduced by 2 feet.

Traveled Way Width for Two-Lane Two-Way Turning Roadways

Figure 641-1a



Note:

Width (W) is for facilities with 12-foot lanes. When 11-foot lanes are called for, width may be reduced by 2 feet.

Traveled Way Width for Two-Lane Two-Way Turning Roadways

Figure 641-1b

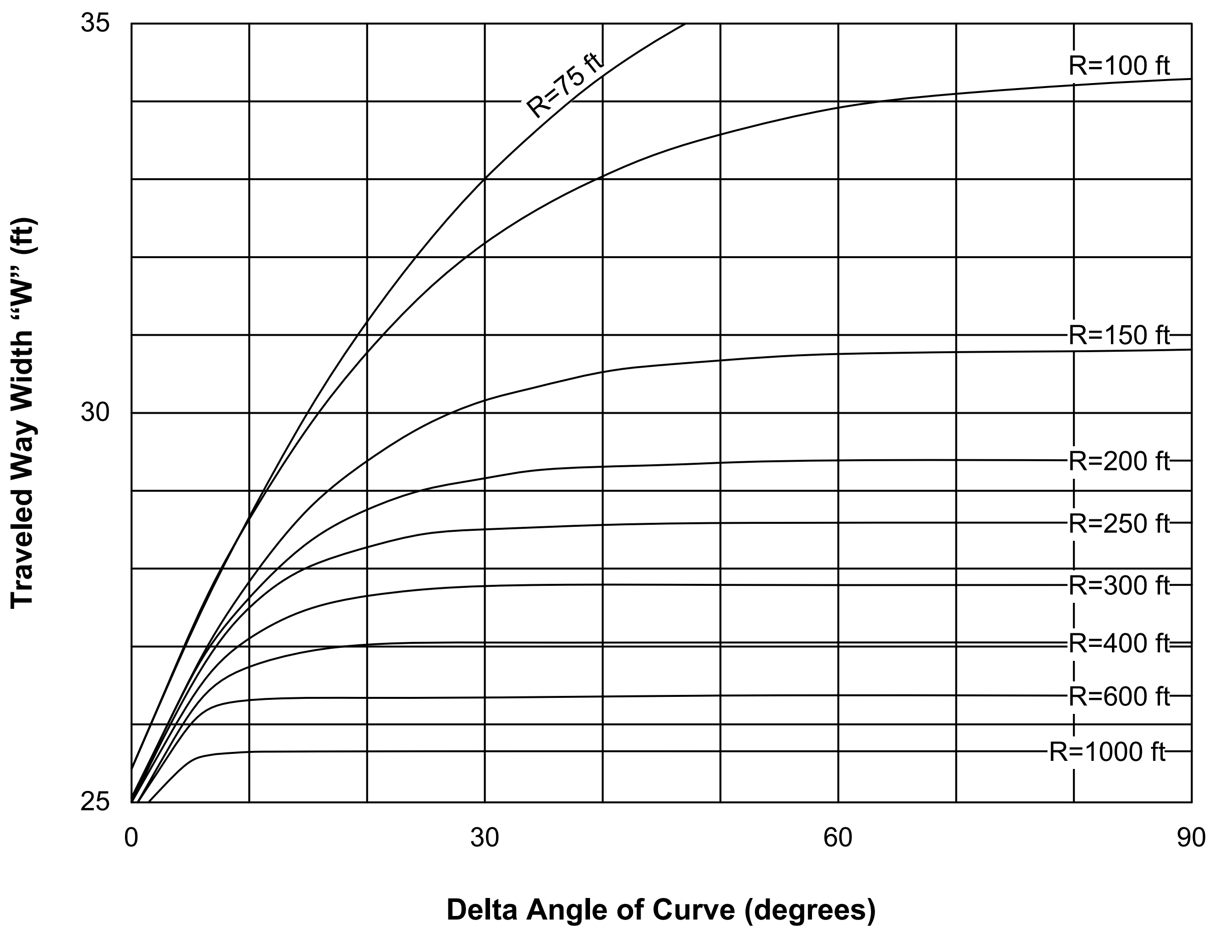
Radius on Centerline of Traveled Way (ft)	Design Traveled Way Width (W) (ft)(1)
3000 to tangent	24
1000 to 2999	25
999	26
600	26
500	27
400	27
300	28
250	29
200	29
150	31
100	34

Note:

(1) Width (W) is for facilities with 12-foot lanes. When 11-foot lanes are called for, width may be reduced by 2 feet.

Traveled Way Width for Two-Lane One-Way Turning Roadways

Figure 641-2a

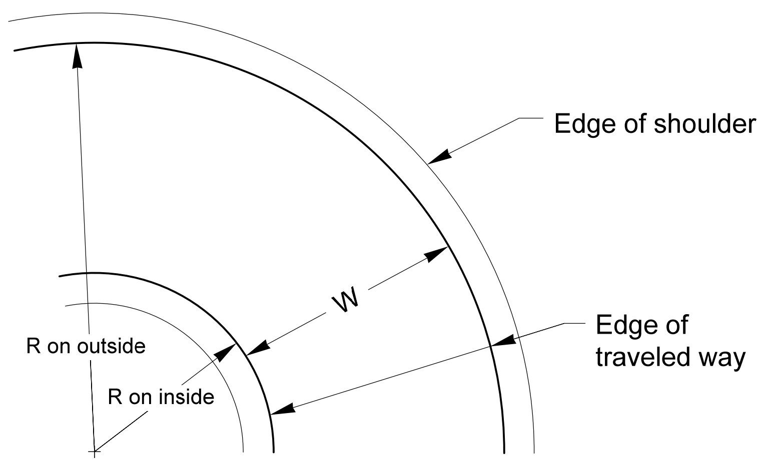


Note:
(1) Width (W) is for facilities with 12-foot lanes. When 11-foot lanes are called for, width may be reduced by 2 feet.

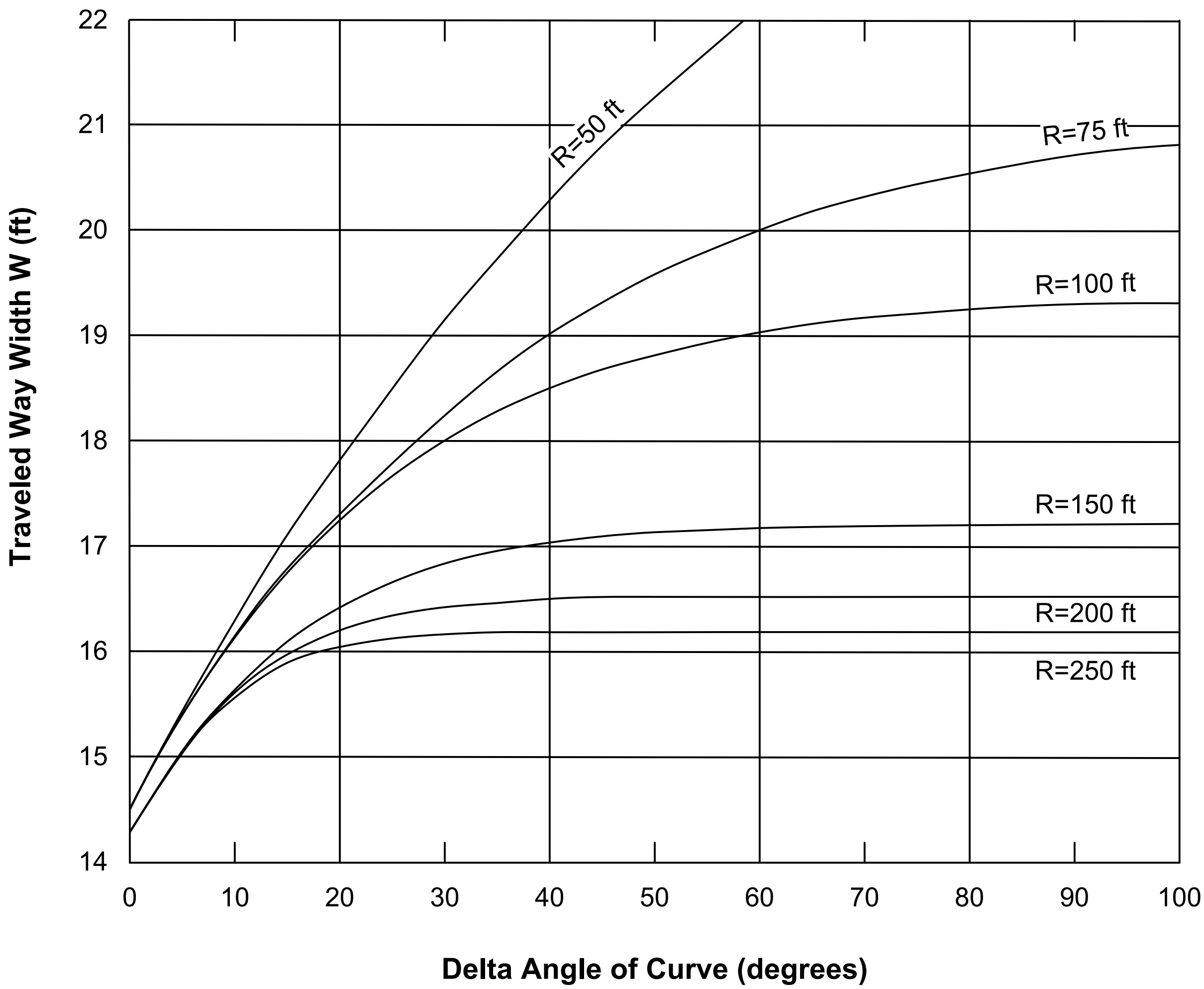
Traveled Way Width for Two-Lane One-Way Turning Roadways
Figure 641-2b

Radius (ft)	Design Traveled Way Width (W) (ft)	
	Radius on outside edge of traveled way	Radius on inside edge of traveled way
7500 to tangent	13(1)	13(1)
1600	14	14
300	15	15
250	16	16
200	17	17
150	17	17
100	19	18
75	21	19
50	26	22

Note:
(1) On tangents, the minimum lane width may be reduced to 12 feet.



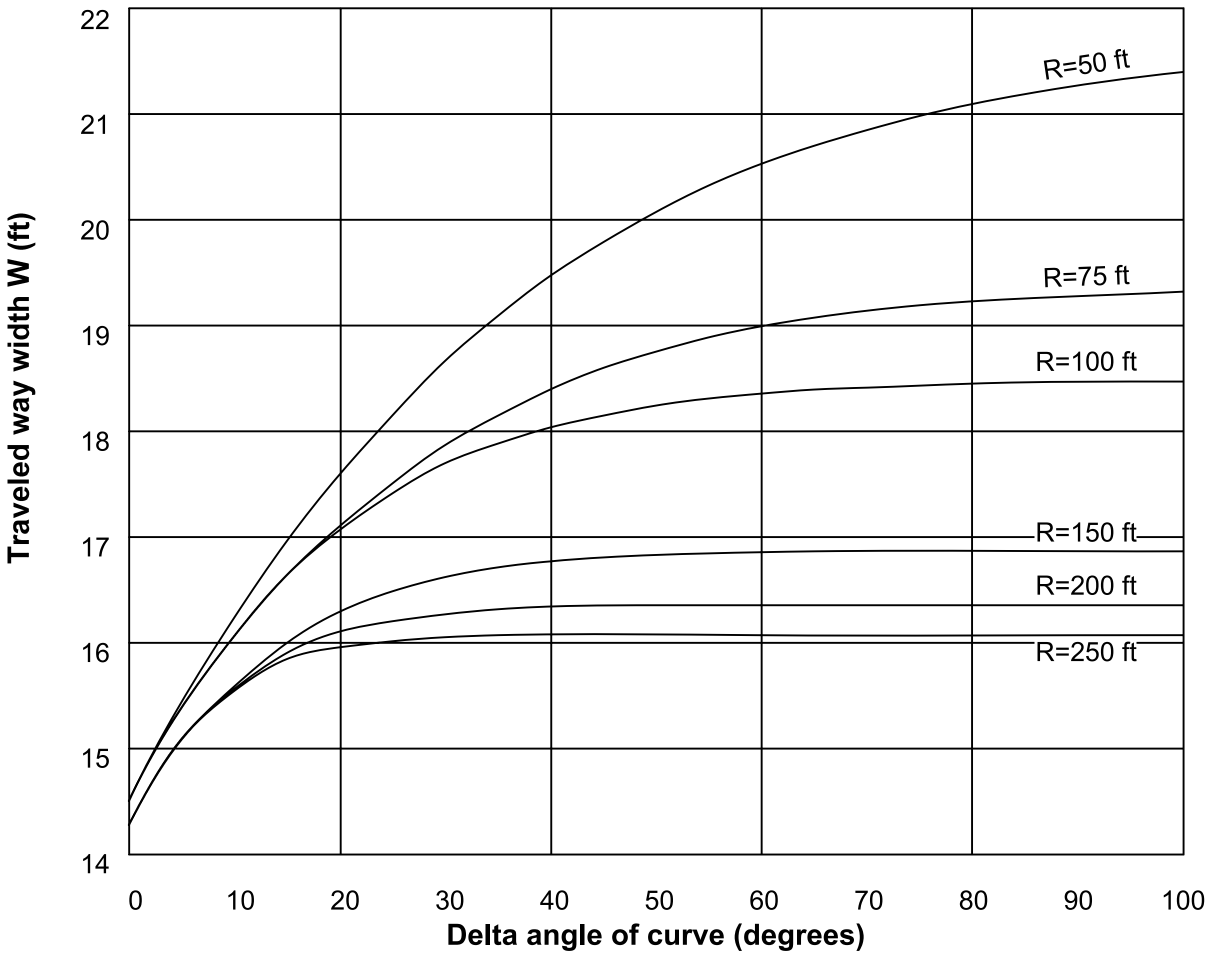
Traveled Way Width for One-Lane Turning Roadways
Figure 641-3a



Note:

All radii are to the outside edge of traveled way.

Traveled Way Width for One-Lane Turning Roadways
Figure 641-3b



Note:
All radii are to the inside edge of traveled way.

Traveled Way Width for One-Lane Turning Roadways
Figure 641-3c

642.01 General

To maintain the desired design speed, highway and ramp curves are usually superelevated to overcome part of the centrifugal force that acts on a vehicle.

See the following chapters for additional information:

Chapter	Subject
430	roadway widths and cross slopes for modified design level
440	minimum lane and shoulder widths for full design level
940	lane and shoulder widths for ramps

642.02 References

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10,WSDOT.

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

642.03 Definitions

lane A strip of roadway used for a single line of vehicles.

lane width The lateral design width for a single lane, striped as shown in the Standard Plans and the Standard Specifications.

median The portion of a highway separating the traveled ways for traffic in opposite directions.

roadway The portion of a highway, including shoulders, for vehicular use.

superelevation The rotation of the roadway cross section in such a manner as to overcome part of the centrifugal force that acts on a vehicle traversing a curve.

superelevation runoff The length of highway needed to accomplish the change in cross slope from a section with adverse crown removed (level) to a fully superelevated section, or vice versa.

superelevation transition length The length of highway needed to change the cross slope from normal crown or normal pavement slope to full superelevation.

tangent runout The length of highway needed to change the cross slope from normal crown to a section with adverse crown removed (level).

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

turning roadway A curve on an open highway, a ramp, or the connecting portion of roadway between two intersecting legs of an intersection.

642.04 Rates for Open Highways and Ramps

The maximum superelevation rate allowed for open highways or ramps is 10%. (See Figure 642-3a.)

Base superelevation rate and its corresponding radius for open highways on Figure 642-3a, Superelevation Rate (10% Max), with the following exceptions:

- Figure 642-3b, Superelevation Rate (6% Max), may be used under the following conditions:

    1. Urban non freeways.

    2. Mountainous areas or locations that normally experience regular accumulations of snow and ice.

    3. Short-term detours (generally implemented and removed in one construction season). For long-term detours, consider a higher rate up to 10%, especially when associated with a main line detour.

- Figure 642-3c, Superelevation Rate (8% Max), may be used for existing roadways, urban freeways, and areas where the 6% rate is allowed but will not work; for example, where a curve with a radius less than the minimum for the 6 % rate at the design speed is required.

Design the superelevation for ramps the same as for open highways. With justification, superelevation for ramps in urban areas with a design speed of 40 mph or less, may be determined as an urban managed access highway [642.05 & Figure 642-4].

Round the selected superelevation rate to the nearest full percent.

Document which set of curves is being used and, when a curve other than the 10% maximum rate is used, document why the curve was selected.

Depending on design speed, construct large radius curves with a normal crown section. The minimum radii for normal crown sections are shown in Figure 642-1. Superelevate curves with smaller radii in accordance with the appropriate superelevation from Figures 642-3a through 3c.

Design Speed (mph)	Minimum Radius for Normal Crown Section (ft)
15	955
20	1695
25	2,450
30	3,340
35	4,375
40	5,545
45	6,860
50	8,315
55	9,920
60	11,675
65	13,130
70	14,675
75	16,325
80	18,065

Minimum Radius for Normal Crown Section

Figure 642-1

642.05 Rates for Low-Speed Urban Managed Access Highway

Curves on low-speed Urban Managed Access Highways may be superelevated using a higher side friction than used for open highways. Figure 642-4 may be used to determine superelevation for Urban Managed Access Highways with a design speed of 40 mph or less. Figure 642-4 was developed using the higher side friction.

642.06 Existing Curves

Evaluate the superelevation on an existing curve to determine its adequacy. Use the following equation to determine the minimum radius for a given superelevation and design speed:

$$R = \frac{6.69 V^2}{e + f}$$

Where:

R = The minimum allowable radius of the curve in feet.

V = Design speed in mph

e = Superelevation rate in percent

f = Side friction factor from Figure 642-2

Superelevation is deficient when the existing radius is less than the minimum from the equation.

For preservation projects, where the existing pavement is to remain in place, the superelevation on existing curves may be evaluated with a ball banking analysis.

Corrective action is required to address deficient superelevation, when the existing radius is less than the minimum radius calculated using the equation or when the maximum speed determined by a ball banking analysis is less than the design speed. Provide superelevation as given in 642.04.

Design Speed (mph)	Side Friction Factor (f)
15	17.5
20	17
25	16.5
30	16
35	15.5
40	15
45	14.5
50	14
55	13
60	12
65	11
70	10
75	9
80	8

Side Friction Factor

Figure 642-2

642.07 Turning Movements at Intersections

Curves associated with the turning movements at intersections are superelevated using the side friction factors for low-speed urban managed access highway curves. Since speeds of turning vehicles are not constant and curve lengths are not excessive, these higher friction factors can be tolerated. Use superelevation rates as high as practical, consistent with curve length and climatic conditions. Figure 642-4 shows the minimum superelevation for given design speed and radius. Use judgment in considering local conditions such as snow and ice. When using high superelevation rates on short curves, provide smooth transitions with merging ramps or roadways.

642.08 Runoff for Highway Curves

For added comfort and safety, provide uniform superelevation runoff over a length adequate for the likely operating speeds. The length of the runoff is based on a maximum allowable difference between the grades on the pivot point and the outer edge of the traveled way for one 12 ft lane.

Provide transitions for all superelevated highway curves as specified in Figures 642-5a through 5e. Which transition to use depends on the location of the pivot point, the direction of the curve, and the roadway cross slope.

Consider the profile of the edge of traveled way. To be pleasing in appearance, do not let it appear distorted. The combination of superelevation transition and grade may result in a hump or dip in the profile of the edge of traveled way. When this happens, the transition may be lengthened to eliminate the hump or dip. If the hump or dip cannot be eliminated this way, pay special attention to drainage in the low areas.

When reverse curves are necessary, provide sufficient tangent length for complete superelevation runoff for both curves (that is, from full superelevation of the first curve to level to full superelevation of the second curve). If tangent length is longer than this but not sufficient to provide full super transitions (that is, from full superelevation of the first curve to normal crown to full superelevation of the second curve), increase the superelevation runoff lengths until they abut. This provides one continuous transition, without a normal crown section, similar to Designs C2 and D2 in Figures 642-5c and 5d except full super will be attained rather than the normal pavement slope as shown.

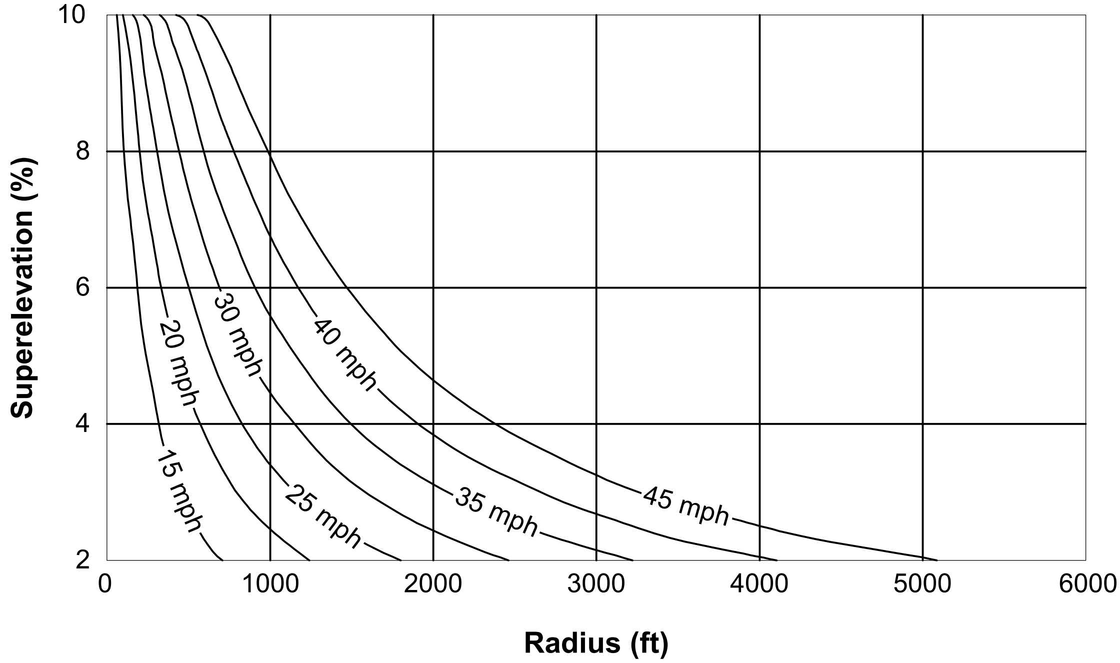
Superelevation runoff is permissible on structures but not desirable. Whenever practical, strive for full super or normal crown slopes on structures.

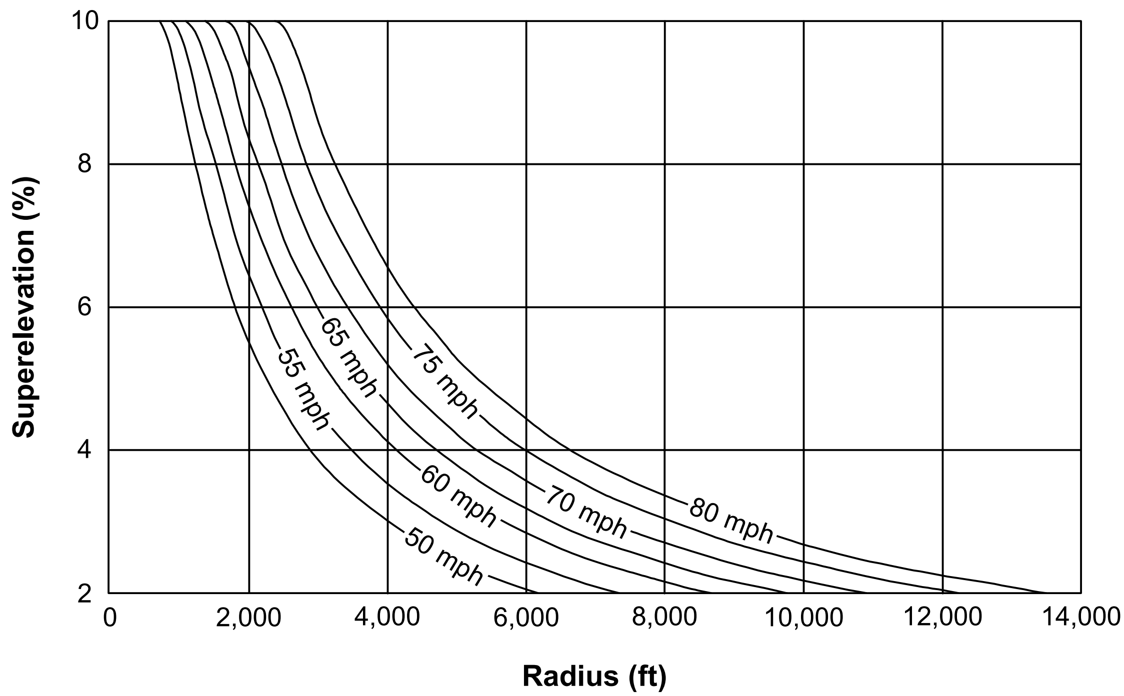
642.09 Runoff for Ramp Curves

Superelevation runoff for ramps use the same maximum relative slopes for specific design speeds used for highway curves. Multilane ramps have a width similar to the width for highway lanes; therefore, Figures 642-5a through 5e are used to determine the superelevation runoff for ramps. Single lane ramps have a lane width of 15 ft in curves, requiring the runoff length to be adjusted. Superelevation transition lengths (L_T) for single-lane ramps are given in Figures 642-6a and 6b. Additional runoff length for turning roadway widening is not required.

642.10 Documentation

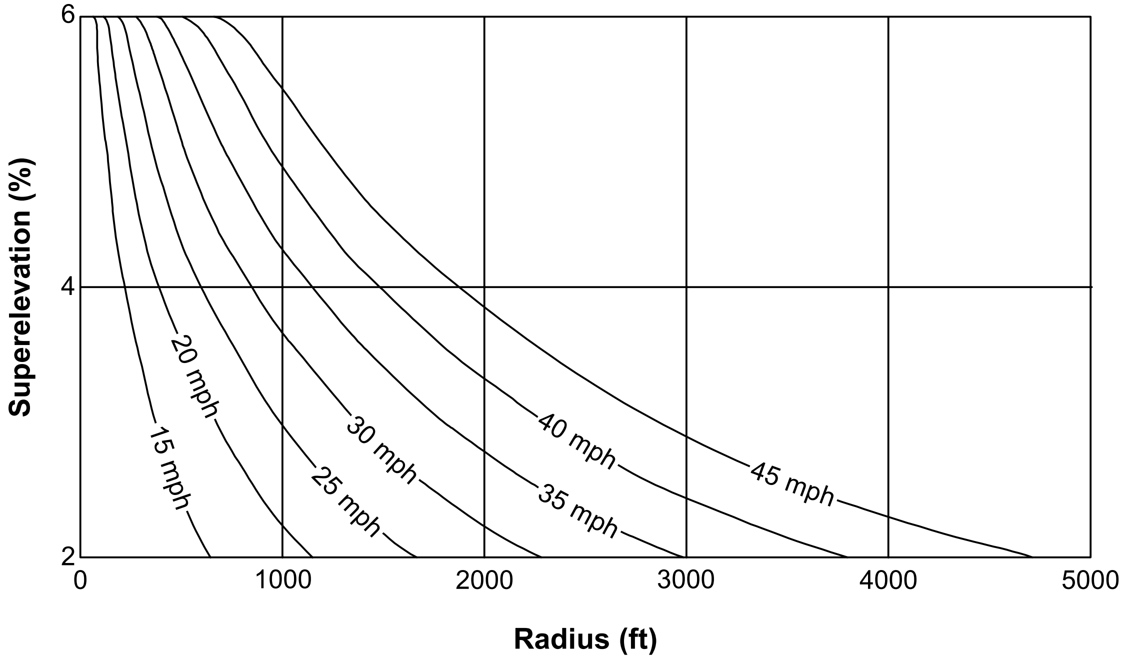
A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

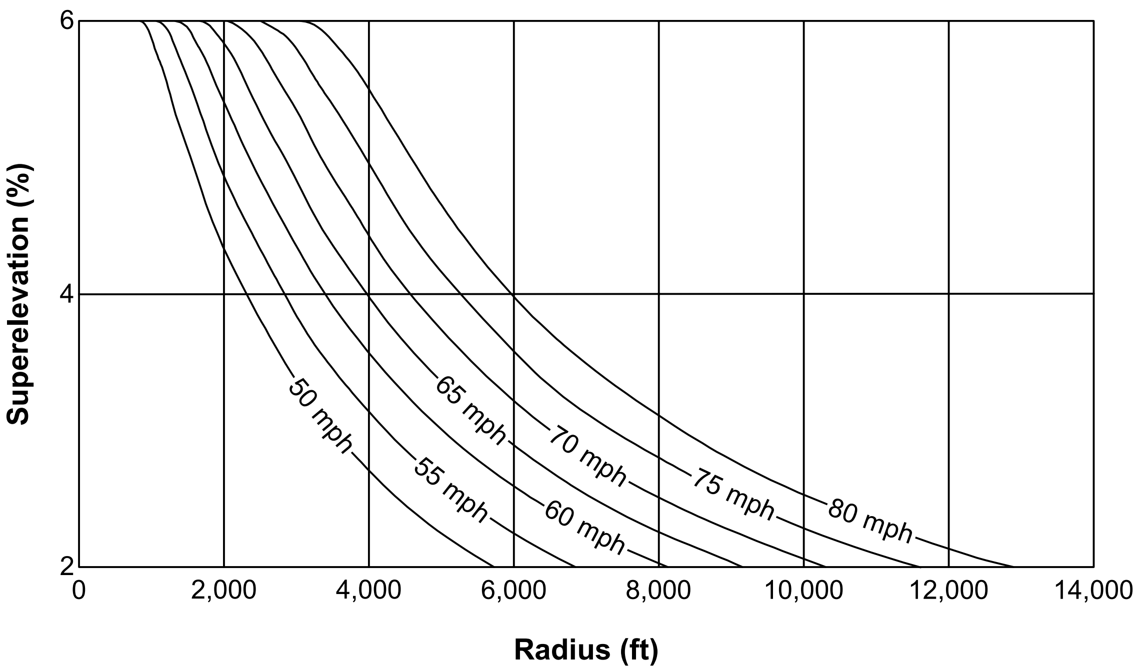




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	55	100	160	235	325	430	555	700	880	1095	1345	1640	1980	2380

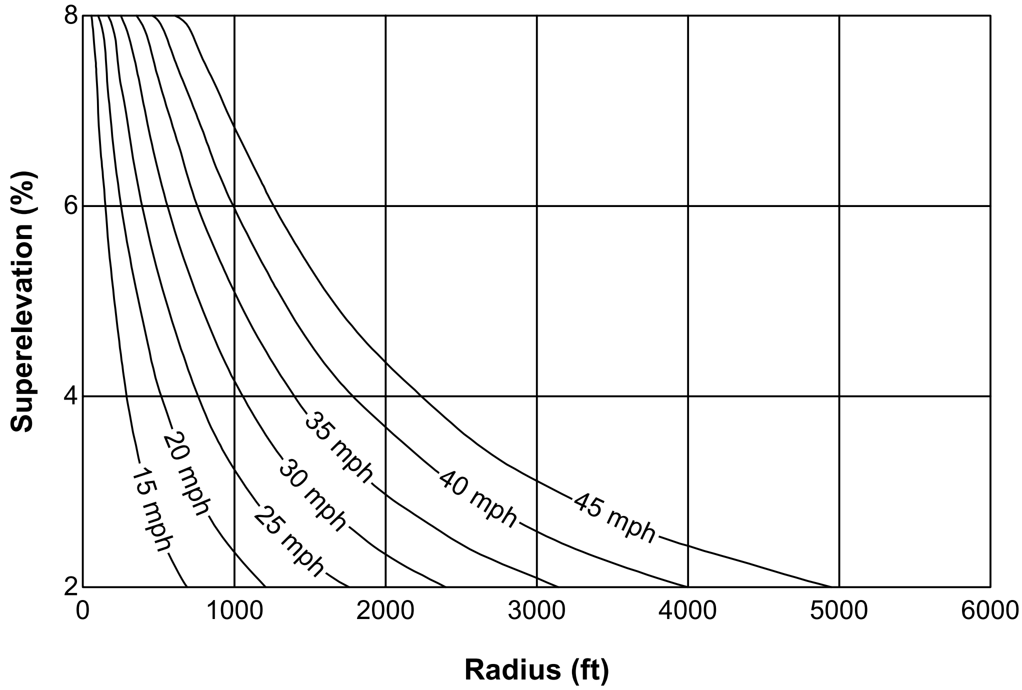
Superelevation Rates (10% max)
Figure 642-3a

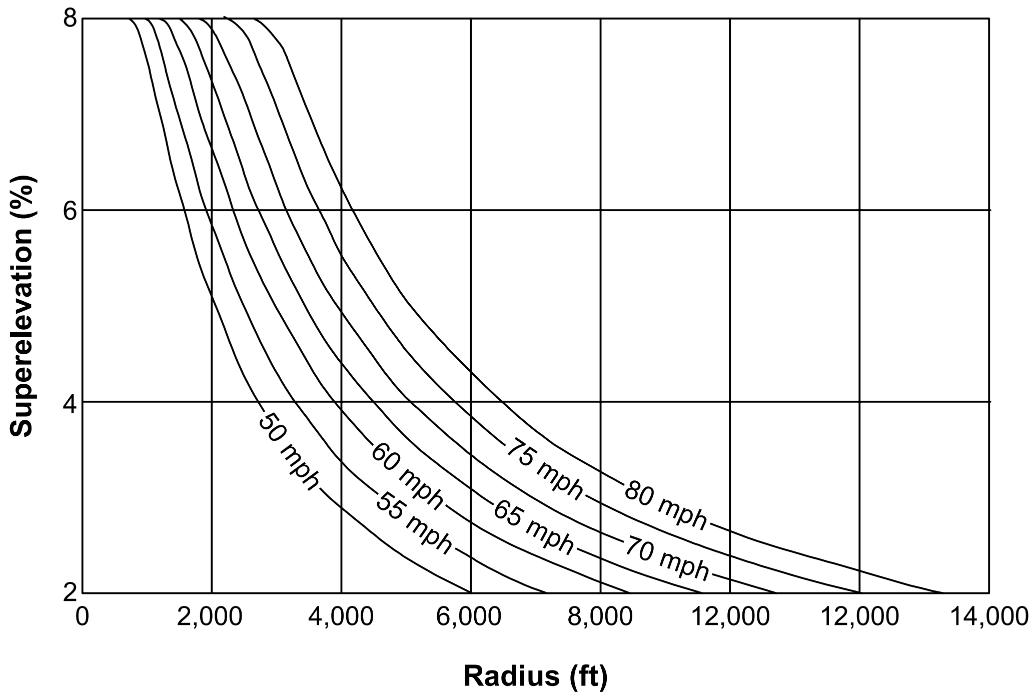




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	65	120	190	270	385	510	660	840	1065	1340	1665	2050	2510	3055

Superelevation Rates (6% max)
Figure 642-3b

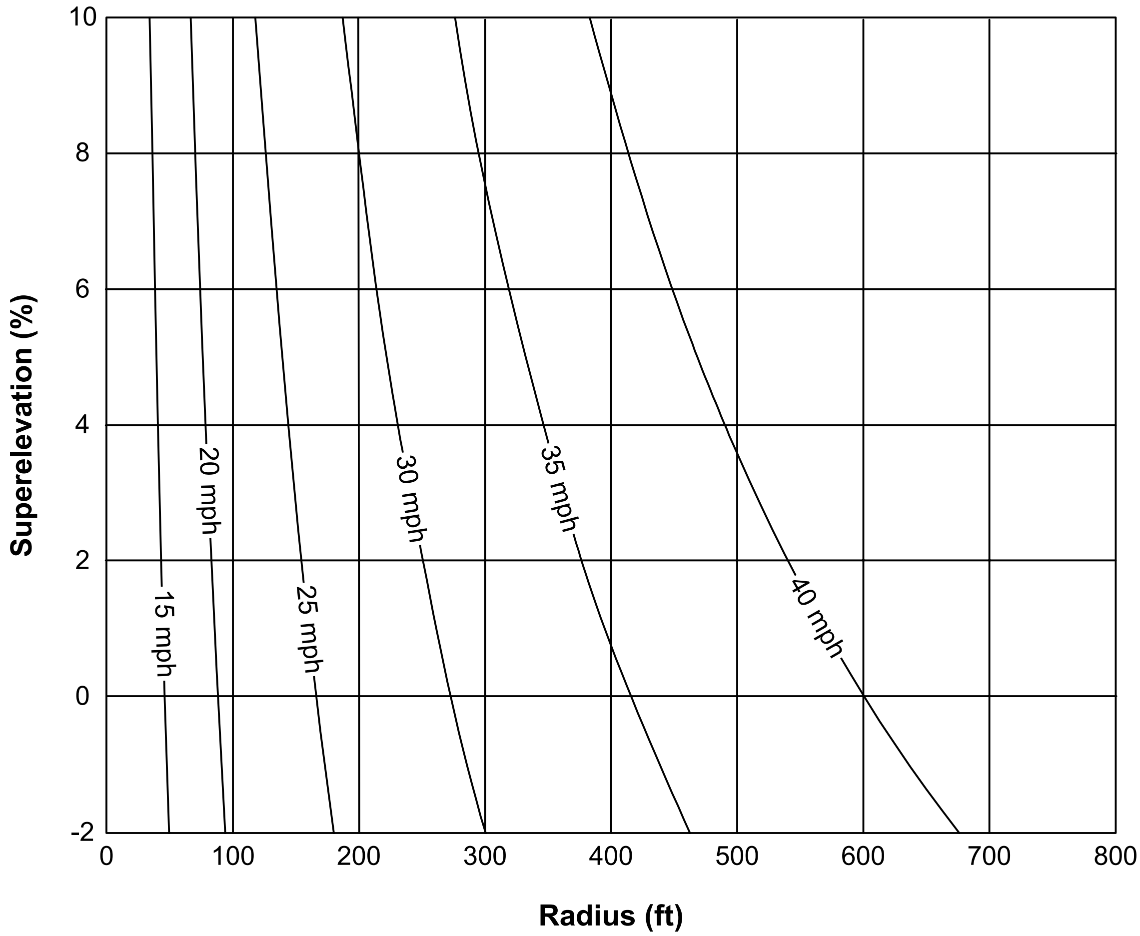




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	60	110	175	255	350	465	605	760	965	1205	1490	1820	2215	2675

Superelevation Rates (8% max)

Figure 642-3c



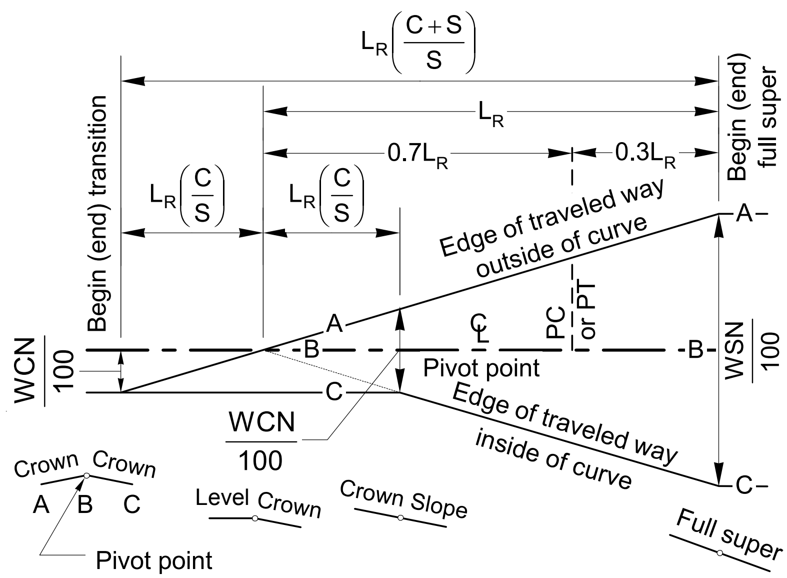
Superelevation Rates for Low-Speed Urban Managed Access Highways
Figure 642-4

S (%)	L_B=Basic runoff in feet for Design Speed of:													
	15 mph	**20 mph**	**25 mph**	**30 mph**	**35 mph**	**40 mph**	**45 mph**	**50 mph**	**55 mph**	**60 mph**	**65 mph**	**70 mph**	**75 mph**	**80 mph**
2	30	30	35	35	40	40	45	50	50	55	55	60	65	70
3	45	50	50	55	60	60	65	70	75	80	85	90	95	105
4	60	65	70	75	75	85	90	95	100	105	110	120	125	135
5	75	80	85	90	95	105	110	120	130	135	140	150	160	170
6	90	95	105	110	115	125	135	145	155	160	170	180	190	205
7	110	115	120	130	135	145	155	170	180	185	195	210	220	240
8	125	130	135	145	155	165	180	190	205	215	225	240	250	275
9	140	145	155	165	175	185	200	215	230	240	250	270	285	310
10	155	160	170	180	195	205	220	240	255	265	280	300	315	345

* Based on one 12 ft lane between the pivot point and the edge of traveled way. When the distance exceeds 12 ft use the following equation to obtain L_R:
$L_R = L_B(1+0.04167X)$

Where:

X = The distance in excess of 12 ft between the pivot point and the furthest edge of traveled way, in feet



Design A Pivot Point on Center Line
Crown Section

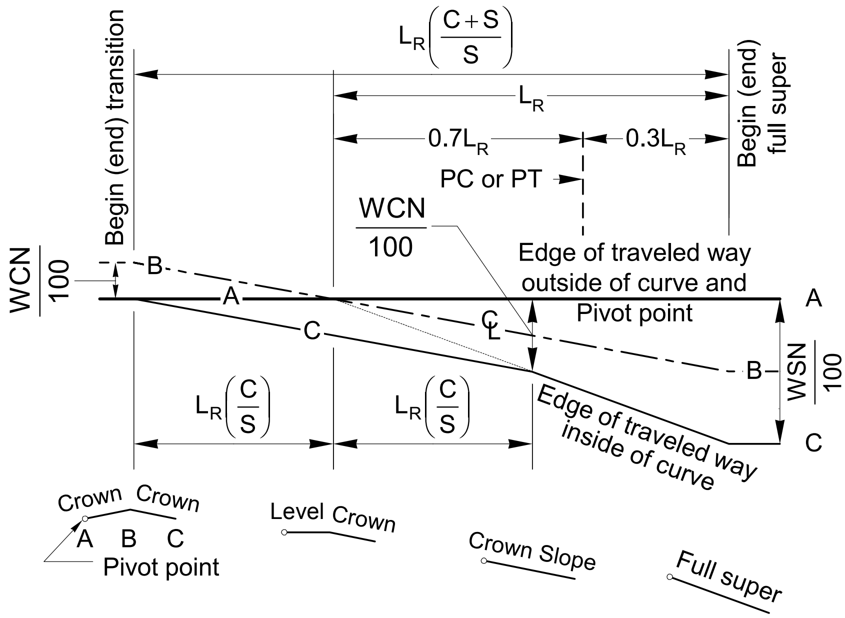
C = Normal crown(%)

S = Superelevation rate (%)

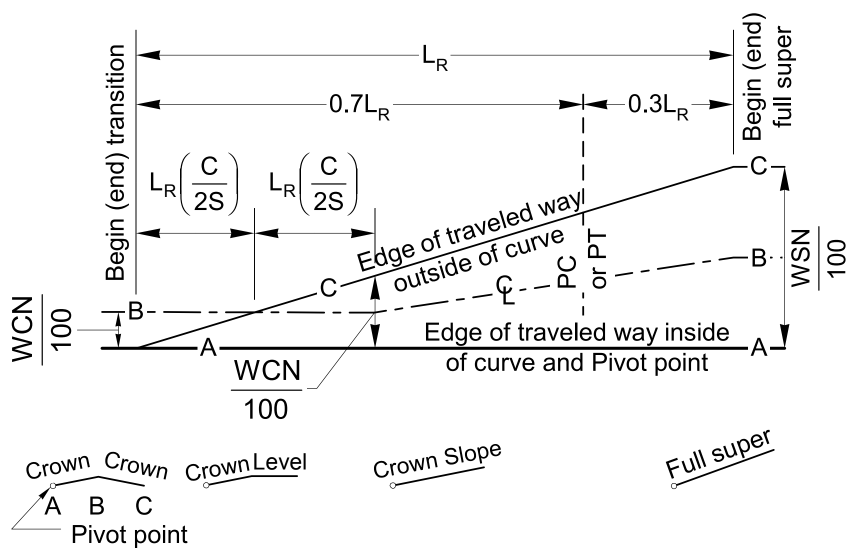
N = Number of lanes between points

W = Width of lane

Superelevation Transitions for Highway Curves
Figure 642-5a



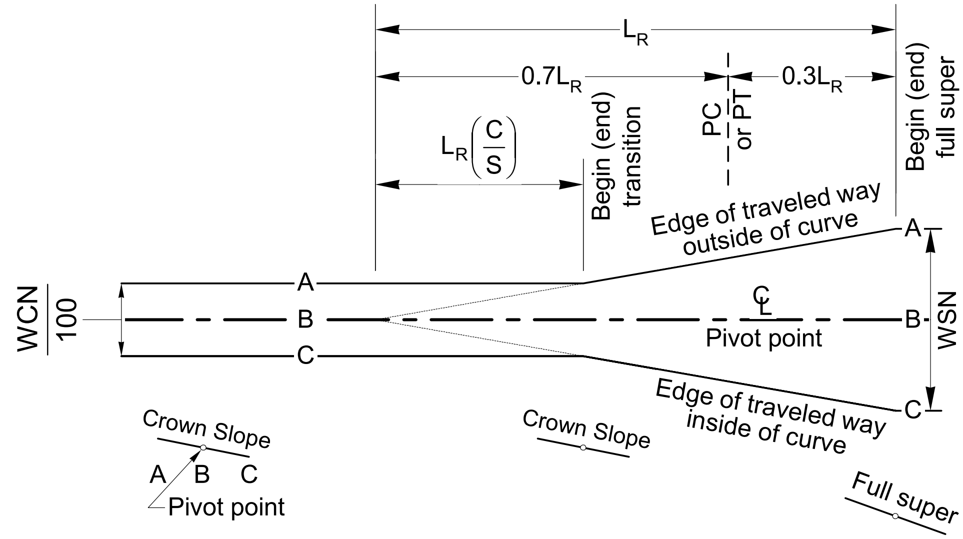
Design B[1] Pivot Point on Edge of Traveled Way
Outside of Curve Crowned Section



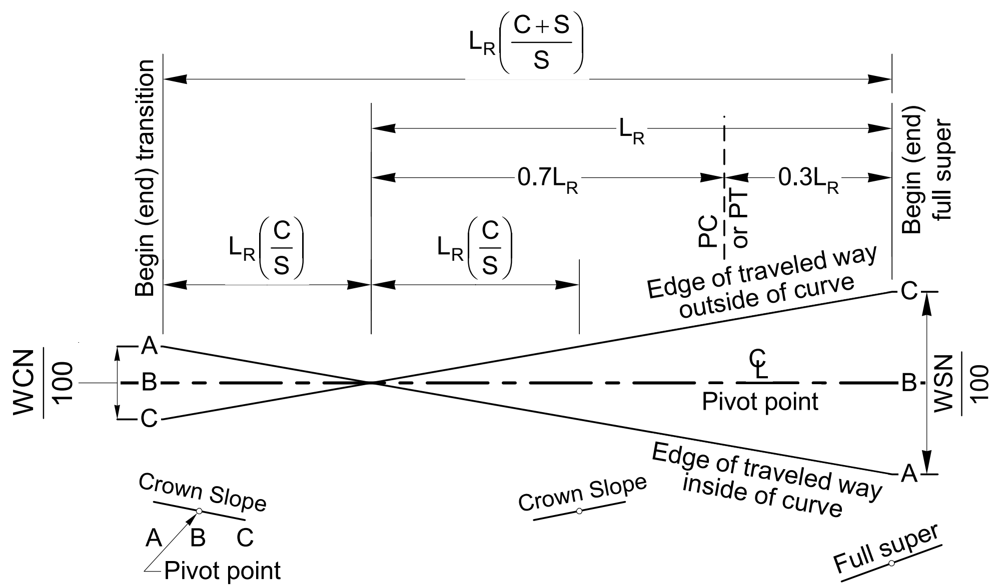
Design B[2] Pivot Point on Edge of Traveled Way
Inside of Curve Crowned Section

C = Normal crown(%)
S = Superelevation rate (%)
N = Number of lanes between points
W = Width of lane

Superelevation Transitions for Highway Curves
Figure 642-5b



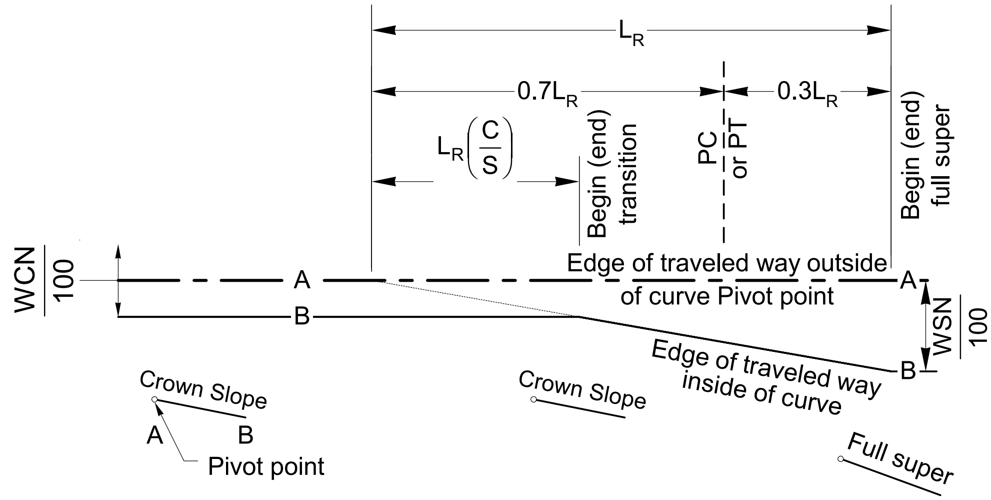
Design C[1] Pivot point on center line curve in direction of normal pavement slope - plane section



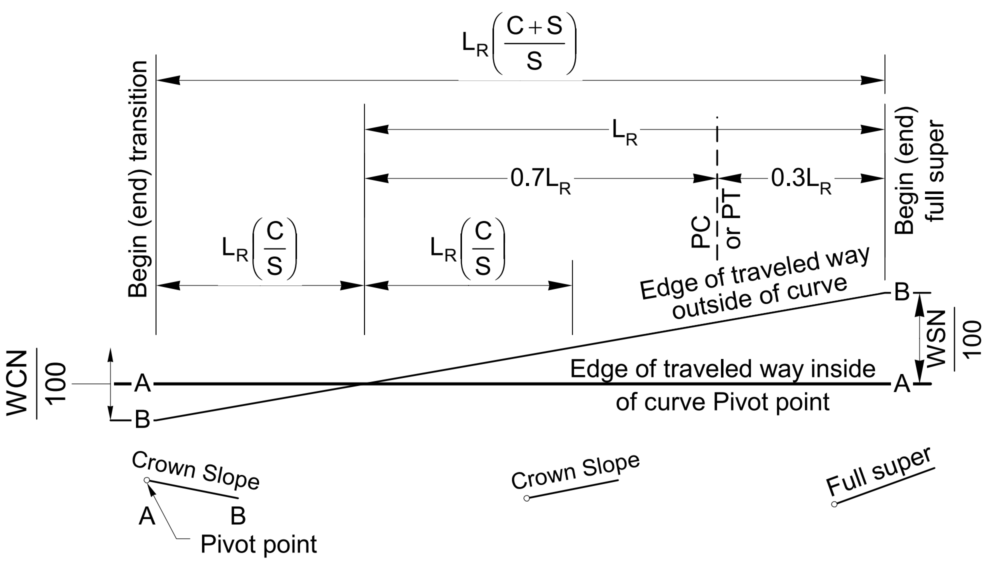
Design C[2] Pivot point on center line curve opposite to normal pavement slope - plane section

C = Normal crown(%)
S = Superelevation rate (%)
N = Number of lanes between points
W = Width of lane

Superelevation Transitions for Highway Curves
Figure 642-5c



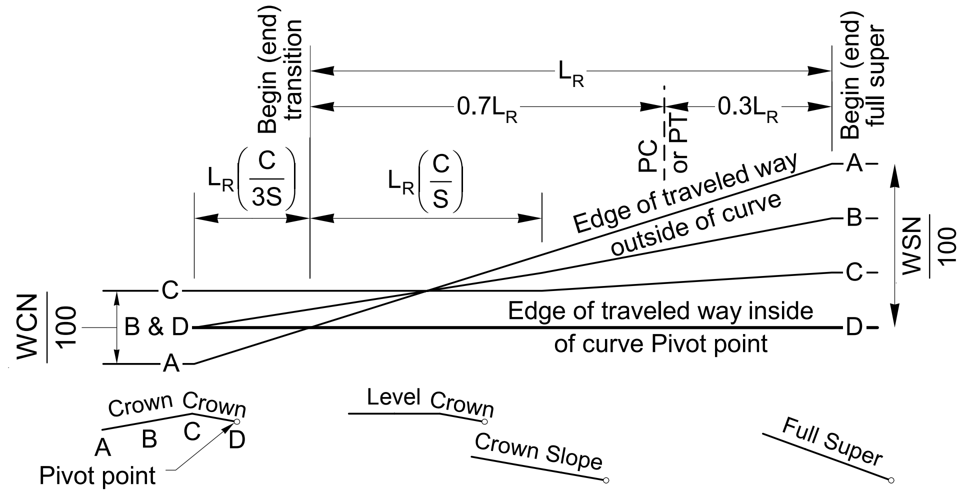
Design D[1] Pivot point on edge of traveled way curve in direction of normal pavement slope - plane section



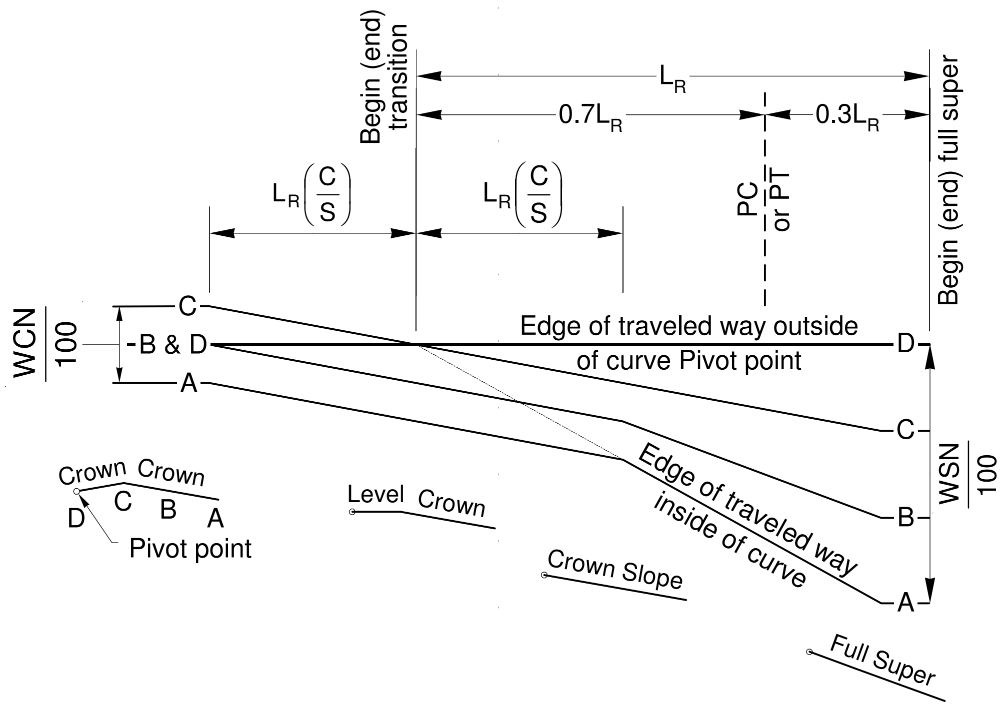
Design D[2] Pivot point on edge of traveled way curve opposite to normal pavement slope - plane section

C = Normal crown(%)
S = Superelevation rate (%)
N = Number of lanes between points
W = Width of lane

Superelevation Transitions for Highway Curves
Figure 642-5d



Design E[1] Six lane with median, pivot point on edge of traveled way inside of curve crown section

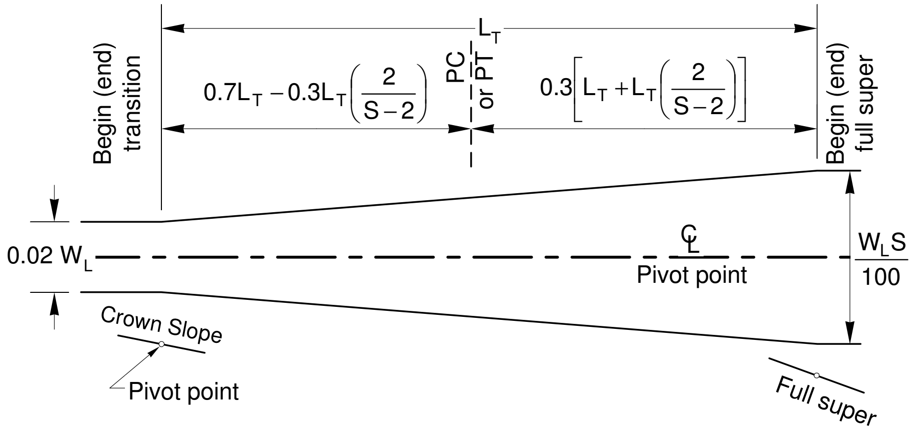


Design E[2] Six lane with median, pivot point on edge of traveled way outside of curve crown section

C = Normal crown(%)
S = Superelevation rate (%)
N = Number of lanes between points
W = Width of lane

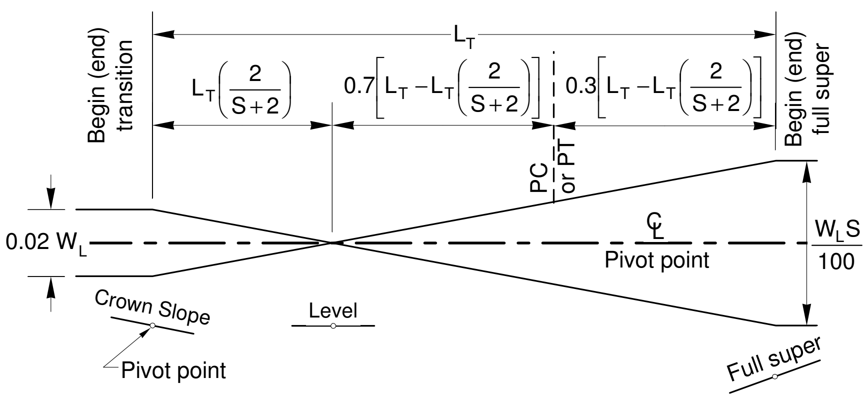
Superelevation Transitions for Highway Curves

Figure 642-5e



S (%)	Length of transition in feet for Design Speed of:							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
3	10	15	15	15	15	15	15	15
4	20	25	25	25	25	30	30	35
5	30	35	35	35	40	45	45	50
6	40	45	45	50	55	55	60	65
7	50	55	55	60	65	70	75	80
8	60	65	70	75	80	85	90	95
9	70	75	80	85	95	100	105	110
10	80	85	90	100	105	115	120	130

Table 1 Pivot Point on Center Line — Curve in Direction of Normal Pavement Slope

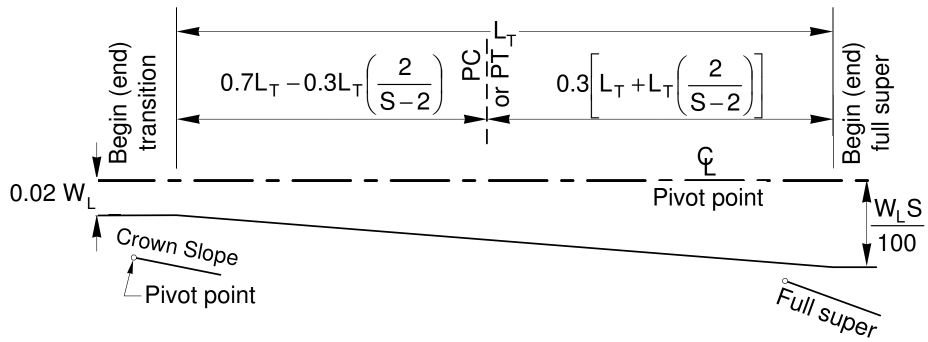


S (%)	Length of transition in feet for Design Speed of:							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
2	40	40	45	50	55	55	60	65
3	50	55	55	60	65	70	75	80
4	60	65	70	75	80	85	90	95
5	70	75	80	85	90	100	105	110
6	80	85	90	95	105	115	120	130
7	90	95	100	110	120	125	135	145
8	100	105	115	120	130	140	150	160
9	110	120	125	135	145	155	165	175
10	120	130	135	145	160	170	180	190

Table 2 Pivot Point on Center Line — Curve in Direction Opposite to Normal Pavement Slope
W_L=width of ramp lane.

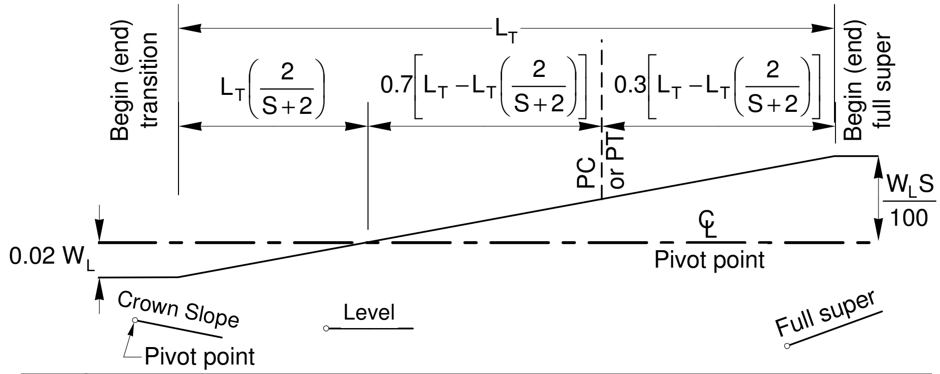
Superelevation Transitions for Ramp Curves

Figure 642-6a



S (%)	Length of transition in feet for Design Speed of:							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
3	20	25	25	25	25	30	30	35
4	40	45	45	50	55	55	60	65
5	60	65	70	75	80	85	90	95
6	80	85	90	100	105	115	120	130
7	100	105	115	120	130	140	150	160
8	120	130	135	145	160	170	180	190
9	140	150	160	170	185	195	210	225
10	160	170	180	195	210	225	240	255

Table 3 Pivot point on edge of traveled way — curve in direction of normal pavement slope



S (%)	Length of transition in feet for Design Speed of:							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
2	80	85	90	100	105	115	120	130
3	100	105	115	120	130	140	150	160
4	120	130	135	145	160	170	180	190
5	140	150	160	170	185	195	210	225
6	160	170	180	195	210	225	240	255
7	180	190	205	220	235	255	270	290
8	200	210	225	245	265	280	300	320
9	220	235	250	265	290	310	330	350
10	240	255	270	290	315	340	360	385

Table 4 Pivot point on edge of traveled way — curve in direction opposite to normal pavement slope

W_L=width of ramp lane.

Superelevation Transitions for Ramp Curves

Figure 642-6b

650.01 General

It is essential that the driver of a vehicle be able to see far enough ahead to assess developing situations and take appropriate action. For purposes of design, the required sight distance is considered in terms of passing sight distance, stopping sight distance, and decision sight distance.

For additional information, see the following chapters:

Chapter	Subject
910	sight distance at intersections at grade
915	sight distance at roundabouts
920	sight distance at road approaches
930	sight distance at railroad crossings
1020	sight distance for paths and trails

650.02 References

Design Guidance Guidance included by reference within the text includes:

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the Washington State Modifications to the MUTCD, Chapter 468-95 WAC, (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Supporting Information Other resources used or referenced in this chapter includes:

A Policy on Geometric Design of Highways and Streets, AASHTO, 2001

650.03 Definitions

decision sight distance The distance required for a driver to detect an unexpected or difficult-to-perceive information source or hazard, interpret the information, recognize the hazard, select an appropriate maneuver, and complete it safely and efficiently.

design speed The speed used to determine the various geometric design features of the roadway.

passing sight distance The distance (on a two-lane highway) required for a vehicle to execute a normal passing maneuver based on design conditions and design speed.

roadside That area between the outside shoulder edge and the right of way limits. The median area between the edges the shoulders on a divided highway is also considered roadside.

roadway The portion of a highway, including shoulders, for vehicular use.

rural design area An area that meets none of the conditions to be an urban design area.

sight distance The length of highway visible to the driver.

stopping sight distance The distance required to safely stop a vehicle traveling at design speed.

suburban area A term for the area at the boundary of an urban area. Suburban settings may combine the higher speeds common in rural areas with activities that are more similar to urban settings.

urban area An area designated by WSDOT in cooperation with the Transportation Improvement Board and regional transportation planning organizations, subject to the approval of the FHWA.

urban design area An area where urban design criteria is appropriate, that is defined by one or more of the following:

- An urban area.
- An area within the limits of an incorporated city or town.

- An area characterized by intensive use of the land for the location of structures and receiving such urban services as sewer, water, and other public utilities and services normally associated with an incorporated city or town. This may include an urban growth area defined under the Growth Management Act (Chapter 36.70A RCW Growth management—planning by selected counties and cities), but outside the city limits.
- An area with not more than 25% undeveloped land.

650.04 Stopping Sight Distance

(1) Design Criteria

Stopping sight distance is the sum of two distances: the distance traveled during perception and reaction time and the distance required to stop the vehicle. The perception and reaction time used in design is 2.5 seconds. The stopping distance is calculated using a constant deceleration rate of 11.2 feet/second^2.

Provide design stopping sight distance (see Figure 650-1) at all points on all highways and on all intersecting roadways, except when evaluating an existing roadway, as provided in 650.04(7).

Available stopping sight distance is calculated for a passenger car using an eye height (h_1) of 3.50 feet and an object height (h_2) of 0.50 foot. Although AASHTO allows a 2-foot object height, a 0.5-foot object height is used because objects with a height between 0.5 foot and 2 feet may be perceived as hazards that would likely result in an erratic maneuver. In urban design areas, with justification, the object height (h_2) may be increased to 2.00 feet. Figure 650-1 gives the design stopping sight distances for grades less than 3%, the minimum curve length for a 1% grade change to provide the sight distance (using h_2=0.50 feet) for a crest (K_C) and sag (K_S) vertical curve, and the minimum length of vertical curve for the design speed (VCL_m). (See 650.04(2) for sight distances when the grade is 3% or greater.)

Design Speed (mph)	Design Stopping Sight Distance (ft)	K_C	K_S	VCL_m (ft)
25	155	18	25	75
30	200	30	36	90
35	250	47	49	105
40	305	70	63	120
45	360	98	78	135
50	425	136	96	150
55	495	184	115	165
60	570	244	136	180
65	645	313	157	195
70	730	401	180	210
75	820	506	206	225
80	910	623	231	240

Design Stopping Sight Distance
Figure 650-1

(2) Effects of Grade

The grade of the highway has an effect on the vehicle's stopping sight distance. The stopping distance is increased on downgrades and decreased on upgrades. Figure 650-2 gives the stopping sight distances for grades of 3% and steeper. When evaluating sight distance with a changing grade, use the grade for which the longest sight distance is needed.

Design Speed (mph)	Stopping Sight Distance (ft)					
	Downgrade			Upgrade		
	-3%	-6%	-9%	3%	6%	9%
25	158	165	173	147	143	140
30	205	215	227	190	184	179
35	258	271	288	237	229	222
40	315	333	354	289	278	269
45	378	401	428	345	331	320
50	447	474	508	405	389	375
55	520	553	594	470	450	433
60	599	638	687	539	515	495
65	683	729	786	612	585	561
70	772	826	892	690	658	631
75	867	928	1004	773	736	705
80	966	1037	1123	860	818	782

Design Stopping Sight Distance on Grades
Figure 650-2

For stopping sight distances on grades between those listed, interpolate between the values given or use the equation in Figure 650-3.

$$S = 1.47Vt + \frac{V^2}{30\left[\left(\frac{a}{32.2}\right) \pm \frac{G}{100}\right]}$$

Where:
S = Stopping sight distance on grade (ft)
V = Design speed (mph)
t = Perception/reaction time (2.5 sec)
a = Deceleration rate (11.2 ft/sec^2)
G = Grade (%)

Stopping Sight Distance on Grades
Figure 650-3

(3) Crest Vertical Curves

Use Figure 650-11 or the equations in Figure 650-4 to find the minimum crest vertical curve length to provide stopping sight distance when given the algebraic difference in grades. When using the equations in Figure 650-4, use h_1=3.50 feet and h_2=0.50 foot. Figure 650-11 does not use the sight distance greater than the length of curve equation. When the sight distance is greater than the length of curve and the length of curve is critical, the S>L equation given in Figure 650-4 may be used to find the minimum curve length.

When a new crest vertical curve is built or an existing one is rebuilt with grades less than 3%, provide Design Stopping Sight Distance from Figure 650-1. When grades are 3% or greater, see 650.04(2) for required sight distance.

In urban design areas, with justification, an object height (h_2) of 2.00 feet may be used with the equations in Figure 650-4.

When evaluating an existing roadway, see 650.04(7).

When S>L

$$L = 2S - \frac{200\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}{A} \qquad S = \frac{L}{2} + \frac{100\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}{A}$$

When S<L

$$L = \frac{AS^2}{200\left(\sqrt{h_1} + \sqrt{h_2}\right)^2} \qquad S = \sqrt{\frac{200L\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}{A}}$$

Where:
L = Length of vertical curve (ft)
S = Sight distance (ft)
A = Algebraic difference in grades (%)
h_1 = Eye height (3.50 ft)
h_2 = Object height—*see text* (ft)

Sight Distance, Crest Vertical Curve
Figure 650-4

(4) Sag Vertical Curves

Sag vertical curves are only a sight restriction during the hours of darkness. Headlight sight distance is used for the sight distance design criteria at sag vertical curves. In some cases, a lesser length may be allowed. (See Chapter 630 for guidance and requirements.)

Use Figure 650-12 or the equations in Figure 650-5 to find the minimum length for a sag vertical curve to provide the headlight stopping sight distance when given the algebraic difference in grades. The sight distance greater than the length of curve equation is not used in Figure 650-12. When the sight distance is greater than the length of curve and the length of curve is critical, the S>L equation given in Figure 650-5 may be used to find the minimum length of curve.

When a new sag vertical curve is built or an existing one is rebuilt with grades less than 3%, provide Design Stopping Sight Distance from Figure 650-1. When grades are 3% or greater, see 650.04(2) for required sight distance.

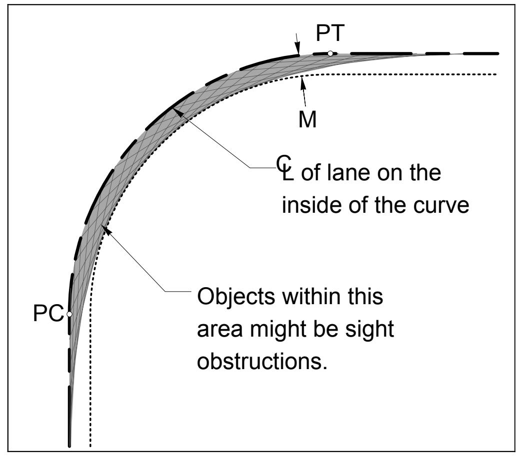
When evaluating an existing roadway, see 650.04(7).

Where S>L	
$L = 2S - \frac{400 + 3.5S}{A}$	$S = \frac{LA + 400}{2A - 3.5}$
Where S<L	
$L = \frac{AS^2}{400 + 3.5S}$	$S = \frac{3.5L \pm \sqrt{(3.5L)^2 + 1600AL}}{2A}$
Where: L = Curve length (ft) A = Algebraic grade difference (%) S = Sight distance (ft)	

Sight Distance, Sag Vertical Curve
Figure 650-5

(5) Horizontal Curves

Use Figure 650-13a or the equation in Figure 650-7 to check for adequate stopping sight distance where sight obstructions are on the inside of a curve. A stopping sight distance obstruction is any roadside object within the M distance (such as median barrier, guardrail, bridges, walls, cut slopes, wooded areas, and buildings), 2 feet or greater above the roadway surface at the centerline of the lane on the inside of the curve. Figure 650-13a and the equation in Figure 650-7 are for use when the length of curve is greater than the sight distance and the sight restriction is more than half the sight distance from the end of the curve. When the length of curve is less than the stopping sight distance or the sight restriction is near either end of the curve, the desired sight distance may be available with a lesser M distance. (See Figure 650-6.) When this occurs, the sight distance can be checked graphically.



Sight Distance Area on Horizontal Curves
Figure 650-6

When the road grade is less than 3%, provide Design Stopping Sight Distance from Figure 650-1.

When the grade is 3% or greater, see 650.04(2) for required sight distance.

In urban design areas, with justification, a 2.00-foot object height (h_2) may be used. When h_2=2.00 feet, roadside objects between 2.00 feet and 2.75 feet might not be a sight obstruction. (See Figure 650-13b for guidance on determining whether a roadside object is a sight obstruction.)

When evaluating an existing roadway, see 650.04(7).

$M = R\left[1 - \cos\left(\frac{28.65\,S}{R}\right)\right]$
$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R - M}{R}\right)\right]$
Where: M = Distance from the centerline of the inside lane of the curve to the sight obstruction (ft) R = Radius of the curve (ft) S = Sight distance (ft)

Sight Distance, Horizontal Curves
Figure 650-7

(6) Overlapping Horizontal and Vertical Curves

A vertical curve will affect the height at which a roadside object will become a sight obstruction. A crest vertical curve will raise roadside objects and make them more likely to become sight obstructions. A sag vertical curve will lower roadside objects, making them less likely to be sight obstructions.

(7) Existing Stopping Sight Distance

Existing stopping sight distance is used when the vertical and horizontal alignments are unchanged, the sight obstruction is existing, and there are no problems related to the sight distance. Figure 650-8 gives the values for existing stopping sight distance and the associated K_C and K_S. When evaluating the existing sight distance, use an object height (h_2) of 2.00 feet.

For crest vertical curves where the existing vertical alignment is retained and the existing roadway pavement is not reconstructed, existing stopping sight distance values in Figure 650-8 may be used. The minimum length of an existing crest vertical curve may be found using the equations in Figure 650-4 and h_2=2.00 feet, or using the K_C values from Figure 650-8.

For sag vertical curves where the existing vertical alignment is retained and the existing roadway pavement is not being reconstructed, existing stopping sight distance values in Figure 650-8 may be used. The minimum length of an existing sag vertical curve may be found using the equations in Figure 650-5, or using the K_S values from Figure 650-8. In some cases, when continuous illumination is provided, a lesser length may be allowed. (See Chapter 630 for guidance.)

For horizontal curves, existing stopping sight distance values from Figure 650-8 may be used when all of the following are met at the curve:

- The vertical and horizontal alignments are existing
- The roadway pavement will not be reconstructed
- The roadway will not be widened
- The sight obstruction is existing
- Roadside improvements to sight distance do not require additional right of way`

A sight obstruction is any roadside object within the M distance from the equation in Figure 650-7 with a height more than 2.75 feet above the centerline of the inside lane. Roadside objects between 2.00 feet and 2.75 feet might be a sight obstruction. (See Figure 650-13b for guidance on determining whether a roadside object is a sight obstruction.)

Design Speed (mph)	Existing Stopping Sight Distance (ft)	K_C	K_S
20	115	6	16
25	145	10	23
30	180	15	31
35	220	22	41
40	260	31	52
45	305	43	63
50	350	57	75
55	400	74	89
60	455	96	104
65	495	114	115
70	540	135	127
75	585	159	140
80	630	184	152

Existing Stopping Sight Distance
Figure 650-8

650.05 Passing Sight Distance

(1) Design Criteria

Passing sight distance is the sum of four distances:

- The distance traveled by the passing vehicle during perception and reaction time and initial acceleration to the point of encroachment on the opposing lane.
- The distance the passing vehicle travels in the opposing lane.
- The distance that an opposing vehicle travels during two-thirds of the time the passing vehicle is in the opposing lane.
- A clearance distance between the passing vehicle and the opposing vehicle at the end of the passing maneuver.

Sight distance for passing is calculated for a passenger car using an eye height (h_1) of 3.50 feet and an object height (h_2) of 3.50 feet. Figure 650-9 gives the passing sight distances for various design speeds.

Design Speed (mph)	Passing Sight Distance (ft)
20	710
25	900
30	1090
35	1280
40	1470
45	1625
50	1835
55	1985
60	2135
65	2285
70	2480
75	2580
80	2680

Passing Sight Distance
Figure 650-9

On two-lane two-way highways, provide passing opportunities to meet traffic volume demands. This can be accomplished by using numerous sections with safe passing sight distance or by adding passing lanes at critical locations. (See Chapter 1010.)

In the design stage, passing sight distance can be provided by adjusting the alignment either vertically or horizontally to increase passing opportunities.

These considerations also apply to multilane highways where staged construction includes a two-lane two-way operation as an initial stage. Whether auxiliary lanes are provided, however, depends on the time lag proposed between the initial stage and the final stage of construction.

(2) Vertical Curves

Figure 650-14 gives the length of crest vertical curve needed to provide passing sight distance for two-lane highways. The distance from Figure 650-9 and the equations in Figure 650-4, using 3.50 feet for both h_1 and h_2, may also be used to determine the minimum length of vertical curve to provide the required passing sight distance.

Sag vertical curves are not a restriction to passing sight distance.

(3) Horizontal Curves

Passing sight distance can be restricted on the inside of a horizontal curve by roadside objects that are 3.50 feet or more above the roadway surface. Use the distance from Figure 650-9 and the equation in Figure 650-7 to determine whether the object is close enough to the roadway to be a restriction to passing sight distance. The equation assumes that the curve length is greater than the sight distance. Where the curve length is less than the sight distance, the desired sight distance may be available with a lesser M distance.

(4) No-Passing Zone Markings

Knowledge of the practices used for marking no-passing zones on two-lane roads is helpful in designing a safe highway. The values in Figure 650-9 are the passing sight distances starting at the point the pass begins. The values in the MUTCD are lower than the Figure 650-9 values. They are for no-passing zone marking limits and start at the point the safe pass must be completed.

The MUTCD values are not to be used directly in design, but are discussed for the designer's recognition of locations requiring no-passing pavement markings. Sections of highway providing passing sight distance in the range of values between the distances in Figure 650-9 and MUTCD values require careful review by the designer.

650.06 Decision Sight Distance

Decision sight distance values are greater than stopping sight distance values because they give the driver an additional margin for error and afford sufficient length to maneuver at the same or reduced speed rather than to just stop.

Provide decision sight distance where highway features create the likelihood for error in information reception, decision making, or control actions. Example highway features include interchanges; intersections; changes in cross section (such as at toll plazas and drop lanes); and areas of concentrated demand where sources of information compete (for example, those from roadway elements, traffic, traffic control devices, and advertising signs). If possible, locate these highway features where decision sight distance can be provided. If this is not possible, use suitable traffic control devices and positive guidance to give advanced warning of the conditions.

Use the decision sight distances in Figure 650-10 where highway features require complex driving decisions.

Design Speed (mph)	Decision Sight Distance for Maneuvers (ft)				
	A	B	C	D	E
30	220	490	450	535	620
35	275	590	525	625	720
40	330	690	600	715	825
45	395	800	675	800	930
50	465	910	750	890	1030
55	535	1030	865	980	1135
60	610	1150	990	1125	1280
65	695	1275	1050	1220	1365
70	780	1410	1105	1275	1445
75	875	1545	1180	1365	1545
80	970	1685	1260	1455	1650

Decision Sight Distance
Figure 650-10

The maneuvers in Figure 650-10 are as follows:

A. Rural stop

B. Urban stop

C. Rural speed/path/direction change

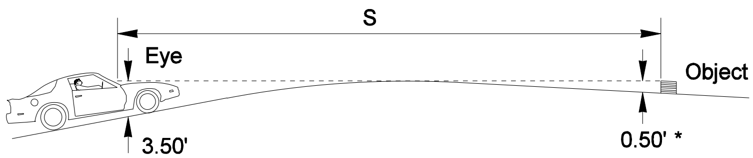
D. Suburban speed/path/direction change

E. Urban speed/path/direction change

Decision sight distance is calculated using the same criteria as stopping sight distance: h_1=3.50 feet and h_2=0.50 foot. Use the equations in Figures 650-4, 5, and 7 to determine the decision sight distance for crest vertical curves, sag vertical curves, and horizontal curves.

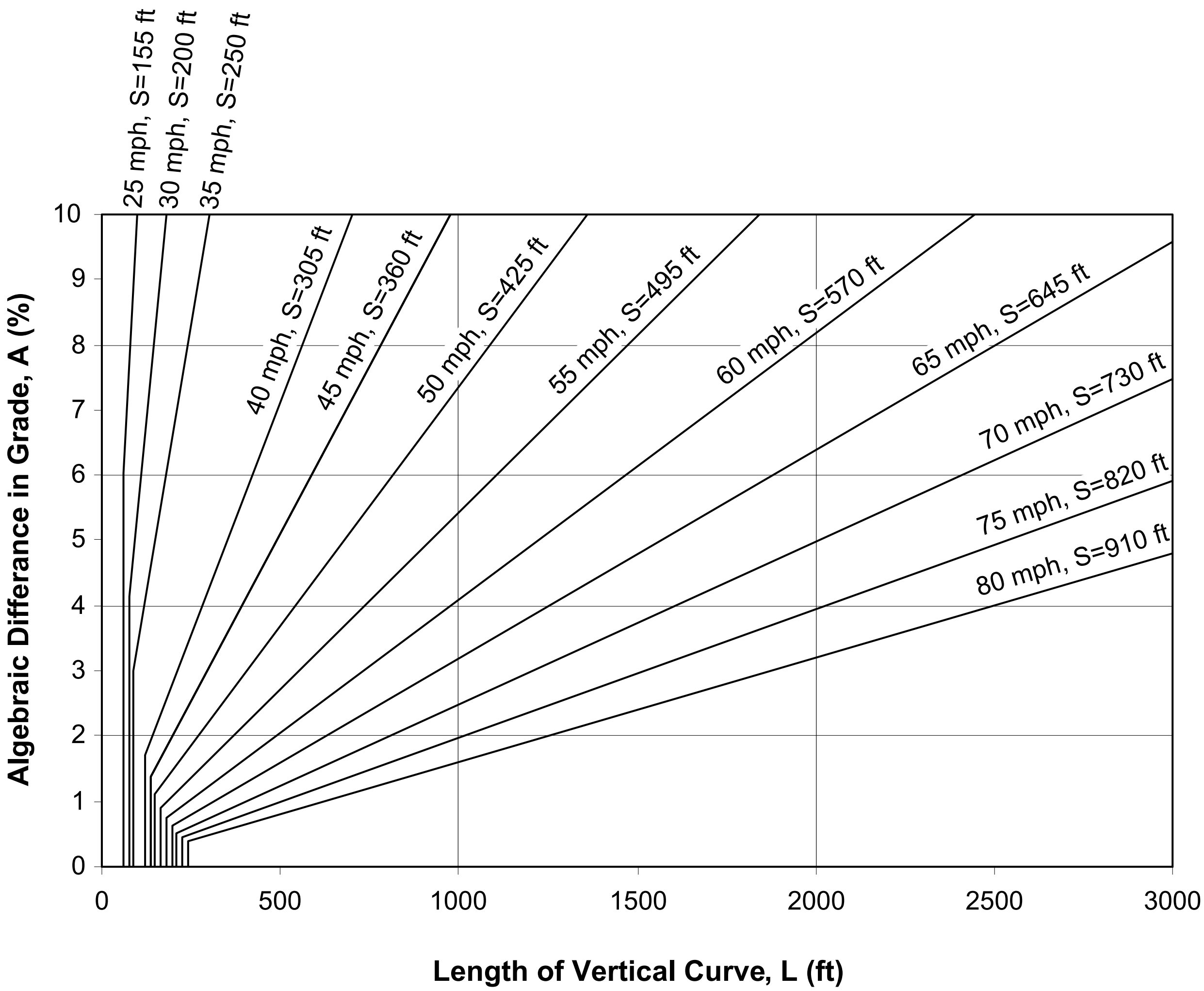
650.07 Documentation

The list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

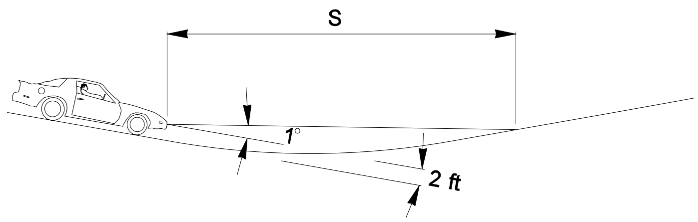


The minimum length can also be determined by multiplying the algebraic difference in grades by the K_C value from Figure 650-1 ($L=K_C*A$). Both the figure and the equation give approximately the same length of curve. Neither use the S>L equation.

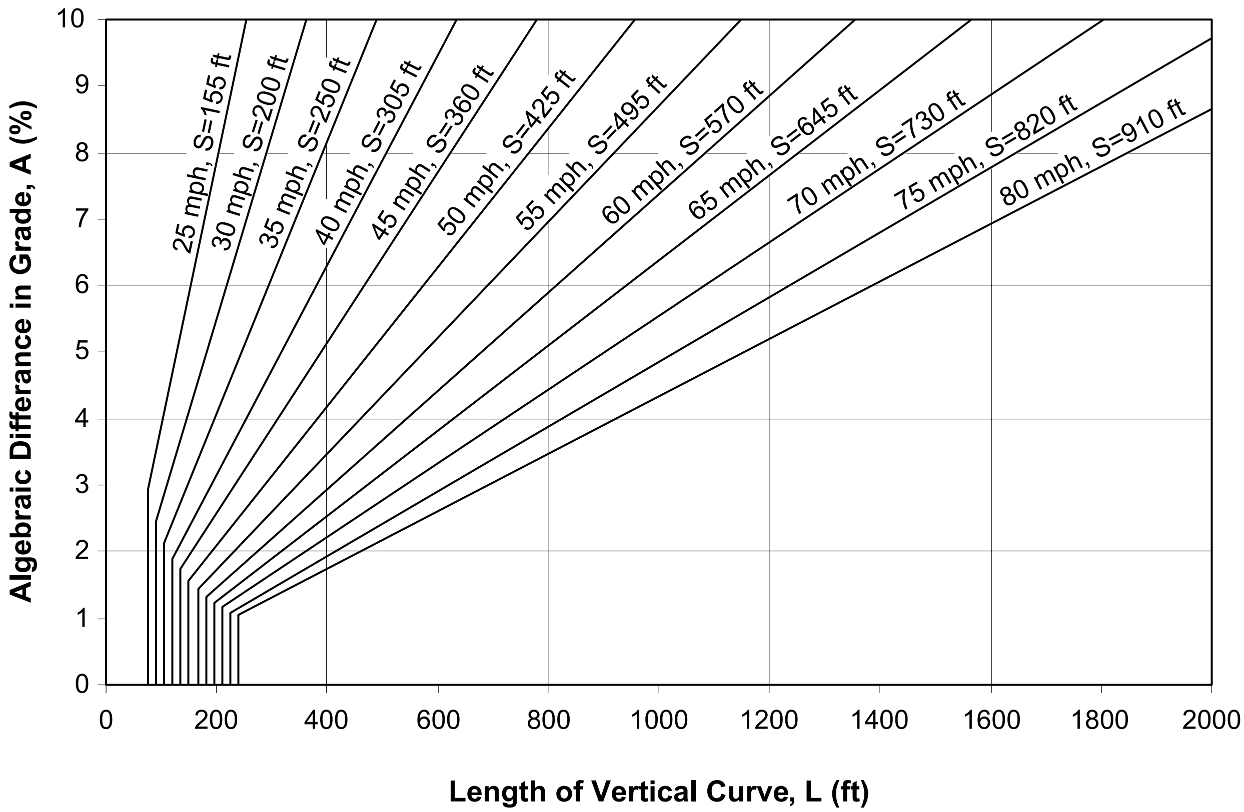
* This chart is based on a 0.50-foot object height. When a higher object height is allowed (see 650.04(3) for guidance), the equations in Figure 650-4 must be used.



Stopping Sight Distance for Crest Vertical Curves
Figure 650-11

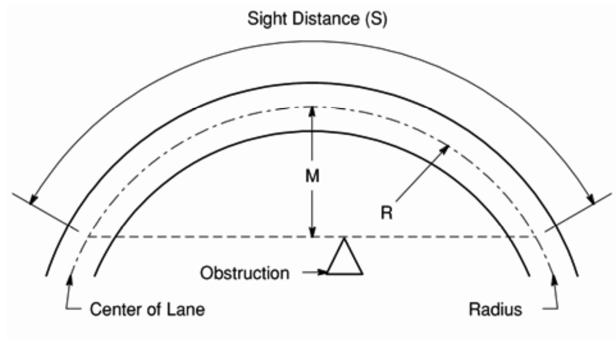


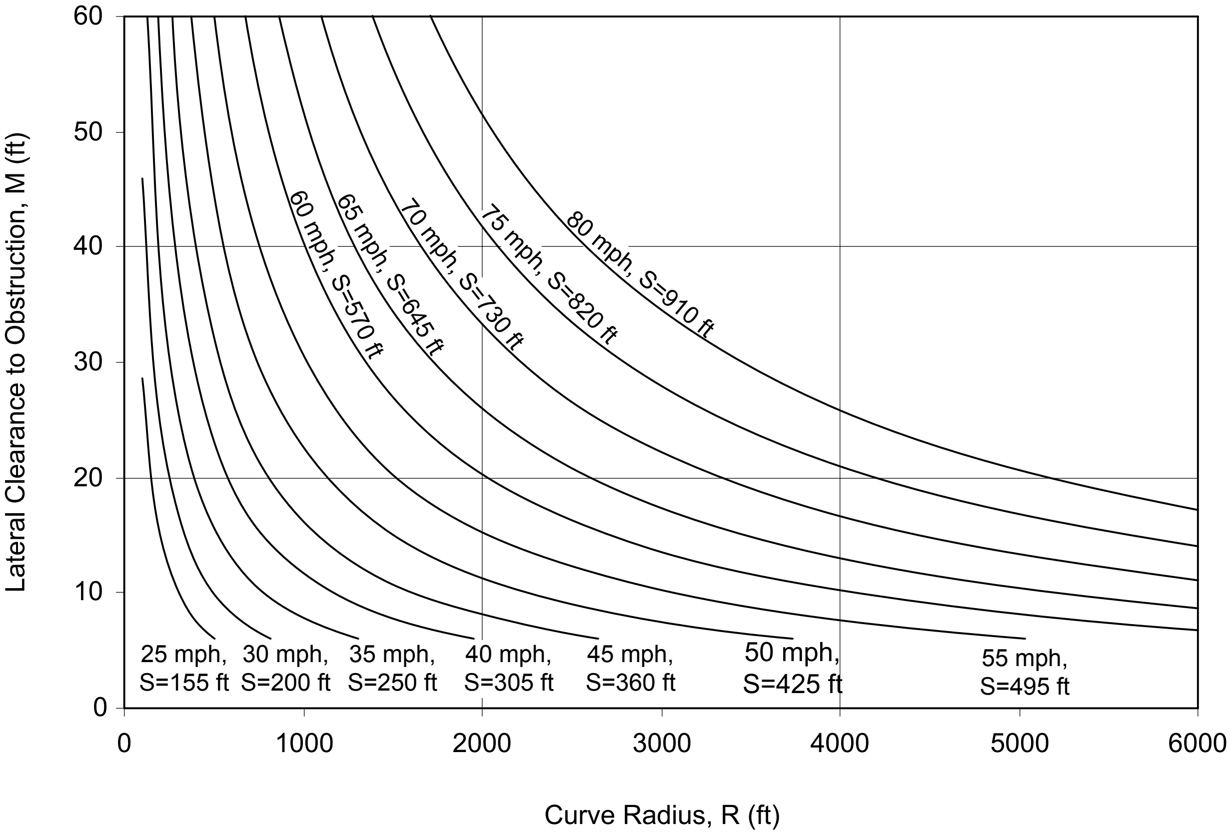
The minimum length can also be determined by multiplying the algebraic difference in grades by the K_S value from Figure 650-1 ($L=K_S*A$). Both the figure and equation give approximately the same length of curve. Neither use the S>L equation.



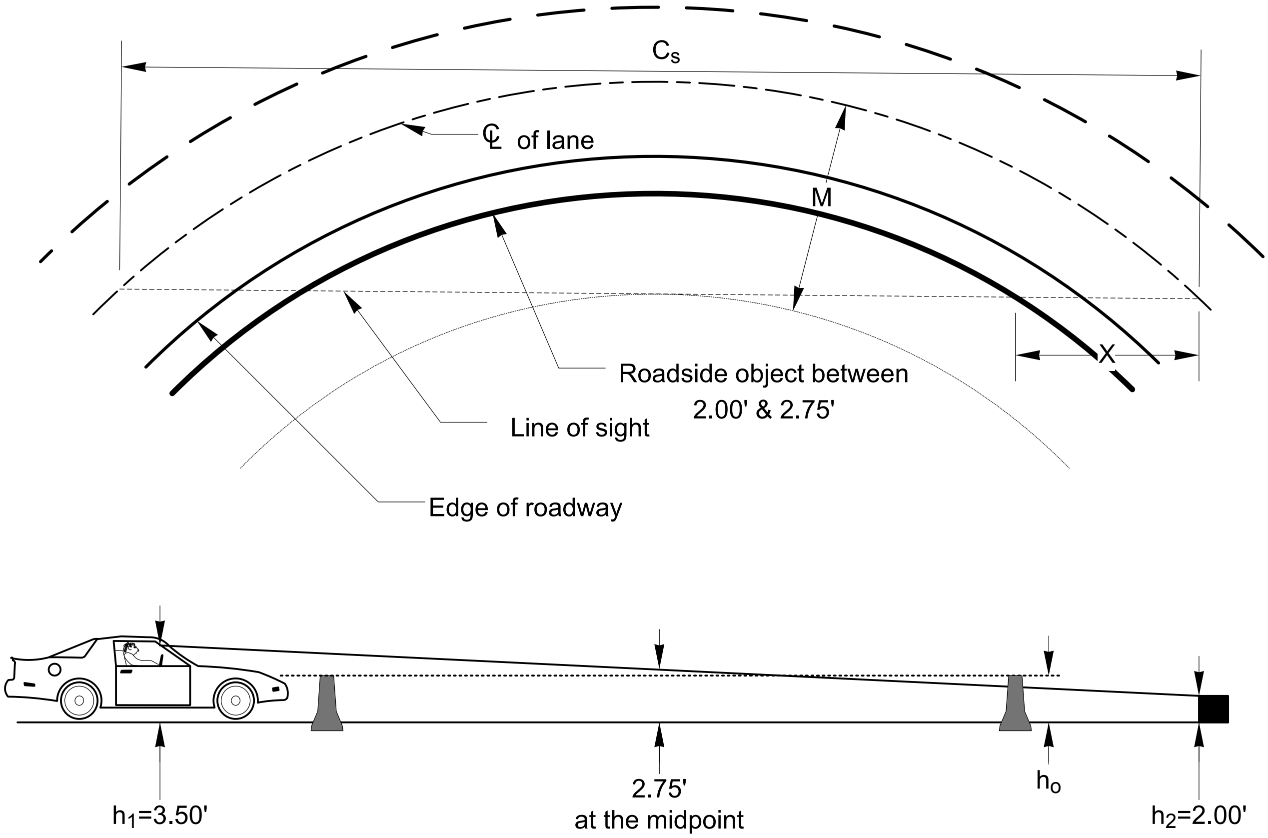
Stopping Sight Distance for Sag Vertical Curves
Figure 650-12

When h_2=2.00 ft, objects between 2.00 ft and 2.75 ft above the centerline of the inside lane might be a sight obstruction. (See Figure 650-13b for guidance.)





Horizontal Stopping Sight Distance
Figure 650-13a



When $h_o > \left(2 + \frac{0.75X}{½C_s}\right)$, roadside object is a sight obstruction.

Where:

M = Lateral clearance for sight distance (feet) (see Figure 650-7)

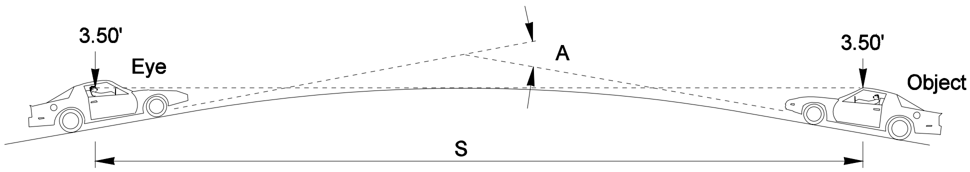
C_s = Stopping sight distance chord (feet)

X = Distance from the sight obstruction to the end of the sight distance chord (feet)

h_o = Height of roadside object above the centerline of the inside lane (feet)

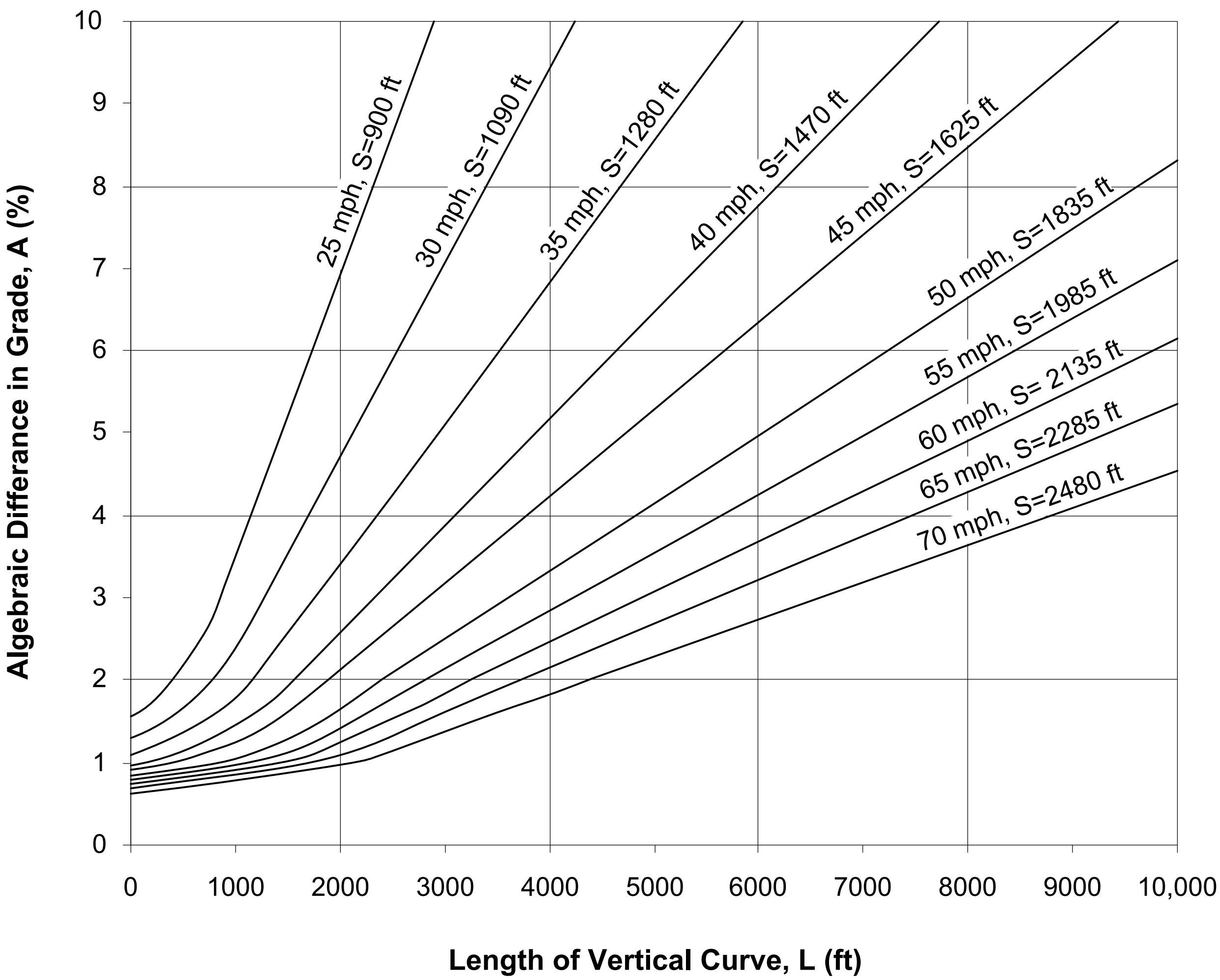
Horizontal Stopping Sight Distance

Figure 650-13b



Where S>L	
$L = 2S - \frac{2800}{A}$	$S = \frac{L}{2} + \frac{1400}{A}$
Where S<L	
$L = \frac{AS^2}{2800}$	$S = \sqrt{\frac{2800L}{A}}$

L = Curve length (ft)
A = Algebraic grade difference (percent)
S = Sight distance (ft)



Passing Sight Distance for Crest Vertical Curves
Figure 650-14

700.01 General

Roadside safety addresses the area outside of the roadway and is an important component of total highway design. There are numerous reasons why a vehicle leaves the roadway. Regardless of the reason, a forgiving roadside can reduce the seriousness of the consequences of a roadside encroachment. From a safety perspective, the ideal highway has roadsides and median areas that are flat and unobstructed by hazards.

Elements such as side slopes, fixed objects, and water are potential hazards that a vehicle might encounter when it leaves the roadway. These hazards present varying degrees of danger to the vehicle and its occupants. Unfortunately, geography and economics do not always allow ideal highway conditions. The mitigative measures to be taken depend on the probability of an accident occurring, the likely severity, and the available resources.

In order of preference, mitigative measures are: removal, relocation, reduction of impact severity (using breakaway features or making it traversable), and shielding with a traffic barrier. Consider cost (initial and life cycle costs) and maintenance requirements in addition to accident severity when selecting a mitigative measure. Use traffic barriers only when other measures cannot reasonably be accomplished. See Chapter 710 for additional information on traffic barriers.

700.02 References

A Policy on Geometric Design of *Highways and Streets* (Green Book), AASHTO, 2001

Revised Code of Washington (RCW) 47.24.020(2), "Jurisdiction, control"

RCW 47.32.130, "Dangerous objects and structures as nuisances"

City and County Design Standards (contained in the *Local Agency Guidelines,* M 36-63), WSDOT

Roadside Design Guide, AASHTO, 2002

Roadside Manual, M 25-30, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

700.03 Definitions

ADT The average daily traffic for the design year under consideration.

backslope A sideslope that goes up as the distance increases from the roadway (cut slopes).

clear run-out area The area beyond the toe of a nonrecoverable slope available for safe use by an errant vehicle.

clear zone The total roadside border area, starting at the edge of the traveled way, available for use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a nonrecoverable slope, and/or a clear run-out area. The clear zone cannot contain a critical fill slope.

critical fill slope A slope on which a vehicle is likely to overturn. Slopes steeper than 3H:1V are considered critical fill slopes.

Design Clear Zone The minimum target value used in highway design.

foreslope A sideslope that goes down as the distance increases from the roadway (fill slopes and ditch inslopes).

hazard A side slope, a fixed object, or water that, when struck, can result in unacceptable impact forces on the vehicle occupants or place the occupants in a hazardous position. A hazard can be either natural or manmade.

nonrecoverable slope A slope on which an errant vehicle will continue until it reaches the bottom, without having the ability to recover control. Fill slopes steeper than 4H:1V, but no steeper than 3H:1V, are considered nonrecoverable.

recoverable slope A slope on which the driver of an errant vehicle can regain control of the vehicle. Slopes of 4H:1V or flatter are considered recoverable.

recovery area The minimum target value used in highway design when a fill slope between 4H:1V and 3H:1V starts within the Design Clear Zone.

traffic barrier A longitudinal barrier, including bridge rail or an impact attenuator, used to redirect vehicles from hazards located within an established Design Clear Zone, to prevent median crossovers, to prevent errant vehicles from going over the side of a bridge structure, or (occasionally), to protect workers, pedestrians, or bicyclists from vehicular traffic.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

700.04 Clear Zone

A clear roadside border area is a primary consideration when analyzing potential roadside and median hazards (as defined in 700.05). The intent is to provide as much clear, traversable area for a vehicle to recover as practical. The Design Clear Zone is used to evaluate the adequacy of the existing clear area and proposed modifications of the roadside. When considering the placement of new objects along the roadside or median, evaluate the potential for impacts and try to select locations with the least likelihood of an impact by an errant vehicle.

(1) Design Clear Zone on All Limited Access State Highways and Other State Highways Outside Incorporated Cities and Towns

Evaluate the Design Clear Zone when the Clear Zone column on the design matrices (see Chapter 325) indicates evaluate upgrade (EU) or Full Design Level (F) or when considering the placement of a new fixed object on the roadside or median. Use the Design Clear Zone Inventory form (Figures 700-2a & 2b) to identify potential hazards and propose corrective actions.

Guidance for establishing the Design Clear Zone for highways outside of incorporated cities is provided in Figure 700-1. This guidance also applies to limited access state highways within the city limits. Providing a clear recovery area that is consistent with this guidance does not require any additional documentation. However, there might be situations where it is not practical to provide these recommended distances. In these situations, document the decision as an evaluate upgrade or deviation as discussed in Chapter 330.

For additional Design Clear Zone guidance relating to roundabouts, see Chapter 915.

While not required, the designer is encouraged to evaluate potential hazards even when they are beyond the Design Clear Zone distances.

For state highways that are in an urban environment but outside of an incorporated city, evaluate both median and roadside clear zones as discussed above using Figure 700-1. However, there might be some flexibility in establishing the Design Clear Zone in urbanized areas adjacent to incorporated cities and towns. To achieve this flexibility, an evaluation of the impacts including safety, aesthetics, the environment, economics, modal needs, and access control can be used to establish the Design Clear Zone. This discussion, analysis, and agreement must take place early in the consideration of the median and roadside designs. An agreement on the responsibility for these median and roadside sections must be formalized with the city and/or county. The justification for the design decision for the selected Design Clear Zone must be documented as part of a project or corridor analysis. (See Chapter 330.)

(2) Design Clear Zone Inside Incorporated Cities and Towns

For managed access state highways within an urban area, it is recognized that in many cases it will not be practical to provide the Design Clear Zone distances shown in Figure 700-1. Roadways within an urban area generally have curbs and sidewalks and might have objects such as trees, poles, benches, trash cans, landscaping, and transit shelters along the roadside.

(a) ***Roadside.*** For managed access state highways, it is the city's responsibility to establish an appropriate Design Clear Zone in accordance with guidance contained in the City and County Design Standards. Document the Design Clear Zone established by the city in the Design Documentation Package.

(b) ***Median.*** For managed access state highways with raised medians, the median's Design Clear Zone is evaluated using Figure 700-1. In some instances, a median analysis will show that certain median designs provide significant benefits to overall corridor or project operations. In these cases, flexibility in establishing the Design Clear Zone is appropriate. To achieve this flexibility, an evaluation of the impacts (including safety, aesthetics, the environment, economics, modal needs, and access control) can be used to establish the median clear zone. This discussion, analysis, and agreement must take place early in the consideration of the flexible median design. An agreement on the responsibility for these median sections must be formalized with the city. The justification for the design decision for the selected Design Clear Zone must be documented as part of a project or corridor analysis. (See Chapter 330.)

(3) Design Clear Zone and Calculations

The Design Clear Zone guidance provided in Figure 700-1 is a function of the posted speed, side slope, and traffic volume. There are no distances in the table for 3H:1V fill slopes. Although fill slopes between 4H:1V and 3H:1V are considered traversable if free of fixed objects, these slopes are defined as nonrecoverable slopes. A vehicle might be able to begin recovery on the shoulder, but will be unable to further this recovery until reaching a flatter area (4H:1V or flatter) at the toe of the slope. Under these conditions, the Design Clear Zone distance is called a recovery area. The method used to calculate the recovery area and an example are shown in Figure 700-3.

For ditch sections, the following criteria determine the Design Clear Zone:

(a) For ditch sections with foreslopes 4H:1V or flatter (see Figure 700-4, Case 1, for an example) the Design Clear Zone distance is the greater of the following:

- The Design Clear Zone distance for a 10H:1V cut section based on speed and the average daily traffic (ADT).
- A horizontal distance of 5 feet beyond the beginning of the backslope.

When a backslope steeper than 3H:1V continues for a horizontal distance of 5 feet beyond the beginning of the backslope, it is not necessary to use the 10H:1V cut slope criteria.

(b) For ditch sections with foreslopes steeper than 4H:1V, and backslopes steeper than 3H:1V the Design Clear Zone distance is 10 feet horizontal beyond the beginning of the backslope. (See Figure 700-4, Case 2, for an example.)

(c) For ditch sections with foreslopes steeper than 4H:1V and backslopes 3H:1V or flatter, the Design Clear Zone distance is the distance established using the recovery area formula (Figure 700-3). (See also Figure 700-4, Case 3, for an example.)

700.05 Hazards to Be Considered for Mitigation

There are three general categories of hazards: side slopes, fixed objects, and water. The following sections provide guidance for determining when these obstacles present a significant hazard to an errant motorist. In addition, several conditions require special consideration:

- Locations with high accident rate histories.
- Locations with pedestrian and bicycle usage. See Chapters 1020, "Bicycle Facilities," and 1025, "Pedestrian Design Considerations."

- Playgrounds, monuments, and other locations with high social or economic value.
- Redirectional land forms, also referred to as earth berms, were installed to mitigate hazards located in depressed medians and at roadsides. They were constructed of materials that provided support for a traversing vehicle. With slopes in the range of 2H:1V to 3H:1V, they were intended to redirect errant vehicles. The use of redirectional land forms has been discontinued as a means for mitigating fixed objects. Where redirectional land forms currently exist as mitigation for a fixed object, ensure that the hazard they were intended to mitigate is removed, relocated, made crashworthy, or shielded with barrier. Landforms may be used to provide a smooth surface at the base of a rock cut slope.

Use of a traffic barrier for hazards other than those described below requires justification in the Design Documentation Package.

(1) Side Slopes

(a) ***Fill Slopes.*** Fill slopes can present a hazard to an errant vehicle with the degree of severity dependent upon the slope and height of the fill. Providing fill slopes that are 4H:1V or flatter can mitigate this hazard. If flattening the slope is not feasible or cost effective, the installation of a barrier might be appropriate. Figure 700-5 represents a selection procedure used to determine whether a fill side slope constitutes a hazard for which a barrier is a cost-effective mitigation. The curves are based on the severity indexes and represent the points where total costs associated with a traffic barrier are equal to the predicted accident cost associated with selected slope heights without traffic barrier. If the ADT and height of fill intersect on the "Barrier Recommended" side of the embankment slope curve, then provide a barrier if flattening the slope is not feasible or cost effective. Do not use Figure 700-5 for slope design. Design guidance for slopes is in Chapters 430 and 640. Also, if the figure indicates that barrier is not recommended at an existing slope, that result is not justification for a deviation.

For example, if the ADT is 4,000 and the embankment height is 10 feet, barrier will be cost effective for a 2H:1V slope, but not for a 2.5H:1V slope.

This process only addresses the potential hazard of the slope. Obstacles on the slope can compound the hazard. Where barrier is not cost effective, use the recovery area formula to evaluate fixed objects on critical fill slopes less than 10 feet high.

(b) ***Cut Slopes.*** A cut slope is usually less of a hazard than a traffic barrier. The exception is a rock cut with a rough face that might cause vehicle snagging rather than providing relatively smooth redirection.

Analyze the potential motorist risk and the benefits of treatment of rough rock cuts located within the Design Clear Zone. A cost-effectiveness analysis that considers the consequences of doing nothing, removal, or smoothing of the cut slope, and all other viable options to reduce the severity of the hazard, can be used to determine the appropriate treatment. Also consider options to reduce the potential for roadway departures. Some potential options are:

- Graded landform along the base of a rock cut.
- Flexible barrier.
- More rigid barrier.
- Rumble strips.

Conduct an individual investigation for each rock cut or group of rock cuts. Select the most cost-effective treatment.

(2) Fixed Objects

Consider the following objects for mitigation:

- Wooden poles or posts with cross sectional area greater than 16 square inches that do not have breakaway features.
- Nonbreakaway steel sign posts.
- Nonbreakaway light standards.
- Trees having a diameter of 4 inches or more measured at 6 inches above the ground surface.

- Fixed objects extending above the ground surface by more than 4 inches; for example, boulders, concrete bridge rails, signal and electrical cabinets, piers, and retaining walls.
- Existing guardrail that does not conform to current design guidance. (See Chapter 710.)
- Drainage items, such as culvert and pipe ends.

Mitigate hazards that exist within the Design Clear Zone when feasible. Although limited in application, there may be situations where removal of a hazard outside of the R.O.W. is appropriate. The possible mitigative measures are listed below in order of preference.

- Remove.
- Relocate.
- Reduce impact severity (using a breakaway feature).
- Shield the object by using longitudinal barrier or impact attenuator.

(a) **Trees.** When evaluating new plantings or existing trees, consider the maximum allowable diameter of 4 inches measured at 6 inches above the ground when the tree has matured. When removing trees within the Design Clear Zone, complete removal of stumps is preferred. However, to avoid significant disturbance of the roadside vegetation, larger stumps may be mitigated by grinding or cutting them flush to the ground and grading around them. See the *Roadside Manual* for further guidance on the treatment of the disturbed roadside.

(b) **Mailboxes.** Ensure that all mailboxes located within the Design Clear Zone have supports and connections as shown in the Standard Plans. The height from the ground to the bottom of the mailbox is 3 feet 3 inches. This height may vary from 3 feet 3 inches to 4 feet if requested by the mail carrier. If the desired height is to be different from 3 feet 3 inches provide the desired height in the contract plans. See Figure 700-6 for installation guidelines.

In urban areas where sidewalks are prevalent, contact the postal service to determine the most appropriate mailbox location. Locate mailboxes on limited access highways in accordance with Chapter 1430 "Limited Access". A turnout, as shown on Figure 700-6, is not required on limited access highways with shoulders of 6 feet or more where only one mailbox is to be installed. On managed access highways, mailboxes must be on the right-hand side of the road in the direction of travel of the postal carrier. Avoid placing mailboxes along high-speed, high-volume highways. Locate Neighborhood Delivery and Collection Box Units (NDCBUs) outside the Design Clear Zone.

(c) **Culvert Ends.** Provide a traversable end treatment when the culvert end section or opening is on the roadway side slope and within the Design Clear Zone. This can be accomplished for small culverts by beveling the end to match the side slope, with a maximum of 4 inches extending out of the side slope.

Bars might be necessary to provide a traversable opening for larger culverts. Place bars in the plane of the culvert opening in accordance with the Standard Plans when:

1. Single cross culvert opening exceeds 40 inches measured parallel to the direction of travel.
2. Multiple cross culvert openings that exceed 30 inches each, measured parallel to the direction of travel.
3. Culvert approximately parallel to the roadway that has an opening exceeding 24 inches measured perpendicular to the direction of travel.

Bars are permitted where they will not significantly affect the stream hydraulics and where debris drift is minor. Consult the regional Maintenance Office to verify these conditions. If debris drift is a concern, consider options to reduce the amount of debris that can enter the pipe. (See the *Hydraulics Manual*). Other treatments are extending the culvert to move the end outside the Design Clear Zone or installing a traffic barrier.

(d) **Sign Posts.** Whenever possible, locate signs behind existing or planned traffic barrier installations to eliminate the need for breakaway posts. Place them at least 25 feet from the end of the barrier terminal and with the sign face behind the barrier. When barrier is not present, use terrain features to reduce the likelihood of an errant vehicle striking the sign posts. Whenever possible, depending on the type of sign and the sign message, adjust the sign location to take advantage of barrier or terrain features. This will reduce accident potential and, possibly, future maintenance costs. See Chapter 820 for additional information regarding the placement of signs.

Sign posts with cross sectional areas greater than 16 square inches that are within the Design Clear Zone and not located behind a barrier must have breakaway features as shown in the Standard Plans.

(e) **Traffic Signal Standards/Posts/Supports.** Breakaway signal posts generally are not practical or desirable. Since these supports are generally located at intersecting roadways, there is a higher potential for a falling support to impact vehicles and/or pedestrians. In addition, signal supports that have overhead masts may be too heavy for a breakaway design to work properly. Other mitigation such as installing a traffic barrier is also very difficult. With vehicles approaching the support from many different angles, a barrier would have to surround the support and would be subject to impacts at high angles. Additionally, barrier can inhibit pedestrian movements. Therefore, barrier is generally not an option. However, since speeds near signals are generally lower, the potential for a severe impact is reduced. For these reasons, the only mitigation is to locate the support as far from the traveled way as possible.

In locations where signals are used for ramp meters, the supports can be made breakaway as shown on the Standard Plan.

(f) **Fire Hydrants.** Fire Hydrants are allowed on WSDOT right of way by franchise or permit. Fire hydrants that are made of cast iron can be expected to fracture on impact and can therefore be considered a breakaway device. Any portion of the hydrants that will not be breakaway must not extend more then 4 inches above the ground. In addition, the hydrant must have a stem that will shut off water flow in the event of an impact. Mitigate all other hydrants.

(g) **Utility Poles.** Since utilities often share the right of way, utility objects such as poles will often be located along the roadside. It is undesirable/impractical to install barrier for all of these objects so mitigation is usually in the form of relocation (underground or to the edge of the right of way) or delineation. In some instances where there is a history of impacts with poles and relocation is not possible, a breakaway design might be appropriate.

Contact Headquarters Design for information on breakaway features. Coordinate with the Utilities Office where appropriate.

(h) **Light Standards.** Provide breakaway light standards unless fixed light standards can be justified. Fixed light standards may be appropriate in areas of extensive pedestrian concentrations, such as adjacent to bus shelters. Document the decision to use fixed bases in the Design Documentation Package.

(3) Water

Water with a depth of 2 feet or more and located with a likelihood of encroachment by an errant vehicle must be considered for mitigation on a project-by-project basis. Consider the length of time traffic is exposed to this hazard and its location in relationship to other highway features such as curves.

Analyze the potential motorist risk and the benefits of treatment of bodies of water located within the Design Clear Zone. A cost-effectiveness analysis that considers the consequences of doing nothing versus installing a longitudinal barrier can be used to determine the appropriate treatment.

For fencing considerations along water features, see Chapter 1460.

700.06 Median Considerations

Medians must be analyzed for the potential of an errant vehicle to cross the median and encounter oncoming traffic. Median barriers are normally used on limited access, multilane, high-speed, high traffic volume highways. These highways generally have posted speeds of 45 mph or greater. Median barrier is not normally placed on collectors or other state highways that do not have limited access control. Providing access through median barrier requires openings and, therefore, end-treatments.

Provide median barrier on full access control, multilane highways with median widths of 50 feet or less and posted speeds of 45 mph or more. Consider median barrier on highways with wider medians or lower posted speeds when there is a history of cross median accidents.

When installing a median barrier, provide left-side shoulder widths as shown in Chapters 430 and 440 and shy distance as shown in Chapter 710. Consider a wider shoulder area where the barrier will cast a shadow on the roadway and hinder the melting of ice. See Chapter 640 for additional criteria for placement of median barrier. See Chapter 710 for information on the types of barriers that can be used. See Chapter 650 for lateral clearance on the inside of a curve to provide the required stopping sight distance.

When median barrier is being placed in an existing median, identify the existing crossovers and enforcement observation points. Provide the necessary median crossovers in accordance with Chapter 960, considering enforcement needs. Chapter 1050 provides guidance on HOV enforcement.

700.07 Other Roadside Safety Features

(1) Rumble Strips

Rumble strips are grooves or rows of raised pavement markers placed perpendicular to the direction of travel to alert inattentive drivers.

There are three kinds of rumble strips:

(a) **Roadway rumble strips** are placed across the traveled way to alert drivers approaching a change of roadway condition or a hazard that requires substantial speed reduction or other maneuvering. Examples of locations where roadway rumble strips may be used are in advance of:

- Stop controlled intersections.
- Port of entry/customs stations.
- Lane reductions where accident history shows a pattern of driver inattention.

They may also be placed at locations where the character of the roadway changes, such as at the end of a freeway.

Contact the Headquarters Design Office for additional guidance on the design and placement of roadway rumble strips.

Document justification for using roadway rumble strips.

(b) **Shoulder rumble strips** are placed on the shoulders just beyond the traveled way to warn drivers when they are entering a part of the roadway not intended for routine traffic use. Shoulder rumble strips may be used when an analysis indicates a problem with run-off-the-road accidents due to inattentive or fatigued drivers. A comparison of rolled-in and milled-in Shoulder Rumble Strips (SRS) has determined that milled-in rumble strips, although more expensive, are more cost effective. Milled-in rumble strips are recommended.

When SRS are used, discontinue them where no edge stripe is present such as at intersections and where curb and gutter are present. Where bicycle travel is allowed, discontinue SRS at locations where shoulder width reductions can cause bicyclists to move into or across the area where rumble strips would normally be placed, such as shoulders adjacent to bridges with reduced shoulder widths.

SRS patterns vary depending on the likelihood of bicyclists being present along the highway shoulder, and whether they are placed on divided or undivided highways. Rumble strip patterns for undivided highways are shallower and may be narrower than patterns used on divided highways. They also provide gaps in the pattern, providing opportunities for bicycles to move across the pattern without having to ride across the grooves. There are four shoulder rumble strip patterns. Consult the Standard Plans for the patterns and construction details.

1. **Divided Highways**

SRS are required on both the right and left shoulders of rural Interstate highways. Consider them on both shoulders of rural divided highways. Use the Shoulder Rumble Strip Type 1 pattern on divided highways.

Omitting SRS on rural highways is a design exception (DE) under any one of the following conditions:

- When another project scheduled within two years of the proposed project will overlay or reconstruct the shoulders or will use the shoulders for detours.
- When a pavement analysis determines that installing SRS will result in inadequate shoulder strength.
- When overall shoulder width will be less than 4 feet wide on the left and 6 feet wide on the right.

2. **Undivided Highways**

SRS are not required on undivided highways, but may be used where run-off-the-road accident experience is high. SRS usage on the shoulders of undivided highways demands strategic application because bicycle usage is more prevalent along the shoulders of the undivided highway system. Rumble strips affect the comfort and control of bicycle riders; consequently, their use is to be limited to highway corridors that experience high levels of run-off-the-road accidents. Apply the following criteria in evaluating the appropriateness of rumble strips on the shoulders of undivided highways.

- Use on rural roads only.
- Ensure shoulder pavement is structurally adequate to support milled rumble strips.
- Posted speed is 45 mph or greater.
- Ensure that at least 4 feet of usable shoulder remains between the rumble strip and the outside edge of shoulder. If guardrail or barrier is present, increase the dimension to 5 feet of usable shoulder.
- Preliminary evaluation indicates a run-off-the-road accident experience of approximately 0.6 crashes per mile per year, or approximately 34 crashes per 100 million miles of travel. (These values are intended to provide relative comparison of crash experience and are not to be used as absolute guidance on whether rumble strips are appropriate.)
- Do not place shoulder rumble strips on downhill grades exceeding 4% for more than 500 feet in length along routes where bicyclists are frequently present.
- An engineering analysis indicates a run-off-the-road accident experience considered correctable by shoulder rumble strips.
- Consult the regional members of the Washington Bicycle and Pedestrian Advisory Committee to determine bicycle usage along a route, and involve them in the decision-making process when considering rumble strips along bike touring routes or other routes where bicycle events are regularly held.

The Shoulder Rumble Strip Type 2 or Type 3 pattern is used on highways with minimal bicycle traffic. When bicycle traffic on the shoulder is high, the Shoulder Rumble Strip Type 4 pattern is used.

Shoulder rumble strip installation considered at any other locations must involve the WSDOT Bicycle and Pedestrian Advisory Committee as a partner in the decision-making process.

Consult the following web site for guidance on conducting an engineering analysis: http://www.wsdot.wa.gov/EESC/Design/Policy/RoadsideSafety/Chapter700/Chapter700B.htm

(c) **Centerline rumble strips** are placed on the centerline of undivided highways to alert drivers that they are entering the opposing lane. They are applied as a countermeasure for crossover accidents. Centerline rumble strips are installed with no differentiation between passing permitted and no passing areas. Pavement marking should be refreshed when removed by centerline rumble strips.

Drivers tend to move to the right to avoid driving on centerline rumble strips. Narrow lane and shoulder widths may lead to dropping a tire off the pavement when drivers have shifted their travel path. Centerline rumble strips are inappropriate when the combined lane and shoulder widths in each direction is less than twelve feet. See Chapters 430 and 440 for guidance on lane and shoulder width. Consider short sections of roadway that are below this width only when added for route continuity.

Apply the following criteria in evaluating the appropriateness of centerline rumble strips:

- An engineering analysis indicates a crossover accident history with collisions considered correctable by centerline rumble strips. Review the accident history to determine the frequency of collisions with contributing circumstances such as inattention, apparently fatigued, apparently asleep, over centerline, or on wrong side of road.
- Centerline rumble strips are most appropriate on rural roads, but with special consideration may also be appropriate for urban roads. Some concerns specific to urban areas are noise in densely populated areas, the frequent need to interrupt the rumble strip pattern to accommodate left turning vehicles, and a reduced effectiveness at lower speeds (35 MPH and below).
- Ensure the roadway pavement is structurally adequate to support milled rumble strips. Consult the region's Materials Engineer to verify pavement adequacies.
- Centerline rumble strips are not appropriate where two-way left-turn lanes exist.

(2) Headlight Glare Considerations

Headlight glare from opposing traffic can cause safety problems. Glare can be reduced by the use of wide medians, separate alignments, earth mounds, plants, concrete barrier, and by glare screens. Consider long term maintenance when selecting the treatment for glare. When considering earth mound and planting to reduce glare, see the *Roadside Manual* for additional guidance. When considering glare screens, see Chapter 650 for lateral clearance on the inside of a curve to provide the required stopping sight distance. In addition to reducing glare, taller concrete barriers also provide improved crash performance for larger vehicles such as trucks.

Glare screen is relatively expensive and its use must be justified and documented. It is difficult to justify the use of glare screen where the median width exceeds 20 feet, the ADT is less than 20,000 vehicles per day, or the roadway has continuous lighting. Consider the following factors when assessing the need for glare screen:

- Higher rate of night accidents compared to similar locations or statewide experience.
- Higher than normal ratio of night to day accidents.
- Unusual distribution or concentration of nighttime accidents.
- Over representation of older drivers in night accidents.
- Combination of horizontal and vertical alignment, particularly where the roadway on the inside of a curve is higher than the roadway on the outside of the curve.
- Direct observation of glare.
- Public complaints concerning glare.

The most common glare problem is between opposing main line traffic. Other conditions for which glare screen might be appropriate are:

- Between a highway and an adjacent frontage road or parallel highway, especially where opposing headlights might seem to be on the wrong side of the driver.

- At an interchange where an on-ramp merges with a collector distributor and the ramp traffic might be unable to distinguish between collector and main line traffic. In this instance, consider other solutions, such as illumination.
- Where headlight glare is a distraction to adjacent property owners. Playgrounds, ball fields, and parks with frequent nighttime activities might benefit from screening if headlight glare interferes with these activities.

There are currently three basic types of glare screen available: chain link (see Standard Plans), vertical blades, and concrete barrier. (See Figure 700-7.)

When the glare is temporary (due to construction activity), consider traffic volumes, alignment, duration, presence of illumination, and type of construction activity. Glare screen may be used to reduce rubbernecking associated with construction activity, but less expensive methods, such as plywood that seals off the view of the construction area, might be more appropriate.

700.08 Documentation

A list of documents that are required to be preserved in the Design Documentation Package (DDP) or the Project File (PF) is on the following website:
http://www.wsdot.wa.gov/eesc/design/projectdev/

Design Clear Zone Distances for State Highways Outside Incorporated Cities**

(In feet from edge of traveled way***)

Posted Speed mph	Average Daily Traffic	Cut Section (Backslope) (H:V)						Fill Section (H:V)					
		3:1	4:1	5:1	6:1	8:1	10:1	3:1	4:1	5:1	6:1	8:1	10:1
35 or Less	The Design Clear Zone distance is 10 feet												
40	Under 250	10	10	10	10	10	10	*	13	12	11	11	10
	251-800	11	11	11	11	11	11	*	14	14	13	12	11
	801-2000	12	12	12	12	12	12	*	16	15	14	13	12
	2001-6000	14	14	14	14	14	14	*	17	17	16	15	14
	Over 6000	15	15	15	15	15	15	*	19	18	17	16	15
45	Under 250	11	11	11	11	11	11	*	16	14	13	12	11
	251-800	12	12	13	13	13	13	*	18	16	14	14	13
	801-2000	13	13	14	14	14	14	*	20	17	16	15	14
	2001-6000	15	15	16	16	16	16	*	22	19	17	17	16
	Over 6000	16	16	17	17	17	17	*	24	21	19	18	17
50	Under 250	11	12	13	13	13	13	*	19	16	15	13	13
	251-800	13	14	14	15	15	15	*	22	18	17	15	15
	801-2000	14	15	16	17	17	17	*	24	20	18	17	17
	2001-6000	16	17	17	18	18	18	*	27	22	20	18	18
	Over 6000	17	18	19	20	20	20	*	29	24	22	20	20
55	Under 250	12	14	15	16	16	17	*	25	21	19	17	17
	251-800	14	16	17	18	18	19	*	28	23	21	20	19
	801-2000	15	17	19	20	20	21	*	31	26	23	22	21
	2001-6000	17	19	21	22	22	23	*	34	29	26	24	23
	Over 6000	18	21	23	24	24	25	*	37	31	28	26	25
60	Under 250	13	16	17	18	19	19	*	30	25	23	21	20
	251-800	15	18	20	20	21	22	*	34	28	26	23	23
	801-2000	17	20	22	22	23	24	*	37	31	28	26	25
	2001-6000	18	22	24	25	26	27	*	41	34	31	29	28
	Over 6000	20	24	26	27	28	29	*	45	37	34	31	30
65	Under 250	15	18	19	20	21	21	*	33	27	25	23	22
	251-800	17	20	22	22	24	24	*	38	31	29	26	25
	801-2000	19	22	24	25	26	27	*	41	34	31	29	28
	2001-6000	20	25	27	27	29	30	*	46	37	35	32	31
	Over 6000	22	27	29	30	31	32	*	50	41	38	34	33
70	Under 250	16	19	21	21	23	23	*	36	29	27	25	24
	251-800	18	22	23	24	26	26	*	41	33	31	28	27
	801-2000	20	24	26	27	28	29	*	45	37	34	31	30
	2001-6000	22	27	29	29	31	32	*	50	40	38	34	33
	Over 6000	24	29	31	32	34	35	*	54	44	41	37	36

* When the fill section slope is steeper than 4H:1V but net steeper than 3H:1V, the Design Clear Zone distance is modified by the recovery area formula (Figure 700-3) and is referred to as the recovery area. The basic philosophy behind the recovery area formula is that the vehicle can traverse these slopes but cannot recover (control steering) and, therefore, the horizontal distance of these slopes is added to the Design Clear Zone distance to form the recovery area.

** This figure also applies to limited access state highways in cities and median areas on managed access state highways in cities. See 700.04 for guidance on managed access state highways within incorporated cities.

*** See 700.03 for the definition of traveled way.

Design Clear Zone Distance Table

Figure 700-1

Washington State Department of Transportation

Design Clear Zone Inventory

Region	SR	Control Section	MP	to MP	Date
Project Number	Project Title		Responsible Unit		

Item Number	MP to MP	Distance From Traveled Way L	Distance From Traveled Way R	Description	Corrective Actions Considered (2)	Estimated Cost to Correct	Correction Planned (1) Yes	Correction Planned (1) No

(1) Only one "Yes" or "No" per item number. Corrections not planned must be explained on reverse side.
(2) A list of Location 1 & 2 Utility Objects to the forwarded to the region Utility Office for coordination per Control Zone Guidelines.

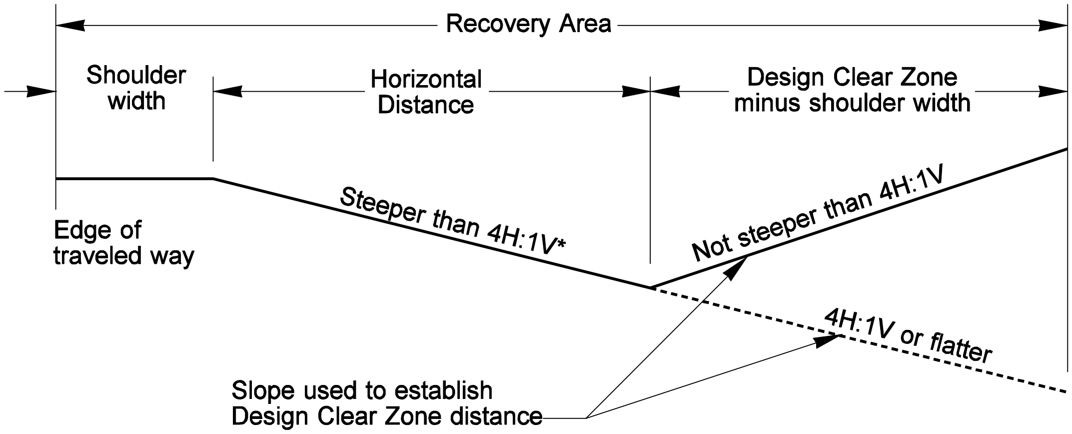
DOT Form 410-026 EF
Revised 9/02

Design Clear Zone Inventory Form
Figure 700-2a

Item Number	Reasons for Not Taking Corrective Action

DOT Form 410-026 EF
Revised 9/02

Design Clear Zone Inventory Form
Figure 700-2b



* Recovery area normally applies to slopes steeper than 4H:1V, but no steeper than 3H:1V. For steeper slopes, the recovery area formula may be used as a guide if the embankment height is 10 feet or less.

Formula:

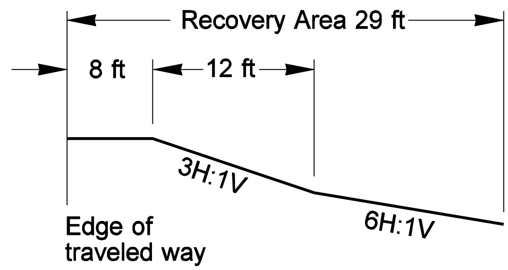
Recovery area = (shoulder width) + (horizontal distance)
+ (Design Clear Zone distance - shoulder width)

Example:

Fill section (slope 3H:1V or steeper)

Conditions: Speed – 45 mph
Traffic – 3000 ADT
Slope – 3H:1V

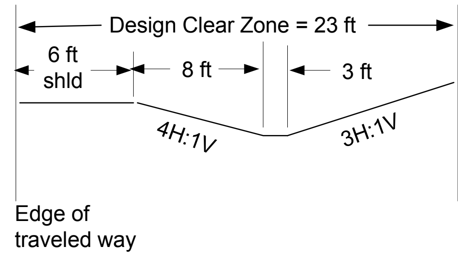
Criteria: Slope 3H:1V – use
Recovery area formula



Recovery area = (shoulder width) + (horizontal distance)
+ (Design Clear Zone distance - shoulder width)
= 8 + 12 + (17-8)
= 29 feet

Recovery Area
Figure 700-3

Cut section with ditch (fore slope 4H:1V or flatter)



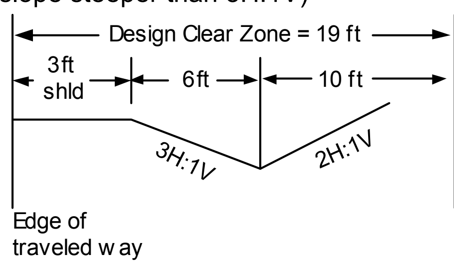
Conditions: Speed - 55 mph
Traffic - 4200 ADT
Slope - 4H:1V

Criteria: Greater of
(1) Design Clear Zone for 10H:1V Cut Section, 23 feet
(2) 5 feet horizontal beyond beginning of back slope, 22 feet

Design Clear Zone = 23 feet

Case 1

Cut section with ditch (fore slope 3H:1V or steeper and back slope steeper than 3H:1V)



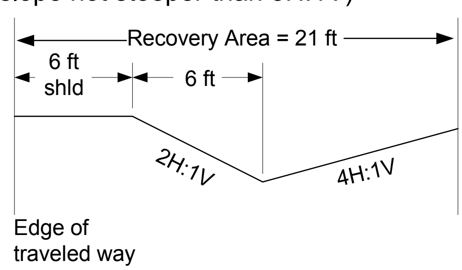
Conditions: NA

Criteria: 10 feet horizontal beyond beginning of back slope

Design Clear Zone = 19 feet

Case 2

Cut section with ditch (fore slope 3H:1V or steeper and back slope not steeper than 3H:1V)



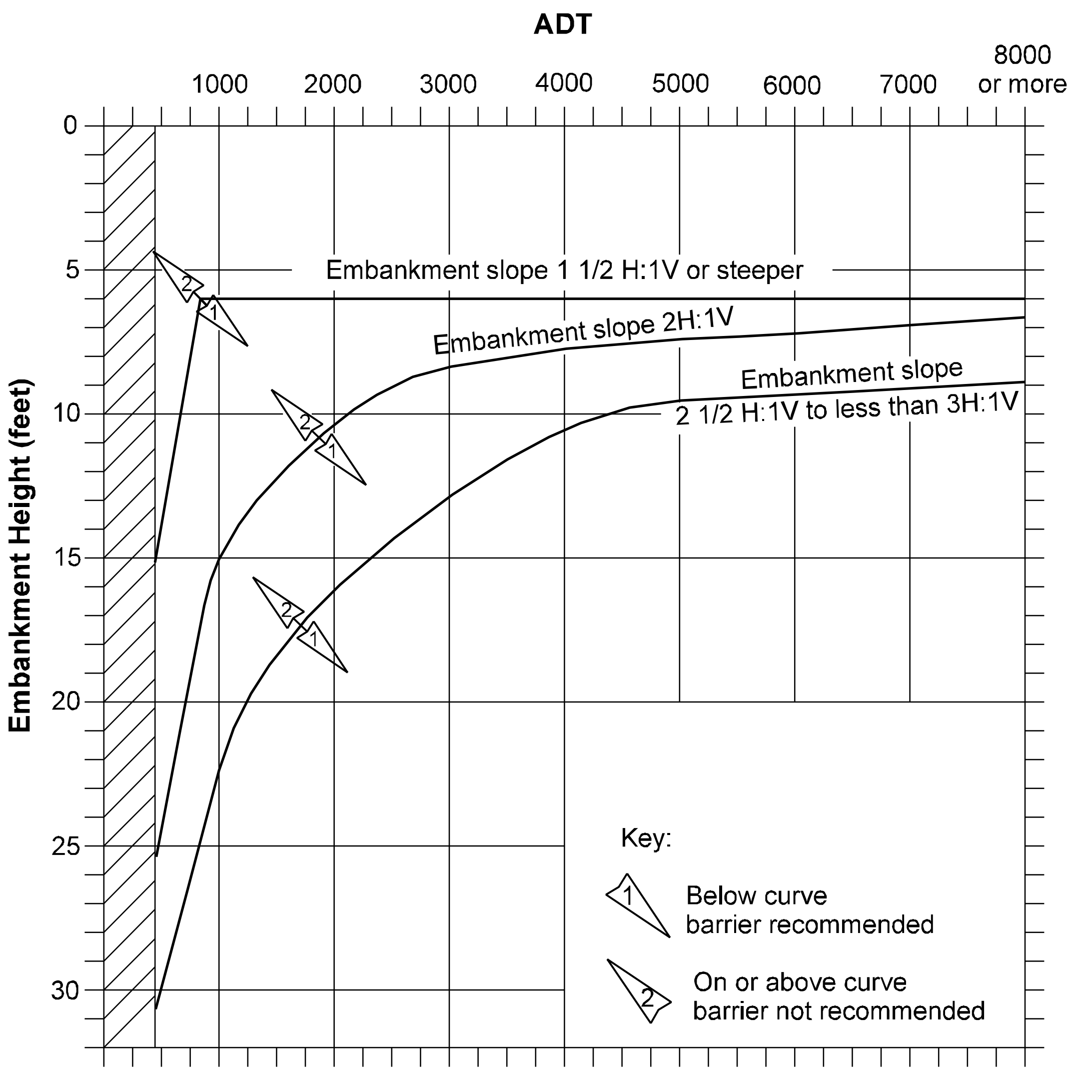
Conditions: Speed - 45 mph
Traffic - 3000 ADT
Foreslope - 2H:1V
Back slope 4H:1V

Criteria: Use recovery area formula

Recovery Area = (shoulder width) + (horizontal distance) + (Design Clear Zone distance - shoulder width)
= 6 + 6 + (15 - 6)
= 21 feet

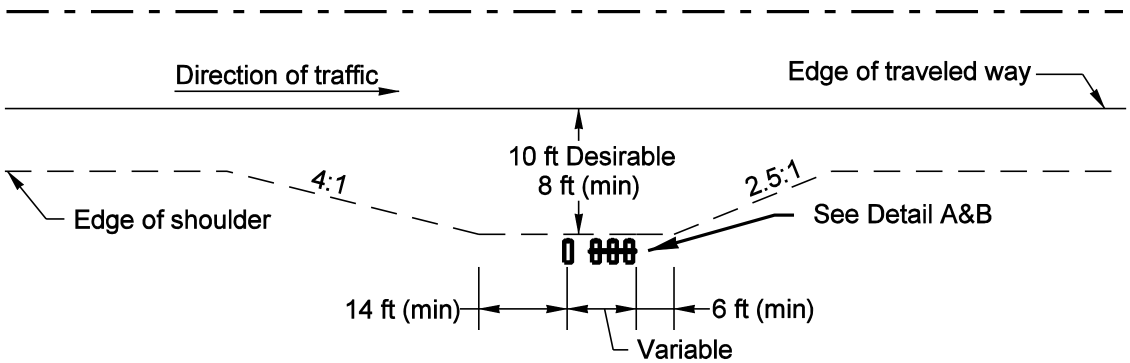
Case 3

Design Clear Zone for Ditch Sections
Figure 700-4

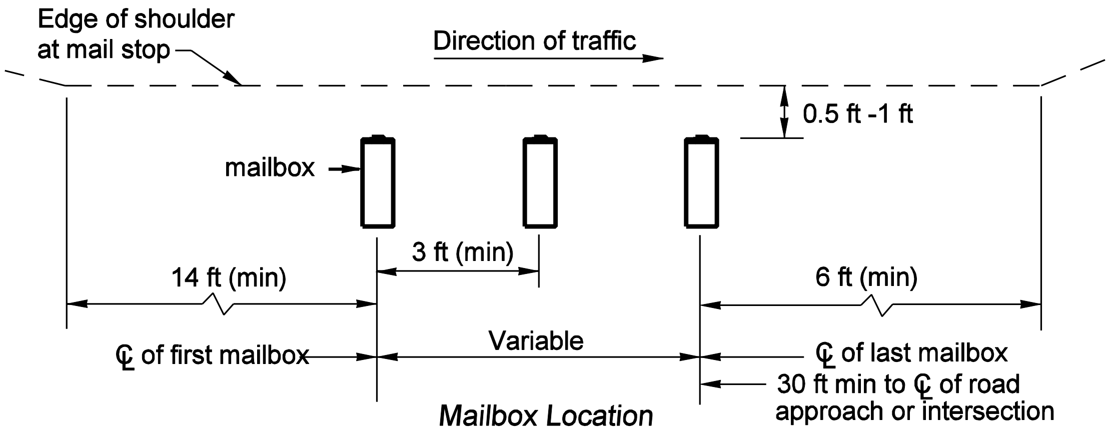


Note: Routes with ADTs under 400 may be evaluated on a case by case basis.

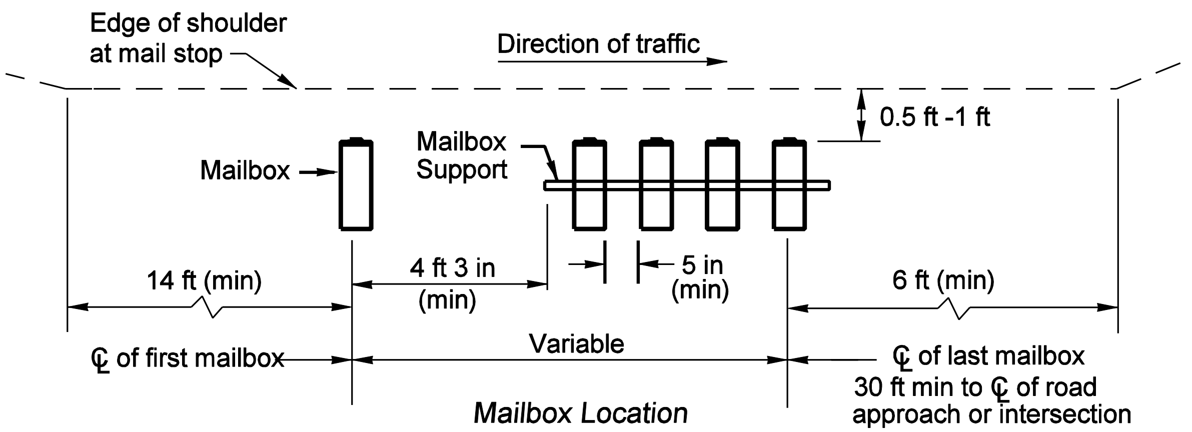
Guidelines for Embankment Barrier
Figure 700-5



Mailbox Turnout

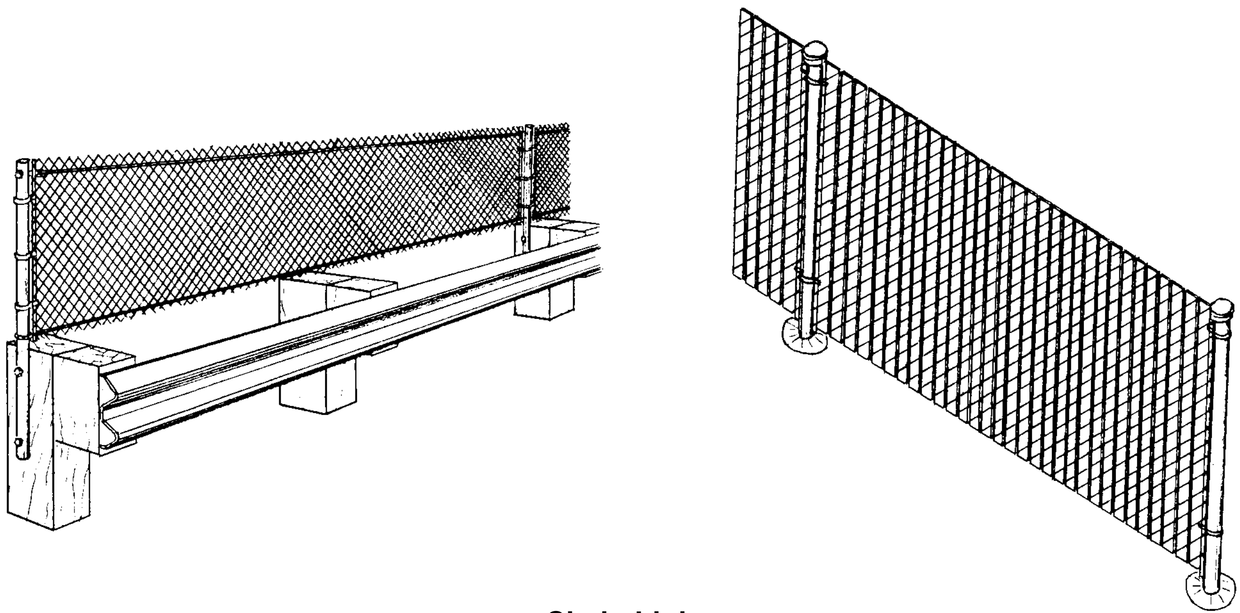


Mailbox Location
Single Box Design
Detail A

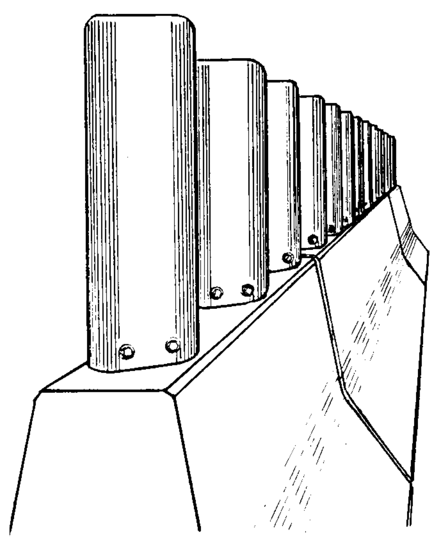


Mailbox Location
Multiple Box Design
Detail B

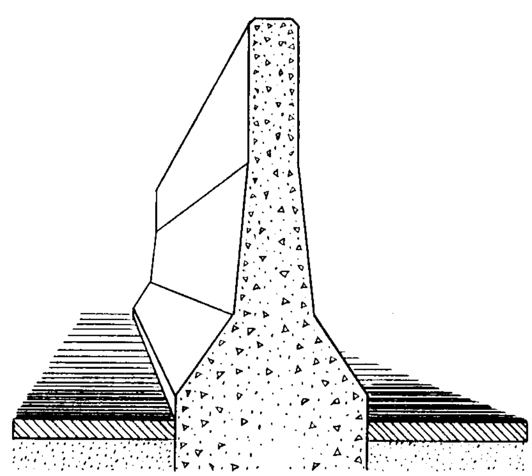
Mailbox Location and Turnout Design
Figure 700-6



Chain Link



Vertical Blades



Concerete Barrier

Glare Screens
Figure 700-7

Chapter 710 Traffic Barriers

710.01 General

Traffic barriers are used to reduce the severity of accidents that occur when an errant vehicle leaves the traveled way. However, traffic barriers are obstacles that the vehicle will encounter and they must only be used when justified by accident history or the criteria in Chapter 700.

710.02 References

Design Guidance

Bridge Design Manual, M 23-50, WSDOT

Roadside Design Guide, AASHTO

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Traffic Manual, M 51-02, WSDOT

710.03 Definitions

barrier terminal A crashworthy end treatment for longitudinal barriers that is designed to reduce the potential for spearing, vaulting, rolling, or excessive deceleration of impacting vehicles from either direction of travel. Barrier terminals include applicable anchorage.

controlled releasing terminal (CRT) post A standard length guardrail post that has two holes drilled through it so that it will break away when struck.

crashworthy A feature that has been proven acceptable for use under specified conditions, either through crash testing or in-service performance.

hazard A side slope, a fixed object, or water that, when struck, can result in unacceptable impact forces on a vehicle's occupants or place the occupants in a hazardous position. A hazard can be either natural or manmade.

impact attenuator system A device that acts primarily to bring an errant vehicle to a stop at a deceleration rate tolerable to the vehicle's occupants or to redirect the vehicle away from a hazard.

length of need The length of a traffic barrier needed to shield a hazard.

longitudinal barrier Traffic barrier oriented parallel or nearly parallel to the roadway. The purpose is to contain or redirect errant vehicles. Beam guardrail, cable barrier, bridge rail, and concrete barrier are longitudinal barriers, which are categorized as rigid, unrestrained rigid, semirigid, and flexible. They can be installed as roadside or median barriers.

shy distance The distance from the edge of the traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver to the extent that the driver will change the vehicle's placement or speed.

traffic barrier A longitudinal barrier, including bridge rail, or an impact attenuator used to redirect vehicles from hazards located within an established Design Clear Zone, to prevent median crossovers, to prevent errant vehicles from going over the side of a bridge structure, or (occasionally) to protect workers, pedestrians, or bicyclists from vehicular traffic.

transition A section of barrier used to produce the gradual stiffening of a flexible or semirigid barrier as it connects to a more rigid barrier or fixed object.

710.04 Project Requirements

This section identifies the barrier elements that must be addressed according to the Design Matrices in Chapter 325. Remove any barrier that is not needed (based on the criteria in Chapter 700) or that poses a more severe hazard than the hazard it is shielding.

(1) Barrier Terminals and Transitions

Install, replace, or upgrade transitions as discussed in 710.06(5), Transitions and Connections.

Impact attenuator requirements can be found in Chapter 720, "Impact Attenuator Systems."

When installing new terminals, consider extending the guardrail to meet the length of need criteria in 710.05(4) as a spot safety enhancement.

Concrete barrier terminal requirements can be found in 710.08(3). When the end of a concrete barrier has been terminated with a small mound of earth (a design formerly known as a Concrete Barrier Berm), remove and replace with a crashworthy terminal, except as noted in 710.09.

Redirectional land forms, also referred to as earth berms, were installed to mitigate hazards located in depressed medians and at roadsides. They were constructed of materials that provided support for a traversing vehicle. With slopes in the range of 2H:1V to 3H:1V, they were intended to redirect errant vehicles. The use of redirectional land forms has been discontinued as a means for mitigating fixed objects. Where redirectional land forms currently exist as mitigation for a fixed object, ensure that the hazard they were intended to mitigate is removed, relocated, made crashworthy, or shielded with barrier. Landforms may be used to provide a smooth surface at the base of a rock cut slope.

Replace guardrail terminals that do not have a crashworthy design with crashworthy guardrail terminals. (See 710.06(4), Terminals and Anchors.) Common features of noncrashworthy designs include the following:

- No cable anchor
- A cable anchored into concrete in front of the first post
- Second post not breakaway (CRT)
- Design A end section (Design C end sections may be left in place—see the Standard Plans for end section details)
- Beam guardrail on both sides of the posts (two-sided)
- Buried guardrail terminals that slope down such that the guardrail height is reduced to less than 2 feet

When the height of a standard terminal will be reduced to less than 26 inches from the ground to the top of the rail element, adjust the height to a minimum of 26 inches and a maximum of 28 inches. A rail height of 28 inches is desirable to accommodate future overlays. Terminals are equipped with CRT posts with drilled holes that need to remain at the surface of the ground.

One terminal that was used extensively on Washington's highways was the Breakaway Cable Terminal (BCT). This system used a parabolic flare similar to the SRT and a Type 1 anchor. Type 1 anchor posts are wood set in a steel tube or a concrete foundation.

Replace BCTs on Interstate routes. On non-Interstate routes, BCTs that have at least a 3-foot offset may remain in place, unless the guardrail run or anchor is being reconstructed or reset. (Raising the rail element is not considered reconstruction or resetting.) Replace all BCTs that have less than a 3-foot offset.

Existing transitions that do not have a curb, but are otherwise consistent with the designs shown in the Standard Plans, may remain in place.

For preservation projects, terminal and transition work may be programmed under a separate project, as described in Chapter 410.

(2) Standard Run of Barrier

In Chapter 325, the Design Matrices offer guidance on how to address standard barrier runs for different project types. A "Standard Run" of barrier consists of longitudinal barrier that is detailed in the Washington State Department of Transportation (WSDOT) Standard Plans.

(a) **Basic Design Level (B).** When the basic design level (B) is indicated in the Standard Run column of a Design Matrix and the height of W-beam guardrail is or would be reduced to less than 26 inches from the ground to the top of the rail element, adjust the height to a minimum of 26 inches and maximum of 28 inches. A rail height of 28 inches is desirable to accommodate future overlays.

If Type 1 Alternate W-beam guardrail is present, raise the rail element after each overlay. If Type 1 Alternate is not present, raise the existing blockout up to 4 inches higher than the top of the existing post by boring a new hole in the post.

Overlays in front of safety shape concrete barriers can extend to the top of the lower, near-vertical face of the barrier before adjustment is required. Allow no more than 1 foot 1 inch from the pavement to the beginning of the top near-vertical face of the safety shape barriers. Allow no less than 2 feet 8 inches from the pavement to the top of the single-slope barrier. Allow no less than 2 feet 3 inches from the ground to the top cable of the Type 1 cable barrier, and no less than 2 feet 6 inches for the Type 2 and Type 3 and high tension cable barriers.

(b) **Full Design Level (F).** When the full design level (F) is indicated, in addition to the requirements for the basic design level, the barrier must meet the requirements found in the following:

Chapter	Subject
700.06	Median considerations
710.05(1)	Shy distance
710.05(2)	Barrier deflections
710.05(3)	Flare rate
710.05(4)	Length of need
710.05(5)	Median barrier selection and placement considerations
710.06	Beam guardrail
710.07	Cable barrier
710.08	Concrete barrier

Examples of barriers that are not acceptable as a "Standard Run" are:

- W-beam guardrail (excluding the Type 31 NB4 proprietary system) with 12-foot-6-inch post spacing and/or no blockouts.
- W-beam guardrail on concrete posts.
- Cable barrier on wood or concrete posts.
- Half-moon or C-shaped rail elements.

(3) Bridge Rail

When the Bridge Rail column of a matrix applies to the project, the bridge rails must meet the following requirements:

Use an approved, crash-tested concrete bridge rail on new bridges or bridges to be widened. The *Bridge Design Manual* provides examples of typical bridge rails. Consult the Headquarters (HQ) Bridge and Structures Office regarding bridge rail selection and design, and for design of the connection to an existing bridge.

An existing bridge rail on a highway with a posted speed of 30 miles per hour or less may remain in place if it is not located on a bridge over a National Highway System (NHS) highway. When Type 7 bridge rail is present on a bridge over an NHS highway with a posted speed of 30 miles per hour or less, it may remain in place, regardless of the type of metal rail installed. All other bridge rails must be evaluated for strength and geometrics. (See 710.10 for guidance on retrofit techniques.) The funding source for retrofit of existing bridge rail is dependent on the length of the structure. Bridge rail retrofit, for bridges less than 250 feet in length (or a total bridge rail length of 500 feet), is funded by the project (Preservation or Improvement). For longer bridges, the retrofit can be funded by the I-2 subprogram. Contact programming personnel to determine if funding is available.

The Type 7 bridge rail is common. Type 7 bridge rails have a curb, a vertical-face parapet, and an aluminum top rail. The curb width and the type of aluminum top rail dictate the adequacy of the Type 7 bridge rail, as shown in Figure 710-1. Consult the HQ Bridge and Structures Office for assistance in evaluating other bridge rails.

710.05 Barrier Design

When selecting a barrier, consider the flexibility, cost, and maintainability of the system. It is generally desirable to use the most flexible system possible to minimize damage to the impacting vehicle and injury to the vehicle's occupant(s). However, since nonrigid systems sustain more damage during an impact, the exposure of maintenance crews to traffic might be increased.

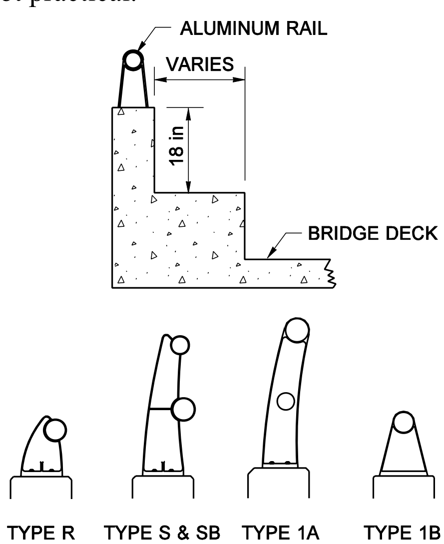
Concrete barrier maintenance costs are lower than for other barrier types. Deterioration due to weather and vehicle impacts is limited. Unanchored precast concrete barrier can usually be realigned or repaired when moved from its alignment. However, heavy equipment may be required to reposition or replace barrier segments. Therefore, in medians, consider the shoulder width and the traffic volume when determining the acceptability of unanchored precast concrete barrier versus rigid concrete barrier.

Drainage, alignment, and drifting snow or sand are considerations that can influence the selection of barrier type. Beam guardrail and concrete barrier can contribute to snow drifts. Consider long-term maintenance costs associated with snow removal at locations prone to snow drifting. Slope flattening is highly recommended, even at additional cost, to eliminate the need for the barrier. Cable barrier is not an obstruction to drifting snow and can be used if slope flattening is not practical.

When designing a barrier for use on a Scenic Byway, consider barriers that are consistent with the recommendations in the associated Corridor Management Plan (if one is available). Contact the region's Landscape Architect or the Scenic Byways Coordinator in the HQ Highways and Local Programs Office to determine whether the project is on such a designated route. Low-cost options, such as using weathering steel beam guardrail (see 710.06) or cable barrier (see 710.07), might be feasible on many projects. Higher-cost options, such as steel-backed timber rail and stone guardwalls (see 710.09), might require a partnering effort to fund the additional costs. Grants might be available for this purpose if the need is identified early in the project definition phase. (See Chapter 120.)

(1) Shy Distance

Provide 2 feet of additional widening for shy distance when a barrier is to be installed in areas where the roadway is to be widened and the shoulder width will be less than 8 feet. This shy distance is not required when the section of roadway is not being widened or the shoulders are at least 8 feet wide.



Aluminum Rail Type	Curb Width	
	9 inches or less	Greater than 9 inches*
Type R, S, or SB	Bridge rail adequate	Bridge rail adequate
Type 1B or 1A	Bridge rail adequate	Upgrade bridge rail
Other	Consult the HQ Bridge and Structures Office	

* When the curb width is greater than 9 inches, the aluminum rail must be able to withstand a 5 kip load.

Type 7 Bridge Rail Upgrade Criteria
Figure 710-1

(2) Barrier Deflections

All barriers except rigid barriers (concrete bridge rails, for example) will deflect when hit by an errant vehicle. The amount of deflection is primarily dependent on the stiffness of the system. Vehicle speed, angle of impact, and weight also affect the amount of barrier deflection. For flexible and semirigid roadside barriers, the deflection distance is designed to prevent the impacting vehicle from striking the object being shielded. For unrestrained rigid systems (unanchored precast concrete barrier), the deflection distance is designed to prevent the barrier from being knocked over the side of a drop-off or steep fill slope (2H:1V or steeper).

In median installations, the deflected system must not become a hazard to oncoming traffic. Use a rigid system where deflection cannot be tolerated, such as in narrow medians or at the edge of bridge decks or other vertical drop-off areas. Runs of rigid concrete barrier can be cast in place or extruded with appropriate footings.

In some locations, where deflection distance is limited, precast concrete barrier can be anchored. However, unless the anchoring system has been designed to function as a rigid barrier, some movement can be expected and repairs may be more expensive. Use of a nonrigid barrier on top of a retaining wall requires approval from the HQ Design Office.

Refer to Figure 710-2 for barrier deflection design values to be used when selecting a longitudinal barrier. The deflection distances for cable and beam guardrail are the minimum measurements from the face of the barrier to the hazard. The deflection distance for unanchored concrete barrier is the minimum measurement from the back edge of the barrier to the drop-off or slope break.

(3) Flare Rate

Flare the ends of longitudinal barriers where possible. There are four functions of the flare:

- To locate the barrier and its terminal as far from the traveled way as is feasible
- To reduce the length of need
- To redirect an errant vehicle
- To minimize a driver's reaction to the introduction of an object near the traveled way

Keeping flare rates as flat as practicable preserves the barrier's redirectional performance and minimizes the angle of impact. However, it has been shown that an object (or barrier) close to the traveled way might cause a driver to shift laterally, slow down, or both. The flare reduces this reaction by gradually introducing the barrier so that the driver does not perceive the barrier as a hazard. The flare rates in Figure 710-3 satisfy all four functions listed above. More gradual flares may be used. Flare rates are offset parallel to the edge of the traveled way. Transition sections are not normally flared.

(4) Length of Need

The length of traffic barrier required to shield a hazard (length of need) is dependent on the location and geometrics of the hazard, direction(s) of traffic, posted speed, traffic volume, and type and location of traffic barrier. When designing a barrier for a fill slope as recommended in Chapter 700, the length of need begins at the point where barrier is recommended. For fixed objects and water hazards, Figures 710-11a and 11b show design parameters for determining the necessary length of a barrier for both adjacent and opposing traffic on relatively straight sections of highway.

When the barrier is to be installed on the outside of a horizontal curve, the length of need can be determined graphically, as shown in Figure 710-11c. For installations on the inside of a curve, determine the length of need as though it were straight. Consider the flare rate, barrier deflection, and barrier end treatment to be used when determining the length of need. When beam guardrail is placed in a median, consider the potential for impact from opposing traffic when conducting a length of need analysis. When guardrail is placed on either side of objects in the median, consider whether the trailing end of each run of guardrail will shield the leading end of the opposing guardrail. Shield the leading end when it is within the clear zone of opposing traffic. (See Figure 710-11d.)

Barrier Type	System Type	Deflection
Cable barrier or beam guardrail (Types 20 and 21) on G-2 posts	Flexible	up to 12 ft (face of barrier to object)
Beam guardrail Types 1, 1a, 2, 10, 11, 31, and 31NB	Semirigid	3 ft (face of barrier to object)
Two-sided W-beam guardrail Types 3 and 4	Semirigid	2 ft (face of barrier to object)
Permanent concrete barrier, unanchored	Unrestrained Rigid	3 ft(1) (back of barrier to object)
Temporary concrete barrier, unanchored	Unrestrained Rigid	2 ft(2) (back of barrier to object)
Precast concrete barrier, anchored	Semirigid	6 inches (back of barrier to object)
Rigid concrete barrier	Rigid	no deflection

(1) When placed in front of a 2H:1V or flatter fill slope, the deflection distance can be reduced to 2 feet.
(2) When used as temporary bridge rail, anchor all barrier that is within 3 feet of a drop-off.

Longitudinal Barrier Deflection
Figure 710-2

Posted Speed (mph)	Rigid System	Unrestrained Rigid System	Semirigid System
70	20:1	18:1	15:1
60	18:1	16:1	14:1
55	16:1	14:1	12:1
50	14:1	12:1	11:1
45	12:1	11:1	10:1
40 or below	11:1	10:1	9:1

Longitudinal Barrier Flare Rates
Figure 710-3

Before the actual length of need is determined, establish the lateral distance between the proposed barrier installation and the item shielded. Provide a distance that is greater than or equal to the anticipated deflection of the longitudinal barrier. (See Figure 710-2 for barrier deflections.) Place the barrier as far from the edge of the traveled way as possible while maintaining the deflection distance.

If the end of the length of need is near an adequate cut slope, extend the barrier and embed it in the slope. (See 710.06(4)(a).) Avoid gaps of 300 feet or less. Short gaps are acceptable when the barriers are terminated in a cut slope. If the end of the length of need is near the end of an existing barrier, it is recommended that the barriers be connected to form a continuous barrier. Consider maintenance access when determining whether to connect barriers.

(5) Median Barrier Selection and Placement Considerations

As with all barriers, the most desirable installation uses a system that is the most flexible system appropriate for the location and that is placed as far from the traveled way as practicable. With median barriers, the deflection characteristics and placement of the barrier for a traveled way in one direction can have an impact on the traveled way in the opposing direction. In addition, the median slopes and environmental issues might influence the type of barrier that is appropriate.

In narrow medians, avoid placement where the design deflection extends into oncoming traffic. In addition, narrow medians provide little space for maintenance crews to repair or reposition the barrier. Avoid installing deflecting barriers in medians that provide less than 8 feet from the edge of the traveled way to the face of the barrier. In wider medians, the selection of barrier might depend on the slopes in the median.

At locations where the median slopes are relatively flat (10H:1V or flatter), unrestrained precast concrete barrier, beam guardrail, and cable barrier can be used depending on the available deflection distance. At these locations, position the barrier as close to the center as possible so that the recovery distance can be maximized for both directions. It might be necessary to offset the barrier from the flow line to avoid impacts to the drainage flow. Cable barrier is recommended with medians that are 30 feet or wider. In wide medians where the slopes are steeper than 10H:1V but not steeper than 6H:1V, cable barrier placed near the center of the median is preferred. Placement of beam guardrail requires that the barrier be placed at least 12 feet from the slope break, as is shown in Figure 710-4. Do not use concrete barrier at locations where the foreslope into the face of the barrier is steeper than 10H:1V.

At locations where the roadways are on independent alignments and there is a difference in elevation between the roadways, the slope from the upper roadway might be steeper than 6H:1V. In these locations, position the median barrier along the upper roadway and provide deflection and offset distance as discussed previously. Barrier is generally not necessary along the lower roadway, except where there are fixed objects in the median.

When barrier is placed in a median as a countermeasure for cross median collisions, design the barrier to be struck from either direction of travel. For example, beam guardrail should be double-sided (Type 3 or 4).

710.06 Beam Guardrail

(1) Beam Guardrail Systems

Beam guardrail systems are shown in the Standard Plans.

Strong post W-beam guardrail (Types 1 through 4, 31, and 31NB) and thrie beam guardrail (Types 10 and 11) are semirigid barriers used predominantly on roadsides. They also have limited application as median barrier. Installed incorrectly, strong post beam guardrail can cause vehicle snagging or spearing. This can be avoided by lapping the rail splices in the direction of traffic (as shown in the Standard Plans), by using crashworthy end treatments, and by blocking the rail away from the strong posts. However, avoid the use of blockouts that extend from the post to the rail element for a distance exceeding 16 inches.

W-beam guardrail has typically been installed with a rail height of 27 inches. However, there are some newer designs that use a 31-inch rail height. One is the 31-inch-high WSDOT Type 31. The other is a proprietary system called the Type 31NB system.

The Type 31 system uses many of the same components as the WSDOT Type 1 system. However, the main differences are that the blockouts extend 12 inches from the posts, the rail height is 31 inches from the ground, and the rail elements are spliced between posts.

The main characteristics of the Type 31NB system are that it incorporates posts designed to bend on impact, and it does not use blockouts, which potentially can offer advantages in applications with narrow shoulder widths. This system is also 31 inches measured from the ground to the top of the rail element, and the rail element is spliced between posts. Currently the Type 31 NB system is not approved for the use of curb with this system.

Although somewhat different, both systems offer tolerances for future HMA overlays. The Type 31 system allows a 4-inch tolerance from 31 inches to 27 inches without adjustment of the rail element. The Type 31NB system offers a tolerance from 31 inches to 29 inches.

(2) W-Beam Barrier Selection and Placement

- Existing runs with rail height at 27 inches are acceptable to leave in place and can be extended if the design height of 27 inches is maintained in the extended section. Where future overlays are anticipated, extend with Type 1 alternate or the 31-inch design.
- For existing runs below 26 inches, adjust or replace the rail to a height of 26 inches minimum to 28 inches maximum or replace the run.
- Use the 31-inch-high guardrail design for new runs.

1. For existing roadways where the shoulder will not be widened and the shoulder is greater than 4 feet, use the Type 31 system. The existing shoulder width may be reduced up to 4 inches to accommodate the 12-inch blockout without processing a deviation.
2. For existing roadways where the shoulder width is 4 feet or less, the Type 31NB system can be used.

For currently available plans for Type 31, refer to the HQ Design Standards (Plan Sheet Library) at the following web site: http://www.wsdot.wa.gov/eesc/design/designstandards/psl/default.htm

Some transitions and connections are currently under development and will be added to this site as soon as they are completed. Plans will be housed at this location until they are transitioned into the Standard Plans.

(3) Additional Guidance

Weak post W-beam guardrail (Type 20) and thrie beam guardrail (Type 21) are flexible barrier systems that can be used where there is adequate deflection distance. These systems use weak steel posts. The primary purpose of these posts is to position the guardrail vertically, and they are designed to bend over when struck. These more flexible systems will result in less damage to the impacting vehicle. Since the weak posts will not result in snagging, blockouts are not necessary.

Keep the slope of the area between the edge of the shoulder and the face of the guardrail 10H:1V or flatter. On fill slopes between 6H:1V and 10H:1V, beam guardrail must not be placed within 12 feet of the break point. Do not place beam guardrail on a fill slope steeper than 6H:1V. For additional guidance on beam guardrail slope placement, refer to Figure 710-4.

On the high side of superelevated sections, place beam guardrail at the edge of shoulder prior to the slope break.

For guardrail installed at or near the shoulder, 2 feet of shoulder widening behind the barrier is generally provided from the back of the post to the beginning of a fill slope. If the slope is 2H:1V or flatter, this distance can be measured from the face of the guardrail rather than the back of the post. (See Figure 710-12, Case 1.)

On projects where no roadway widening is proposed and the minimum 2-foot shoulder widening behind the barrier is not practicable, long post installations are available as shown in Figure 710-12, Cases 3, 4, 5, and 6. When guardrail is to be installed in areas where the roadway is to be widened, the use of Cases 4, 5, or 6 requires a design deviation.

Rail washers on beam guardrail are not normally used. If rail washers are present, they are not required to be removed. However, if the rail element is removed for any reason, do not reinstall rail washers. In areas where heavy snow accumulations are expected to cause the bolts to pull out, specify snowload post and rail washers in the contract documents. (Snowload post washers are used to prevent the bolts from pulling through the posts, and snowload rail washers are used to prevent the bolt head from pulling through the rail.) In other installations, it is normal to have the rail pull loose from the bolt head when impacted. Rail washers are never to be used within the limits of a guardrail terminal, except at the end post where they are required for anchorage of the rail.

The use of curb in conjunction with beam guardrail is discouraged. If a curb is necessary, the 3-inch-high curb is preferred. If necessary, the 4-inch-high extruded curb can be used behind the face of rail at any posted speed. The 6-inch-high extruded curb can be used at locations where the posted speed is 50 miles per hour or less. When replacing extruded curb at locations where the posted speed is greater than 50 miles per hour, use 3-inch-high or 4-inch-high curb. (See the Standard Plans for extruded curb designs.)

When curb is used in conjunction with 31-inch-high Type 31 W-beam guardrail, it is acceptable to place a 6-inch-high curb at a 7-inch offset from the face of the rail.

Currently, curb is not approved for use with the Type 31 NB system.

Beam guardrail is usually galvanized and has a silver color. It can also be provided in a weathering steel that has a brown or rust color. Along Scenic Byways, Heritage Tour Routes, state highways through national forests, or other designated areas, consider using weathering steel guardrail, weathering steel terminals, and wooden posts to minimize the barrier's visual impact. (See 710.05.)

(4) Terminals and Anchors

A guardrail anchor is required at the end of a run of guardrail to develop tensile strength throughout its length. In addition, when the end of the guardrail is subject to head-on impacts, a crashworthy guardrail terminal is required. (See the Standard Plans.)

The buried terminal (BT) is designed to terminate the guardrail by burying the end in a backslope. The BT is the preferred terminal because it eliminates the exposed end of the guardrail.

The BT uses a Type 2 anchor to develop the tensile strength in the guardrail. Design the length of need beginning at the point where the W-beam remains at full height in relation to the roadway shoulder, usually beginning at the point where the barrier crosses the ditch line. The backslope required to install a BT must be 3H:1V or steeper and at least 4 feet in height above the roadway. Flare the guardrail into the backslope using a flare rate that meets the criteria in 710.05(3). Provide a 10H:1V or flatter foreslope into the face of the guardrail (and up to 4H:1V in the ditch section of the Type 2 buried terminal), and maintain the full guardrail height to the foreslope/backslope intersection. This might require filling ditches and installing culverts in front of the guardrail face. The entire BT can be used within the length of need for backslopes of 1H:1V or steeper if the barrier remains at full height in relation to the roadway shoulder.

If the backslope is flatter than 1H:1V, provide a minimum 75-foot-long clear area on the back side of the barrier prior to the mitigated hazard.

(a) **Flared Terminal.** If a BT cannot be installed as described above, consider a flared terminal. (See Figure 710-13.) There are currently two acceptable sole source proprietary designs: the Slotted Rail Terminal (SRT) and the Flared Energy Absorbing Terminal (FLEAT). Both of these designs include an anchor for developing the tensile strength of the guardrail. The length of need begins at the third post for both flared terminals.

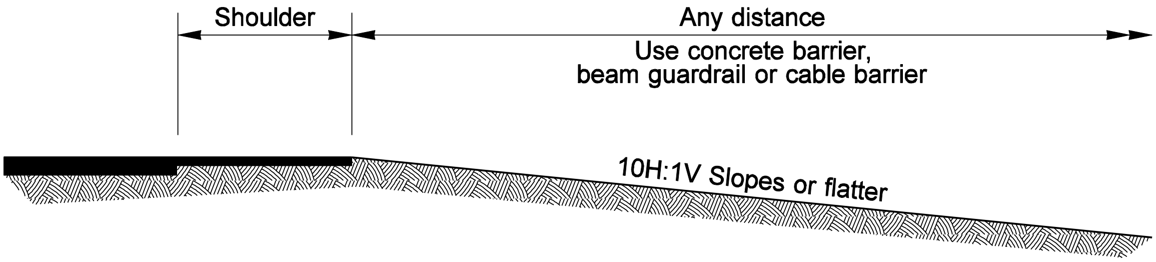
1. The SRT uses W-beam guardrail with slots cut into the corrugations, and wood breakaway and controlled release terminal (CRT) posts that are designed to break away when hit. The end of the SRT is offset from the tangent guardrail run by the use of a parabolic flare. When struck head on, the first two posts are designed to break away, and the parabolic flare gives the rail a natural tendency to buckle, minimizing the possibility of the guardrail end entering the vehicle. The buckling is facilitated by the slots in the rail. The CRT posts provide strength to the system for redirection and deceleration without snagging the vehicle. The SRT has a 4-foot offset of the first post.
2. The FLEAT uses W-beam guardrail with a special end piece that fits over the end of the guardrail and wood breakaway and CRT posts. The end of the FLEAT is offset from the tangent guardrail run by the use of a straight flare. When struck head on, the end piece is forced over the rail, bending the rail and forcing it away from the impacting vehicle.

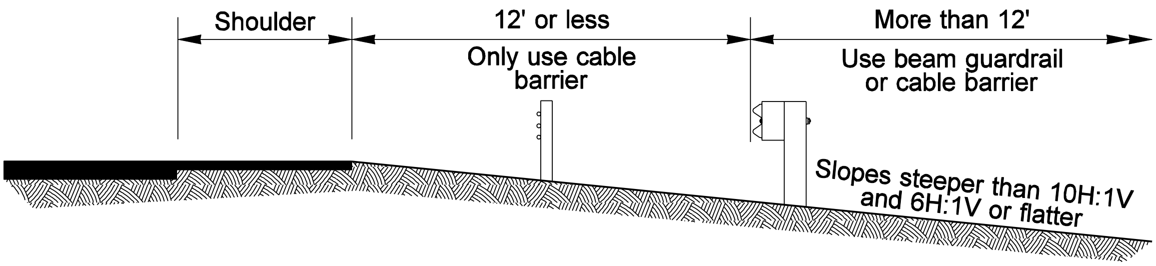
   The FLEAT is available in two designs based on the posted speed of the highway. For highways with a posted speed of 45 miles per hour or greater, use a FLEAT 350 that has a 4-foot offset at the first post. For lower-speed highways (a posted speed of 40 miles per hour or less), use a FLEAT TL-2 that has a 1-foot-8-inch offset at the first post.

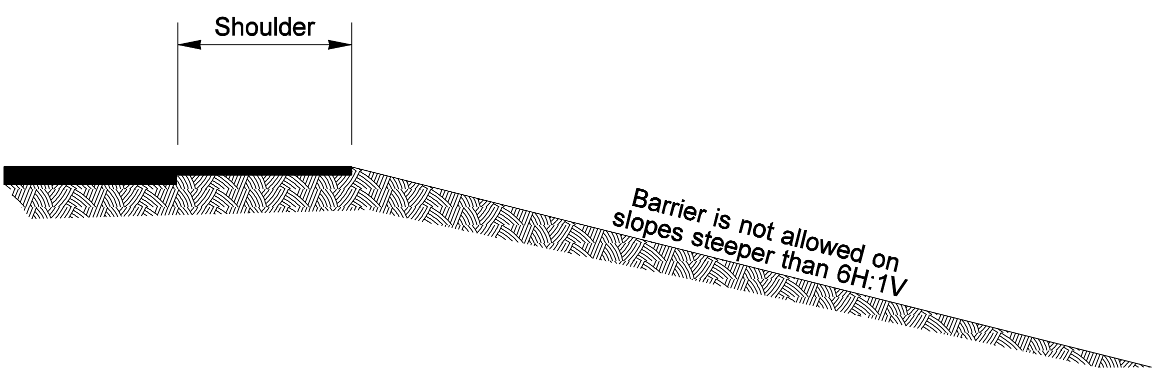
When a flared terminal is specified, it is critical that embankment also be specified so that the area around the terminal can be flattened as shown on the Standard Plans. For every foot of height of the embankment, 13 cubic yards of embankment are required.

No snowload rail washers are allowed within the limits of these terminals.

The FHWA has granted approval to use these sole source proprietary terminals without justification.







Traffic Barrier Locations on Slopes
Figure 710-4

(b) **Nonflared Terminal.** Where widening to provide the offset for a flared terminal is not practicable, consider a nonflared terminal. (See Figure 710-13.) There are currently two acceptable sole source proprietary designs: the ET PLUS and the Sequential Kinking Terminal (SKT). Both of these systems use W-beam guardrail with a special end piece that fits over the end of the guardrail and wood breakaway and CRT posts. When hit head on, the end piece is forced over the rail and either flattens or bends the rail and then forces it away from the impacting vehicle.

Both of these terminals include an anchor for developing the tensile strength of the guardrail. The length of need begins at the third post for both terminals.

Both of these terminals are available in two designs based on the posted speed of the highway. The primary difference in these designs is the length of the terminal. For highways with a posted speed of 45 miles per hour or greater, use the 50-foot-long ET PLUS TL3 or SKT 350. For lower-speed highways (a posted speed of 40 miles per hour or less), use the 25-foot-long ET PLUS TL2 or SKT-TL2.

While these terminals do not require an offset at the end, a flare is recommended so that the end piece does not protrude into the shoulder. These terminals may have a 1-foot offset to the first post. Four feet of widening is required at the end posts to ensure that the system is properly anchored. For every foot of embankment height, 3 cubic yards of embankment are required.

No snowload rail washers are allowed within the limits of these terminals.

The FHWA has granted approval to use these sole source proprietary terminals without justification.

(c) **Terminal Evolution Considerations.** Some approved terminals have been in service for a number of years. During this time, there have been minor design changes. However, these minor changes have not changed the devices' approval status. All previous designs for these terminals may remain in place. If questions arise concerning the current approval status of a device, contact the HQ Design Office for clarification when replacement is being considered.

(d) **Other Anchor Applications.** Use the Type 1 anchor to develop the tensile strength of the guardrail on the end of guardrail runs where a crashworthy terminal is not required. Use the Type 4 anchor to develop the tensile strength of the guardrail on the trailing end of guardrail runs along one-way highways. Use the Type 5 anchor with the Weak Post Intersection Design. (See 710.06(6), Cases 12 and 13.) Use the Type 7 anchor to develop tensile strength in the middle of a guardrail run when the guardrail curves and weak posts are used. (See 710.06(6), Cases 9, 12, and 13.)

The old Type 3 anchor was primarily used at bridge ends. (See Figure 710-5.) This anchor consisted of a steel pipe mounted vertically in a concrete foundation. Bridge approach guardrail was then mounted on the steel pipe. On one-way highways, these anchors were usually positioned so that neither the anchor nor the bridge rail posed a snagging hazard. In these cases, the anchor may remain in place if a stiffened transition section is provided at the connection to the post. On two-way highways, the anchor may present a snagging hazard. In these cases, install a connection from the anchor to the bridge rail if the offset from the bridge rail to the face of the guardrail is 1 foot 6 inches or less. If the offset is greater than 1 foot 6 inches, remove the anchor and install a new transition and connection.

Locations where crossroads and driveways cause gaps in the guardrail require special consideration. Elimination of the need for the barrier is the preferred solution. Otherwise, a barrier flare might be required to provide sight distance. If the slope is 2H:1V or flatter and there are no hazards on or at the bottom of the slope, a terminal can be used to end the rail. Place the anchor of this installation as close as possible to the road approach radius PC. If there is a hazard at or near the bottom of the slope that cannot be mitigated, then the Weak Post Intersection Design (see 710.06 and the Standard Plans) can be used. This system can also be used at locations where a crossroad or road approach is near the end of a bridge and installing a bridge approach guardrail placement (including guardrail transition and terminal) is not possible.

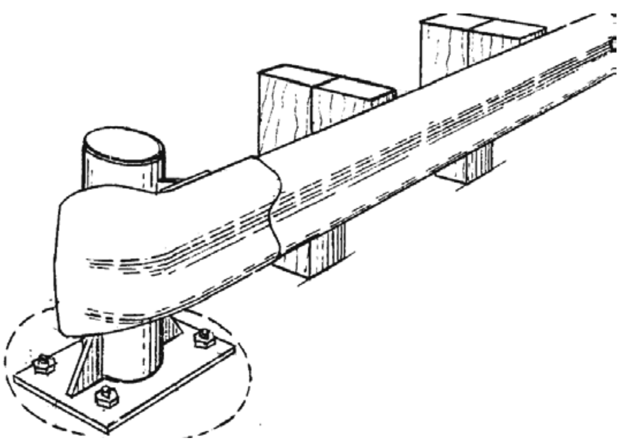
(5) Transitions and Connections

When there is an abrupt change from one barrier type to a more rigid barrier type, a vehicle hitting the more flexible barrier is likely to be caught in the deflected barrier pocket and directed into the more rigid barrier. This is commonly referred to as “pocketing." A transition stiffens the more flexible barrier by decreasing the post spacing, increasing the post size, and using stiffer beam elements to eliminate the possibility of pocketing.

When connecting beam guardrail to a more rigid barrier or a structure, or when a rigid object is within the deflection distance of the barrier, use the transitions and connections that are shown in Figures 710-6 and 710-10 and detailed in the Standard Plans. The transition pay item includes the connection.

For currently available transitions and connections for Types 31 and 31NB, refer to the HQ Design Standards (Plan Sheet Library) at the following web site: http://www.wsdot.wa.gov/eesc/design/designstandards/psl/default.htm

Some transitions and connections are currently under development and will be added to this site as soon as they are completed. Plans will be housed at this location until they are transitioned into the Standard Plans.



Old Type 3 Anchor
Figure 710-5

Condition	Connection
Unrestrained concrete barrier	A
Rigid untapered safety shape bridge rails or barriers(1)	B
Bridge rails with curbs 9 inches or less in width	B
Bridge rails with curbs between 9 and 18 inches wide	C
Vertical walls or tapered safety shape barrier(1)	D
(1) New safety shape bridge rails are designed with the toe of the barrier tapered so that it does not project past the face of the approach guardrail.	

Guardrail Connections
Figure 710-6

(6) Guardrail Placement Cases

The Standard Plans contains placement cases that show all of the beam guardrail elements required for typical situations. Following is a description of each case:

Case 1 is used only where there is one-way traffic. It uses a crashworthy terminal on the approach end and a Type 4 anchor on the trailing end.

Case 2 is used where there is two-way traffic. A crashworthy terminal is used on both ends. When flared terminals are used on both ends, a minimum of 25 feet of guardrail is required between the terminal limits.

Case 3 is used at railroad signal supports on one-way or two-way roadways. A terminal is used on the approach end, but usually cannot be used on the trailing end because of its proximity to the railroad tracks. For one-way roadways, a Type 4 anchor is used on the trailing end. On two-way roadways, a Type 1 anchor is used on the trailing end. If there is a history of crossover accidents, consider additional protection, such as an impact attenuator.

Case 4 is used where guardrail on the approach to a bridge is to be shifted laterally to connect with the bridge rail. A terminal is used on the approach end and a transition is required at the bridge end. A curve in the guardrail is shown to shift it to the bridge rail. However, the length of the curve is not critical and the only requirement is to provide a smooth curve that is not more abrupt than the allowable flare rate. (See Figure 710-3.)

Case 5 is a typical bridge approach where a terminal and a transition are required.

Case 6 is used on bridge approaches where opposing traffic is separated by a median that is 36 feet or wider. This case is designed so that the end of the guardrail will be outside the clear zone for the opposing traffic.

Cases 7 and 8 are used with beam guardrail median barrier when median hazards such as bridge piers are encountered. A transition is required on the approach end for each direction and the flare rate must not be more abrupt than the allowable flare rate. (See Figure 710-3.)

Case 9 (A, B, and C) is used on bridge approaches where opposing traffic is separated by a median less than 36 feet wide. This design, called a "Bull Nose Terminal," treats both bridge ends and the opening between the bridges. The "nose" is designed to collapse when struck head on, and the ribbon strength of the rail brings the vehicle to a controlled stop. Type 7 anchors are installed on each side of the nose to develop the ribbon strength.

Since an impacting vehicle will penetrate into the system, it is critical that no fixed object be located within the first 30 feet of the system.

Case 10 (A, B, and C) is used at roadside hazards (such as bridge piers) when 3 feet or more are available from the face of the guardrail to the hazard. The approach end is the same for one-way or two-way traffic. Case 10A is used with two-way traffic; therefore, a terminal is required on the trailing end. Case 10B is used for one-way traffic when there is no need to extend guardrail past the bridge pier and a Type 4 anchor is used to end the guardrail. Case 10C is used for one-way traffic when the guardrail will extend for a distance past the bridge pier.

Case 11 (A, B, and C) is used at roadside hazards (such as bridge piers) when the guardrail is to be placed within 3 feet of the hazard. Since there is no room for deflection, the rail in front of the hazard must be considered a rigid system and a transition is necessary. The trailing end cases are the same as described for Case 10.

Cases 12 and 13 are called "Weak Post Intersection Designs." They are used where an intersection requires a gap in the guardrail or there is not adequate space for a bridge approach installation that includes a transition and/or terminal. These placements are designed to collapse when hit at the nose, and the ribbon strength of the rail brings the vehicle to a stop. A Type 7 anchor is used to develop the ribbon strength. These designs include a Type 5 transition for connection with bridge rail and a Type 5 anchor at the other end of the rail. The Type 5 anchor is not a breakaway anchor and, therefore, can only be used on low-speed side roads and driveways.

Since an impacting vehicle will penetrate into the system, it is critical that no fixed object be located within the clear area shown on the Standard Plan. The 25 feet along the side road are critical for the operation of this system.

These designs were developed for intersections that are approximately perpendicular. Evaluate installation on skewed intersections on a case-by-case basis. Use the Case 22 placement if it is not feasible to install this design according to the Standard Plan.

Case 14 shows the approach rail layout for a Service Level 1 bridge rail system. Type 20 guardrail is used on the approach and no transition is required between the Type 20 guardrail and the Service Level 1 bridge rail since they are both weak post systems. A Type 6 transition is used when connecting the Type 20 to a strong post guardrail or a terminal.

Case 15 is used to carry guardrail across a box culvert where there is insufficient depth to install standard posts for more than 17 feet 8 inches. This design uses steel posts anchored to the box culvert to support the rail. Newer designs, Cases 19, 20, and 21, have replaced this design for shorter spans.

Cases 16 and 17 are similar to Cases 1 and 2, except that they flare the rail and terminal as far from the road as possible and reduce the length of need.

Case 18 is used on the trailing end of bridge rail on a one-way roadway. No transition is necessary.

Case 19 (A and B) is used where it is not possible to install a post at the 6-foot-3-inch spacing. This design omits one post (resulting in a span of 11 feet 6 inches, which is consistent with a post spacing of 12 feet 6 inches) and uses nested W-beam to stiffen the rail. The cases differ by the location of the splice. No cutting of the rail or offsetting of the splices is necessary or desirable.

Case 20 is similar to Cases 19A and 19B, except that it allows for two posts to be omitted (which results in a span consistent with a post spacing of 18 feet 9 inches).

Case 21 has a similar intent as Cases 19A, 19B, and 20 in that it allows for the omission of posts to span an obstruction. This design uses CRT posts with additional post blocks for three posts before and after the omitted posts. The design allows for three posts to be omitted (which results in a span consistent with a post spacing of 25 feet).

Case 22 is the "Strong Post Intersection Design" that provides a stiff barrier. This design is only to be used as a last resort at crossroads or road approaches where a barrier is necessary and there isn't a clear area behind the nose or minimum distances for a "Weak Post Intersection Design." (See Cases 12 and 13.)

Case 23 – the placement/connection of generic cable barrier to W-beam flared terminals.

Case 24 – the placement/connection of generic cable barrier to W-beam bull nose applications.

Case 25 – the placement of generic cable barrier at thrie beam bull nose locations.

Case 26 – the generic cable barrier to W-beam shielding at redirectional landform locations.

Case 27 – the placement of generic cable barrier for shielding at redirectional landform locations.

710.07 Cable Barrier

Cable barrier is a flexible barrier system that can be used on a roadside or as a median barrier. The primary advantage of cable barrier is that it provides effective vehicle containment and redirection while imposing the lowest deceleration forces on the vehicle's occupants. It also has advantages in heavy snowfall areas in that it has minimal potential to create snowdrifts. In addition, it does not present a visual barrier, which may make it desirable on Scenic Byways. (See 710.05.)

Maintenance is a consideration because routine maintenance is necessary to keep tension in the cables, and a comparatively long run of cable barrier will have to be repaired after an impact. However, the effort (time and materials) required to maintain and repair cable barrier is much less than the effort required for a W-beam system.

There are currently two main types of cable barrier in use. The first is the generic cable barrier system, which is detailed in the Standard Plans. The second is the proprietary high-tension (H.T.) cable barrier systems (available from several manufacturers).

For new installations, the high-tension cable barriers are the first choice. However, it is acceptable for the generic system to remain in place or to be installed new, if needed.

(1) WSDOT Generic Cable Barrier

The WSDOT Generic System consists of three steel cables mounted to steel posts (weak posts). The maximum spacing for the steel posts is 16 feet on tangent sections and curves with a 700-foot radius or greater. A deflection of 11 feet 6 inches is anticipated with this post spacing. A smaller spacing is required on radii less than 700 feet. For tangent sections and large radius curves, the deflection can be reduced to 7 feet by reducing the post spacing to 4 feet.

At each end of the barrier run, the cable is turned down and anchored to concrete blocks. A coil spring and turnbuckle are required on each cable to maintain tension on the system.

(2) High-Tension Cable Barrier

In addition to the generic cable barrier system described above, proprietary high-tension (H.T.) cable barrier systems are now available from a few different manufacturers. Potentially, these systems offer some advantages over the WSDOT Generic Cable Barrier System. For example, these systems deflect less than the standard WSDOT design. Depending on the system and post spacing, deflection distances range from 6 feet 8 inches to 9 feet 3 inches. In addition, when impacted, the H.T. systems also result in less damage to the barrier. In many cases, the cables remain at the proper height after a collision has damaged several posts, which offers some maintenance benefits. (See Figure 710-14 for placement details.)

(3) Cable Barrier Placement

Cable barrier can be installed up to 1 foot in front of side slopes as steep as 2H:1V. Cable barrier is the only barrier that can be placed on a side slope steeper than 10H:1V within the 12-foot area immediately beyond the breakpoint. Do not place this barrier on a side slope steeper than 6H:1V. Figure 710-14 shows the placement of cable barrier.

Narrow medians provide little space for maintenance crews to repair or reposition the barrier. Whenever sight conditions permit, provide at least 14 feet of clearance from the adjacent lane edge to the cable barrier.

When cable barrier is to be connected to a more rigid barrier, a transition section is required. (See the Standard Plans or contact the HQ Design Office for further details.)

710.08 Concrete Barrier

Concrete barriers are rigid or unrestrained rigid systems. They are also used as shoulder barriers. These systems are stiffer than beam guardrail or cable barrier, and impacts with these barriers will tend to be more severe.

Light standards mounted on top of concrete median barrier must not have breakaway features. (See the Standard Plans for the concrete barrier light standard section.)

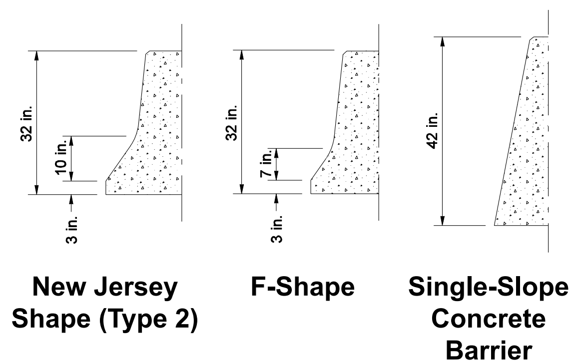
Where drainage might be a problem, contact the HQ Hydraulics Branch for guidance.

(1) Concrete Barrier Shapes

Concrete barriers use a safety shape (New Jersey shape and, on bridges, the F-Shape) or single-sloped face to redirect vehicles while minimizing vehicle vaulting, rolling, and snagging. A comparison of these barrier shapes is shown in Figure 710-7.

The New Jersey shape face is used on precast concrete barrier.

The single-slope barrier face is recommended when separating roadways with different elevations (stepped medians). The single-slope barrier face can be used for bridge rails (median or outside) when it is to be used on any approach to a bridge and an existing bridge rail is to be replaced.



Concrete Barrier Shapes
Figure 710-7

The F-Shape face is used on all other bridge rails and on cast-in-place barrier where the New Jersey and single-slope face are not appropriate. When the F-Shape face is used and precast barrier is to be used on the approaches, a cast-in-place transition section is required so that no vertical edges of the barriers are exposed to oncoming traffic. For details on the F-Shape barrier or any of the bridge rail designs, see the *Bridge Design Manual*.

For aesthetic reasons, avoid changes in the shape of the barrier face within a project or corridor.

(a) **New Jersey Shape Barrier.** The New Jersey shape face is primarily used on precast concrete barrier.

Concrete barrier Type 2 (see the Standard Plans) is a precast barrier that has the New Jersey shape on two sides and can be used for both median and shoulder installations. This barrier is 2 feet 8 inches in height, which includes 3 inches for future pavement overlay.

The cost of precast Type 2 barrier is significantly less than the cost of the cast-in-place barriers. Therefore, consider the length of the barrier run and the deflection requirements to determine whether transitioning to precast Type 2 barrier is desirable. If precast Type 2 barrier is used for the majority of a project, use the New Jersey face for small sections that require cast-in-place barrier, such as for a light standard section.

Concrete barrier Type 4 is also a precast, single-faced New Jersey shape barrier. These units are not freestanding and must be placed against a rigid structure or anchored to the pavement. If Type 4 barriers are used back to back, consider filling any gap between them to prevent tipping.

Concrete barrier Type 5 is a precast barrier that has a single New Jersey face and is intended for use at bridge ends where the flat side is highly visible. Both Type 2 and Type 5 designs are freestanding, unanchored units connected with steel pins through wire rope loops. For permanent installation, this barrier is placed on a paved surface and a 2-foot-wide paved surface is provided beyond the barrier for its displacement during impact. (See Chapter 640.)

Precast barrier can be anchored where a more rigid barrier is desired. (Anchoring methods are shown in the Standard Plans.) The Type 1 and Type 2 anchors are for temporary installations on a rigid pavement. Type 3 anchors can be used in temporary or permanent installations on an asphalt pavement. Consult the HQ Bridge and Structures Office for details when anchoring permanent precast concrete barrier to a rigid pavement.

Precast barrier used on the approach to bridge rail must be connected to the bridge rail by installing wire rope loops embedded 1 foot 3 inches into the bridge rail with epoxy resin.

Place unrestrained (unanchored) precast concrete barrier, on foundation slopes of 5% or flatter. In difficult situations, a maximum slope of 8% may be used. Keep the slope of the area between the edge of the shoulder and the face of the traffic barrier as flat as possible. The maximum slope is 10H:1V (10%).

(b) **Single-Slope Barrier**. The single-slope concrete barrier can be cast in place, slipformed, or precast. The most common construction technique for this barrier has been slipforming, but some precast single-slope barrier has been installed. The primary benefit of using precast barrier is that it can be used as temporary barrier during construction and then reset into a permanent location.

This barrier is considered a rigid system regardless of the construction method used. For new installations, the minimum height of the barrier above the roadway is 2 feet 10 inches, which allows 2 inches for future overlays. The minimum total height of the barrier section is 3 feet 6 inches, with a minimum of 3 inches embedded in the roadway wearing surface. This allows for use of the 3-foot-6-inch barrier between roadways with grade separations of up to 5 inches. A grade separation of up to 10 inches is allowed, as shown in the Standard Plans. The barrier must have a depth of embedment equal to or greater than the grade separation. Contact the HQ Bridge and Structures Office for grade separations greater than 10 inches. (See the Standard Plans.)

(c) **Low Profile Barrier.** Low profile barrier designs are available for median applications where the posted speed is 45 miles per hour or less. These barriers are normally used in urban areas. They are typically 18 to 20 inches high and offer sight distance benefits. For barrier designs, terminals, and further details, contact the HQ Design Office.

(2) High Performance Concrete Barrier

High Performance Concrete Barrier (HP Barrier) is a rigid 42-inch-high barrier designed to function better during heavy-vehicle collisions. This taller barrier may also offer the added benefits of reducing headlight glare and reducing noise in surrounding environments. HP Barrier is generally considered single-slope barrier. However, other shapes are available. (See the Standard Plans for barrier details.)

Use HP Barrier in freeway medians of 22 feet or less. Also, use HP Barrier on Interstate or freeway routes where accident history suggests a need, or where roadway geometrics increase the possibility of larger trucks hitting the barrier at a high angle (such as on-ramps for freeway-to-freeway connections with sharp curvature in the alignment).

Consider the use of HP Barrier at other locations, such as near highly sensitive environmental areas, near densely populated areas, over or near mass transit facilities, or on vertically divided highways.

(3) Concrete Barrier Terminals

Whenever possible, bury the end of the concrete barrier in the backslope. The backslope required to bury the end must be 3H:1V or steeper and at least 4 feet in height above the roadway. Flare the concrete barrier into the backslope using a flare rate that meets the criteria in 710.05(3). Provide a 10H:1V or flatter foreslope into the face of the barrier and maintain the full barrier height to the foreslope/backslope intersection. This might require filling ditches and installing culverts in front of the barrier face.

The 7-foot-long precast concrete terminal end section for Concrete Barrier Type 2 may be used:

- Outside the Design Clear Zone.
- On the trailing end of the barrier when it is outside the Design Clear Zone for opposing traffic.
- On the trailing end of one-way traffic.
- Where the posted speed is 25 miles per hour or less.

Another available end treatment for Type 2 barriers is a precast or cast-in-place tapered terminal section having a minimum length of 48 feet and a maximum length of 80 feet. It is used infrequently for special applications and can only be used for posted speeds of 35 miles per hour or less. For details, contact the HQ Design Office or refer to the Plan Sheet Library at the following web site: http://www.wsdot.wa.gov/eesc/design/designstandards/psl/default.htm

When the "Barrier Terminals and Transitions" column of a design matrix applies to a project, existing sloped-down concrete terminals that are within the Design Clear Zone must be replaced when they do not meet the criteria above.

When the end of a concrete barrier cannot be buried in a backslope or terminated as described above, terminate the barrier using a guardrail terminal and transition or an impact attenuator. (See Chapter 720.)

(4) Assessing Impacts to Wildlife

The placement of concrete barriers in locations where wildlife frequently cross the highway can influence traffic safety and wildlife mortality. When wildlife encounter physical barriers that are difficult to cross, they often travel parallel to those barriers. With traffic barriers, this means that they often remain on the highway for a longer period, increasing the risk of wildlife/vehicle collisions or vehicle/vehicle collisions as motorists attempt avoidance.

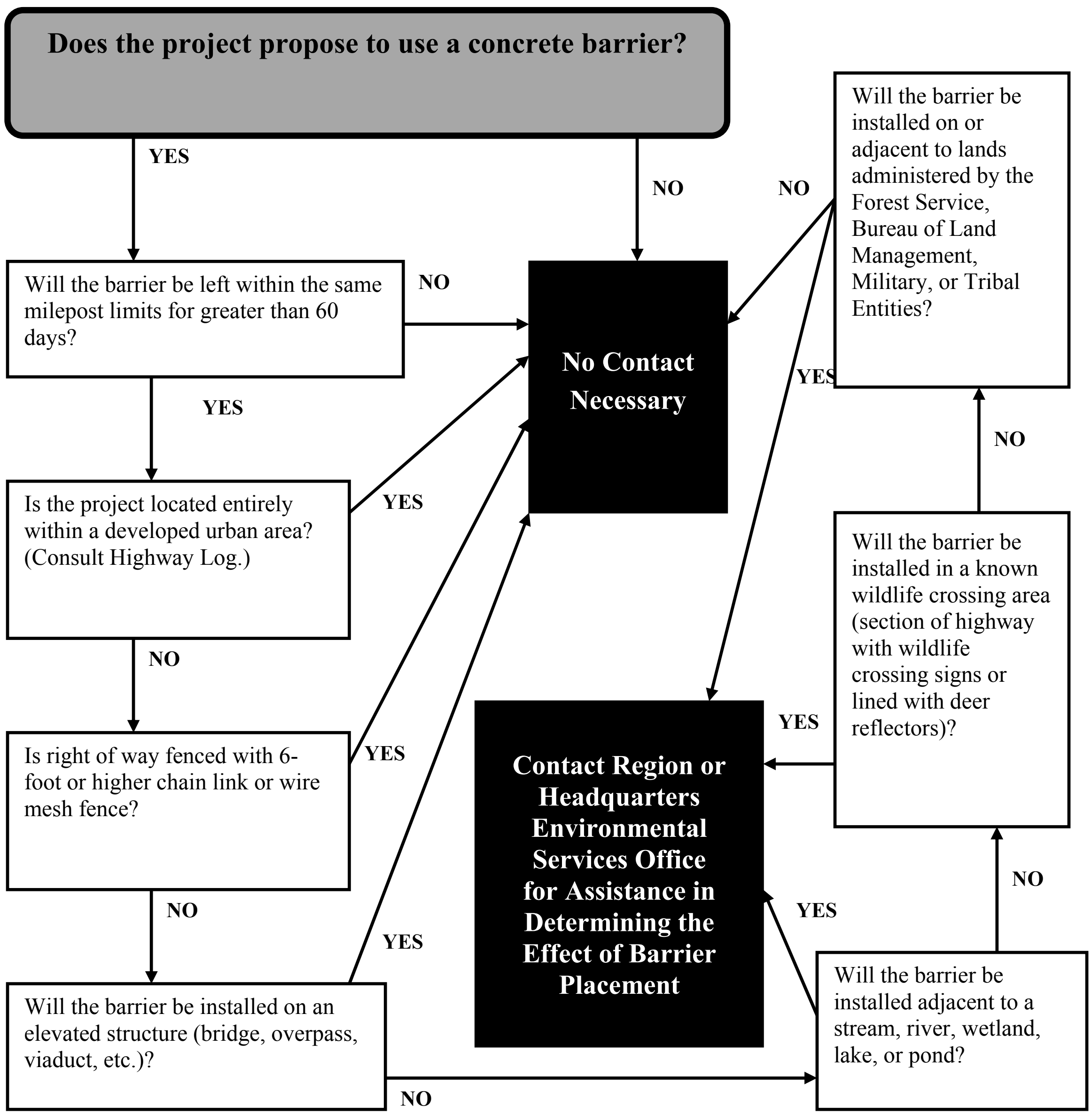
Traffic-related wildlife mortality may play a role in the decline of some species listed under the Endangered Species Act. To address public safety and wildlife concerns, see Figure 710-8 to assess whether concrete barrier placement requires an evaluation by the Environmental Services Office to determine its effect on wildlife. Make this evaluation early in the project development process to allow adequate time for discussion of options.

710.09 Special-Use Barriers

The following barriers may be used on designated Scenic Byway and Heritage Tour routes if funding can be arranged. (See 710.05 and Chapter 120.)

(1) Steel-Backed Timber Guardrail

Steel-backed timber guardrails consist of a timber rail with a steel plate attached to the back to increase its tensile strength. There are several variations of this system that have passed crash tests. The nonproprietary systems use a beam with a rectangular cross section that is supported by either wood or steel posts. A proprietary (patented) system called the Ironwood guardrail is also available. This system uses a beam with a round cross section and is supported by steel posts with a wood covering to give the appearance of an all-wood system from the roadway. The Ironwood guardrail can be allowed as an alternative to the nonproprietary system. However, specifying this system exclusively requires approval by the Assistant State Design Engineer of a public interest finding for the use of a sole source proprietary item.



Concrete Barrier Placement Guidance (Assessing Impacts to Wildlife)
Figure 710-8

The most desirable method of terminating the steel-backed timber guardrail is to bury the end in a backslope as described in 710.06(4). When this type of terminal is not possible, the use of the barrier is limited to highways with a posted speed of 45 miles per hour or less. On these lower-speed highways, the barriers can be flared away from the traveled way and terminated in a berm.

For details on these systems, contact the HQ Design Office.

(2) Stone Guardwalls

Stone guardwalls function like rigid concrete barriers but have an appearance of natural stone. These walls can be constructed of stone masonry over a reinforced concrete core wall or of simulated stone concrete. These types of barriers are designed to have a limited projection of the stones that will not affect the redirectional characteristics of the barrier. The most desirable method of terminating this barrier is to bury the end in a backslope, as described in 710.08(3). When this type of terminal is not possible, the use of the barrier is limited to highways with a posted speed of 45 miles per hour or less. On these lower-speed highways, the barrier can be flared away from the traveled way and terminated in a berm.

For details on these systems, contact the HQ Design Office.

710.10 Bridge Traffic Barriers

Bridge traffic barriers redirect errant vehicles and prevent them from going over the side of the structure. (See the *Bridge Design Manual* for information regarding bridge barrier on new bridges and replacement bridge barrier on existing bridges.)

For most new bridge rail installations, use a 2-foot-8-inch-high safety shape (F-Shape) bridge barrier. A transition is available to connect the New Jersey shape (Type 2 Concrete Barrier) and the F-Shape bridge barrier. (See the Standard Plans for further details.) The single-slope bridge barrier that is 2 feet 10 inches high can be used to be consistent with the heights of connecting single-slope barrier. (See 710.08(1)(b).)

Use taller 3-foot-6-inch safety shape or single-slope bridge barriers on Interstate or freeway routes where accident history suggests a need or where roadway geometrics increase the possibility of larger trucks hitting the barrier at a high angle (such as on-ramps for freeway-to-freeway connections with sharp curvature in the alignment).

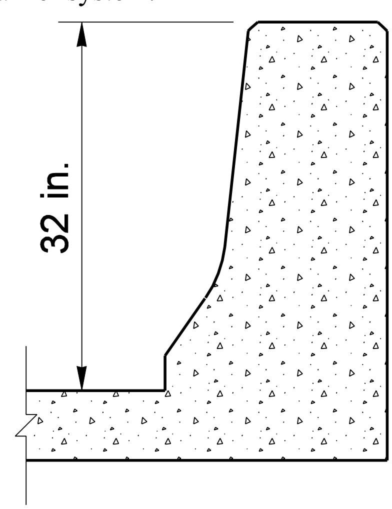
For bridges where high volumes of pedestrian traffic are anticipated, see Chapter 1020 for further guidance.

Approach barriers, transitions, and connections are usually required on all four corners of bridges carrying two-way traffic and on both corners of the approach end for one-way traffic. (See 710.06(5) for guidance on transitions.)

If the bridge barrier system does not meet the criteria for strength and geometrics, modifications to improve its redirectional characteristics and its strength may be required. The modifications can be made using one of the retrofit methods described below.

(1) Concrete Safety Shape

Retrofitting with a new concrete bridge barrier (see Figure 710-9) is costly and requires justification when no widening is proposed. Consult the HQ Bridge and Structures Office for design details and to determine if the existing bridge deck and other superstructure elements are of sufficient strength to accommodate this bridge barrier system.



Safety Shape Concrete Bridge Rail Retrofit
Figure 710-9

(2) Thrie Beam Retrofit

Retrofitting with thrie beam is an economical way to improve the strength and redirectional performance of bridge barriers. The thrie beam can be mounted to steel posts or the existing bridge barrier, depending on the structural adequacy of the bridge deck, the existing bridge barrier type, the width of curb (if any), and the curb-to-curb roadway width carried across the structure.

The HQ Bridge and Structures Office is responsible for the design of thrie beam bridge barrier. Figure 710-15 shows typical installation criteria. Contact the HQ Bridge and Structures Office for assistance with thrie beam retrofit design.

Consider the Service Level 1 (SL-1) system on bridges with wooden decks and for bridges with concrete decks that do not have adequate strength to accommodate the thrie beam system. Contact the HQ Bridge and Structures Office for information required for the design of the SL-1 system.

A sidewalk reduction of up to 6 inches as a result of a thrie beam retrofit can be documented as a design exception.

Many bridge rail retrofit projects involve bridges over 250 feet in length. These projects will normally be funded from the I-2 program. Shorter bridges may be funded as a spot safety improvement. Contact the HQ Project Control and Reporting Office for clarification.

710.11 Other Barriers

(1) Dragnet

The Dragnet Vehicle Arresting Barrier consists of chain link or fiber net that is attached to energy absorbing units. When a vehicle hits the system, the Dragnet brings the vehicle to a controlled stop with a minimum of damage. Possible uses for this device include the following:

- Reversible lane entrances and exits
- Railroad crossings
- Truck escape ramps (instead of arrester beds—see Chapter 1010)
- T-intersections
- Work zones
- Swing span bridges

For permanent installations, this system can be installed between towers that lower the unit into position when needed and lift it out of the way when it is no longer needed. For work zone applications, it is critical to provide deflection space for stopping the vehicle between the system and the work zone. For additional information on the Dragnet, contact the HQ Design Office.

710.12 Documentation

The list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

Connecting W-Beam Guardrail to: Transitions and Connections			Transition Type*	Connection
Bridge Rail	New		1[1] 4[5]	D
	Existing Concrete	Concrete Parapet > 20 inches	1[1] 4[5]	Figure 710-6
		Concrete Parapet < 20 inches	2 4[5]	Figure 710-6
		Existing W-Beam Transition	2[2][6] 4[5]	[2]
	Thrie Beam at face of curb[4]	Approach end	10	na
		Trailing end (two-way traffic only)	11 12	na
	Thrie Beam at bridge rail (curb exposed)[4]	Approach end	13	na
		Trailing end (two-way traffic only)	14 15	na
	Weak Post Intersection Design (see 710.06(4) Cases 12 & 13)		5	Figure 710-6
Concrete Barrier	Rigid Restrained		1 4[5]	Figure 710-6
	Unrestrained		2 4[5]	A
Weak Post Barrier Systems (Type 20 and 21)			6	na
Rigid Structures such as Bridge Piers	New Installation (see Case 11)		16 17 18	na
	Existing W-Beam Transition		[3]	na
Connecting Thrie Beam Guardrail to:				
Bridge Rail or Concrete Barrier	New installation (example: used with thrie beam bull nose)		1B	Figure 710-6

* Consult Section C of the Standard Plans for detail on transition types.

Notes:

(1) A Type 1A transition can be used where there is a problem placing a post within 2'-5" from the end of the bridge, in which case a B or E connection is required. When the E connection is to be used, a special detail for the end of the bridge is required. Contact the HQ Bridge and Structures Office.

(2) If work requires reconstruction or resetting of the transition, upgrade as shown above. Raising the guardrail is not considered reconstruction. If the transition is not being reconstructed, the existing connection may remain in place. (See Section 710.06(4)(d) for guidance when Type 3 anchors are encountered.)

(3) For new/reconstruction, use Case 11 (thrie beam). For existing Case 11 with W-beam, add a second W-beam rail element.

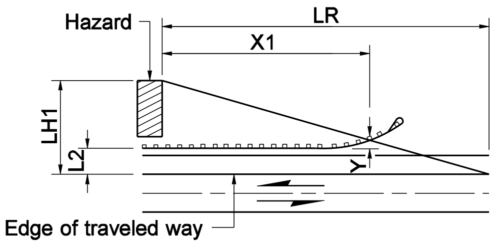
(4) For Service Level 1 bridge rail, see Section 710.06(6), Case 14.

(5) Use on highways with speeds 45 miles per hour or less.

(6) If existing transition has adequate guardrail height—three 10"x10" (nominal) posts and three 6" x 8" (nominal) posts spaced 3'-1.5" apart—it is acceptable to nest existing single W-beam element transitions.

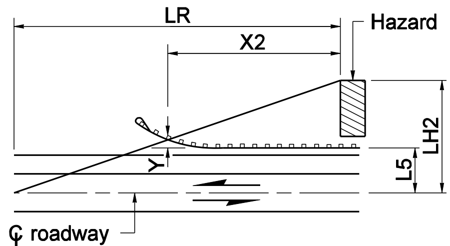
Transitions and Connections

Figure 710-10



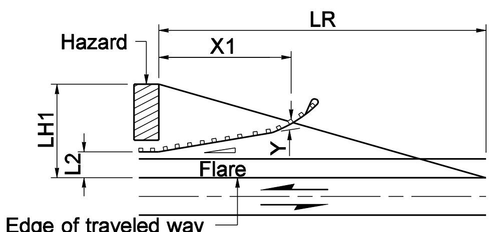
$$X1 = \frac{LH1 - (L2+Y)}{(LH1/LR)}$$

Adjacent-Side Hazard
Barrier Parallel to Roadway



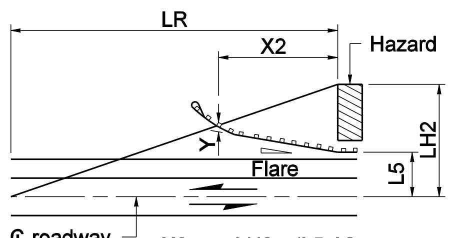
$$X2 = \frac{LH2 - (L5+Y)}{(LH2/LR)}$$

Opposite-Side Hazard
Barrier Parallel to Roadway



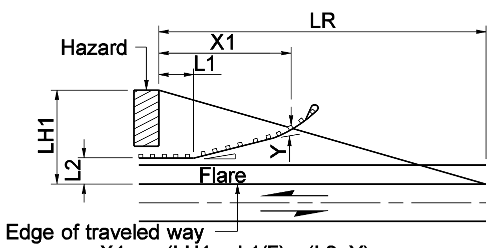
$$X1 = \frac{LH1 - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Hazard
Barrier Flare Begins at Hazard



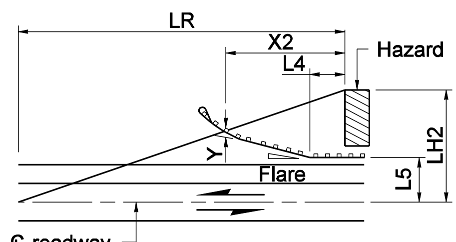
$$X2 = \frac{LH2 - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Hazard
Barrier Flare Begins at Hazard



$$X1 = \frac{(LH1 + L1/F) - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Hazard
Barrier Flare Begins Before Hazard



$$X2 = \frac{(LH2 + L4/F) - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Hazard
Barrier Flare Begins Before Hazard

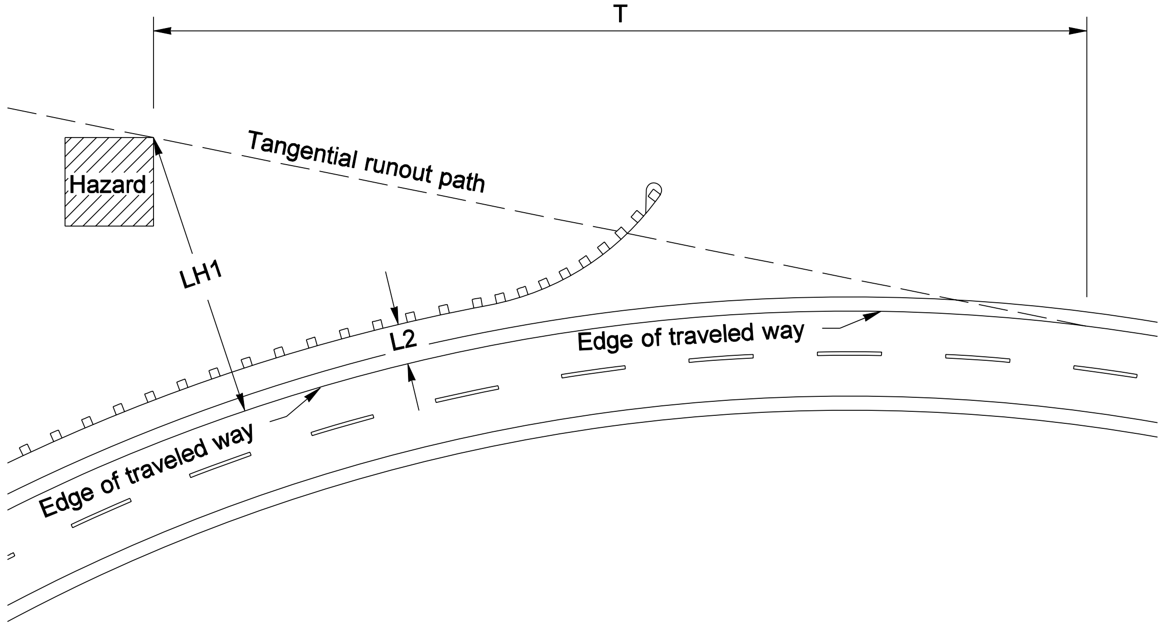
Barrier Length of Need on Tangent Sections
Figure 710-11a

Design Parameters							
Posted Speed (mph)	ADT				Barrier Type		
	Over 10,000	5,000 to 10,000	1,000 to 4,999	Under 1,000	Rigid Barrier	Unrestrained Barrier	Semirigid Barrier
	LR (ft)	LR (ft)	LR (ft)	LR (ft)	F	F	F
70	460	395	345	295	20	18	15
60	360	295	260	230	18	16	14
55	310	260	230	195	16	14	12
50	260	215	180	165	14	12	11
45	245	195	165	150	12	11	10
40	215	180	150	130	11	10	9
35	185	155	130	115	11	10	9
30	165	135	115	105	11	10	9
25	150	125	105	95	11	10	9

L1 = Length of barrier parallel to roadway from adjacent-side hazard to beginning of barrier flare. This is used if a portion of the barrier cannot be flared (such as a bridge rail and the transition).
L2 = Distance from adjacent edge of traveled way to portion of barrier parallel to roadway.
L4 = Length of barrier parallel to roadway from opposite-side hazard to beginning of barrier flare.
L5 = Distance from centerline of roadway to portion of barrier parallel to roadway. Note: If the hazard is outside the Design Clear Zone when measured from the centerline, it may only be necessary to provide a crashworthy end treatment for the barrier.
LH1 = Distance from outside edge of traveled way to back side of adjacent-side hazard. Note: If a hazard extends past the Design Clear Zone, the Design Clear Zone can be used as LH1.
LH2 = Distance from centerline of roadway to back side of opposite-side hazard. Note: If a hazard extends past the Design Clear Zone, the Design Clear Zone can be used as LH2.
LR = Runout length (measured parallel to roadway).
X1 = Length of need for barrier to shield an adjacent-side hazard.
X2 = Length of need for barrier to shield an opposite-side hazard.
F = Flare rate value.
Y = Offset distance required at the beginning of the length of need.

Different end treatments require different offsets.
For the SRT 350 and FLEAT 350, use Y = 1.8 feet.
For evaluating existing BCTs, use Y = 1.8 feet.
For the FLEAT TL-2, use Y = 0.8 feet.
No offset is required for the nonflared terminals or impact attenuator systems. Use Y = 0.
Buried terminal end treatments are used with barrier flares and have no offset. Use Y = 0.

Barrier Length of Need
Figure 710-11b

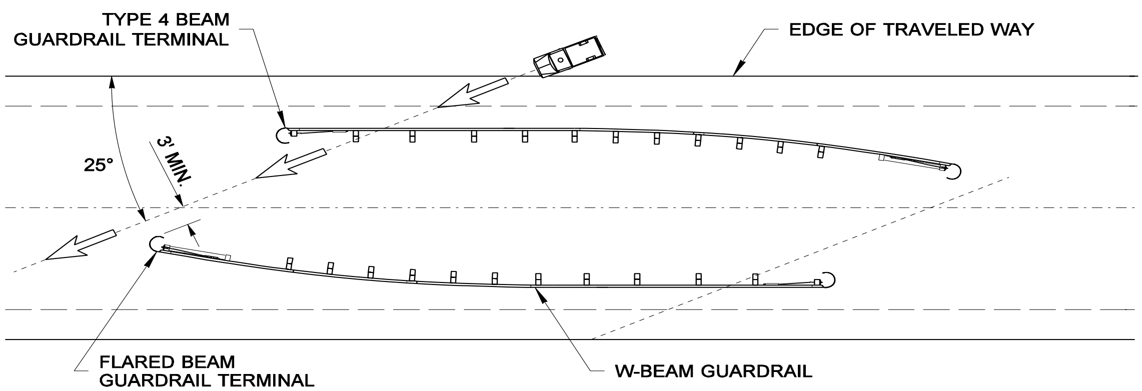


Notes:

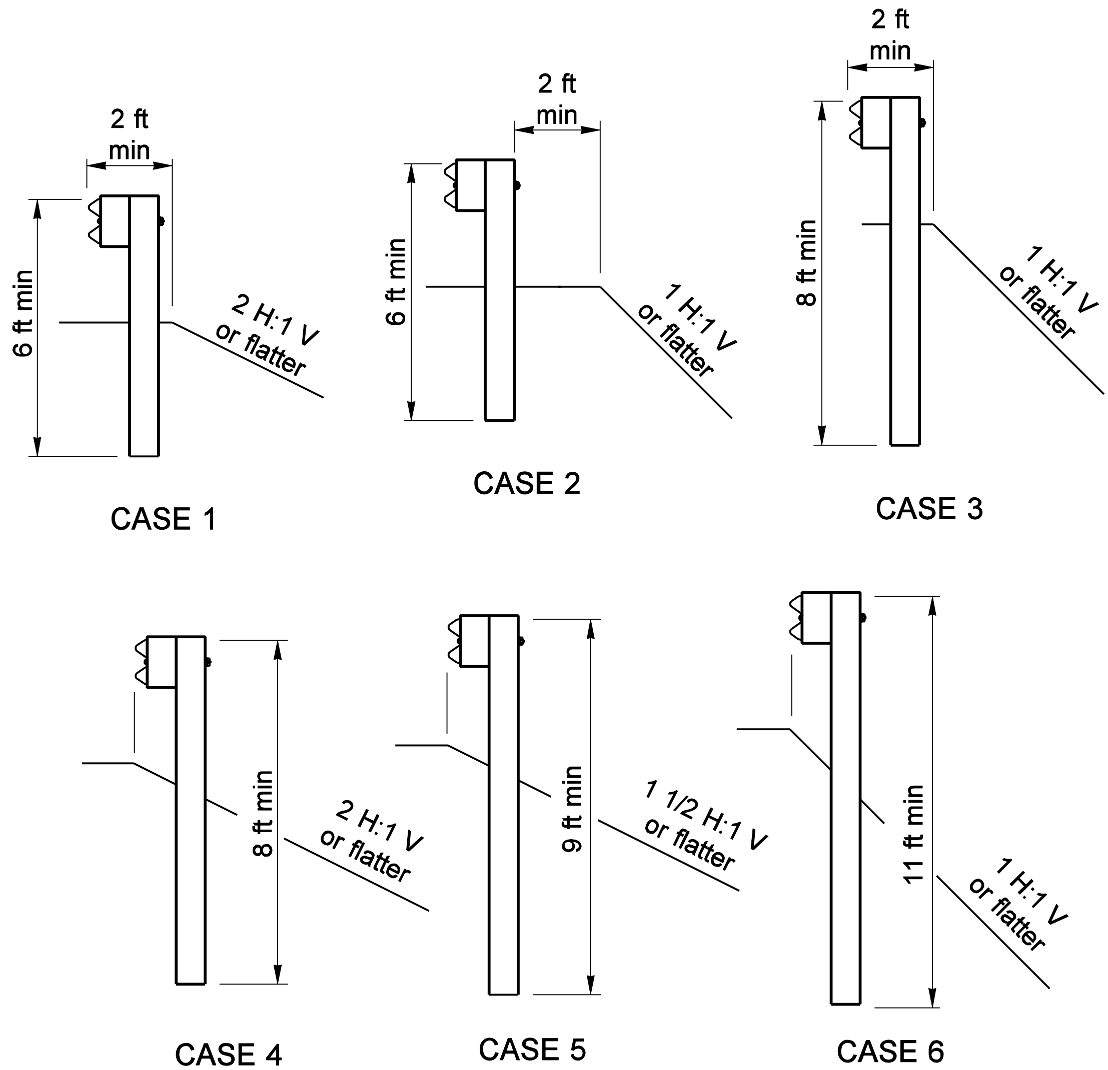
This is a graphical method for determining the length of need for barrier on the outside of a curve.
On a scale drawing, draw a tangent from the curve to the back of the hazard. Compare T to LR from Figure 710-11b and use the shorter value.
If using LR, follow Figures 710-11a and 11b.
If using T, draw the intersecting barrier run to scale and measure the length of need.

Barrier Length of Need on Curves

Figure 710-11c



W-Beam Guardrail Trailing End Placement for Divided Highways
Figure 710-11d



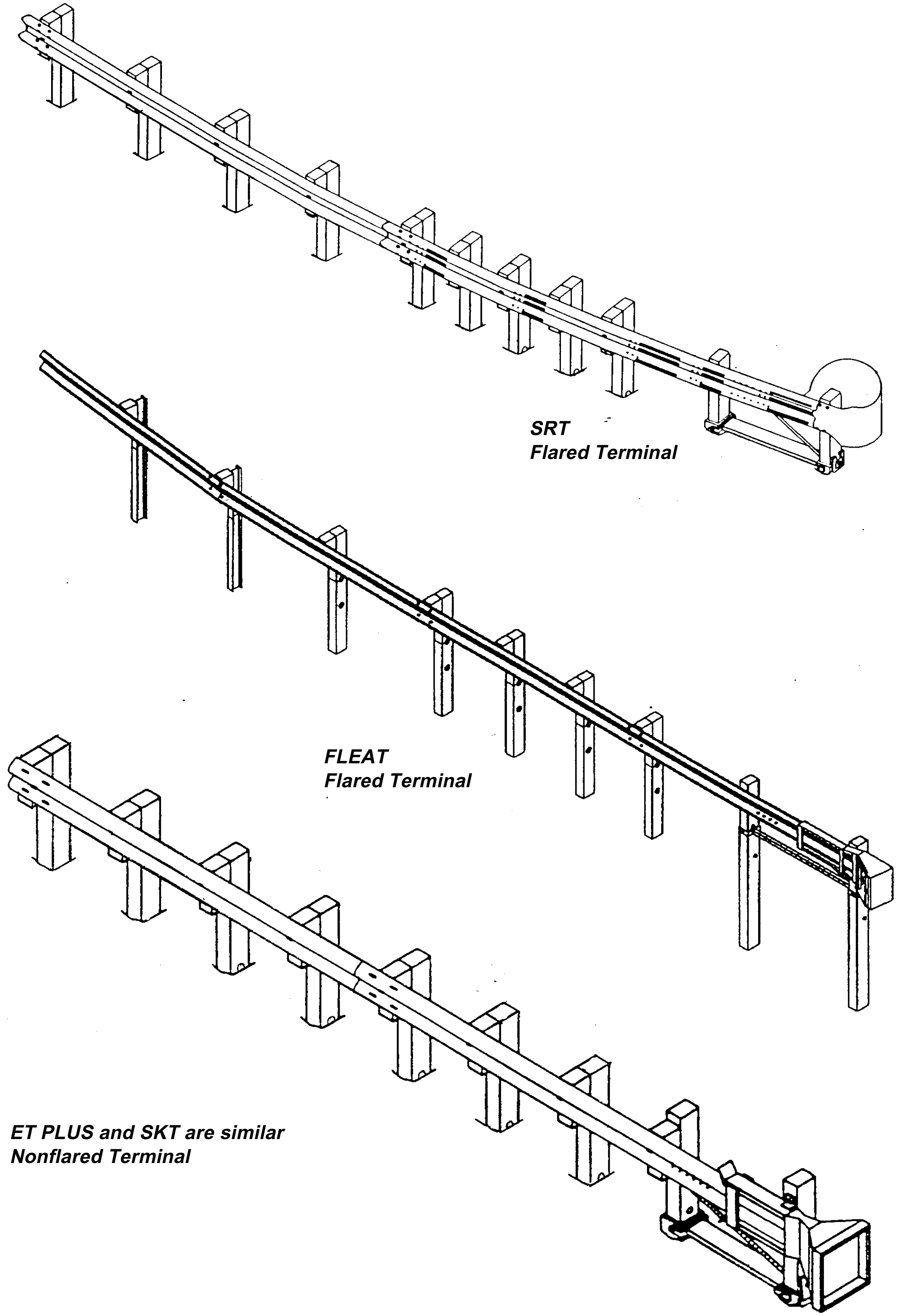
Notes:

Use Cases 1, 2, and 3 when there is a 2-foot or greater shoulder widening from face of guardrail to the breakpoint.

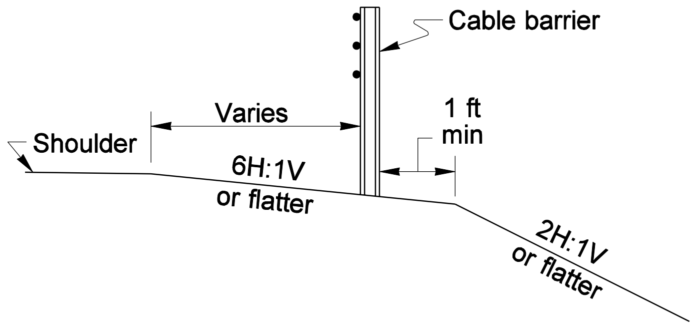
Use Cases 4, 5, and 6 when there is less than a 2-foot shoulder widening from face of guardrail to the breakpoint.

Beam Guardrail Post Installation

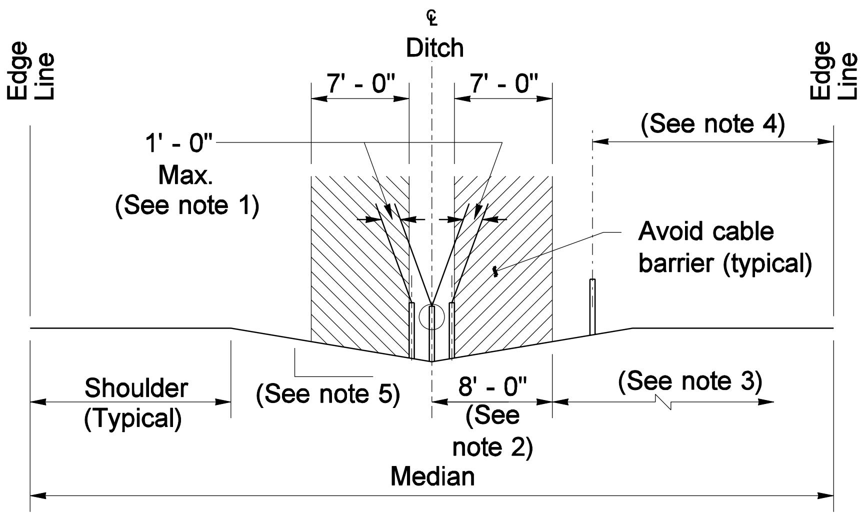
Figure 710-12



Beam Guardrail Terminals
Figure 710-13



Shoulder Installation



Notes:

(1) Cable barrier may be installed in the center of the ditch. The cable barrier may be offset from the ditch centerline a maximum of 1 foot in either direction.
(2) Avoid installing cable barrier within a 1 foot to 8 foot offset from the ditch centerline.
(3) Cable barrier may be installed a distance of 8 feet or greater from the ditch centerline.
(4) Depending on the system used and post spacing, this distance varies from 6 feet 8 inches to 12 feet.
(5) Applies to slopes between 6H:1V to 10H:1V.

Cable Barrier Locations on Slopes

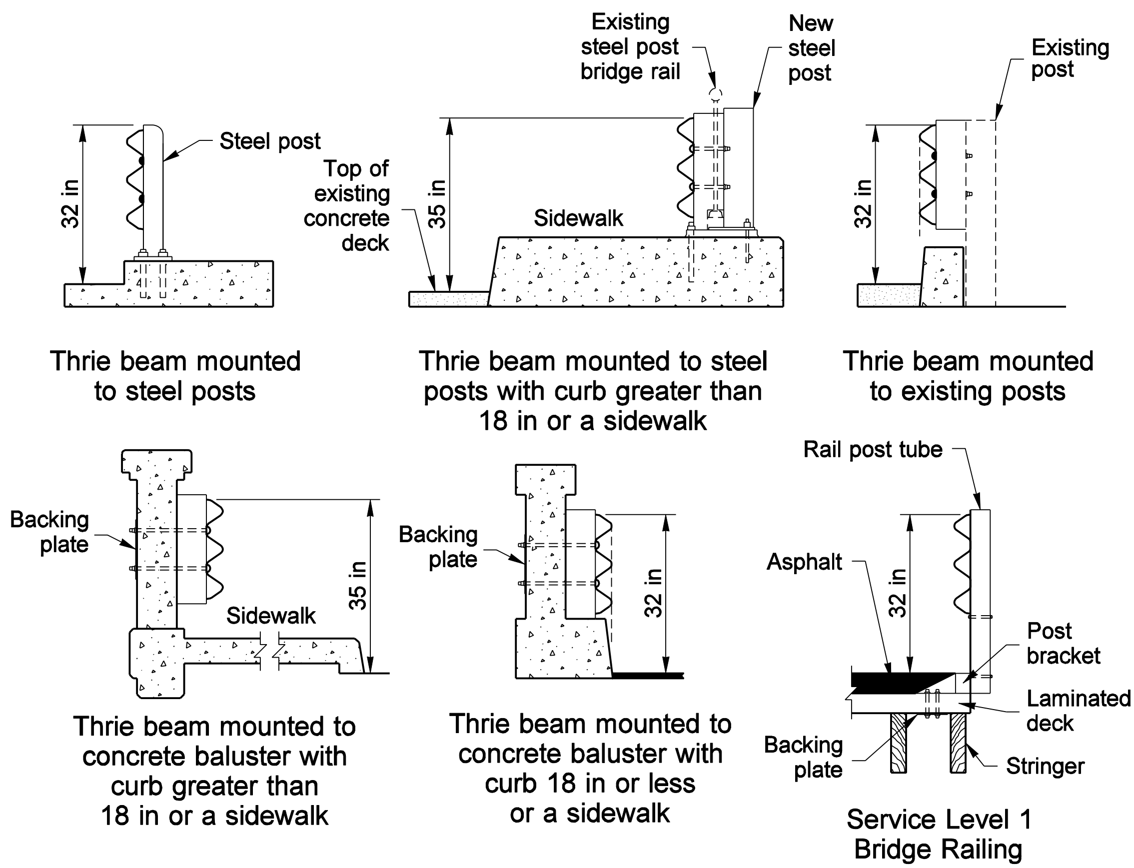
Figure 710-14

<table>
<tr><th colspan="2"></th><th colspan="2">Concrete Bridge Deck</th><th>Wood Bridge Deck or Low- Strength Concrete Deck</th></tr>
<tr><th>Curb Width</th><th>Bridge Width</th><th>Concrete Bridge Rail (existing)</th><th>Steel or Wood Post Bridge Rail (existing)</th><td rowspan="4">Service Level 1 Bridge Rail[2]

Height = 32 inches

Curb or wheel guard must be removed</td></tr>
<tr><td><18 inches</td><td></td><td>Thrie beam mounted to existing bridge rail[2] and blocked out to the face of curb. Height = 32 inches</td><td>Thrie beam mounted to steel posts[2] at the face of curb. Height = 32 inches</td></tr>
<tr><td>>18 inches</td><td>> 28 feet (curb to curb)</td><td colspan="2">Thrie beam mounted to steel posts[2] at the face of curb.[1] Height = 32 inches</td></tr>
<tr><td>>18 inches</td><td>< 28 feet (curb to curb)</td><td>Thrie beam mounted to existing bridge rail.[2] Height = 35 inches</td><td>Thrie beam mounted to steel posts[2] in line with existing rail. Height = 35 inches</td></tr>
</table>

(1) Thrie beam may be mounted to the bridge rail to accommodate pedestrians (height = 35 inches).
(2) Contact the HQ Bridge and Structures Office for design details on bridge rail retrofit projects.



Thrie Beam Rail Retrofit Criteria
Figure 710-15

720.01 Impact Attenuator Systems

Impact attenuator systems are protective systems that prevent an errant vehicle from impacting a hazard by either gradually decelerating the vehicle to a stop when hit head-on or by redirecting it away from the hazard when struck on the side. These barriers are used for rigid objects or hazardous conditions that cannot be removed, relocated, or made breakaway.

Approved systems are shown in Figures 720-2a through 720-4b and on the WSDOT Headquarters (HQ) Design Office web page at: http://www.wsdot.wa.gov/EESC/Design/Policy/RoadsideSafety/Chapter720/Chapter720B.htm

(1) Permanent Installations

For systems used in permanent installations, a description of the system's purpose, parts, and function, as well as requirements for transition, foundation, and slope, are provided as follows and in Figure 720-5:

(a) **Crash Cushion Attenuating Terminal (CAT-350)**

1. **Purpose:** The CAT-350 is an end treatment for W-beam guardrail. It can also be used for concrete barrier if a transition is provided.

2. **Description:** The system consists of slotted W-beam guardrail mounted on both sides of breakaway timber posts. Steel sleeves with soil plates hold the timber posts in place. (See Figure 720-2a.)

3. **Function**: When hit head-on, the slotted guardrail is forced over a pin that shears the steel between the slots. This shearing dissipates the energy of the impact.

4. **Foundation:** Concrete footings or foundations are not required.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(b) **Brakemaster 350**

1. **Purpose:** The Brakemaster 350 system is an end treatment for W-beam guardrail. It can also be used for concrete barrier if a transition is provided.

2. **Description:** The system contains an embedded anchor assembly, W-beam fender panels, transition strap, and diaphragm. (See Figure 720-2a.)

3. **Function:** The system uses a brake and cable device for head-on impacts and for redirection. The cable is embedded in a concrete anchor at the end of the system.

4. **Foundation:** A concrete foundation is not required for this system, but a paved surface is recommended.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(c) **QuadTrend 350**

1. **Purpose:** The QuadTrend 350 is an end treatment for 2-foot-8-inches-high concrete barriers. The system's short length allows it to be used at the ends of bridges where the installation of a beam guardrail transition and terminal is not feasible.

2. **Description:** This system consists of telescoping quadruple corrugated fender panels mounted on steel breakaway posts. (See Figure 720-2a.)

3. **Function:** Sand-filled boxes attached to the posts dissipate a portion of the energy of an impact. An anchored cable installed behind the fender panels directs the vehicle away from the barrier end.

4. **Foundation:** The system is installed on a concrete foundation to support the steel posts.

5. **Slope:** A 6H:1V or flatter slope is required behind the barrier to allow for vehicle recovery.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(d) **Universal TAU-II**

1. **Purpose:** The Universal TAU-II crash cushion system is an end treatment for concrete barrier, beam guardrail, and fixed objects up to 8 feet wide.

2. **Description:** The system is made up of independent collapsible bays containing energy-absorbing cartridges that are guided and supported during a head-on hit by high strength galvanized steel cables and thrie beam rail panels. Each bay is composed of overlapping thrie beam panels on the sides and structural support diaphragms on the ends. Structural support diaphragms are attached to two cables running longitudinally through the system and attached tofoundations at each end of the system. (See Figure 720-2c.)

3. **Function:** Overlapping panels, structural support diaphragms, cable supports, cables, and foundation anchors allow the system to resist angled impacts and mitigate head-on impacts.

4. **Foundation:** The system is installed on a concrete foundation or asphaltic concrete foundations conforming to the manufacturer's recommendations.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Barrier Systems, Inc.

(e) QuadGuard

1. **Purpose:** The QuadGuard is an end treatment for concrete barrier and beam guardrail and is also used to mitigate fixed objects up to 10 feet wide.

2. **Description:** The system consists of a series of Hex-Foam cartridges surrounded by a framework of steel diaphragms and quadruple corrugated fender panels. (See Figure 720-2b.)

3. **Function:** The internal shearing of the cartridges and the crushing of the energy absorption material absorb impact energy from end-on hits. The fender panels redirect vehicles impacting the attenuator on the side.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the QuadGuard.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(f) **QuadGuard Elite**

1. **Purpose:** The QuadGuard Elite is an end treatment for concrete barrier and beam guardrail and is also used for fixed objects up to 7 feet 6 inches wide.

2. **Description:** The system consists of telescoping quadruple corrugated fender panels mounted on both sides of a series of polyethylene cylinders. (See Figure 720-2b.)

3. **Function:** The cylinders are compressed during a head-on impact and will return to their original shape when the system is reset. It is anticipated that this system will require very few replacement parts or extensive repair.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the QuadGuard Elite.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(g) **Reusable Energy Absorbing Crash Terminal (REACT** 350)

1. **Purpose:** The REACT 350 is an end treatment for concrete barriers and is also used for fixed objects up to 3 feet wide.

2. **Description:** The system consists of polyethylene cylinders with varying wall thickness, redirecting cables, a steel frame base, and a backup structure. (See Figure 720-2d.)

3. **Function:** The redirecting cables are anchored in the concrete foundation at the front of the system and in the backup structure at the rear of the system. When hit head-on, the cylinders compress, absorb the impact energy, and immediately return to much of their original shape, position, and capabilities. For side impacts, the cables restrain the system enough to prevent penetration and redirect the vehicle. It is anticipated that this system will require very few replacement parts or extensive repair.

4. **Foundation:** The system is installed on a concrete foundation.

5. **Slope**: If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the REACT 350.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(h) (REACT 350 Wide)

1. Purpose: The REACT 350 Wide is a device that can be used to shield objects with widths up to 10 feet wide.

2. Description: The system consists of polyethylene cylinders with varying wall thickness, internal struts, space frame diaphragms, and a monorail. (See Figure 720-2d.)

3. Function: When hit head-on, the cylinders compress, absorb the impact energy, and immediately return to much of their original shape, position, and capabilities. For side impacts, the system is designed to restrain and redirect the vehicle. It is anticipated that this system will require very few replacement parts or extensive repairs.

4. Foundation: The system is installed on a concrete foundation.

5. Slope: If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the REACT 350 Wide.

6. Manufacturer/Supplier: Energy Absorption Systems

(i) **Inertial Barrier**

Inertial barrier configurations are shown in the Standard Plans. If a situation is encountered the configurations in the Standard Plans are not appropriate, contact the HQ Design Office for further information.

1. **Purpose:** Inertial barrier is an end treatment for concrete barrier and is used to mitigate fixed objects. This system does not provide redirection from a side impact.

2. **Description:** This system consists of an array of plastic containers filled with varying weights of sand. (See Figure 720-2d.)

3. **Function:** The inertial barriers slow an impacting vehicle by the transfer of the momentum of the vehicle to the mass of the barrier. This system is not suitable where space is limited to less than the widths shown in the Standard Plans. Whenever possible, align inertial barriers so that an errant vehicle deviating from the roadway by 10° would be on a parallel path with the attenuator alignment. (See the Standard Plans.) In addition, inertial barriers do not provide any redirection and are not appropriate where high angle impacts are likely.

4. **Foundation**: A concrete or paved surface is recommended.

5. **Slope**: If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 5% for inertial barriers.

(j) **SCI100GM / SCI70GM**

1. **Purpose:** The SCI100GM / SCI70GM are end treatments that can be used for concrete barrier and beam guardrail with widths up to 2 feet.

2. **Description:** The system for both models consists of telescoping quadruple corrugated fender panels mounted on both sides of a series of tubular steel support frames. (See Figure 720-2e.)

3. **Function:** A hydraulic cylinder is compressed during a head-on impact.

4. **Foundation:** The system is installed on a concrete or asphalt foundation. (See manufactures installation requirements for details.)

5. **Slope:** 12H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Work Area Protection Corp.

In addition to the systems approved above, the TRACC impact attenuator may be considered for permanent use, with the concurrence of Maintenance personnel.

(2) Work Zone (Temporary) Installation

Several of the impact attenuators previously listed under the heading "Permanent Installations" are also appropriate for use in work zones or other temporary locations. The following is a list of these devices:

- QuadGuard
- QuadGuard Elite
- REACT 350
- REACT 350 Wide
- Inertial Barriers
- SCI100GM
- SCI70GM

The following systems are appropriate only in work zones or other temporary installations.

A description of each work zone (or other temporary) system's purpose, parts, and functionality, as well as requirements for transition, foundation, and slope, are provided as follows and in Figure 720-5:

(a) **ABSORB 350**

1. **Purpose:** The ABSORB 350 is an end treatment limited to temporary installations for both concrete barrier and the Quickchange Moveable Barrier (QMB).

2. **Description:** The system contains water-filled Energy Absorbing Elements. Each element is 2 feet wide, 2 feet 8 inches high, and 3 feet 3 ½ inches long. (See Figure 720-3.)

3. **Function:** The low-speed (below 45 mph) system uses five Energy Absorbing Elements and the high-speed (45 mph and above) system uses eight. The energy of an impact is dissipated as the elements are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Barrier Systems, Inc.

(b) **Advanced Dynamic Impact Extension Module 350 (ADIEM 350)**

1. **Purpose:** The ADIEM 350 is limited to temporary installations where vehicle speeds are 45 mph or less. It is generally used as an end treatment for concrete barrier. Currently, there are a few existing permanent units in service. It is permissible to reset these existing devices. However, some of these units may exhibit significant deterioration and replacement may be the appropriate option.

2. **Description:** The system is 30 feet long and consists of 10 lightweight concrete modules on an inclined base. (See Figure 720-3.)

3. **Functionality:** An inclined base provides a track for placement of the modules and provides redirection for side impacts for roughly half the length. The energy of an impact is dissipated as the concrete modules are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. Excessive is defined as steeper than 8% for the ADIEM 350.

6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(c) **QuadGuard CZ**

This system is like the permanent QuadGuard listed for permanent systems above except that it can be installed on a 6-inch-minimum-depth asphalt concrete surface that has a 6-inch-minimum-depth compacted base. (See Figure 720-2b.)

(d) **Reusable Energy Absorbing Crash Terminal (REACT 350)**

This is the same system listed for permanent systems above except that it can be installed on a 6-inch-minimum-depth asphalt concrete surface that has a 6-inch-minimum-depth compacted base. (See Figure 720-2d.)

(e) **Non-Redirecting Energy Absorbing Terminal (N-E-A-T)**

1. **Purpose:** The N-E-A-T system is an end treatment for temporary concrete barrier where vehicle speeds are 45 mph or less.

2. **Description:** The N-E-A-T System's cartridge weighs about 300 pounds and is 9 feet-8 inches long. The system consists of aluminum cells encased in an aluminum shell with steel backup, attachment hardware, and transition panels. It can be attached to the ends of New Jersey shaped portable concrete barrier and the QuickChange Moveable Barrier. (See Figure 720-3.)

3. **Functionality:** The energy of an impact is dissipated as the aluminum cells are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Energy Absorption Systems

(f) **Trinity Attenuating Crash Cushion (TRACC)**

1. **Purpose:** The TRACC is an end treatment for concrete barriers. It is limited to use in construction or other work zones on a temporary basis.

2. **Description:** The 21-foot-long TRACC includes four major components: a pair of guidance tracks, an impact sled, intermediate steel frames, and 10 gauge W-beam fender panels. (See Figure 720-3.)

3. **Functionality:** The sled (impact face) is positioned over the upstream end of the guidance tracks and contains a hardened steel blade that cuts the metal plates on the sides of the guidance tracks as it is forced backward when hit head-on.

4. **Foundation:** The system requires a concrete foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(g) **Inertial Barrier**

This is the same system listed for permanent systems above. It is not suitable where space is limited to less than the widths shown in the Standard Plans. (See Figure 720-2d.)

(h) **Truck Mounted Attenuator (TMA)**

TMAs are portable systems mounted on trucks. They are intended for use in work zones and for temporary hazards.

(i) **Triton CET**

1. **Purpose:** The Triton CET is an end treatment limited to temporary concrete barrier installations.

2. **Description:** The system contains water-filled Energy Absorbing Elements. (See Figure 720-3.)

3. **Function:** The system uses six Energy Absorbing Elements. The energy of an impact is dissipated as the elements are crushed.

4. **Foundation:** The system does not require a paved foundation.

5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.

6. **Manufacturer/Supplier:** Energy Absorption, Inc.

(j) **QUEST**

1. **Purpose:** The QUEST is an end treatment limited to temporary applications. This system is designed to shield hazards 2 feet or less in width.

2. **Description:** The system consists of two front anchor assemblies; a nose assembly containing an integrated trigger assembly; two shaper rail assemblies; a support rail assembly with two energy absorbing tube shapers; a diaphragm assembly; a bridge assembly; two rear rails; a freestanding backup assembly; and W-beam fender panels. Transition panels are required when traffic approaches from the rear of the unit.

3. **Function:** During head-on impacts, the Quest system telescopes rearward and energy is absorbed through momentum transfer, friction, and deformation. When impacted from the side, the QUEST System restrains lateral movement by dynamic tension developed between the end restraints.

4. **Foundation:** The system is installed on a concrete or asphalt foundation. (See manufacturer's installation requirements for details.) The unit is attached to the road surface with 30 to 34 anchors.

5. **Slope:** 12H:1V (8%) or flatter slope between the edge of the traveled way and the near face of the unit is required. In addition, if the slope varies (twists) more than 2% over the length of the system, a concrete leveling pad may be required.

6. **Manufacture/Supplier:** Energy Absorption Systems Inc.

(3) Older Systems

The following systems are in use on Washington State highways and may be left in place or reset. New installations of these systems require approval from the HQ Design Office.

(a) **Sentre**

The Sentre is a guardrail end treatment. Its overall length of 17 feet allowed it to be used where space was not available for a guardrail transition and terminal. The system is very similar to the QuadTrend 350 in both appearance and function except that it uses thrie beam fender panels instead of the quadruple corrugated panels. This system requires a transition when used to terminate rigid barriers. (See Figure 720-4a.)

(b) **TREND**

The TREND is an end treatment with a built-in transition and was used at the end of rigid barriers including bridge rails. The system is similar to the QuadTrend 350 except that it uses thrie beam fender panels. (See Figure 720-4a.)

(c) **G-R-E-A-T (Guard Rail Energy Absorption Terminal)**

This system was primarily used as an end treatment for concrete barrier. It is similar to the QuadGuard except that it uses thrie beam fender panels. (See Figure 720-4a.)

(d) **Low Maintenance Attenuator System (LMA)**

The LMA is an end treatment for concrete barrier and beam guardrail and was used for fixed objects up to 3 feet wide. The system is similar to the QuadGuard Elite except that it uses thrie beam fender panels and rubber cylinders. See Figure 720-4b.

(e) **Hex-Foam Sandwich**

The Hex-Foam Sandwich system is an end treatment for beam guardrail and concrete barrier and was also used for fixed objects 3 feet or more in width. This system consists of a number of Hex-Foam cartridges containing an energy absorption material separated by a series of diaphragms and restrained by anchor cables. It is installed on a concrete slab. Impact energy is absorbed by the internal shearing of the cartridges and crushing of the energy absorption material. The lapped panels on the perimeter serve to redirect vehicles for side impacts. If the site has grade or cross slope in excess of 5%, additional site preparation or modification to the units in accordance with the manufacturer's literature is required. (See Figure 720-4b.)

720.02 Design Criteria

The following design criteria apply to all new or reset permanent and temporary impact attenuators. The design criteria also apply to existing systems to be left in place when the Barrier Terminals and Transition Sections columns on a design matrix applies to the project. (See Chapter 325.)

Impact attenuators must be placed so that they do not present a hazard to opposing traffic. For median and reversible lane locations, the backup structure or attenuator-to-object connection must be designed to prevent opposing traffic from being snagged. It is desirable that all existing curbing be removed and the surface smoothed with asphalt or cement concrete pavement before an impact attenuator is installed. However, curbs 4 inches or less in height may be retained depending on the practicality of their removal. In general, attenuators are aligned parallel to the roadway except the inertial barriers.

720.03 Selection

When selecting an impact attenuator system, consider the following:

- Posted speed
- Available space (length and width)
- Maintenance costs
- Initial cost
- Duration (permanent or temporary use)
- The portion of the impact attenuator that is redirective/nonredirective. (See figures 720-5 and 6.)

It is very important for designers to consider the portion of an impact attenuator that will redirect vehicles during a side impact of the unit. It is crucial to consider that fixed objects, either permanent or temporary (such as construction equipment), should not be located behind the non-redirective portion of these devices.

The posted speed is a consideration in the selection of the QuadGuard, REACT 350 Universal TAU-II and the Inertial Barrier systems. Use Figure 720-1 to select permanent system sizes required for the various posted speeds.

Posted Speed (mph)	Quad Guard (Bays)	Universal TAU-II(1) (Bays)	REACT 350 (Cylinders)	Inertial Barrier (Type)
40 or less	3	2-3	4	1
45	4	3-4	6	2
50	5	4-5	6	3
55	6	5-7	6	4
60	6	7-8	9	5
65	8	7-8	9	6
70	9	7-8	9	6
(1) Dependent on the width of the system				

Impact Attenuator Sizes
Figure 720-1

If it is anticipated that a large volume of traffic will be traveling at speeds greater than the posted speed limit, then the next larger unit may be specified.

For a summary of space and initial cost information related to the impact attenuator systems, see Figure 720-5.

When considering maintenance costs, anticipate the average annual impact rate. If few impacts are anticipated, lower-cost devices such as inertial barriers might meet the need. Inertial barriers have the lowest initial cost and initial site preparation. However, maintenance will be costly and necessary after every impact. Labor and equipment are necessary to clean up the debris and install new containers (barrels). Also, inertial barriers must not be used where flying debris might be a danger to pedestrians.

The REACT 350 and the QuadGuard Elite have a higher initial cost, requiring substantial site preparation, including a backup or anchor wall in some cases and cable anchorage at the front of the installation. However, repair costs are comparatively low, with labor being the main expense. Maintenance might not be required after minor side impacts with these systems.

For new installations where at least one impact is anticipated per year, limit the selection of impact attenuators to the low maintenance devices (QuadGuard Elite and REACT 350). Consider upgrading existing ADIEM, G-R-E-A-T, and Hex-Foam impact attenuators with these low maintenance devices when the repair history shows one to two impacts per year over a three to five year period.

In selecting a system, one consideration that must not be overlooked is how dangerous it will be for the workers making repairs. In areas with high exposure to danger, a system that can be repaired quickly is most desirable. Some systems require nearly total replacement or replacement of critical components (such as cartridges or braking mechanisms) after a head-on impact, while others only require resetting.

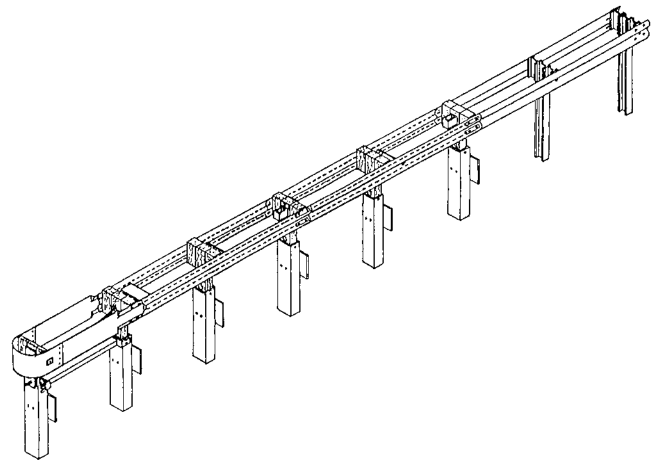
It is very important to consider that each application is unique when selecting impact attenuators for use in particular applications. This applies to both permanent and temporary installations. When specifying the system or systems that can be used at a specific location, the list shown in Figure 720-5 is to be used as a starting point. As the considerations discussed previously are analyzed, inappropriate systems may be identified and eliminated from further consideration. Systems that are not eliminated may be appropriate for the project. When the site conditions vary, it might be necessary to have more than one list of acceptable systems within a contract. Systems are not to be eliminated without documented reasons. Also, wording such as or *equivalent* is not to be used when specifying these systems. If only one system is found to be appropriate, then approval from the Assistant State Design Engineer of a public interest finding for the use of a sole source proprietary item is required.

When a transition to connect with a concrete barrier (see Figure 720-5) is required, the transition type and connection must be specified and are included in the cost of the impact attenuator. (See Chapter 710 for information on the transitions and connections to be used.)

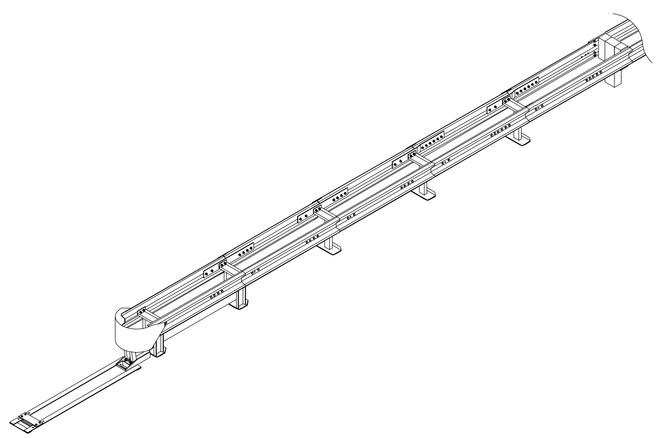
Contractors can be given more flexibility in the selection of work zone (temporary) systems, since long-term maintenance and repair are not a consideration.

720.04 Documentation

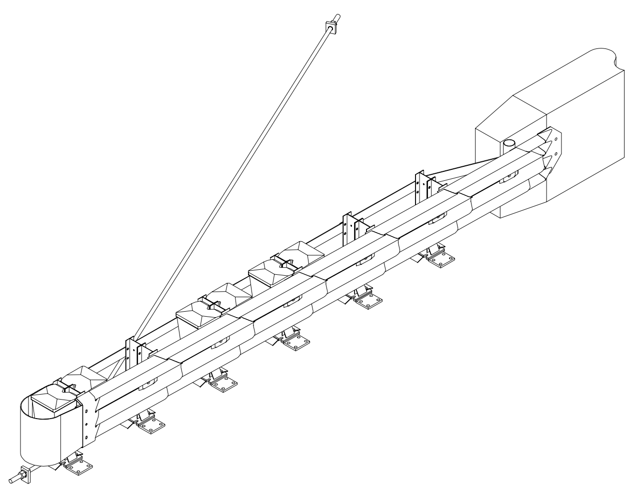
A list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found is on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/



CAT -350

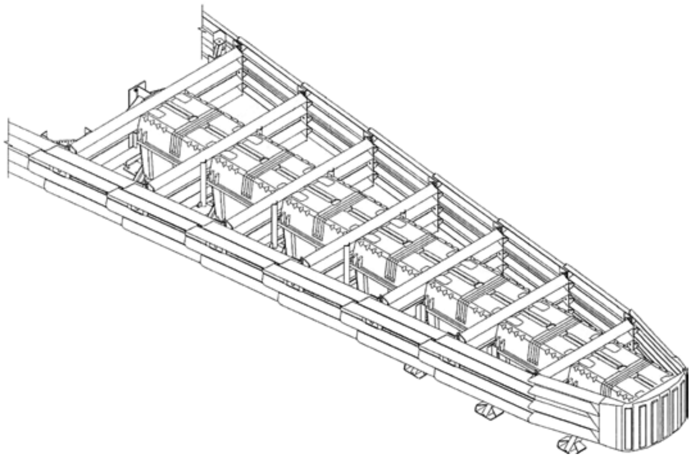


Brakemaster

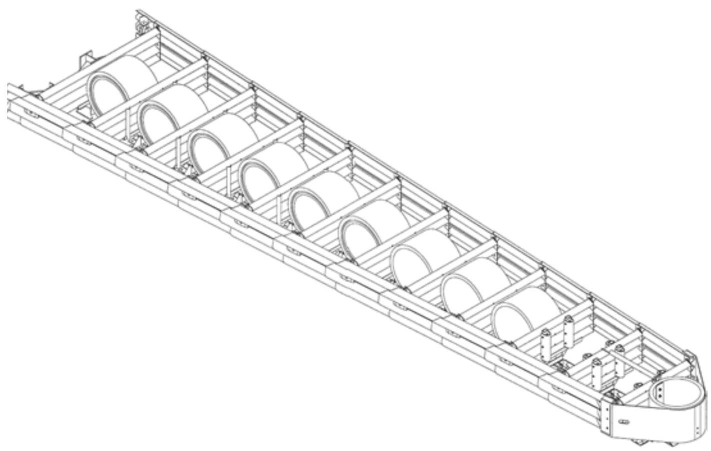


QuadTrend 350

Impact Attenuator Systems – Permanent Installations
Figure 720-2a



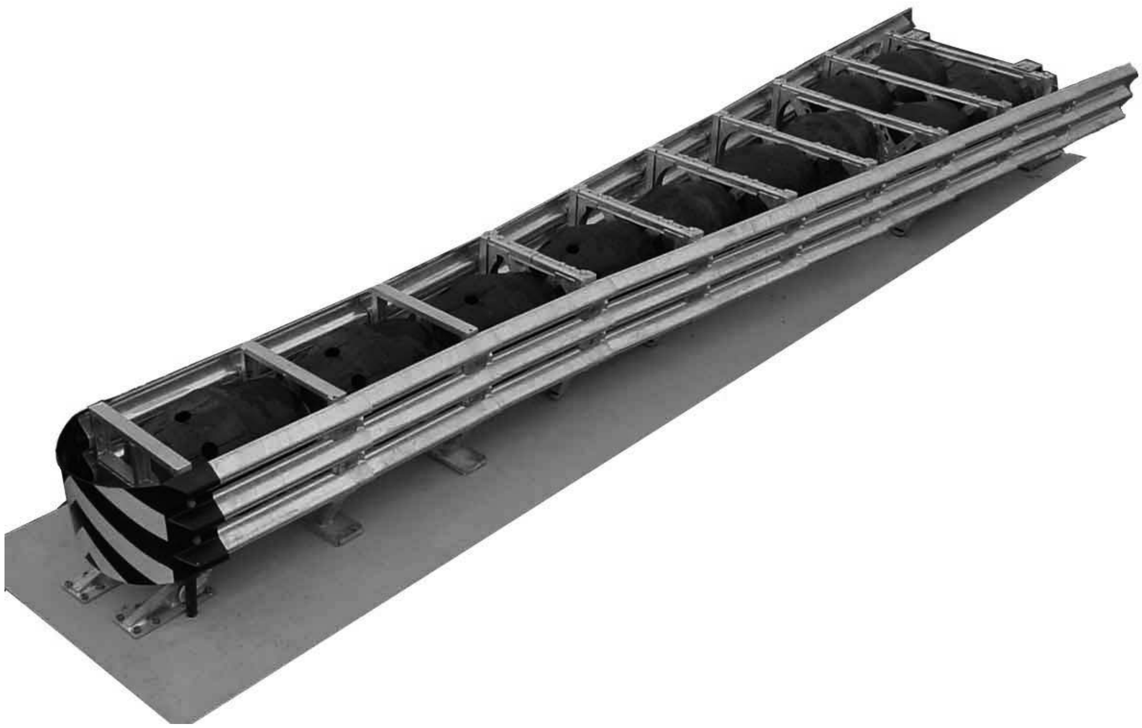
QuadGuard



QuadGuard Elite

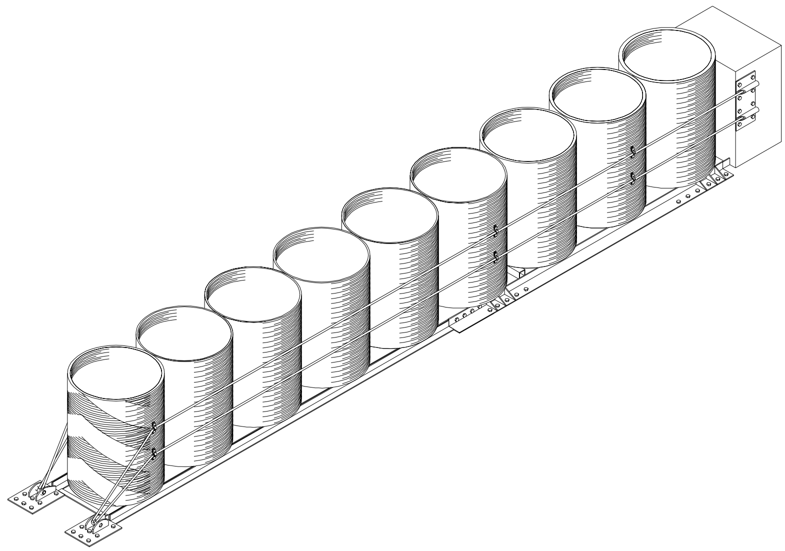
Impact Attenuator Systems – Permanent Installations

Figure 720-2b

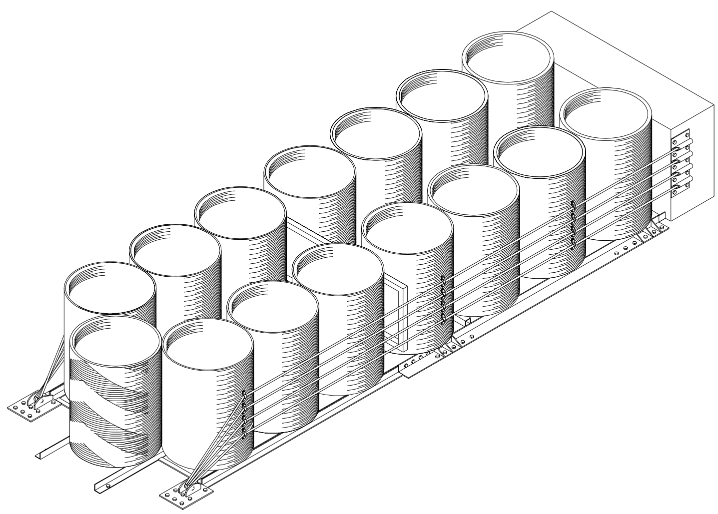


Universal TAU-II

Impact Attenuator Systems – Permanent Installations
Figure 720-2c



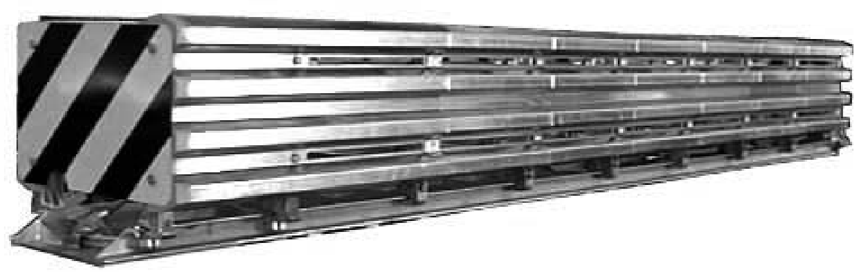
REACT 350



REACT 350 Wide

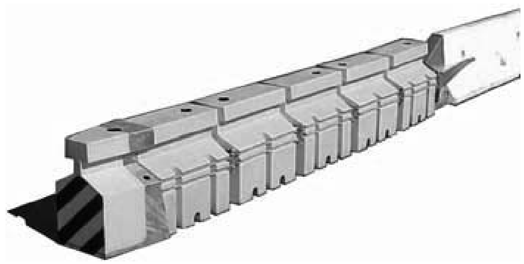
Inertial Barrier

Impact Attenuator Systems – Permanent Installations
Figure 720-2d



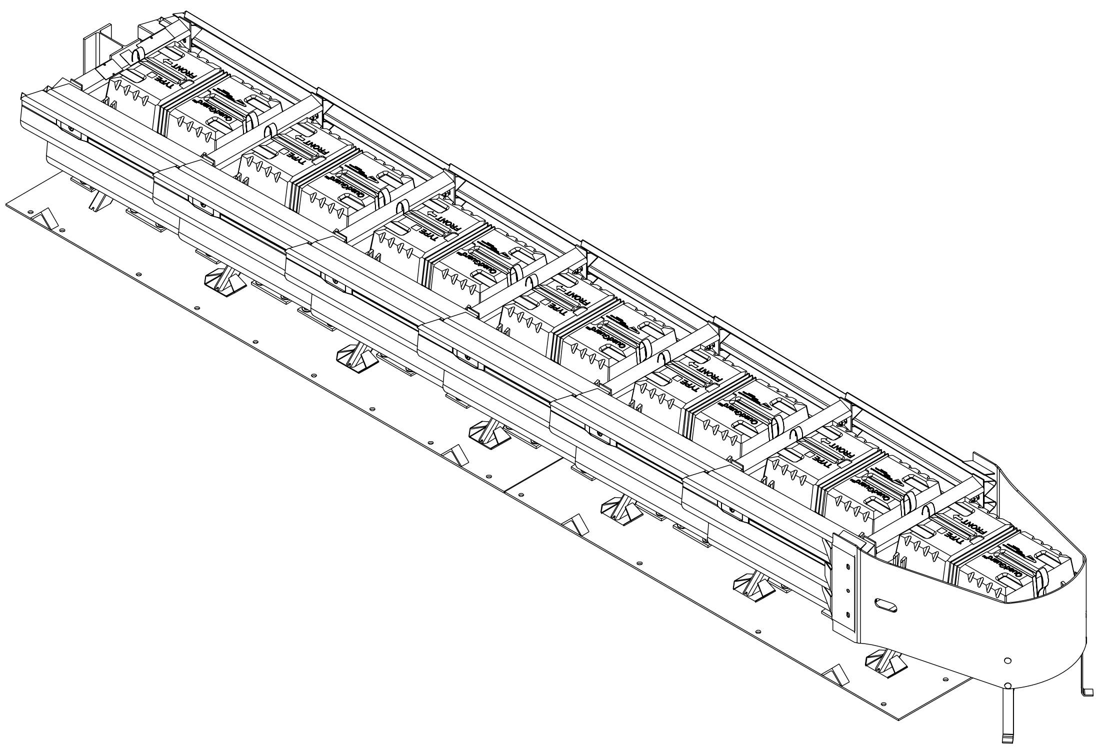
SCI100GM / SCI70GM

Impact Attenuator Systems – Permanent Installations
Figure 720-2e



ABSORB 350

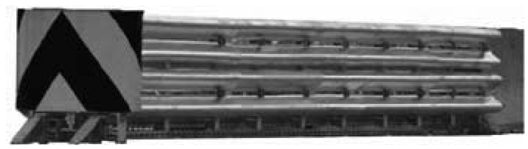
ADIEM 350



QuadGuard CZ

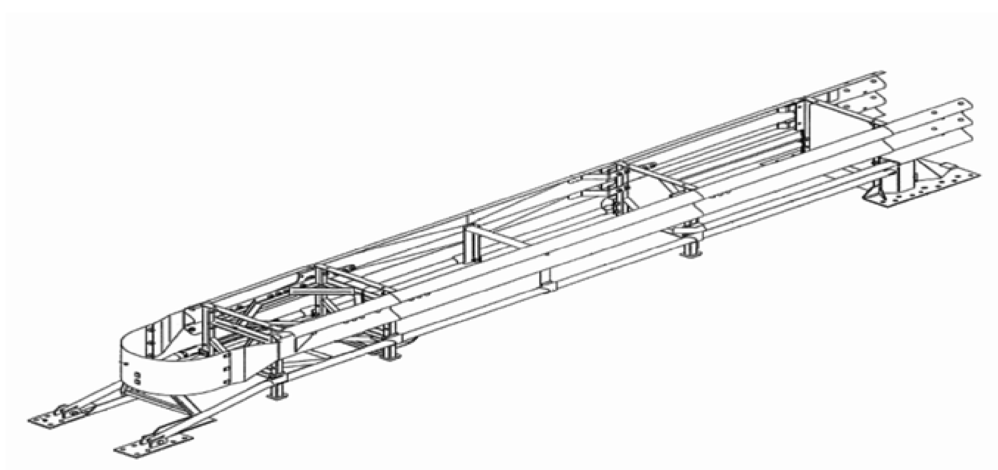
Impact Attenuator Systems – Work Zone Installations
Figure 720-3a

N-E-A-T



TRACC

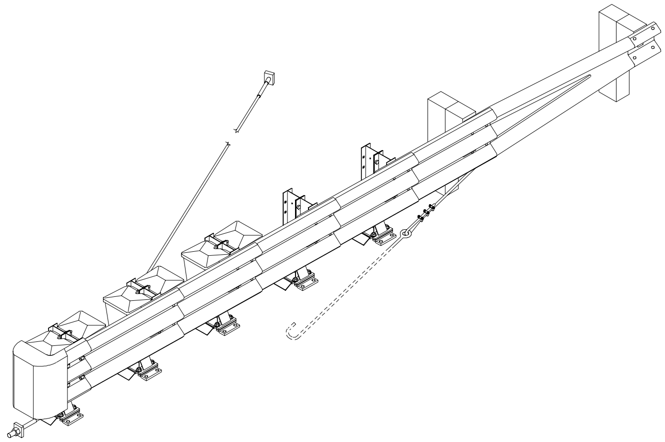
Triton CET



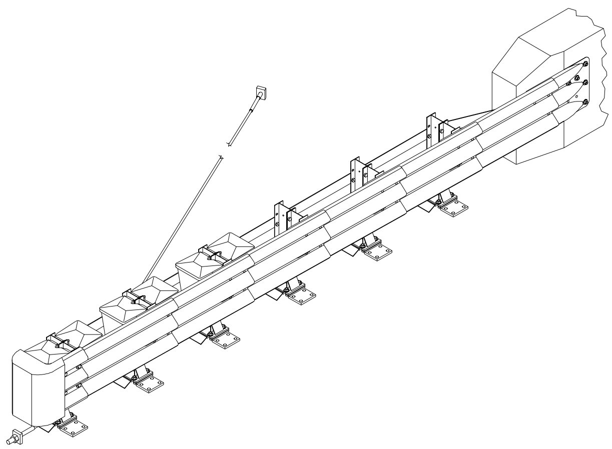
QUEST

Impact Attenuator Systems – Work Zone Installations

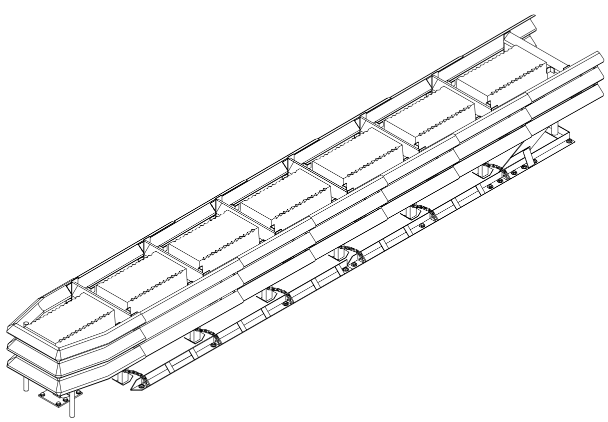
Figure 720-3b



Sentre

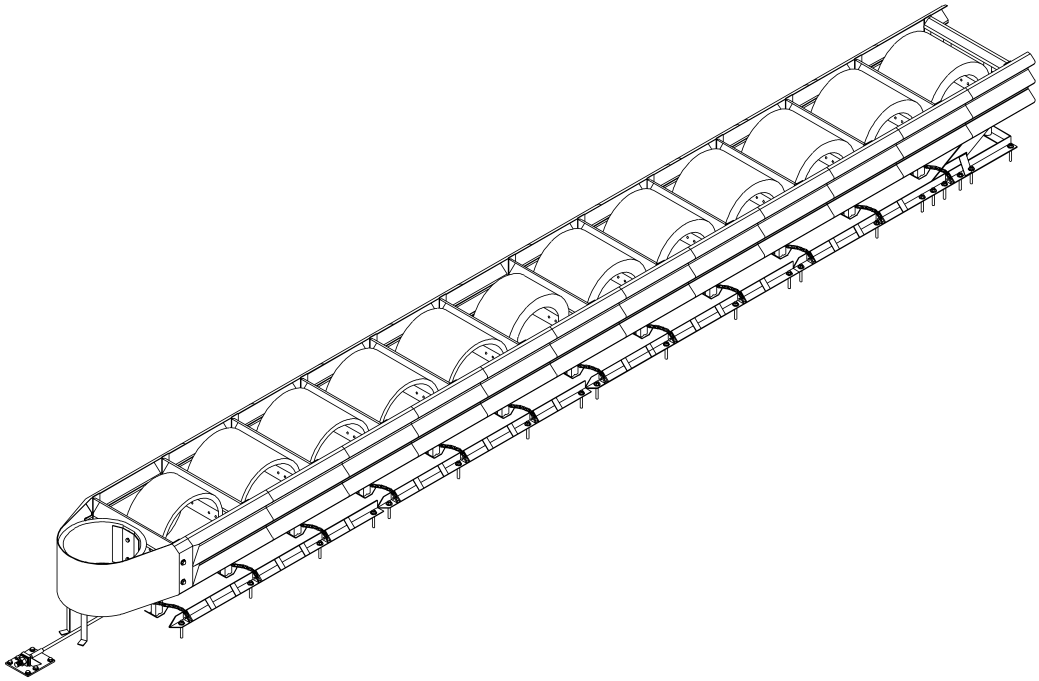


TREND

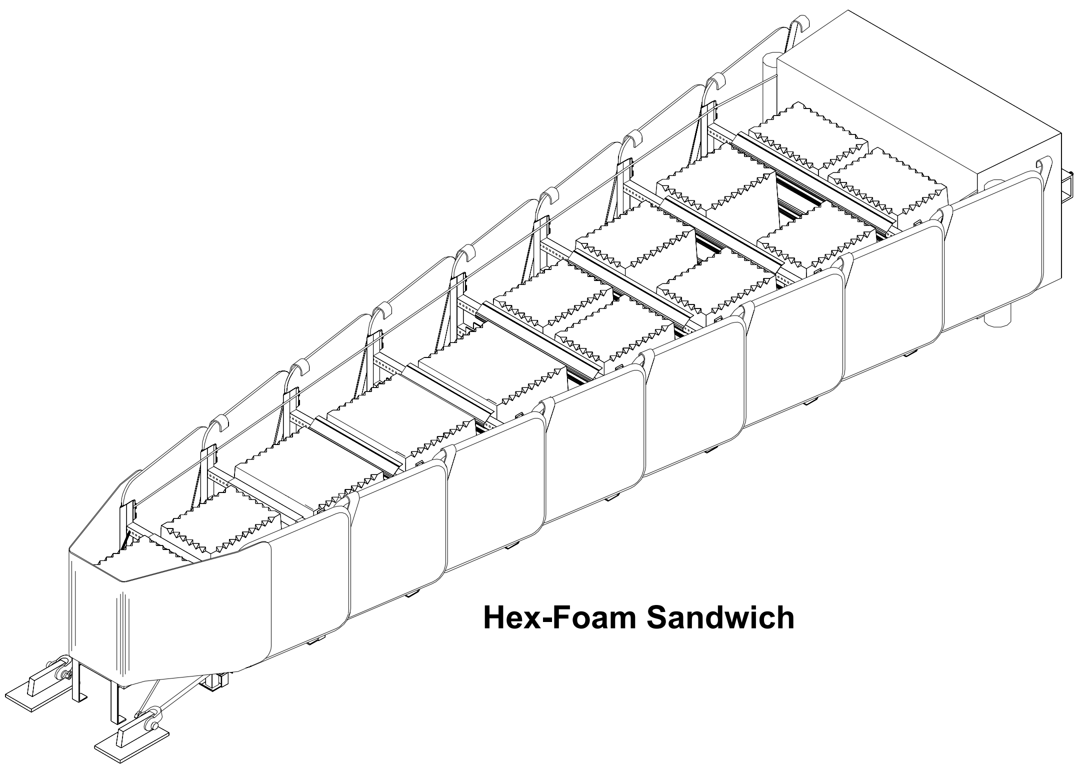


G-R-E-A-T

Impact Attenuator Systems – Older Systems
Figure 720-4a



L.M.A.



Hex-Foam Sandwich

Impact Attenuator Systems – Older Systems
Figure 720-4b

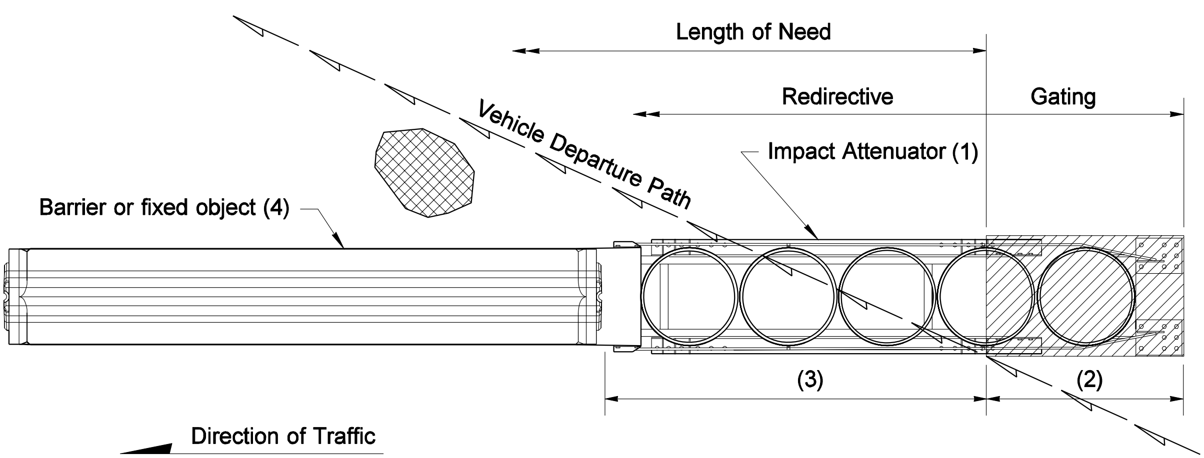
Impact Attenuator Systems (All dimensions in feet)

System	(P) Permanent (T) Temporary (B) Both	Approximate Outside Width (See Note 10)	Approximate System Length (See Note 11)	Transition to Rigid System Required?	Distance Beyond Length of Need (See Figure 720-6)	Initial Cost Category(1)
CAT 350(2)	P	2.5	31.3	Y	18.8	A
Brakemaster 350(2)	P	2.1	31.5	Y	15.8	A
QuadTrend – 350(6)	P	1.3	20.0	N	10.5	A
Universal TAU-II	P	2.9 - 8.7	12.0-26.0(4)	N	3.0	B(5)
QuadGuard	B	2.8-10.8	13.1-32.5(4)	N	3.3	B(5)
QuadGuard Elite	B	2.8-8.3	23.8-35.5	N	3.3	D
REACT 350	B	4	13.8-30.2(4)	N	4.3	C(5)
REACT 350 Wide	B	5.7-10.7	30.8-34.8	Y	4.3	D(5)
Inertial Barriers	B	7	17.0-34.5(4)	N	(3)	A(5)
SCI100GM	B	3.1	21.5	Y	3	C
SCI70GM(8)	B	2.8	13.5	Y	3	B
ABSORB 350(9)	T	2	19.0-32.0	Y	(3)	A(5)
ADIEM 350(7)(8)	T	2.7	30	N	14.1	B
QuadGuard CZ	T	2.75-3.25	13.1-22.1	N	3.3	C(5)
N-E-A-T(8)	T	1.9	9.7	N	(3)	A(5)
TRACC(12)	T	2.6	21.3	N	8	B
Triton CET(9)	T	1.8	40	N	(3)	A
QUEST	T	2.8	22.2	Y	3.5	B

Impact Attenuator Comparison
Figure 720-5a

1) A ($5,000 to $10,000); B ($10,000 to $15,000); C ($15,000 to $25,000); D ($25,000 to $50,000). These are rough initial cost estimates - verify actual costs through manufacturers/suppliers. Some products are priced very close to the margin between cost categories.
2) Generally for use with double-sided beam guardrail. Use as an end treatment for concrete barrier requires a transition.
3) The N-E-A-T, inertial barriers, Triton CET, and ABSORB 350 may only be used beyond the required length of need.
(4) For sizes or configuration type, see Figure 720-1.
(5) The lengths of the Universal TAU-II, QuadGuard, QuadGuard Elite, REACT 350, REACT 350 Wide, ABSORB 350, QuadGuard CZ, and Inertial Barriers vary because their designs are dependent upon speed. Costs indicated are for a typical 60 mph design. In addition to length, several of the systems also vary in width. For estimating purposes, the following model widths were considered.
   - Universal TAU II – 24”
   - QuadGuard – 24”
   - QuadGuard Elite – 24”
   - REACT 350 Wide – 60”
   - QuadGuard CZ – 24”
(6) Generally for use at the ends of bridges where installation of a beam guardrail transition and terminal is not feasible.
(7) Generally for use with concrete barrier. Other uses may require a special transition design.
(8) Use limited to highways with posted speeds of 45 mph or less.
((9) Test Level 3 version on high-speed facilities should be limited to locations where the likelihood of being hit is low.
(10) The given dimension is the approximate outside width of each system. In most cases, this width is slightly wider than the effective width. To determine the width of an object that may be shielded refer to the manufacture’s specifications. (See the WSDOT Design Policy, Standards, & Safety Research Unit web site for links to this information.)
(11) The given dimension is the approximate system length. The effective length may vary depending on such factors as the physical design and type of anchorage used. To determine the total length needed, refer to the manufacture’s specifications. (See the WSDOT Design Policy, Standards, & Safety Research Unit web site for links to this information.)
(12) May be considered for permanent installations with concurrence of Maintenance personnel.

Impact Attenuator Comparison
Figure 720-5b



(1) Impact Attenuator type and manufacturer varies with application. (See Figure 720-5).

(2) Distance beyond the length of need. (See Figure 720-5). This portion is non-redirective, (Gating).

(3) This portion is re-directive and can be included as part of the barrier needed to satisfy length of need requirerments.

(4) Concrete barrier shown for illustration purposes only. Type of object varies.

Impact Attenuator Distance Beyond Length of Need
Figure 720-6

Chapter 810 Work Zone Safety and Mobility

810.01 General

Work zones are an important component in overall project design, but sometimes designers do not give them adequate consideration. All work zones create some level of traffic and safety impacts; therefore, all work areas and operations must be identified and addressed in project design. Complex work zones can account for up to 30% of project costs and can impact the safety and mobility of workers and road users. These impacts must be identified, mitigated, and managed. It is not acceptable to allow a project to move forward to advertisement without appropriately addressing work zone impacts. A Work Zone Traffic Control Checklist is included in Figure 810-4. Use the checklist to identify and address work zone safety and mobility impacts. Include the completed checklist in the Project File.

Depending on the work zone, traffic control measures such as lane closures, detours, shoulder closures, temporary channelization, flagging, and pilot cars are common and usually acceptable methods of maintaining traffic through or around work zones. Designers must also consider additional unique or innovative traffic control measures to adequately address those work zone impacts that cannot be mitigated through traditional means. Designers must find the most effective work zone solutions to overcome mobility and safety impacts and maintain levels of service and safety that match existing conditions or are otherwise mitigated through or around the work zone.

Planners, designers, construction engineers, maintenance personnel, and others all play a role in developing a comprehensive work zone design. Designers must completely assess all work zone impacts at the project planning and design stages.

This chapter provides the designer with guidance and direction in developing a comprehensive work zone design that addresses all related safety and mobility impacts. Consider that large numbers of drivers, workers, pedestrians, and others have to drive, build, and walk through the work zone. A comprehensive work zone design is not only a critical component, it is also required by state and federal law. The designer must also develop a transportation management plan (TMP) that incorporates the needs of roadway users and workers within the project design in an effective, constructible manner.

810.02 References

Federal/State Laws and Codes

Final Rule on Work Zone Safety and Mobility http://www.ops.fhwa.dot.gov/wz/resources/final_rule.htm

Chapter 468-95 (WAC), "Manual on uniform traffic control devices for streets and highways" (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Design Guidance

Construction Manual, M 41-01, WSDOT

Directive D 55-20, Reduced speed in maintenance and construction zones

Executive Order E 1001.01, Work Zone Safety and Mobility

Executive Order E 1033.00, WSDOT Employee Safety

Highway Capacity Manual, 2000, TRB

Instructional Letter IL 4008.00, WSP traffic control assistance in work zones

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA, as adopted and modified by WAC 468-95

Planning and Scheduling Work Zone Traffic Control, USDOT, 1981

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans) M 21-10, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

Traffic Manual, M 51-02, WSDOT

Work Zone Traffic Control Guidelines, M 54-44, WSDOT

Supporting Information

American Traffic Safety Services Association (ATSSA) http://www.atssa.com/default.asp

AASHTO Roadside Design Guide, 2006

Crashworthy Work-Zone Traffic Control Devices Report 553, NCHRP, 2006

FHWA Work Zone Operations Best Practices
http://ops.fhwa.dot.gov/wz/practices/practices.htm

FHWA Work Zone Safety and Mobility
http://ops.fhwa.dot.gov/wz/index.asp

ITE Temporary Traffic Control Device Handbook, 2001

ITS in Work Zones
http://tig.transportation.org/?siteid=57&pageid=694

Recommended Procedures for the Safety Evaluation of Highway Features Report 350, NCHRP, 1993

Work Zone and Traffic Analysis
http://www.ops.fhwa.dot.gov/wz/traffic_analysis.htm

WSDOT – Project Delivery Lessons Learned
http://fmpwebi.wsdot.wa.gov/lessonslearned/FMPro?-db=DebriefReport&-lay=Web&-format=Main.htm&-op=eq&MonthlyHighlight=Yes&-find=

WSDOT – Work Zone Safety Webpage
http://www.wsdot.wa.gov/biz/trafficoperations/workzone/default.htm

810.03 Definitions

ADA Americans with Disabilities Act of 1990: federal law prohibiting discrimination against people with disabilities.

lag up Bringing adjacent lifts of hot mix asphalt (HMA) to match the latest lifts for safety.

tapered wedge joint A tapered edge of a lift of HMA to eliminate an abrupt drop-off.

traffic control devices Signs, signals, pavement markings, and other devices placed on, over, or adjacent to a street or highway to regulate, warn, or guide traffic.

transportation management plan (TMP) Provides a set of strategies for managing the work zone impacts of a project. The TMP is required for all projects and is the key element in addressing all work zone safety and mobility impacts.

work zone "An area of a highway with construction, maintenance, or utility work activities. A work zone is typically marked by signs, channelizing devices, barriers, pavement markings, and/or work vehicles. It extends from the first warning sign or high-intensity rotating, flashing, oscillating, or strobe lights on a vehicle to the END ROAD WORK sign or the last temporary traffic control device." (MUTCD)

work zone traffic control The planning, design, and preparation of contract documents for the modification of traffic patterns during construction.

810.04 Work Zone Policy

The Washington State Department of Transportation (WSDOT) has an overarching policy on work zone safety and mobility. WSDOT does not delegate safety and mobility responsibility for the traveling public. Designers need to be familiar with Executive Order E 1001.01, Work Zone Safety and Mobility. This policy refers to the relationship between WSDOT programs that set the policy to identify and address work zone safety and mobility issues during planning programming, design, construction, and maintenance.

The policy on work zone safety and mobility ensures that all work zone impacts are appropriately identified, mitigated, and managed on a systematic basis. Safety considerations are the first priority and a high level of safety must be integrated into all work zone strategies. All those with work zone responsibilities are directed to make the safety of workers, responders, and the traveling public the highest priority. Closely following is the need to maintain traffic mobility through the work zone and any other routes impacted by the work zone. Mobility affects safety; many work zone crashes can be attributed to work zone congestion.

It is imperative that roadway workers have a safe work zone environment to conduct work operations. Without first addressing safety, the project cannot proceed. Roadway users must also have a safe and functional path through the work zone.

Mobility is secondary to safety in the hierarchy of work zone priorities, but is generally the number one operational problem related to overall work zone effectiveness. Mobility must be addressed at a level that is compatible with existing traffic demands. Ultimately, some loss of capacity through the work zone may be unavoidable, but not without providing other mitigating solutions as part of the project.

It is not acceptable to leave work zone impacts unresolved or otherwise not identified or addressed in the project design. Work zone strategies must be developed enough that an accurate scoping estimate can be prepared. Include any unique or innovative work zone elements that may require additional funding.

Work zone policy is required to be implemented within the intent and direction of FHWA Final Rule on Work Zone and Mobility, and WSDOT Executive Order E 1001.01. Specific direction and guidance is contained throughout this chapter and is linked to the appropriate work zone policy elements. (*See E 1001.01 Work Zone Safety and Mobility.)

810.05 Work Zone Process

WSDOT 's policy on work zone safety and mobility is that work zone operations should be conducted in the best interests of worker safety, with minimal impacts to the traveling public. In order to fulfill the intent of this policy, projects must be designed to ensure that all work zone impacts are addressed.

Although WSDOT makes every attempt to not affect the traveling public, many highway construction projects have impacts based on the types of work activities being performed. In all but a very few instances, the public must have some form of access through or around the work site. The designer must identify all work areas and operations that interact with the existing project location traffic patterns. This includes all vehicles, pedestrians (including ADA considerations), bicycles, construction traffic, transit, schools, business access, U.S. postal service, emergency response, work zone ingress and egress, oversize loads, and any other transportation mode, construction activity, or operation that initiates the need for some form of traffic control or hazard protection. Intimate knowledge of the project location and local traffic patterns and how these relate to the work zone and related construction activities is key to developing a complete work zone design. Designers will need to gather this information through field reconnaissance and investigation as well as seeking input from others with expertise in these areas.

The responsibility of the designer to fully address all work zone traffic control impacts is very important in that the level of traffic safety and mobility will be directly affected by the effectiveness of the Transportation Management Plan (TMP). Several resources that are available to assist the designer with various aspects of the work zone design effort are as follows:

- **Region Work Zone Resources.** Each region has individuals and offices with various resources that provide work zone guidance and direction beyond what may be available at the project design office level.
  1. Region Traffic Office
  2. Region Work Zone Specialist
  3. Region Construction & Design Offices
- **Headquarters (HQ) Work Zone Resources.** The HQ Traffic Office has a work zone team available to answer questions, provide information, or otherwise assist. The HQ Design and Construction offices may also be able to assist with some work zone issues.
  1. State Work Zone Safety & Mobility Manager
  2. State Work Zone Engineer
  3. WSDOT Work Zone Web Page
- **FHWA Work Zone Resources.** The FHWA Washington Division Office and Headquarters Office may be able to provide some additional information through the WSDOT HQ Traffic Office. The FHWA also has a work zone web page:
  http://www.ops.fhwa.dot.gov/wz/

The frequency of traffic collisions in work zones is disproportionately higher than at any other highway location. Safety is the primary consideration for all people within the work zone: motorists, pedestrians, bicyclists, contractors' workers, agency inspectors, surveyors, responders, and other personnel on the site.

Maintaining the optimum carrying capacity of an existing facility during construction may not be possible, but an effort must be made to maintain existing traffic mobility through and/or around the work zone. As construction progresses, existing traffic lanes may be either temporarily narrowed or closed. Even when the construction work does not affect adjacent traffic lanes, slowdowns in the traffic flow are common because these activities can be a distraction to the motorist. Providing improvements to alternate routes of travel, widening temporary traffic lanes, staging work to occur in off-peak traffic hours, and other means of offsetting the capacity reduction are part of a comprehensive work zone traffic control strategy. The impacts these operations have on the traffic flow are important, but not at the expense of safety. Reductions in traffic capacity must be mitigated and managed as part of the TMP. This all needs to be balanced with providing a reasonable work window that offers sufficient time to complete construction tasks.

It is important that the TMP, region policy, and commitments to impacted local government, public agencies, businesses, and communities are consistent. Region managers should be made aware of potential work zone traffic impacts as early as possible in the planning and design process.

This chapter provides specific direction and guidance to assist the designer with the development of an effective TMP.

810.06 Project Development

The project development process is the design engineering effort that brings the project from conceptual level to actual construction. It includes the traffic control strategy that establishes the framework to develop the Plans, Specifications, and Estimates (PS&E) relative to the traffic management of the project.

A comprehensive work zone traffic control plan (TCP) or transportation management plan (TMP) is actually a project within a project. WSDOT is obligated to provide a safe and workable proposal for controlling traffic, which is consistent with the project construction requirements. Even though there may be more than one workable solution, a thorough analysis of all the variables will help produce a TMP that addresses all impacts and establishes the appropriate levels of safety, mobility, and service. The goal of this effort is to reduce or eliminate the variations that contractors, work zone workers, and the traveling public are confronted with as they travel through construction projects.

Project development can be broken down into a three-step process that represents key milestones in the development of the project (see Figure 810-1). The process includes the following steps:

1. Planning and Strategy Development
2. Design and Analysis
3. Final Work Zone Traffic Control Plan (WZTCP)

Depending on the overall scope of the project, these three steps may overlap one another. Traffic control is very dynamic and fluid and the strategy may change or be refined as the design progresses. Good communication between the project designer and construction project engineer is recommended to ensure all work areas are included in the design and any potential constructibility issues can be identified and documented.

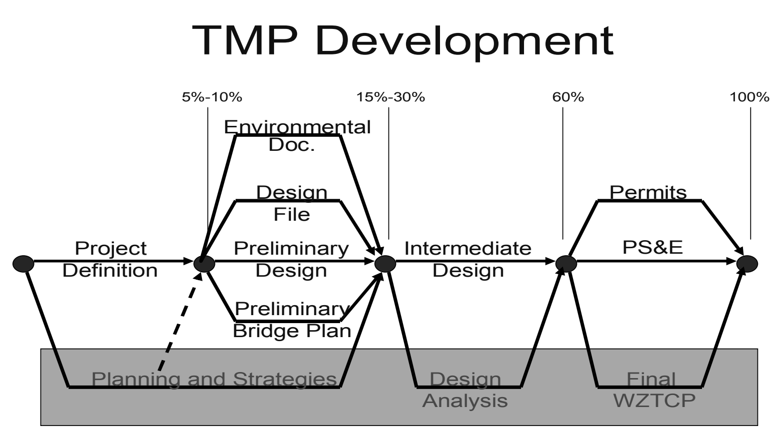
(1) Traffic Control Strategies

During the planning and strategy phase, basic information about the project is collected and examined. The intent of this phase is to select traffic control strategies that would be appropriate for the project. These strategies will establish the approach for the plan development process to construct the project while maintaining traffic movements. A complete and accurate preliminary estimate is essential to implement the strategies.

There are often several strategies that can be employed to manage traffic through a work zone. For any given project, the designer may consider several of these strategies for different construction phases. The final strategy is influenced by a number of factors such as traffic volumes and capacity, number of lanes available, and the anticipated work operation. Selecting a strategy is often a compromise and involves many engineering and nonengineering factors.

Strategies in managing work zone traffic control activities become increasingly important and sophisticated when the size, complexity of work, and time available to do the work become critical. For simple projects, the strategies may be very basic. However, for large, more complex projects, the TCP strategies are developed around the traffic control requirements to maintain traffic movements. On these types of projects, special traffic control details, layouts, work-hour restrictions, and staged plans may need to be developed.

The designer will use the strategy and preliminary estimate through the design effort as the project design elements are developed and a method is determined to best maintain traffic during construction. The plan development process must encompass all potential work operations and work areas within the project. (See 810.17 for tips and considerations on the development of the plans.) Other WSDOT and local agency construction projects may require coordination.



Transportation Management Plan Development
Figure 810-1

A Design Checklist (see Figure 810-4) has been developed to support the project development process. Use the checklist during all phases of the traffic control plan development to ensure that all applicable information is available, and that all necessary coordination work is accomplished.

(2) Contract Specifications

Work hour restrictions for lane closure operations are to be specifically identified for each project where traffic impacts are expected and liquidated damages need to be applied to the contract. Refer to the *Plans Preparation Manual* for additional information on writing traffic control specifications.

810.07 Work Zone Safety

"All WSDOT employees are directed to make the safety of workers and the traveling public our highest priority during roadway design, construction, maintenance, and related activities" (excerpt from E 1001.01).

An effective work zone traffic control strategy encompasses the safety of all users and is not limited to providing safety measures for the motorist only. Work zones present constantly changing roadway conditions that might increase the likelihood of confusion for users. An increased degree of vulnerability is present for workers, flaggers, motorists, pedestrians, and bicyclists in the work zone.

The designer's role in work zone safety is to provide for the safety of workers and roadway users as an integral part of the project work zone design strategy, and to conduct a comprehensive work zone safety assessment. This information provides the basis for incorporating safety into the actual work zone design and traffic control plan development.

Work zones present situations that can lead to the serious injury or death of workers and roadway users. Drivers, passengers, workers, inspectors, flaggers, law enforcement personnel, pedestrians, and bicyclists are among those that may interact within the work zone. Nationally, work zone fatalities have risen to over 1000 annually and appear to be on an upward trend. Washington State has averaged less than ten work zone fatalities annually for the past several years. While statistics provide valuable information on many levels, it is WSDOT's practice to use statistical data as an indicator or possible performance measure, but not as a value that would dictate a level of applied safety measures. Work zones are planned and designed to conduct work operations, which must include specific safety measures at a level that addresses all safety impacts. Workers, pedestrians, and others that are not drivers or passengers may be exposed to an even higher level of risk related to the actual work operation, plus exposure to moving vehicles.

Some work zone hazards are easily identified and addressed, while others may require more intense investigation. The following information on some of the risks and associated impacts on workers and roadway users in work zones is intended to provide awareness of the different types of hazards. Each individual work zone must be assessed for hazards, as each work zone usually has unique features. The work zone safety assessment process and checklist provided is intended to assist the designer in determining the hazards that need to be addressed.

(1) Work Zone Hazards

The following list provides many common examples of work zone risks to drivers, workers, and flaggers that designers need to be aware of and address with protection, removal, or other solutions. Also, work zones are very dynamic, with many operations in progress while maintaining the flow of traffic. Work zones must function safely while these activities occur. A work zone design is not complete without addressing issues of ingress and egress, truck and equipment movements, moving work operations, and more.

Designers must consider the following conditions for drivers when developing a work zone TCP:

- Pavement markings
- Clear zone/safety zone issues
- Night work visibility issues (poor illumination or lack of positive guidance)
- Confusing or conflicting signs, markings, and features
- Unstable traffic flow

- Roadway geometrics
- Unexpected queues
- Congestion-related crashes
- Unexpected roadway configuration, merging, tapers, and drop lanes
- Vertical hazards, drop-offs, and diverging roadway profiles
- Emergency vehicle access
- Disabled vehicle refuges

Designers must consider the following conditions for flaggers and workers when developing a work zone TCP:

- Work zone protection
- Impaired, distracted, or inattentive drivers
- Errant vehicles
- Narrow work zones, equipment, and material
- Lack of protection behind flaggers from approaching traffic
- No escape route
- Exposure to moving equipment
- Aggressive drivers
- Speeding drivers
- Vehicle crashes
- Work zone access (ingress/egress issues, merging trucks, etc.)

Examine every work zone to determine the specific conditions that may be unique to that work zone.

(2) Workers

Working on or along the highway on construction projects is one of the more hazardous work environments. The risk of being struck by a vehicle traveling through the work zone increases as traffic volumes and speeds increase. Long delays can cause some motorists to become impatient and act unpredictably. A number of drivers are impaired from alcohol intoxication and legal or illegal drugs. Other driver conditions such as being sleep-deprived, elderly, aggressive, or inattentive are also potential hazards to workers. Consider the risk to workers when developing traffic control plans.

(3) Positive Protection

Traffic barriers provide the most effective protection for workers and they eliminate many traffic control devices. The costs of furnishing and removing temporary traffic barriers on longer-duration projects can often be less than the costs associated with the frequent repositioning of other traffic control devices. Positive barrier protection is often the preferred method for work zone protection and separation from traffic. Consider a strategy that offers the highest level of protection for workers. Temporary concrete barrier is the most common and available type of positive protection. Movable temporary concrete barrier could also be considered for those projects that require lane closures outside the limits of the normal barrier location. Truck-mounted attenuators are mobile and can be used strategically to protect isolated work zones or access points in the event of an errant vehicle. Traffic safety drums are generally considered to be the most versatile and effective of the types of portable channelization devices, especially for high-speed (45 miles per hour or higher) and high-volume traffic locations.

The selection of barriers and devices to separate workers from traffic is a critical decision and may become the key component of the work zone strategy. (See the MUTCD.) Do not assume that long-term stationary projects are the only practical application for barrier-protected work zones. Consider a staging plan on other projects that would allow for the use of barrier, even though it may need to be relocated several times. Excessive use of barrier may increase the potential for collision. Avoid the use of barrier for longer lengths or durations than is required for protection of active work areas. Traditional lane closure work zones using channelization devices are acceptable and may be the practical choice, but all additional means of protecting workers should be considered. Consider work zones of an isolated or restrictive nature, as workers also need safe access to and from the work zone. (See Chapter 710 for guidance on barriers.)

(4) Flaggers and Spotters

Although flaggers are also workers, their function in the work zone is uniquely different than other workers and they are treated as a separate group. Flaggers must perform their duties in potentially hazardous situations. Flagger safety is a high emphasis area. Do not include flaggers in the development of traffic control strategies until all other reasonable means of traffic control have been considered. These include more innovative traffic control methods such as automated flagging assistance devices (AFAD), temporary traffic signals, detour routes, and alternative traffic control plans, which can eliminate the need for flaggers.

Flaggers are normally used to stop and direct traffic for work activities such as one-lane alternating traffic control, intersection control, and road closures. Using flaggers solely to instruct motorists to proceed slowly is ineffective and is an unacceptable practice. When flaggers are used, provide a method of alerting them to the hazard of a vehicle approaching from behind. When flagging is needed for nighttime construction activities, provide adequate illumination of the flagger's station. Two-way radios or cellular phones are necessary to allow flaggers to communicate with one another when they are required to control traffic movements in shared right of way work zones.

Flaggers need escape routes in case of an errant vehicle or other hazards. The flagger's location, escape route, protection, and any other safety-related issues all need to be incorporated into the traffic control plan for the flagging operation. The WSDOT publication, *Work Zone Traffic Control Guidelines* (M 54-44), and the Standard Specifications have more information on flaggers, including the Washington State Department of Labor and Industries safety regulations for flaggers.

A spotter (not to be confused with a flagger) is used solely to alert workers. The spotter can be used to watch traffic and alert workers of the approach of an errant vehicle. A spotter does not use a flagging paddle, but instead uses a warning sounding device like an air horn. Use spotters only when the risks to the workers exceed those of the spotter. Intended spotter locations are to be shown on traffic control plans.

Law enforcement personnel may be considered for some flagging operations and can be very effective where additional driver compliance is desired. Law enforcement personnel are the only personnel allowed to flag from the center of an intersection. If flaggers are used at an intersection, a flagger is required for each leg of the intersection. When multiple lanes are present at an intersection, close the lanes so there is only one lane of traffic approaching the flagger location. When an existing signal is present at the intersection, the signal is to either be turned off or set to flash mode. The *Traffic Manual* contains information on the use of law enforcement personnel at work zones.

(5) Road Users

Road users assume (rightfully) they have full use of the roadway, unless directed otherwise. The message conveyed to the user through signing, markings, and devices must be consistent and credible.

(a) **Drivers.** Drivers and their passengers account for approximately 90% of work zone fatalities. It is important that efforts be made to effectively guide and protect drivers in work zones. Effective planning and design of work zones begins with the driver, and work zone design must be initiated from the driver's perspective. If drivers can easily understand the traffic control and have adequate time to react or make rational decisions, they will generally operate their vehicles in a safe and expected manner.

It is essential that designs be based upon the characteristics and limitations of drivers who use the highway and street networks. As speeds increase on a facility, the motorist requires more time to respond to conditions. Work zone temporary channelization and alignment must be designed to accepted roadway geometric design policy, not based on a design that may fit a given location without regard to safe design or predicated on a reduced speed that drivers may not follow. Perceived, insufficient, or conflicting information and/or too much information conveyed by signing will confuse the motorist and contribute to erratic driving behavior. Drivers may begin to ignore signing and other devices if they warn the motorist of a condition that no longer exists.

(b) **Pedestrians.** Public highways and streets that permit pedestrian use cannot deny access to pedestrians if no other route is available to them. Even in work zones, adequate facilities are provided to allow pedestrians to travel through or around the work zone. In urban areas and other locations where pedestrian travel is pronounced, the construction of temporary pathways that route the pedestrian around the work zone may be necessary. Covered walkways are provided in the work zone when there is a potential for falling objects to strike pedestrians. When existing pedestrian facilities are disrupted, closed, or relocated in a work zone, the temporary facilities shall be detectable and shall include accessibility features consistent with the features present in the existing pedestrian facility. Give careful consideration to the existing pedestrian path in that, even though no ADA-compliant features may be existing, the path may still be accessible to some extent and would need to be maintained in that manner. (See Chapter 1025 for pedestrian work zone design requirements.)

(c) **Bicyclists.** Bicyclists are allowed on most highways and streets, and many use the bike as their principal means of transportation. In work areas where the speeds are in the range of 25 to 30 miles per hour, bicyclists can use the same route as motorized vehicles. Within work zones on higher-speed facilities, bicyclists will not be able to match the speed of motorized vehicles and a different route or detour is sometimes necessary for safety and to reduce vehicular delays. When this is not possible, bicyclists can be instructed to dismount and walk their bikes through the work zone on the route provided for pedestrians. Bicyclists' access should be considered when developing the traffic control plans and staging plans. If it is feasible to maintain bike access through the work area with shoulder use, the minimum shoulder width of 4 feet should be designed into the plans.

Bicycles may also be allowed where pedestrians are not and there may be no pedestrian path for temporary bike use. Those work zones where there may be no available bike or pedestrian path must be officially closed and a detour route provided. It may be possible to make other provisions to transport bikes and riders through the work zone, as needed, by the traffic control supervisor or with a walking escort around the active work area. Riding surfaces are important for safe bicycle operation.

Consider the condition of the surface the bicyclist will be required to use, as loose gravel, uneven surfaces, milled pavement, and various asphaltic tack coats endanger the bicyclist. Much information can be gathered on bike issues by contacting local bike clubs. Coordination with local bike clubs is recommended to ensure their members are notified of work zone impacts. (See Chapter 1020 for more bicycle design requirements.)

(d) **Motorcycles.** The riding surface is also important for the safety of motorcycle riders. The same surfaces that are a problem for bicyclists are also difficult for motorcyclists. Stability at high speed is a far greater concern for motorcycles than cars on grooved pavement, milled asphalt, and tapers from existing pavement down to milled surfaces. Contractors must provide adequate warning signs for these conditions to alert the motorcycle rider. The WSDOT publication, *Work Zone Traffic Control Guidelines* (M 54-44), has more information on the regulations for providing warning to motorcyclists. (See also RCW 47.26.200.)

(e) **Oversized Vehicles.** Oversized vehicles exceed the legal width, height, or weight limits for vehicles, but are allowed on certain state highways. The regions' maintenance offices and HQ Motor Carrier Services issue permits that allow oversized vehicles to use these routes. If the proposed work zone will not accommodate those vehicles, provide adequate warning signs and notify HQ Motor Carrier Services and the regions.

In the permit notification, identify the type of restriction (height, weight, or width) and specify the maximum size that can be accommodated. On some projects, it may be necessary to designate a detour route for oversized vehicles. An important safety issue associated with oversized loads is that they can sometimes be unexpected in work zones, even though warning and restriction or prohibition signs may be in place. Some oversized loads can overhang the temporary barrier or channelization devices and endanger workers.

Consider the potential risk to those within the work zone. Routes with high volumes of oversized loads or routes that are already strategic oversized load routes may not be able to rely on warning or prohibition signs only. Protective features or active early warning devices may be needed. If the risk is so great that one oversized load could potentially cause significant damage or injury to workers, failsafe protection measures may be needed to protect structures and workers. The structure design may need to be reconsidered to more safely accommodate oversized loads by using an alternate girder type or other features, as well as staging and falsework opening size. The most common occurrence of this case may be a structure supported by falsework.

810.08 Mobility

Work zone congestion and delay is a significant issue for many highway projects. It is relatively easy to classify work zones on either end of the mobility spectrum. High-volume locations with existing capacity problems will most certainly be candidates for further capacity problems when a work zone is in place. Conversely, low-volume locations may not be affected at a significant level as long as the work zone impacts are not too severe. Work zones that fall somewhere between either end of the spectrum may not be so easy to recognize. All work zones need to be analyzed at an initial basic level to determine if further analysis is needed to address traffic capacity impacts. Significant impacts (see 810.15, Impacts Assessment) will most likely require a detailed capacity analysis to determine the most effective strategies for work zone mobility needs. It is not acceptable to develop a work zone strategy without traffic data to identify the projected impacts to traffic.

Mobility plays a role through and around work zones and other construction project activities in addition to traffic delays and congestion.

- **Crashes.** Most work zone crashes are congestion-related, usually in the form of rear end collisions due to traffic queues. Traffic queues beyond the advance warning signs increase the risk of crashes.
- **Driver Frustration.** Drivers expect to travel to their destinations in a timely manner. If delays occur, driver frustration can lead to aggressive or otherwise dangerous driving actions, causing crashes or danger to workers.
- **Constructibility.** The ability to construct a project efficiently relies (to a large extent) on the ability to pursue work operations while maintaining traffic flow. Delays in the form of material delivery, work hour restrictions, and constant installation and removal of traffic control devices all detract from constructibility.
- **Local Road Impacts.** Projects with capacity deficiencies can sometimes cause traffic to divert to local roadways, which may impact the surrounding local roadway system and community. Local roads may have lower geometric standards than state facilities. Placing additional and new types of traffic on a local road may create new safety hazards, especially when drivers are used to the geometrics associated with state highways.
- **Public Credibility.** Work zone congestion and delay can create poor credibility with drivers and the surrounding community in general.
- **Restricted Access.** Severe congestion can effectively "gridlock" a road system, preventing access to important route connections, businesses, schools, hospitals, etc.
- **User Cost Impacts.** Congestion and delay, as well as associated crashes and other impacts, can create significant economic impact to road users and the surrounding community. Calculate user costs as part of a work zone capacity analysis; the costs may be used to justify project congestion mitigation costs.
- **Bikes and Pedestrians.** Most roadways allow bike and pedestrian travel as legitimate modes of travel. Closing bike and pedestrian routes is generally not acceptable without providing alternate routes and access if they cannot be accommodated through the work zone.

WSDOT has a responsibility to maintain traffic mobility through and around its projects, which can be accomplished in many ways. The need to maintain mobility does not rule out innovative strategies such as planned roadway closures, because a mitigation strategy or other justification would be part of that overall strategy. It would not be appropriate to allow traffic restrictions without including a strategy to notify, mitigate, and manage the congestion. There is no absolute answer for how much congestion and delay is acceptable or unacceptable. The goal is a work zone strategy that maintains a work zone capacity level that minimizes all the related impacts. For further guidance on developing this type of strategy, see 810.16, Work Zone Design Strategy.

Traffic capacity mitigation measures are an important component in minimizing impacts, since many projects cannot effectively contain all the impacts through the work zone. Mitigation measures that provide the right combination of good public information, informative advance signing and notification, alternate routes, detours, and work hour restrictions, as well as innovations such as strategic closures, accelerated construction schedules, or parallel roadway system capacity improvements can be very effective in absorbing the over-capacity traffic and maintaining mobility.

Designers may want to enlist the assistance of others to adequately address work zone mobility impacts, such as the following:

- HQ Transportation Data Office
- HQ & Region Traffic Offices
- Region Work Zone Specialist
- Traffic Analysis Engineers
- Region Public Information Office

Training or experience with the following traffic analysis programs is also recommended, since at some level a work zone capacity analysis will need to be conducted. (See 810.20, Training Resources, for more information on training.)

- Quewz 98
- QuickZone
- Other capacity programs

810.09 Work Zone Classification

The duration of work is a major factor in determining the number and types of devices used in traffic control work zones. There are three classes of zones categorized by the expected duration of work. Different criteria apply to the design and planning for each of these classes. Several work zone classifications might be present during the construction phase of a project. Refer to the MUTCD for additional information regarding work duration. The three classes of work zones are as follows:

(1) Long-Term Stationary Work Zones

Long-term stationary work zones occupy locations longer than one hour. At these locations, there is ample time to install and realize benefits from the full range of traffic control procedures and devices that are available for use. Generally, larger channelizing devices are used, as they have more retroreflective material and offer increased nighttime visibility. Consider the use of temporary illumination to improve nighttime visibility (see 810.10 for additional information and considerations). The larger devices are also less likely to be displaced or tipped over by passing traffic. This can be an important consideration during those periods when the work crew is not present.

Since long-term operations can extend into nighttime, retroreflective and illuminated devices are necessary. Temporary detours and barriers can be provided, and inappropriate pavement markings can be removed and replaced with temporary markings. The time required for the installation and removal of temporary barriers and pavement markings is justifiable when they are required for about a week. Long-term stationary work zones encompass many various work zone operations, which range from a lane closure operation lasting a full work shift, to a roadway-widening project with staged traffic control. Stationary work zone traffic control is usually associated with a substantial work operation that may have many workers, with large quantities of equipment, and increased truck hauling and flagging.

(2) Short-Duration Work Zones

Short-duration work zones occupy a location for up to one hour. During short-duration work, the work crew sets up and takes down the traffic control devices. Because the work time is short, the impact to motorists is usually not significant and simplified traffic control procedures are used. Due to the short work time, simplified traffic control set-ups are allowed, to reduce the traffic exposure to workers. The time it may take to set up a full complement of signs and devices could approach or exceed the amount of time required to perform the work.

Short-duration work zones provide a safety benefit for both drivers and workers since the time duration is less than the implementation of stationary work zones, thereby reducing exposure time to traffic and work hazards. Motorists also receive a mobility benefit from reduced traffic impacts and associated rear-ending congestion crashes. These safety and mobility benefits are consistent with the department's responsibility and policy to protect both drivers and workers, while maintaining an acceptable level of mobility. Examples of short-duration work zone operations include relamping, pothole repair, surveying, minor repairs, bridge inspection, field recon, and prework layout.

These simplified control procedures can often be standardized plans, as contained in the HQ Design Office plan sheet library and the *Work Zone Traffic Control Guidelines* (M 54-44). The traffic control setup should fit the work operation.

(3) Mobile Work Zones

Mobile work zones are work activities that progress along the road either intermittently or continuously. Mobile operations often involve frequent stops for activities such as sweeping, paint striping, litter cleanup, pothole patching, or utility operations and are similar to short-duration work zones. Truck-mounted attenuators, warning signs, flashing vehicle lights, flags, and channelizing devices are used and move along with the work. When the operation moves along the road at low speeds without stopping, the advance warning devices are often attached to mobile units and move with the operation. Flaggers encounter more exposure in these operations and safeguards are necessary. Electronic signs and flashing arrow displays are far more effective than flaggers in these situations. Pavement milling and paving activities are similar to mobile operations in that they can progress along a roadway several miles in a day. These operations, however, are not considered mobile work zones and work zone traffic control consistent with construction operations is required.

810.10 Work Zone Devices

FHWA regulations require that all roadside appurtenances such as portable sign stands, barricades, traffic barriers, barrier terminals, crash cushions, and work zone hardware shall be compliant with the federal National Cooperative Highway Research Program (NCHRP) 350 crash test requirements. For additional information on the NCHRP 350 requirements and for additional descriptions of devices, refer to the MUTCD. For additional information and use guidelines for the following work zone devices, refer to *Work Zone Traffic Control Guidelines*.

(1) Channelization Devices

Channelization devices are used to alert and guide road users through the work zone. They are a supplement to signing, pavement markings, and other work zone devices. Typical devices include:

(a) **Cones.** Traffic safety cones are the most commonly used devices for traffic control and are very effective in providing delineation to the work zone. Cones are orange in color and are constructed of a material that will not cause injury to the occupants of a vehicle when impacted. For daytime operations on lower-speed (40 miles per hour or less) roadways, 18-inch-high cones can be used. For nighttime operations and high-speed roadways, reflectorized 28-inch-high cones are necessary. Traffic cones are used to channelize traffic, divide opposing traffic lanes, and delineate short-duration work zones.

(b) **Traffic Safety Drums.** Traffic safety drums are preferred for use on high-speed, high-volume roadways, and are required in some regions. Drums are fluorescent orange in color, constructed of lightweight, flexible materials, and are a minimum of 3 feet in height and 18 inches in diameter. Drums are the more commonly used devices in lane closure tapers to channelize or delineate traffic routes. They are highly visible and appear to be formidable obstacles. Drums are used at locations where high vehicular speeds are present, because they have weighted bases and are less likely to be displaced by the wind generated by moving traffic. The use of Type C steady-burn lights atop drums is recommended for high-speed urban freeway lane closure operations to improve visibility.

(c) **Tall Channelizing Devices.** Tall channelizing devices are 42 inches tall, fluorescent orange in color, and are constructed of lightweight, flexible material that will not cause injury in an impact. Tall channelizing devices are used to channelize traffic, divide opposing traffic lanes, and delineate short-duration work zones. These devices provide a larger target value in terms of retroreflectivity than cones, but less than that of drums. They do have a smaller footprint than drums, so they are a good alternative in narrow shoulder conditions, but they should not be a primary choice of device.

(d) **Tubular Markers.** Tubular markers are not a recommended device, unless they are being used to separate traffic on low-volume, low-speed roadways. For descriptions and restrictions for use, refer to the MUTCD and the Channelization Device Application Matrix in the *Work Zone Traffic Control Guidelines* (M 54-44) for additional information.

(e) **Barricades.** The barricades used in work zone applications are portable devices. They are used to control traffic by closing, restricting, or delineating all or a portion of the roadway. There are four barricade types:

1. The Type I Barricade is used on lower-speed roads and streets to mark a specific hazard.
2. The Type II Barricade is used on higher-speed roadways and has more reflective area for nighttime use to mark a specific hazard.
3. The Type III Barricade is used for lane and road closures.
4. The Directional Indicator Barricade is a special-use device and not commonly used. The device is used to define the route of travel on low-speed streets or in urban areas where tight turns are required. In lane reductions, the directional arrow on this barrier can be used in the transition taper to indicate the direction of the merge.

(f) **Longitudinal Channelization Devices.** Longitudinal channelization barrier systems such as lightweight water-filled barrier are an improvement over traffic cones and drums used to channelize traffic through a work zone. Water-filled barriers are *not intended* as a replacement for concrete barriers; however, they may be considered for short-term use as a substitute for concrete barrier in emergency situations.

(2) Barriers

Barriers are used to separate opposing traffic movements and to separate the road users from the work zone. Work zone intrusions can jeopardize the safety of the motorist or the workers. Types of barrier protection used in construction work zones vary between temporary concrete barriers, movable barriers, steel barriers, and water-filled barriers.

Barriers are normally installed at the following locations:

- The separation of opposing traffic, where two-way traffic must be maintained on one roadway of a normally divided highway for an extended period of time
- The separation of opposing traffic, where a four-lane divided highway transitions to a two-lane two-way roadway that is being upgraded to become a divided four-lane roadway
- Where drums, cones, or barricades do not provide adequate guidance for the motorist or protection for the worker
- Multiple lane separations in a long-term stationary work zone
- Where workers are exposed to unusually hazardous traffic conditions

- Where existing traffic barriers and bridge railings are removed during a construction phase

(a) **Temporary Concrete Barriers** are the safety-shape barriers shown in the Standard Plans. They are used in long-term stationary work zones on high-speed multilane facilities. They are also used as a temporary bridge rail when existing bridges are being modified. These concrete barriers are often displaced in impacts with errant vehicles. Lateral displacement is usually in the range of 2 to 4 feet. When any barrier displacement is unacceptable, these barriers are anchored to the roadway or bridge deck. Anchoring systems are also shown in the Standard Plans.

(b) **Movable Barriers** are specially designed segmental barriers that can be moved laterally as a unit to close or open a traffic lane. Initial costs are high and they will only be considered in a long-term stationary work zone if frequent or daily relocation of a barrier is required. The ends of the barrier are not crashworthy and must be located out of the clear zone or fitted with an impact attenuator. Adequate storage sites at both ends of the barrier are required for the unique barrier-moving machine.

(c) **Portable Steel Barriers** have a lightweight stackable design, which reduces transport costs. They are most frequently used in short-term work zones because of the relative ease and rapidity of installation and removal. Lateral displacement is usually in the range of 6 to 8 feet.

(d) **Water-Filled Barriers** are not recommended for use due to their large deflection and potential for penetration when impacted. When they are used, special care must be taken to ensure they are used properly. They may be used as an improvement over traffic cones and drums to channelize traffic through a work zone. They are most frequently used in short-term work zones because of the relative ease and rapidity of installation and removal. Therefore, they cannot be considered as a substitute for concrete barrier. A common decision-making issue on many projects is when to use barriers. As discussed throughout this chapter, there are many considerations in selecting the devices and strategies that ultimately go into the TMP to be used on the project. In almost every case, there is some level of compromise between the major project elements of constructibility, mobility, safety, time duration, project features, and so on. The key is to find the best balance of all the elements in an effort to ensure an overall successful project. Safety, however, must not be compromised.

Barriers can be one of the most effective safety measures, because they accomplish, to a large extent, the separation of workers and the work area from traffic. The following is a listing of the elements to consider when deciding on the use of barriers:

- Project features and the associated construction activities must be addressed within the work zone design (this means applying the Work Zone Clear Zone to those features and activities that may represent a hazard)
- Excavations
- Drop-offs
- Unprotected features (walls, piers, sign structures, foundations, etc.)
- Working and nonworking equipment (hauling, excavating, etc.)
- Interim unprotected features or objects (nonstandard slopes, rock stockpiles, ditches within the clear zone, etc.)
- Worker exposure to traffic and work hazards
- Number of workers
- Proximity to hazards
- Time duration of exposure
- Suitable work area available to workers
- Traffic exposure (drivers and occupants) to work hazards or new hazards introduced by a temporary roadway configuration
- Type of work operation (mobile, stationary, or both)

The cost of using barriers is a valid consideration, but not in the sense that an exact cost can be placed on the safety benefit value vs. the actual cost to include it. An informed decision to use barriers or not requires careful consideration of all the related factors, and cost should not be the only or primary influence on that outcome. Many projects of a stationary nature, with some of the issues identified above, would be good candidates for the use of barriers and should be developed along that concept.

(3) Impact Attenuators

Within the Design Clear Zone, the approach ends of temporary concrete barriers are fitted with impact attenuators to reduce the potential for occupant injury during a vehicle collision with the barrier. Impact attenuators are addressed in Chapter 720.

The selection and location of impact attenuators in work zones can present situations that do not exist on a fully operational highway. Designers must consider all work zone and traffic protection needs. The information in Chapter 720 provides all the needed impact attenuator performance information, but the actual work zone location may require careful consideration by the designer to ensure that the correct application is used. Consider the dynamic nature of work operations where work zone ingress and egress, work area protection, worker protection, and traffic protection all enter into the equation of the final selection. Redirective and nonredirective devices can both be used as long as the aforementioned issues are resolved and the devices also meet the Chapter 720 criteria when applied to a given work zone location. Also, impact attenuators used in work zones are much more likely to be impacted, which again requires careful consideration of those devices that are durable and easy to repair. Some common impact attenuator work zone issues are:

- Nonredirective device improperly located. This is usually associated with an inadequate length of need calculation (see Chapter 710) or the oversight of not fully considering all the protection issues.
- Narrow temporary medians, narrow work zones, narrow or no shoulders, temporary median openings, and inadequate installation area (width, cross and approach slope, base material).
- Temporary or short-term protection issues associated with removal or relocation of existing or temporary barriers and impact attenuators.

Designers need to ensure that the approved list of temporary impact attenuators is in fact appropriate for the individual work zone plan locations. The designer may remove those devices from the list that are not appropriate for a given location.

(4) Truck-Mounted Attenuators

A truck-mounted attenuator (TMA) is a portable impact attenuator attached to the rear of a large truck. Ballast is added to the truck to minimize the roll-ahead distance when impacted by a vehicle. The TMA is used as a shield to prevent errant vehicles from entering the work zone. If a TMA is not available, the use of a protective or shadow vehicle is still highly recommended.

(5) Fixed Signing

Fixed signing are the signs mounted on conventional sign supports along or over the roadway. This signing is used for long-term stationary work zones. Ground-mounted sign supports are usually wood and details for their design are in Chapter 820 and the Standard Plans. Sign messages, color, configuration, and usage are shown in the MUTCD and the *Sign Fabrication Manual*, M 55-05. When preparing the work zone signing plan, review all existing signing in advance of and within the work zone for consistency and sign locations. Cover or remove existing signs that can be misinterpreted or be inappropriate during construction.

(6) Portable and Temporary Signing

Portable and temporary signing is generally used in short-term or mobile work zones where frequent repositioning of the signs is necessary to keep pace with the work along the highway. These signs are mounted on crashworthy, collapsible sign supports or vehicles.

(7) Delineation

Pavement markings provide motorists with clear guidance through the work zone and are necessary in all long-term work zones. Temporary pavement markings can be either painted, preformed tape, or raised pavement markers. Remove existing confusing or contradictory pavement markings. Other delineation devices are guideposts, concrete barrier delineators, and lateral clearance markers, which should be shown on the traffic control plans. These devices have retroreflective properties and are used as a supplement in delineating the traveled way during the nighttime. (See Chapter 830 for delineation requirements.)

Removal of some types of existing or temporary pavement markings (generally paint stripe, but can include RPMs and other materials like plastic and MMA stripes) can leave a "ghost stripe" effect on the pavement. This is a scar left by the removal process that discolors the pavement and/or leaves a portion of the existing marking where a ghost stripe creates a visual distraction to drivers. Destructive removal such as intensive grinding can actually leave a groove in the pavement that can hold rainwater and leave the appearance of a stripe, especially at night when headlight reflection intensifies the effect.

Designers need to consider the types of removal for markings and their potential for ghost stripes and other distracting or conflicting leftover markings. Less destructive types of removal such as hydroblasting and the use of removable temporary markings can significantly improve pavement marking performance through the work zone. Continuous positive guidance through high quality temporary pavement markings, alone or in combination with existing markings, is a substantial benefit to drivers in work zones. Contact the region or HQ Traffic Office for further information on this subject.

Lateral clearance markers are used at the angle points of barriers where they encroach on or otherwise restrict the adjacent shoulder. Concrete barrier delineation is necessary when the barrier is less than 4 feet from the edge of the traveled way. This delineation can be either barrier reflectors attached to the face of the barrier or saddle drum delineators that sit on the barrier.

(8) Illumination

Illumination might be justified if construction activities take place on the roadway at night for an extended period of time. Illumination might also be justified for long-term construction projects at the following locations:

- Road closures with detours
- Road closures with diversions
- Median crossovers on freeways
- Complex or unexpected alignment or channelization
- Haul road crossings (if operational at night)
- Temporary traffic signals
- Temporary ramp connections
- Disruption of an existing illumination system

For information on light levels and other electrical design requirements, see Chapter 840.

When flaggers are necessary for nighttime construction activities, supplemental lighting of the flagger stations by using portable light plants or other approved methods is required.

(9) Portable Changeable Message Signs (PCMS)

PCMS displays have electronic displays that can be modified and programmed with specific messages, and are supplemental to other warning signs. These signs are usually mounted on trailers and use solar power or batteries to energize the electronic displays. The maximum number of message panels is two per location. If additional information is necessary, consider using a second PCMS sign. Place the PCMS far enough in advance of the roadway condition to allow the approaching driver adequate time to see and read the sign's message twice. The following are some typical situations where PCMS are used:

- Where traffic speed is expected to drop substantially
- Where significant queuing and delays are expected
- Where adverse environmental conditions, such as ice and snow, are present
- Where there are extreme changes in alignment or surface conditions

- Where advance notice of ramp, lane, or roadway closures is necessary
- When accident or incident management teams are used

(10) Arrow Panel

The arrow panel displays either an arrow or a chevron pointing in the direction of the intended route of travel. Arrow panel displays are used for lane closures on multilane roadways. When closing more than one lane, use an arrow panel display for each lane reduction. Place the arrow panel at the beginning of the transition taper and out of the traveled way. The caution display (four corner lights) is only used for shoulder work. Arrow panels are not used on two-lane two-way roadways. (See the MUTCD for additional information.)

(11) Temporary and Portable Traffic Signals

Temporary traffic control signals are typically used in work zones to control traffic such as temporary one-way operations along a one-lane two-way highway, where one lane is closed and alternating traffic movements are necessary. Examples of work operations are temporary one-way operations on bridges and intersections. Contact the region's Traffic Office and signal superintendent for specific guidance and advice on the use of these systems; a traffic control plan is required.

- **Temporary Signal System.** A permanent signal system typically modified in a temporary configuration such as temporary pole locations during intersection construction, span wire systems, and adjustment of signal heads to accommodate a construction stage. (See Chapter 850.)
- **Portable Traffic Signal System.** A trailer-mounted traffic signal used in work zones to control traffic. These versatile portable units allow for alternative power sources such as solar power, generator, and deep cycle marine batteries, in addition to AC power. (See the MUTCD for additional information.)

(12) Warning Lights

Warning lights are either flashing or steady burn (Types A, B, or C), mounted on channelizing devices, barriers, and signs. Secure warning lights to the channelizing device or sign so they will not come loose and become a flying object if impacted by a vehicle. (See the MUTCD for additional information.)

- **Type A** – Low-intensity flashing warning light used to warn road users during nighttime hours that they are approaching a potentially hazardous area.
- **Type B** – High-intensity flashing warning light used to warn road users during both daytime and nighttime hours.
- **Type C** – Steady-burn warning light designed to operate 24 hours per day to delineate the edge of the roadway.

(13) Portable Highway Advisory Radio (HAR)

A HAR is a roadside radio system that provides traffic and travel-related information (typically affecting the roadway being traveled) via AM radio. The system may be a permanently located transmitter or a portable trailer-mounted system that can be moved from location to location, as necessary. Contact the region's Traffic Office for specific guidance and advice on the use of these systems.

(14) Automated Flagger Assistance Device (AFAD)

The AFAD is an automated flagging machine that is operated remotely by a flagger located off the roadway and away from traffic. The device is a safety enhancement for projects that use alternating traffic control by physically placing the human flagger off the roadway while maintaining control of the traffic movements approaching the work zone. Contact the region's Traffic Office for specific guidance and advice on the use of these systems. A traffic control plan is required for use of the AFAD.

(15) Screening

Screening is used to block the motorist's view of construction activities adjacent to the roadway. Construction activities can be a distraction, and motorist reactions might cause unsafe vehicle operation and undesirable speed reductions. Consider screening the work area when the traffic volume approaches the roadway's capacity. Screening can be either vertically supported plywood or plastic panels, or chain link fencing with vertical slats. These types of screening are positioned behind traffic barriers to prevent impacts by errant vehicles. The screening is anchored or braced to resist overturning when buffeted by wind. Commercially available screening or contractor-built screening can be used, provided the device meets crashworthy standards and is approved by the Engineer prior to installation.

Another type of screening, glare screening, is also used on concrete barriers separating two-way traffic to reduce headlight glare from oncoming traffic. Woven wire and vertical blade-type screens are commonly used in this installation. This screening also reduces the potential for motorist confusion at nighttime by shielding the headlights of other vehicles on adjacent roadways or construction equipment. Make sure that motorists' sight distance to critical roadway features is not impaired by these glare screens. Contact the HQ Design Office and refer to AASHTO's *Roadside Design Guide* for additional information on screening.

810.11 Work Zone Intelligent Transportation Systems (ITS)

Work zones present safety challenges to both travelers and road workers. Using ITS in work zones, however, can help ease the frustration and prevent crashes.

Intelligent Transportation Systems apply advanced technologies to optimize the safety and efficiency of the existing transportation network. Many permanent systems already exist throughout Washington State and provide the opportunity to greatly enhance construction projects that fall within the limits of the ITS network. ITS applications in work zones can be used to provide traffic monitoring and management, data collection, and traveler information. ITS provide the most up-to-date information to motorists so they have the opportunity to make informed, educated choices regarding their travel plans.

ITS can help secure the safety of workers and travelers in a work zone while facilitating traffic flow through and around the construction area. ITS technologies do make a difference in reducing crashes, reducing delays, and reducing costs when used in work zones.

The use of ITS technology in work zones such as portable camera systems, highway advisory radios, variable speed limits, ramp metering systems, and queue detection information is aimed at increasing safety for both workers and road users and ensuring a more efficient traffic flow. ITS technologies for work zones is an emerging area; these technologies provide the means to better monitor and manage traffic flow through and around work zones. Minimizing the impact of work zone delays through technology has a positive impact on safety, mobility, access, and productivity.

(a) **Safety**. ITS work zone applications increase safety by providing drivers with advance notice of the presence of work zones and associated traffic conditions, such as slowed or stopped traffic ahead. Safety is measured in terms of the number and severity of vehicle crashes in the work zone that are attributable to the presence of construction or maintenance activities. Another factor used to measure the safety of work zones is the number of citations issued. Decreasing numbers of citations indicate improved safety conditions in the work zone.

Identify work zone ITS elements early in the strategy development process and include in the preliminary estimate so they can be designed along with the other traffic control elements. For large mobility projects that have existing freeway cameras already in place, temporary ITS features (temporary poles, portable systems, etc.) may be necessary to ensure that the network can be maintained during construction, especially if existing camera locations are in conflict with construction activities.

In locations that do not have existing camera locations, but have significant construction projects planned, portable ITS systems may be a good opportunity to bring ITS technology to the route.

(b) **Mobility**. ITS applications in work zones improve mobility by providing drivers with traffic condition information so that they can adjust routes or travel times. ITS applications may also improve mobility by smoothing traffic flow through a work zone. Mobility is measured in terms of the absence or decrease of observed or reported traffic backups or delays at the work zone.

Refer to Chapter 860 for additional ITS information and guidance.

810.12 Work Zone Design Policy and Considerations

Work zone design is consistent with permanent design and must be maintained during temporary traffic control configurations. Use accepted geometric design when temporary alignments and channelization are necessary to perform the work tasks (if necessary, consider additional roadway design features.) The following information provides some basic guidance and considerations for temporary channelization designs:

(1) Lane Widths

Maintain existing lane widths during work zone operations whenever possible. For projects that require lane shifts or narrowed lanes due to work area limits and staging, before determining the final lane width to be implemented, consider the following:

- Overall roadway width available
- Posted speed limit
- Traffic volumes through the project limits
- Number of lanes
- Existing lane and shoulder widths
- Length of project
- Duration lane width reduction (if in place)
- Roadway geometry (vertical and horizontal curves)
- Truck percentage

The sudden transition to tighter geometrics and the close proximity of traffic control devices must be incorporated into the work area in a manner that will not violate driver expectancy. Maintain approach lane width, if possible, throughout the connection. Design lane width reductions prior to any lane shifts within the transition area. Do not reduce curve radii and lane widths simultaneously.

The minimum allowable lane width for low-speed, low-volume roadways is 10 feet, with 1 foot of shy distance. However, this requires prior approval from the region's Traffic Engineer before being accepted. For all other roadway situations, 11 feet is the minimum allowable striped lane width, with a 2-foot shy distance to a traffic control device or shoulder width. The maximum allowable lane width is 14 feet when the radius is not less than 500 feet. Follow existing lane widths when delineating temporary lanes with channelizing devices.

When determining lane widths, the objective is to use lane geometrics that will be clear to the driver and keep the vehicle in the intended lane. Lane lines and construction joints must be treated to provide a smooth flow through the transition area. In order to maintain the minimum lane widths and shy distances, temporary widening may need to be considered.

(2) Lateral Buffer Space and Shy Distance

Lateral buffer space provides space between the driver and the active work space, traffic control device, or to a potential hazard such as an abrupt lane edge or drop-off. Shy distance is the distance from the edge of the traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver to the extent that the driver will change the vehicle's placement or speed.

Refer to Chapter 710 and the Standard Plans for determining the appropriate lateral clearance and shy distance values.

In order to achieve the minimum lateral

clearances, there may be instances where temporary pavement widening or a revision to a stage may be necessary. In the case of short-term lane closure operations, the adjacent lane may need to be closed or traffic may need to be temporarily shifted onto a shoulder to maintain a lateral buffer space. During the design of the traffic control plan, the lateral clearance needs to be identified on the plan to ensure that additional width is available. Temporary roadway cross sections are a great way to show the space in relation to the traffic and work area.

(3) Work Zone Clear Zone

The contractor's operations present opportunities for errant vehicles to impact the clear area adjacent to the traveled way. A Work Zone Clear Zone (WZCZ) is established for each project to ensure the contractor's operations provide an appropriate clear area. The WZCZ addresses items such as storage of the contractor's equipment, employee's private vehicles, and storage or stockpiling of project materials. The WZCZ applies during working and nonworking hours. The WZCZ applies only to roadside objects introduced by the contractor's operations and is not intended to resolve preexisting deficiencies in the Design Clear Zone, or clear zone values established at the completion of the project. Those work operations or objects that are actively in progress and delineated by approved traffic control measures are not subject to the WZCZ requirements.

Minimum WZCZ values are presented in Figure 810-2. WZCZ values may be less than Design Clear Zone values, due to the temporary nature of the construction and limitations on horizontal clearance. To establish an appropriate project-specific WZCZ, it may be necessary to exceed the minimum values. The following conditions warrant closer scrutiny of the WZCZ values, with consideration of wider clear zone:

- Outside of horizontal curves, or other locations where the alignment presents an increased potential for vehicles to leave the traveled way
- The lower portion of long downgrades or other locations where gradient presents an increased potential for vehicles to exceed the posted speed
- Steep fill slopes and high traffic volumes*

*Although it is not presented as absolute guidance, the Design Clear Zone figure in Chapter 700 may be used as a tool to assess increases in WZCZ values.

Posted Speed	Distance From Traveled Way (Feet)
35 mph or less	10
40 mph	15
45 to 55 mph	20
60 mph or greater	30

Minimum Work Zone Clear Zone Distance
Figure 810-2

(4) Abrupt Lane Edges and Drop-offs

Minimize, mitigate, or eliminate abrupt lane edges adjacent to the traveled lane whenever possible. There are work operations where drop-offs are unavoidable in order to perform the work, but in these instances, the drop-off generally can be anticipated and included in the plan design. Lag up the paving on paving projects to minimize the instances of abrupt lane edges being exposed.

The driving or roadway surface is also important for motorcycle rider safety. The same surfaces that are a problem for bicyclists are also difficult for motorcyclists. Stability at high speeds is a far greater concern for motorcycles than cars on grooved pavement, milled asphalt and tapers from existing pavement down to milled surfaces. Adequate signing to warn for these conditions to alert the motorcycle rider is required. See Word Zone Traffic Control Guidelines (M 54-44) for signing details.

(5) Vertical Clearance

Per Chapter 1120, vertical clearance over highways is 16.5 feet. Anything less than the minimum must follow the reduced clearance criteria discussed in Chapter 1120 and included in the temporary traffic control plans. Maintain legal height on temporary falsework for bridge construction projects whenever possible. (See *Design Manual* Supplement 1120, April 24, 2006.) Anything less than this must consider overheight vehicle impacts and possible additional signing needs. Widening of existing structures can prove challenging when the existing height is at or less than legal height, so extra care may be necessary in the consideration of overheight vehicles when temporary falsework is necessary. Coordination with the HQ Bridge and Structures Office is essential to ensure that traffic needs have been accommodated. Vertical clearance requirements associated with local road networks may be different than what is shown in Chapter 1120. Coordinate with the local agency.

(6) Temporary Median Crossover Requirements

Geometrics for temporary crossovers need to follow the same guidance as permanent construction and have horizontal curves calculated to fit the location. When road closure, stage construction, detouring, and two-lane two-way traffic control must be maintained on one roadway of a normally divided highway, opposing vehicular traffic shall be separated with either temporary traffic barriers or with channelizing devices throughout the length of the two-way operation. The use of markings and complementary signing, by themselves, shall not be used.

The following are some of the guiding principles for the design of crossovers:

- The roadway surface shall be paved, and temporary pavement markings are required. Temporary illumination is required to improve the visibility of the crossover location. Temporary drainage may be necessary under the median fill when applicable.
- Design crossovers for operating speeds not less than 10 miles per hour below the posted speed limit, unless unusual site conditions require that a lower design speed be used.
- Separate tapers used for lane closures and crossovers. Separate and sign them far enough apart for drivers to clearly understand what is ahead of them.
- Flat, diagonal taper crossovers are better than reverse curves with super-elevation.
- Design crossovers to accommodate all roadway traffic, including trucks, buses, and motor homes.
- A good array of channelizing devices and properly placed pavement markings are essential in providing good, positive guidance to drivers.
- Temporary concrete barriers and excessive use of traffic control devices cannot compensate for poor geometric design of crossovers.
- Provide a clear roadside recovery area adjacent to the crossover. Consider how the roadway safety hardware (guardrail, crash cushions, etc.) may be impacted by the traffic using the crossover if the traffic is going against the normal traffic flow direction. Avoid or mitigate possible snagging potential.
- A site-specific traffic control plan is required.

(7) Temporary Alignment and Channelization

Temporary alignment and channelization plans are necessary for multiple staged projects that impact traffic by moving the lanes in order to accommodate a specific work operation or construction stage. Staged construction plans are generally separate from the temporary traffic control plans but share consistent concepts and features, and will be used in conjunction with one another.

Specific details shown on the plans include beginning and ending stations and taper rates when applicable for all alignment changes. The more detail that can be shown on the plans during the design phase, the more accurate the layout will be in the field and the less chance that the alignment will not fit the location or will cause a constructibility issue. Be aware of existing crown points, lane/shoulder cross slope breaks, and superelevation transitions that may affect a driver's ability to maintain control of a vehicle through a work zone.

The following are a few guiding principles for the design of temporary alignment and channelization plans:

- Use site-specific base data.
- Provide beginning and ending station ties to all alignment changes and all angle points for temporary concrete barrier.
- Include lane and shoulder widths.
- Provide temporary roadway sections for emphasis.
- Avoid using angle points when showing temporary pavement markings.
- To avoid confusion, do not show existing conflicting details that are not necessary on the plan.
- No straight line tapers through curves; use circular alignment.
- As staging plans are developed, the plan details also need to change in regard to how existing features are changed or impacted by the stages. For example, if an edge line is removed in one stage, the following stage would show the change by indicating where the new edge line is located.
- Consider the time constraints for the removal of existing markings and the time required to install new markings, especially if the work is for multi-lane staged construction. In urban areas where work hour restrictions for lane closures are limited, special consideration may be necessary to allow for time to address pavement markings or interim stages may be necessary. Re-opened temporary traffic lanes must be marked and in compliance with standards established in this chapter.
- When showing a run of temporary concrete barrier and the temporary impact attenuator location on a channelization plan, the shoulder approaching the attenuator location also must be closed using shoulder closure signing and channelizing device taper consistent with the MUTCD. Refer to the MUTCD for example detail.

810.13 Work Zone Types

The work zone type is the basic layout of the worksite and the configuration of traffic lanes through the work zone. Many variables such as location of work operation, duration, road user volumes, road vehicle mix (buses, trucks, and cars), and road user speeds affect the needs of each zone. The goal of temporary traffic control in work zones is safety with minimum disruption to road users. Site-specific traffic control plans are required for most of these operations. Standard plans that may be adapted for specific work zone applications are available at the following web site: http://www.wsdot.wa.gov/eesc/design/designstandards/psl/wz-1-17/wz-1-17.htm

A description of each of the work zone types is as follows:

(1) Reduced Lane Width

The lanes in this work zone type retain their normal number and general alignment. One or more of the traffic lanes have reduced widths to provide the necessary separation from the work zone. This arrangement causes the least disruption to traffic by maintaining capacity, but the narrowed lanes may still create congestion with drivers feeling pinched as they work their way through the work zone. Reduction of lane width for more than one lane of traffic in a direction requires modification to pavement markings and cannot be done using only channelization devices.

(2) Buffer Space and Shy Distance

Buffer space is a lateral and/or longitudinal area that separates road user flow from the work space or an unsafe area, and might provide some recovery space for an errant vehicle.

- Lateral buffer space provides space between the driver and the active work space, traffic control device, or a potential hazard such as an abrupt lane edge or drop-off. A minimum of a 2-foot lateral buffer space is recommended.
- Shy distance is the distance from the edge of the traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver to the extent that the driver will change the vehicle’s placement or speed.

- Longitudinal buffer is the space between the protective vehicle and the work activity.

Devices used to separate the driver from the work space should not encroach into adjacent lanes. If encroachment is necessary it is recommended to close the adjacent lane to maintain the lateral buffer space. Refer to Chapter 710 of the *Design Manual* and the MUTCD to determine the appropriate buffer space and shy distance values.

In order to achieve the minimum lateral clearances, there may be instances where temporary pavement widening or a revision to a stage may be necessary. In the case of short-term lane closure operations, the adjacent lane may need to be closed or traffic may need to be temporarily shifted onto a shoulder to maintain a lateral buffer space. During the design of the traffic control plan, the lateral clearance needs to be identified on the plan to ensure that additional width is available; temporary roadway cross sections are a great way to show the space in relation to the traffic and work area.

(3) Lane Closure

One or more of the traffic lanes are closed in this work zone type. A capacity analysis is necessary to determine the extent of congestion that might result.

(4) Alternating One-Lane Two-way Traffic

This work zone type involves using one lane for both directions of traffic. Flaggers or traffic signals are normally used to control the alternation of traffic movements.

(5) Temporary Bypass

This work zone type involves total closure of one or both directions of travel on the roadway. Traffic is routed to a temporary bypass usually constructed within the highway's right of way. An example of this would be the replacement of an existing bridge by building an adjacent temporary structure and shifting traffic onto the temporary structure.

(6) Intermittent Closure

This work zone type involves stopping all traffic in both directions for a relatively short time to allow the work to proceed. After a certain amount of time, driven by the traffic volume, the roadway is reopened. An example of this type of closure would be a girder setting operation for a bridge project; typically, the closure would be limited to a ten-minute maximum and would occur in early morning hours when traffic volumes are at their minimum.

(7) Rolling Slowdown

A rolling slowdown is a legitimate form of traffic control commonly practiced by the Washington State Patrol (WSP), contractors, and highway maintenance crews. Their use is valuable for emergency or *very specific* short-duration closures (for example, to set bridge girders, remove debris from the roadway, push a blocking disabled to the shoulder, or pull power lines across the roadway). The traffic control vehicles form a moving blockade, which reduces traffic speeds and creates a large gap (or clear area) in traffic, allowing very short-term work to be accomplished without completely stopping the traffic.

Other traditional forms of traffic control should be considered before the rolling slowdown and be the primary choice. A site-specific traffic control plan (TCP) must be developed for this operation. The gap in traffic created by the rolling slowdown, and other traffic issues, need to be addressed on the TCP. Also, use of the WSP is encouraged whenever possible.

(8) Reduced Speeds in Work Zones

As part of the design process for construction projects, speed reductions are an option requiring a thorough traffic analysis conducted prior to making a change. Traffic control plans should be designed on the assumption that drivers will only reduce their speeds if they clearly perceive a need to do so. Reduced speed limits should be used only where roadway and roadside conditions or restrictive features are present such as narrow, barrier-protected work areas with major shifts in roadway alignment, and where a reduced speed limit is truly needed to address the safe speed of the roadway. Work zone design of roadway geometrics, hazards, and worker protection should be accomplished using the existing posted speed limits. Speed reductions should not be applied as a means for selecting lower work zone design criteria (tapers, temporary alignment, device spacing, etc.). However, frequent changes in the speed limit should be avoided. A TCP should be designed so that vehicles can reasonably safely travel through the work zone with a speed limit reduction of no more than 10 miles per hour.

Speed reductions must be approved by the Regional Administrator and included on a traffic control plan prior to implementation. Guidelines for speed changes are outlined in RCW 47.38.020, the *Traffic Manual*, Chapter 5, and Directive D55-20, "Reduced Speed in Maintenance and Construction Zones."

- **Advisory Speeds.** The advisory speed plaque shall not be used in conjunction with any sign other than a warning sign, nor shall it be used alone. In combination with a warning sign, an advisory speed plaque may be used to indicate a recommended safe speed through a work zone. Refer to the MUTCD for additional guidance.

(9) Median Crossover

This work zone type involves routing the traffic from one direction onto a portion of the median and roadway of the opposing traffic. It can also incorporate reduced lane widths in order to maintain the same number of lanes. On higher-speed roadways, temporary barrier is used to separate the two directions of traffic. (See the Temporary Median Crossover requirements in 810.12 for additional information.)

(10) Lane Shift

Traffic lanes may be shifted in order to accommodate a work area when it is not practicable, for capacity reasons, to reduce the number of available lanes. The benefit of this work zone type is being able to maintain traffic flow with the existing number of lanes. Shifting more than one lane of traffic requires the removal of conflicting pavement markings and the installation of temporary markings; the use of devices to separate traffic is not allowed. A warning sign shall be used to show the changed alignment when the lateral shifting distance is greater than one-half of a lane width.

Utilizing the existing shoulder may be necessary to accommodate the shifting movement, but the structural capacity of the shoulder must first be analyzed to determine its ability to carry the proposed traffic. Remove and inlay existing shoulder rumble strips prior to routing any traffic onto the shoulder.

(11) Median Use

This work zone type is similar to the shoulder use type and is used on divided highways where the median and adjacent shoulders are used for the traffic lanes. Barriers are usually necessary to separate opposing traffic. Remove and inlay existing median rumble strips.

(12) Diversion

A diversion is a temporary rerouting of drivers onto a temporary highway or alignment placed around the work area. This work zone type involves total closure of one or both directions of travel on the roadway. Traffic is routed to a temporary bypass usually constructed within the highway's right of way. An example of this would be the replacement of an existing bridge by building an adjacent temporary structure and shifting traffic onto the temporary structure.

(13) Total Road Closure

This work zone type requires the complete closure of the roadway in order to pursue the work operation. Traffic is rerouted to an adjacent street or highway to avoid the work zone. Advance notification of the closure is required and a signed detour route may be required. Clearly sign detours over the entire length so that drivers can easily use existing highways to return to the original highway. Closing a highway, street, or ramp, while not always practicable, is a desirable option from a safety viewpoint. For the traveling public, closing the road for a short time might be less of an inconvenience than driving through a work zone for an extended period of time. (See the *Traffic Manual* and RCW 47.)

(14) Traffic Split or Island Work Zone

Island work zones and traffic splits should be considered only after alternative work operations have been explored before going forward with the design. In this work zone type, the traffic lanes in one direction are separated to allow construction activities within one of the lanes. On higher-speed roadways, temporary barriers are provided to prevent errant vehicles from entering the work area.

Typically, drivers have difficulty understanding "lane split" configurations, which sometimes results in poor driving decisions such as unnecessary lane changes, indecision on lane choice, or drivers being generally uncomfortable with driving through an island work zone. Most drivers are able to navigate these work zones at a reasonable level, but the few drivers who aren't can create unstable traffic conditions that are projected to arriving traffic upstream. This decreases the traffic capacity through the work zone resulting in queues that either increase or subside based on approaching traffic volume and the stability of the traffic flow at the lane split. Also, drivers often do not expect slow or stopped traffic approaching the work zone, so additional advance warning is a requirement.

Consider the following guidance for traffic split operations:

- Define the work operation and develop the traffic control strategy around the specific operation.
- Limit the duration the traffic split can be in place. Consider incentives/disincentives for the contractor to be as efficient as possible. A higher level of traffic impacts may be acceptable if offset with fewer impacted days.
- Advance warning signs advising drivers of the approaching roadway condition are required. Consider the use of PCMS, portable HAR, and other dynamic devices.
- Consider how the operation will impact truck traffic. If the truck volumes are high, additional consideration may be prudent to control in which lane the trucks drive. If the trucks are controlled, this eliminates much of the potential for truck/car conflicts and sorts out undesirable truck lane changes through the work zone.
- Consider the use of solid lane line markings to delineate the traffic split or island. There are two striping options to consider during the design of a traffic split: (1) when lane changes are DISCOURAGED, a single solid lane line shall be used, and (2) when lane changes are PROHIBITED, two solid lane lines shall be used. Refer to the MUTCD for additional details.
- Consider supplementing the existing roadway lighting with additional temporary lighting to improve the visibility of the island work area.
- Consider the use of "STAY IN LANE" (black on white) signs, or set up a "no pass" zone approaching the lane split and coordinate with the WSP.

810.14 Capacity Analysis

As emphasized throughout this chapter, work zone mobility is a high priority for many projects and is the number one operational issue for those projects. A work zone traffic analysis is conducted to identify impacts and manage those impacts with appropriate mitigating strategies and solutions.

Work zones can decrease the traffic capacity through the area where roadway restrictions are necessary to accomplish the project work operations and can form a "bottleneck" effect. Avoid and mitigate reductions in capacity to the extent that mobility is maintained at a level compatible with existing traffic demands. The area of influence generated by work zone restrictions can extend far beyond the work zone limits; sometimes for miles if these impacts are not fully mitigated. Work zones can create many different types of roadway restrictions such as lane closures, shoulder closures, narrow lanes, detours, and diversions, which all reduce capacity to some extent. Work zone features such as barriers, work distractions, signs, and construction traffic movements, when combined with actual roadway restrictions, can further reduce capacity.

Work zone capacity and related mobility impacts are the primary traffic analysis focus since those impacts have the greatest affect on overall mobility. This should be the initial starting point and most effective means of determining the extent of mobility impacts for selecting a given work zone strategy. Other mobility impacts may also need to be addressed, such as:

- Maintaining access points (road approaches, intersections, and turning movements)
- Ramp restrictions
- Local roadway impacts
- Detour capacity and related impacts
- Pedestrian and bike access

Not all projects require an extensive work zone traffic analysis. Conduct the analysis at a level consistent with project complexity and those impacts that are identified through strategy development and impact analysis (see 810.15, Impacts Assessment, and 810.16, Work Zone Design Strategy). The tools used to analyze traffic impacts can vary from complex to basic analysis programs, or a basic engineering assessment may be conducted for minor impacts. All analyses must be based on current existing traffic data compared to the proposed work zone strategy and the identified impacts.

Complex projects may have several potential work zone strategies, while other projects may only have one obvious work zone strategy. Even though innovative work zone strategy development is encouraged in an effort to maximize safety and mobility benefits, not all projects will have this potential. Furthermore, it is possible that significant mobility impacts will be present as a result of minimal strategy options. These impacts still need to be analyzed and mitigated. It is not acceptable to conclude that since there is only one way to maintain traffic and construct the project, the impacts do not need to be addressed and mitigation solutions do not need to be developed. In these cases, impacts can generally be mitigated by means other than the work zone traffic control method, such as work hour restrictions, alternate routes, advance notice, and other means. An analysis will show the results of these mitigating measures.

A work zone traffic analysis can provide an accurate look at the extent of impacts and lead to the selection of mitigating measures that offer the most benefit. Some of the impact issues and mitigating measures commonly addressed by traffic analyses are:

- Work hour time restrictions
- Hourly liquidated damage assessment
- Staged or nonstaged construction
- Working day assessment
- Public information campaign
- User cost assessment
- Local roadway impacts
- Special event and holiday time restrictions
- Closure and detour options
- Mitigation cost justification
- Level of service
- Queue lengths
- Delay time
- Running speed
- Coordination with adjoining projects (both internal and local agency)

In order to conduct a work zone traffic analysis, traffic volume data must first be collected and assembled. Accurate volume data is directly related to the usefulness of the traffic analysis results. Assess existing and needed data as early as possible to make sure it is available to conduct the analysis and therefore benefit the development of the work zone strategy. The region's Traffic Office and the HQ Traffic Data Office can assist with collecting traffic volume data. Coordination with local agencies may be needed to obtain data on affected local roads. Some locations may require conducting traffic counts in the field if recent data is not available. These offices will also be available to assist with the actual analysis upon request. Training is also available for those designers who have a need to obtain further knowledge and expertise or to actually conduct the analysis.

Several analysis programs are available to conduct the traffic analysis. The selection of the program is based on the complexity of the analysis and the individual impacts in question. Some common programs include:

- **Quewz 98** is a basic-level program that is mainly used to determine capacity-related issues on isolated multilane facilities. Outputs are queue length, delay time, user costs, and running speed. Basic hourly volume data input is required.

- **QuickZone** is a midlevel program that provides results for basic capacity issues. It also has the capability to analyze multiple alternatives and a basic roadway system that would include outputs for alternate routes or detours, as well as affected local roadways. More data input is also required.

More complex traffic analysis programs are available and may be appropriate for some work zone applications. Consulting region and HQ traffic analysis experts is recommended.

A basic level of analysis is recommended for all work zones to determine the initial level of traffic capacity impacts. 810.16, Work Zone Design Strategy, contains useful information on capacity thresholds and other values that are useful in determining not only the strategy selection, but the need for the level of analysis as well. Further analysis may be needed on some projects, and complex, high traffic volume projects will most likely need a higher level of analysis to determine the extent of capacity impacts. Maintain analysis documents in the Project File. The work zone capacity impacts assessment will become an important part of the overall work zone strategy. Significant projects will rely on the traffic analysis to shape the transportation management plan as the work zone strategy is brought to life in the form of traffic control plans and specifications.

810.15 Impacts Assessment

One of the top goals in developing a successful TMP and ultimately leading to a successful construction project is that all work zone safety and mobility impacts must be identified and assessed to determine the approach to mitigating and managing those impacts. Without a complete assessment of all work zone impacts, the TMP will not be as effective, since the missing impacts will undoubtedly become unresolved issues during the construction phase of the project.

These unresolved and unanticipated impacts can cause significant project cost and time increases, as well as significant traffic delays and safety concerns. Project staging, features, and work operations may have to be adjusted under less than ideal circumstances since the project may be well underway and the flexibility to change may be limited. A complete impacts assessment allows the project design to incorporate solutions as an integral component to the project, and it reduces costs, saves time, and helps maintain traffic safety and mobility.

This section is intended to provide the designer with guidance and decision-making support in conducting a complete work zone impacts assessment. All work zone issues reside in either the safety or mobility areas, but there are many specific elements within those areas that, once identified, will guide the designer to investigate the existence of an impact or potential impact. Each project is different and will have different impacts, but following this process will allow the designer to determine the actual impacts for a given project.

Some impacts may be difficult to resolve and may ultimately become a management decision to determine the level of mitigation or develop a strategy to manage the impact during construction, which may include accepting a certain level of impacts. The final impacts assessment must identify all impact issues.

The TMP will contain the strategies to mitigate the impacts and ultimately take the form of plans and specifications. It is important to remember that an unresolved impact still needs to be addressed in the TMP. Even though it may be unresolved, there needs to be awareness that it exists so it can be managed as effectively as possible and not become forgotten, only to appear later as the project work proceeds.

Work zone impacts are not limited to the actual work zone or project limits. Impacts can be far reaching and have a negative effect on local roadways, businesses and communities, other road projects, a highway corridor, or even a regional area if the project impacts are at a critically strategic location.

The following approach allows the designer to work through the listed levels of work zone impact items and compare them to specific project features, locations, schedule, and work operations, which will result in a list of actual and potential work zone impacts. Potential impacts will be further assessed as project development proceeds, but must be included in the TMP. Some work zone impacts may contain both safety and mobility issues and, in many cases, several impacts may be related to a combination of project features, locations, schedule, and work operations. The impacts assessment will start at the most basic level with the initial project information and proceed on a path that is dictated by the availability of information as the project scope and features are developed and traffic data is gathered. Even basic projects can have unique features that could result in a significant impact even though the project on the whole may not be significant. It is intended that the impacts assessment be conducted to a point where all impacts, even apparently minor ones, are identified, assessed for significance, mitigated or otherwise resolved, and included in the TMP to be incorporated and managed within the project.

(1) Work Zone Safety and Mobility Impacts Assessment

(a) **Design Level Safety and Mobility Impacts**

Construction Project:

- **Location** – Where the project is located (route, mileposts, structures, crossroads, interchanges, etc.)
- **Features** – What features will be constructed to build the improvement.
- **Operation** – How the project will be constructed at a conceptual level.
- **Schedule** – When the project is constructed (project milestones leading up to a projected start date).

Traffic Conditions:

- **Project Limits** – Existing traffic conditions and operational issues on site.
- **Local Area** – Existing traffic conditions adjacent to the project.
- **Regional Area** – Existing traffic conditions within the projected area of influence.

The combination of the above factors may begin to indicate safety and mobility impacts. Additional investigation may be needed at this point. Document findings and move to the next level as more specific information becomes available.

(b) **Project Level Safety and Mobility Impacts**

Construction Project:

- **Location**
  1. Existing site features within project limits
  2. Existing roadway configuration
  3. Right of way limits
  4. General site location issues (substandard features, rock slides, water/drainage issues)
- **Features**
  1. Major project features (paving, bridge, etc.)
  2. Related site work (excavation, grading, blasting)
- **Operation**
  1. Typical type of work operation (moving, stationary, or both)
  2. Assess potential worker safety issues
  3. Assess alternatives to flagging if needed
- **Schedule**
  1. Projected construction start and completion

Traffic Conditions:

- **Project Limits**
  1. Volume data (current traffic capacity)
  2. Operational data (level of service, crash data)
- **Local Area**
  1. Access points (interchange ramps, intersections, crossings)
  2. Alternate routes (parallel routes, frontage roads)
- **Regional Area**
  1. Strategic importance (critical system link, available alternate routes, commercial, recreational, connections to other routes)
  2. Other projects in progress
  3. Route corridor impacts (access to cities, businesses, schools, emergency services)
  4. Access and service to other modes (airports, ferries, trains, transit)

Safety and mobility impacts may start to become more apparent at this level, but not yet fully assessed, and more information and investigation may be needed. Document findings and move to the next level as more specific information becomes available.

(c) **Work Zone Level Safety and Mobility Impacts**

Construction Project:

- **Location**
  1. Limits of work encroachment (lanes, shoulders, clear/safety zone)
  2. Access to work (hauling, worker access)
- **Features**
  1. Constructibility/traffic-related issues
  2. Vertical clearance
  3. Drop-offs
  4. Narrow shoulders and lanes
  5. Work area protection of potential hazards to workers and traffic
     - Fixed objects
     - Equipment, work space, access, protection, clear/safety zone
     - Worker traffic exposure level
- **Operation**
  1. Staged/phased work
  2. Daily closures and openings
  3. Daily moving operation
  4. Stationary with off-peak closures
  5. Worker safety assessment
  6. Consider unique traffic control (portable signals, etc.)
- **Schedule**
  1. Critical dates (fish window, holidays, events)
  2. Seasonal issues
  3. Night vs. day work hours (work hour restrictions)

Traffic Conditions:

- **Project Limits**
  1. Analyze capacity impacts (QuickZone and Quewz)
  2. Assessment of capacity impacts (maintain on- or off-site)
  3. Mitigation possibilities
- **Local Area**
  1. Analyze capacity impacts
  2. Mitigation possibilities
- **Regional Area**
  1. Projected impacts
  2. Mitigation possibilities

Base the assessment of safety and mobility impacts at this level on information specific to a given work zone and operation. A complete assessment of most previously identified impacts should be possible. New impacts may also become apparent at this level due to the specific detailed nature of the available information. Document findings in the form of a list of actual and potential impacts with a brief description of each impact. This list will then be addressed in the TMP.

The above elements should alert the designer to investigate the specific details of a given project to determine the types of work zone impacts involved. The list of impacts and potential impacts needs to be assessed to determine the extent of the impacts. Some minor impacts may be manageable within the framework of the project without additional mitigation measures or design solutions, but still should be part of the TMP. Significant impacts will most likely need to be mitigated and addressed within the TMP. 810.05, Work Zone Process, and 810.16, Work Zone Design Strategy, provide additional guidance and direction to address, mitigate, and manage work zone impacts. It is recommended that designers seek the assistance of others with traffic, construction, and design experience, as needed, to fully address this area.

810.16 Work Zone Design Strategy

The work zone design strategy is the key element in establishing an effective work zone design, yet is often overlooked or underestimated in its value. Only through the development of a comprehensive work zone design strategy is it reasonable to expect the development of an effective transportation management plan

(TMP) that addresses all safety, mobility, and constructibility impacts associated with maintaining traffic and providing for worker and road user safety during project construction. Construction projects are sometimes limited by poor work zone design strategies with missing components or lack of a constructible concept.

A given project may and probably will have several work zone strategies that, when combined, become the project TMP. Strategies may be needed for several individual work zones, construction stages, and project features to address the related safety and mobility impacts. The individual elements needed to analyze and develop a strategy are gathered from the impacts assessment process described in 810.15. Work zone strategies are developed through a detailed analysis of all the relevant information and are generally included in the following categories:

- Traffic volume/capacity data
- Traffic/user access issues
- Local and regional traffic impacts
- Project schedule/time (working days, work hours restrictions, critical work/material time, seasonal issues)
- Project site conditions
- Project work operations (access, hauling)
- Project purpose and features (road encroachment impacts)
- Safety assessment (workers, road users)

Safety and mobility are the primary work zone strategy elements; however, project constructibility, costs, and time must also be addressed. Start strategy development from the most desirable work zone safety and mobility concept and then carefully apply the related project factors to determine the most overall effective and feasible strategy. Traffic mobility, work, and road user safety should not be needlessly compromised to facilitate a more effective construction approach, but should be held to a high level that initiates reasonable construction alternatives and innovations.

Construction needs to be accomplished while accommodating safety and mobility. Consider road work operations hazardous and disruptive; it is necessary to address those issues at a detailed level to make safety and mobility improvements. Many traditional approaches do not address or otherwise provide for safety and mobility issues, and those approaches need to be reevaluated for improvement opportunities. Do not assume that a traditional traffic control plan applied to certain types of construction completely addresses all safety and mobility impacts. There may be similarities with the type of work, but each project is unique and must be approached in that manner. Work zone strategies need to comply with and reflect the intent of policies and requirements as identified throughout this chapter.

Identify all safety and mobility impacts in the work zone assessment. These impacts are not restricted to the work zone location or even the project limits, but could extend far beyond the project. Adjacent or overlapping projects may also be impacted. Therefore, work zone strategies are not just limited to on-site issues, but will also need to address the impacts off-site wherever they may exist. Some strategies may need to be justified if costs begin to escalate. A benefit cost analysis comparing road user costs to affected project costs is useful. Safety benefits are somewhat more difficult to justify since cost is not the best measure. Safety and mobility impacts are presented in more detail throughout this chapter.

Start work zone strategies from a perspective of providing the highest level of safety, mobility, and constructibility possible. A total road closure may be the best example of this approach. It would appear to provide the safest, most mobile and constructible work zone since workers and road users would be exposed to far fewer hazards, road users would not be delayed through a restrictive work zone, and construction could proceed without accommodating traffic. This may be a desirable starting point and may actually be feasible for some projects or work stages. Unfortunately, most projects would not be good candidates for this strategy. The lack of alternate route capacity could cause severe congestion throughout a widespread area, the cost and feasibility of building a detour would not be acceptable, and having no local access through the project limits would also not be acceptable.

A more common and usually acceptable approach may be a mix of short-term closures and planned work stages, with work zones that positively separate and protect both workers and road users, while accommodating efficient work operations and traffic mobility. Many projects would benefit from efficiently staged and protected work operations instead of routine lane closures that close and open each day. Some projects may appear to have very few options or opportunities for innovation, but still need to have a strategy that addresses all impacts. Never assume that other options or innovative approaches are not available. Many projects have unique features that can be turned to an advantage if carefully considered. Even a basic paving project on a rural two-lane highway may have opportunities for detours, shifting traffic, or other strategies.

The following strategies may be useful to consider for some projects:

- Closures: full, partial, short-term, ramps, approaches, detours, alternate routes
- Overbuilding: beyond normal project needs to maintain additional traffic
- Flagging alternatives: AFADs, portable signals, lane shifts
- Staged traffic control: moving work operations or unlimited work operations
- Local road improvements: capacity improvements, signals modifications, widening, frontage roads
- Vehicle restrictions: combination of hours and vehicle type (trucks, oversize, local traffic)
- Temporary connections: ramps, offset intersections
- Temporary access: road approaches, work zone access, ramps
- Innovative bidding: incentives, A+B bidding, lane rental (see http://www.wsdot.wa.gov/Projects/delivery/alternative/ABBidding.htm)
- Work zone ITS traffic management: driver information, queue detection, demand management
- Public information campaign: media, HAR, PCMS
- Accelerated work schedules: overall impact duration reduction
- Temporary median crossover detours: allows full work access to one-half of the roadway
- Temporary express lane: no access lane through the project
- Performance-based traffic control: contractor incentives for efficiency and safety
- Incident response patrols: delay reduction through quick response
- Law enforcement patrols: safety issues, speeding, DUI, aggressive drivers
- Driver Incentives: additional transit use, alternate route use
- Alternative bridge designs: super girders, falsework restrictions, temporary structures
- Emergency pullouts for disabled vehicles

It is also important to remember that there are practical limits to work zone strategies. Mobility and safety benefits that are relatively short term may not be practical if the implementation of that strategy offsets a significant portion of the benefit.

Some projects may benefit from a wider review and discussion on possible work zone strategies, such as:

- CRA (cost risk assessment)
- VE (value engineering) study
- Constructibility study
- Peer review
- Work zone strategy conference
- Traffic survey/study

As mentioned previously, constructibility is a key element in a successful work zone strategy. Within the constructibility element, those issues of material selection, production rates, and work operation efficiencies have a direct tie to the feasibility of the strategy. A strong emphasis has been placed on this area and several successful strategies have been implemented:

- Total short duration closures (weekend, week, or a combination)
- 72-hour continuous weekday closure
- 55-hour weekend closure
- 10-hour nighttime lane closures

These strategies use specific materials such as quick-curing concrete, accelerated work schedules, prefabricated structure components, on-site mix plants, etc., and are based on actual production rates. The WSDOT Materials Laboratory and the HQ Construction Office are good resources for more information on constructibility as a component of an effective work zone strategy.

Work zone strategy development is a fluid process and may be ongoing as project information and design features are developed during the design process. There may be many factors involved with strategy development and it is necessary to be well organized to make sure all the relative factors are identified and evaluated. To assist the designer with work zone strategy development, a work zone checklist and work zone tool box are included to provide additional detailed information and decision-making assistance.

810.17 Transportation Management Plan (TMP)

A transportation management plan (TMP) provides a set of strategies for managing the work zone impacts of a project. Detailed information on strategy development can be found in 810.16, Work Zone Design Strategy. The TMP is a requirement for all projects and is the key element in addressing all work zone safety and mobility impacts. The TMP is a dynamic document that is maintained and revised as the project development process progresses. Start preparing the TMP as early as possible in the design phase of the project by gathering project information, traffic data, impacts assessment, strategies, mitigation solutions, and design solutions. The work zone portion of the project Plans, Specifications, and Estimates (PS&E) will ultimately contain much of the TMP elements. Other TMP elements may become part of the overall project management strategy or contained within the project design features and work operations.

The three major components of a TMP are described below:

- **Traffic Control Plan (TCP).** TCPs and related elements are the common component for all projects and become actual plan sheets in the contract documents. TCPs are further defined below and in 810.18, Traffic Control Plans and Details Development.
- **Traffic Operations Plan (TOP).** TOPs are strategies that address operations and management of the affected roadway system in and around the work zone. These strategies may be work zone ITS elements to inform travelers and manage traffic, law enforcement, incident management, etc. These strategies may become actual contract plans, specifications, or pay items, but could also be a WSDOT-managed element outside of the contract items.
- **Public Information Plan (PIP).** PIPs are public information and stakeholder communication strategies that may be initiated before and during the construction. These strategies may take the form of brochures, web sites, news media releases, highway advisory radio, message signs, etc., to disseminate information both pretrip and enroute. The region Public Information Officer will be an important resource in this area. The elements of these strategies may be implemented by either the contractor or WSDOT, or both. A specification and contract pay item will be needed for contract work.

Within the TMP, these plans may take the form of strategies that contain specific information and solutions to address, mitigate, and otherwise resolve and manage work zone safety and mobility impacts. Ultimately, these strategies will become the basis for developing the actual contract traffic control plans, details, specifications, and estimates. It is important to remember that not all work zone impacts will be addressed within the specific work zone elements of the contract plans. This is why it is critical to consider work zone impacts during the ongoing design of the actual project features, materials selection, working day considerations, overbuilding, phasing, structures, etc. Many work zone impacts will need to be addressed by design solutions that resolve the impacts within staging plans, structure plans, and various construction plans and details. Some work zone impacts, especially those that are related to time duration may be resolved through innovative bidding and contract administration.

All projects must have a TMP, but the only required component is the TCP, unless the project is considered significant* (see below). The required TCP component is further defined as follows:

- TCPs must address all work zone impacts not otherwise resolved in the contract plans.
- TCPs that address work zones at an appropriate level of detail must be included. Typical TCPs are only allowed if they accurately address the work operations, worker safety, traffic safety, appropriate traffic control, and traffic delay, movements, and access. Typical, project-specific, site-specific, or a combination of all three types of TCPs may be needed to address all issues.
- An appropriate level of contract work zone traffic control specifications is required to fully address those issues not otherwise addressed within the TCPs or other contract documents.
- Pay items must be included that are consistent with the type of traffic control devices, work operations, and TCPs. Lump sum items are allowed if appropriate for the project.

Even though not all projects initially require TOP and PIP components, the intent is to include these components to address TOP and PIP issues not fully addressed in the TCP component, even though the project may not be defined as significant.

*A "significant project" is defined by FHWA as one that, alone or in combination with other concurrent projects nearby, is anticipated to cause sustained work zone impacts that are greater than what is considered tolerable based on an assessment of work zone safety and mobility impacts and the level of mitigation possible. Interstate system projects within the boundaries of a Transportation Management Area (TMA) that occupy a location for more than three days with either intermittent or continuous lane closures shall be considered a significant project. It is possible to request an exception from FHWA for interstate system projects if sufficient justification is present to demonstrate that the project will not have sustained work zone impacts. Significant projects must be identified as early as possible and indicated as such in Box Six, Work Zone Strategy Statement, on the Final Project Definition document.

Addressing project work zone impacts is further defined as:

- Any project, not just interstate or within a TMA, that indicates a work zone-related impact (see 810.15, Impacts Assessment) beyond existing conditions that cannot be mitigated to an acceptable level will be treated as significant based on those identified impact issues.
- Mitigating impacts to an acceptable level is defined as a regional determination of the extent and adverse affect a given impact may have beyond the average accepted impact levels incurred by work zones at the local or regional area. Examples of this may be:
    1. Traffic delay beyond a localized accepted level,—possibly in the range of 15 to 30 minutes (but could vary based on local expectations).
    2. Safety or access impacts to a school, hospital, or community that exceed local expectations based on public input.
    3. Economic impacts due to traffic delay or restricted access beyond normal local expectations.
    4. Seasonal-related impacts that affect recreation or business due to work zone impacts.
- Identified impacts must be included and managed within the structure of the TMP, even though the project may not be identified as significant.
- TCPs, TOPs and PIPs will be developed to address identified impacts, as needed, to effectively manage the project.

- Potential work zone impacts need to be resolved within the project design features as design decisions are made. Informed decisions that consider work zone impacts during bridge type selection, materials selection, advertisement dates, and more have the potential to resolve work zone impacts before they happen.
- Construction PEs need to be involved at the design level for input on the management of impact issues. Also, the TMP needs to reflect those decisions to manage impacts during construction.
- Innovative mitigation strategies such as staged closures or ITS solutions are strongly encouraged and may be a successful approach to solving an otherwise difficult impact that would be hard to manage during construction.

It is very important to actively pursue the development of the TMP throughout the project development process. Ongoing communication with those who are designing project features that may conflict with maintaining traffic mobility or that impact worker and road user safety is critical to facilitating the incorporation of design solutions and mitigation measures within the project. The approach of waiting until the design is complete to determine work zone impacts is not acceptable and may jeopardize the project budget and schedule.

810.18 Traffic Control Plans and Details Development

The traffic control plans (TCPs) shown in the MUTCD and the Design Standards Plan Sheet Library (http://www.wsdot.wa.gov/eesc/design/designstandards/) provide the basic traffic control for individual work zones. Most real-world work zones have a combination of several unique features that require further augmentation of traffic control.

The preparation of traffic control plans requires the designer to not only have a thorough knowledge of highway construction activities, but also traffic engineering knowledge and an understanding of the unique traffic flow patterns within the specific project.

The designer must be cognizant of the dynamic nature of construction activities and provide a constructible traffic control plan that will also safely and efficiently manage traffic. In addition, the users of the facility have little or no understanding of the construction occurring in the work zone and require far greater guidance than the contractor's or agency's people, who are familiar with the project.

TCPs can generally be broken down into three specific categories: (1) typical traffic control plans, (2) project-specific traffic control plans, and (3) site-specific traffic control plans. Depending on the scope of the project being designed and the level of detail necessary to construct the project, consider each of these categories as the project is initially scoped and as the design proceeds.

TCPs are always designed from the perspective of drivers, pedestrians, and bicyclists to provide the necessary information to allow them to proceed in a safe and orderly manner through a work zone. Unexpected roadway conditions, changes in alignment, and temporary roadside obstacles relating to the work activity need to be defined adequately to minimize the users' uncertainty. Also, working on or along the highway can present a potentially hazardous work environment. As the traffic control plans are being developed, keep in mind that the risk of injury or death to workers performing the construction operations is real and ever-present as the traffic control plans are being developed. Whenever possible, it is recommended to combine work operations under a single traffic control plan to minimize the impacts to traffic and encourage the efficiency of the contractor.

The intention is not to direct the contractor in how to pursue the work, but to provide a workable approach to protecting the work area and to establish the level of safety and traffic control while maintaining traffic movements. Consider the inspector and the traffic control supervisor in the field: will they be able to effectively lay out what you have designed, and does it fit in the "real world"? The contractor has the option of proposing an alternative method once the project is under construction. A constructible and biddable set of traffic control plans is the goal; the more specific and consistent we can make our traffic control plans, the better work zones will perform, regardless of which traffic control plans are modified and implemented.

“Typical” traffic control plans are generally considered generic in nature and are not intended to satisfy all conditions for all work zones. They are adaptable to many roadway conditions and work operations without being specific to any one condition. Typical plans are to be considered a “starting point” in the development of the traffic control plans for a project, with the goal being to have the plans consistent with the project needs.

For lump sum projects it is particularly important to have detailed traffic control plans to fully define the work zone expectations. It may be entirely appropriate and acceptable to utilize lump sum traffic control items as long as the project is not overly complex and lump sum items are compatible with the level of TCP development. Designers need to consider this issue from the bidder’s perspective and ensure that TCPs are developed at a high enough level to adequately reflect the intent of the traffic control devices and strategies to be employed on the project.

Typical TCPs may need to be modified to a more specific level, or additional plans may be needed to adequately address those work zone issues that could affect the type, quantity, and placement of devices, or to ensure that a desired work zone strategy is appropriately implemented (road closure, lane shift, intersection control, etc.).

Typical plans can be expected to be included in every project to some degree. The majority of the time, they will be used to supplement project- or site-specific plans with generic details and will not be the only plans in the contract, especially for a project of any complexity. For projects that are routine in nature and do not change much in the day-to-day operations, such as a several-mile paving project on a two-lane roadway, typical plans may be more than adequate. Even “routine” projects may have some unique features that need further plan development.

A “project-specific plan” is generally a traffic control plan that has been modified to include project-specific details such as side roads, business approaches, horizontal curves, etc., in order to better address traffic control needs that generally cannot be covered without substantial modification in the field. A project-specific plan may also have been drawn using existing base data, but may not necessarily be a scaled drawing. Project-specific plans are a good compromise between a typical drawing without much specific detail and a full-blown site-specific plan when site-specific base data may not be available. Typical plans can be modified to more accurately represent the project location without being site-specific in nature, and thus be considered project-specific.

“Site-specific plans” are drawn using scaled base data and are encouraged whenever possible to achieve the highest level of accuracy. They ensure that the proposed work operation will actually fit the location and that a workable method to maintain traffic flow can be achieved. The use of site-specific plans will closely match the need to provide a transportation management plan, and the goal is to address the major impacts anticipated by the project through these more detailed plans. For complex projects and projects that contain staging, draw the traffic control plans with site-specific base data.

Do not mix typical details with a scaled, site-specific plan layout; this will cause confusion and often will not represent a truly constructible traffic control scenario. An example of this would be to use a scaled, site-specific intersection and then to include a generic “L” distance to represent the lane closure taper distance. Another example would be to include the construction signs on the plan by showing them at a specific location on the scaled plan, but then to refer to the generic “X” distance representing how far the sign should be (this will not work and is not representative of where the sign will actually need to be placed in the field).

Other considerations when designing traffic control plans include the following:

- **Temporary roadway cross sections**. These details can be invaluable in providing additional details not easily visible when looking at the plan view of a TCP, especially when the roadway is in a temporary shift or configuration. This is also an excellent way to identify roadway drop-off hazards and vertical clearance hazards.
- **Temporary channelization plans.** For projects with staged traffic control and lane shifts, temporary channelization plans show the station limits for the beginning and ending locations of the temporary markings and taper rates when applicable. These plans will also show the type of markings (lane line, edge line, etc.) on the plan with enough detail to assist the field inspector with field layout. When applicable, these plans also include temporary concrete barrier locations, flare rates, beginning and ending stations, and attenuator information (among others).
- **Temporary pavement marking details.** Detail sheets can be helpful in providing the specific details necessary to explain marking installation needs to supplement temporary pavement marking special provisions.
- **Temporary portable signal plan.** For projects that include temporary portable signal systems, a traffic control plan is required. Example projects would be alternating one-lane traffic operations on a two-way facility such as two-lane bridge widening, replacement projects, or emergency slide repair. The plan must include the entire advance signing for the system, temporary markings, location in relation to work operation, temporary lighting at stop bars, etc. Use a portable signal unit only for projects where the length between signal heads is 1,500 feet maximum. There are specific temporary signal requirements that go into a project; therefore, for assistance, contact with the region's Traffic Office is recommended.
- **Temporary signal plan.** The temporary signal plan will follow conventions used to develop permanent signals, as described in Chapter 850, but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations. Some existing systems can be maintained using temporary span wires for signal heads and video, microwave actuation, or timed control.
- **Temporary illumination plan.** Full lighting is normally provided through traffic control areas where power is available. The temporary illumination plan will follow conventions used to develop permanent illumination, as described in Chapter 840, but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations.

  Consider using temporary illumination on the following projects:

  1. Multistaged projects with lane shifts and restricted geometrics
  2. Projects with existing illumination that must be removed as part of the construction process
  3. Road closures and detour alignments where grade and alignment are unusual or complex
  4. Temporary ramp connections and signal locations
  5. Construction activities will take place at night
  6. Traffic flow is split around or near an obstruction (illumination is required for this operation)
- **Detour and alternate route plan.** For projects that anticipate the need for a detour or alternate route, ensure that sign placement will fit the locations shown along the route and that the signs will not conflict with existing signs, driveways, or pedestrian movements. Depending on the duration, the detour that will be in place, and the anticipated amount of traffic that will use the route, consider upgrades to the route (signal timing, intersection turning radius for large

vehicle, structural pavement enhancements, shoulder widening, etc.). Coordination and possibly signed agreements with the appropriate local agency are required prior to implementing any detour routes on local roadways.

- **Pedestrian and bike detour route.** When existing pedestrian and signed bike routes are disrupted due to construction activities, detour routes must be addressed with a traffic control plan. The plan must show enough detail and be specific enough to address the conflicts and ensure the temporary route is safe and adequate to meet the needs of the user. Also, consider the impacts to the transit stops for pedestrians: Will the bus stops be able to remain in use during construction or will adjustments be necessary?
- **Advance warning sign plan.** While not required for all projects, consider advance warning signs. Show specific sign locations when known by either station or milepost. The signs are subject to movement in the field to fit specific conditions.
- **Sign specification and sign details.** While not a requirement, consider sign specifications and sign details for all complex or staged projects. The sign detail sheet is recommended to assist sign manufacturers with construction requirements for nonstandard signs.
- **Summary of Quantities and Quantity Tabulation sheets.** Traffic control items are required to be included in the Summary of Quantity sheets and, when applicable, the Quantity Tabulation sheets. Depending on the scale of the project and the number of temporary traffic control items, a separate Quantity Tabulation sheet may be appropriate for traffic items (temporary markings, temporary barrier, etc.).
- **Traffic control plan index.** An index sheet is a useful tool for projects that contain a large quantity of traffic control plans and multiple work operations at various locations throughout the project. The index sheet will provide at a quick glance a cross-referencing tool to indicate what applicable traffic control plan is to be used for the specific work operation.
- **Temporary median crossovers.** These plans are not frequently used, but when they are, the design must be kept at a high level to ensure safety. Geometrics for the crossovers need to follow the same guidance as permanent alignments and have horizontal curves calculated to fit the location. The roadway surface shall be paved, and temporary pavement markings are required. Consider temporary illumination to improve the visibility of the operation. Temporary drainage may be necessary under the median fill (when applicable).
- **Roundabouts.** Site-specific staging plans need to be developed for the construction of roundabouts. Traffic operations during the construction phases are greatly impacted by construction activities when the roundabout is built on existing alignment, and it creates many unique challenges that other intersection construction operations do not typically face. There are no established national standards or guidelines for the construction of roundabouts. Each roundabout must be approached specifically for the location and the traffic operational movements that exist.
- **Often overlooked work operations.** Operations that are often overlooked during the design, but need to be considered to ensure that the traffic control plan will address the work, include the following:
    1. Bridge falsework openings often do not accurately represent the relationship between existing traffic movements and the bridge falsework. Coordination with the HQ Bridge and Structures Office is essential. Maintain the legal height of 16 feet 6 inches as the minimum falsework opening whenever possible; anything less than this must consider overheight vehicle impacts and possible additional signing needs. Refer to Chapter 1120 for additional requirements.
    2. Traffic signal head installation and adjustment (turn pockets and adjacent lane) overhead work is not allowed over live traffic.

3. Existing illumination: Can the existing lighting be maintained during the construction phases or do temporary connections need to be considered or temporary systems installed? Existing lighting at the exit and entrance ramps must be maintained at all times: it is often one of the first items of work that the contractor disables.
4. Permanent traffic loop installation (advance loops, turn pockets, stop bars, etc.).
5. Temporary traffic loops and signal detection. Consider the detection needs in relation to the work operation and duration (temporary loops, video, radar, timed system, etc.).
6. Pavement marking installations (crosswalks, arrows, etc.).
7. Temporary pavement marking needs: What type of marking is most appropriate for the work operation and the pavement surface? When removed, how are existing markings going to impact the roadway surface? Consider how to best minimize for ghost stripe potential.
8. Utility relocation needs: How will existing utilities conflict with temporary needs?
9. Temporary impact attenuator installation needs (appropriate type for work operation, specific needs or materials for installation pad).
10. Lane shifts onto existing shoulders.
    - Is the depth of the existing shoulder adequate to carry the extra traffic?
    - Are there any existing catch basins or junction boxes located in the shoulder that cannot accept traffic loads over them? Are there existing shoulder rumble strips? (Existing rumble strips must be filled.)
    - What is the existing side slope rate? If steeper than 4H:1V, does it need mitigation? Are there existing roadside objects that, when the roadway is shifted, are now within the clear zone limits?
    - Shifting of more than one lane in a direction is only allowed with temporary pavement markings. Shifting lanes by using channelizing devices is not allowed due to the high probability that devices used to separate the traffic will be displaced.
    - Existing drainage features: Will they be adversely impacted by temporary lane shifts or by anticipated work operations?
    - Signal head alignment: When the lane is shifted approaching the intersection, is the signal head alignment within appropriate limits?

810.19 Work Zone Toolbox

The information and values contained in this section are intended to assist designers with conceptual decision-making guidance and are not intended to replace a thorough analysis and detailed assessment of the applicable work zone issues. This toolbox may be helpful for preliminary analysis of potential impacts and strategy feasibility. Base final strategy decisions on a comprehensive assessment and analysis of the actual project data.

(1) Work Zone Requirements and Key Elements

This list provides a quick check of elements that are contained within or are related to this chapter and as part of WSDOT's work zone policy, and are required or key to the successful development of the work zone design decision. Federal and state regulations set the level of compliance for work zones. This list is intended to alert the designer that these items are not optional and must be addressed. The elements summarized below have more detailed information within this chapter or are contained within the related manuals and documents such as the MUTCD, Revised Codes of Washington, and Washington Administrative Codes:

- Safety is the highest priority.
- Minimize, mitigate, and manage work zone impacts.

- Early consideration and integration of work zone impacts during planning, programming, and design.
- Transportation Management Plan (TMP).
- Traffic Control Plan (TCP),
- Public Information Plans (PIPs) and Transportation Operations Plans (TOPs) must be considered to address those related issues.
- An accurate scoping estimate must be developed based on the work zone strategies.
- The Work Zone Design Checklist must be utilized.
- A Work Zone Design Strategy Conference is a key part of the design process.
- Flagger safety is a high emphasis area.
- Work zone mobility must be determined through a capacity analysis.
- Work zone impacts must be determined through the impact assessment process.
- Project constructibility must be integrated into the work zone design strategy.
- WSDOT does not delegate safety and mobility.
- Work zone training is required.
- The state of Washington traffic and safety regulations, as provided for by state law, must be addressed.
- The *Manual on Uniform Traffic Control Devices* (MUTCD) and Washington State modifications are the legally adopted minimum standard.
- The appropriate level of plan TCP development must be addressed.
- Work zone ITS solutions may be a key element.
- Work zone roadway and roadside design must be consistent with established design criteria.
- Pedestrians (including ADA requirements) and bicycles must be addressed.
- Risk management and tort liability exposure are key elements.
- Work efficiency and cost containment are important considerations.
- The work zone design must be approached from the road user's perspective.
- The work zone design must incorporate worker and other roadway user needs.
- All work areas and operations need to be accounted for.

(2) General Lane Closure Work Zone Capacity

Applying the following values to known volume data can provide a quick determination of the capacity level (over- or under-capacity) for a given lane closure scenario. (Alternating one-way flagger traffic control and 15- to 30-minute traffic delay.)

Roadway Type	Work Zone Capacity
Multilane Freeways/ Highways	1300 VPHPL*
MultiLane Urban/ Suburban	600 VPHPL*
Two-Lane Rural Highway	400 VPHPL/ 800 VPH total*

*These are average capacity values. The actual values would be dependent on several factors, which include the existing number of lanes, number of lanes closed, traffic speed, truck percentage, interchanges/intersections, type of work, type of traffic control, and seasonal factors (among others). For further information, consult the *Highway Capacity Manual*.

(3) General Road Closure Considerations

Road and access closures are generally allowable and should be considered for many strategies. Closures usually offer the highest levels of safety and productivity. Generally, the main roadblocks to a closure strategy are traffic concerns about congestion, delay, and access. The following closure issues may be useful to consider:

- Closures that affect large traffic volumes must be mitigated with alternate routes, off-peak closures, or other appropriate means.
- A closure strategy should be analyzed and compared to other strategies, such as staged work zones, to determine which is more beneficial overall.

- Closures that reopen to a new completed roadway or other noticeable improvements are generally more accepted by the public.
- A closure decision (other than short-term, minor impact closures) will generally be made by project stakeholder and manager input by judging the value of the closure benefit vs. impacts.
- Route-to-route connections and other strategic access points may have to be maintained, or a reasonable alternative provided.

810.20 Training Resources

Work zone-related training is an important component in an effective work zone safety and mobility program. Federal regulations require that those involved with work zone design and implementation be trained at a level consistent with their responsibility. It is valuable to know what training classes are available and how those classes relate to the project design and construction programs.

There are many work zone-related courses available, and the HQ Staff Development Office and HQ Traffic Office's Traffic Training Program Manager can assist with the availability and scheduling of classes. Consider the training courses listed below to develop an overall proficiency in work zone safety and mobility design:

- **Traffic Control Plan Design Course. –** This course, taught by Transpeed, focuses on work zone strategy development and TCP design and preparation, as well as key elements of the overall project development process.
- **QuickZone Course. –** This course, taught by McTrans, explores the QuickZone work zone traffic capacity analysis program. QuickZone is a useful tool for determining capacity needs and it allows comparison of alternative strategies.
- **MUTCD Course. –** This course, taught by Transpeed, focuses on the content and use of the MUTCD, including Part 6, Temporary Traffic Control.
- **Traffic Control Supervisor (TCS) Course. –** This course, taught by the Evergreen Safety Council, is primarily for those students who intend to become a TCS or those who have TCS-related responsibilities. TCS offers value to designers regarding how implementation issues interact with design issues. Designer attendance may be restricted to "space available" status.
- **Certified Flagger Training Course. –** This course is directed at students who will become certified flaggers in Washington State and is not intended for designers. Designers may want to use the *Flagger Handbook* as a resource to learn about flagger-controlled traffic control and flagging techniques and issues. This class may be valuable in increasing the safety of designers anticipating extensive field surveying and data gathering work during the project development phase.

Other courses on work zone safety, mobility, and related subjects may be available on a limited basis. Some of these courses would fall into the categories of traffic analysis and traffic engineering and may be appropriate, depending on individual designer needs and responsibilities.

810.21 Documentation

The list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

Work Zone FAQs for Designers

1. **In the Final Project Definition form, what do I really need to write in Box 6, Work Zone Strategy?**
   A finalized strategy or TMP is not expected since some information may be conceptual at this level. The important information to include is as follows:
   - Indicate whether the project is considered significant or potentially significant.
   - Indicate known or potential major impacts.
   - Even if the project is not considered significant, list the known elements that the TMP will address (type of TCPs, TOP issues, and PIP needs).
   - It is not acceptable to leave the box empty or to write 'to be determined later.'
2. **How am I supposed to know how the contractor will build the project?**
   There are often many ways to stage a construction project, bearing in mind traffic safety and construction efficiencies. During the design of a project, there is the requirement to provide a constructible, maintainable, safe, and mobile project concept that is translated into an effective TMP, even though the contractor may propose another TMP.
3. **How do I know what is meant by safe and mobile?**
   These terms are definable within the context of the project. There is no one answer to fit every case and no project is completely safe or fully mobile. Complete consideration of all the factors involved will lead to conclusions that include known effective safety and mobility measures.
4. **Aren't we exposed to more legal liability by providing a TMP at such a detailed level?**
   No. A well-developed TMP that is based on known accepted policy and accurate information is actually the best defense against legal action. Poor implementation of the TMP would more likely be the cause for concern.
5. **Doesn't a comprehensive TMP add more cost to the project?**
   Cost is a legitimate concern and cost-effectiveness and containment are intended to be part of the selected strategy analysis and TMP. The bottom line is that it is less costly to include work zone costs as part of the project than it is to add them later by change order. Also, providing for safety and mobility can add costs, but these costs are usually more than offset by the benefits provided. These costs need to be identified early on in the scoping phase to provide an adequate project estimate.
6. **Why can't I just reuse the TCPs from a previous project?**
   You may be able to do so, but not without careful consideration of all the project information. Usually, each project has some unique features or different traffic conditions, even though the work may be similar. It is strongly recommended to conduct the impact assessment process first, then determine what plans may be appropriate. You may also be able to consult with the construction office that implemented a previous TCP to determine if it was effective.
7. **Where do I go for work zone assistance and answers?**
   Working within the structure and protocol of your office and region, there are several resources in the form of expert advice or information available. Also, inquire at the region and the HQ Design, Construction, and Traffic offices. Generally, work zone design is not a "cookbook" approach, and the designer needs to be prepared to actively pursue all available information and resources.

Work Zone Frequently Asked Questions

Figure 810-3

REMEMBER, a comprehensive traffic control PS&E is actually a project within a project. WSDOT is obligated to provide a safe and workable proposal for controlling traffic that is consistent with the project construction requirements. Even though there may be more than one workable solution, a thorough analysis of all the variables will help to produce a traffic control PS&E that sets the appropriate level of safety. The Work Zone Traffic Control Design Checklist must be thoroughly reviewed to assist in capturing all related work zone elements.

PROJECT DEFINITION & PLANNING

- ☐ **Work Zone Traffic Control Strategy Statement for Design Documents**
  - ☐ **Informal in-house conference with PEO & Region WZTC specialist**
  - ☐ **WZTC options and strategies**
  - ☐ formal conference with local agencies & WSDOT
  - ☐ **Final WZTC strategy statement for project definition documentation**
  - ☐ **Traffic Management Plan**
- ☐ **Work Zone Capacity Analysis**
  - ☐ **Existing level of service**
  - ☐ **Existing lane capacity (VPHPL)**
  - ☐ **Work hour restrictions (days & hours)**
  - ☐ **Detour route capacity analysis**
  - ☐ **Select appropriate work zone type(s)**
    - (1) long-term stationary
    - (2) intermediate stationary
    - (3) short-term stationary
    - (4) short-duration
    - (5) mobile
- ☐ **Existing Operational Factors**
  - ☐ **Coordinate with region traffic operations**
  - ☐ **Localized traffic operational problems**
  - ☐ **Accidents (include previous WZTC, maintenance or contract)**
  - ☐ **Geometric conflicts or issues**
  - ☐ **High-speed/low-speed**
  - ☐ **Coordinate with local maintenance supervisor**
  - ☐ commercial/private access impacts
  - ☐ adjacent project coordination
  - ☐ special events
  - ☐ ferry schedules
  - ☐ seasonal factors
  - ☐ on-street parking
  - ☐ emergency services
  - ☐ other regulatory conditions
  - ☐ transit, schools, parks, etc.
- ☐ **Work Zone Location Considerations**
  - ☐ **Define all work zone limits/locations**
  - ☐ existing lane conflicts
  - ☐ roadside conflicts/hazards
  - ☐ overhead & overwidth clearance conflicts
  - ☐ vertical/grade/profile conflicts
  - ☐ staged work zones
  - ☐ work zone base plan (CADD files & aerial photo)
- ☐ **Worker Safety**
  - ☐ **Positive protection (barriers)**
  - ☐ **Worker exposure during:**
    (1) set up
    (2) removal
    (3) work operations
  - ☐ **Flagger protection (no freeway use)**
  - ☐ **Truck-mounted attenuator**
  - ☐ **Portable barriers (temporary concrete, movable barrier, steel, etc.)**
  - ☐ **Inspector protection**
  - ☐ **Work zone intrusion analysis & mitigation techniques**

NOTES:

Required checklist items are **bold**.

Not all items listed on the checklist apply to every project, but it does provide a comprehensive list of possible items that may apply and should be considered when applicable.

Work Zone Traffic Control Design Checklist

Figure 810-4

TYPES OF WORK ZONE TRAFFIC CONTROL

☐ **Long-Term**

STRATEGY	***PLAN TYPE***
☐ total road closure	detour
☐ partial road closure	crossover
☐ interchange closure	detour
☐ ramp closure	detour/alt route
☐ crossroad closure	detour/alt route
☐ lane shift	**Temporary channelization**
☐ lane closure	temporary channelization
☐ shoulder closure	temporary channelization
☐ reversible lanes	TCP
☐ temp./portable traffic signal control	TCP
☐ temp. yield/stop control	TCP
☐ temp. widening/connections	temporary channelization
☐ temp. structures	temporary channelization
☐ staged traffic control	staging plans

☐ Short-Term

STRATEGY	***PLAN TYPE***
☐ off-peak roadway closures:	detour
(1) total & partial road closure	detour
(2) interchange & ramps	detour/alt route
(3) crossroad, intersection	detour/alt route
☐ off-peak lane closures	TCP
☐ shoulder closure	TCP
☐ flagger control	TCP
☐ pilot car control	TCP
☐ traffic stop	TCP

Refer to the MUTCD for guidelines on work zone type and duration.

☐ **Construction Considerations for WZTC**

- ☐ **Removal of permanent traffic control features**
- ☐ **Maintaining existing features (illumination, signing, etc.)**
- ☐ **Work area access control (safe ingress & egress)**
- ☐ **Adequate work zone space for contractor**
- ☐ **Time frame to complete work and reopen to traffic**
- ☐ innovative work methods
- ☐ time-saving materials
- ☐ temporary illumination or signals
- ☐ winter shut-down (intermediate WZTC stage?)
- ☐ cure time, closure pours
- ☐ temporary drainage
- ☐ construction/traffic compatibility
- ☐ staged WZTC switchover time to new stage (pavement marking revisions)
- ☐ existing shoulder durability for temporary lane shift (shoulder failure)

Refer to the MUTCD, the *Traffic Manual*, the *Design Manual*, the Standard Specifications, and the *Construction Manual* for further guidance.

Work Zone Traffic Control Design Checklist (continued)

Figure 810-4

TRAFFIC CONTROL FEATURES

- ☐ **Work Zone Devices**
  - ☐ work zone ITS
  - ☐ portable/temp. traffic signal
  - ☐ intrusion alarms
  - ☐ truck-mounted attenuator
  - ☐ buffer/shadow vehicles
  - ☐ high-level warning flags
  - ☐ glare/work zone screen
  - ☐ pedestrian fence
  - ☐ automated flagger assistance device
  - ☐ portable HARs
  - ☐ port. changeable message sign
  - ☐ advance notice of closure signs
  - ☐ speed advisory signs
  - ☐ regulatory speed zone signs
  - ☐ temporary rumble strips
- ☐ **Special Considerations**
  - ☐ **WSP assistance**
  - ☐ **Public information**
  - ☐ **Night work**
  - ☐ **Oversized loads**
  - ☐ **Peds and bikes (ADA needs)**
  - ☐ **WZTC supervisor**
  - ☐ **WZTC patroller**
  - ☐ roadway flares
  - ☐ reduced sight distance
  - ☐ safe speed for temp. alignment (ball bank)
  - ☐ liquidated damages
  - ☐ A+B bidding, lane rental, etc.
  - ☐ innovative contract techniques
  - ☐ haul routes
  - ☐ blasting operations
  - ☐ emergency traffic control
  - ☐ emergency parking
- ☐ **Special Lighting**
  - ☐ **Flagger station illumination**
  - ☐ detour illumination
  - ☐ temporary illumination
  - ☐ high mast lighting
  - ☐ warning lights
- ☐ **Work Zone/Positive Protection**
  - ☐ **Roadside hazard protection**
  - ☐ **Buffer space (lateral and longitudinal)**
  - ☐ temporary impact attenuators
  - ☐ barrier/guardrail connections
  - ☐ movable concrete barrier
  - ☐ water-filled barrier
  - ☐ temporary concrete barrier
  - ☐ barricades
  - ☐ recovery area
  - ☐ shy distance
- ☐ **Positive Continuous Guidance**
  - ☐ temporary RPMs
  - ☐ temporary pavement marking
  - ☐ mimic permanent markings
  - ☐ traffic safety drums
  - ☐ type "c" steady burn lights
  - ☐ reduced device spacing
  - ☐ temporary guidepost

Work Zone Traffic Control Design Checklist (continued)
Figure 810-4

DESIGN CONSIDERATIONS

- ☐ preliminary field review
- ☐ design with existing driver expectation in mind
- ☐ design for existing speed: posted or higher
- ☐ start design from work zone perspective
- ☐ design based on the most desirable, yet practical, traffic configuration
- ☐ design from drivers' point of view
- ☐ layout temporary channelization
- ☐ build in recovery area and buffer space
- ☐ provide adequate detail (station callouts for temporary features) for field layout
- ☐ temporary channelization must provide positive driver guidance
- ☐ clear separation between work zone and traffic (use positive protection?)
- ☐ use permanent design guidelines whenever possible
- ☐ build in work area ingress and egress access
- ☐ design above minimums when possible
- ☐ establish highly visible sign locations (verify where possible, field review, SRView, etc.)
- ☐ don't depend on signs to guide traffic
- ☐ mentally drive through the TCP from all approaches and all lanes
- ☐ will TCP actually fit site conditions? (scaled site-specific plan)
- ☐ final field review
- ☐ risk assessment: comfortable with level of safety, liability issues?
- ☐ constructibility issues (can this be built?)
- ☐ final approval with traffic engineer and construction P.E.

PROJECTED IMPACTS

- ☐ **Worker/traffic exposure**
- ☐ **Local agency impact**
- ☐ **Coordination with region PIO for public awareness & media notification**
- ☐ traffic delay (time)
- ☐ user costs ($)
- ☐ backups (queue length)
- ☐ traffic control costs
- ☐ constructibility issues
- ☐ commercial impacts
- ☐ overlapping project coordination/WZTC conflicts
- ☐ conflicts with existing permanent traffic control features, signs, markings, etc.
- ☐ removal of existing conflicting pavement markings
- ☐ reversed/revised intersection control

FINAL APPROVAL

- ☐ **Regional Traffic Engineer or Regional Traffic Control Specialist**
- ☐ **Regional Management Approval**
- ☐ **Construction P.E. Concurrence**
- ☐ **Consistent with FHWA (MUTCD) & WSDOT policies**
- ☐ Detour Agreement Approval
- ☐ WSP Agreement Approval
- ☐ Local Agency Approvals & Agreements
- ☐ Noise Ordinance
- ☐ Blasting Ordinance

Work Zone Traffic Control Design Checklist (continued)
Figure 810-4

820.01 General

Signing is a primary mechanism for regulating, warning, and guiding traffic. Signing must be in place when any section of highway is open to the motoring public. Each highway project has unique and specific signing requirements. For statewide signing uniformity and continuity, it is sometimes necessary to provide signing beyond the project limits. Design characteristics of the facility determine the size and legend for a sign. As the design speed increases, larger sign sizes are necessary to provide adequate message comprehension time. The MUTCD, the *Traffic Manual*, and the *Sign Fabrication Manual* contain standard sign dimensions, specific legends, and reflective sheeting types for all new signs. Guide signing provides the motorist with guidance to destinations. This information is always presented in a consistent manner. In some cases, there are specific laws, regulations, and policies governing the content of the messages on these signs. All proposed guide signs for a project require the approval of the region's Traffic Engineer. The use of nonstandard signs is strongly discouraged and their use requires the approval of the State Traffic Engineer.

The Design Matrices identify the design levels for signing on all preservation and improvement projects. These levels are indicated in the column "Signing" for Interstate main line and the column "Signing, Delineation, and Illumination" for all other routes.

Review and update existing signing within the limits of all preservation and improvement projects as indicated in the matrices. Provide standard signing on projects with either a "B" (basic design level) or "EU" (evaluate upgrade) matrix designation by applying the following criteria to determine the need to replace or modify existing signs:

- Lack of nighttime retroreflectivity.
- Substantial damage, vandalism, or deterioration.
- Age of signs (seven to ten years old).
- A change in sign use policy.
- Improper location.
- Message or destination changes necessary to satisfy commitments to public or local agencies.
- Substandard mounting height.
- Change in jurisdiction, for example a county road becomes a state route.

Address sign support breakaway features when identified in the "Clear Zone" columns of the Matrices. When the "F" (full design level) matrix designation is present, the preceding criteria are still applicable and all existing signing is required to conform to the current policy for reflective sign sheeting requirements. Remove or replace signing not conforming to this policy.

820.02 References

Revised Code of Washington (RCW) 47.36.030, Traffic control devices

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, Washington DC, 1988, including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT, 1996

Traffic Manual, M 51-02, WSDOT

Sign Fabrication Manual, M 55-05, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Directive D 32-20, "State Route Mileposts," WSDOT

820.03 Design Components

(1) Location

The MUTCD contains the guidelines for positioning signs. Check sign locations to ensure that the motorist's view of the sign is not obscured by other roadside appurtenances. Also, determine if the proposed sign will obstruct the view of other signs or limit the motorist's sight distance of the roadway. Reposition existing signs, when necessary, to satisfy these visibility requirements. Where possible, locate signs behind existing traffic barriers, on grade separation structures, or where terrain features will minimize their exposure to errant vehicles.

(2) Longitudinal Placement

The MUTCD and the *Traffic Manual* provide guidelines for the longitudinal placement of signs that are dependent on the type of sign. Select a location to fit the existing conditions to ensure visibility and adequate response time. In most cases, signs can be shifted longitudinally to enhance safety without compromising their intended purpose.

(3) Lateral Clearance

The MUTCD contains minimum requirements for the lateral placement of signs. These requirements are shown in Figures 820-1a and 820-1b. When possible, position the signs at the maximum practical lateral clearance for safety and reduced maintenance costs. Locate large guide signs and motorist information signs beyond the Design Clear Zone, when limited right of way or other physical constraints are not a factor. See Chapter 700. On steep fill slopes, an errant vehicle is likely to be partially airborne from the slope break near the edge of shoulder to a point 12 ft down the slope. When signs are placed on fill slopes steeper than 6:1, locate the support at least 12 ft beyond the slope break. Use breakaway sign support features, when required, for signs located within the Design Clear Zone and for signs located beyond this zone where there is a possibility they might be struck by an errant vehicle. Breakaway features are not necessary on sign posts located behind traffic barriers. Install longitudinal barrier to shield signs without breakaway features within the Design Clear Zone when no other options are available.

Sign bridges and cantilever sign structures have limited span lengths. Locate the vertical components of these structures as far from the traveled way as possible and, where appropriate, install traffic barriers or land forms. See Chapter 710.

Do not locate sign posts in the bottom of a ditch or where the posts will straddle the ditch. The preferred location is beyond the ditch or on the ditch backslope. In high fill areas, where conditions require placement of a sign behind a traffic barrier, consider adding embankment material to reduce the length of the sign supports.

(4) Sign Heights

For ground-mounted signs installed at the side of the road, provide a mounting height of at least 7 ft, measured from the bottom of the sign to the edge of traveled way. Supplemental plaques, when used, are mounted directly below the primary sign. At these locations, the minimum mounting height of the plaque is 5 ft.

Do not attach supplemental guide signs to the posts below the hinge mechanism or saw cut notch on multiple post installations. The location of these hinges or saw cuts on the sign supports are shown in the Standard Plans.

A minimum 7 ft vertical height from the bottom of the sign to the ground directly below the sign is necessary for the breakaway features of the sign support to function properly when struck by a vehicle. The minimum mounting height for new signs located behind longitudinal barriers is 7 ft, measured from the bottom of the sign to the edge of traveled way. A lower mounting height of 5 ft may be used when replacing a sign panel on an existing sign assembly located behind longitudinal barrier.

Signs used to reserve parking for people with disabilities are installed at each designated parking stall and are mounted between 3 ft and 7 ft above the surface at the sign location. Figures 820-1a and 820-1b show typical sign installations.

(5) Foundations

Foundation details for wood and steel ground mounted sign supports are shown in the Standard Plans. That manual also contains foundation designs for truss-type sign bridges and cantilever sign structures. Three designs, Types 1, 2, and 3, are shown for each structure.

An investigation of the foundation material is necessary to determine the appropriate foundation design. The Type 1 foundation design uses a large concrete shaft and is the preferred installation when the lateral bearing pressure of the soil is 2,500 psf or greater. The Type 2 foundation has a large rectangular footing design and is an alternate to the Type 1 foundation when the concrete shaft is not suitable. The Type 3 foundation is used in poorer soil conditions where the lateral bearing pressure of the soil is between 1,500 psf and 2,500 psf. Use the data obtained from the geotechnical report to select the foundation type.

If a <u>nonstandard foundation</u> or monotube structure design is planned, forward the report to the Bridge and Structures Office for their use in developing a suitable foundation design. See Chapter 510.

(6) Sign Posts

Ground mounted signs are installed on <u>either</u> wood posts, laminated wood box posts, or steel posts. The size and number of posts required for a sign installation are based on the height and surface area of the sign, or signs, being supported. Use the information in Figures 820-2, 820-3, and 820-4 to determine the posts required for each installation. Use steel posts with breakaway supports that are multidirectional if the support is likely to be hit from more than one direction. Design features of breakaway supports are shown in the Standard Plans. Steel posts with Type 2A and 2B bases have multidirectional breakaway features.

820.04 Overhead Installation

Conditions justifying the use of overhead sign installations are noted in the MUTCD. Where possible, mount overhead signs on grade separation structures rather than sign bridges or cantilever supports.

Details for the construction of truss-type sign bridges and cantilever sign supports are shown in the Standard Plans.

The Bridge and Structures Office designs structure mounted sign mountings, monotube sign bridges, and monotube cantilever sign supports. For overhead sign installation <u>designs, provide</u> sign dimensions, horizontal location in relation to the roadway, and the location of the lighting fixtures, to facilitate design of the mounting components by the Bridge and Structures Office.

(1) Illumination

In urban areas, all overhead signs on multilane highways are illuminated. In rural areas, all overhead regulatory and warning signs including guide signs with “Exit Only” panels on both multilane and conventional highways are illuminated. All other overhead signs are only illuminated when one of the following conditions is present:

- Sign visibility is less than 800 ft due to intervening sight obstructions such as highway structures or roadside features
- Ambient light from a non-highway light source interferes with the sign’s legibility
- The sign assembly includes a flashing beacon

Sign illumination is provided with sign lighting fixtures mounted directly below the sign. The light source of the fixture is a 175 watt mercury vapor lamp. Provide one sign light for a sign with a width of 16 ft or less. For wider signs, provide two or more sign lights with a spacing not exceeding 16 ft. If two or more closely spaced signs are in the same vertical plane on the structure, consider the signs as one unit and use a uniform light fixture spacing for the entire width.

Voltage drops can be significant when the electrical service is not nearby. See Chapter 840 for guidance in calculating electrical line loss.

In areas where an electrical power source is more than $^1/_2$ mile away, utility company installation costs can be prohibitive. Reconsider the benefit of an overhead sign installation at these locations.

(2) Vertical Clearance

The minimum vertical clearance from the roadway surface to the lowest point of an overhead sign assembly is <u>17 ft-6 in</u>. The maximum clearance is <u>21 ft</u>.

(3) Horizontal Placement

Consider roadway geometrics and anticipated traffic characteristics <u>in order to locate</u> signs above the lane, or lanes, to which they apply. Install advance guide signs and exit direction signs that require an EXIT ONLY and "down arrow" panel directly above the drop lanes. <u>To reduce</u> driver confusion as to which lane is being dropped, avoid locating a sign with an EXIT ONLY panel on a horizontal curve.

(4) Service Walkways

Walkways are provided on structure-mounted signs, truss-type sign bridges, and truss-type cantilever sign supports where the roadway and traffic conditions prohibit normal sign maintenance activities. <u>Normally,</u> monotube sign bridges and cantilever sign supports do not have service walkways.

Vandalism of signs, particularly in the form of graffiti, can be a major problem in some areas. Vandals sometimes use the service walkways. Maintenance costs in cleaning or replacing vandalized signs at these locations can exceed the benefit of providing the service walkway.

820.05 Mileposts

Milepost markers are a part of a statewide system for all state highways and are installed in accordance with the Directive D 32-20, State Route Mileposts.

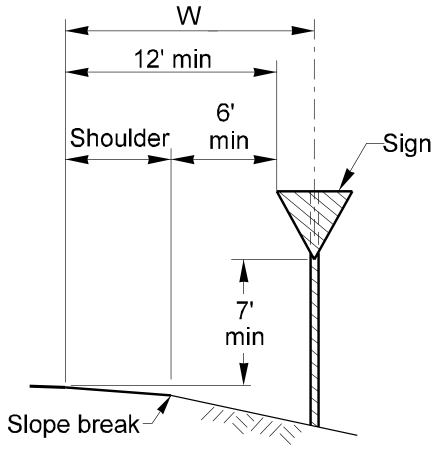
820.06 Guide Sign Plan

A guide sign plan is used by the region to identify existing and proposed guide signing on state highways. The plan provides an easily understood graphic representation of the signing and allows assessment of the continuity in signing to motorist destinations, activities, and services. It is also used to identify deficiencies or poorly defined routes of travel. A guide sign plan <u>for safety and mobility improvement projects</u> is desirable. When proposed highway work affects signing to a city or town, the guide sign plan can be furnished to the official governing body for review and consideration. The guide sign plan is reviewed and approved by the region's Traffic Engineer.

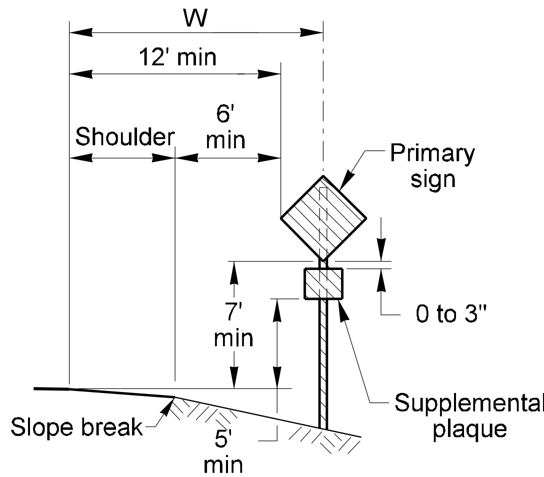
820.07 Documentation

Include the following items in the project file:

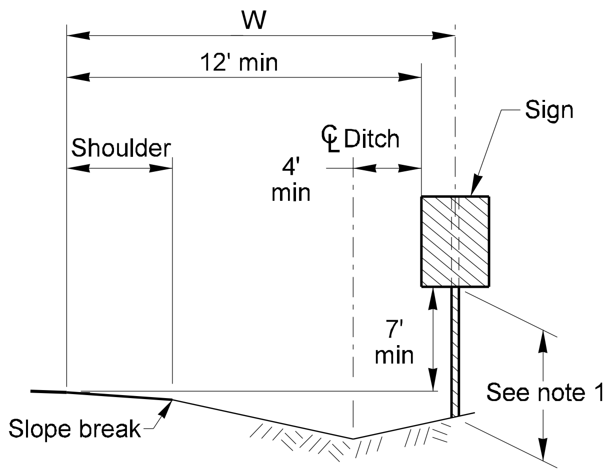
- ☐ An inventory of all existing signing within the project limits
- ☐ Approval of proposed guide signs
- ☐ Approval of non-standard signs
- ☐ Soils investigations for all sign bridge and cantilever sign supports



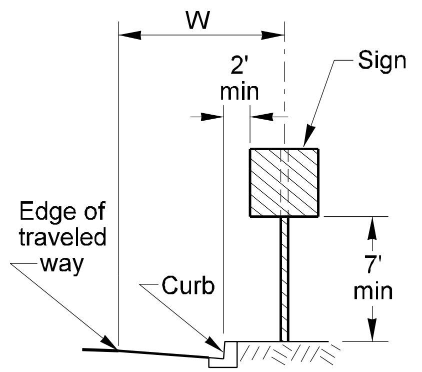
Sign Installation in Fill Section



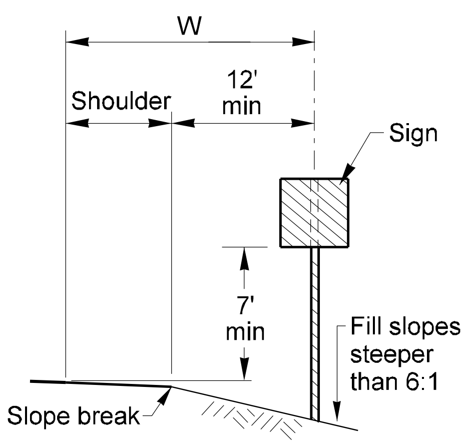
Sign with Supplemental Plaque Installation in Fill Section



Sign Installation in Ditch section



Sign Installation in Curb Section



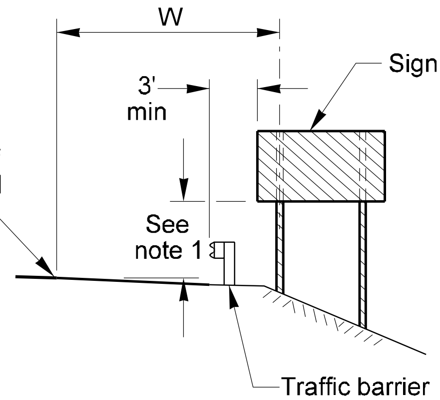
Sign Installation on Steep Fill Slopes

Notes

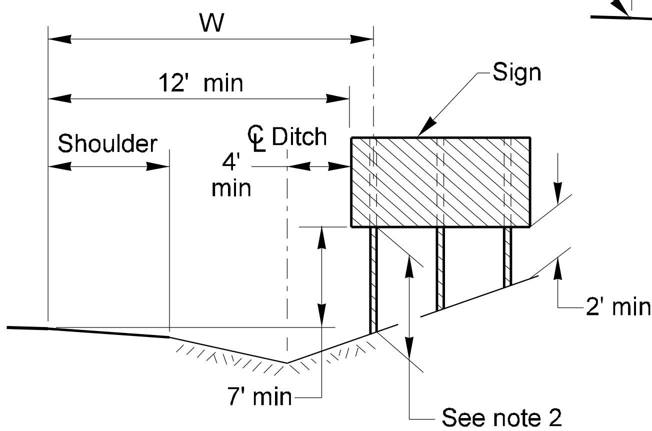
1. 7' min vertical clearance for sign supports with breakaway features

Sign Support Locations

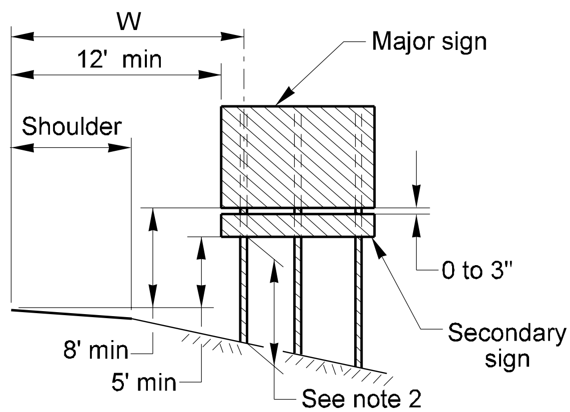
Figure 820-1a



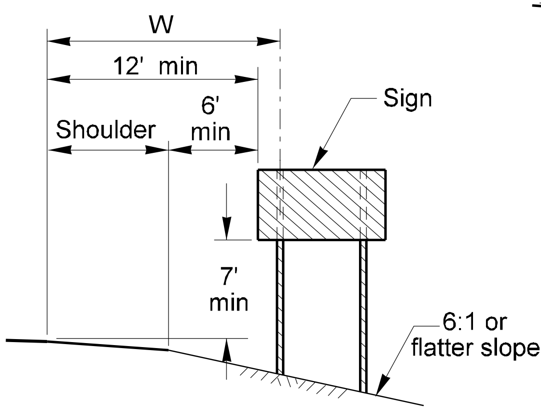
Sign Installation Behind Traffic Barrier



Multiple Sign Post Installation in Ditch Section



Guide or Directional Sign with Secondary Sign Installation on Expressways and Freeways



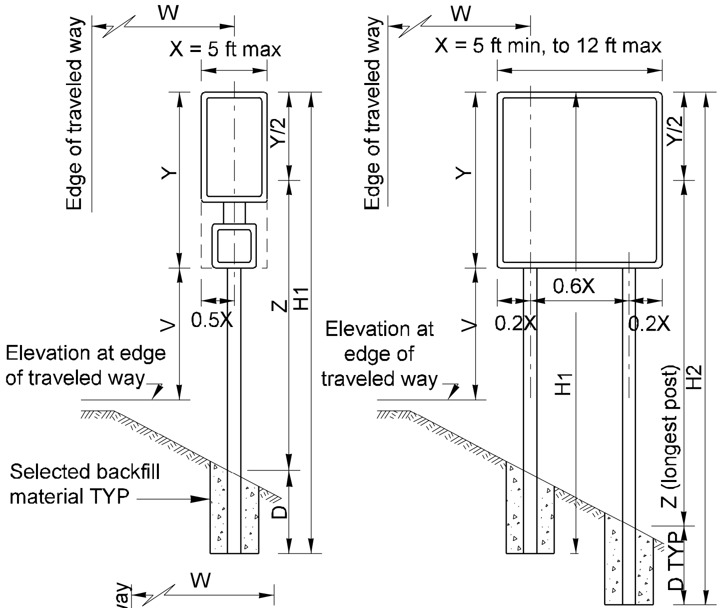
Multiple Sign Post Installation in Fill Section

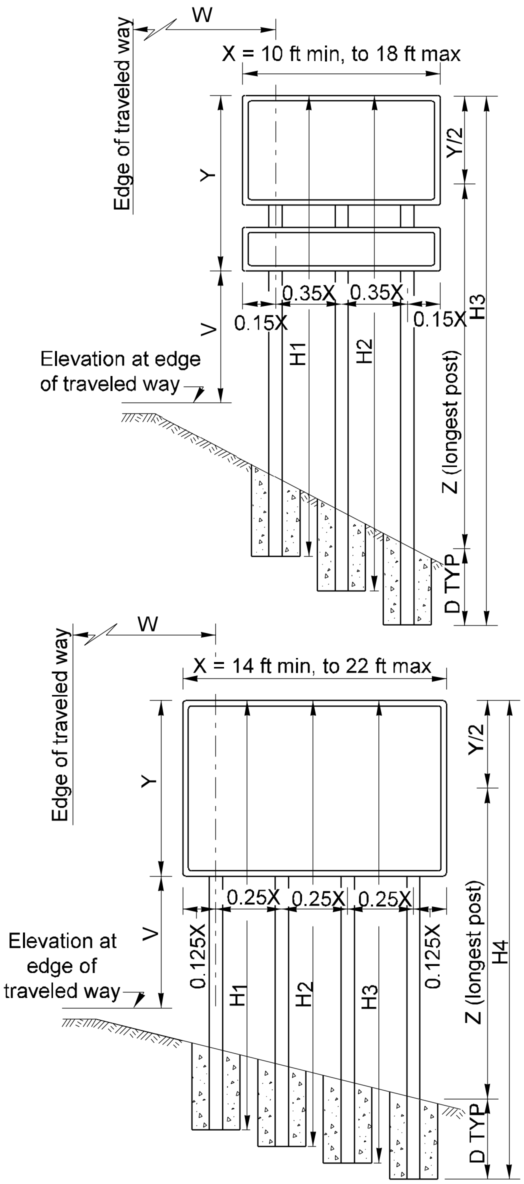
Notes

1. 7' min for new sign installations
   5' min for existing sign installations
2. 7' min vertical clearance for sign supports with breakaway features

Sign Support Locations

Figure 820-1b





For the purpose of post selection, X and Y are as follows:

Single sign, or back-to-back signs, X and Y are the overall dimensions of the sign.

Multiple sign installations, X and Y are the dimensions of a rectangle enclosing all signs.

Z is the height from ground line to mid-height of sign at longest post.

H1 + H2, etc., equals overall post length.

D is the required post embedment depth.

V is the vertical clearance from edge of traveled way.

Post size	(X)(Y)(Z) in ft^3 * *				D
	1 Post	2 Post	3 Post	4 Post	
4x4	60*	135	175	235	3 ft
4x6	175*	355	530	705	4 ft
6x6	210	425	635	845	4 ft
6x8	300	850	1280	1700	4 ft
6x10	385	1180	1770	2360	5 ft
8x10	575	1610	2410	3215	5 ft
8x12	775	2310	3465	4620	6 ft

*Single post application utilizing Western Red Cedar has (X)(Y)(Z) allowable of 50 and 155 respectively.

**Values shown are the maximum permitted. If the quantity (X)(Y)(Z) exceeds the limit for 8X12 posts, use steel post installations.

When sign is to be located in the clear zone or outside of the clear zone, but in an area where it is likely to be struck by an errant vehicle, the following configurations are not permitted:

1. Timber posts larger than 6X8.
2. Signs less than 12 ft wide and three 6X6 or larger posts.
3. Signs less than 17 ft wide and four 6X6 or larger posts.

Use steel or laminated wood posts in these situations.

Design Example

Given: 36 in wide, 42 in high sign with a 18 in wide, 24 in high sign mounted 3 in below. 8 ft shoulder with 2% slope and 6H:1V embankment. W = 15 ft.
V =5 ft.

Solution: Use single post. X=3 ft, Y=5.75 ft, Z=5.75/2 +(0.02x8)+5 + 7/6 = 9.21. (X)(Y)(Z)=3x5.75x9.21=159 ft^3. From table, select smallest post having (X)(Y)(Z) of 159 ft^3 or more. Use 4X6 post. H=Z + Y/2 + D=9.46 + 6.25/2 + 4.0=16.6 ft. Use 6X6 when using Western Red Cedar.

Design Example

Given: 10 ft wide. 4 ft high sign. 10 ft shoulder with 2% slope and 6H:1V embankment. W=35 ft. V=7 ft. Assume sign is inside of clear zone.

Solution: Try two posts. X=10 ft, Y=4 ft, Z=4/2 + 7 + (0.02x10) + (25 + 0.6x10)/6=14.37 ft. (X)(Y)(Z)=10x4x14.37=5.75 ft. From table, select smallest post having (X)(Y)(Z) of 575 or more. Two 6X6 posts are not sufficient, use 6X8 posts because three 6X6 posts would require a traffic barrier.

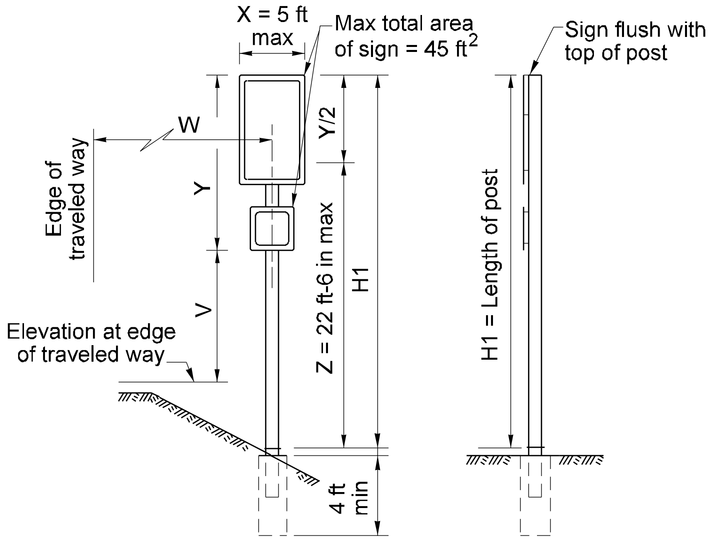
H2=14.37 + 2 + 4=20.4 ft

H1=20.4 - (0.6x10)/6=19.8 ft

All dimensions are in ft unless otherwise noted.

Wood Posts

Figure 820-2



For the purpose of post selection, X and Y are as follows:

Single sign, or back-to-back signs, X and Y are the overall dimensions of the sign.

Multiple sign installations, X and Y are the dimensions of a rectangle enclosing all signs.

Z is the height from the base connection (2 1/2 in above the post foundation) to mid-height of sign at the longest post.

H1, H2, etc., equals overall post length (base connection to top of sign).

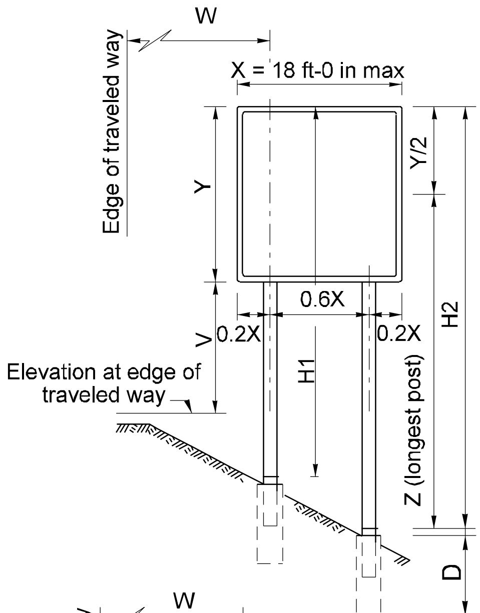
D is the required post embedment depth (see standard plans).

V is the vertical clearance from the edge of traveled way.

Single Post Signs

For a maximum 20 ft^2 sign, use 4 in standard pipe for Z less than 18 ft 6 in or 5 in standard pipe for Z greater than 18 ft 6 in.

For a maximum 45 ft^2 sign, use 5 in standard pipe for Z less than 15 ft 6 in or 6 in standard pipe for Z greater than 15 ft 6 in.



Two and Three post signs

Post Selection (X)(Y)(Z) in ft^3*		Post Size	
2 Posts	3 Posts	* *	AASHTO M183
1570	2355	W6x9	W6x12
2810	4220	W6x12	W6x16
4940	7410	W8x18	W8x21
7580	11370	W10x22	W10x26

*Value shown are the maximum permitted.

* *AASHTO M222 or M223 may be used as an acceptable alternative to AASHTO M 183 at the sizes listed.

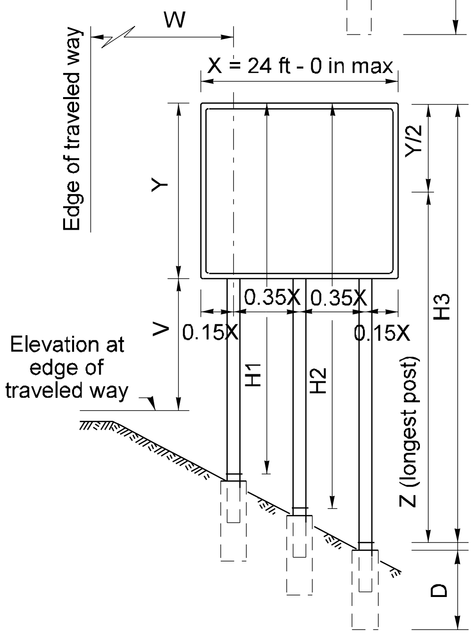
Design Example

Given: 22 ft wide, 12 ft high sign. 10 ft shoulder with 2% slope and a 3H:1V embankment slope. W = 32 ft.

Solution: Use three posts. X = 22 ft, Y = 12 ft, V = 7 ft, Z = 12/2 + 7 + (0.02x10) + (22 + 0.70x22)/3 - 0.21 = 25.46 ft. (X)(Y)(Z) = 22x12x25.46 = 6721 ft^3. From table, select smallest post having (X)(Y)(Z) of 6721 or more. Use W8x18 (AASHTO M222 or M223) or W8x21 (AASHTO M183) posts.

H3 = 25.46 + 12/2 = 31.46 ft = 31 ft 5 1/2 in
H2 = 31.46 - (0.35x22)/3 = 28.89 ft = 28 ft 10 5/8 in
H1 = 31.46 - (0.70x22)/3 = 26.33 ft = 26 ft 4 in

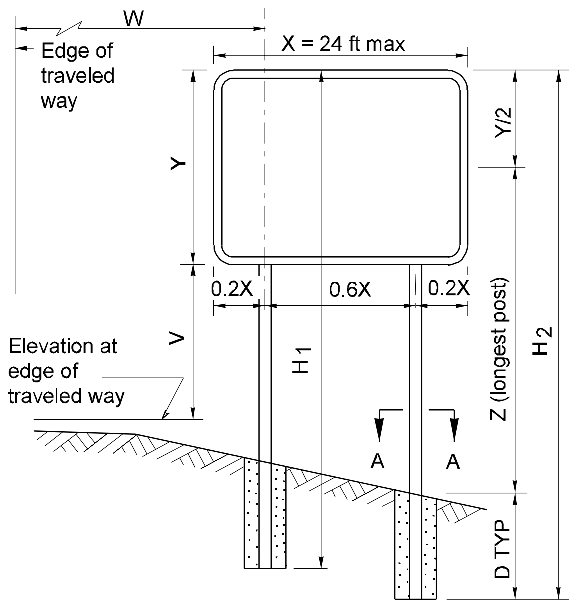
For any sign installation located within the clear zone distance of the lane edge, the total weight of all the posts in the 7 ft wide path shall not exceed a combined post weight of 36 lbs/ft. If the proposed sign configuration does not meet this criteria, relocate, resize or provide additional protection for the proposed installation.
Use the following table to determine post weights.
All dimensions are in feet unless otherwise noted.

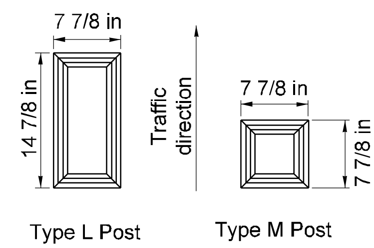


Wide Flange Beam Dimensions

Beam size	Weight lbs/ft
W6x9	9
W6x12	12
W6x16	16
W8x18	18
W8x21	21
W10x22	22
W10x26	26

Steel Posts
Figure 820-3





SECTION A-A

For the purpose of post selection, X and Y are as follows:

Single sign, or back-to-back signs. X and Y are the overall dimensions for the sign.

Multiple sign installations, X and Y are the dimensions of a rectangle enclosing all signs.

Z is the height from ground line to mid-height of sign at the longest post.

H_1 and H_2 equal overall post length.

D is the required post embedment depth.

V is the vertical clearance from edge of traveled way.

Box Post Type	Z (ft)	(X)(Y)(Z) ft^3
M	15 < Z < = 30	1329
M	Z < 15	1661
L	15 < Z < = 30	3502
L	Z < 15	4378

Design Example
Given: 16 ft wide, 6 ft high sign. 10 ft shoulder with 2% slope and a 6H:1V embankment. W = 25 ft. V = 7 ft.
Solution: Use two posts. X = 16 ft. Y = 6 ft.
For two posts: Z = 6/2 + 7 +(0.02x10) + (15 + 0.6x16)/6 = 14.3 ft.
(X)(Y)(Z) = 16x6x14.3 = 1,373 ft^3
From table, select smallest post having (X)(Y)(Z) of 1,373 or more and meets the "Z" requirements.
Use two M posts

H_2 = Z + Y/2 + D = 14.3 + 3.0 + 6.0 = 23.3 ft.

H_1 = 23.3 - (0.6x16)/6 = 21.7 ft.

Design Example
Given: 18 ft wide, 8 ft high sign, 10 ft shoulder with 2% slope and a 6H:1V embankment. W = 25 ft, V = 7 ft.

Solution: Use two posts. X = 18 ft, Y = 8 ft.
For two posts: Z = 8/2 + 7 + (0.02x10) + (15 + 0.6x18)/6 = 15.5 ft.
(X)(Y)(Z) = 18x8x15.5 = 2,232 ft^3.
From table, select smallest post having (X)(Y)(Z) of 2,232 or more and meets the "Z" requirements.
Use two L posts.

H_2 = Z + Y/2 + D = 15.5 + 4.0 + 9.0 = 28.5 ft.

H_1 = 28.5 - (0.6x18)/6 = 26.7 ft.

All dimensions are in feet unless otherwise noted.

Z (ft)	Total Sign Area (Square Feet)					
	Up to 50	51 to 100	101 to 150	151 to 200	201 to 250	251 to 290
9 to 12	6	6	7	8	9	10
12.1 to 15	6	6	7.5	9	10	
15.1 to 18	7.0	7.5	9			
18.1 to 22	7.0	8	10		Not Permitted	
22.1 to 26	7.5	8.5				

Laminated Post Embedment Depth

Laminated Wood Box Posts

Figure 820-4

Chapter 830 Delineation

830.01 General

The primary function of delineation is to provide the visual information needed by a driver to operate a vehicle safely in a variety of situations. Delineation can be the marking of highways with painted or more durable pavement marking lines and symbols, guideposts, and other devices, such as curbs. (See Chapter 440.) These devices use retroreflectance, reflecting light from a vehicle's headlights back to the driver, to enhance their visibility at nighttime. The Washington State Department of Transportation (WSDOT) uses the latest edition of the MUTCD as a guide for the design, location, and application of delineation.

Delineation is a required safety item of work and is addressed on all projects. A decision to omit delineation work can only be justified if the existing delineation is unaffected by construction and an evaluation of accident rates clearly shows that delineation is not a contributing factor. It is important to maintain an adequate level of retroreflectivity for both traffic signs and traffic markings to enhance safety for motorists during hours of darkness and during adverse weather conditions.

Consult with the region's Traffic Operations Office early in the design process to ensure that the proposed delineation is compatible with WSDOT policy and region preference. These policies and preferences address both the type of markings and the material selection.

830.02 References

Laws – Federal and state laws and codes that may pertain to this chapter include:

Manual on Uniform Traffic Control Devices, USDOT, FHWA, National Advisory Committee on Uniform Traffic Control Devices, including the Washington State Modifications to the MUTCD, Chapter 468-95 *Washington Administrative Code* (WAC), (MUTCD)
http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Design Guidance – Design guidance included by reference within the text includes:

Roadway Delineation Practices Handbook, FHWA report, Washington, DC, 1994

Sign Fabrication Manual, M 55-05, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Supporting Information – Other resources used or referenced in this chapter include:

NCHRP Synthesis 306, Long-Term Pavement Practices, Transportation Research Board

830.03 Definitions

coefficient of retroreflection (R_L) A measure of retroreflection.

delineation Any method of defining the roadway operating area for the driver.

durability A measure of a traffic line's resistance to the wear and deterioration associated with abrasion and chipping.

extrude A procedure for applying marking material to a surface by forcing the material through a die to give it a certain shape.

glass beads Small glass spheres used in highway pavement markings to provide the necessary retroreflectivity.

mcd/m^2/lux Pavement marking retroreflectivity is represented by the coefficient of retroreflected luminance (R_L) measured in millicandelas per square meter.

mil Unit of measurement equivalent to 0.001 inches.

MUTCD *Manual on Uniform Traffic Control Devices.*

pavement marking A colored marking applied to the pavement to provide drivers with guidance and other information.

retroreflection The phenomenon of light rays striking a surface and being returned directly back to the source of light.

retroreflectometer An instrument used to measure retroreflectivity.

spraying A procedure for applying marking material to a surface as a jet of fine liquid particles.

service life The service life of a pavement marking is the time or number of traffic passages required for its retroreflectivity to decrease from its initial value to a minimum threshold value indicating that the marking needs to be refurbished or replaced.

traffic paint A pavement marking material that consists mainly of a binder and a solvent. The material is kept in liquid form by the solvent, which evaporates upon application to the pavement, leaving the binder to form a hard film.

wet film thickness Thickness of a pavement marking at the time of application without glass beads.

830.04 Pavement Markings

(1) Pavement Marking Types

Pavement markings have specific functions: (1) they guide the movement of traffic, and (2) they promote safety on the highway. In some cases, they are used to supplement the messages of other traffic control devices. In other cases, markings are the only way to convey a message without distracting the driver. Pavement markings are installed and maintained to provide adequate performance year round. Adequate performance is defined as meaning the marking meets or exceeds standards of both daytime and nighttime visibility. Pavement markings are classified as either longitudinal or transverse. Centerlines, lane lines (where applicable), and edge lines (except as noted), are required on all paved state highways, unless an exception is granted by the State Traffic Engineer with justification. Guidelines for the application of various pavement markings are provided in the Standard Plans and the MUTCD.

(a) **Longitudinal pavement markings** define the boundary between opposing traffic flows, and identify the edges of traveled way, multiple traffic lanes, turn lanes, and special use lanes. The Standard Plans show the dimensions of longitudinal pavement markings. Longitudinal pavement markings are as follows:

barrier centerline A very wide (18 inches minimum, usually 20 inches—five 4-inch lines) solid yellow line or a combination of two single 4-inch solid yellow lines with yellow crosshatching between the lines with a total width not less than 18 inches used to separate opposing traffic movements where all movements over the line are prohibited. Barrier centerline locations require the approval of the region's Traffic Engineer and Access Engineer.

centerline A broken yellow line used to separate lanes of traffic moving in opposite directions, where passing in the opposing lane is allowed.

dotted extension line A broken white or yellow line that is an extension of an edge line or centerline used at exit ramps, intersections on horizontal curves, multiple turn lanes, and other locations where the direction of travel for through traffic is unclear.

double centerline Two parallel solid yellow lines used to separate lanes of traffic moving in opposite directions where passing in the opposing lane is prohibited.

double lane line Two solid white lines used to separate lanes of traffic moving in the same direction where crossing the lane line marking is prohibited.

double wide lane line Two solid wide white lines used to separate a concurrent preferential lane of traffic where crossing is prohibited.

drop lane line A wide broken white line used in advance of a wide line to delineate a lane that ends at an off-ramp or intersection.

edge line A solid white or yellow line used to define the outer edges of the traveled way. Edge lines are not required where curbs or sidewalks are 4 feet or less from the traveled way.

lane line A broken white line used to separate lanes of traffic moving in the same direction.

no-pass line A solid yellow line used in conjunction with a centerline where passing in the opposing lane is prohibited.

reversible lane line Two broken yellow lines used to delineate a lane where traffic direction is periodically reversed.

solid lane line A solid white line used to separate lanes of traffic moving in the same direction where crossing the lane line marking is discouraged. Note: While this marking is in the MUTCD, it may not be in wide use by WSDOT, as it is the same as the edge line.

two-way left-turn centerline Two yellow lines, one solid and one broken, used to delineate each side of a two-way left-turn lane.

wide broken lane line A wide broken white line used to designate a portion of a high occupancy vehicle (HOV) lane located on a divided highway where general purpose vehicles may enter to make an exit.

wide dotted lane line A wide broken white line used to designate a portion of a high occupancy vehicle (HOV), or business access and transit (BAT) lane located on an arterial highway where general purpose vehicles may enter to make a turn at an intersection.

wide lane line A wide solid white line used to separate lanes of traffic moving in the same direction at ramp connections, storage lanes at intersections, and high occupancy vehicle (HOV) lanes, or business access and transit (BAT) lanes, bike lanes, and other preferential lanes where crossing is discouraged.

(b) **Transverse pavement markings** define pedestrian crossings and vehicle stopping points at intersections. They are also used to warn the motorist of approaching conditions, required vehicular maneuvers, or lane usage. Typical transverse pavement markings are as follows:

access parking space symbol A white marking used to designate parking stalls provided for motorists with disabilities. The marking may have an optional blue background and white border.

aerial surveillance marker White markings used at one-mile and one-half-mile intervals on sections of highways where the State Patrol uses airplanes to enforce speed limits.

bicycle lane symbol A white marking consisting of a symbol of a bicyclist and an arrow used in a marked bike lane. (See the Standard Plans for an example of the bicycle lane symbol.) The bicycle lane symbol shall be placed immediately after an intersection and at other locations as needed. (See the MUTCD.) Typical spacing is 500 feet, with a maximum distance of 1,500 feet.

crosswalk line A series of parallel solid white lines used to define a pedestrian crossing.

drainage marking A white line used to denote the location of a catch basin, grate inlet, or other drainage feature in the shoulder of a roadway.

HOV symbol A white diamond marking used for high occupancy vehicle lanes. The spacing of the markings is an engineering judgment based on the conditions of use. Typical spacing is 1,000 feet for divided highways and 500 feet for arterial highways.

railroad crossing symbol A white marking used in advance of a railroad crossing where grade crossing signals or gates are located or where the posted speed of the highway is 40 mph or higher.

stop line A solid white line used to indicate the stopping point at an intersection or railroad crossing.

traffic arrow A white marking used in storage lanes and two-way left-turn lanes to denote the direction of turning movement. Arrows are also used at ramp terminals and intersections on divided highways to discourage wrong-way movements.

traffic letters White markings forming word messages, such as "ONLY," used in conjunction with a traffic arrow at drop-lane situations. Traffic letters are not required for left- and right-turn storage lanes where the intended use of the lane is obvious.

(2) Pavement Marking Materials

Pavement markings are applied using various materials. These materials are divided into two categories: paint and plastic. When selecting the pavement marking material to use in a project, consider the initial cost of the material; its service life; the location; the traffic conditions; the snow and ice removal practices of the particular maintenance area; and the region's ability to maintain the markings.

Both painted and plastic pavement markings can accomplish the goal of providing a visible (daytime) and retroreflective (nighttime) pavement marking at the completion of a contract. The difference between the two marking materials is the projected service life of the markings. Paint used on sections of highway subjected to high traffic volumes and/or snow removal operations might have a service life of only two to three months. Maintenance crews cannot restripe a highway during winter months; therefore, if a painted marking wears out prematurely, the highway will not have a stripe until maintenance crews can restripe in April or May. When these conditions are encountered in a highway project, it is strongly recommended that the designer specify one of the more durable plastic marking materials and application types that will provide an adequate service life for the marking.

For the recommended pavement marking material for different highway types and snow removal practices, see Figure 830-1. Consult with the region's Traffic Office and Maintenance Office to select the best material for the project.

(a) **Paint.** Paint is the most common pavement marking material. It is relatively easy to apply and dries quickly (30–90 seconds in warm, dry weather) after application. This allows the application to be a moving operation, which minimizes traffic control costs and delay to the roadway users. On construction contracts, paint is applied with two coats; the first coat is 10 mils thick, followed by a second coat 15 mils thick. The disadvantage of using paint as a pavement marking material is its short service life when subjected to traffic abrasion, sanding, or snow-removal activities. Specify paint only where it will have a service life that will provide a retroreflective stripe until the maintenance crews can repaint the line and extend its service life until the next repainting.

Paint is one of two material types dependent upon the solids carrier: solvent or waterborne. The designer is encouraged to specify waterborne paint. Waterborne paints developed in the last ten years have proven to be more durable than solvent paints. Solvent paint is also subject to a monetary penalty because it contains a high level of volatile organic compounds (VOC). There is an Environmental Protection Agency (EPA) Clean Air Act penalty assessed on solvent paint that is passed on to those that purchase solvent paint in quantity.

Durable waterborne paint or high-build waterborne paint (a recent development) allows a thicker application (20 to 30 mils), which provides additional service life. The additional thickness permits the use of larger glass beads that enhance wet night retroreflectivity.

(b) **Plastic.** Plastic markings have a higher installation cost than paint. They can, however, be a more cost-effective measure than paint because of their longer service life. Plastic marking materials may provide a year-round retroreflective pavement marking, while paint may not last until the next restriping. Plastic marking materials currently listed in the Standard Specifications include the following:

- **Type A – Liquid Hot Applied Thermoplastic.** Thermoplastic material consists of resins and filler materials in solid form at room temperature. The material is heated to a semi-liquid, molten state (400º Fahrenheit) and is then applied to the roadway by spray or extrusion methods. This material can be used for both transverse and longitudinal line applications. Special equipment is required for both the initial application and subsequent maintenance renewal. Sprayed material can be applied at a thickness of 30 mils and dries in 30 to 60 seconds. The service life of material applied in this manner is slightly longer than that of paint. Extruded material is applied at a thickness of 125 mils and has a drying time of 15 minutes. This material can be applied as a flat line or it can be applied with ridges or bumps that enhance wet night visibility. These bumps produce a rumble effect similar to raised pavement markers when a vehicle crosses over the marking.

- **Type B – Preformed Fused Thermoplastic.** This material consists of a mixture of pigment, fillers, resins, and glass beads that is factory produced in sheet form 125 mils thick. The material is applied by heating (drying) the pavement and top heating the material. The heating process fuses the preformed thermoplastic material to the pavement surface. These materials are available in white, yellow, blue, and other colors. These materials are used for transverse markings.
- **Type C – Cold Applied Preformed Tape.** Preformed tape is composed of thermoplastic or other materials that are fabricated under factory conditions. After curing, the material is cut to size and shipped to the work site in rolls or in flat pieces. The material is then applied to the roadway with an adhesive on the underside of the tape. Preformed tape is available in a thickness of 60 mils, 90 mils, or 125 mils. (WSDOT does not currently specify 125 mil tape.) The most durable application of preformed tape is achieved when the tape is either inlaid (rolled) into hot asphalt and the top of the tape is flush with the surface of the pavement, or it is placed in a groove cut into the pavement surface and the top of the tape is slightly below the surface of the pavement.

  ASTM has classified preformed tape into two categories: Type 1 and Type 2. Type 1 tape has a profiled surface and a requirement to have a retroreflectivity of over 500 mcd/m^2/lux. Type 1 tape has proven to be very durable. It is used on high-volume, high-speed highways. Type 2 tape has a flat surface and a requirement to have a retroreflectivity of over 250 mcd/m^2/lux. Field tests show that Type 2 tape has a shorter service life than Type 1 tape.
- **Type D – Liquid Cold Applied Methyl Methacrylate (MMA).** Methyl methacrylate can be applied by either spraying or extrusion. Sprayed applications can be one or two coats, 30 to 45 mils thick. Extruded applications are 90 mils thick for dense asphalt or PCC pavement, or 120 mils thick for open-graded asphalt pavement. MMA can also be extruded using specialized equipment to produce a textured line 150 mils thick. The material is not heated and can be applied within an approximate temperature range of 40º to 105º Fahrenheit, provided the pavement surface is dry. The material can be used for both transverse and longitudinal applications. The material can also be applied with bumps (Type D profiled) that slightly enhance wet night retroreflectivity. The bumps also produce the rumble effect similar to raised pavement markers.
- **Type E – Polyurea.** Polyurea is a two-component, 100% solid coating designed as a fast-setting highway marking coating that provides durability and abrasion resistance. Polyurea is formulated to provide a simple volumetric mixing ratio of two volumes of Component A to one volume of Component B. Polyurea is typically sprayed at 20 to 25 mils thickness.

(c) **Glass Beads.** Glass beads are small glass spheres used in highway markings to provide the necessary retroreflectivity. The beads are dropped onto the wet marking material immediately after it is applied (drop-on beads) or premixed into the marking material and dropped onto the wet marking material immediately after it is applied.

Proper installation of glass beads is critical to achieving good pavement marking retroreflectivity. Each glass bead works like a light-focusing lens reflecting light back to the driver. Glass beads are embedded into the pavement marking material; for optimum performance, the bead is embedded between 55% and 60% of its diameter.

Large glass beads are effective when roads are wet. Large glass beads are not appropriate for paint as the paint is too thin to properly embed the large glass beads; therefore, WSDOT specifies small glass beads for paint applications. The use of large glass beads is limited to high-build waterborne paint and other materials with a thickness of at least 22 mils.

(3) Pavement Marking Application Types

There are five application types used for pavement markings. Most pavement marking applications are applied directly to the pavement surface. In steel bit snow plowing areas, the pavement markings may be inlaid or grooved to protect the markings.

Pavement markings, because they are higher than the surrounding pavement surface, are subject to rapid wear caused by traffic and snowplows. As they wear, they lose visibility and retroreflectivity particularly in wet weather. Wear on the stripes can be greatly reduced and their service life considerably increased by placing them in a shallow groove in the surface of the pavement. The five application types for pavement markings are:

- **Flat Lines.** Pavement marking lines with a flat surface.
- **Profiled Marking.** A profiled pavement marking that consists of a base line thickness and a profiled thickness, which is a portion of the pavement marking line that is applied at a greater thickness than the base line thickness. Profiles are applied using the extruded method in the same application as the base line. The profiles may be slightly rounded if the minimum profile thickness is provided for the entire length of the profile. (See the Standard Plans for the construction details.)
- **Embossed Plastic Line.** Embossed plastic lines consist of a flat line with transverse grooves. An embossed plastic line may also have profiles. (See the Standard Plans for the construction details.)
- **Inlaid Plastic Line.** A line constructed by rolling Type C tape into Hot Mix Asphalt with the finish roller. Closely monitor the temperature of the mat to ensure compliance with the manufacturer’s recommendations.
- **Grooved Plastic Line.** A line constructed by cutting a groove into the pavement surface and spraying, extruding, or gluing pavement marking material into the groove. The groove depth is dependent upon the material used, the pavement surface, and the location. The groove is typically in the range of 20 to 250 mils deep and 4 inches wide. Coordinate with the region’s Traffic Office on the use and dimensions of grooved plastic line marking.

(4) Raised Pavement Markers

Raised Pavement Markers (RPMs) are installed as positioning guides with long line pavement markings. They can also be installed as a complete substitution for certain long line markings. RPMs have a service life of two years, and provide good wet night visibility and a rumble effect. RPMs are made from plastic materials and are available in three different types:

- **Type 1** markers are 4 inches in diameter, 3/4–inch high, and nonreflectorized
- **Type 2** markers are 4 inches wide, 2 1/2 to 4 inches long, 3/4–inch high, and reflectorized
- **Type 3** markers are 6, 8, 10, or 12 inches wide, 4 inches long, 3/4–inch high, and nonreflectorized

Type 2 RPMs are not used as a substitute for right edge lines. They can only be used to supplement the right edge line markings at lane reductions, at sections with reduced lane widths such as narrow structures, and at the gore of exit ramps. All other applications supplementing right edge line markings require approval of the region’s Traffic Engineer. Type 3 RPMs are used in locations where additional emphasis is desired, including vehicle separations and islands. Approval by the region’s Traffic Engineer is required for all installations of Type 3 RPMs.

Reflectorized RPMs are not required for centerline and lane line applications in continuously illuminated sections of highway. However, if reflectorized RPMs are used at an intersection within an illuminated section, they are also provided throughout that section.

For raised pavement marker application details, see the Standard Plans.

(5) Recessed Raised Pavement Markers

Recessed raised pavement markers (RRPMs) are raised pavement markers (RPMs) installed in a groove ground into the pavement in accordance with the Standard Plans. RRPMs provide guidance similar to RPMs in ice chisel and steel blade snow removal areas. RRPMs can also be used in rubber blade snow removal areas in accordance with region policy.

RRPMs, when specified, are installed at the locations shown for Type 2W RPMs on multilane one-way roadways, and Type 2YY RPMs on two-lane two-way roadways.

For recessed pavement marker application details, see the Standard Plans.

830.05 Guideposts

(1) General

Guideposts are retroreflective devices mounted to a support post installed at the side of the roadway to indicate alignment. They are considered to be guidance devices rather than warning devices. They are used as an aid to nighttime driving primarily on horizontal curves; all multilane divided highways; ramps; tangent sections where they can be justified due to snow, fog, or other reduced visibility conditions; and at intersections without illumination.

The retroreflective device may be mounted on either a white or brown post. The types of guideposts and their application are as follows:

(a) **Type W** guideposts have silver-white reflective sheeting, are facing traffic, and are used on the right side of divided highways, ramps, right-hand acceleration and deceleration lanes, intersections, and ramp terminals.

(b) **Type WW** guideposts have silver-white reflective sheeting on both sides, and are used on the outside of horizontal curves on two-way, undivided highways.

(c) **Type Y** guideposts have yellow reflective sheeting, are facing traffic, and are used on the left side of ramps, left-hand acceleration and deceleration lanes, ramp terminals, intersections on divided highways, median crossovers, and horizontal curves on divided highways.

(d) **Type YY** guideposts have yellow reflective sheeting on both sides, and are used in the median on divided highways.

(e) **Type G1** guideposts have silver-white reflective sheeting on both sides, and green reflective sheeting below the silver-white sheeting on the side facing traffic. They are used at intersections of undivided highways without illumination.

(f) **Type G2** guideposts have silver-white reflective sheeting on both sides, and green reflective sheeting below the silver-white reflective sheeting on the back side. They are used at intersections of undivided highways without illumination.

(2) Placement and Spacing

Guideposts are placed not less than 2 feet nor more than 8 feet outside the outer edge of the shoulder. Place guideposts at a constant distance from the edge of the roadway. When an obstruction intrudes into this space, position the guideposts to smoothly transition to the inside of the obstruction. Guideposts are not required along continuously illuminated divided or undivided highways. (See Figure 830-2 for guidepost placement requirements.) The Standard Plans contain information on the different types and placement of guideposts.

830.06 Barrier Delineation

Traffic barriers are delineated where guideposts are required, such as bridge approaches, ramps, and other locations on unilluminated roadways. (See Figure 830-2.) At these locations, the barrier delineation has the same spacing as that of guideposts. Barrier delineation is also required when the traffic barrier is 4 feet or less from the traveled way. Use a delineator spacing of no more than 40 feet at these locations.

Beam guardrail is delineated by either mounting flexible guideposts behind the rail or by attaching shorter flexible guideposts to the wood guardrail posts.

Concrete barrier is delineated by placing retroreflective devices on the face of the barrier about 6 inches down from the top. Consider mounting these devices on the top of the barrier at locations where mud or snow accumulates against the face of the barrier.

830.07 Object Markers

Object markers are used to mark obstructions within or adjacent to the roadway. The MUTCD details three types of object markers. The Type 3 object marker with yellow and black sloping stripes is the most commonly used object marker.

The MUTCD contains criteria for the use of object markers to mark objects in the roadway and objects adjacent to the roadway. These criteria shall be followed in project design.

The terminal ends of impact attenuators are delineated with modified Type 3 object markers. These are the impact attenuator markers in the *Sign Fabrication Manual*. When the impact attenuator is used in a roadside condition, the marker with diagonal stripes pointing downward toward the roadway is used. When the attenuator is used in a gore where traffic will pass on either side, the marker with chevron stripes is used.

End of Roadway markers are similar to Type 1 object markers and are detailed in the MUTCD. They are used to alert users about the end of the roadway. The MUTCD criteria shall be followed in project design.

830.08 Wildlife Warning Reflectors

Studies show that wildlife warning reflectors are ineffective at reducing the accident potential for motor vehicle/wildlife collisions. WSDOT policy is to no longer design, place, or maintain wildlife warning reflectors.

830.09 Documentation

The list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

Ice Chisel Snow Removal Areas					
Roadway Classification	Marking Type(3)				
	Centerlines(5)	**Lane Lines(5)**	**Edge Lines**	**Wide Lines**	**Transverse Markings**
Interstate	N.A.	Grooved Plastic(1)	Paint	Paint	Paint
Major Arterial	Paint & RRPMs(4) or Plastic (2)& RRPMs(4)	Paint	Paint	Paint	Paint
Minor Arterial	Paint	Paint	Paint	Paint	Paint
Collector	Paint	Paint	Paint	Paint	Paint
Steel Blade Snow Removal Areas					
Roadway Classification	**Marking Type(3)**				
	Centerlines(5)	**Lane Lines(5)**	**Edge Lines**	**Wide Lines**	**Transverse Markings**
Interstate-Urban	N.A.	Plastic(2)	Paint or Plastic(2)	Paint or Plastic(2)	Paint or Plastic(2)
Interstate-Rural	N.A.	Paint	Paint or Plastic(2)	Paint or Plastic(2)	Paint or Plastic(2)
Major Arterial	Paint & RRPMs(4) or Plastic(2) & RRPMs(4)	Paint	Paint or Plastic(2)	Paint or Plastic(2)	Paint or Plastic(2)
Minor Arterial	Paint	Paint	Paint	Paint or Plastic(2)	Paint or Plastic(2)
Collector	Paint	Paint	Paint	Paint or Plastic(2)	Paint or Plastic(2)
Rubber Blade Snow Removal Areas					
Roadway Classification	**Marking Type(3)**				
	Centerlines(5)	**Lane Lines(5)**	**Edge Lines**	**Wide Lines**	**Transverse Markings**
Interstate-Urban	N.A.	PMMA(6) only or PMMA(6) & RPMs	Paint or Plastic(2)	Plastic(7)	FMMA(8)
Interstate-Rural	N.A.	MMA only or (8) MMA & RPMs	Paint	Plastic(2)(7)	FMMA(8)
Major Arterial	Paint & RPMs or Plastic(2) & RPMs	(7)	Paint	Plastic(7)(2)	Plastic(2)(7)
Minor Arterial	Paint & RPMs	Paint & RPMs	Paint	Plastic(2)	Plastic(2)
Collector	Paint & RPMs	Paint	Paint	Plastic(2)	Plastic(2)

Notes:

(1) Grooved Plastic is a line constructed by cutting a groove into the pavement surface and spraying, extruding, or gluing pavement marking material into the groove.
(2) Plastic refers to methyl methacrylate (MMA), thermoplastic, or preformed tape.
(3) For RPM substitute applications and RPM applications supplementing paint or plastic, see the Standard Plans, Section M.
(4) RRPMs refer to RPMs installed in a groove ground into the pavement. RRPMs are identified as "Recessed Pavement Markers" in the Standard Specifications and the Standard Plans.
(5) Type 2 RPMs are not required with painted or plastic centerline or lane line in illuminated sections.
(6) PMMA refers to profiled methyl methacrylate.
(7) Consult region striping policy.
(8) FMMA refers to flat methyl methacrylate.

Pavement Marking Material Guide
Figure 830-1

Highway Type	Guideposts on Tangents (See Notes 1 & 3)	Guideposts on Horizontal Curves (See Notes 1 & 3)
Divided Highways With Continuous Illumination		
Main Line	None	None
Bridge Approaches	None	None
Intersections	None	None
Lane Reductions	Standard Plan, Section H	Standard Plan, Section H
Median Crossovers	None	None
Ramps	Standard Plan, Section H	Standard Plan, Section H
Divided Highways Without Continuous Illumination		
Main Line with RPMs	None	Standard Plan, Section H
Main Line without RPMs	Right Side Only (0.10 mile spacing)	Standard Plan, Section H
Bridge Approaches	Standard Plan, Section H	Standard Plan, Section H
Intersections	Standard Plan, Section H	Standard Plan, Section H
Lane Reductions	Standard Plan, Section H	Standard Plan, Section H
Median Crossovers	Standard Plan, Section H	Standard Plan, Section H
Ramps	Standard Plan, Section H	Standard Plan, Section H
Undivided Highways With Continuous Illumination		
Main Line	None	None
Bridge Approaches	None	None
Intersections	None	None
Lane Reductions	Standard Plan, Section H	Standard Plan, Section H
Undivided Highways Without Continuous Illumination		
Main Line	See Note 2	Standard Plan, Section H (See Note 2)
Bridge Approaches	Standard Plan, Section H	Standard Plan, Section H
Intersections with Illumination	None	None
Intersections without Illumination	Standard Plan, Section H	Standard Plan, Section H
Lane Reductions	Standard Plan, Section H	Standard Plan, Section H

Notes:

1. For lateral placement of guideposts, see the Standard Plans, Section H.
2. Installation of guideposts on tangents and on the inside of horizontal curves is allowed at locations approved by the region's Traffic Engineer.
3. Barrier delineation is required when the traffic barrier is 4 feet or less from the roadway. Use delineator spacing of 40 feet or less.

Guidepost Placement
Figure 830-2

Chapter 840 Illumination

840.01 General

Illumination is provided along highways, in parking lots, and at other facilities to enhance the visual perception of conditions or features that require additional motorist, cyclist, or pedestrian alertness during the hours of darkness.

The Washington State Department of Transportation (WSDOT) is responsible for illumination on state highways and crossroads (per WAC 468-18-050 and WAC 468-18-040) with partial limited access control, modified limited access control, or full limited access control, regardless of the location. WSDOT is responsible for illumination on state highways and crossroads (per WAC 468-18-050) with managed access control, located outside the corporate limits of cities. Cities are responsible for illumination of managed access state highways within their corporate limits.

For the definition of the types of access control—limited access control and managed access control—see Chapter 1425. For further information, see the "Access Control Tracking System, Limited Access and Managed Access Master Plan," under the 'related sites' heading at: http://www.wsdot.wa.gov/eesc/design/access/. This document provides a listing (by milepost) of the limited access or managed access status for all state highways. (See also the WSDOT/Association of Washington Cities agreement "City Streets as Part of State Highways" at: http://www.wsdot.wa.gov/TA/Operations/LAG/CityStreets.html.)

840.02 References

Federal/State Laws and Codes

National Electrical Code, NFPA, Quincy, MA

Revised Code of Washington (RCW) 47.24.020, "Jurisdiction, control"

Washington Administrative Code (WAC) 296-24-960, "Working on or near exposed energized parts"

WAC 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

WAC 468-18-050, "Policy on the construction, improvement and maintenance of intersections of state highways and city streets"

Chapter 468-95 WAC, "Manual on uniform traffic control devices for streets and highways" (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Design Guidance

American National Standard Practice for Roadway Lighting, IES RP-8-00, New York, NY 2000

Directive D 22-21, "Truck Weigh Stations and Vehicle Inspection Facilities on State Highways"

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA, as adopted and modified by WAC 468-95

NFPA 502: Standard for Road Tunnels, Bridges and Other Limited Access Highways, 2004, NFPA, Quincy, MA

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

Roadway Lighting Handbook, Federal Highway Administration, Implementation Package 78-15, Washington, DC 1978 (Reprinted April 1984)

Roadway Lighting Handbook, Addendum to Chapter Six: Designing the Lighting System Using Pavement Luminance, Federal Highway Administration, Addendum to Implementation Package 78-15, Washington, DC 1983

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01 WSDOT

Roadway Lighting Design Guide, AASHTO, October 2005

Supporting Information

An Informational Guide for Roadway Lighting, AASHTO, Washington, DC 1984

City Streets as a Part of State Highways, Final Report, WSDOT, 1997

Light Trespass: Research Results and Recommendations, IES TM-11-00, New York, NY 2000

Recommended Practice for Tunnel Lighting, IESNA RP-22-05, New York, NY 2005

840.03 Definitions

average light level The average of all light intensities within the design area.

complex ramp alignment and grade The exit advisory speed is 35 miles per hour or lower than the posted main line speed, or there is a 6% or greater change in grade from existing main line grade to the ramp grade.

continuous load When the electrical load on a circuit lasts for a duration of three hours or more on any day.

footcandle (fc) The illumination of a surface one square foot in area on which is uniformly distributed a flux of one lumen. One footcandle equals one lumen per square foot.

lamp lumens The total light output from a lamp, measured in lumens.

lumen The unit used to measure luminous flux.

luminaire A complete lighting unit comprised of a light bulb, wiring, and a housing unit.

luminance The quotient of the luminous flux at an element of the surface surrounding the point, and propagated in directions defined by an elementary cone containing the given direction, by the product of the solid angle of the cone and area of the orthogonal projection of the element of the surface on a plane perpendicular to the given direction. The luminous flux may be leaving, passing through, and/or arriving at the surface.

luminous flux The time rate of the flow of light.

maximum uniformity ratio The average light level within the design area divided by the minimum light level within the design area. (See Figure 840-25.)

maximum veiling luminance ratio This ratio is the maximum veiling luminance divided by the average luminance over a given design area for an observer traveling parallel to the roadway centerline. (See Figure 840-25.)

minimum light level The minimum light intensity of illumination at any single point within the design area measured just prior to relamping the system. (See Figure 840-25, Note 1.)

minimum average light level The average of all light intensities within the design area, measured just prior to relamping the system. (See Figure 840-25, Note 1.)

mounting height – luminaire The vertical distance between the surface of the design area and the center of the light source of the luminaire. Note: This is not to be confused with pole height (H1), but is the actual distance that the luminaire is located above the roadway edge line.

multimodal connection The point where multiple types of transportation activities occur; for example, where transit buses and van pools drop off or pick up passengers (including passengers with bicycles).

nighttime The period of time from one-half hour after sunset to one-half hour before sunrise and any other time when persons or objects may not be clearly discernable at a distance of 500 feet. (See RCW 46.04.200, Hours of Darkness.)

pedestrian crossing For the purpose of lighting design, the number of pedestrian movements that cross through the design area.

pole height (H1) The vertical distance from the light source to the pole base. This distance is specified in contracts and used by the pole manufacturers to fabricate the light standard.

roadway luminance The light projected from a luminaire that travels toward a given area, represented by a point on the pavement surface, and then back toward the observer, opposite to the direction of travel. The units of roadway luminance are footcandles.

security lighting A minimal amount of lighting used to illuminate areas for public safety or theft reduction. Security lighting for walkways is the lighting of areas where shadows and horizontal and vertical geometry obstruct a pedestrian's view.

slip base A mechanical base designed to allow the luminaire pole to break away from the fixed foundation when hit by a vehicle traveling at the design speed.

spacing The distance in feet measured on centerline between adjacent luminaires.

transit flyer stop A multimodal connection located within the boundaries of a limited access facility.

transit stop A connection on the highway where the transit bus stops to pick up or drop off passengers.

uniformity ratio The ratio of the minimum average light level on the design area to the minimum light level of the same area. (See Figure 840-25.)

veiling luminance The stray light produced within the eye by light sources produces a veiling luminance that is superimposed on the retinal image of the objects being observed. This stray light alters the apparent brightness of an object within the visual field and the background against which it is viewed, thereby impairing the ability of the driver to perform visual tasks. Conceptually, veiling luminance is the light that travels directly from the luminaire to the observer's eye.

840.04 Design Considerations

An illumination system is built from many separate components. The simplest illumination system contains:

- A power feed from the local utility company.
- An electrical service cabinet containing a photocell and circuit breaker for each illumination circuit.
- Runs of conduit with associated junction boxes leading to each luminaire.
- Conductors routed from the service cabinet breaker to each luminaire.
- A concrete light standard foundation.
- A luminaire pole with a slip base or a fixed base.
- A luminaire (light) over or near the roadway edge line.

There are design considerations that need to be addressed when performing even the most minimal work on an existing illumination system. An existing electrical system was acceptable for use under the design requirements and National Electric Code (NEC) rules in effect at the time of installation. When modifying an existing electrical system, the designer is responsible for bringing the whole system up to current NEC design standards. Retrofitting an existing fixed base luminaire pole with a slip base feature requires the installation of quick disconnect fittings and fuses in the circuit, at the luminaire. The existing conductor configuration for a fixed base luminaire is not acceptable for use on a breakaway (slip base) installation. Existing conductors and components that no longer meet current NEC requirements are to be replaced and the whole circuit designed to current standards. This may mean replacing the whole circuit back to the nearest overcurrent protection device (circuit breaker). The following are design considerations to be addressed when modifying an existing illumination system:

- Whether the existing circuit is in compliance with current NEC standards (deficient electrical component)
- Whether existing luminaire system components, such as conductors, conduit, junction boxes, foundation, and pole comply with current standards

- Whether conductors meet NEC requirements for temperature rating (deficient electrical component)
- Conductor material: aluminum conductors or copper conductors (deficient electrical component)
- The condition and adequacy of the existing conduit running between the luminaire and the nearest junction box (deficient electrical component)
- The condition of the junction box next to the luminaire (deficient electrical component)
- The suitability of the existing foundation to meet current design requirements
- The suitability of the location to meet current design standards for illumination
- The location and bolt pattern of existing foundation to meet current design standards
- The design life remaining for the existing luminaire pole (deficient electrical component)
- The condition of the existing luminaire pole (deficient electrical component)
- Maintenance personnel assessment of the electrical safety of the installation

Involve appropriate Headquarters (HQ) and region Traffic Office design personnel early in the scoping process. Ensure that potential system deficiencies are reflected in the estimate of work.

Another consideration is the need to maintain illumination during construction. Site preparation, widening, drainage, guardrail installation, or other work can easily impact existing conduit runs or luminaire locations. Furthermore, changed conditions such as merging, weaving, or unusual alignment due to traffic control often require additional temporary illumination. The same lighting requirements apply whether a condition is temporary or permanent.

840.05 Required Illumination

The design matrices identify the design levels for illumination on all preservation and improvement projects. (See Chapter 325.)

At the basic design level for minor safety or preservation work, providing slip base features on existing light standards (when in the Design Clear Zone or recovery area), and bringing electrical components to current standards, is required. Consider other minor safety work as necessary. Providing additional lighting or relocating light standards on preservation projects may be considered spot safety enhancements. When the Illumination column has an EU (evaluate upgrade to full design level), consider providing illumination if it would be beneficial to the specific project, and document accordingly.

- **Evaluate Upgrade:** Review the service to see that it meets current standards for design load. It should be located so that it can be safely accessed from the right of way. Poles, foundations, heads, etc., that have reached their design life should be replaced. Slip base features should be per current design standards. Uniformity should be evaluated in the design areas (see 840.07(2)). Locations that are illuminated per 840.05 should be brought to full standards or documented regarding why they are not (deferred to another project, etc.). Consider additional illumination per 840.06, if warranted, or design additional illumination if it is called for in the Project Definition.

  When it is necessary to relocate existing illumination pole foundations, evaluate the entire conduit run serving those poles and replace deficient components to current (NEC) standards.
- **Full Standards:** For full design level, the illumination specified in this chapter is required when constructing a new system and/or bringing the entire existing system to full standards (such as slip base features, grounding, conduit, light levels, and uniformity). On existing systems, this includes all components not otherwise affected by the project. Review all conduit runs, not just the one affected by relocating poles on that run.

Figures 840-1 through 840-24 show examples of illumination for roadway, transit flyer stops, parking lots, truck weigh stations, tunnels, bridges, work zones, and detour applications. Illumination is required in these examples and in the locations listed below.

For Minor Operational Enhancement projects using the design matrices in Chapter 340, illumination is not required.

(1) Freeway Off-Ramps and On-Ramps

Provide the necessary illumination for the design area of all freeway off-ramp gore areas and on-ramp acceleration tapers. (See 840.07(2) and Figures 840-1a, 1b, and 1c.)

(2) Freeway Ramp Terminals

Provide the necessary illumination for the design area. (See Figure 840-2.) Additional illumination is required if the intersection has left-turn channelization or a traffic signal.

(3) Intersections With Left-Turn Lane Channelization

Illumination of the intersection area and the left-turn storage area is required for intersections with painted or other low-profile pavement markings such as raised pavement markings. When the channelization is delineated with curbs, raised medians, or islands, illuminate the raised channelization from the beginning of the left-turn approach taper. Illumination of the secondary road intersecting the state highway can be beneficial to the motoring public. Funding and design, however, are the local agency's responsibility. Contact that agency to see whether they are interested in participating. (See Figures 840-3a and 3b.)

(4) Intersections With Traffic Signals

Illuminate all intersections with traffic signals on state highways. (See Figure 840-4.) Illumination of the crossroad is beneficial and the participation of the local agency is desirable. In cities with a population under 22,500, the state may assume responsibility for illumination installed on signal standards.

(5) Railroad Crossings With Gates or Signals

Railroad crossings with automated gates or signals on state highways are illuminated if there is nighttime train traffic. Within the corporate limits of a city, and outside limited access control, illumination is the responsibility of the city. Install luminaires beyond the railroad crossing, on the side of the roadway opposite the approaching traffic, so that illumination is behind the train. (See Figure 840-5.)

(6) Transit Flyer Stops

Illuminate the pedestrian-loading areas of transit flyer stops located within the limited access boundaries. (See Figure 840-6.)

(7) Major Parking Lots

All parking lots with usage exceeding 50 vehicles during the nighttime peak hour are considered major parking lots. Provide an illumination design that will produce the light levels shown in Figure 840-25. (See Figure 840-7 for the parking area and bus loading zone.) During periods of low usage at night, security lighting of only the parking area and bus loading zone is required. Provide an electrical circuitry design that allows the illumination system to be reduced to approximately 25% of the required light level.

(8) Minor Parking Lots

Minor parking lots have a nighttime peak hour usage of 50 or fewer vehicles. Provide security-level lighting for those lots owned and maintained by the state. Security lighting for a minor parking lot consists of lighting the entrance and exit to the lot. (See Figure 840-8.)

(9) Truck Weigh Sites

Provide illumination of the roadway diverge and merge sections, scale platforms, parking areas, and inspection areas of weigh sites. (See Figure 840-9.)

(10) Midblock Pedestrian Crossings

Illuminate the entire midblock pedestrian crossing, including the crosswalks, the refuge area in the roadway, and the sidewalks or shoulders adjacent to the crosswalk. When a raised median pedestrian refuge design is used, illuminate this raised channelization. (See Figure 840-10.)

(11) Tunnels

Long tunnels have a portal-to-portal length greater than the stopping sight distance. Provide both nighttime and daytime illumination for long tunnels. Consider illumination for short tunnels if the horizontal to vertical ratio is > 10:1. (See Chapter 650 and Figure 840-11.)

(12) Lane Reduction

Provide the necessary number of light standards to illuminate the design area of all highway lane reduction areas within the urban boundary. (See Figure 840-12.) This requirement does not apply to:

- The end of slow-moving vehicle turnouts.
- The end of the area where driving on shoulders is allowed.

(13) Intersections With Right-Turn Channelization

Illumination of the intersection area and the right-turn storage area is required for intersections with painted or other low-profile pavement markings such as raised pavement markings. Raised channelization such as curb, raised medians, and islands are to be illuminated from the beginning of the right-turn taper. For concurrent left-turn and right-turn channelization, where the left-turn lane and the left-turn taper are longer than the right-turn lane and taper, illuminate the roadway as described in 840.05(3), and include the right-turn lane area in the design area. (See Figure 840-13.) Illumination of the secondary road intersecting the state highway can be beneficial to the motoring public. Funding and design, however, are the local agency's responsibility. Contact that agency to see whether it is interested in participating.

(14) Same Direction Traffic Split Around an Obstruction

Provide the necessary number of light standards to illuminate the design area where traffic is split around an obstruction. This requirement applies to permanent and temporary same-direction split channelization. For temporary work zones, the obstruction is to be illuminated for the duration of the traffic split. (See Figure 840-14.)

(15) Add Lane Channelization

Provide the necessary number of light standards to illuminate the design area of freeway add lanes on high-volume roadways within the urban boundary. (See Figure 840-15.) This requirement does not apply to the following:

- The beginning of an add lane on a low-volume roadway in a rural area beyond the urban boundary
- The beginning of a slow-moving vehicle turnout
- The beginning of an area where driving on shoulders is allowed

(16) Roundabouts

Provide the necessary number of light standards to illuminate the design area of roundabouts. (See Chapter 915, "Roundabouts," and Figure 840-16.)

(17) Bridge Inspection Lighting

Provide the necessary number of light fixtures to illuminate the interior inspection areas of floating bridges and steel box girder bridges. (See Figure 840-17.)

(18) Freeway On-Ramps With Ramp Meter Signals

Provide the necessary number of light standards to illuminate freeway on-ramps with ramp meters, from the beginning of the on-ramp to the ramp meter stop bar. When there is an HOV bypass lane or a two-lane merge beyond the ramp meter, then provide illumination for the entire ramp from the beginning of the on-ramp to the ramp merge point with the main line. (See Figure 840-18.)

(19) Freeway-to-Freeway Ramp Connections

Provide the necessary number of light standards to illuminate freeway-to-freeway ramps that connect full limited access freeway systems from the exit ramp gore area to the main line merge area. (See Figure 840-19.)

(20) HOT (High Occupancy Toll) Lane Enter/Exit Zones

Provide the necessary number of luminaires to illuminate the design area of the enter/exit zones of the HOT Lane. (See Figure 840-20.)

(21) Chain-Up Parking Areas

Provide the necessary number of luminaires to illuminate the design area of the chain-up parking area. (See Figure 840-21.)

(22) Rest Areas

Provide illumination at the roadway diverge and merge sections within rest areas, the walkways between parking areas and rest room buildings, and the parking areas as for a major parking lot. (See Figure 840-22.)

(23) Overhead Sign Illumination

Provide sign lighting on overhead signs as discussed in Chapter 820. (See ***Design Manual*** Supplement, Overhead Sign Illumination [Lighting], August 5, 2005.)

840.06 Additional Illumination

At certain locations, additional illumination is desirable to provide better definition of nighttime driving conditions or to provide consistency with local agency goals and enhancement projects. For improvement projects on state highways, additional illumination is considered under certain circumstances, which are listed in this section. Justify the additional illumination in the Design Documentation Package (DDP).

Some conditions used in making the decision to provide additional illumination are:

- **Diminished Level of Service.** A mobility condition where the nighttime peak hour level of service is D or lower. To determine the level of service, use traffic volume counts taken during the evening peak hour. Peaking characteristics in urban areas are related to the time of day. Traffic counts taken in the summer between 4:30 P.M. and 7:30 A.M. may be used as nighttime volumes if adjustment factors for differences in seasonal traffic volumes are applied for November, December, and January.
- **Nighttime Collision Frequency.** When the number of nighttime collisions equals or exceeds the number of daytime collisions. An engineering study indicating that illumination will result in a reduction in nighttime collisions is required as justification. Consider the seasonal variations in lighting conditions when reviewing reported collisions. Collision reporting forms, using a specific time period to distinguish between “day” and “night,” might not indicate the actual lighting conditions at the time of a collision. Consider the time of year when determining whether a collision occurred at nighttime. A collision occurring at 5:00 P.M. in July would be a daytime collision, but a collision occurring at the same time in December would be during the hours of darkness.
- The mitigation of nighttime pedestrian accident locations (PAL) requires different lighting strategies than vehicular accident locations. Provide light levels to emphasize crosswalks and adjacent sidewalks. Multilane highways with two-way left-turn lanes, in areas transitioning from rural land use to urban land use, or areas experiencing commercial growth or commercial redevelopment, are typically high-speed facilities with numerous road approaches and driveways. These approaches allow numerous vehicle entry and exit points and provide few crossing opportunities for pedestrians. Consider additional illumination for this condition.

(1) Highways

Proposals to provide full (continuous) illumination require the approval of the State Traffic Engineer. Regions may choose to develop system plans (regional or corridor-specific) for providing full (continuous) illumination. The approval of a system plan will eliminate the need for a project-specific approval from the State Traffic Engineer.

The decision whether to provide full (continuous) illumination is to be made in the scoping stage and communicated to the designers as soon as possible.

(a) On the main line of full limited access highways, consider full (continuous) illumination if a diminished level of service exists and any two of the following conditions are satisfied:

- There are three or more successive interchanges with an average spacing of 1 1/2 miles or less, measured from the center of each interchange or a common point such as a major crossroad.
- The segment is in an urban area.
- A nighttime collision frequency condition exists.
- A benefit/cost analysis between the required and full (continuous) illumination indicates a value added condition with the addition of continuous illumination.

(b) On the main line of highways without full limited access control, consider full (continuous) illumination if the segment of highway is in a commercial area and either a diminished level of service exists or a nighttime collision frequency exists, and an engineering study indicates that nighttime driving conditions will be improved.

(2) Ramps

At ramps, consider additional illumination when a diminished level of service exists for the ramps and any of the following conditions are present:

- The ramp alignment and grade are complex
- There are routine queues of five or more vehicles per lane at the ramp terminal during the nighttime peak hour due to traffic control features
- A nighttime collision frequency condition exists
- The criteria for continuous main line illumination have been satisfied

(3) Highway-to-Highway Ramp Connections

Provide the necessary number of light standards to illuminate highway-to-highway ramps that connect partial or modified limited access freeway systems or managed access highway systems, from the exit ramp gore area to the main line merge area. For an example of the ramp connection, see Figure 840-19.

(4) Crossroads

At crossroads, consider additional illumination when a diminished level of service exists and a nighttime collision frequency exists. Also, consider additional illumination if the crossroad is in a tunnel, an underpass, or a lid.

(5) Intersections Without Channelization

Consider illumination of intersections without channelization if a nighttime collision frequency requirement is satisfied or the intersection meets warrants for left-turn channelization. (See Figure 840-23.)

(6) Short Tunnels, Underpasses, or Lids

Consider illumination of short tunnels, underpasses, or lids if portal conditions result in brightness that is less than the measured daytime brightness of the approach roadway divided by 15 and the length to vertical clearance ratio is 10:1 or greater.

(7) Work Zones and Detours

Consider temporary illumination of the highway through work zones and detours when changes to the highway alignment or grade remain in place during nighttime hours, and when the following conditions may be present: (See Figure 840-24)

- When nonstandard roadway features such as narrow lanes, shoulders, or shy distance to barriers or structures are present

- When the temporary alignment includes abrupt changes in highway direction or lane shifts with substandard lane shift tapers
- When other unusual highway features such as abrupt lane edge drop-offs, sudden changes in pavement conditions, or temporary excavation or trenching covers are present
- When there is an anticipation of heavy construction truck traffic, possibly requiring flaggers, entering and exiting the highway during nighttime hours

For further information, see Chapter 810.

(8) Transit Stops

The responsibility for lighting at transit stops is shared with the transit agency. Consider illumination of transit stops with shelters, as they are usually indicative of higher passenger usage. Negotiation with the transit agencies is required for the funding and maintenance of this illumination. Negotiating a memorandum of understanding (MOU) with each transit agency is preferred over spot negotiations. If the transit agency is unable or unwilling to participate in the funding and maintenance of the illumination, a single light standard positioned to illuminate both the transit pullout area and the loading area can be considered.

(9) Bridges

Justification for illuminating the roadway and sidewalk portion of bridges is the same as that for highways on either end of the bridge with or without full limited access control, as applicable. Justification for illuminating the architectural features of a bridge structure requires the approval of the State Traffic Engineer. For justification for illuminating pedestrian walkways or bicycle trails under a bridge, see 840.06(11).

(10) Railroad Crossing Without Gates or Signals

Consider illumination of these facilities when:

- The collision history indicates that motorists experience difficulty in seeing trains or control devices.
- There are a substantial number of rail operations conducted during nighttime hours.
- The crossing is blocked for long periods due to low train speeds.
- The crossing is blocked for long periods during the nighttime.

For further information, see the MUTCD.

(11) Walkways and Bicycle Trails

Consider illumination of a pedestrian walkway if the walkway is a connection between two highway facilities. This might be between parking areas and rest room buildings at rest areas, between drop-off or pick-up points and bus loading areas at flyer stops, or between parking areas and bus loading areas or ferry loading zones (for example). Consider illuminating existing walkways and bicycle trails if security problems have been reported. Also, consider illumination if security problems are anticipated. Under these conditions, the walkways and bicycle trails are illuminated to the level shown in Figure 840-25.

840.07 Design Criteria

(1) Light Levels

Light levels vary with the functional classification of the highway, the development of the adjacent area, and the level of nighttime activity. Light level requirements for highways and other facilities are shown in Figure 840-25. These levels are the minimum average light levels required for a design area at the end of rated lamp life for applications requiring a spacing calculation. Light level requirements *are not applicable* for single light standards or security lighting installations where:

- The light level is reduced to approximately 25% of the required light level in parking lots and parking lot loading areas during periods of low usage at night.
- Walkway or path illumination is installed only at areas where shadows and horizontal and vertical geometry obstruct a pedestrian’s view.

Light level requirements *are applicable* for:

- Walkway or path illumination where, for public safety, the complete walkway or path is to be illuminated.

For design-level classifications of highways, see Chapters 325, 410, 430, and 440.

(a) **Activity Areas.** The types of activity areas (shown below) are related to the number of pedestrian crossings through the design area. These crossings need not occur within a single crosswalk and can be at several locations along the roadway in an area with pedestrian generators. Land use and activity classifications are as follows:

- **High Activity.** Areas with over 100 pedestrian crossings during the nighttime peak hour pedestrian usage. Examples include downtown retail areas; near outdoor stage theaters, concert halls, stadiums, and transit terminals; and parking areas adjacent to these facilities.
- **Medium Activity.** Areas with pedestrian crossings that number between 11 and 100 during the nighttime peak hour pedestrian usage. Examples include downtown office areas; blocks with libraries, movie theaters, apartments, neighborhood shopping, industrial buildings, and older city areas; and streets with transit lines.
- **Low Activity.** Areas with pedestrian crossings that number less than 11 during the nighttime peak hour pedestrian usage. Examples include suburban single-family areas, low-density residential developments, and rural or semirural areas.

(2) Design Areas

The design area is that portion of the roadway, parking lot, or other facility subject to the minimum light level, minimum average light level, uniformity ratio, and maximum veiling luminance ratio design requirements. This encompasses the area between the edges of the traveled way along the roadway; the outer edges of the stopping points at intersections; and, when present, a bike lane adjacent to the traveled way. When the roadway has adjacent sidewalks, the design area includes these features, except that sidewalks adjacent to the traveled way are exempt from maximum veiling luminance ratio requirements. The access areas used for interior inspection of a floating bridge or steel box girder bridge are exempt from lighting level and lighting ratio design requirements.

Design area requirements for various applications are shown in Figures 840-1 through 840-24 and the following:

- **Single-Lane Off-Ramp.** Two main line through lanes and the ramp lane, including gore area, from the gore point to a point 200 feet (minimum) downstream of the gore point. A 100-foot longitudinal tolerance either way from the gore point is allowed.
- **Two-Lane Off-Ramp.** Two main line through lanes and both ramp lanes, including gore area, from a point 200 feet upstream of the gore point to a point 200 feet downstream of the gore point. A 100-foot longitudinal tolerance either way from the gore point is allowed.
- **Single-Lane On-Ramp.** Two main line through lanes and the ramp lane, from a point where the ramp lane is 10 feet wide to a point 200 feet downstream. A 100-foot longitudinal tolerance either way is allowed (this includes auxiliary lane on-connections and lane reductions).
- **Two-Lane On-Ramp.** Two main line through lanes and the ramp lanes from a point where the ramp width is 22 feet wide to a point 200 feet upstream and 200 feet downstream. A 100-foot longitudinal tolerance either way is allowed.
- **Intersections Channelized With Pavement Markings.** The design area has two components: the intersection area and the approach areas. The intersection area is the area between the stopping points on both the main road and the minor road, including marked or unmarked crosswalks. The approach areas are the areas on the main roadway between the stopping point and where the left-turn lane is full width.
- **Intersections With Raised Channelization.** The design area has two components: the intersection area and the approach areas. The intersection area is the area between the stopping points on both the main road and the minor road, including marked or unmarked crosswalks. The approach areas are the areas on the main roadway between the stopping point and where the left-turn taper begins.

- **Unchannelized Intersection.** The area between the stopping points on both the main road and the minor road, including marked or unmarked crosswalks.
- **Railroad Crossing.** The roadway width from a point 50 feet on either side of the track (the approach side only for one-way roadways).
- **Transit Loading Area.** The lane width and length designated for loading.
- **Major Parking Lot.** The entire area designated for parking, including internal access lanes.
- **Scale Platform at Weigh Site.** The approach width from the beginning of the scale platform to the end of the platform.
- **Inspection Area at Weigh Site.** The area dedicated to inspection as agreed upon with the Washington State Patrol.
- **Bridge Inspection Lighting System.** Fixtures are to be ceiling-mounted with a maximum spacing of 25 feet. Illumination is to consists of a 100 watt incandescent (or fluorescent equivalent) fixture. Each fixture is to be designed with a 20 amp rated ground fault circuit interrupt (GFCI) receptacle. A light switch is needed at each entrance to any common inspection area. For inspection areas with two or more entrances, three-way or four-way switches are required.

(3) Light Levels for Tunnels and Underpasses (Daytime Illumination)

It is important to provide sufficient lighting when illuminating the inside of a tunnel. When driving into and through a tunnel, a driver's eyes have to adjust from a high light level (daylight) to a lower lighting level inside the tunnel. Motorists require sufficient time for the eye to adapt to the lower light level of the tunnel itself. When sufficient lighting is not provided in the threshold, transition, or interior zones of a tunnel, a motorist's eyes may not have enough time to adapt to the lower light levels in the tunnel and the motorist experiences a "black hole" or "blackout" effect. This "black hole" effect may cause a motorist to slow down, reducing the efficiency of the roadway. As the motorist leaves the tunnel, the driver's eyes have to adjust from a low lighting level back to daytime conditions. The full design considerations for tunnel lighting are covered in 840.02, References, in the Supporting Information section. All designs for lighting tunnels are to be reviewed and approved by the State Traffic Engineer.

- Long tunnels are divided into zones for the determination of daytime light levels. Each zone is equal in length to the pavement stopping sight distance. The entrance zone beginning point is a point outside the portal where the motorist's view is confined to the predominance of the darkened tunnel structure.
- The daytime entrance zone light level is dependent upon the brightness of the features within the motorists' view on the portal approach. The brightness level is defined as the average brightness measured over a 20° cone at a point 500 feet in advance of the portal. The entrance zone light level produced within the tunnel must be sufficient to provide a brightness level of approximately 5% of the measured portal brightness, after adjustment for the reflectivity of the roadway, walls, and ceiling. Design successive zones for a daytime light level of 5% of the previous zone light level to a minimum value of five footcandles. Requirements for nighttime light levels for long tunnels on continuously illuminated roadways are the same as the light level required on a roadway outside the tunnel. Provide illumination of fire protection equipment, alarm pull boxes, phones, and emergency exits in long tunnels. (See NFPA 502 for additional information.)
- A short tunnel or underpass has a length-to-vertical clearance ratio of 10:1 or less. Short tunnels and underpasses in rural areas or with low pedestrian usage normally do not have daytime illumination. Short tunnels and underpasses in urban areas with high pedestrian usage may require daytime and nighttime illumination. Consultation with the affected local agency is recommended. Short tunnels and underpasses with length-to-vertical clearance ratios greater than 10:1 are treated the same as an entrance zone on a long tunnel to establish daytime light levels.

Short tunnels and underpasses where the exit portal is not visible from the entrance portal due to curvature of the roadway are to be considered long tunnels. Nighttime light level requirements for short tunnels on continuously illuminated roadways are the same as the light level required on the roadway outside the tunnel.

(4) Light Standards

(a) **Light Standards**. Light standards are the most common supports used to provide illumination for highway facilities. The 40-foot and 50-foot-high light standards with slip bases and Type 1 mast arms are used predominately on state highways. The angular Type 2 mast arms are allowed only to match existing systems. Use Type 1 mast arms on all new systems. Cities and counties may elect to use different mounting heights to address factors unique to their environments. On state highways, alternate light standards may be considered if requested by the city or county, provided they agree to pay any additional costs associated with this change.

The typical location for a light standard is on the right shoulder. When considering designs for light standards mounted on concrete barrier in the median, consider the total life cycle cost of the system, including the user costs resulting from lane closures required for relamping and repair operations. Light standards located in the vicinity of overhead power lines require a minimum 10-foot circumferential clearance from the power line (including the neutral conductor) to any portion of the light standard or luminaire. Depending on the line voltage a distance greater than 10 feet may be required (see WAC 296-24-960). Consult the Headquarters (HQ) Bridge and Structures Office when mounting light standards on structures such as retaining walls and bridge railings.

It is preferable to locate a light standard as far from the traveled way as possible to reduce the potential of impacts from errant vehicles. The preferred position for the luminaire is directly over the edge line. However, some flexibility is acceptable with the luminaire position to allow for placement of the light standard. On Type III signal standards, luminaires may be placed more than 4 feet from the edge line. Standard mast arm lengths are available in 2-foot increments between 6 and 16 feet. The preferred design for a single-arm light standard is a 16-foot mast arm installed on a 40-foot or 50-foot standard. The maximum allowable mast arm length for a single-arm light standard is 16 feet. The preferred design for a double mast arm light standard has mast arms between 6 feet and 12 feet in length, installed on a 40-foot or 50-foot standard. The maximum allowable mast arm length for a double luminaire light standard is 12 feet.

When light standards are located within the Design Clear Zone, breakaway and slip base features are used to reduce the severity of an impact. (See Chapter 700 for additional guidance on clear zone issues.)

In curb and sidewalk sections, locate the light standard behind the sidewalk. Slip bases on light standards are a safety requirement for roadways where the posted speed is 35 miles per hour or higher. They are not always desirable at other locations. Following are locations where fixed bases are installed:

- Parking lots
- Medians where the light standard is mounted on median barrier
- Behind traffic barrier, beyond the barrier's deflection design value (see Chapter 710)
- Along pedestrian walkways, bike paths, and shared-use paths

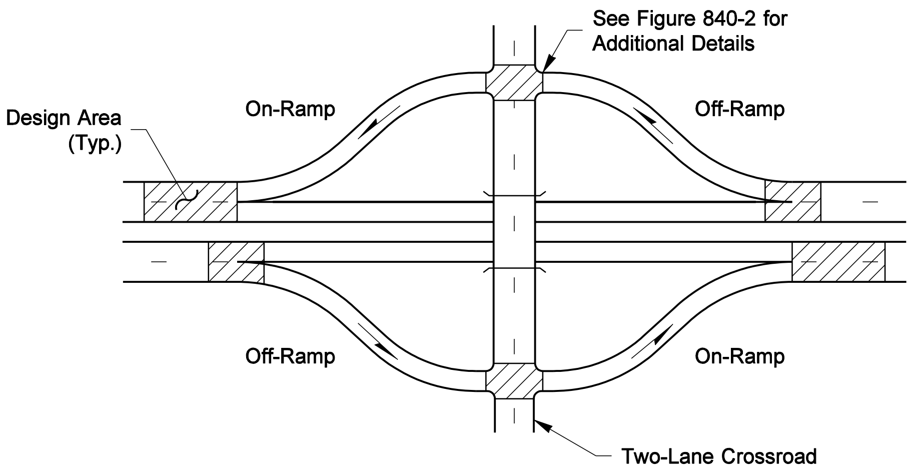
(b) **Light Standard Heights.** Standard pole heights (20-foot, 30-foot, 40-foot, or 50-foot) are readily available from local distributors and manufacturers. Light standards can also be supplied with other lengths. However, WSDOT maintenance offices cannot stock poles with nonstandard lengths for use as replacements in the event of a knockdown. Nonstandard lengths in 5-foot increments (25-foot, 35-foot, or 45-foot) will require a longer delivery time. Other nonstandard lengths (for example, 27-foot, 33-foot, 43-foot, or 47-foot) will not only require a longer delivery time, they will also be more expensive.

In almost all cases, use standard pole heights of 40 feet and 50 feet for roadway illumination. Structure-mounted light standards may need to be shorter than the standard 40-foot or 50-foot grade-mounted pole. Use of 20-foot or 30-foot light standards on bridges, retaining walls, or other structures to compensate for top-of-structure elevation above the roadway surface is acceptable. Use of these standard pole heights will result in variable mounting heights for the luminaires. Luminaire mounting height is defined as the actual distance from the roadway surface directly under the luminaire to the luminaire itself. Use the actual mounting height at each location when calculating light standard spacing. High mast light supports may be considered for complex interchanges where continuous lighting is justified. High mast lighting may be considered for temporary illumination areas during construction. Initial construction costs, long-term maintenance, clear zone mitigation, spillover light onto adjacent properties, and negative visual impacts are important factors when considering high mast illumination. Shorter light standards of 30 feet or less may be used for minor parking lots, trails, pedestrian walkways, and locations with restricted vertical clearance.

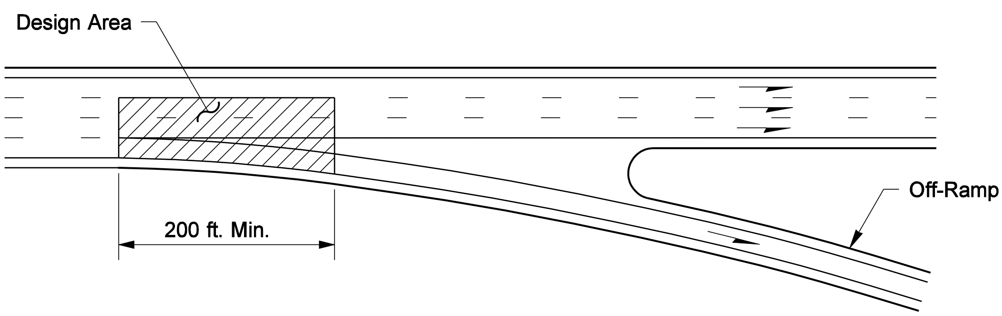
(c) **Standard Luminaire.** The cobra head-style, high-pressure sodium vapor luminaire with Type III, medium cut-off light distribution is the normal light source used for state highway lighting. A Type III distribution projects an oval pattern of light on the roadway, and a Type V distribution projects a circular pattern of light on the roadway. Post top-mounted luminaires and other decorative light fixtures with Type V patterns are more effective for area lighting in parking lots and other locations where more symmetrical light distribution patterns are used.

840.08 Documentation

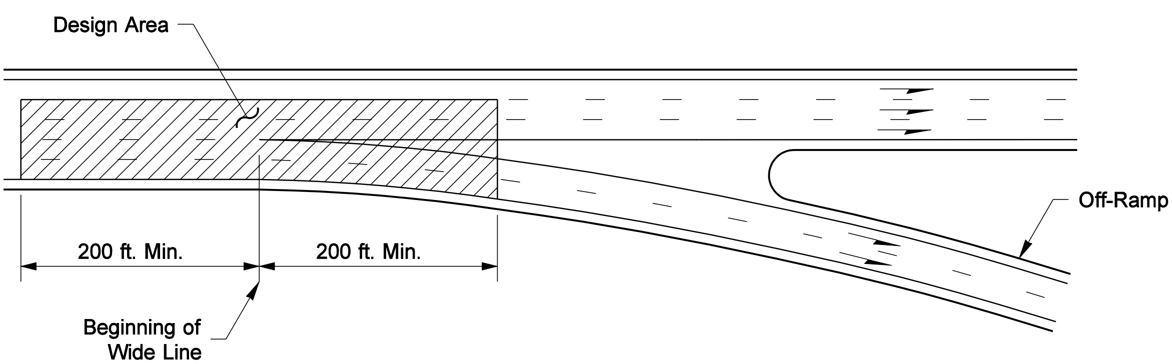
A list of the documents that are to be included in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/



Required Illumination for a Typical Diamond Interchange
(Shown for single-lane ramp connection and a two-lane crossroad without channelization)

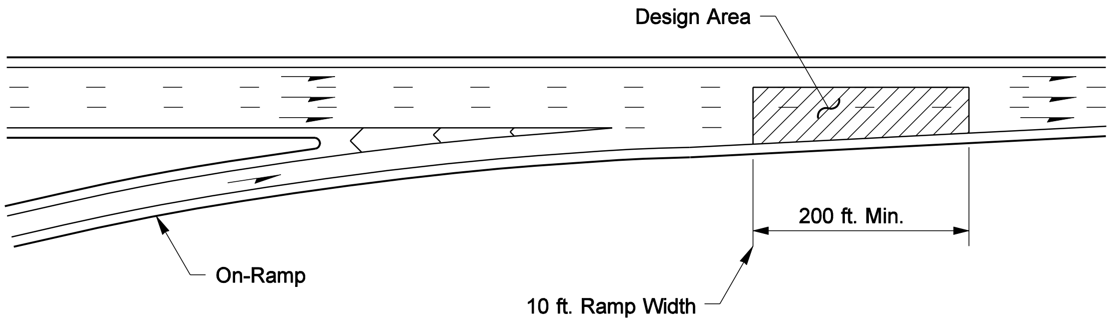


Single-Lane Off-Connection
(The Design Area may be shifted up to 100 feet from the beginning of the wide line)

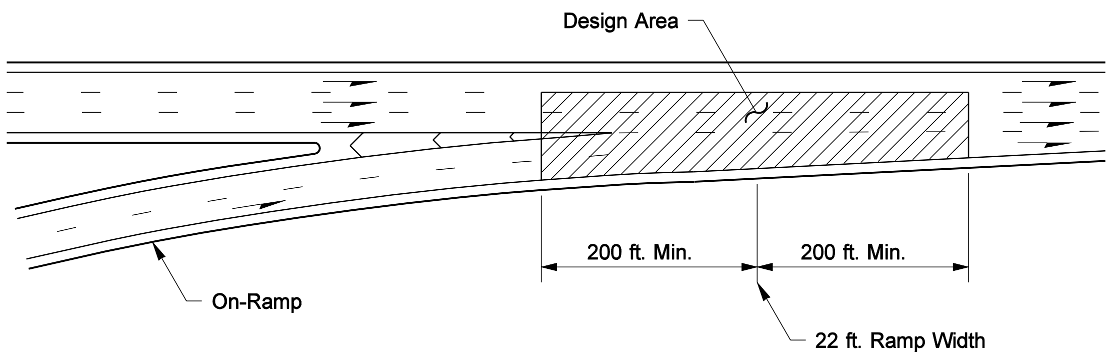


Two-Lane Off-Connection
(The Design Area can be shifted up to 100 feet from the beginning of the wide line)

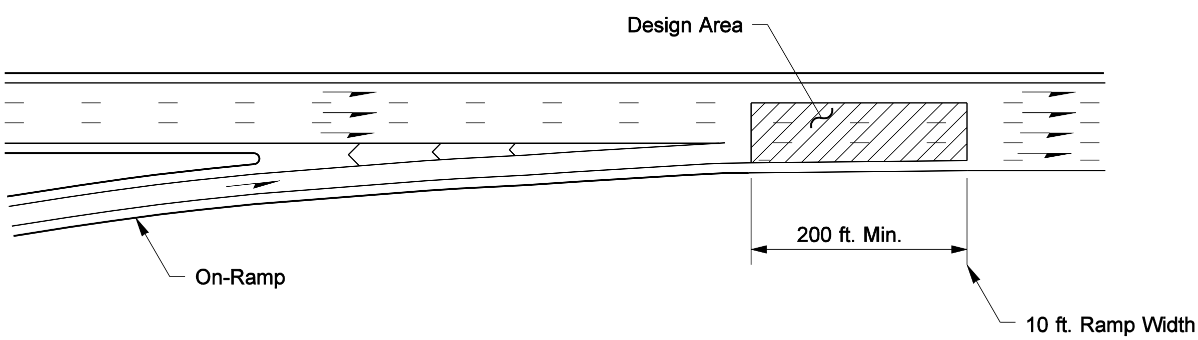
Freeway Lighting Applications
Figure 840-1a



Single-Lane On-Connection
(The Design Area may be shifted up to 100 feet from the 10-foot-wide ramp point)

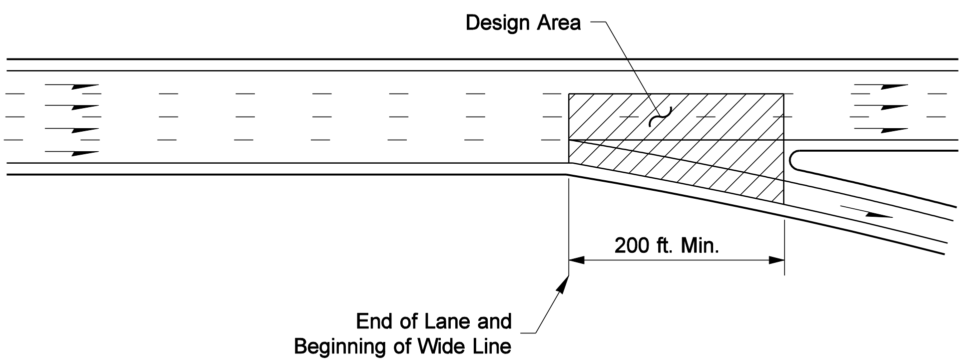


Two-Lane On-Connection
(The Design Area may be shifted up to 100 feet from the 22-foot-wide ramp point)



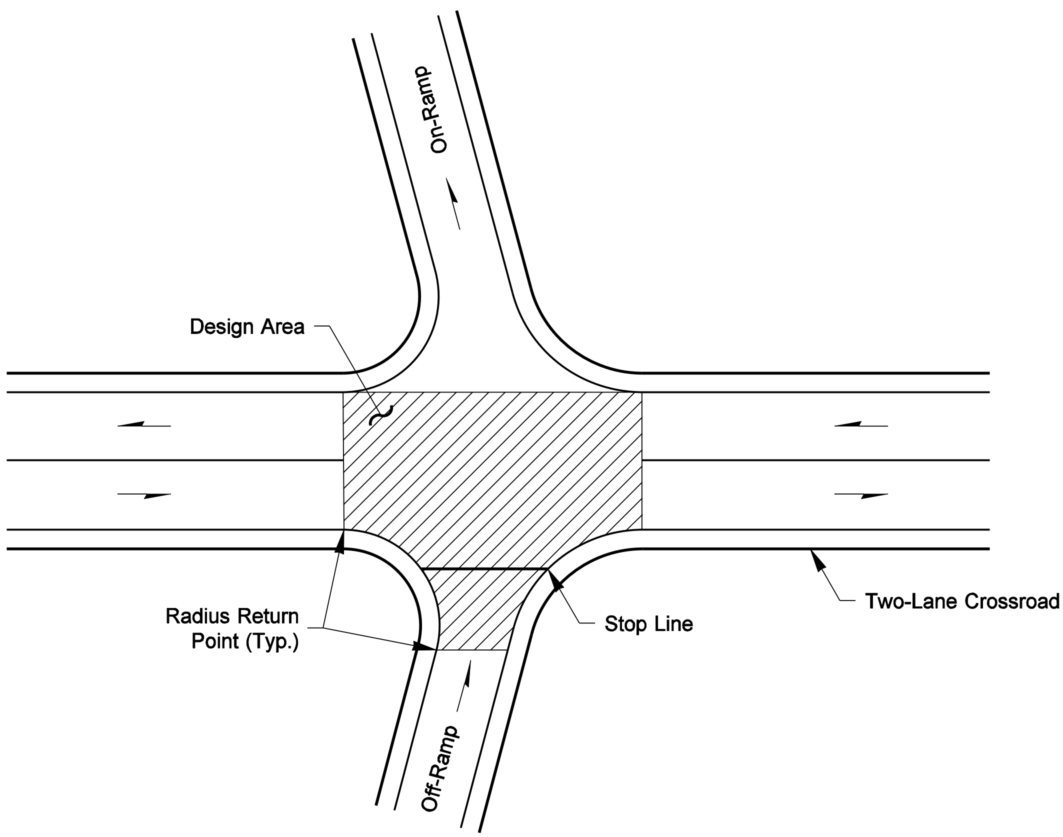
Auxiliary Lane at On-Connection
(The Design Area may be shifted up to 100 feet from the 10-foot-wide ramp point)

Freeway Lighting Applications
Figure 840-1b

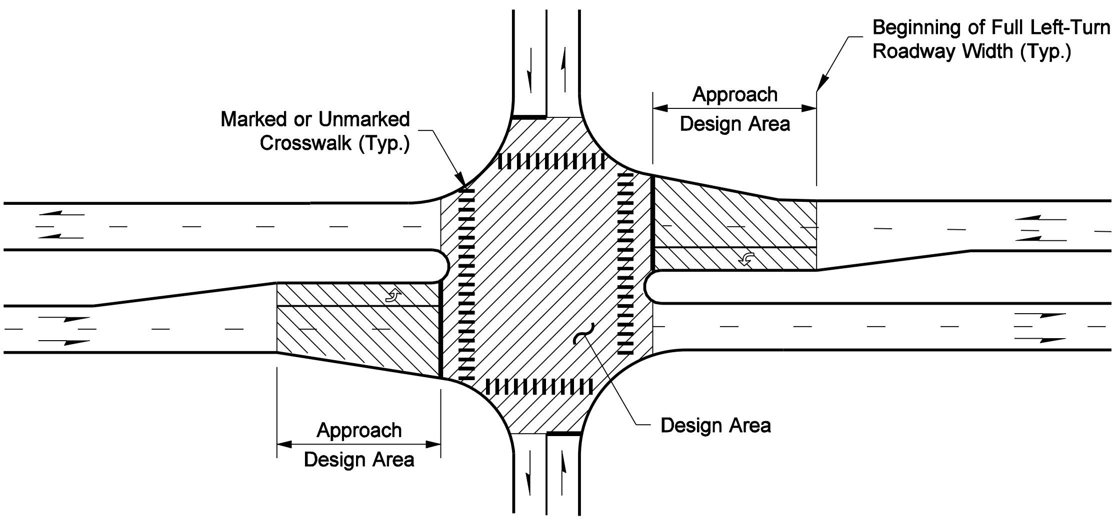


Exit-Only Lane
(The Design Area may be shifted up to 100 feet from the end of lane and the beginning of wide line)

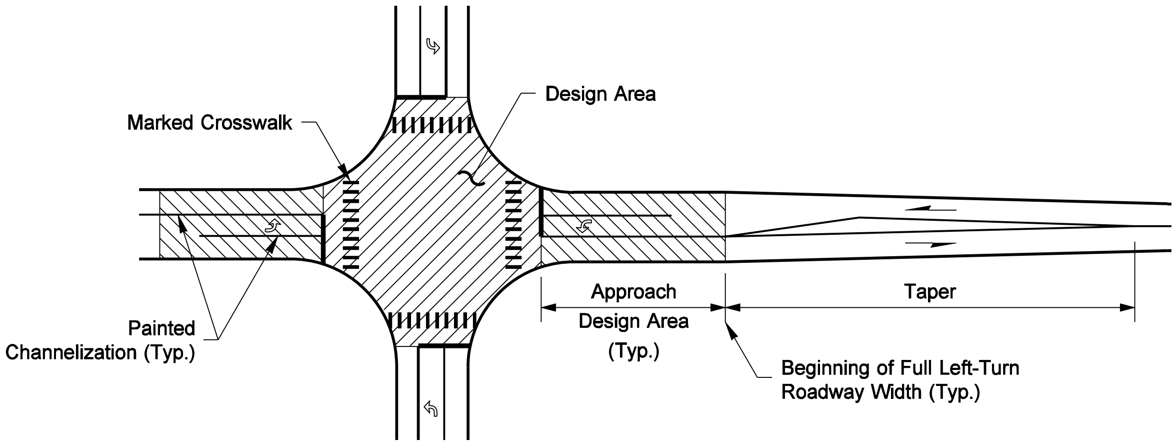
Freeway Lighting Applications
Figure 840-1c



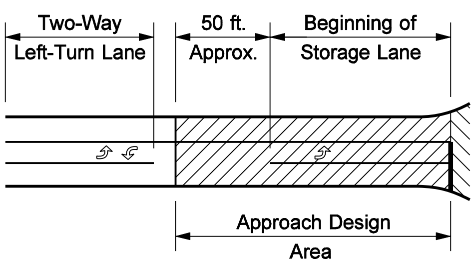
Freeway Ramp Terminals
Figure 840-2



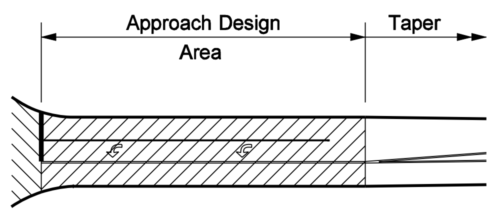
Intersection With Left-Turn Channelization
Figure 840-3a



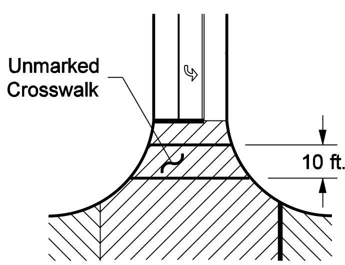
Intersection With Left-Turn Lane Channelization



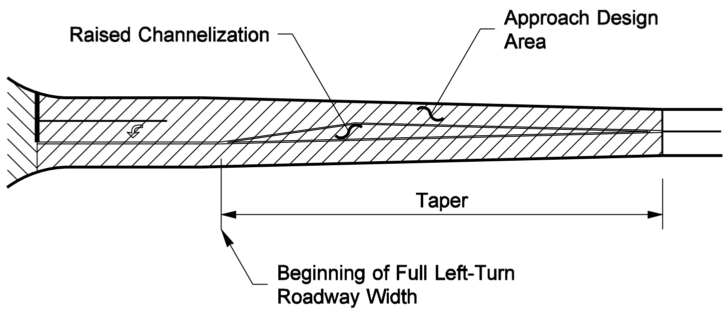
Alternate for Transitions to Two-Way Left-Turn Lanes



Alternate for Long Storage Lanes



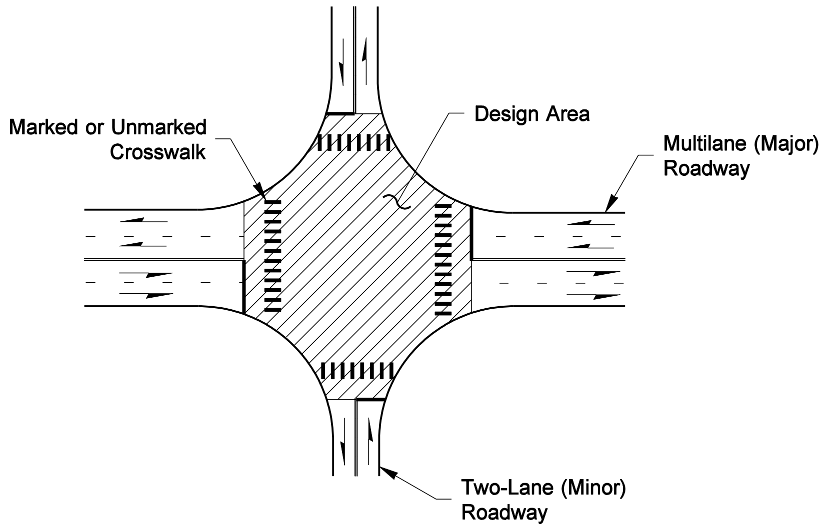
Unmarked Crosswalk Detail



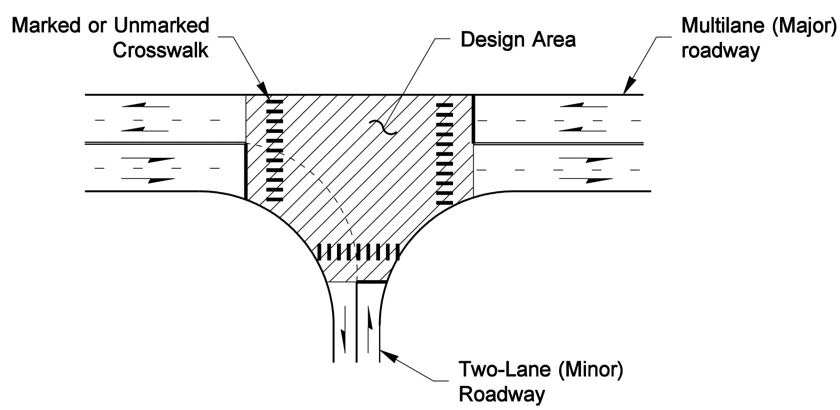
Alternate for Raised Channelization

Intersection With Left-Turn Lane Channelization

Figure 840-3b

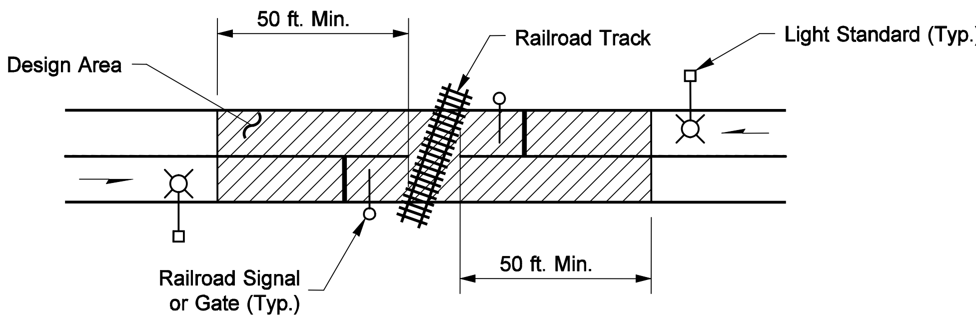


Four-Way Intersection
(Without left-turn channelization)

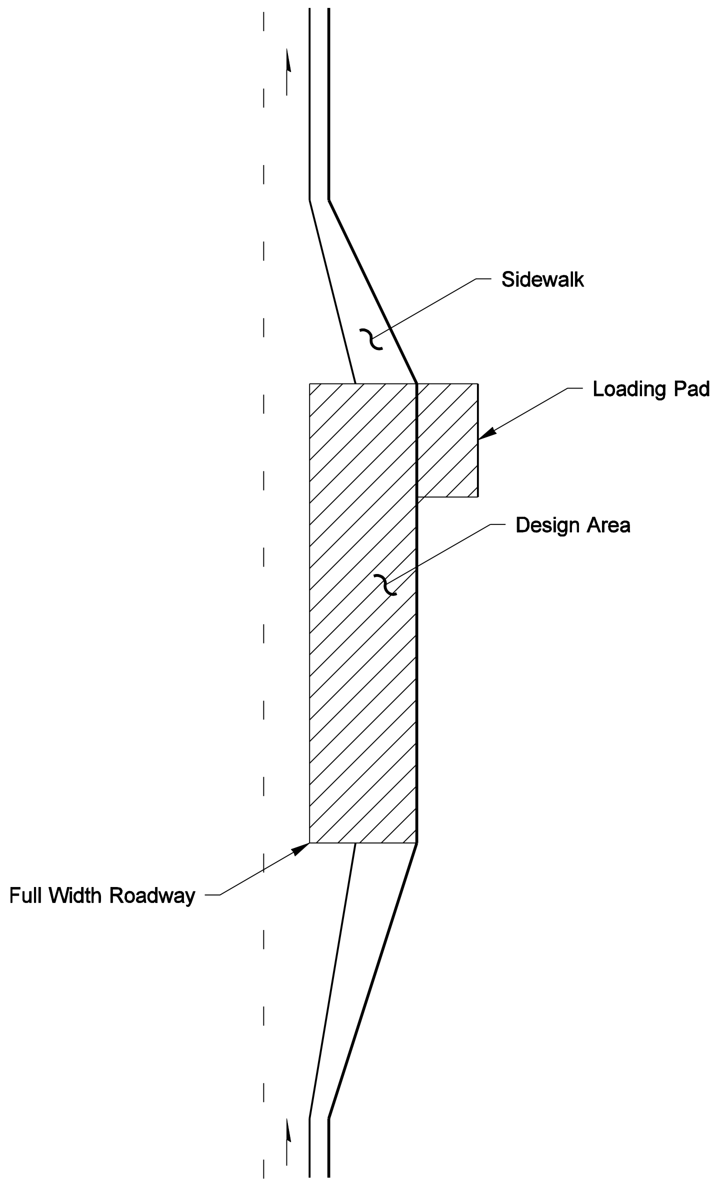


Major Tee Intersection
(Without left-turn channelization)

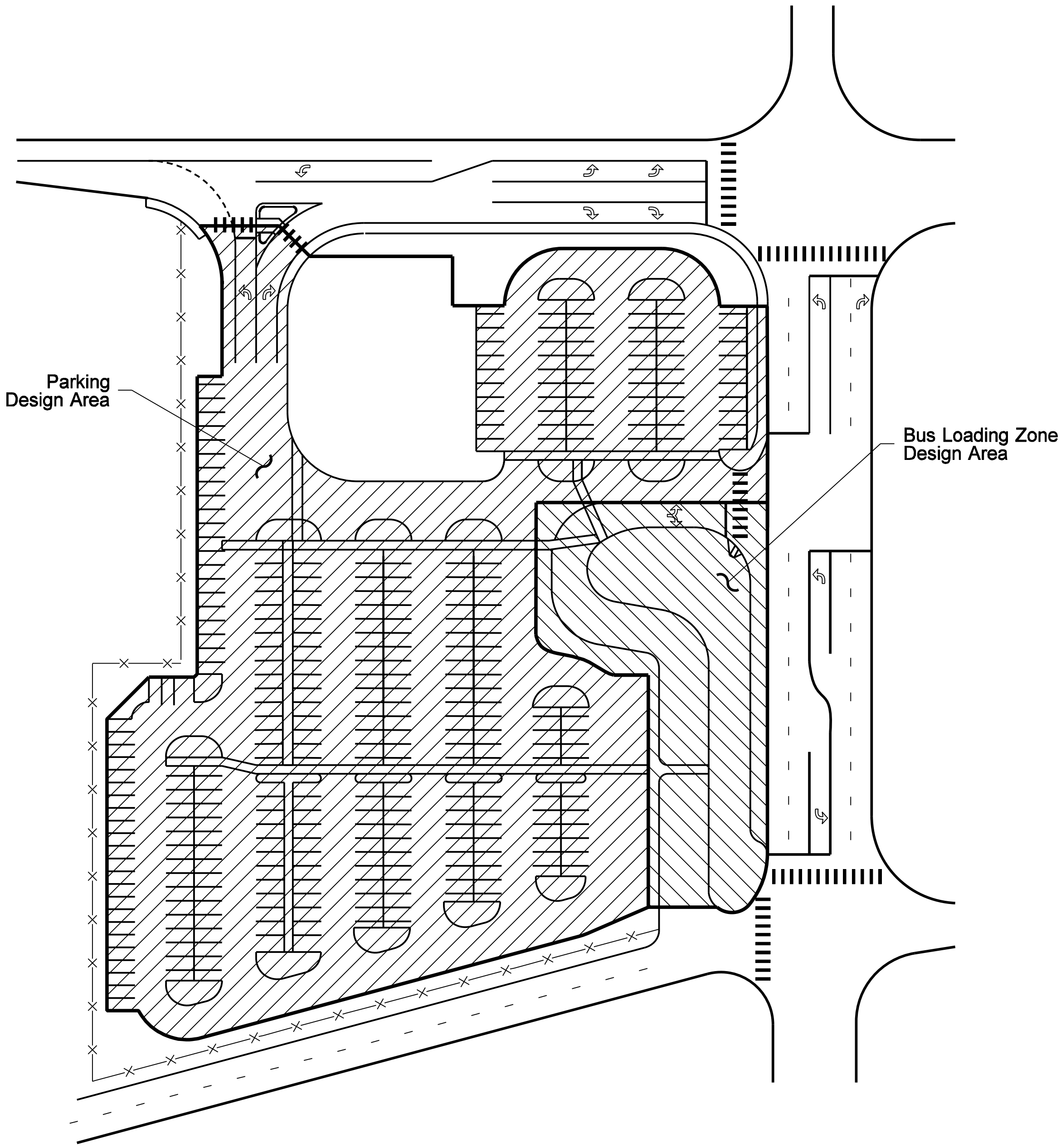
Intersection With Traffic Signals
Figure 840-4



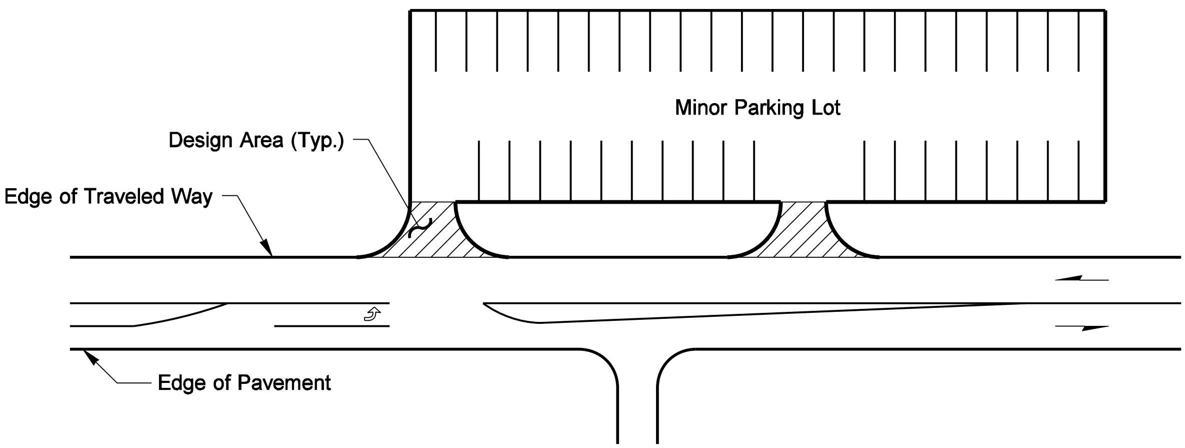
Railroad Crossing With Gates or Signals
Figure 840-5



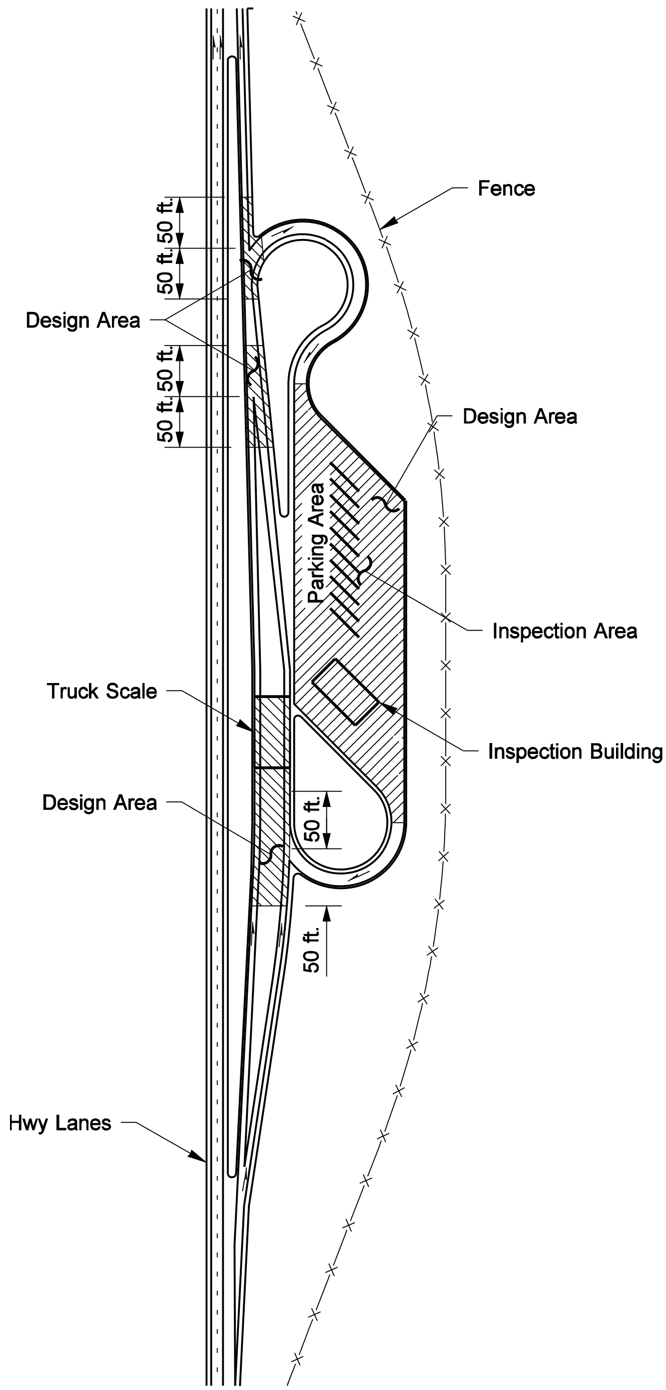
Transit Flyer Stop
Figure 840-6



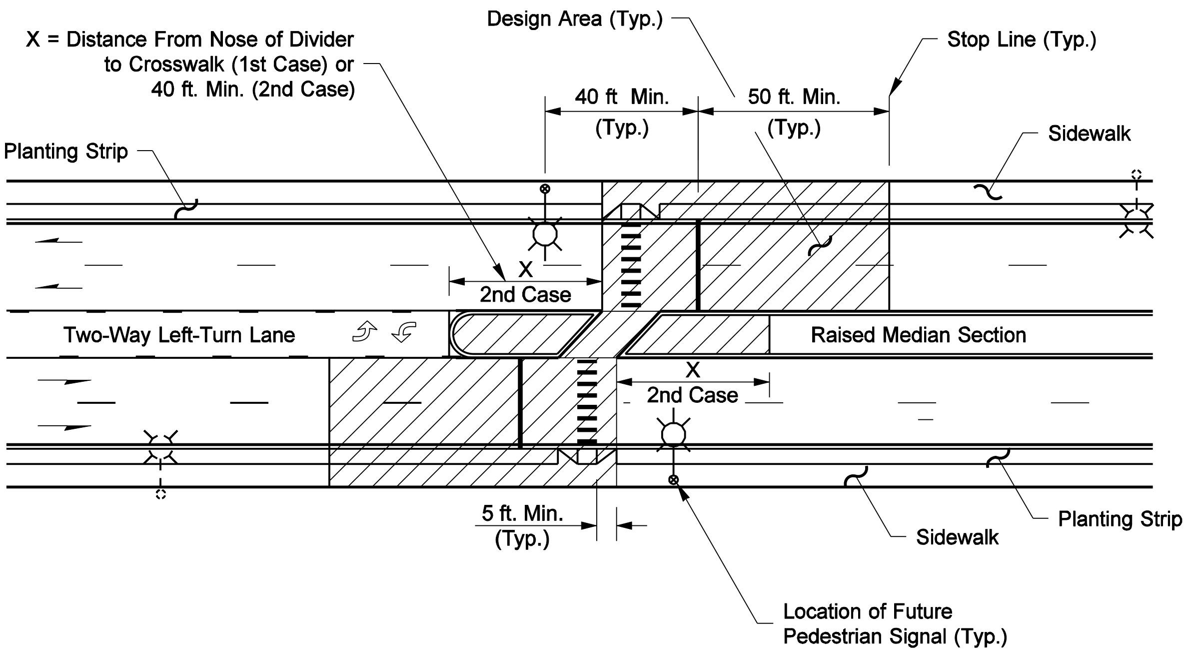
Major Parking Lot
Figure 840-7



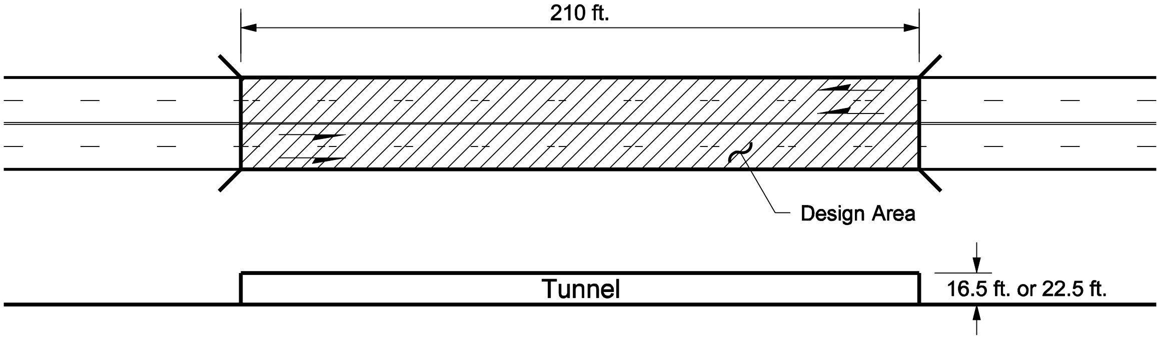
Minor Parking Lot
Figure 840-8



Truck Weigh Site
Figure 840-9



Midblock Crossing
Figure 840-10



If Tunnel Length Exceeds Stopping Sight Distance, Then It Is Classified as a Long Tunnel:

Example #1

- The stopping sight distance for a 30 mph roadway is 196.7’
- The tunnel length is 210’

196.7’ < 210’ – This would be a long tunnel.

Example #2

- The stopping sight distance for a 40 mph roadway is 300.6’
- The tunnel length is 210’

300.6’ > 210’ – This would be a short tunnel.

Determining Whether a Short Tunnel Needs Illumination:

Example #1

- Vertical clearance is 16.5’
- Tunnel length is 210’

If horizontal-to-vertical ratio is 10:1 or greater, then illuminate.

210’ divided by 16.5’ = 12.7:1 ratio – This ratio exceeds the short tunnel horizontal-to-vertical ratio of 10:1, so this tunnel would need illumination—OR–How long can the tunnel be at a given height before it needs to be illuminated?

Tunnel height x maximum ratio factor of short tunnel (10:1 or less).

16.5’ x 10 = 165’

165’ < 210’ – This tunnel would need illumination.

Example #2

- Vertical clearance is 22.5’
- Tunnel length is 210’

If horizontal-to-vertical ratio is 10:1 or greater, then illuminate.

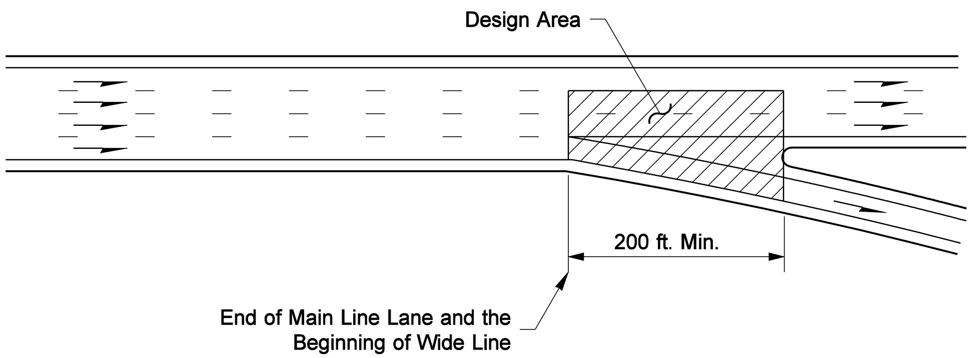
210’ divided by 22.5’ = 9.3:1 ratio – This ratio is less than the short tunnel horizontal-to-vertical ratio of 10:1, so this tunnel would not need illumination—OR—How long can the tunnel be at a given height before it needs to be illuminated?

Tunnel height x maximum ratio factor of short tunnel (10:1 or less).

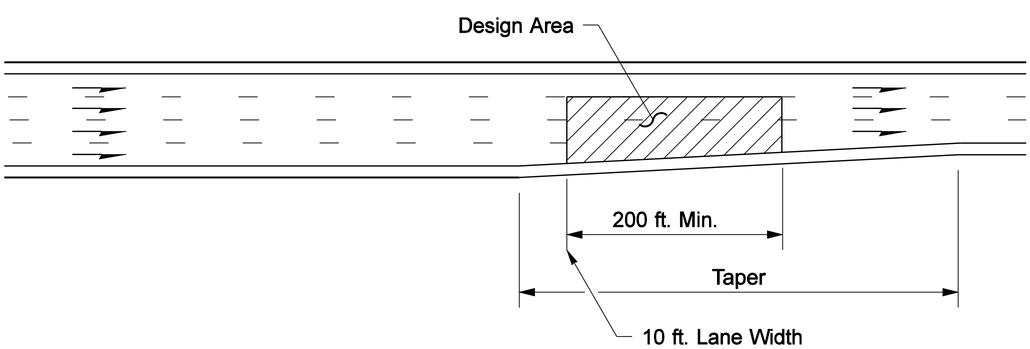
22.5’ x 10 = 225’

225’ > 210’ – This tunnel would not need illumination.

Tunnels
Figure 840-11

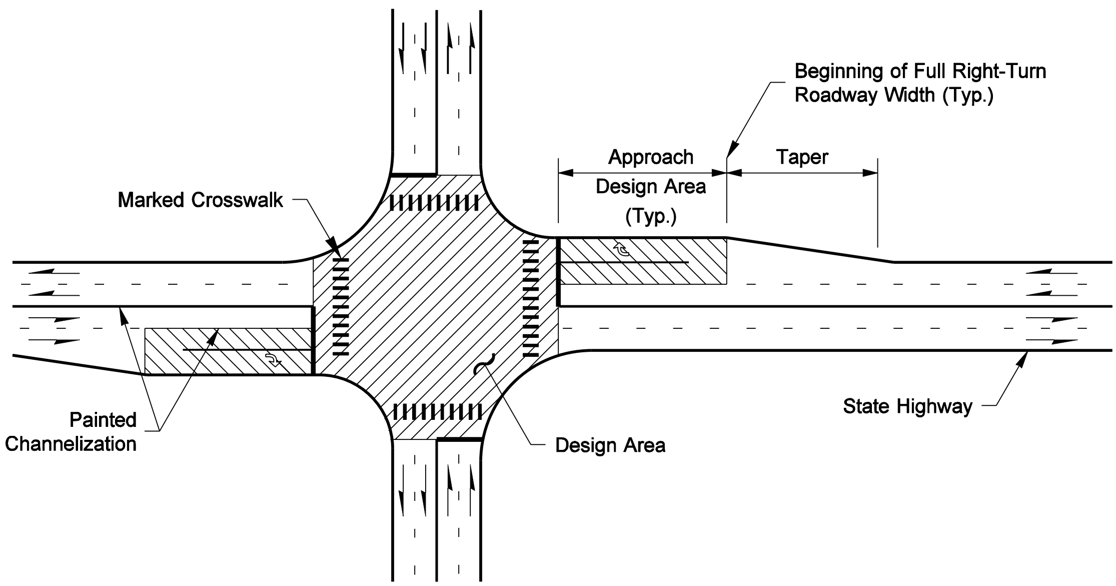


Main Line Lane Reduction
(The Design Area can be shifted up to 100 feet from the end of lane and the beginning of wide line)

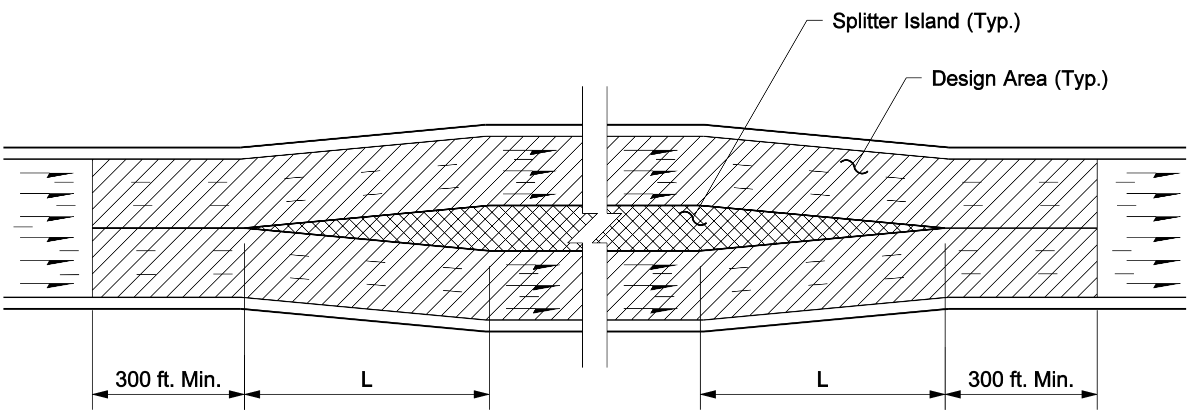


Lane Reduction

Lane Reductions
Figure 840-12



Intersection With Right-Turn Lane Channelization
Figure 840-13

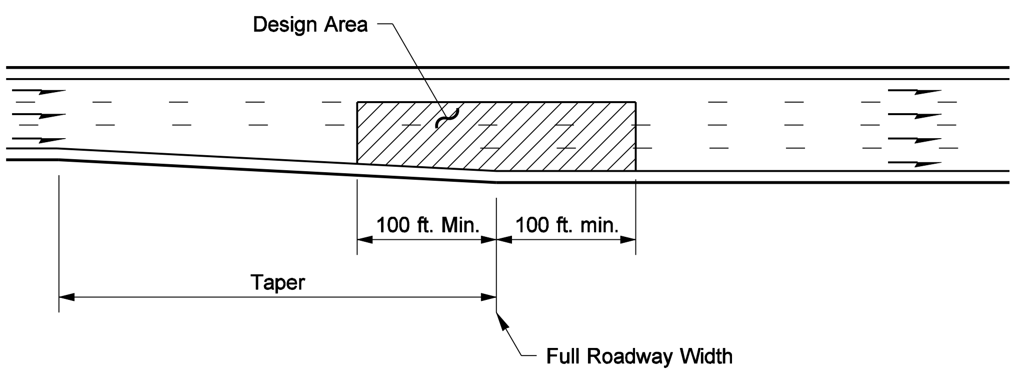


For speeds 45 mph or more: L = WS
For speeds less than 45 mph: L = WS/60

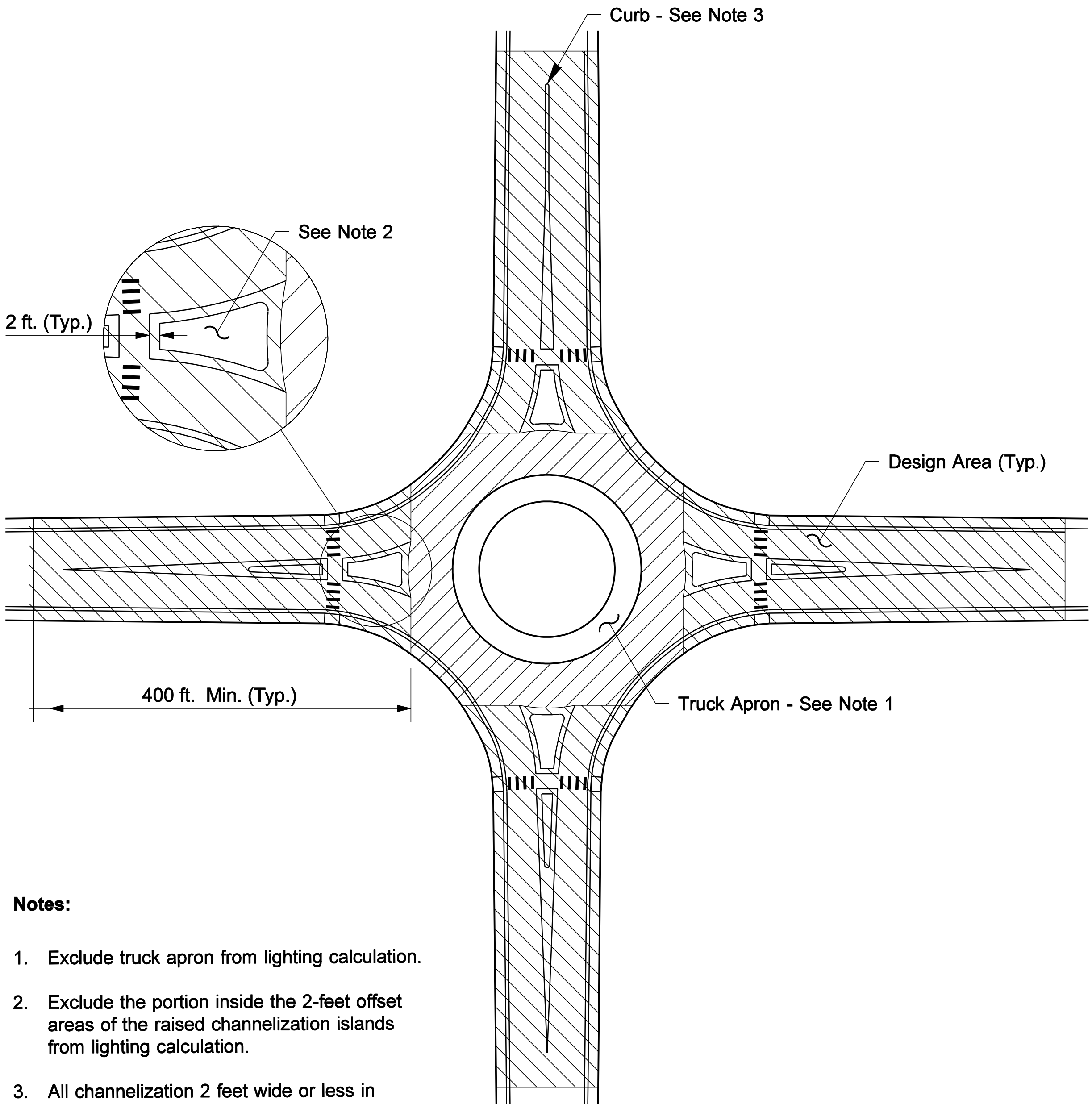
L = Taper length in feet
W = Width of offset in feet
S = Posted speed

For temporary Work Zone Plan applications, a site-specific Traffic Control Plan is required. Refer to Chapters 710 and 720 for traffic barrier and attenuator information, Chapter 810 for Work Zone information, and Chapter 820 for signing information.

Traffic Split Around an Obstruction – Same Direction
Figure 840-14



Add Lane
Figure 840-15

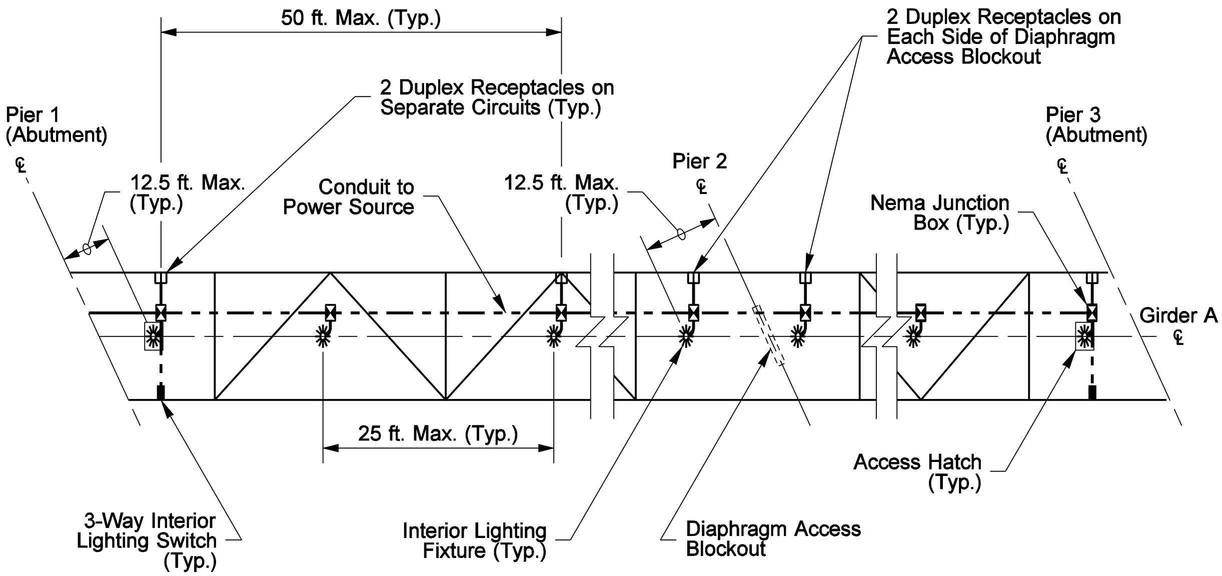


Notes:

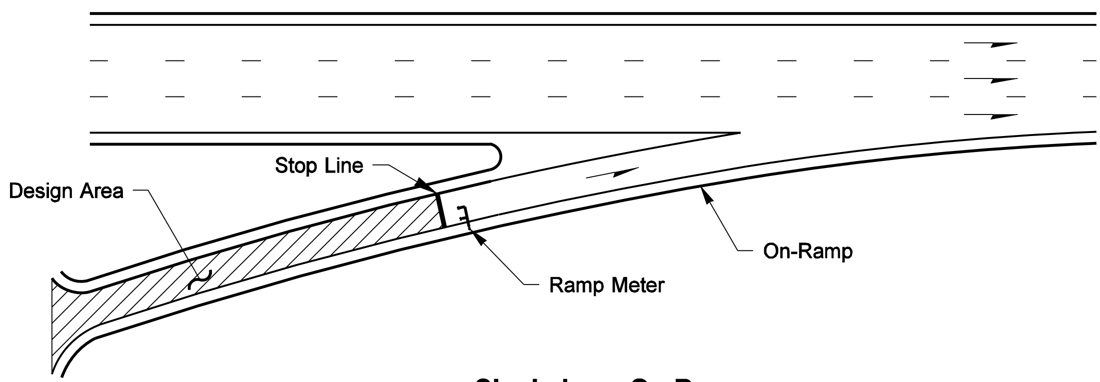
1. Exclude truck apron from lighting calculation.
2. Exclude the portion inside the 2-feet offset areas of the raised channelization islands from lighting calculation.
3. All channelization 2 feet wide or less in Design Area to be included in lighting calculation.

Roundabout

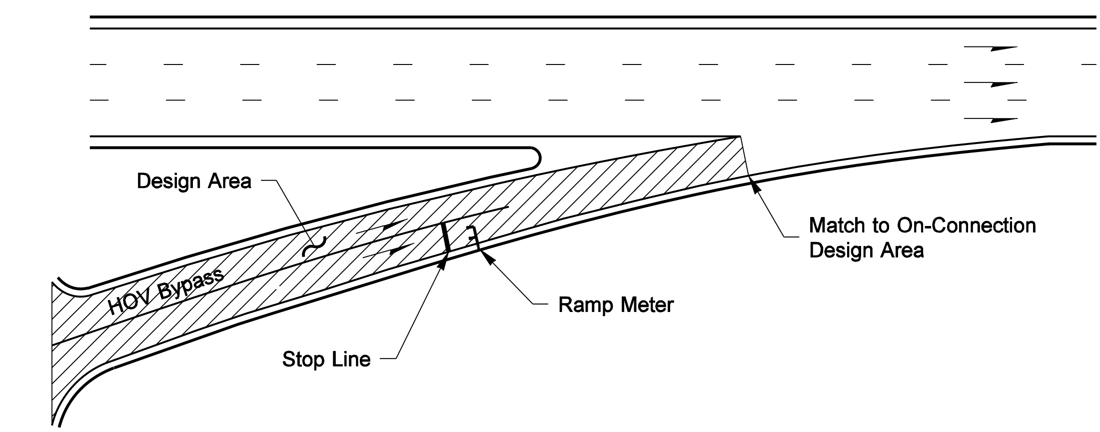
Figure 840-16



Bridge Inspection Lighting System
Figure 840-17

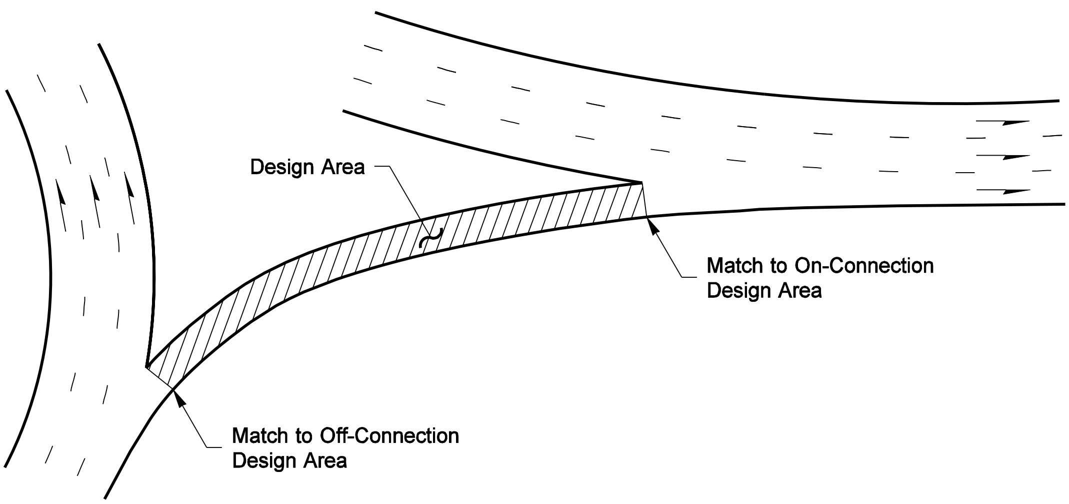


Single-Lane On-Ramp

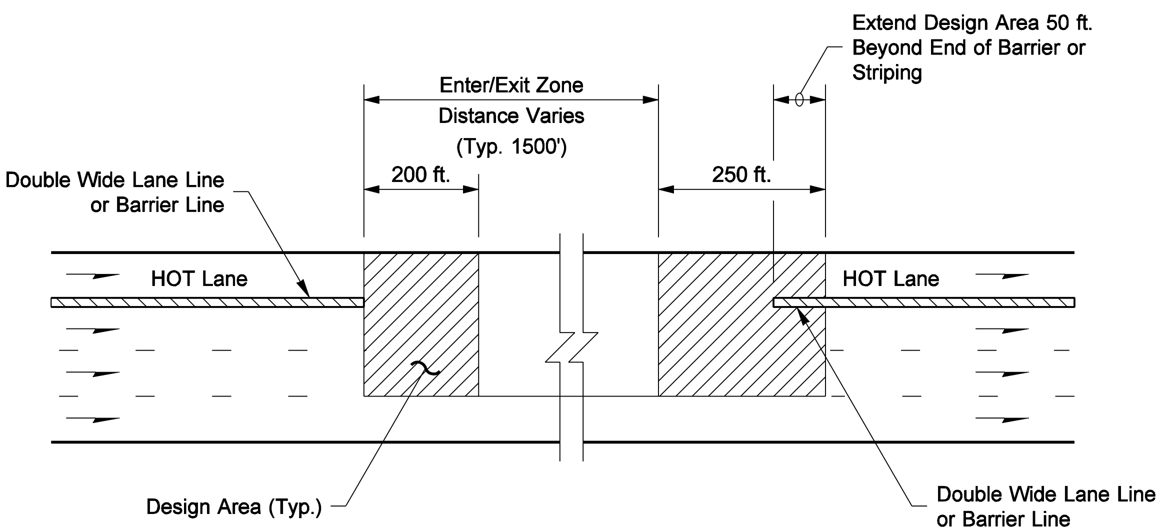


Two or More Lanes

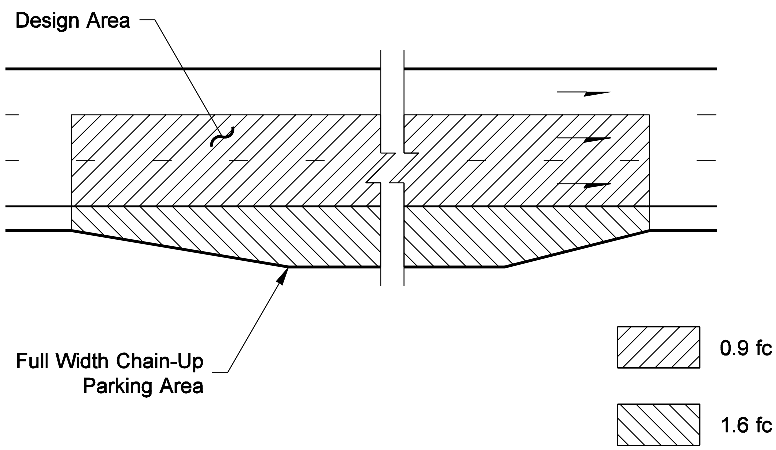
Ramp With Ramp Meter
Figure 840-18



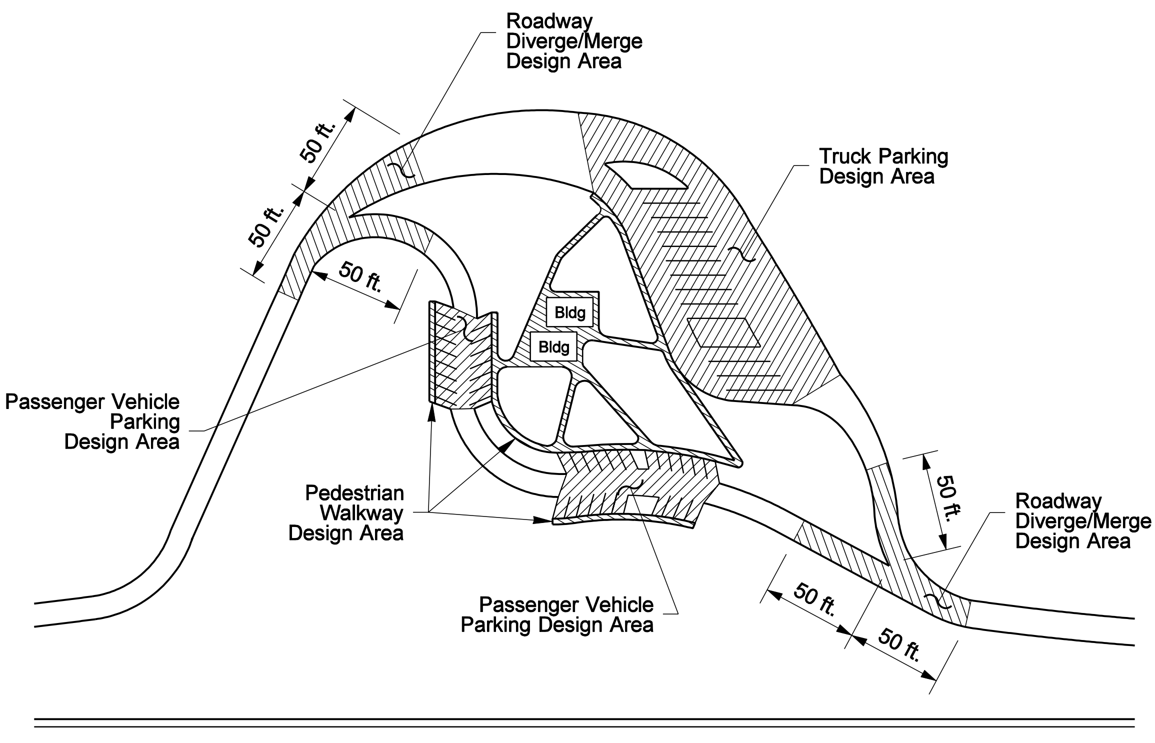
Freeway-to-Freeway Ramp Connection
Figure 840-19



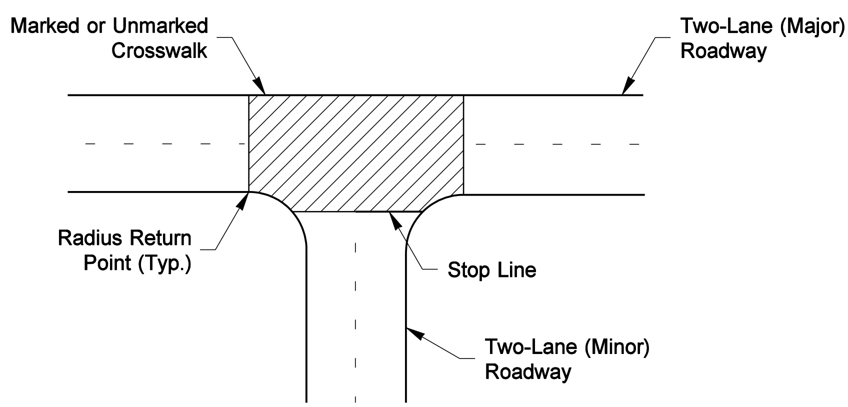
HOT (High Occupancy Toll) Lane Enter/Exit Zone
Figure 840-20



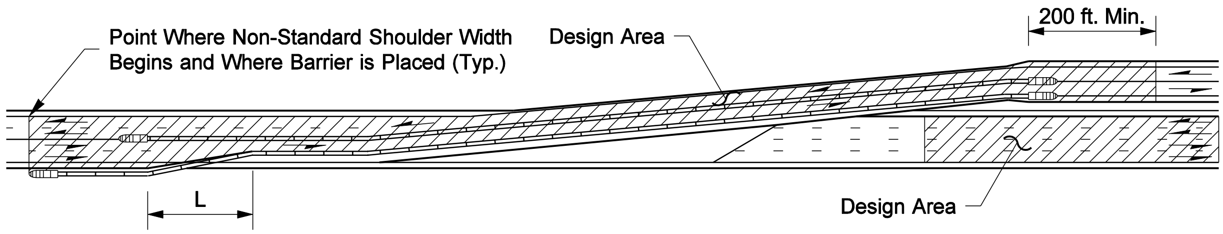
Chain-Up Parking Area
Figure 840-21



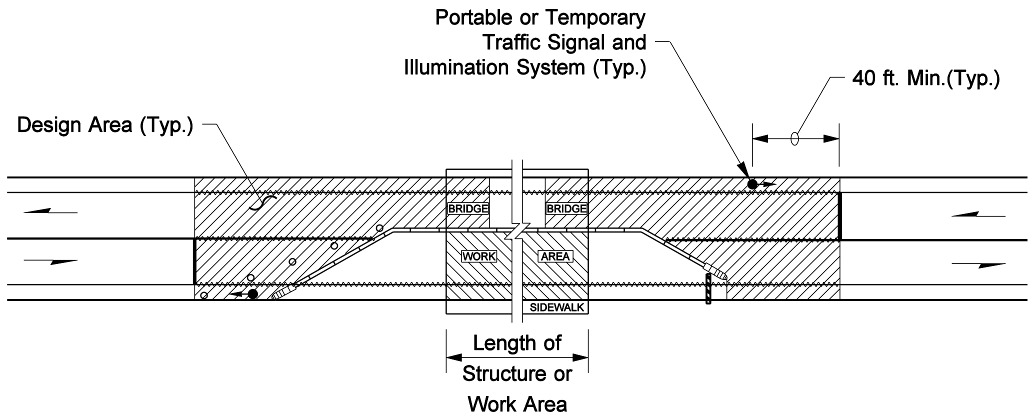
Rest Area
Figure 840-22



Intersection Without Channelization
Figure 840-23



Detour Traffic



Lane Closure With Barrier & Signals Without Flaggers or Spotters
(One Direction Closure Shown/Other Direction Closure Typical)

For temporary Work Zone Plan applications, a site-specific Traffic Control Plan is required.
Refer to Chapters 710 and 720 for traffic barrier and attenuator information,
Chapter 810 for Work Zone information, and Chapter 820 for signing information.
Refer to MUTCD Typical Application 12 for additional details.

Construction Work Zone and Detour

Figure 840-24

Light Level and Uniformity Ratio Chart					
Highway Design Class	**Minimum Average Maintained Horizontal Light Level(2)**			**Maximum Uniformity Ratio(6)**	**Maximum Veiling Luminance(7)**
	Pedestrian/Area Classification				
	High (footcandles)	Medium (footcandles)	Low (footcandles)		
Highways With Full Access Control(1)					
Main Line	0.6	0.6	0.6	4:1	0.3:1
Ramps	0.6	0.6	0.6	4:1	0.3:1
Crossroads	0.6	0.6	0.6	3:1	0.3:1
Ramp Intersections	0.9	0.9	0.9	3:1	0.3:1
Principal Arterials(3)					
Main Line	1.6	1.2	0.6	3:1	0.3:1
Intersections	1.6	1.2	0.9	3:1	0.3:1
Minor Arterials					
Main Line	1.2	0.9	0.6	4:1	0.3:1
Intersections	1.2	0.9	0.9	4:1	0.3:1
Collectors					
Main Line	1.1	0.8	0.6	4:1	0.3:1
Intersections	1.1	1.0	0.9	4:1	0.3:1
Construction Lanes and Detours	1.0	1.0	1.0	3:1	0.3:1
Major Parking Lots/ Rest Areas(5)	0.8	0.8	0.8	3:1	0.3:1
Vehicle Inspection Areas	2.0	2.0	2.0	3:1	0.3:1
Walkways & Bicycle Trails	0.8	0.8	0.8	3:1	0.3:1
Weigh Scales	0.8	0.8	0.8	3:1	0.3:1
Transit Stops(4)	2.0	2.0	2.0	NA(8)	0.3:1
Midblock Ped X-ing	2.0	2.0	2.0	3:1	0.3:1

Notes:

(1) The minimum light level is 0.2 footcandle (fc) for any application with a minimum average maintained horizontal light level of 0.6 fc. The minimum light levels for all other applications are controlled by the uniformity ratio.

(2) Light level and uniformity ratio apply only when installation of more than one light standard is justified.

(3) Light levels shown also apply to modified and partial limited access control.

(4) For single light standard installations, provide the light level at the location where the bus stops for riders. (See 840.06(6).)

(5) Includes illumination at ramp on and off connections.

(6) Minimum Average Maintained Light Level / Minimum Light Level = Maximum Uniformity Ratio.

(7) Maximum Veiling Luminance / Average Luminance = Maximum Veiling Luminance Ratio.

(8) The Maximum Uniformity Ratio is 3:1 when more than one light standard is justified.

Light Levels and Uniformity Ratios

Figure 840-25

850.01 General

Traffic control signals are power-operated traffic control devices that warn or direct motorists to take some specific action. More specifically, signals are used to control the assignment of right of way at locations where conflicts exist or where passive devices, such as signs and markings, do not provide the necessary flexibility of control to move traffic in a safe and efficient manner.

850.02 References

The following references are used in the design, construction, and operation of traffic control signals installed on state highways. The Revised Codes of Washington (RCWs) noted below are specific state laws concerning traffic control signals and conformance to these statutes is required.

RCW 35.77, "Streets-Planning, establishment, construction, and maintenance."

RCW 46.61.085, "Traffic control signals or devices upon city streets forming part of state highways—Approval by department of transportation."

RCW 47.24.020 (6) and (13), "Jurisdiction, control."

RCW 47.36.020, "Traffic control signals."

RCW 47.36.060, "Traffic devices on county roads and city streets."

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings."

Directive D 55-03, "Responsibility for Traffic Control Devices, Pavement Widening, and Channelization at Existing Intersections and Two-Way Left Turn Lanes in Cities"

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT, Washington DC, 1988, including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT, 1996

Plans Preparation Manual, M 22-31, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

850.03 Definitions

The various types of traffic control signals are defined below. Hazard identification beacons and ramp meter signals are energized only at specific times. All other signals remain in operation at all times.

conventional traffic signal A permanent or temporary installation providing alternating right of way assignments for conflicting traffic movements. At least two identical displays are required for the predominant movement on each approach.

emergency vehicle signal A special adaptation of a conventional traffic signal installed to allow for the safe movement of authorized emergency vehicles. Usually this type of signal is installed on the highway at the entrance into a fire station or other emergency facility. The signal assures protected entrance onto the highway for the emergency vehicle. When not providing for this movement, the signal either operates continuously, consistent with the requirements for a conventional traffic signal, or displays continuous green (allowed at nonintersection locations only). At least two identical displays are required per approach.

hazard identification beacon A beacon that supplements a warning or regulatory sign or marking. The display is a flashing yellow indication. These beacons are not used with "stop", "yield", or "do not enter" signs. A hazard identification beacon is energized only during those hours when the hazard or regulation exists.

intersection control beacon (flashing beacon) A secondary control device, generally suspended over the center of an intersection, that supplements intersection warning signs and stop signs. One display per approach may be used but two displays per approach are desirable. Intersection control beacons are installed only at an intersection to control two or more directions of travel.

lane control signal (reversible lanes) A special overhead signal that permits, prohibits, or warns of impending prohibition of lane use.

moveable bridge signal (drawbridge signal) A signal installed to notify traffic to stop when the bridge is opened for waterborne traffic. Moveable bridge signals display continuous green when the roadway is open to vehicular traffic.

overlapped displays Overlapped displays allow a nonconflicting traffic movement to run with another phase. Most commonly, a minor street's exclusive right-turn phase is overlapped with the nonconflicting major street's left-turn phase. An overlapped display can be terminated after the parent phase terminates. An overlapped display programmed for two or more parent phases continues to display until all of the parent phases have terminated.

pedestrian signal An adaptation of a conventional traffic signal installed at established pedestrian crossings. It is used to create adequate gaps in the vehicular movement to allow for safe pedestrian crossings. When not operating as a pedestrian signal, the system operates consistent with the requirements for an emergency vehicle signal.

portable traffic signal A type of conventional traffic signal used in work zones to control traffic. It is typically used on two-way, two-lane highways where one lane has been closed for roadwork. The traffic signal provides alternating right of way assignments for conflicting traffic movements. The signal has an adjustable vertical support with two three-section signal displays and is mounted on a mobile trailer with its own power source.

ramp meter signal A signal used to control the flow rate of traffic entering a freeway or similar facility. A minimum of two displays is required. When not in use, ramp meter signals are not energized.

speed limit sign beacon A beacon installed with a fixed or variable speed limit sign. The display is a flashing yellow indication.

stop sign beacon A beacon installed above a stop sign. The display is a flashing red indication.

temporary traffic signal A conventional traffic signal used during construction to control traffic at an intersection while a permanent signal system is being constructed. A temporary traffic signal is typically an inexpensive span-wire installation using timber strain poles.

850.04 Procedures

(1) Permit

State statutes (RCWs) require Department of Transportation approval for the design and location of all conventional traffic signals and some types of beacons located on city streets forming parts of state highways. Approval by the Department of Transportation for the design, location, installation, and operation of all other traffic control signals installed on state highways is required by department policy.

The Traffic Signal Permit (DOT Form 242-014 EF) is the formal record of the department's approval of the installation and type of signal. The permit is completed by the responsible agency and submitted to the Regional Administrator for approval. The region retains a record of the permit approval, complete with supporting data, and a copy is forwarded to the State Traffic Engineer at the Olympia Service Center (OSC). Permits are required for the following types of signal installations:

- Conventional traffic signals
- Emergency vehicle signals
- Hazard identification beacons, when installed overhead at an intersection

- Intersection control beacons
- Lane control signals
- Moveable bridge signals
- Portable signals
- Ramp meter signals
- Pedestrian signals
- Temporary signals

Emergency vehicle signals require annual permit renewal. The region's traffic office reviews the installation for compliance with standards. If satisfactory, the permit is renewed by the Regional Administrator by way of a letter to the operating agency. A copy of this letter is also sent to the State Traffic Engineer.

Permits are not required for hazard identification beacons that are not installed overhead at an intersection, speed limit sign beacons, stop sign beacons, and lane assignment signals at toll facilities.

When it is necessary to increase the level of control, such as changing from an intersection control beacon to a conventional traffic signal, a new permit application is required. If the change results in a reduction in the level of control, as in the case of converting a conventional signal to a flashing intersection beacon, or if the change is the removal of the signal, submit the "Report of Change" portion of the traffic signal permit to the Regional Administrator with a copy to the State Traffic Engineer.

(2) Responsibility for Funding, Construction, Maintenance, and Operation

Responsibility for the funding, construction, maintenance, and operation of traffic signals on state highways has been defined by legislative action and transportation commission resolutions. See Figure 850-3. Responsibilities vary depending on location, jurisdiction, and whether or not limited access control has been established. Limited access as used in this chapter refers to full, partial, or modified limited access control as identified in the "Master Plan for Limited Access Highways Route Listing".

(a) **Inside the corporate limits of cities with a population of less than 22,500.** The Department of Transportation is responsible for funding, construction, maintenance, and operation of traffic signals.

(b) **Inside the corporate limits of cities with a population of 22,500 or greater where there is no established limited access control.** The city is responsible for the funding, construction, maintenance, and operation of traffic signals.

(c) **Inside the corporate limits of cities with a population of 22,500 or greater where there is established limited access control.** The Department of Transportation is responsible for funding, construction, maintenance, and operation of traffic signals.

(d) **Outside the corporate limits of cities and outside established limited access control areas.** The Department of Transportation is responsible for funding, construction, maintenance, and operation of a signal when a new state highway crosses an existing county road. The Department of Transportation is responsible for only the maintenance and operation when a new county road intersects an existing state highway. The county is responsible for the construction costs of the signal and associated illumination. When it is necessary to construct a traffic signal at an existing county road and state highway intersection, the construction cost distribution is based on the volume of traffic entering the intersection from each jurisdiction's roadway. The county's share of the cost, however, is limited to a maximum of fifty percent. The state is responsible for maintenance and operation. See WAC 468-18-040 for details.

(e) **Outside the corporate limits of cities and inside established limited access control areas**. The Department of Transportation is responsible for funding, construction, maintenance, and operation of traffic signals.

(f) **Emergency Vehicle Signals**. The emergency service agency is responsible for all costs associated with emergency vehicle signals.

(g) **Third Party Agreement Signals**. At those locations where the Department of Transportation is responsible for signals and agrees that the proposed signal is justified but where funding schedules and priorities do not provide for the timely construction of the signal requested by others, the following rules apply:

- The third party agrees to design and construct the traffic signal in conformance with the Department of Transportation's standards.
- The third party agrees to submit the design and construction documents to the Department of Transportation for review and approval.
- The third party obtains a traffic signal permit.

850.05 Signal Warrants

The requirements for traffic signal warrants are in the MUTCD. A signal warrant is a minimum condition in which a signal may be installed. Satisfying a warrant does not mandate the installation of a traffic signal. The warranting condition indicates that an engineering study, including a comprehensive analysis of other traffic conditions or factors, is required to determine whether the signal or another improvement is justified. There are eleven warrants for conventional traffic signal installations. These warrants are as follows:

- Warrant 1 Minimum vehicular volume
- Warrant 2 Interruption of continuous traffic
- Warrant 3 Minimum pedestrian volume
- Warrant 4 School crossings
- Warrant 5 Progressive movement
- Warrant 6 Accident experience
- Warrant 7 Systems
- Warrant 8 Combination of warrants
- Warrant 9 Four Hour Volumes
- Warrant 10 Peak Hour Delay
- Warrant 11 Peak Hour Volume

Warrants 1, 2, 9, and 11 of the MUTCD allow a reduction in the major street vehicle volume requirements when the 85th percentile speed exceeds 40 mph. This provision only acknowledges a difference in driver behavior on higher speed roadways. It does not imply that traffic signals are always the most effective solution on these facilities. A proposal to install a traffic signal on any state route with a posted speed of 45 mph or higher requires an alternatives analysis. See Chapter 910. A proposal to install a traffic signal on a high speed highway requires Olympia Service Center Design Office review and concurrence.

Warrant 6, Accident experience, is used when the types of accidents are correctable by the installation of a traffic signal. Correctable accidents typically are angle and side impact collisions with turning or entering vehicles.

Rear-end, sideswipe, and single vehicle accidents are usually not correctable with the installation of a traffic signal and are only used in special circumstances to satisfy the requirements of the accident warrant. In the project file, include an explanation of the conditions justify using these types of accidents to satisfy the accident warrant.

850.06 Conventional Traffic Signal Design

(1) General

The goal of any signal design is to assign right of way in the most efficient manner possible and still be consistent with traffic volumes, intersection geometrics, and safety.

(2) Signal Phasing

As a general rule, although there are exceptions, the fewer signal phases the more efficient the operation of the traffic signal. The number of phases required for safe, efficient operation is related to the intersection geometrics, traffic volumes, the composition of the traffic flow, turning movement demands, and the level of driver comfort desired. The traffic movements at an intersection have been standardized to provide a consistent system for designing traffic signals. See Figure 850-4 for standard intersection movements, signal head numbering, and the standard phase operation. Figure 850-5 shows the phase diagrams for various signal operations.

(a) **Level of Service.** The efficiency of a traffic signal is measured differently than highways. While highways use the number and width of lanes and other factors to determine capacity and a level of service, traffic signals are measured or rated by the overall delay imposed on the motorists. Phase analysis is the tool used to find the anticipated delay for all movements. These delay values are then equated to a level of service. There are several computer-based programs for determining delay and level of service. Letter designations from "A" to "F" denote the level of service (LOS) with "F" being the worst condition.

In new construction or major reconstruction projects where geometric design can be addressed, a level of service of at least "D" in urban locations and "C" in rural areas is desirable on state highways. These levels of service are a projection of the conditions that will be present during the highest peak hour for average traffic volumes during the design year of the traffic signal's operation. Special or seasonal events of short duration or holidays, which can generate abnormally high traffic volumes, are not considered in this determination. Provide an explanation in the project file when the desired level of service cannot be obtained.

Intersection level of service can be improved by either adding traffic lanes or eliminating conflicting traffic movements. Intersections can sometimes be redesigned to compress the interior of the intersection by eliminating medians, narrowing lanes, or reducing the design vehicle turning path requirements. This compression reduces the travel time for conflicting movements and can reduce overall delay.

(b) **Left-turn phasing.** Left-turn phasing can be either permissive, protected, or a combination of both that is referred to as protected/permissive.

1. **Permissive left-turn phasing** requires the left turning vehicle to yield to opposing through traffic. Permissive left-turn phasing is used when the turning volume is minor and adequate gaps occur in the opposing through movement. This phasing is more effective on minor streets where providing separate, protected turn phasing might cause significant delays to the higher traffic volume on the main street. On high speed approaches or where sight distance is limited, consider providing a separate left-turn storage lane for the permissive movement to reduce the frequency of rear end type accidents and to provide safe turning movements.

2. **Protected/permissive left-turn phasing** means that the left-turn movements have an exclusive nonconflicting phase followed by a secondary phase when the vehicles are required to yield to opposing traffic. Where left-turn phasing will be installed and conditions do not warrant protected-only operation, consider protected/permissive left-turn phasing. Protected/permissive left-turn phasing can result in increased efficiency at some types of intersections, particularly "Tee" intersections, ramp terminal intersections, and intersections of a two-way street with a one-way street where there are no opposing left movements. Due to the geometry of these types of intersections, neither the simultaneous display of a circular red indication with a green left-turn arrow nor the condition referred to as "yellow trap" occur.

"Yellow trap" occurs on a two-way roadway when the permissive left-turn display changes to protected-only mode on one approach, while the display remains in the permissive mode on the opposite approach where a left turning motorist sees a yellow indication on the adjacent through movement. The motorist believes the opposing through movement also has a yellow display, when, in fact, that movement's display remains green. It is possible to prevent "yellow trap" by recalling the side street, however, this can lead to inefficient operation and is not desirable.

3. **Protected left-turn phasing** provides the left turning vehicle a separate phase and conflicting movements are required to stop.

Protected phasing is always required for multilane left-turn movements.

Use protected left-turn phasing when left turning type accidents on any approach equal 3 per year, or 5 in two consecutive years. This includes left turning accidents involving pedestrians.

Use protected left-turn phasing when the peak hour turning volume exceeds the storage capacity of the turn lane because of insufficient gaps in the opposing through traffic and one or more of the following conditions are present:

- The 85th percentile speed of the opposing traffic exceeds 45 mph.
- The sight distance of oncoming traffic is less than 250 ft when the 85th percentile speed is 35 mph or below or less than 400 ft if the 85th percentile speeds are above 35 mph.
- The left-turn movement crosses three or more lanes (including right-turn lanes) of opposing traffic.
- Geometry or channelization is confusing.

Typically, an intersection with protected left turns operates with leading left turns. This means that on the major street, the left-turn phases, phase 1 and phase 5, time before the through movement phases, phase 2 and phase 6. On the minor street, the left-turn phases, phase 3 and phase 7, time before phase 4 and phase 8. Lagging left-turn phasing means that the through phases time before the conflicting left-turn phases. In lead-lag left-turn phasing one of the left-turn phases times before the conflicting through phases and the other left-turn phase times after the conflicting through phases. In all of these cases, the intersection phasing is numbered in the same manner. Leading, lagging, and lead-lag left-turn phasing are accomplished by changing the order in which the phases time internally within the controller.

(c) **Multilane left-turn phasing.** Multilane left turns can be effective in reducing signal delay at locations with high left turning volumes or where the left-turn storage area is limited longitudinally. At locations with closely spaced intersections, a two-lane left-turn storage area might be the only solution to prevent the left-turn volume from backing up into the adjacent intersection. Consider the turning paths of the vehicles when proposing multilane left turns. At smaller intersections the opposing left turn might not be able to turn during the two-lane left-turn phase and it might be necessary to reposition this lane. If the opposing left turns cannot time together the reduction in delay from the two-lane left-turn phase might be nullified by the requirement for separate opposing left-turn phase. Figure 850-6 shows two examples of two-lane left with opposing single left arrangements.

A two-lane exit is required for the two-lane left-turn movements. In addition, this two-lane exit must extend well beyond the intersection. A lane reduction on this exit immediately beyond the intersection will cause delays and backups into the intersection because the left turning vehicles move in dense platoons and lane changes are difficult. See Chapter 910 for the restrictions on lane reductions on intersection exits.

(d) **Right-turn phasing.** Right-turn overlapped phasing can be considered at locations with a dedicated right-turn lane where the intersecting street has a complimentary protected left-turn movement and U-turns are prohibited. Several right-turn overlaps are shown in the Phase Diagrams in Figure 850-5. The display for this movement is dependent on whether a pedestrian movement is allowed to time concurrently with the through movement adjacent to the right-turn movement.

For locations with a concurrent pedestrian movement, use a five section signal head consisting of circular red, yellow, and green displays with yellow and green arrow displays. Connect the circular displays to the through phase adjacent to the right-turn movement and connect the arrow displays to the complimentary conflicting minor street left-turn phase.

For locations without a concurrent pedestrian movement, use a three section signal head with all arrow displays or visibility limiting displays (either optically programmed sections or louvered visors) with circular red, yellow arrow, and green arrow displays. This display is in addition to the adjacent through movement displays. Program this display as an overlap to both the left-turn phase and the adjacent through phase.

(e) **Two-lane right-turn phasing.** Two-lane right-turn phasing can be used for an extraordinarily heavy right-turn movement. They can cause operation problems when “right turn on red” is permitted at the intersection. Limited sight distance and incorrect exit lane selection are pronounced and can lead to an increase in accidents. In most cases, a single unrestricted “right turn only” lane approach with a separate exit lane will carry a higher traffic volume than the two-lane right-turn phasing.

(f) **Phasing at railroad crossings.** Railroad preemption phasing is required at all signalized intersections when the nearest rail of a railroad crossing is within 200 ft of the stop bar of any leg of the intersection, unless the railroad crossing is rarely used or is about to be abandoned. Preemption for intersections with the railroad crossing beyond 200 ft from the intersection stop line is only considered when the queue on that approach routinely occupies the crossing. Contact the railroad company to determine if this line still actively carries freight or passengers.

Railroad preemption has two distinct intervals; the clearance interval before the train arrives and the passage interval when the train is crossing the intersection leg. During the clearance interval, all phases are terminated and the movement on the railroad crossing leg is given priority. When this movement has cleared the crossing, it is then terminated. During the passage interval, the traffic signal cycles between the movements not affected by the train crossing. See Figure 850-7 for an example of railroad preemption phasing.

Arranging for railroad preemption requires a formal agreement with the railroad company. The region’s Utilities Engineer’s office handles this transaction. Contact this office early in the design stage as this process can be time consuming and the railroad company might require some modifications to the design.

(3) Intersection Design Considerations

Left turning traffic can be better accommodated when the opposing left-turn lanes are directly opposite each other. When a left-turn lane is offset into the path of the approaching through lane, the left turning driver might assume that the approaching vehicles are also in a left-turn lane and fail to yield. To prevent this occurrence, less efficient split phasing is necessary.

Consider providing an unrestricted through lane on the major street of a “T” intersection. This design allows for one traffic movement to flow without restriction.

Skewed intersections, because of their geometry, are difficult to signalize and delineate. When possible, modify the skew angle to provide more normal approaches and exits. The large paved areas for curb return radii at skewed intersections, in many cases, can be reduced when the skew angle is lessened. See Chapter 910 for requirements and design options.

If roadway approaches and driveways are located too close to an intersection, the traffic from these facilities can affect signal operation. Consider restricting their access to “Right In / Right Out” operation.

Transit stop and pull out locations can affect signal operation. See Chapter 1060 for transit stop and pull out designs. When possible, locate these stops and pull outs on the far side of the intersection for the following benefits:

- Minimizes overall intersection conflict, particularly the right-turn conflict.
- Minimizes impact to the signal operation when buses need preemption to pull out.
- Provides extra pavement area where U-turn maneuvers are allowed.
- Eliminates the sight distance obstruction for drivers attempting to turn right on red.
- Eliminate conflict with right-turn pockets.

Large right-turn curb radii at intersections sometimes have negative impacts on traffic signal operation. Larger radii allow faster turning speeds and might move the entrance point farther away from the intersection area. See Chapter 910 for guidance in determining these radii.

At intersections with large right-turn radii, consider locating signal standards on raised traffic islands to reduce mast arm lengths. These islands are primarily designed as pedestrian refuge areas. See Chapter 1025 for pedestrian refuge area and traffic island designs.

Stop bars define the point where vehicles must stop to not be in the path of the design vehicle's left turn. Check the geometric layout by using the turning path templates in Chapter 910 or a computerized vehicle turning path program to determine if the proposed phasing can accommodate the design vehicles. Also, check the turning paths of opposing left-turn movements. In many cases, the phase analysis might recommend allowing opposing left turns to run concurrently, but the intersection geometrics are such that this operation cannot occur.

(4) Crosswalks and Pedestrians

Provide pedestrian displays and push buttons at all signalized intersections unless the pedestrian movement is prohibited. Crosswalks, whether marked or not, exist at all intersections. See Chapter 1025 for additional information on marked crosswalks. If a pedestrian movement will be prohibited at an intersection, provide signing for this prohibition. This signing is positioned on both the near side and far side on the street to be visible to the pedestrians. When positioning these signs for visibility, consider the location of the stop bar where this crossing will be prohibited. Vehicles stopped at the stop bar might obstruct the view of the signing. There are normally three crosswalks at a "T" intersection and four crosswalks at "four legged" intersection. For pedestrian route continuity the minimum number of crosswalks is two at "T" intersections and three for "four legged" intersections.

If a crosswalk is installed across the leg where right or left turning traffic enters, the vehicle display cannot have a green turn arrow indication during the pedestrian "walk" phase. If this cannot be accomplished, provide a separate pedestrian or vehicle turn phase.

Locate crosswalks as close as possible to the intersection, this improves pedestrian visibility for the right-turning traffic. Locate the push buttons no more than five feet from the normal travel path of the pedestrian. Locate the push button no more than 15 ft from the center point at the end of the associated crosswalk. At curb and sidewalk areas, locate the pedestrian push buttons adjacent to the sidewalk ramps to make them accessible to people with disabilities. Figures 850-8a and 850-8b show examples of the push button locations at raised sidewalk locations. When the pedestrian push buttons are installed on the vehicle signal standard, provide a paved path, not less than 4 ft in width, from the shoulder or sidewalk to the standard. If access to the signal standard is not possible, install the push buttons on Type PPB push button posts or on Type PS pedestrian display posts. When pedestrian push buttons are installed behind guardrail, use Type PPB posts. Position these posts so that the push button is not more than 1.5 ft from the face of the guardrail.

(5) Control Equipment

Controller assemblies can be either Type 170 controllers or National Electrical Manufacturers Association (NEMA) controllers with dual ring; eight vehicle phase, four pedestrian phase, four overlap, operational capabilities. From a design perspective, identical operation can be obtained from either controller. Specify the Type 170 unless the region's policy is to use NEMA controllers.

In situations where it is necessary to coordinate the traffic movements with another agency, it is necessary for one of the agencies to be responsible for the operation of the traffic signal, regardless of which agency actually owns and maintains the signal. This is accomplished by negotiating an agreement with the other agency. At a new intersection, where the state owns the signal but another agency has agreed to operate the signal, the controller must be compatible with that agency's system.

When Type 170 controllers are used, but it is necessary to coordinate the state owned and operated signals with another jurisdiction's system using NEMA controllers, use compatible NEMA controllers installed in Type 170/332 cabinets. Specify a C1 plug connected to a NEMA A, B, C, and D plug adapter for these installations. The Model 210 conflict monitor in the Type 170/332 cabinet can be used with a NEMA controller by changing a switch setting. The Type 12 NEMA conflict monitor is not used in this configuration. It does not fit in a Type 170/332 cabinet and the operation is not compatible. When a NEMA cabinet is used, specify rack-mountings for the loop detector amplifiers and the preemption discriminators.

Coordinate with the region's electronics technician to determine the optimum controller cabinet location and the cabinet door orientation. The controller cabinet is positioned to provide maintenance personnel access. At this location, a clear view of the intersection is desirable. Avoid placing the controller at locations where it might block the view of approaching traffic for a motorist turning right on red. Avoid locating the controller where flooding might occur or where the cabinet might be hit by errant vehicles. If possible, position the controller where it will not be affected by future highway construction.

If a telephone line connection is desired for remote signal monitoring and timing adjustments by signal operations personnel, provide a modem in the controller cabinet and separate conduits and a junction box between the cabinet and the telephone line access point.

Vehicle and pedestrian movements are standardized to provide uniformity in signal phase numbering, signal display numbering, preemption channel identification, detection numbering, and circuit identification. The following are general guidelines for the numbering system:

- Assign phases 2 and 6 to the major street through movements, orienting phase 2 to the northbound or eastbound direction of the major street.
- Assign phases 1 and 5 to the major street protected left-turn movements.
- Assign phases 4 and 8 to the minor street through movements.
- Assign phases 3 and 7 to the minor street protected left-turn movements.
- At "Tee" intersections, assign the movement on the stem of the "Tee" to either phase 4 or phase 8.
- At intersections with four approaches and each minor street times separately, assign the minor streets as phase 4 and 8 and note on the phase diagram that these phases time exclusively.
- Signal displays are numbered with the first number indicating the signal phase. Signal displays for phase 2, for example, are numbered 21, 22, 23,and so on. If the display is an overlap, the designation is the letter assigned to that overlap. If the display is protected/permissive, the display is numbered with the phase number of the through display followed by the phase number of the left-turn phase. A protected/permissive signal display for phase 1 (the left-turn movement) and phase 6 (the compatible through movement), for example, is numbered 61/11. The circular red, yellow, green displays are connected to the phase 6 controller output and the yellow and green arrow displays are connected to the phase 1 controller output.
- Pedestrian displays and detectors are numbered with the first number indicating the signal phase and the second number as either an 8 or 9. Pedestrian displays and detectors 28 and 29, for example, are assigned to phase 2.
- Detection is numbered with the first number representing the phase. Detection loops for phase 2 detectors are numbered 21, 22, 23, and so on.
- Emergency vehicle detectors are designated by letters; phase 2 plus phase 5 operation uses the letter "A", phase 4 plus phase 7 uses the letter "B", phase 1 plus phase 6 uses the letter "C", and phase 3 plus phase 8 uses the letter "D".

(6) Detection Systems

The detection system at a traffic actuated signal installation provides the control unit with information regarding the presence or movement of vehicles, bicycles, and pedestrians. Vehicle detection systems perform two basic functions: queue clearance and the termination of phases. Depending on the specific intersection characteristics, either of these functions can take priority. The merits of each function are considered and a compromise might be necessary.

The vehicle detection requirements vary depending on the 85th percentile approach speed as follows:

- When the posted speed is below 35 mph, provide stop bar detection from the stop bar to a point 30 ft to 35 ft in advance of that location. Assign the stop bar loops to detection input "extension" channels. When counting loops are installed, calculate the distance traveled by a vehicle in two seconds at the 85th percentile speed and position the advance loops at this distance in advance of the stop bar.
- When the posted speed is at or above 35 mph, provide advance detection based on the "dilemma zone detection design". Where installed, stop bar detection extends from the stop bar to a point 30 ft to 35 ft in advance of that location. Stop bar detection is required on minor streets. Assign stop bar detection to "call" channels and assign advance detection-to-detection input "extension" channels.

A dilemma occurs when a person is forced to make a decision between two alternatives. As applied to vehicle detection design, this situation occurs when two vehicles are approaching a traffic signal and the signal indications turn yellow. The motorist in the lead vehicle must decide whether to accelerate and risk being hit in the intersection by opposing traffic or decelerate and risk being hit by the following vehicle. Dilemma zone detection design has been developed to address this problem. This design allows the 90th percentile speed vehicle and the 10th percentile speed vehicle to either clear the intersection safely or decelerate to a complete stop before reaching the intersection. The method of calculating the dilemma zone and the required detection loops is shown in Figure 850-9.

A study of the approach speeds at the intersection is necessary to design the dilemma zone detection. Speed study data is obtained at the approximate location at or just upstream of the dilemma zone. Only the speed of the lead vehicle in each platoon is considered. Speed study data is gathered during off-peak hours in free-flow conditions under favorable weather conditions. Prior speed study information obtained at this location can be used if it is less than one and a half years old and driving conditions have not changed in the area.

When permissive left-turn phasing is installed on the major street with left-turn channelization, include provisions for switching the detector input for future protected left-turn phasing. Assign the detector a left-turn detector number and connect to the appropriate left-turn detector amplifier. Then specify a jumper connector between that amplifier output and the extension input channel for the adjacent through movement detector. The jumper is removed when the left-turn phasing is changed to protected in the future.

In most cases, electromagnetic induction loops provide the most reliable method of vehicle detection. Details of the construction of these loops are shown in the Standard Plans. Consider video detection systems for projects that involve extensive stage construction with numerous alignment changes. Video detection functions best when the detectors (cameras) are positioned high above the intersection. In this position, the effective detection area can be about ten times the mounting height in advance of the camera. When video detection is proposed, consider using Type III signal standards in all quadrants and install the cameras on the luminaire mast arms. High wind can adversely affect the video equipment by inducing vibration in the luminaire mast arms. Areas that experience frequent high winds are not always suitable for video detection.

(7) Preemption Systems

(a) **Emergency vehicle preemption.** Emergency vehicle preemption is provided if the emergency service agency has an operating preemption system. WSDOT is responsible for the preemption equipment that is permanently installed at the intersection for new construction or rebuild projects. The emergency service agency is responsible for preemption emitters in all cases. If the emergency agency requests additional preemption equipment at an existing signal, that agency is responsible for all installation costs for equipment installed permanently at the intersection. These same guidelines apply for a transit agency requesting transit preemption. The standard emergency vehicle system is optically activated to be compatible with all area emergency service agency emitters. Approval by the State Traffic Engineer is required for the installation of any other type of emergency vehicle preemption system.

Optically activated preemption detectors are positioned for each approach to the intersection. These detectors function best when the approach is straight and relatively level. When the approach is in a curve, either horizontal or vertical, it might be necessary to install additional detectors in or in advance of the curve to provide adequate coverage of that approach. Consider the approximate speed of the approaching emergency vehicle and the amount of time necessary for phase termination and the beginning of the preemption phase when positioning these detectors.

(b) **Railroad preemption.** An approaching train is detected either by electrical contacts under the railroad tracks or by motion sensors. The railroad company installs these devices. The region provides the electrical connections between the railroad signal enclosure (called a bungalow) and the preemption phasing in the traffic signal controller. A two-conductor cable is used for the electrical connection. The electrical circuit is connected to a closed “dry” contact using a normally energized relay. When a train is detected, the relay opens the circuit to the traffic signal controller. Contact the railroad to determine the voltage they require for this relay. This will determine the requirements for the isolator at the traffic signal controller. The railroad company’s signal equipment usually operates at 24 volt DC storage batteries charged by a 120 volt AC electrical system. Conduit crossings under railroad tracks are normally jacked or pushed because open excavation is rarely allowed. The usual depth for these crossings is four feet below the tracks but railroad company requirements can vary. Contact the company for their requirements. They, also, will need the average vehicle queue clearance time values in order to finalize the preemption agreement. These values are shown on Figure 850-10.

Flashing railroad signals are usually necessary when railroad preemption is installed at a signalized intersection. Automatic railroad gates are also necessary when train crossings are frequent and the exposure factor is high. Chapter 930 provides guidance on determining the railroad crossing exposure factor. Advance signals, signal supports with displays, are also only installed at locations with high exposure factors. See Figures 850-11a and 850-11b. When the nearest rail at a crossing is within 88 ft of an intersection stop bar on any approach, provide additional traffic signal displays in advance of the railroad crossing. The 88-foot distance provides storage for the longest vehicle permitted by statute (75 ft plus 3 ft front overhang and 4 ft rear overhang) plus a 6 ft down stream clear storage distance.

Light rail transit crossings at signalized intersections also use a form of railroad preemption. Light rail transit makes numerous stops along its route, sometimes adjacent to a signalized intersection. Because of this, conventional railroad preemption detection, which uses constant speed as a factor, is not effective. Light rail transit uses a type of preemption similar to that used for emergency vehicle preemption.

(c) **Transit priority preemption.** Signal preemption is sometimes provided at intersections to give priority to transit vehicles. The most common form of preemption is the optically activated type normally used for emergency preemption. This can be included in mobility projects, but the transit company assumes all costs in providing, installing, and maintaining this preemption equipment. The department's role is limited to approving preemption phasing strategies and verifying the compatibility of the transit company's equipment with the traffic signal control equipment.

(8) Signal Displays

Signal displays are the devices used to convey right of way assignments and warnings from the control mechanism to the motorists and pedestrians. When selecting display configurations and locations, the most important objective is the need to present these assignments and warnings to the motorists and pedestrians in a clear and concise manner. Typical vehicle signal displays are shown in Figures 850-12a through 850-12e. In addition to the display requirements contained in the MUTCD, the following also apply:

- Always provide two identical indications for the through (primary) or predominate movement, spaced a minimum of 8 ft apart when viewed from the center of the approach. At a tee intersection, select the higher volume movement as the primary movement and provide displays accordingly. A green left-turn arrow on a primary display and a green ball on the other primary display do not comply with this rule.
- Use arrow indications only when the associated movement is completely protected from conflict with other vehicular and pedestrian movements. This includes conflict with a permissive left-turn movement.
- Locate displays overhead whenever possible and in line with the path of the applicable vehicular traffic.
- Locate displays a minimum of 40 ft (60 ft desirable) ands a maximum of 150 ft from the stop line.
- Consider installation of a near-side display when the visibility requirements of Table 4-1 of the MUTCD cannot be met.
- Use vertical vehicle-signal display configurations. Horizontal displays are not allowed unless clearance requirements cannot be achieved with vertical displays. Approval by the State Traffic Engineer is required for the installation of horizontal displays.
- Use 12-inch signal sections for all vehicle displays except the lower display for a post-mount ramp-meter signal.
- Use all arrow displays for protected left turns when the left turn operates independently from the adjacent through movement.
- When green and yellow arrows are used in combination with circular red for protected left turns operating independently from the adjacent through movement, use visibility-limiting displays (either optically programmed sections or louvered visors). Contact the local maintenance superintendent, signal operations office, or traffic engineer to ensure correct programming of the head.
- Use either a five section cluster arrangement (dog house) or a five section vertical arrangement.
- Use either Type M or Type N mountings for vehicle display mountings on mast arms. Provide only one type of mounting for each signal system. Mixing mounting types at an intersection is not acceptable except for supplemental displays mounted on the signal standard shaft.
- Use backplates for all overhead mounted displays.
- Use Type E mountings for pedestrian displays mounted on signal standard shafts.
- Consider installing supplemental signal displays when the approach is in a horizontal or vertical curve and the intersection visibility requirements cannot be met.

The minimum mounting heights for cantilevered mast arm signal supports and span wire installations is 16.5 ft from the roadway surface to the bottom of the signal housing or back plate. There is also a maximum height for signal displays. The roof of a vehicle can obstruct the motorist's view of a signal display. The maximum heights from the roadway surface to the bottom of the signal housing with 12-inch sections are shown in Figure 850-1.

Distance	Signal Display	Maximum Height
Signal displays 40 feet from the stop bar	Vertical 3 section	17.3 feet
	Vertical 4 section	16.9 feet
	Vertical 5 section*	16.5 feet
Signal displays 45 feet from the stop bar	Vertical 3 section	19.1 feet
	Vertical 4 section	17.9 feet
	Vertical 5 section*	16.8 feet
Signal displays 50 feet from the stop bar	Vertical 3 section	20.9 feet
	Vertical 4 section	19.7 feet
	Vertical 5 section*	18.5 feet
Signal displays 53 to 150 feet from the stop bar	Vertical 3 section	21.9 feet
	Vertical 4 section	20.7 feet
	Vertical 5 section*	19.6 feet

* Note: The 5 section cluster display is the same height as a vertical 3-section signal display.

Signal Display Maximum Heights
Figure 850-1

Install an advanced signalized intersection warning sign assembly to warn motorists of a signalized intersection when either of the two following conditions exists:

- The visibility requirements in Table 4-1 of the MUTCD are not achievable.
- The 85th percentile speed is 55 mph or higher and the nearest signalized intersection is more than two miles away.

This warning sign assembly consists of a W3-3 sign, two continuously flashing beacons, and sign illumination. Locate the sign in advance of the intersection in accordance with Table II-1 (Condition A) of the MUTCD.

(9) Signal Supports

Signal supports for vehicle displays consist of metal vertical shaft standards (Type I), cantilevered mast arm standards (Type II, Type III, and Type SD Signal Standards), metal strain poles (Type IV and Type V Signal Standards), or timber strain poles. See the Standard Plans. Mast arm installations are preferred because they provide greater stability for signal displays in high wind areas and reduce maintenance costs. Preapproved mast arm signal standard designs are available with arm lengths up to 65 ft. Use mast arm standards for permanent installations unless display requirements cannot be met. Metal strain poles are allowed when signal display requirements cannot be achieved with mast arm standards or the installation is expected to be in place less than 5 years. Timber strain pole supports are generally used for temporary installations that will be in place less than 2 years.

Pedestrian displays can be mounted on the shafts of vehicle display supports or on individual vertical shaft standards (Type PS). The push buttons used for the pedestrian detection system can also be mounted on the shafts of other display supports or on individual pedestrian push button posts. Do not place the signal standard at a location that blocks pedestrian or wheelchair activities. Locate the pedestrian push buttons so they are ADA accessible to pedestrians and persons in wheelchairs.

Terminal cabinets mounted on the shafts of mast arm standards and steel strain poles are recommended. The cabinet provides electrical conductor termination points between the controller cabinet and signal displays that allows for easier construction and maintenance. Terminal cabinets are usually located on the back side of the pole to reduce conflicts with pedestrians and bicyclists.

In the placement of signal standards, the primary consideration is the visibility of signal faces. Place the signal supports as far as practicable from the edge of the traveled way without adversely affecting signal visibility. The MUTCD provides additional guidance for locating signal supports. Initially, lay out the location for supports for vehicle display systems, pedestrian detection systems, and pedestrian display systems independently to determine the optimal location for each type of support. If conditions allow and optimal locations are not compromised, pedestrian displays and pedestrian detectors can be installed on the vehicular display supports.

Another important consideration that can influence the position of signal standards is the presence of overhead and underground utilities. Verify the location of these lines during the preliminary design stage to avoid costly changes during construction.

Mast arm signal standards are designed based on the total wind load moment on the mast arm. The moment is a function of the XYZ value and this value is used to select the appropriate mast arm fabrication plan. The preapproved mast arm fabrication plans are listed in the special provisions. To determine the XYZ value for a signal standard, the cross sectional area for each component mounted on the mast arm is determined. Each of these values is then multiplied by its distance from the vertical shaft. These values are then totaled to determine the XYZ value. All signal displays and mast arm mounted signs, including street name signs, are included in this calculation. The effect of emergency preemption detectors and any required preemption indicator lights are negligible and are not included. For mast arm mounted signs, use the actual sign area to determine the XYZ value. An example of this calculation is shown in Figure 850-13. Cross sectional areas for vehicle displays are shown in Figure 850-2.

Signal Display	Area
Vertical 3 section	8.7 sq ft
Vertical 4 section	11.0 sq ft
Vertical 5 section	13.1 sq ft
5 section cluster	14.4 sq ft

Signal Display Areas
Figure 850-2

Foundation design is a critical component of the signal support. A soils investigation is required to determine the lateral bearing pressure and the friction angle of the soil and whether ground water might be encountered. The XYZ value is used in determining the foundation depth for the signal standard. Select the appropriate foundation depth from Figure 850-13. A special foundation design for a mast arm signal standard is required if the lateral bearing pressure is less than 1000 psf or the friction angle is less than 26 degrees. The regional materials group determines if these unusual soil conditions are present and a special foundation design is required. They then send this information to the OSC Materials Office for confirmation. That office forwards the findings to the OSC Bridge and Structures Office and requests the special foundation design. The Bridge and Structures Office designs foundations for the regions and reviews designs submitted by private engineering groups performing work for the regions.

Steel strain poles are used in span wire installations and are available in a range of pole classes. A pole class denotes the strength of the pole. The loads and resultant forces imposed on strain poles are calculated and a pole class greater than that load is specified. Figures 850-14a and 850-14b show the procedure for determining the metal strain pole class and foundation. Figure 850-15 shows an example of the method of calculation. The foundation depth is a product of the pole class and the soil bearing pressure. A special design is required for metal strain pole or timber strain pole support systems if the span exceeds 150 ft, the tension on the span exceeds 7200 lbs, or the span wire attachment point exceeds 29 ft in height. Contact the OSC Bridge and Structures Office for assistance.

(10) Preliminary Signal Plan

Develop a preliminary signal plan for the project file. Include with the preliminary signal plan a discussion of the problem that is being addressed by the project. Provide sufficient level of detail on the preliminary signal plan to describe all aspects of the signal installation, including proposed channelization modifications. Use a plan scale of 1 inch = 20 feet and include the following information:

- Stop bars
- Crosswalks
- Left-turn radii, including beginning and ending points
- Corner radii, including beginning and ending points
- Vehicle detector locations

- Pedestrian detector locations
- Signal standard types and locations
- Vehicle signal displays
- Pedestrian signal displays
- Phase diagram including pedestrian movements
- Emergency vehicle preemption requirements
- Illumination treatment

Submit a copy of the preliminary signal plan to the State Traffic Engineer for review and comment. When the proposed traffic signal is on an NHS highway, also submit a copy of the preliminary signal plan to the Assistant State Design Engineer for review and concurrence. After addressing review comments, finalize the plan and preserve as noted in the documentation section of this chapter. Prepare the contract plans in accordance with the *Plans Preparation Manual*.

If HQ is preparing the contract plans, specifications, and estimates for the project, submit the above preliminary signal plan with the following additional items:

- Contact person.
- Charge numbers.
- Critical project schedule dates.
- Existing utilities, both underground and overhead.
- Existing intersection layout, if different from the proposed intersection.
- Turning movement traffic counts; peak hour for isolated intersections; and AM, Midday, and PM peak hour counts if there is another intersection within 500 ft.
- Speed study indicating 90th and 10th percentile speeds for all approaches.
- Electrical service location, source of power, and utility company connection requirements.

After the plans, specifications, and estimate are prepared, the entire package is transmitted to the region for incorporation into their contract documents.

(11) Electrical Design

(a) **Circuitry Layout.** Consider cost, flexibility, construction requirements, and ease of maintenance when laying out the electrical circuits for the traffic signal system. Minimize roadway crossings whenever possible.

(b) **Junction Boxes.** Provide junction boxes at each end of a roadway crossing, where the conduit changes size, where detection circuit splices are required, and at locations where the sum of the bends for the conduit run equals or exceeds 360°. Signal standard or strain pole bases are not used as junction boxes. In general, locate junction boxes out of paved areas and sidewalks. Placing the junction boxes within the traveled way is rarely an effective solution and will present long-term maintenance problems. If there is no way to avoid locating the junction box in the traveled way, use traffic-bearing boxes. Avoid placing junction boxes in areas of poor drainage. In areas where vandalism can be a problem, consider junction boxes with locking lids. The maximum conduit capacities for various types of junction boxes are shown in the Standard Plans.

(c) **Conduit.** Use galvanized steel conduit for all underground raceways for the traffic signal installation on state highways. Thick-walled polyvinyl chloride (Schedule 80 PVC) conduit is used by many local agencies for ease of installation. At existing intersections, where roadway reconstruction is not proposed, place these conduits beyond the paved shoulder or behind existing sidewalks to reduce installation costs. With the exception of the 1/2 inch conduit for the service grounding electrode conductor, the minimum size conduit is 1 inch. The minimum size conduit for installations under a roadway is $1^1/4$ inch. Size all conduits to provide 26% maximum conductor fill for new signal installations. A 40% fill area can be used when installing conductors in existing conduits. See Figure 850-16 for conduit and signal conductor sizes.

(d) **Electrical Service and other components.** Electrical service types, overcurrent protection, and other components are covered in Chapter 840.

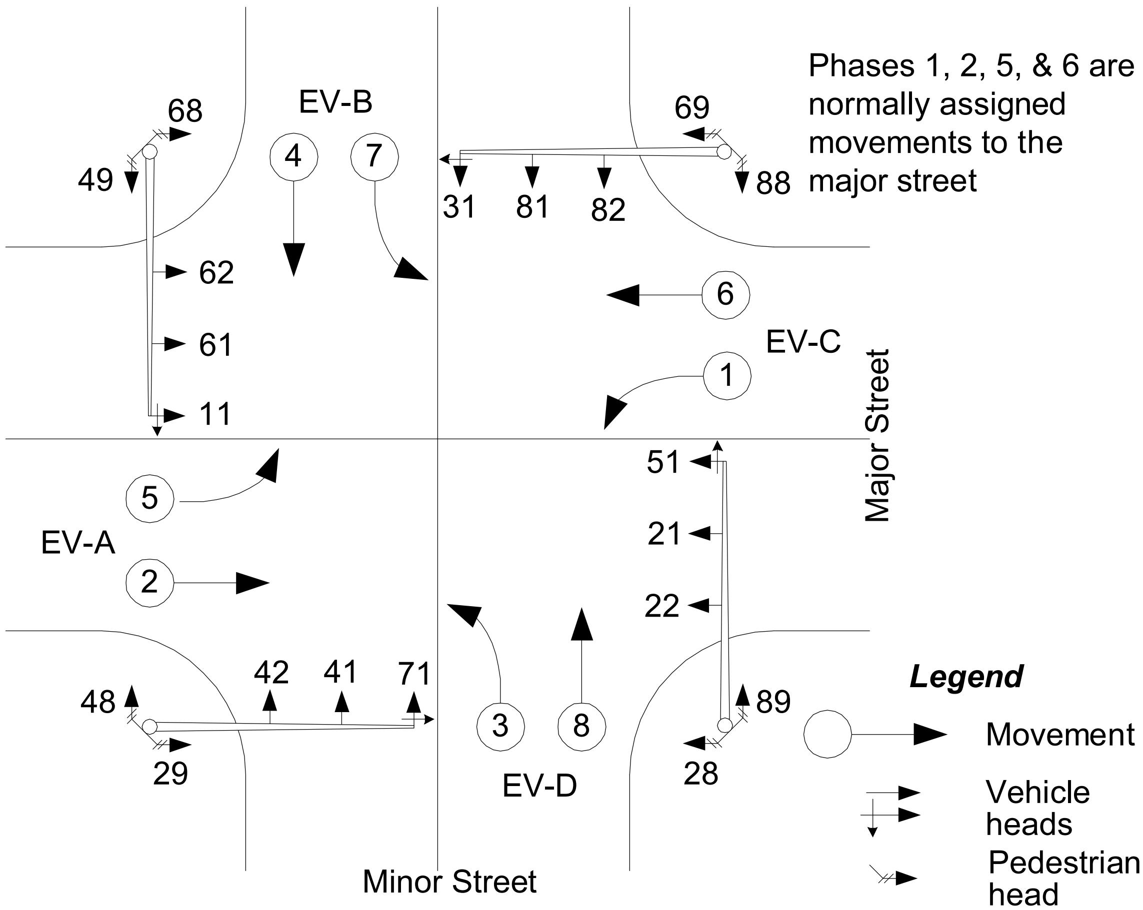
850.07 Documentation

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

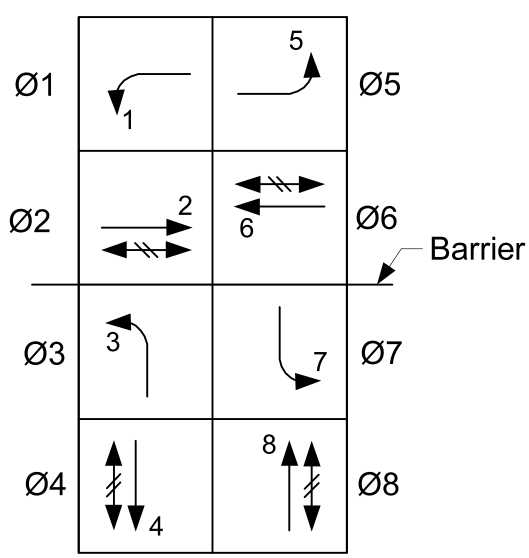
Responsibility for Various Types of Facilities on State Highways				
Area	Responsibility	Emergency vehicle signals	Traffic signals, school signals, & intersection control beacons	Reversible lane signals & moveable bridge signals
Cities with less than 22,500 population	Finance	ESD (1)	State	State
	Construct	ESD (1)	State	State
	Maintain	ESD (1)	State	State
	Operate	ESD (1)	State	State
Cities with 22,500 or greater population	Finance	ESD (1)	City (2)	City (2)
	Construct	ESD (1)	City (2)	City (2)
	Maintain	ESD (1)	City (2)	City (2)
	Operate	ESD (1)	City (2)	City (2)
Beyond corporate limits	Finance	ESD (1)	State Country (3)	State
	Construct	ESD (1)	State	State
	Maintain	ESD (1)	State	State
	Operate	ESD (1)	State	State
Access control	Finance	ESD (1)	State	State
	Construct	ESD (1)	State	State
	Maintain	ESD (1)	State	State
	Operate	ESD (1)	State	State

Notes:
(1) ESD refers to the applicable Emergency Service Department.
(2) State highways without established limited access control. See 850.04(2)b.
(3) See 850.04(2)d.

Responsibility for Facilities
Figure 850-3

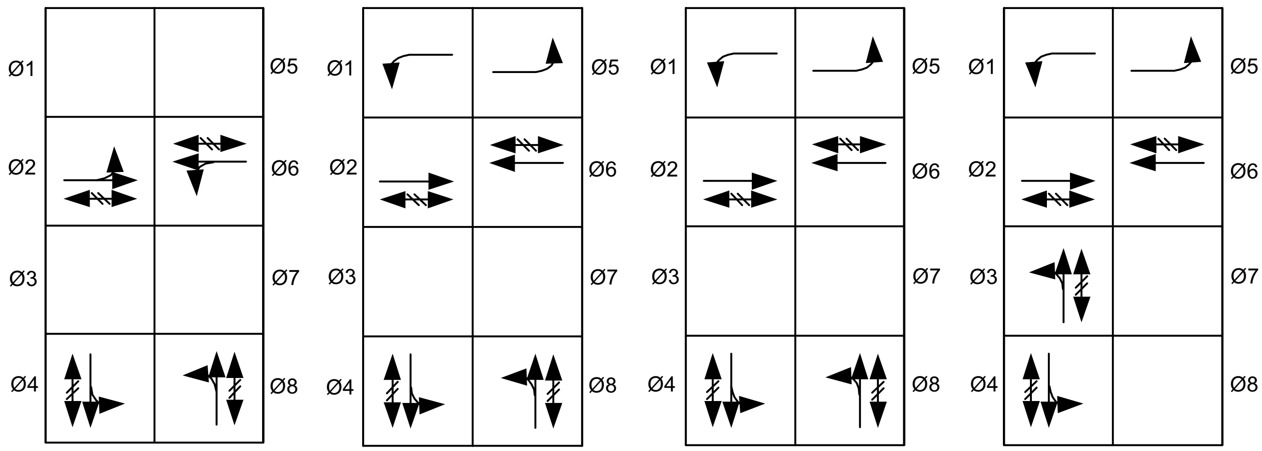


Standard Intersection Movements and Head Numbers



Standard Eight Phase Operation

Standard Intersection Movements and Head Numbers
Figure 850-4

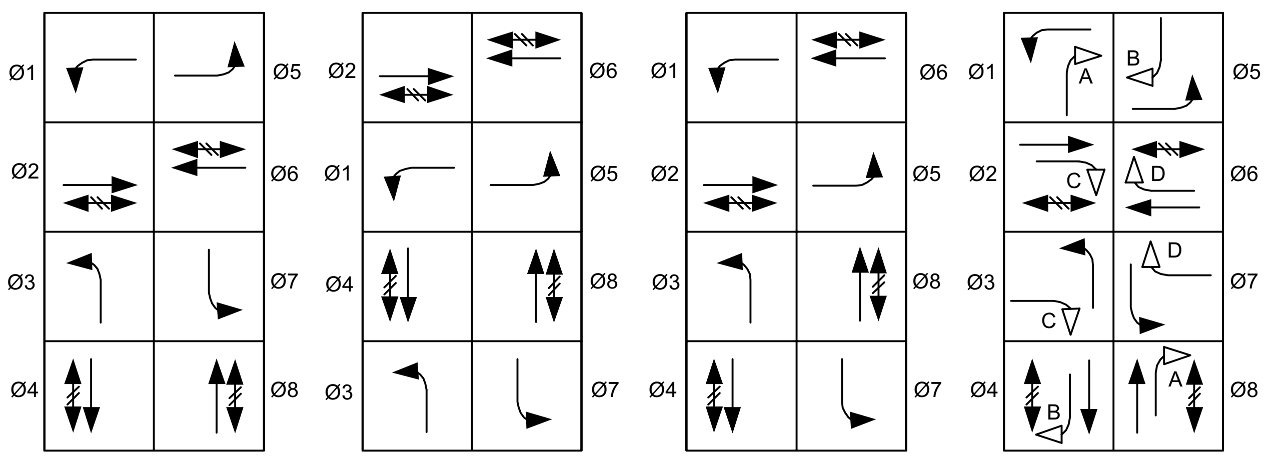


Two Phase Operation
Permissive lefts

Five Phase Operation
Main St. protected lefts
Minor St. permissive lefts

Six Phase Operation
Main St. protected leading lefts
Minor St. split phasing
(Ø4 first, then Ø8)

Six Phase Operation
Alternate phasing
Main St. protected leading lefts
Minor St. split phasing



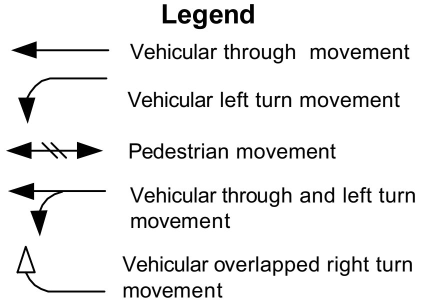
Eight Phase Operation
Main St. protected leading lefts
Minor St. protected leading lefts

Eight Phase Operation
Main St. protected lagging lefts
Minor St. protected lagging lefts

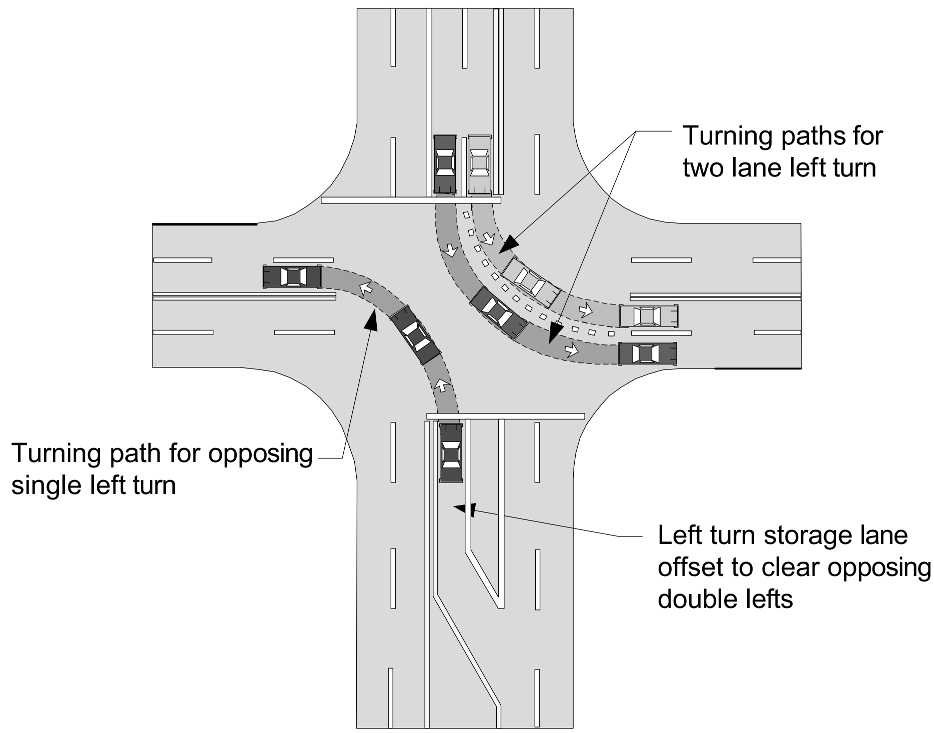
Eight Phase Operation
Main St. protected lead & lag lefts
Minor St. protected lead & lag lefts

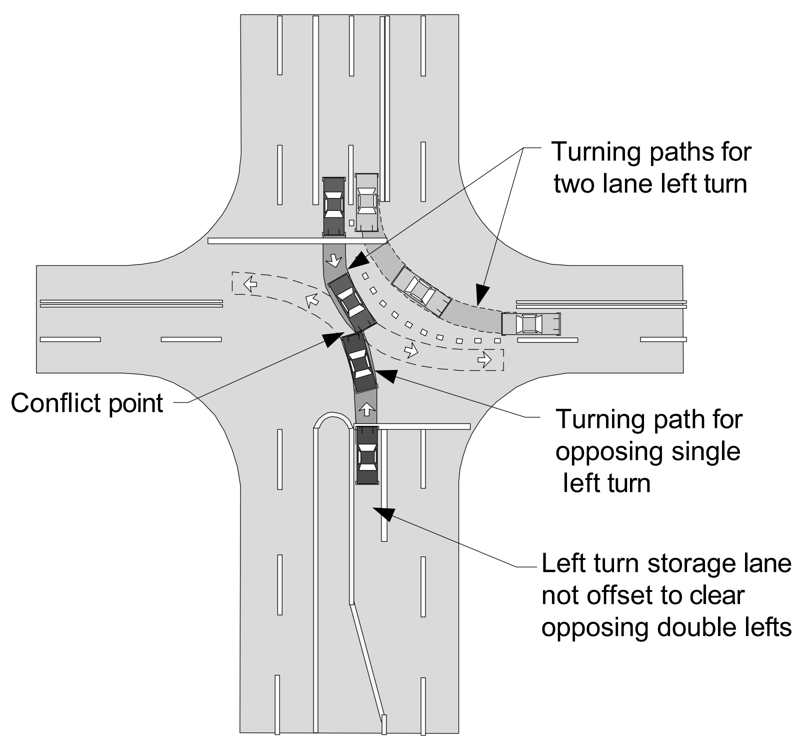
Eight Phase Operation
Protected leading lefts
and overlapped rights

Legend

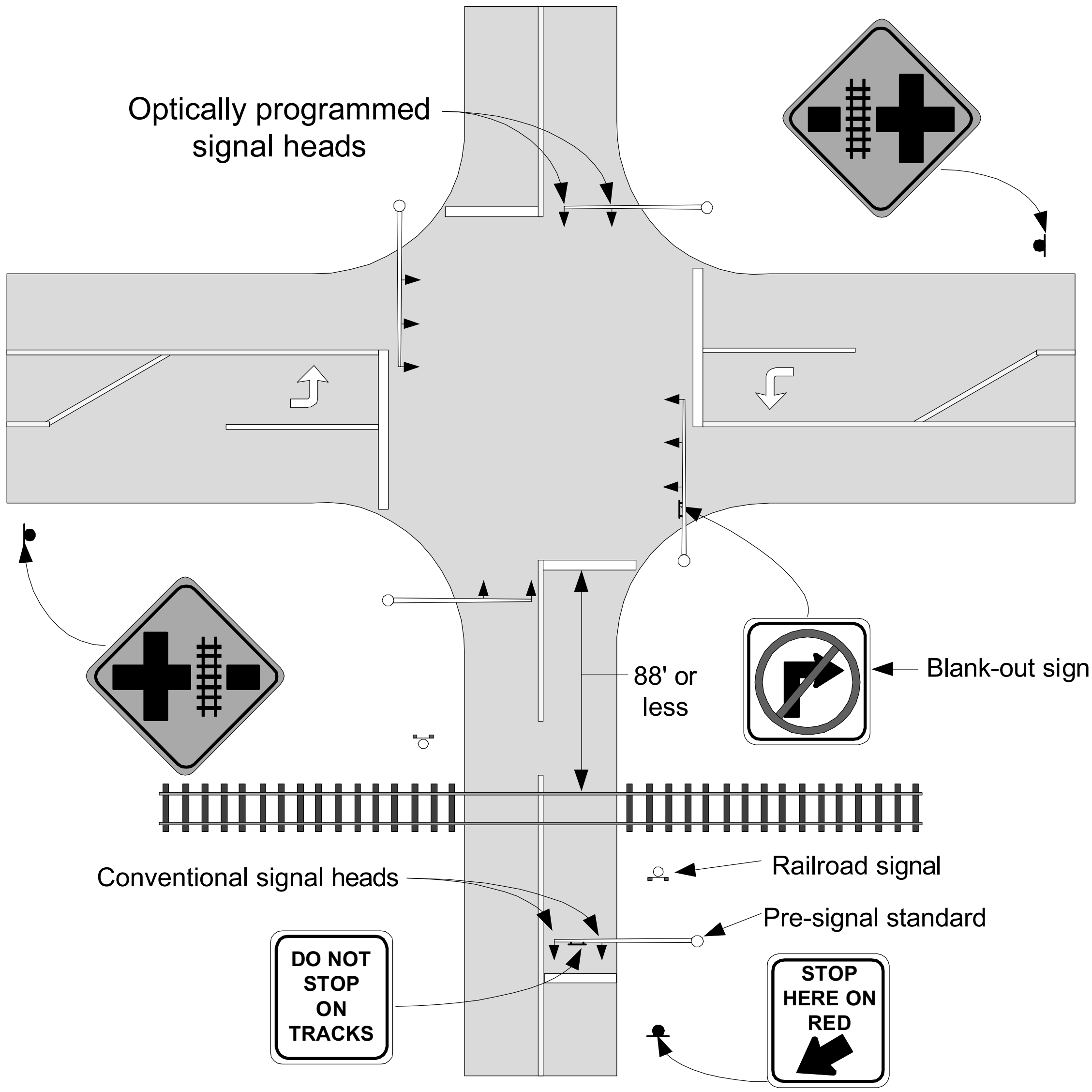


Phase Diagrams — Four Way Intersections
Figure 850-5

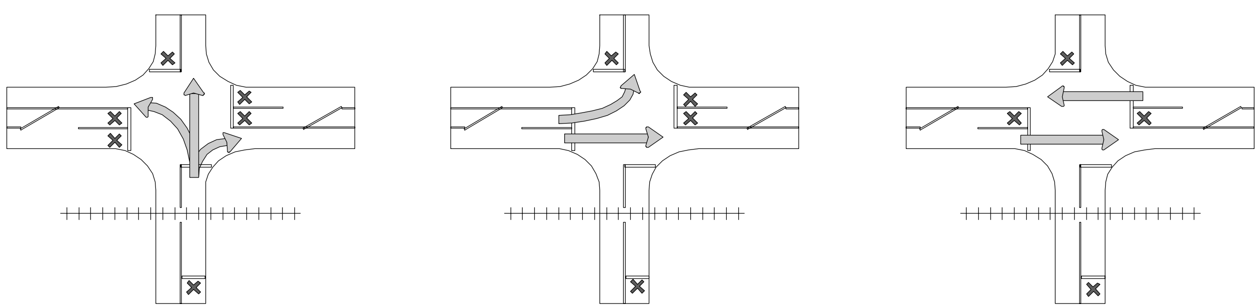




Turn Lane Configuration Preventing Concurrent Phasing
Double Left Turn Channelization
Figure 850-6



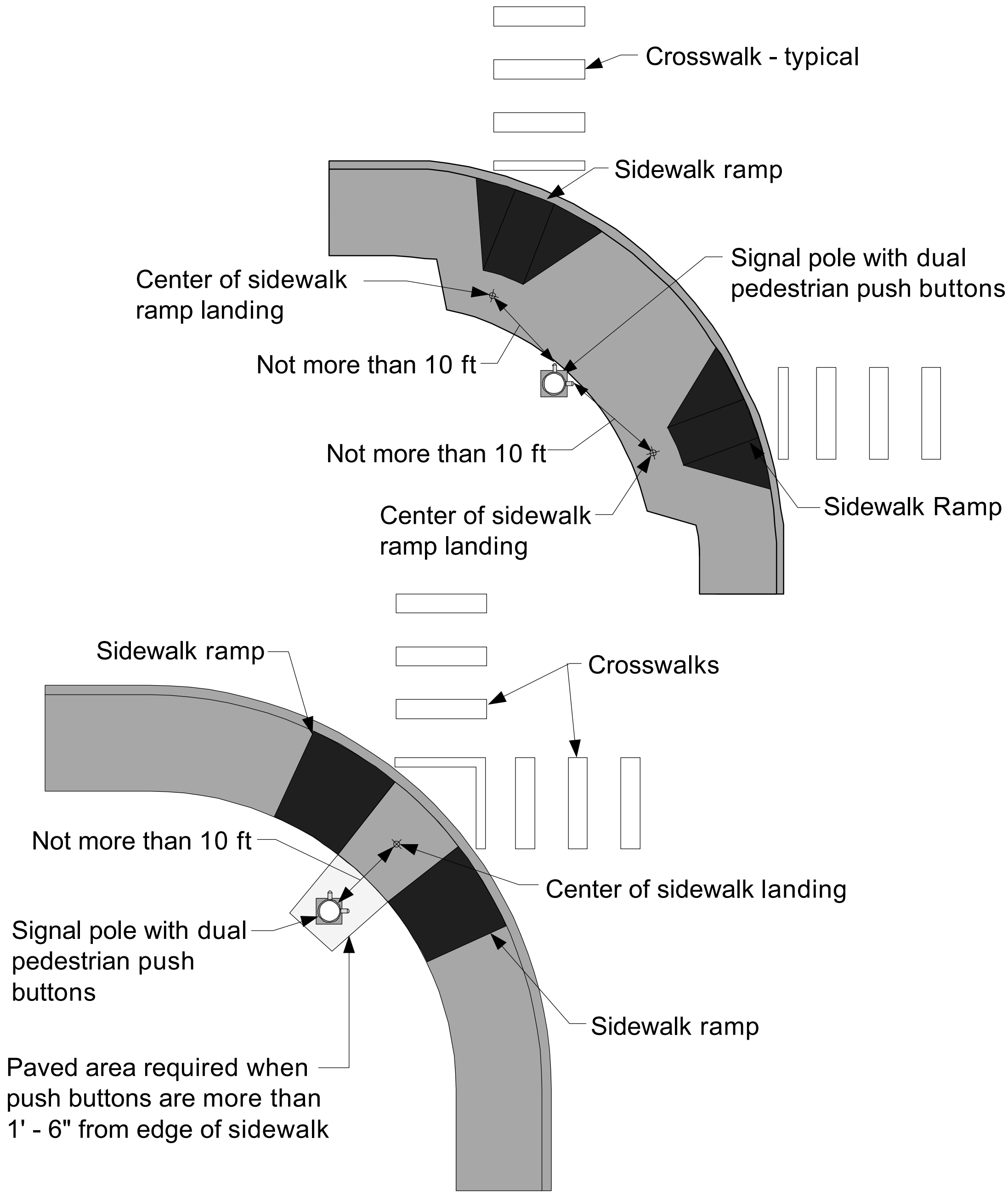
Typical Signal Installation Adjacent to Railroad



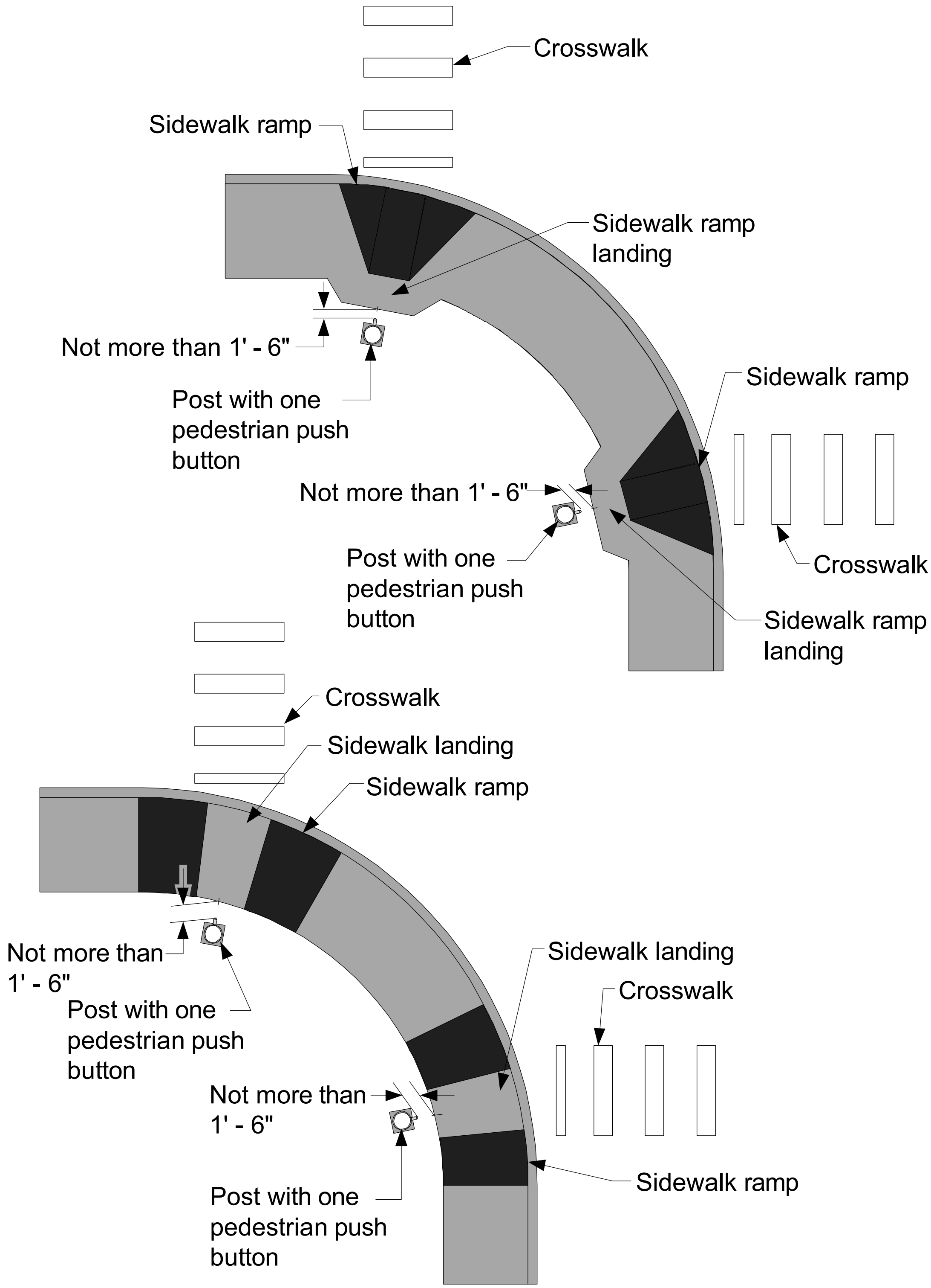
Clearance Phase before Train Arrival

Phase Sequence During Train Crossing

Railroad Preemption Phasing
Figure 850-7



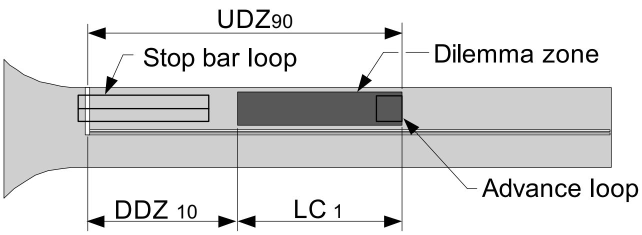
Pedestrian Push Button Locations
Figure 850-8a



Pedestrian Push Button Locations
Figure 850-8b

Where: V_{90} = 90th pecentile speed in feet per second
V_{10} = 10th percentile speed in feet per second
UDZ_{90} = Upstream end of dilemma zone for 90th percentile speed
DDZ_{10} = Downstream end of dilemma zone for 10th percentile speed

LC_1 = V_{10} travel time to downstream DDZ_{10}
LC_2 = V_{10} travel time from 1st loop to 2nd loop
LC_3 = V_{10} travel time from 3rd loop to DDZ_{10}



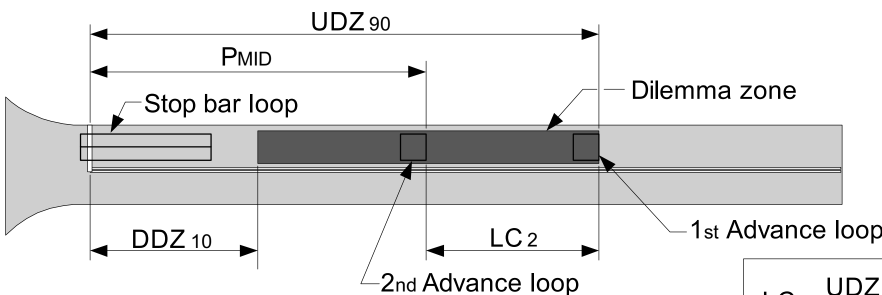
$$UDZ_{90} = \frac{V_{90}^2}{16} + V_{90}$$

$$DDZ_{10} = \frac{V_{10}^2}{40} + V_{10}$$

$$LC_1 = \frac{UDZ_{90} - DDZ_{10}}{V_{10}}$$

Single Advance Loop Design

When LC_1 is equal to or less than 3 seconds

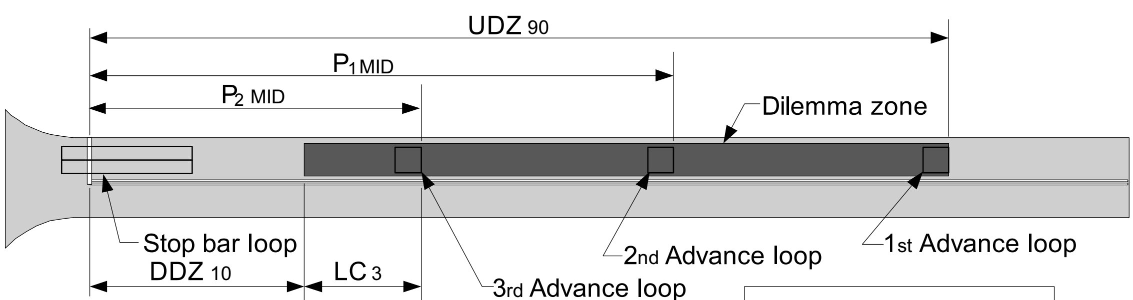


$$LC_2 = \frac{UDZ_{90} - P_{MID}}{V_{10}}$$

$$P_{MID} = \frac{UDZ_{90} + DDZ_{10}}{2}$$

Double Advance Loop Design

When LC_2 is equal to or less than 3 seconds



$$LC_3 = \frac{P_2MID - DDZ_{10}}{V_{10}}$$

$$P_1MID = UDZ_{90} - 3V_{10}$$

$$P_2MID = UDZ_{90} - 6V_{10}$$

Triple Advance Loop Design

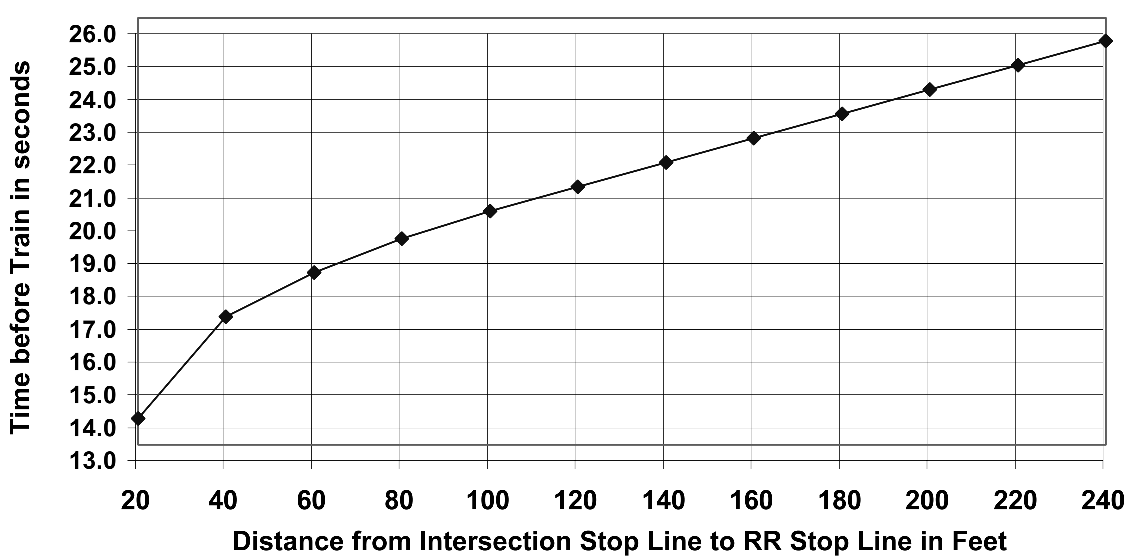
When LC_2 is greater than 3 seconds

Dilemma Zone Loop Placement
Figure 850-9

Traffic Signal Railroad Track Clearance Interval Table (Single Track)

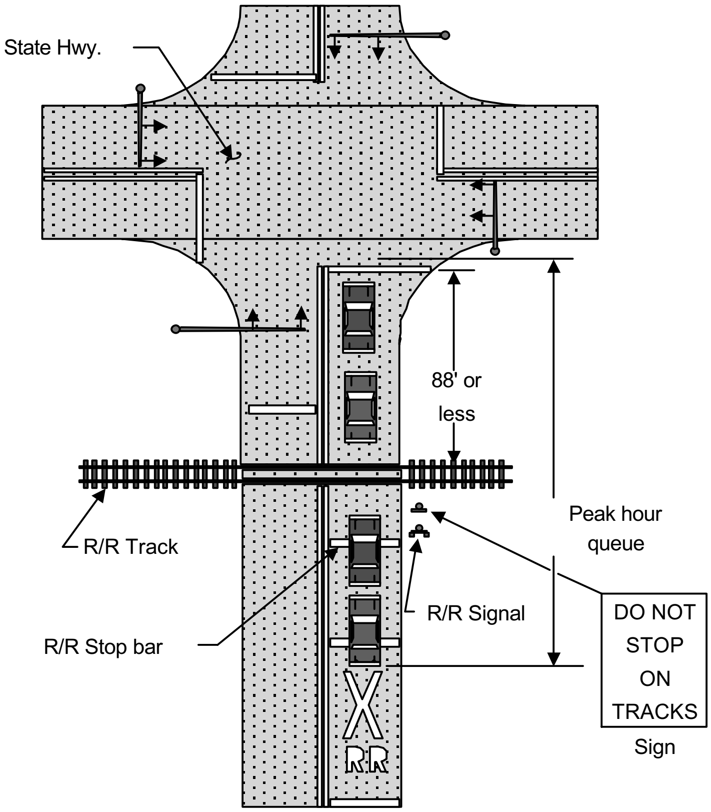
Queue	Start-Up Time	Queue Length	Intersection Clearance	Start-Up Time	Queue Clear Time	Time from PE start to Q	Time Before Train
Vehicles	Seconds	Feet	Seconds	Seconds	Seconds	Seconds	Seconds
A	B	C	D	E	F	G	H
1	3.8	20	10	3.8	3.8	13.8	13.8
2	3.1	40	10	3.1	6.9	16.9	16.9
3	2.7	60	10	2.7	9.6	19.6	18.2
4	2.4	80	10	2.4	12.0	22.0	19.3
5	2.2	100	10	2.2	14.2	24.2	20.1
6	2.1	120	10	2.1	16.3	26.3	20.9
7	2.1	140	10	2.1	18.4	28.4	21.6
8	2.1	160	10	2.1	20.5	30.5	22.3
9	2.1	180	10	2.1	22.6	32.6	23.1
10	2.1	200	10	2.1	24.7	34.7	23.8
11	2.1	220	10	2.1	26.8	36.8	24.6
12	2.1	240	10	2.1	28.9	38.9	25.3

A = Number of Vehicles in the queue.
B = Vehicle startup time.
C = Distance from intersection stop line to R/R gate or R/R stop line. For single track, the stop bar is 20' upstream from the nearest rail.
D = Worst Case intersection clearance (5 seconds mainline green/flashing "don't walk" + 5 seconds yellow/all red = 10 seconds).
E = Startup time for each vehicle by position in the queue.
F = Cumulative startup time, includes the track approach green time (7 seconds minimum).
G = Total time from railroad relay closure until last car in the queue has cleared the intersection stop bar. G = D + F
H = Total time from railroad relay closure until the last car in the queue is 20 ft beyond nearest rail. This assumes a departure speed of 10 MPH. H = G - ((C-40') ÷ 14.7)

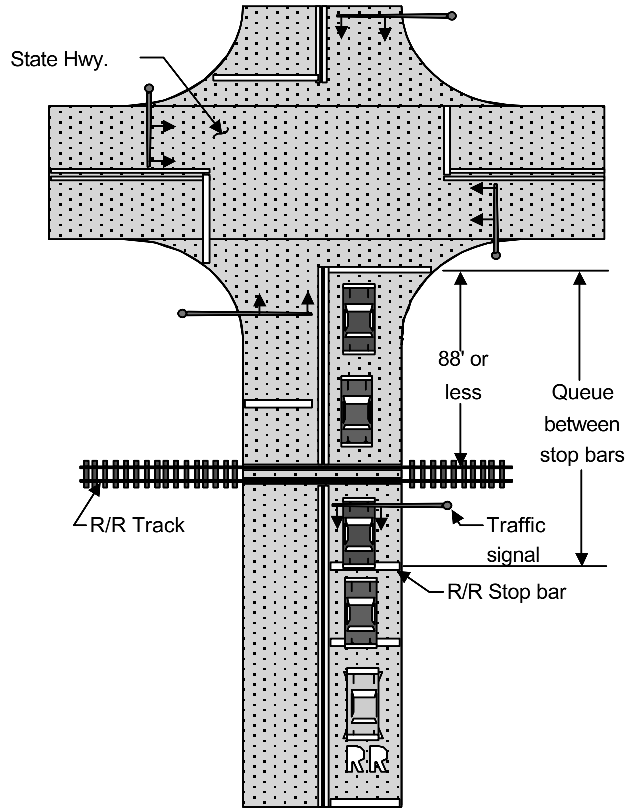


Example: A location where it is 60 ft from stop bar to nearest rail of a single track crossing.
Solution: Enter table at queue length of 80 ft (60 ft + 20 ft to R/R stop bar). Graph value is 19.3 seconds.

Railroad Queue Clearance
Figure 850-10

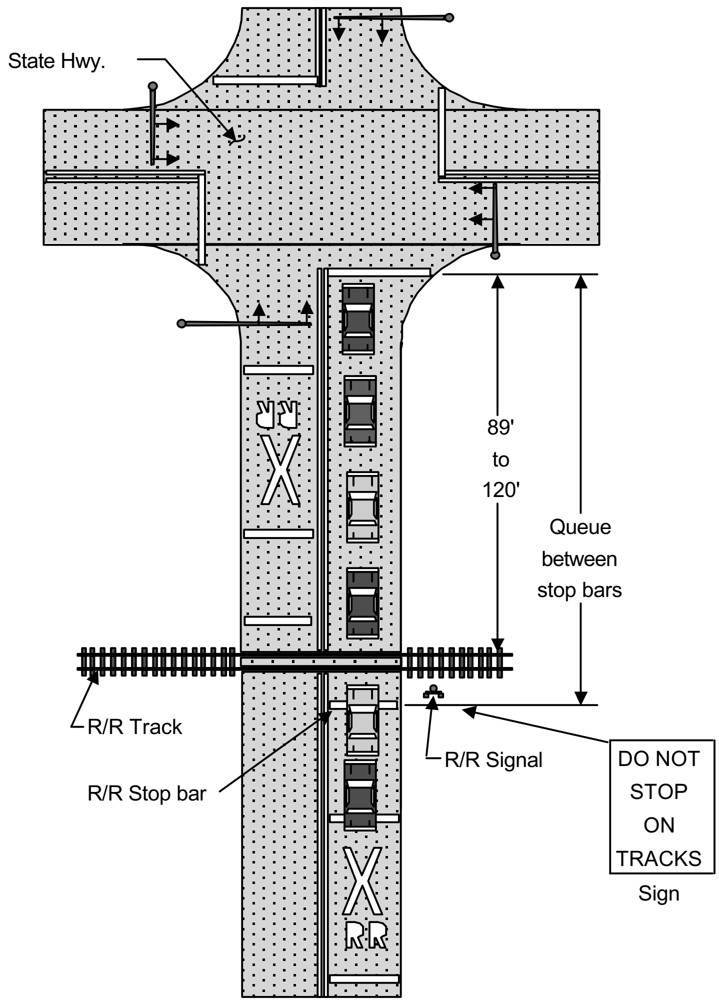


Railroad Crossing
with Low Exposure Factor
(See Chapter 930 for R/R crossing protection guidelines)



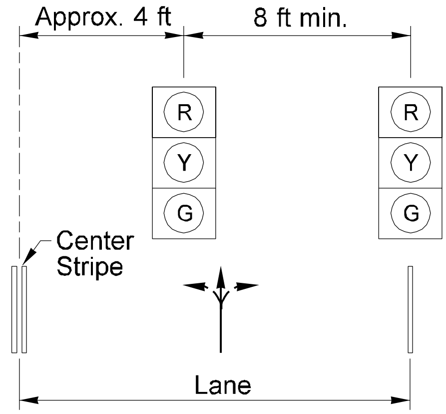
Railroad Crossing
with High Exposure Factor
(See Chapter 930 for R/R crossing protection guidelines)

Intersections With Railroad Crossings
Figure 850-11a

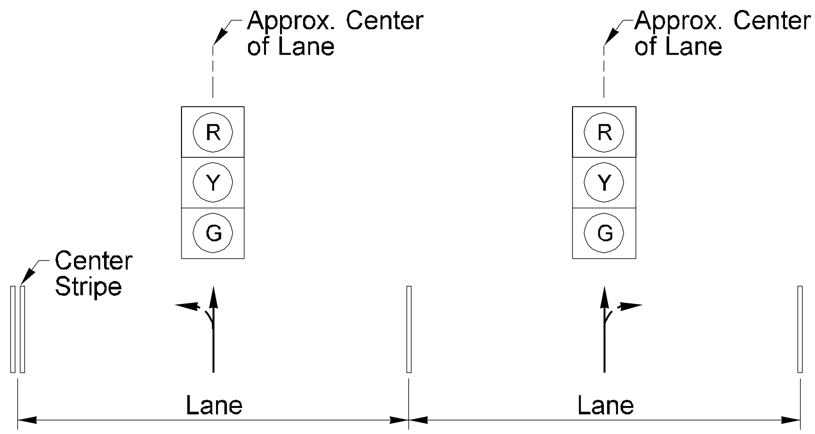


Railroad Crossing more than 88 Ft from Intersection

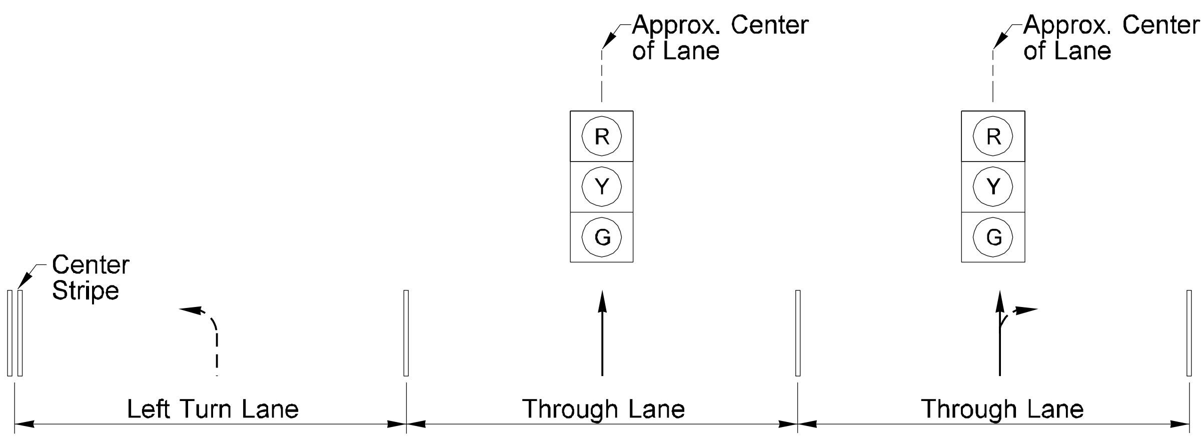
Intersections With Railroad Crossings
Figure 850-11b



One Through Lane
With Permissive Left Turn

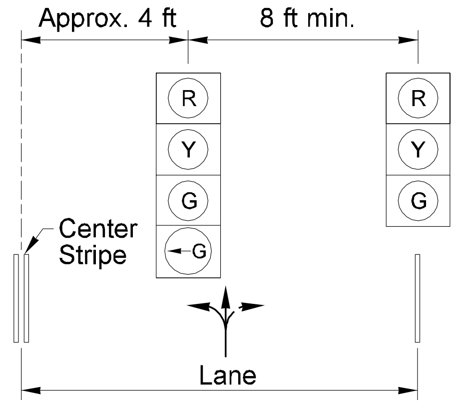


Two Through Lanes
With Permissive Left Turn

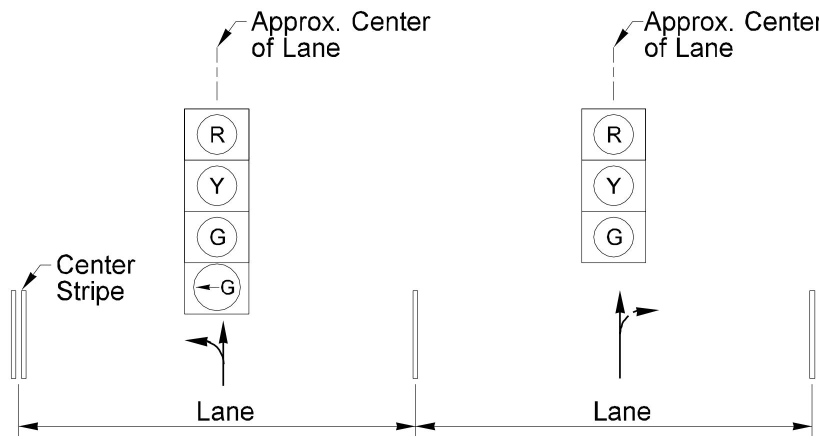


Two Through Lanes and One Left Turn Storage Lane
With Permissive Left Turn

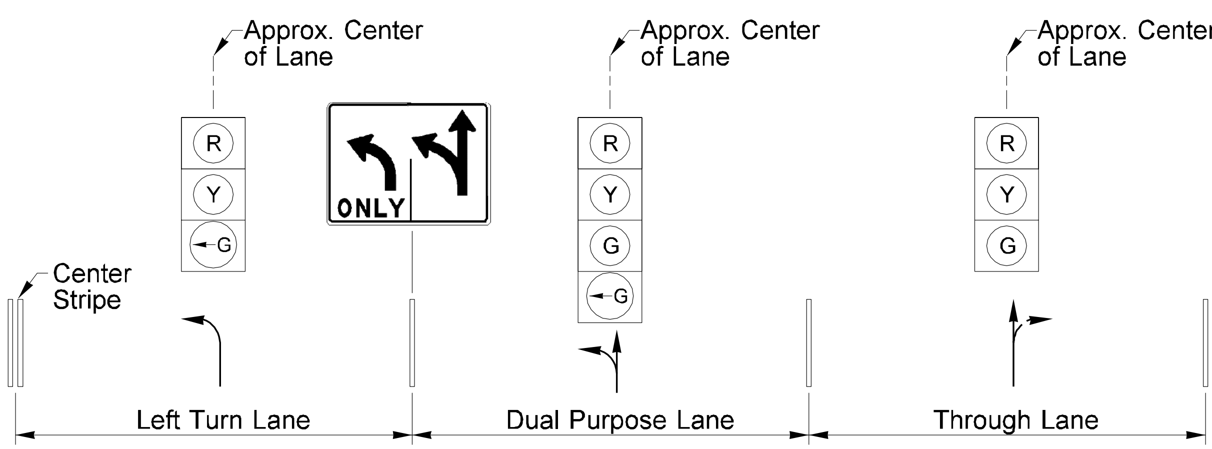
Traffic Signal Display Placements
Figure 850-12a



One Through Lane
With Protected Left Turn Phasing

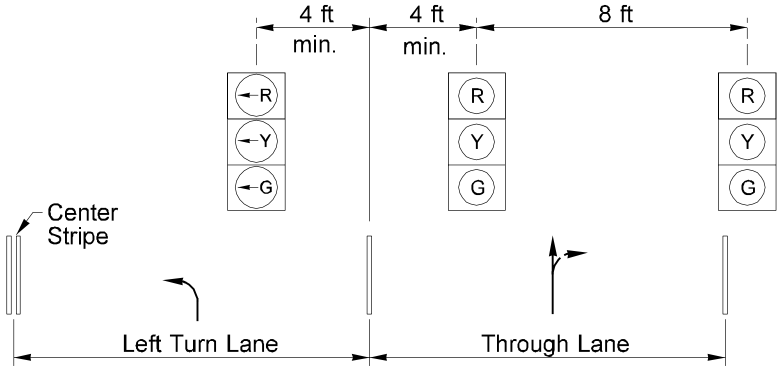


Two Through Lanes
With Split Phasing for Protected Left Turns
(Left turn and through movements terminate together.)



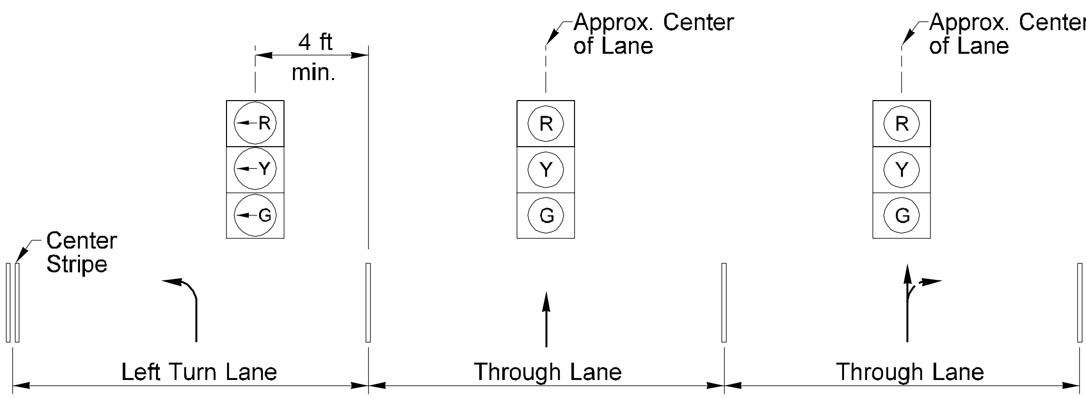
One Through Lane, a Dual Purpose (Left or Through) Lane
and One Left Turn Storage Lane With Split Phasing for Protected Left Turns
(Left turn and through movements terminate together.)

Traffic Signal Display Placements
Figure 850-12b



One Through Lane and One Left Turn Storage Lane
With Protected Left Turn Phasing

(Left turn and through movements terminate independently.)

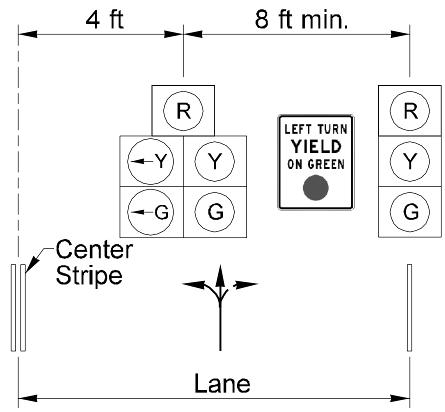


Two Through Lanes and One Left Turn Storage Lane
With Protected Left Turn Phasing

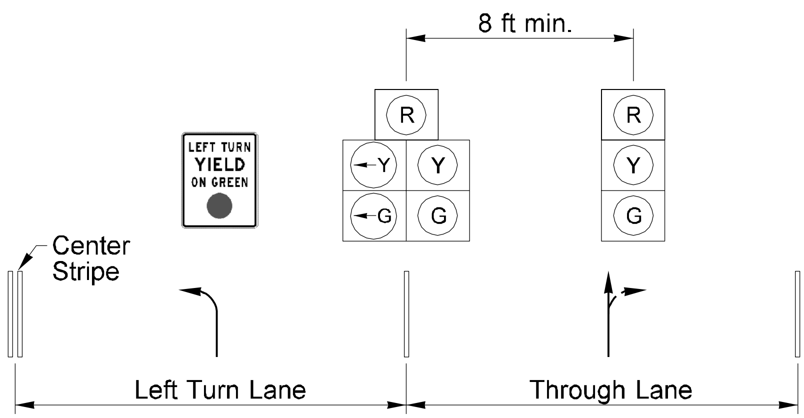
(Left turn and through movements terminate independently.)

Traffic Signal Display Placements

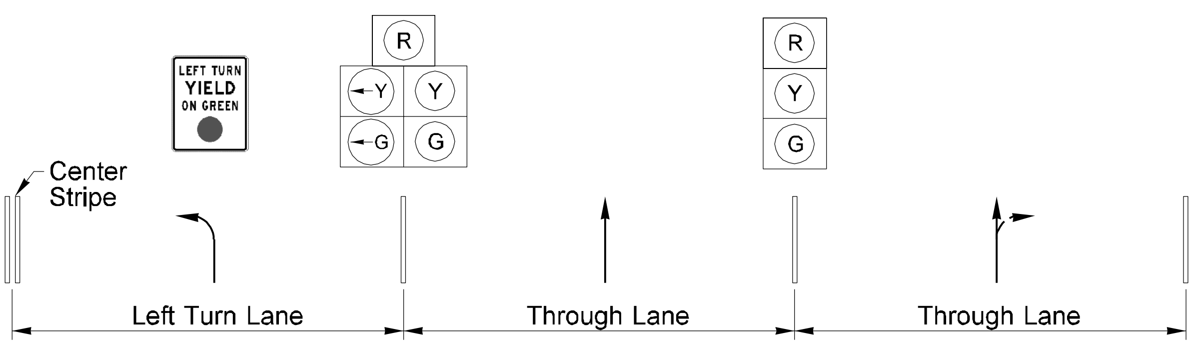
Figure 850-12c



One Through Lane
With Protected / Permissive Left Turn Phasing

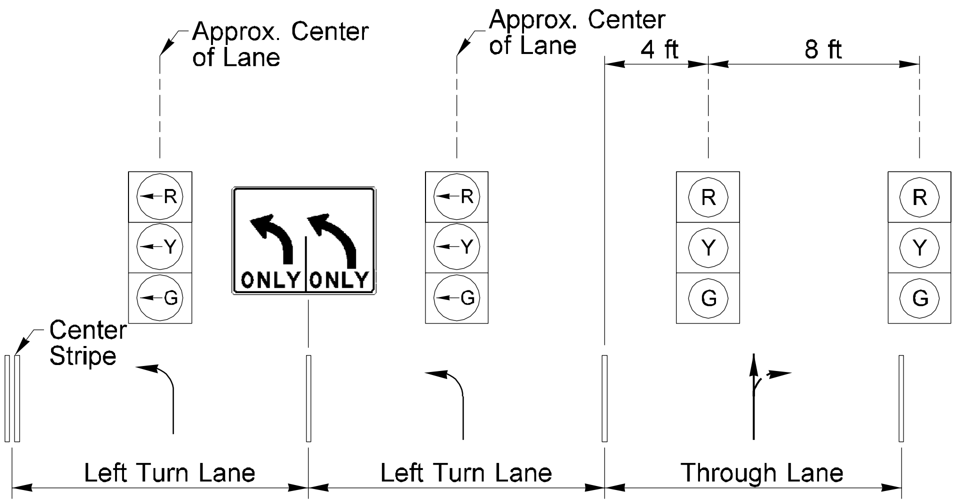


One Through Lane and One Left Turn Storage Lane
With Protected / Permissive Left Turn Phasing



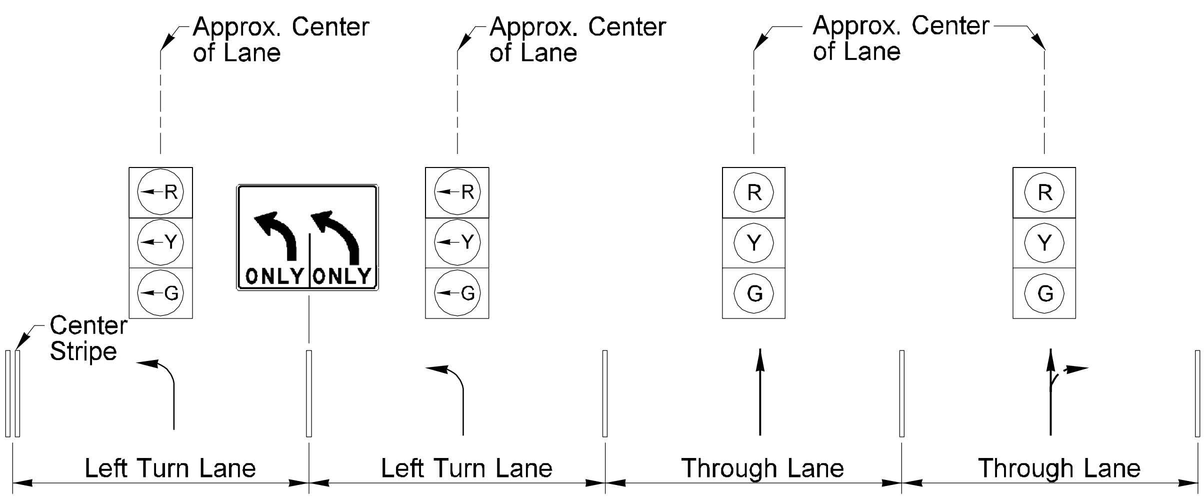
Two Through Lanes and One Left Turn Storage Lane
With Protected / Permissive Left Turn Phasing

Traffic Signal Display Placements
Figure 850-12d



One Through Lane and Two Left Turn Storage Lanes With Protected Left Turn Phasing

(Left Turn and Through Movements Terminate Independently.)

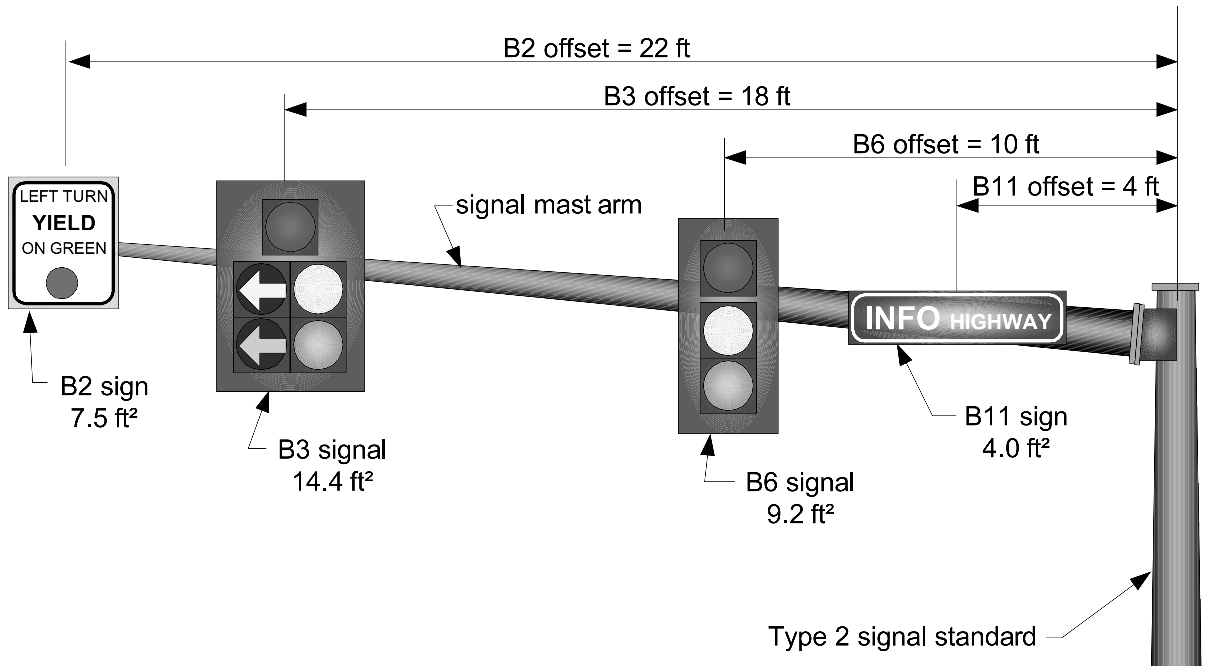


Two Through Lanes and Two Left Turn Storage Lanes With Protected Left Turn Phasing

(Left turn and through movements terminate independently.)

Traffic Signal Display Placements

Figure 850-12e



First

Total windload calculation (XYZ)

B2 area X B2 offset

$7.5\ ft^2$ X 22 ft = 165.0

B3 area X B3 offset

$14.4\ ft^2$ X 18 ft = 259.2

B6 area X B6 offset

$9.2\ ft^2$ X 10 ft = 92.0

B11 area X B11 offset

$4.0\ ft^2$ X 4 ft = 16.0

Total XYZ = $532.2\ ft^3$

Then

Determine foundation depth from chart

If the lateral bearing pressure is 1500 psf and the XYZ is $532\ ft^3$,

Then the foundation depth is:

8 ft ~ 3 ft round foundation type
7 ft ~ 3 ft square foundation type
7 ft ~ 4 ft round foundation type

FOUNDATION DEPTH TABLE							
Lateral Bearing Pressure	Foundation Type	XYZ (cubic feet) Type II, III, and SD mast arm standards					
		$600\ ft^3$	$900\ ft^3$	$1200\ ft^3$	$1500\ ft^3$	$1900\ ft^3$	$2300\ ft^3$
1000 psf	3' Round	10'	10'	11'	11'	13'	15'
	3' Square	8'	8'	9'	9'	10'	11'
	4' Round	8'	8'	9'	9'	10'	11'
1500 psf	3' Round	8'	8'	9'	11'	13'	15'
	3' Square	7'	7'	7'	8'	8'	9'
	4' Round	7'	7'	7'	8'	8'	9'
2500 psf	3' Round	6'	6'	7'	11'	13'	15'
	3' Square	6'	6'	6'	6'	7'	7'
	4' Round	6'	6'	6'	6'	7'	7'

Mast Arm Signal Moment and Foundation Depths

Figure 850-13

Selection Procedure

1. Determine span length
.
2. Calculate the total dead load (P) per span. Use 40 pounds per signal section and 6.25 pounds per square foot of sign area.

3. Calculate the average load (G) per span. G = P/n where (n) is the number of signal head assemblies plus the number of signs.

4. Determine cable tension (T) per span. Enter the proper chart with the average load (G) and number of loads (n). If (n) is less than minimum (n) allowed on chart, use minimum (n) on chart.

5. Calculate the pole load (PL) per pole. If only one cable is attached to the pole, the pole load (PL) equals the cable tension (T). If more than one cable is attached, (PL) is obtained by
computing the vector resultant of the (T) values.

6. Select the pole class from the "Foundation Design Table". Choose the pole class closest to but greater than the (PL) value.

7. Calculate the required foundation depth (D). Use the formula: $D = a\frac{DT}{\sqrt{S}}$
Select the table foundation depth (DT) from the "Foundation Design Table". Lateral soil bearing pressure (S) is measured in pounds per square foot (psf). The formula value (a) is a variable for the cross-sectional shape of the foundation. The values for these shapes are:
a = 50 for a 3' round foundation
a = 43 for a 4' round foundation
a = 41 for a 3' square foundation
Round (D) upwards to nearest whole number if 0.10 foot or greater,

8. Check vertical clearance (16.5' minimum) assuming 29' maximum cable attachment height and 5% minimum span sag.

Notes:
A special design by the Bridge and Structures Office is required if:
The span length exceeds 150 ft.
The (PL) value exceeds 7200 lbs
The vertical distance between the base plate and the first cable attachment exceeds 29 feet.

1. Charts are based on a cable weight of 3 pounds per foot (1.25 lbs/ft, cable and conductors, 1.75 lbs/ft ice). Total dead load (P) includes weight of ice on sign and signal section.
2. On timber strain pole designs, specify two down guy anchors when the (PL) value exceeds 4500 Lbs.

Foundation Design Table	
Pole Class (Pounds)	Foundation Depth (DT)
1900	6' - 0"
2700	7' - 0"
3700	8' - 0"
4800	9' - 6"
5600	10' - 0"
6300	11' - 0"
7200	12' - 0"

Strain Pole and Foundation Selection Procedure
Figure 850-14a

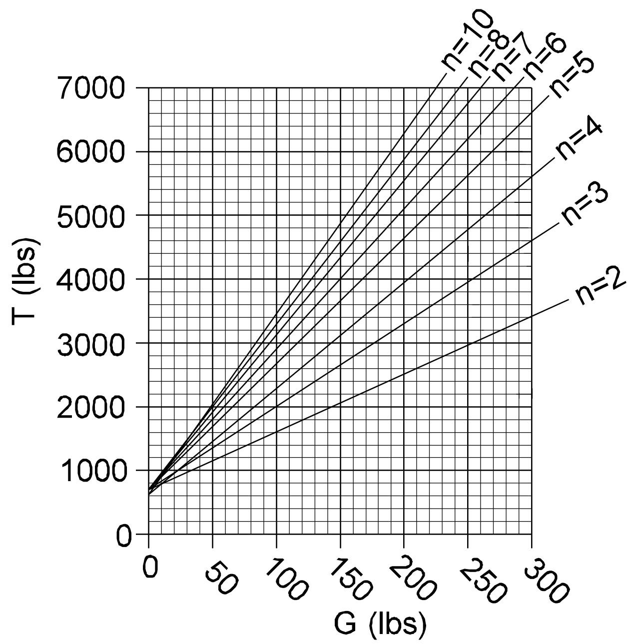


Chart 1 - Span Length 90' and Less

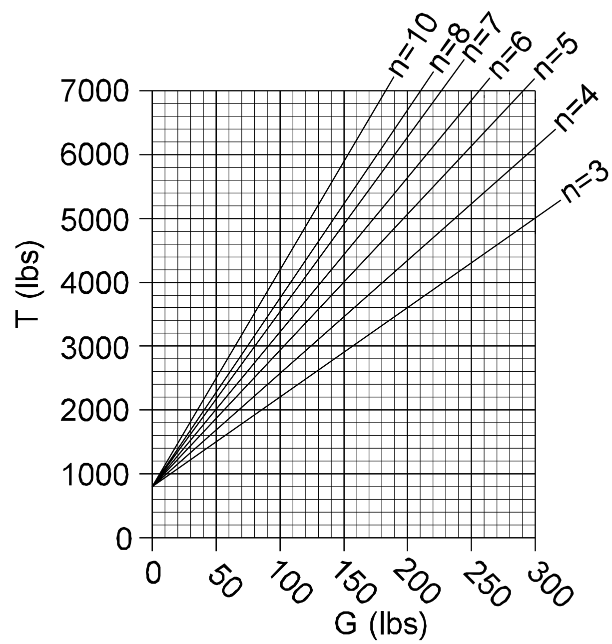


Chart 2 - Span Length 91' to 120'

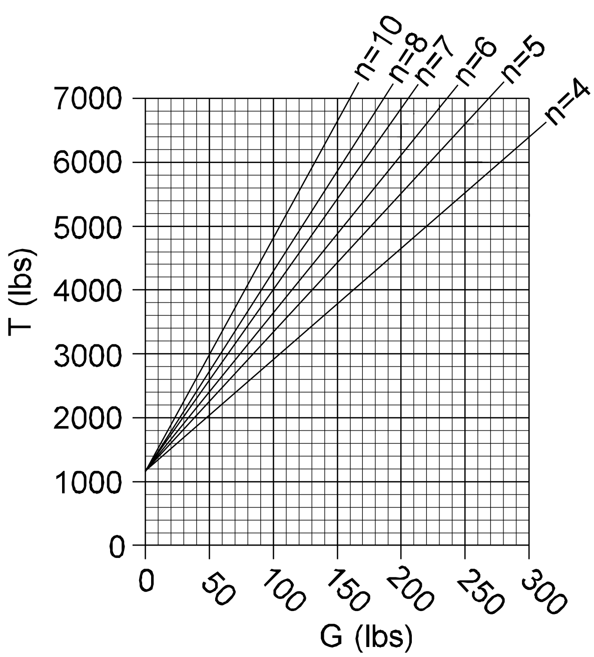
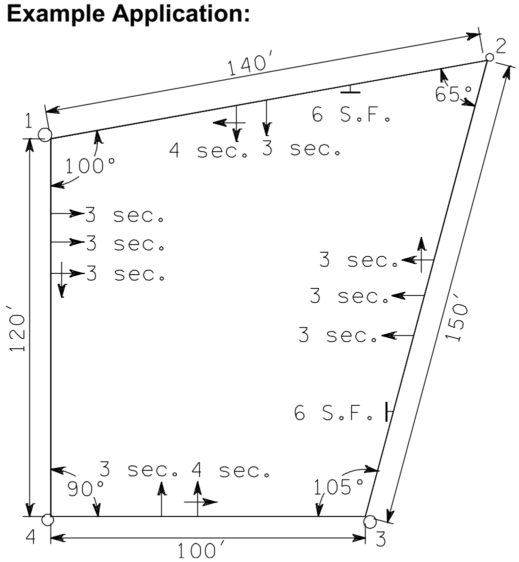


Chart 3 - Span Length 121' to 150'

Strain Pole and Foundation Selection Procedure
Figure 850-14b

Example Application:



Determine the following:

- Cable Tensions (T)
- Pole Loads (PL)
- Pole Classes
- Foundation Depths (D)

Step 1.
Span lengths given above.
Step 2.
Calculate (P) and (G) values.

Span 1-2, n = 3
7 sections x 40 lbs/sec = 280 pounds
6 s.f. sign x 6.25 lbs/s.f. = 38 pounds
Total (P) = 318 pounds
G = P/n = 318/3 = 106 pounds

Span 2-3, n = 4
9 sections x 40 lbs/sec = 360 pounds
6 s.f. sign x 6.25 lbs/s.f. = 38 pounds
Total (P) = 398 pounds
G = P/n = 398/4 = 100 pounds

Span 3-4, n =2
7 sections x 40 lbs/sec = 280 pounds
Total (P) = 280 pounds
G = P/n = 280/2 = 140 pounds

Span 4-1, n = 3
9 sections x 40 lbs/sec = 360 pounds
Total (P) = 360 pounds
G = P/n = 360/3 = 120 pounds

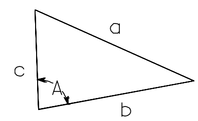
Step 3.
Determine (T) values.

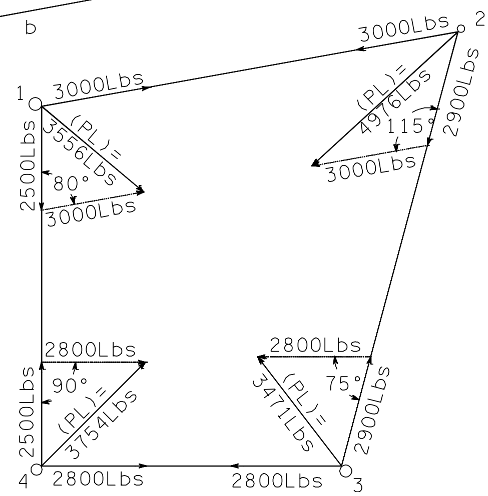
Span	Length	G	Chart	n	min n	T
1-2	140'	106 lbs	III	3	4	3000 lbs
2-3	150'	100 lbs	III	4	4	2900 lbs
3-4	140'	140 lbs	II	2	3	2800 lbs
4-1	120'	120 lbs	II	3	3	2500 lbs

Step 4.

Calculate (PL) values by computing the vector resultant of the (T) values.

$$a = \sqrt{b^2 + c^2 - 2bc(\cos A)}$$





Step 5.
Select the pole class from the Design Table (Figure 850-14b).

Pole Number	(PL)	Pole Class
1	3556 lbs	3700 lbs
2	4976 lbs	5600 lbs
3	3471 lbs	3700 lbs
4	3754 lbs	4800 lbs

Step 6.
Calculate the required foundation depths.
Given: (S) = 1000 psf.

$$D = a\frac{DT}{\sqrt{S}}$$

Pole No.	Pole Class	DT	Foundation Depths (D) 3' Rd (a=50)	4' Rd (a=43)	3' Sq (a=41)
1	3700 lbs	8'	13'	11'	11'
2	5600 lbs	10'	16'	14'	13'
3	3700 lbs	8'	13'	11'	11'
4	4800 lbs	9'-6"	15'	13'	13'

Strain Pole and Foundation Selection Example
Figure 850-15

Conduit Sizing Table			
Trade Size	Inside Diam. (inches)	Maximum Fill (inch²)	
		26%	40%
1/2”	0.632	0.08	0.13
3/4”	0.836	0.14	0.22
1”	1.063	0.23	0.35
1 1/4”	1.394	0.40	0.61
1 1/2”	1.624	0.54	0.83
2”	2.083	0.89	1.36
2 1/2”	2.489	1.27	1.95
3”	3.09	1.95	3.00
3 1/2”	3.57	2.60	4.00
4”	4.05	3.35	5.15

Conductor Size Table			
Size (AWG)	Area (inch²)	Size (AWG)	Area (inch²)
# 14 USE	0.021	2cs (# 14)	0.090
# 12 USE	0.026	3cs (# 20)	0.070
# 10 USE	0.033	4cs (# 18)	0.060
# 8 USE	0.056	5c (# 14)	0.140
# 6 USE	0.073	7c (# 14)	0.170
# 4 USE	0.097	10c (# 14)	0.290
# 3 USE	0.113	6pcc (# 19)	0.320
# 2 USE	0.133		

Conduit and Conductor Sizes

Figure 850-16

860.01 General

Intelligent Transportation Systems (ITS) apply advanced technologies in communications and computer science to optimize the safety and efficiency of the existing surface transportation network. In highway design, this goal is achieved by collecting and using traffic data to develop predictive models, regulating access to the freeway system, and providing timely information on traffic conditions to motorists. Previously, this technology was called Surveillance, Control, and Driver Information (SC&DI). In the context of highway design, ITS and SC&DI are synonymous.

The Transportation Equity Act (TEA-21) requires ITS projects to comply with the standards being developed in association with the federal government and private industry. These standards will be known as the National ITS Architecture. These standards are intended to ensure interoperability and efficiency to the maximum extent practicable for the many different types of ITS devices under development. The National ITS Architecture organizes a "system of subsystems" and makes managing ITS deployment easier. The Architecture helps agencies communicate complex ideas by providing a common language and definitions. One benefit of using the National ITS Architecture is that it helps identify all agencies and jurisdictions that should be included in ITS projects.

The ITS program in Washington State is known as "Venture Washington." It focuses on five areas within Washington State. These areas were chosen because they each have unique characteristics and problems associated with traffic. These five areas are:

- The Greater Puget Sound Region
- The Spokane Area
- The Vancouver Area
- Other Statewide Urban Areas
- Rural Areas and Intercity Corridors

An intelligent transportation system can be implemented in stages, starting with a small project for immediate benefit and then expanding the system as needed. Consider installing an ITS at any of the following locations:

- Where congestion frequently causes accidents.
- At freeway on-ramps where merging problems routinely occur.
- Where heavy traffic volumes occur between closely spaced on-ramps.
- Where the motorist would benefit from information on traffic conditions or alternative routes.

The initial stage of an intelligent transportation system can be as simple as installing a dynamic message sign that warns motorists of unusual driving conditions. Appropriate messages can be displayed on the sign using information obtained by direct observation of road conditions or by reports from law enforcement agencies.

Automated systems incorporate a traffic data collection system. The data collection system provides basic data to determine traffic volumes, vehicular speeds, and levels of congestion. The traffic data can be analyzed and used to verify the locations of traffic problems. This data can also be used in freeway computer models to predict the impacts of proposed improvements.

Design each stage of the system so that the associated technology can be used in subsequent, more sophisticated stages. For example, the stage following data collection could be the installation of closed circuit television cameras (CCTV) to monitor freeway locations where congestion is commonplace. The CCTV monitoring is used to detect or confirm incidents noted by other forms of data collection. The installation of motorist information devices such as dynamic message signs or highway advisory radio provides a means of transmitting this information to the motorist. Eventually, as traffic congestion increases, ramp meters are installed to control the traffic flow entering the facility.

When planning a staged system, attempt to determine the ultimate communication system to the degree that underground conduit size and quantity are known and can be installed in the initial construction. Consider long-term maintenance issues and component standardization.

The Northwest Region Traffic Systems Management Center (TSMC) is an example of a traffic operations center (TOC). Because a TOC usually works best with existing radio communication, it is located adjacent to or as part of a radio communication office. In addition to the location of a TOC, consider the work force and equipment costs required to operate and maintain the entire system. The size of a TOC is dependent on the complexity of the system and can vary from a single person at a desk to a large room with advanced equipment requiring continuous staffing.

860.02 References

Transportation Equity Act (TEA-21) of 1998

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), USDOT,

SC&DI Design Guide, WSDOT Northwest Region

SC&DI Operations Guide, WSDOT Northwest Region

I-90 Seattle to Spokane, ITS Corridor Study, WSDOT Advanced Technology Branch

I-5 Seattle to Vancouver, BC, ITS Corridor Study, WSDOT Advanced Technology Branch

Portland/Vancouver to Boise, ITS Corridor Study Plan, WSDOT Advanced Technology Branch

Application of Advanced Transportation Technology Within Washington State: Discussion and Policy Recommendations, WSDOT Advanced Technology Branch

State-Wide Communications Strategic Plan, WSDOT Advanced Technology Branch

Seattle to Portland Inter-City ITS Corridor Study and Communications Plan, WSDOT Advanced Technology Branch

Venture Washington, WSDOT Advanced Technology Branch

860.03 Traffic Data Collection

Loop detectors, placed in traffic lanes, are the most common devices used to collect traffic data. In general, data stations are spaced at 1/2 mile intervals between interchanges. Alternative methods of detection include video detection cameras, microwave detectors, and other newer technologies. This information can be augmented with cellular phone calls from motorists, Washington State Patrol (WSP) reports, and commercial traffic reporters.

The loops sense the amount of time a vehicle is over them. This is called *occupancy* and is recorded by a data station in a nearby roadside cabinet. The data station periodically transmits the data to a central computer. The information from the detection system is transmitted over leased phone lines, WSDOT phone lines, fiber optic lines, or microwave transmitters to a traffic operations center. A spread spectrum radio is another method of transmitting data. The central computer translates these data into an indication of traffic congestion for incident detection and traffic flow information.

A single loop provides traffic volumes and lane occupancy from which, given some basic assumptions, speeds can be computed. Two loops spaced a known distance apart, longitudinally, provide better determinations of traffic speeds.

CCTV is used by the department to manage the freeway system. It is not usually used as a traffic law enforcement tool. The primary function of CCTV is to confirm or detect incidents. As a secondary function, this information can be provided to the WSP, incident response teams, maintenance forces, and the local media.

860.04 Traffic Flow Control

During peak traffic volume periods, freeway on-ramps are metered with either roadside or overhead traffic signals. These ramp meters control or regulate the flow of traffic entering the freeway. The metering prevents the entering traffic from exceeding freeway capacity by limiting the number of vehicles that enter within a specific time period. The meters also keep long platoons of cars from merging onto the freeway. This process makes on-ramp merges safer and allows freeway traffic to move at a more efficient speed.

Ramp meters are traffic control signals and an approved traffic signal permit is required. The approval procedures for traffic signal permits are noted in Chapter 850.

Consider the available area for vehicle storage on the ramp when locating a ramp meter. If the arrival rate of the entering traffic exceeds the metered flow rate, traffic queues will develop. A common concern is that this queue might extend onto the crossroads and interfere with local traffic. Chapter 1050 provides guidance on the placement of the ramp meter. This guidance, however, only addresses the required acceleration needed to merge onto the freeway. The storage area needed at the meter varies at each location and is determined separately. If it is not possible to provide an adequate storage length on the ramp, consider alternate methods of addressing the problem.

(1) Adjust the ramp metering rate to temporarily increase the rate.

(2) Allow two vehicles to pass the meter at a time.

(3) Widen to two metered lanes.

(4) Provide storage lanes on the crossroad.

(5) Provide alternate routes for local traffic.

(6) Provide HOV bypass lanes.

(1) **Adjust Rate.** Ramp metering uses information from the detection loops to determine freeway congestion adjacent to and downstream from the ramps. Data from the loops are sent to a central computer or a local computer that adjusts the metering rate for the traffic congestion and transmits this rate to the ramp meter controllers. The ramp controllers implement the metering rate and control the signal. A ramp metering rate can be determined in two ways: remote metering and standby metering.

For remote metering, the metering rates of all ramp meter locations are determined by the local controller and adjusted by the central computer at the TOC. This is the normal mode of operation for the Seattle system. The central computer is capable of adjusting upstream metering rates on the basis of downstream conditions. A metering rate at an upstream location is decreased if traffic congestion develops downstream. Metering start and end times, as well as metering rates, can be remotely adjusted from the TOC with an override function.

Standby metering, also called local control, is used when communications with the central computer are interrupted or when that computer is not in service. In these cases, each ramp meter determines a metering rate for its on-ramp according to local traffic conditions or by a predetermined rate based on a time of day table. These time of day tables are developed to predict averages of the actual traffic volume peaking characteristics of the on-ramp. In standby metering, each ramp meter operates independently without coordinating with other controllers.

Single lane metering rates normally vary between 4 and 15 vehicles per minute (240 and 900 vehicles per hour). If a ramp has heavier traffic volumes and queue storage is not adequate, several actions can be taken.

(2) **Two Vehicles**. The metering capacity can be increased by allowing two vehicles to enter during each green cycle. This can increase a single lane ramp meter maximum capacity to about 1,100 vehicles per hour. This procedure is a temporary, operational solution and is not a recommended design practice.

(3) **Widen**. The metering capacity can be increased by widening the ramp to install additional lanes. Widening a single-lane on-ramp to create two lanes can double the metered traffic volume to 1,800 vehicles per hour, provided no downstream traffic congestion develops. Changes in ramp access to the freeway might require an access point decision report. (See Chapter 1425.)

(4) **Storage Lanes**. If adequate storage length cannot be provided on the ramp, it might be possible to provide storage as turn lanes on the crossroad and adjust the ramp terminal traffic signal timing to limit freeway access movements.

(5) **Diversion**. Diversion of some ramp traffic to local arterial streets might can be desirable, assuming a suitable alternate route is available. When diversion occurs, modification of traffic signal timing and coordination plans on the alternative routes might be necessary. Coordinate efforts with the local agency and, if appropriate, initiate public meetings to identify needs and impacts.

(6) **HOV Bypass.** Wherever possible, provide bypass lanes for high occupancy vehicles (HOV) around the traffic queue at the ramp meter. The HOV bypass allows transit vehicles to maintain schedules and indirectly provides an incentive for carpooling. (See Chapter 1050.)

860.05 Motorist Information

Motorist information includes dynamic message signs, highway advisory radio, telephone traffic information lines, commercial radio and television messages, and Internet access for personal computers. These are all used to transmit traffic conditions to freeway users. The motorist information system is also used to alert drivers to short term construction and maintenance activities that might affect normal travel patterns. It can also be used to suggest alternative travel routes.

(1) Dynamic Message Signs

Dynamic message signs (DMS) are used to provide motorists with current road and traffic conditions. Accidents, incidents, construction and maintenance activities, reversible lane status, traffic congestion, and traction device requirements are examples of this information. Because motorists receive many distractions while driving, consider the location of the DMS. The best location for a DMS is on a tangent section of roadway with few roadside distractions. Overhead installations have more visual impact. When possible, use sign bridges, cantilever sign structures, or bridge mounts on existing overcrossings for DMSs. Use the message displays and sign location requirements contained in the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) and Chapter 820.

(2) Highway Advisory Radio

The highway advisory radio (HAR) system uses car radios to provide information to motorists. Warning signs, usually with flashing beacons, direct motorists to select a specific AM radio station for information. HAR has an advantage over DMS because longer messages with more detailed information can be relayed to the motorist. The major disadvantages are that not all vehicles have radios that can receive HAR frequencies, and some motorists might not use the radio for this information. HAR works best when used in conjunction with DMS.

HAR locations and assigned radio frequencies are restricted to prevent interference with other frequencies in use. HAR message content is restricted by federal regulations and WSDOT restricts HAR messages to noncommercial voice information pertaining to roadway and mountain pass conditions, major incidents, traffic hazards, and travel advisories.

(3) Additional Public Information Components

A telephone number can be provided to give the same prerecorded messages as the HAR and can also include transit and carpool information. A computer generated flow map can be developed, using the data collection system, to graphically depict actual traffic flows within a geographical area. The flow map can be made accessible to the public by providing links to a WSDOT web site.

860.06 Documentation

Preserve the following documents in the project file: See Chapter 330.

- ☐ Justification for the installation of ramp meters.
- ☐ Approved traffic signal permit for ramp meters.
- ☐ All correspondence and coordination with local agencies.
- ☐ Designs for the ultimate system when staged implementation is used.

P65:DP/DMM

910.01 General

Intersections are a critical part of highway design because of increased conflict potential. Traffic and driver characteristics, bicycle and pedestrian needs, physical features, and economics are considered during the design stage to develop channelization and traffic control to enhance safe and efficient multimodal traffic flow through intersections.

This chapter provides guidance for designing intersections at grade, including at-grade ramp terminals. See the following chapters for additional information:

Chapter	Subject
915	Roundabouts
920	Road Approaches
940	Interchanges

If an intersection design situation is not covered in this chapter, contact the Headquarters (HQ) Design Office, for assistance.

910.02 References

Laws – Federal and state laws and codes that may pertain to this chapter include:

Americans with Disabilities Act of 1990 (ADA)

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, Chapter 468-95 WAC (MUTCD), http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Washington Administrative Code (WAC) 468-18-040, "Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings"

WAC 468-52, "Highway access management—Access control classification system and standards"

Design Guidance – Design guidance included by reference within the text includes:

Local Agency Guidelines (LAG), M 36-63, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Supporting Information – Other resources used or referenced in this chapter include:

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians, FHWA-RD-01-051, USDOT, FHWA, May 2001

Highway Capacity Manual (HCM), Special Report 209, Transportation Research Board, National Research Council

Highway Research Record No. 211 *Aspects of Traffic Control Devices*, pp 1-18, "Volume Warrants for Left-Turn Storage Lanes at Unsignalized Grade Intersections." Harmelink, M. D.

NCHRP 279 *Intersection Channelization Design Guide*

Roundabouts: An Informational Guide, FHWA-RD-00-067, USDOT, FHWA

910.03 Definitions

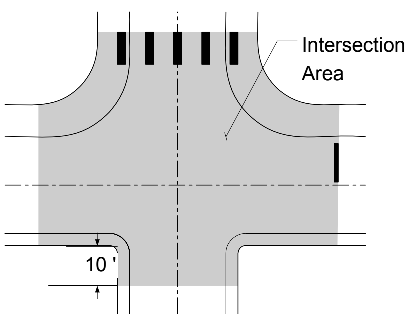
bulb out A curb and sidewalk bulge or extension out into the roadway used to decrease the length of a pedestrian crossing. (See chapter 1025.)

conflict An event involving two or more road users, in which the action of one user causes the other user to make an evasive maneuver to avoid a collision.

crossroad The minor roadway at an intersection. At a stopped controlled intersection, the crossroad has the stop.

intersection angle The angle between any two intersecting legs at the point that the center lines intersect.

intersection area The area of the intersecting roadways bounded by the edge of traveled ways and the area of the adjacent roadways to the end of the corner radii, any marked crosswalks adjacent to the intersection, or stop bar, but not less than 10 feet from the edge of shoulder of the intersecting roadway. See Figure 910-1.



Intersection Area
Figure 910-1

intersection at grade The general area where a state route or ramp terminal is met or crossed at a common grade or elevation by another state route, a county road, or a city street.

> ***four leg intersection*** An intersection with four legs, as where two highways cross.
>
> ***tee (T) intersection*** An intersection with three legs in the general form of a "T."
>
> ***split tee*** A four leg intersection with the cross road intersecting the through roadway at two tee intersections. The crossroad must be offset at least the width of the roadway.
>
> ***wye (Y) intersection*** An intersection with three legs in the general form of a "Y" and the angle between two legs is less than 60°.

intersection leg Any one of the roadways radiating from and forming part of an intersection.

> ***entrance leg*** The lanes of an intersection leg for traffic entering the intersection.
>
> ***exit leg*** The lanes of an intersection leg for traffic leaving the intersection.
>
> Whether an intersection leg is an entrance leg or an exit leg depends on which movement is being analyzed. For two way roadways, each leg is an entrance leg for some movements and an exit leg for other movements.

intersection sight distance The distance that the driver of a vehicle on the crossroad can see along the through roadway, as compared to the distance required for safe operation.

island A defined area within an intersection, between traffic lanes, for the separation of vehicle movements or for pedestrian refuge. It may be outlined with pavement markings or delineated by curbs. Within an intersection, a median is considered an island.

> ***channelization island*** An island that separates traffic movements into definite paths of travel and guides traffic into the intended route.
>
> ***divisional island*** An island introduced, on an undivided roadway, at an intersection to warn drivers of the crossroad ahead and regulate traffic through the intersection.
>
> ***refuge island*** An island at or near a crosswalk or bicycle path to aid and protect pedestrians and bicyclists crossing the roadway.

median crossover An opening in a median provided for crossings by maintenance, law enforcement, emergency, and traffic service vehicles. (See Chapter 960.)

roundabout A circular intersection at which all traffic moves counterclockwise around a central island. (See Chapter 915)

rural intersection An intersection in a nonurban area.

urban intersection An intersection that is in one of the following areas:

- The area within the federal urban area boundary as designated by FHWA.
- An area characterized by intensive use of the land for the location of structures and receiving such urban services as sewers, water, and other public utilities and services normally associated with urbanized areas.
- An area with not more than 25% undeveloped land.

910.04 Design Considerations

Intersection design requires consideration of all potential users of the facility. This involves addressing the needs of a diverse mix of user groups including passenger cars, heavy vehicles of varying classifications, bicycles, and pedestrians. Often, meeting the needs of one user group requires a compromise in service to others. Intersection design balances these competing needs, resulting in appropriate levels of operation for all users.

In addition to reducing the number of conflicts, minimize the conflict area as much as possible while still providing for the required design vehicle (910.05). This is done to control the speed of turning vehicles and reduce vehicle, bicyclist, and pedestrian exposure.

(1) Traffic Analysis

Conduct a traffic analysis and an accident analysis to determine the design characteristics of each intersection. Include recommendations for channelization, turn lanes, acceleration and deceleration lanes, intersection configurations, illumination, bicycle and pedestrian accommodations, ADA requirements, and traffic control devices in the traffic analysis.

(2) Intersection Configurations

(a) **Intersection angle.** An important intersection design characteristic is the intersection angle. The desirable intersection angle is 90°, with 75° to 105° allowed for new, reconstructed, or realigned intersections.

Existing intersections with an intersection angle between 60° and 120° may remain. Intersection angles outside this range tend to restrict visibility, increase the area required for turning, increase the difficulty to make a turn, increase the crossing distance and time for vehicles and pedestrians, and make traffic signal arms difficult or impossible to design.

(b) **Lane alignment.** Design intersections with entrance lanes aligned with the exit lanes. Do not put angle points on the roadway alignments within intersection areas or on the through roadway alignment within 100 feet of the edge of traveled way of a crossroad. This includes short radius curves where both the PC and PT are within the intersection area. However, angle points within the intersection are allowed at intersections with a minor through movement, such as at a ramp terminal (Figure 910-18).

When practical, locate intersections so that curves do not begin or end within the intersection area. It is desirable to locate the PC and PT at least 250 feet from the intersection so that a driver can settle into the curve before the gap in the striping for the intersection area.

(c) **Split Tee.** Avoid split tee intersections where there is less than the required intersection spacing. See 910.04(4). Split tee intersections with an offset distance to the left greater than the width of the roadway, but less than the intersection spacing, may be designed with justification. Evaluate the anticipated benefits against the increased difficulty in driving through the intersection and a more complicated traffic signal design.

Split tee intersections with the offset to the right have the additional disadvantages of overlapping main line left-turn lanes, increased possibility of wrong way movements, and traffic signal design that is even more complicated. Do not design a split tee intersection with an offset to the right less than the required intersection spacing [see 910.04(4)] unless traffic is restricted to right-in right-out only.

(d) **Other Nonstandard Configurations.** Do not design intersections with nonstandard configurations such as:

- Intersections with offset legs, except for split tee intersections [910.04(2)(c)].
- Intersections with more than four legs.
- Tee intersections with the major traffic movement making a turn.
- Wye intersections that are not a one-way merge or diverge.

A roundabout might be an alternative to these nonstandard configurations. (See 910.08 and Chapter 915.)

With justification and approval from the region's Traffic Engineer existing intersections with nonstandard configurations may remain in place when an analysis shows no accident history related to the configuration.

(3) Crossroads

When the crossroad is a city street or county road, design the crossroad beyond the intersection area according to the applicable design criteria given in Chapter 440 for a city street or county road.

When the crossroad is a state facility, design the crossroad according to the applicable design level and functional class (Chapters 325, 430, and 440). Continue the cross slope of the through roadway shoulder as the grade for the crossroad. Use a vertical curve that is at least 60 feet long to connect to the grade of the crossroad.

Consider the profile of the crossroad in the intersection area. To prevent operational problems, the crown slope of the main line might need to be adjusted in the intersection area.

In areas that experience accumulations of snow and ice and for all legs that will require traffic to stop, design a maximum grade of ±4% for a length equal to the anticipated queue length for stopped vehicles.

(4) Intersection Spacing

Adequate intersection spacing is required to provide for safety and the desired operational characteristics for the highway. The minimum spacing for highways with limited access control is covered in Chapter 1430. For other highways, the minimum spacing is dependent on the Highway Access Management Class. See Chapter 1435 for minimum intersection spacing on Managed Access highways.

As a minimum, provide enough space between intersections for left-turn lanes and storage length. Space signalized intersections, and intersections expected to be signalized, to maintain efficient signal operation. It is desirable to space intersections so that queues will not block an adjacent intersection.

910.05 Design Vehicle

The physical characteristics of the design vehicle control the geometric design of the intersection. The following design vehicle types are commonly used:

Design Symbol	Vehicle Type
P	Passenger car, including light delivery trucks.
BUS	Single unit bus
A-BUS	Articulated bus
SU	Single unit truck
WB-40	Semitrailer truck, overall wheelbase of 40 ft
WB-50	Semitrailer truck, overall wheelbase of 50 ft
WB-67	Semitrailer truck, overall wheelbase of 67 ft
MH	Motor home
P/T	Passenger car pulling a camper trailer
MH/B	Motor home pulling a boat trailer

Design Vehicle Types
Figure 910-2

The geometric design of an intersection requires identifying and addressing the needs of all intersection users. There are competing design objectives when considering the turning requirements of the larger design vehicles and the crossing requirements of pedestrians. To reduce the operational impacts of large design vehicles, larger turn radii are used. This results in increased pavement areas, longer pedestrian crossing distances, and longer traffic signal arms.

To reduce the intersection area, a smaller design vehicle is used or encroachment is allowed. This reduces the potential for vehicle/pedestrian conflicts, decreases pedestrian crossing distance, and controls speeds of turning vehicles. The negative impacts include possible capacity reductions and greater speed differences between turning vehicles and through vehicles.

Select a design vehicle that is the largest vehicle that normally uses the intersection. The primary use of the design vehicle is to determine radii requirements for each leg of the intersection. It is possible for each leg to have a different design vehicle. Figure 910-3 shows the minimum design vehicles. As justification to use a smaller vehicle, include a traffic analysis showing that the proposed vehicle is appropriate.

Intersection Type	Design Vehicle
Junction of Major Truck Routes	WB-67
Junction of State Routes	WB-50
Ramp Terminals	WB-50
Other Rural	WB-50
Industrial	WB-40
Commercial	SU(1)(2)
Residential	SU(1)(2)

(1) To accommodate pedestrians, the P vehicle may be used as the design vehicle if justification, with a traffic analysis, is documented.
(2) When the intersection is on a transit or school bus route, use the BUS design vehicle as a minimum. See Chapter 1060 for additional guidance for transit facilities.

Intersection Design Vehicle
Figure 910-3

To minimize the disruption to other traffic, design the intersection to allow the design vehicles to make each turning movement without encroaching on curbs, opposing lanes, or same-direction lanes at the entrance leg. Use turning path templates (Figures 910-6a through 6c, templates from another published source, or computer generated templates) to verify that the design vehicle can make the turning movements.

Encroachment on same-direction lanes of the exit leg and the shoulder might be necessary to minimize crosswalk distances; however, this might negatively impact vehicular operations. Document and justify the operational tradeoffs associated with this encroachment. When encroachment on the shoulder is required, increase the pavement structure to support the anticipated traffic.

In addition to the design vehicle, often a larger vehicle must be considered. When vehicles larger than the design vehicle are allowed and are anticipated to occasionally use the intersection make certain that they can make the turn without leaving the paved shoulders or encroaching on a sidewalk. The amount of encroachment allowed is dependent on the frequency of the vehicle and the resulting disruption to other traffic. Use the WB-67 as the largest vehicle at all state route to state route junctions. Document and justify any required encroachment into other lanes, and any degradation of intersection operation.

910.06 Right-Turn Corners

The geometric design of an intersection requires identifying and addressing the needs of all intersection users. For the design of right-turn corners, there can be competing design objectives when considering the turning requirements of the design vehicle and the crossing requirements of pedestrians. To reduce the operational impacts of large trucks, right-turn radii are designed so that the truck can complete its turn without encroaching on the adjacent lanes at either the entrance or the exit legs of the turn. This results in larger corner radii, increased pavement area and pedestrian crossing distance, a larger conflict area, and higher vehicle turning speeds.

When pedestrian issues are a primary concern, the design objectives become one of reducing the potential for vehicle/pedestrian conflicts. This is done by minimizing pedestrian crossing distance and controlling the speeds of turning vehicles. This normally leads to right-corner designs with smaller turning radii. The negative impacts include possible capacity reductions and greater speed differences between turning vehicles and through vehicles.

Pedestrian refuge islands can also improve pedestrian safety. Pedestrian refuge islands minimize the crossing distance, reduce the conflict area, and minimize the impacts on vehicular traffic. When designing islands, speeds can be reduced by designing the turning roadway with a taper or large radius curve at the beginning of the turn and a small radius curve at the end. This allows larger islands while forcing the turning traffic to slow down.

Figure 910-7 shows right-turn corner designs for the design vehicles. These are considered the minimum pavement area to accommodate the design vehicles without encroachment on the adjacent lane at either leg of the curve.

With justification, right-turn corner designs given in Figure 910-7 may be modified. Document the benefits and impacts of the modified design including: changes to vehicle pedestrian conflicts, vehicle encroachment on the shoulder or adjacent same direction lane at the exit leg, capacity restrictions for right-turning vehicles or other degradation of intersection operations, and the effects on other traffic movements. To verify that the design vehicle can make the turn, include a plot of the design showing the design vehicle turning path template.

910.07 Channelization

Channelization is the separation or regulation of traffic movements into delineated paths of travel to facilitate the safe and orderly movement of vehicles, bicycles, and pedestrians.

Painted or plastic pavement markings are normally used to delineate travel paths. (See Chapter 830 and the Standard Plans for details.)

(1) Left-Turn Lanes

Left-turn lanes provide storage, separate from the through lanes, for left-turning vehicles waiting for a signal to change or for a gap in opposing traffic. (See 910.07(3) for a discussion on speed change lanes.)

Design left-turn channelization to provide sufficient operational flexibility to function under peak loads and adverse conditions.

(a) **One-Way Left-Turn Lanes** are separate storage lanes for vehicles turning left from one roadway onto another. When recommended, one-way left-turn lanes may be an economical way to lessen delays and accident potential involving left-turning vehicles. In addition, they can allow deceleration clear of the through traffic lanes. When considering left-turn lanes, consider impacts to all intersection movements and users.

At signalized intersections, use a traffic signal analysis to determine if a left-turn lane is needed and what the storage requirements are. (See Chapter 850.)

At unsignalized intersections, use the following as a guide to determine whether or not to provide one-way left-turn lanes:

- A traffic analysis indicates that a left-turn lane will reduce congestion. On two-lane highways, use Figure 910-8a, based on total traffic volume (DHV) for both directions and percent left-turn traffic, to determine if further investigation is needed. On four-lane highways, use Figure 910-8b to determine if a left-turn lane is recommended.
- An accident study indicates that a left-turn lane will reduce accidents.
- Restrictive geometrics require left-turning vehicles to slow greatly below the speed of the through traffic.
- There is less than decision sight distance at the approach to the intersection.

An HCM analysis may also be used to determine if left-turn lanes are necessary to maintain the desired level of service.

Determine the storage length required on two-lane highways by using Figures 910-9a through 9c. On four-lane highways use Figure 910-8b. These lengths do not consider trucks. Use Figure 910-4 for storage length when trucks are present.

Storage* Length (ft)	% Trucks in Left-Turn Movement				
	10	20	30	40	50
100	125	125	150	150	150
150	175	200	200	200	200
200	225	250	275	300	300
250	275	300	325	350	375
300	350	375	400	400	400
*Length from Figures 910-8b, 9a, 9b, or 9c.					

Left-Turn Storage With Trucks (ft)
Figure 910-4

Design opposing left-turn design vehicle paths with a minimum 4-foot (12-foot desirable) clearance between opposing turning paths. Existing signalized intersections that do not meet the 4-foot clearance may remain with split signal phasing, an evaluate upgrade, and concurrence from the HQ Traffic Office.

Where one-way left-turn channelization with curbing is to be provided, ensure that surface water will drain.

Provide illumination at left-turn lanes in accordance with the guidelines in Chapter 840.

At signalized intersections with high left-turn volumes, double left-turn lanes may be needed to maintain the desired level of service. A throat width of 30 to 36 feet is desirable on the exit leg of the turn to offset vehicle offtracking and the difficulty of two vehicles turning abreast. Use turning path templates to verify that the design vehicle can complete the turn. Where the design vehicle is a WB-40 or larger it is preferred to provide for the design vehicle and an SU turning abreast rather than two design vehicles turning abreast.

Figures 910-10a through 10e show one-way left-turn geometrics. Figure 910-10a shows widening to accommodate the new lane. Figures 910-10c and 10d show the use of a median. Figure 910-10e shows the minimum protected left-turn with a median.

1. **Widening (Figure 910-10a).** It is desirable that offsets and pavement widening be symmetrical about the centerline or base line. Where right of way or topographic restrictions, crossroad alignments, or other circumstances preclude symmetrical widening, pavement widening may be on one side only.

2. **Divided Highways (Figure 910-10b through 10d).** Widening is not required for left-turn lane channelization where medians are 11 feet wide or wider. For medians between 13 feet and 23 feet or where the acceleration lane is not provided, it is desirable to design the left-turn lane adjacent to the opposing lane, as shown on Figure 910-10b, to improve sight distance.

A median acceleration lane, shown on Figures 910-10c and 10d, may be provided where the median is 23 feet or wider. The median acceleration lane might not be necessary at a signalized intersection. When a median acceleration lane is to be used, design it in accordance with 910.07(3) Speed Change Lanes. Where medians have sufficient width, provide a 2-foot shoulder adjacent to a left-turn lane.

3. **Minimum Protected Left-Turn with a Median (Figure 910-10e).** At intersections on divided highways where channelized left-turn lanes are not provided, consider the minimum protected storage area.

With justification, left-turn lane designs given in Figures 910-10a through 10d may be modified. Document the benefits and impacts of the modified design including: changes to vehicle pedestrian conflicts, vehicle encroachment, deceleration length, capacity restrictions for turning vehicles or other degradation of intersection operations, and the effects on other traffic movements. The modified design must be able to accommodate the design vehicle and provide for the striping requirements of the Standard Plans and the MUTCD. To verify that the design vehicle can make the turn, include a plot of the design showing the design vehicle turning path template.

(b) **Two-Way Left-Turn Lanes** (TWLTL) are located between opposing lanes of traffic. They are used by vehicles making left turns from either direction, either from or onto the roadway.

Use TWLTLs only on managed access highways where there are no more than two through lanes in each direction. Consider installation of TWLTLs where:

- An accident study indicates that a TWLTL will reduce accidents.
- There are existing closely spaced access points or minor street intersections.
- There are unacceptable through traffic delays or capacity reductions because of left turning vehicles.

A TWLTL can reduce delays to through traffic, reduce rear-end accidents, and provide separation between opposing lanes of traffic. However, they do not provide a safe refuge for pedestrians and can encourage strip development with additional closely spaced access points. Consider other alternatives, before using a TWLTL, such as prohibiting midblock left-turns and providing for U-turns. See Chapters 440 and 1435 for additional restrictions on the use of TWLTLs.

The basic design for a TWLTL is illustrated on Figure 910-10f. Additional criteria are:

- The desirable length of a TWLTL is not less than 250 feet.
- Provide illumination in accordance with the guidelines in Chapter 840.
- Pavement markings, signs, and other traffic control devices must be in accordance with the MUTCD and the Standard Plans.
- Provide clear channelization when changing from TWLTL to one-way left-turn lanes at an intersection.

(2) Right-Turn Lanes and Drop Lanes

Right-turn movements influence intersection capacity even though there is no conflict between right-turning vehicles and opposing traffic. Right-turn lanes might be needed to maintain efficient intersection operation. Use the following as guidelines to determine when to consider right-turn lanes at unsignalized intersections:

- Recommendation from Figure 910-11 based on same direction approach and right-turn traffic volumes for multilane roadways with a posted speed 45 miles per hour or above and for all two-lane roadways.
- An accident study indicates that a right-turn lane will result in an overall accident reduction.
- Presence of pedestrians who require right-turning vehicles to stop.
- Restrictive geometrics that require right-turning vehicles to slow greatly below the speed of the through traffic.
- Less than decision sight distance at the approach to the intersection.

For unsignalized intersections, see 910.07(3) Speed Change Lanes for guidance on right-turn lane lengths. For signalized intersections, use a traffic signal analysis to determine if a right-turn lane is needed and the length requirement. (See Chapter 850.)

A capacity analysis may be used to determine if right-turn lanes are necessary to maintain the desired level of service.

Where adequate right of way exists, providing right-turn lanes is relatively inexpensive and can provide increased safety and operational efficiency.

The right-turn pocket or the right-turn taper (Figure 910-12) may be used at any minor intersection where a deceleration lane is not required and turning volumes indicate a need as set forth in Figure 910-11. These designs will cause less interference and delay to the through movement by offering an earlier exit to right-turning vehicles.

If the right-turn pocket is used, Figure 910-12 shows taper lengths for various posted speeds.

A lane may be dropped at an intersection with a turn-only lane or beyond the intersection with an acceleration lane (Figure 910-14). Do not allow a lane-reduction taper to cross an intersection or end less than 100 feet before an intersection.

When a lane is dropped beyond a signalized intersection, provide a lane of sufficient length to allow smooth merging. For facilities with a posted speed of 45 miles per hour or higher, use a minimum length of 1,500 feet. For facilities with a posted speed less than 45 miles per hour, provide a lane of sufficient length so that the advanced lane reduction warning sign will be placed not less than 100 feet beyond the intersection area.

(3) Speed Change Lanes

A speed change lane is an auxiliary lane primarily for the acceleration or deceleration of vehicles entering or leaving the through traveled way. Speed change lanes are normally provided for at-grade intersections on multilane divided highways with access control. Where roadside conditions and right of way allow, speed change lanes may be provided on other through roadways. Justification for a speed change lane depends on many factors such as speed, traffic volumes, capacity, type of highway, the design and frequency of intersections, and accident history.

A deceleration lane is advantageous because, if a deceleration lane is not provided the driver leaving the highway must slow down in the through lane regardless of following traffic.

An acceleration lane is not as advantageous because entering drivers can wait for an opportunity to merge without disrupting through traffic.

When either deceleration or acceleration lanes are to be used, design them in accordance with Figures 910-13 and 14. When the design speed of the turning traffic is greater than 20 miles per hour, design the speed change lane as a ramp in accordance with Chapter 940. When a deceleration lane is used with a left-turn lane, add the deceleration length to the storage length.

(4) Shoulders

With justification, shoulder width requirements may be reduced within areas channelized for intersection turning lanes or speed change lanes. Apply left shoulder width criteria to the median shoulder of divided highways. On one-way couplets, apply the width criteria for the right shoulder to both the right and left shoulders.

For roadways without curb sections, the shoulder adjacent to turn lanes and speed change lanes may be reduced to 2 feet on the left and 4 feet on the right. When a curb and sidewalk section is used with a turn lane or speed change lane, 400 feet or less in length, the shoulder abutting the turn lane may be eliminated. In instances where curb is used without sidewalk, provide a minimum of 4 foot wide shoulders on the right. Where curbing is used adjacent to left turn lanes, the shoulder may be eliminated. Adjust the design of the intersection as necessary to allow for vehicle tracking.

Reducing the shoulder width at intersections facilitates the installation of turn lanes without unduly affecting the overall width of the roadway. A narrower roadway also reduces pedestrian exposure in crosswalks and discourages motorists from using the shoulder to bypass other turning traffic.

On routes where provisions are made for bicycles, continue the bicycle facility between the turn lane and the through lane. (See Chapter 1020 for information on bicycle facilities.)

(5) Islands

An island is a defined area within an intersection between traffic lanes for the separation of vehicle movements or for pedestrian refuge. Within an intersection, a median is considered an island. Design islands to clearly delineate the traffic channels to drivers and pedestrians.

Traffic islands perform these functions:

- Channelization islands control and direct traffic movement.
- Divisional islands separate traffic movements.
- Refuge islands provide refuge for pedestrians.
- Islands can provide for the placement of traffic control devices and luminaires.
- Islands can provide areas within the roadway for landscaping.

(a) **Size and Shape.** Divisional and refuge islands are normally elongated and at least 4 feet wide and 20 feet long. (Mountable curb, used to discourage turn movements, is not a divisional island.)

Channelization islands are normally triangular. In rural areas, 75 ft^2 is the minimum island area and 100 ft^2 is desirable. In urban areas where posted speeds are 25 miles per hour or less, smaller islands are acceptable. Use islands with at least 200 ft^2 if pedestrians will be crossing or traffic control devices or luminaires will be installed.

Design triangular shaped islands as shown on Figure 910-15a through 15c. The shoulder and offset widths illustrated are for islands with vertical curbs 6 inches or higher. Where painted islands are used, such as in rural areas, these widths are desirable but may be omitted. See Chapter 641 for turning roadway widths.

Island markings may be supplemented with reflective raised pavement markers.

Barrier-free access must be provided at crosswalk locations where raised islands are used. See Chapter 1025.

(b) **Location.** Design the approach ends of islands to provide adequate visibility to alert the motorist of their presence. Position the island so that a smooth transition in vehicle speed and direction is attained. Begin transverse lane shifts far enough in advance of the intersection to allow gradual transitions. Avoid introducing islands on a horizontal or vertical curve. If the use of an island on a curve cannot be avoided, provide adequate sight distance, illumination, or extension of the island.

(c) **Compound Right-Turn Lane.** To design large islands, the common method is to use a large radius curve for the turning traffic. While this does provide a larger island, it also encourages higher turning speeds. Where pedestrians are a concern, higher turning speeds are undesirable. An alternative is a compound curve with a large radius followed by a small radius (Figure 910-15b). This design forces the turning traffic to slow down.

(d) **Curbing.** Provide vertical curb 6 inches or higher for:

- Islands with luminaires, signals, or other traffic control devices.
- Pedestrian refuge islands.

In addition consider curbing for:

- Divisional and channelizing islands.
- Landscaped islands.

In general, unless required for the uses listed above, it is preferred not to use curbs on facilities with a posted speed of 45 miles per hour or greater.

Avoid using curbs if the same objective can be attained with pavement markings.

See Chapter 440 for additional information and requirements on the use of curbs.

910.08 Roundabouts

Modern roundabouts are circular intersections. They can be an effective intersection type.

Modern roundabouts differ from the old rotaries and traffic circles in two important respects: they have a smaller diameter, which lowers speeds; and they have splitter islands that provide entry constraints, slowing down the entering speeds.

When well designed, roundabouts are an efficient form of intersection control. They have fewer conflict points, lower speeds, easier decision making, and they require less maintenance. When properly designed and located, they have been found to reduce injury accidents, traffic delays, fuel consumption, and air pollution. Roundabouts also permit U-turns.

Consider roundabouts at intersections with the following characteristics:

- Where stop signs result in unacceptable delays for the cross road traffic. Roundabouts reduce the delays for the cross road, but increase the delays for the through roadway.
- With a high left-turn percentage. Unlike most intersection types, roundabouts can operate efficiently with high volumes of left-turning traffic.
- With more than four legs. When the intersection cannot be modified by closing or relocating legs, a roundabout can provide a solution.
- Where a disproportionately high number of accidents involve crossing or turning traffic.
- Where the major traffic movement makes a turn.

- Where traffic growth is expected to be high and future traffic patterns are uncertain.
- Where it is not desirable to give priority to either roadway.

There are some disadvantages with roundabouts. Roundabouts do not allow for a primary roadway to have priority because all legs entering a roundabout are treated the same.

Also, all traffic entering a roundabout is required to reduce speed. Therefore, roundabouts are not appropriate on high speed facilities, where traffic flows are unbalanced, or where an arterial intersects a collector or local road.

See Chapter 915 for information and requirements on the design of roundabouts.

910.09 U-Turns

For divided highways without full access control that have access points where a median prevents left turns, consider providing locations designed to allow U-turns. Normally, the U-turn opportunities are provided at intersections; however, where intersections are spaced far apart, consider median openings between intersections to accommodate U-turns. Use the desirable U-turn spacing (Figure 910-5) as a guide to determine when to consider U-turn locations between intersections. When the U-turning volumes are low, use longer spacing.

	U-Turn Spacing	
	Desirable	Minimum
Urban(1)	1,000 ft	(2)
Suburban	1/2 mi	1/4 mi(3)
Rural	1 mi	1/2 mi

(1) For design speeds greater than 45 mph use suburban spacing.
(2) The minimum spacing is the acceleration lane length from a stop (Figure 910-14) plus 300 feet
(3) For design speeds 60 mph or greater, the minimum spacing is the acceleration lane length from a stop (Figure 910-14) plus 300 feet

U-Turn Spacing
Figure 910-5

When designing U-turn locations, use Figure 910-16 as a guide. Where the median is less than 40 feet wide and a large design vehicle is required, consider the use of a U-turn roadway (jug handle).

Document the need for U-turn locations, the spacing used, and justify the selected design vehicle.

U-turns at signal controlled intersections do not require the acceleration lanes shown in Figure 910-16. At new U-turn locations at signal controlled intersections, ensure that right-turning vehicles from side streets will not conflict with U-turning vehicles. Warning signs on the cross street might be appropriate.

910.10 Sight Distance at Intersections

For traffic to move safely through intersections, drivers need to be able to see stop signs, traffic signals, and oncoming traffic in time to react accordingly.

Provide decision sight distance, where practical, in advance of stop signs, traffic signals, and roundabouts. See Chapter 650 for guidance.

The driver of a vehicle that is stopped, waiting to cross or enter a through roadway, needs obstruction-free sight triangles in order to see enough of the through roadway to safely complete all legal maneuvers before an approaching vehicle on the through roadway can reach the intersection. Use Figure 910-17a to determine minimum sight distance along the through roadway.

The sight triangle is determined as shown in Figure 910-17b. Within the sight triangle, lay back the cut slopes and remove, lower, or move hedges, trees, signs, utility poles, and anything else large enough to be a sight obstruction. Consider eliminating parking so sight distance is not obstructed. In order to maintain the sight distance, the sight triangle must be within the right of way or a state maintenance easement (see Chapter 1410).

The minimum setback distance for the sight triangle is 18 feet from the edge of traveled way. This is for a vehicle stopped 10 feet from the edge of traveled way. The driver is almost always 8 feet or less from the front of the vehicle; therefore, 8 feet is added to the setback. When the stop bar is placed more than 10 feet from the edge of traveled way, consider providing the sight triangle to a point 8 feet back of the stop bar.

Provide a clear sight triangle for a P vehicle at all intersections. In addition to this, provide a clear sight triangle for the SU vehicle for rural highway conditions. If there is significant combination truck traffic, use the WB-50 or WB-67 rather than the SU. In areas where SU or WB vehicles are minimal, and right of way restrictions prohibit adequate sight triangle clearing, only the P vehicle need be considered.

At existing intersections, when sight obstructions within the sight triangle cannot be removed due to limited right of way, the intersection sight distance may be modified. A driver that does not have the desired sight distance will creep out until the sight distance is available; therefore, the 10-foot stopping distance from the edge of traveled way may be reduced to 2-foot, reducing the setback to 10 feet. Also, the time gap (t_g) may be reduced by the 2-second perception/reaction time. Document the right of way width and provide a brief analysis of the intersection sight distance clarifying the reasons for reduction. Verify and document that there is not an accident problem at the intersection. Document as a design exception.

If the intersection sight distance cannot be provided using the reductions in the preceding paragraph, the calculated sight distance may be reduced, with HQ Design Office approval. Provide as much sight distance as practical, but not less than the stopping sight distance required for the major roadway, with visibility at the 10-foot setback point. (For required stopping sight distance, see Chapter 650.) Document the right of way width and provide a brief analysis of the intersection sight distance clarifying the reasons for reduction. Verify and document that there is not an accident problem at the intersection. Document as a design exception.

In some instances intersection sight distance is provided at the time of construction, but subsequent vegetative growth has degraded the sight distance available. The growth may be seasonal or occur over time. In these instances, the intersection sight distance will be restored through periodic scheduled maintenance of vegetation in the sight triangle within the WSDOT right of way or state maintenance easement.

At intersections controlled by traffic signals, provide sight distance for right-turning vehicles.

Designs for movements that cross divided highways are influenced by the median widths. If the median is wide enough to store the design vehicle, with 3 feet clearance at both ends of the vehicle, sight distances are determined in two steps. The first step is for crossing from a stopped position to the median storage; the second step is for the movement, either across, or left into the through roadway.

Design ramp terminal sight distance as at-grade intersections considering only left- and right- turning movements. An added element at ramp terminals is the grade separation structure. Figure 910-17b gives the sight distance considerations in the vicinity of a structure. In addition, when the crossroad is an undercrossing, check the sight distance under the structure graphically using a truck eye height of 6 feet and an object height of 1.5 feet.

Document a brief description of the intersection area, sight distance restrictions, and traffic characteristics to support the design vehicle and sight distances chosen.

910.11 Traffic Control at Intersections

Intersection traffic control is the process of moving traffic safely through areas of potential conflict where two or more roadways meet. Signs, signals, channelization, and physical layout are the major tools used to establish intersection control.

There are three objectives to intersection traffic control that can greatly improve intersection operations.

- **Maximize Intersection Capacity.** Since two or more traffic streams cross, converge, or diverge at intersections, capacity of an intersection is normally less than the roadway between intersections. It is usually necessary to assign right of way through the use of traffic control devices to maximize capacity for all users of the intersection. Turn prohibitions may be used to increase intersection capacity.
- **Reduce Conflict Points.** The crossing, converging, and diverging of traffic creates conflicts which increase the potential for accidents. Establishing appropriate controls can reduce the possibility of two cars attempting to occupy the same space at the same time. Pedestrian accident potential can also be reduced by appropriate controls.
- **Priority of Major Streets.** Traffic on major routes is normally given the right of way over traffic on minor streets to increase intersection operational efficiency.

If a signal is being considered or exists at an intersection that is to be modified, a preliminary signal plan is required (Chapter 850). If a new signal permit is required, it must be approved before the design is approved.

A proposal to install a traffic signal or a roundabout on a state route, either NHS or Non-NHS, with a posted speed limit of 45 miles per hour or higher requires an analysis of alternatives, approved by the region's Traffic Engineer with review and comment by the Headquarters Design Office, prior to proceeding with the design. Include the following alternatives in the analysis:

- Channelization, providing deceleration lanes, storage, and acceleration lanes for left- and right-turning traffic.
- Right-off /right-on with U-turn opportunities.
- Grade separation.
- Roundabouts.
- Traffic control signals.

Include a copy of the analysis with the preliminary signal plan or roundabout justification.

910.12 Interchange Ramp Terminals

The design to be used or modified for use on one-way ramp terminals with stop or traffic signal control at the local road is shown on Figure 910-18. Higher volume intersections with multiple ramp lanes are designed individually.

Due to probable development of large traffic generators adjacent to an interchange, width for a median on the local road is desirable whenever such development is believed imminent. This allows for future left-turn channelization. Use median channelization when justified by capacity determination and analysis, or by the need to provide a smooth traffic flow.

Determine the number of lanes for each leg by capacity analysis methods assuming a traffic signal cycle, preferably 45 or 60 seconds in length, regardless of whether a signal is used or not. Consider all terminals in the analysis.

Adjust the alignment of the intersection legs to fit the traffic movements and to discourage wrong way movements. Use the allowed intersecting angles of 75° to 105° (60° to 120° for modified design level) to avoid broken back or reverse curves in the ramp alignment.

910.13 Procedures

Document design considerations and conclusions in accordance with Chapter 330. For highways with limited access control, see Chapter 1430 for requirements.

(1) Approval

An intersection is approved in accordance with Chapter 330. When required, the following items must be completed before an intersection may be approved:

- Traffic analysis.
- Deviations approved in accordance with Chapter 330.
- Preliminary traffic signal plan approved by the HQ Traffic Office. (See Chapter 850.)
- HQ Design Office approval for intersections with roundabouts. See Chapter 915 for approval procedures.

(2) Intersection Plans

Intersection plans are required for any increases in capacity (turn lanes) of an intersection, modification of channelization, or change of intersection geometrics. Support the need for intersection or channelization modifications with history, school bus and mail route studies, hazardous materials route studies, pedestrian use, public meeting comments, and so forth.

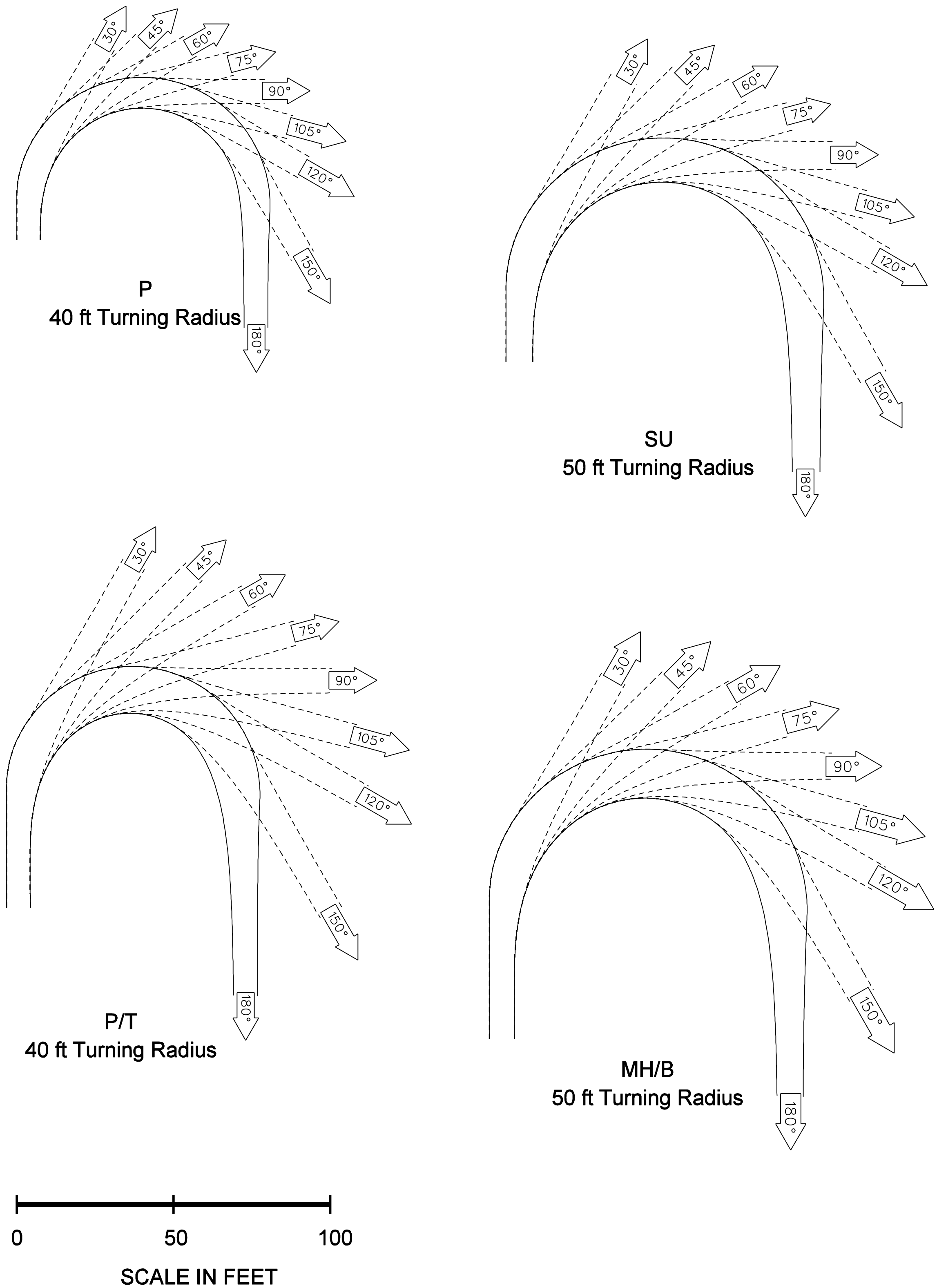
For information to be included on the Intersection Plan for Approval, see the Intersection/ Channelization Plan for Approval Check List on the following web site: http://www.wsdot.wa.gov/EESC/Design/projectdev/default.htm

(3) Local Agency or Developer Initiated Intersections

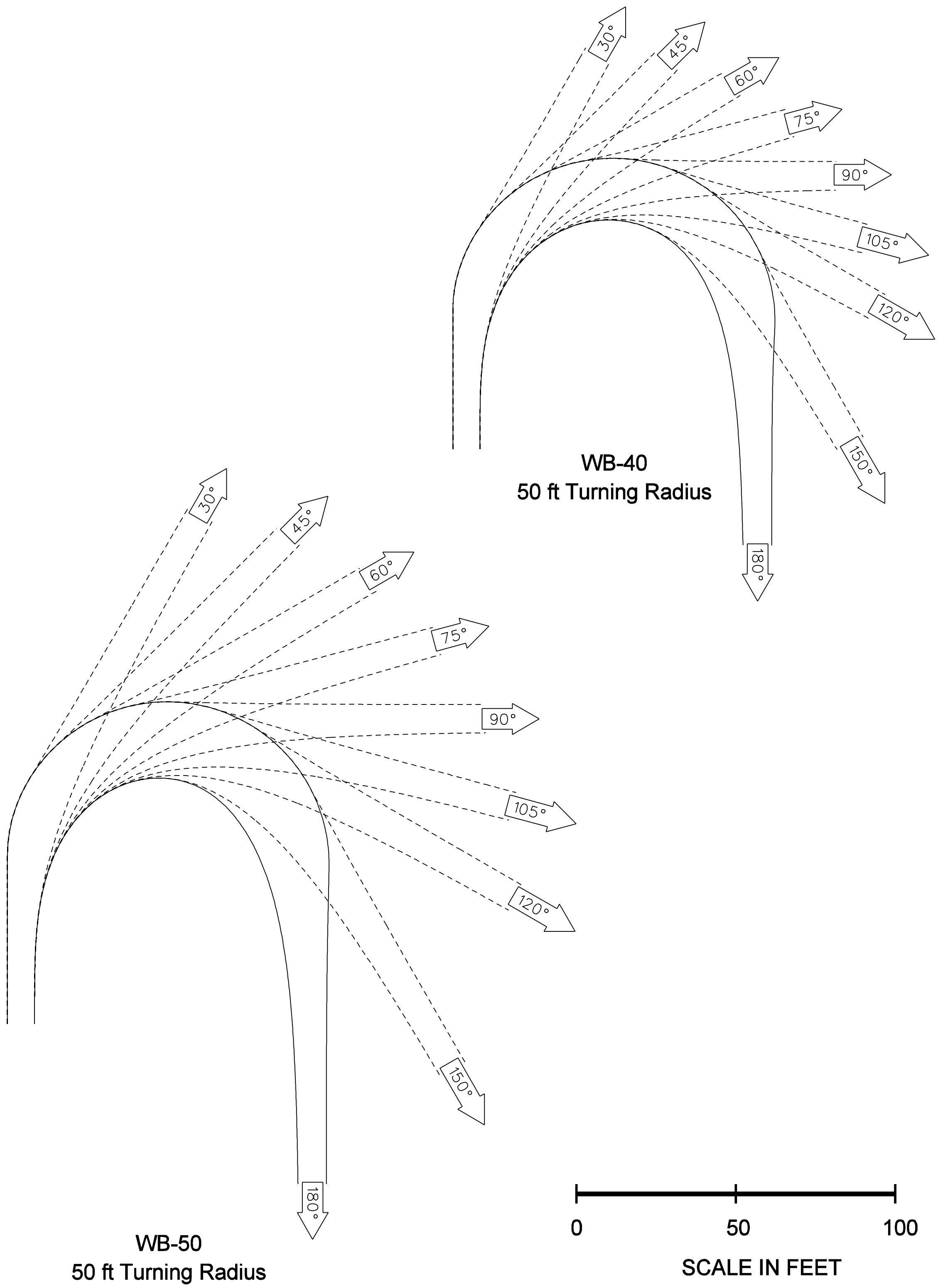
There is a separate procedure for local agency or developer-initiated projects at intersections with state routes. The project initiator submits an intersection plan, and the documentation of design considerations that led to the plan, to the region for approval. For those plans requiring a deviation, the deviation must be approved in accordance with Chapter 330 prior to approval of the plan. After the plan approval, the region prepares a construction agreement with the project initiator. (See the *Utilities Manual*.)

910.14 Documentation

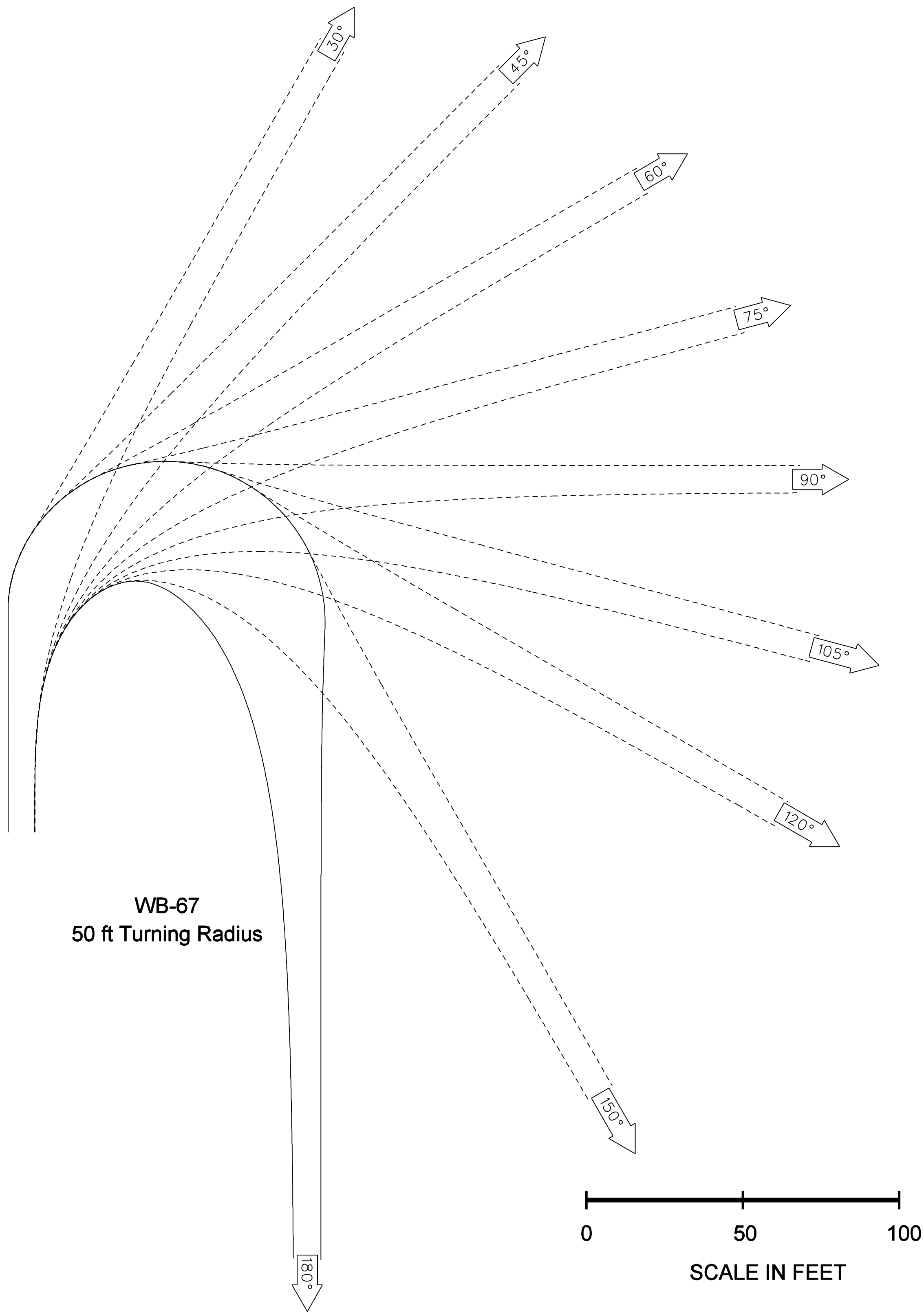
The list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/



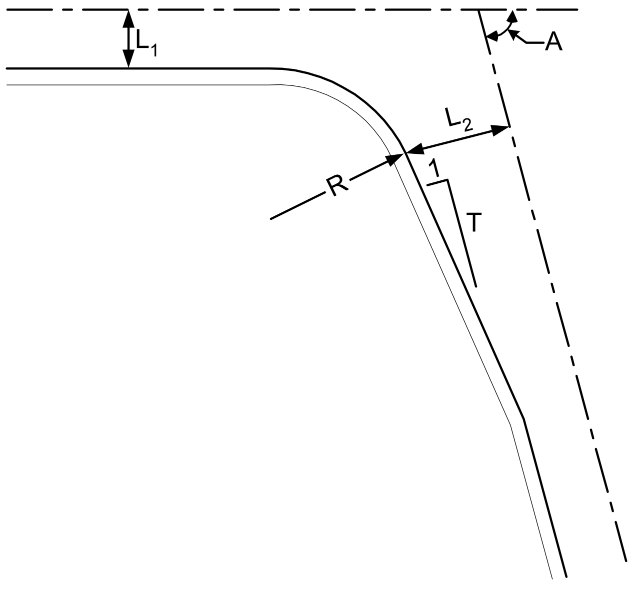
Turning Path Template
Figure 910-6a



Turning Path Template
Figure 910-6b



Turning Path Template
Figure 910-6c



L_1 = Minimum available roadway width (2) that the vehicle is turning from.

L_2 = Minimum available roadway width (2) that the vehicle is turning into.

R = Radius to the edge of traveled way.

T = Taper rate (length per unit of width of widening)

A = Delta angle of the turning vehicle

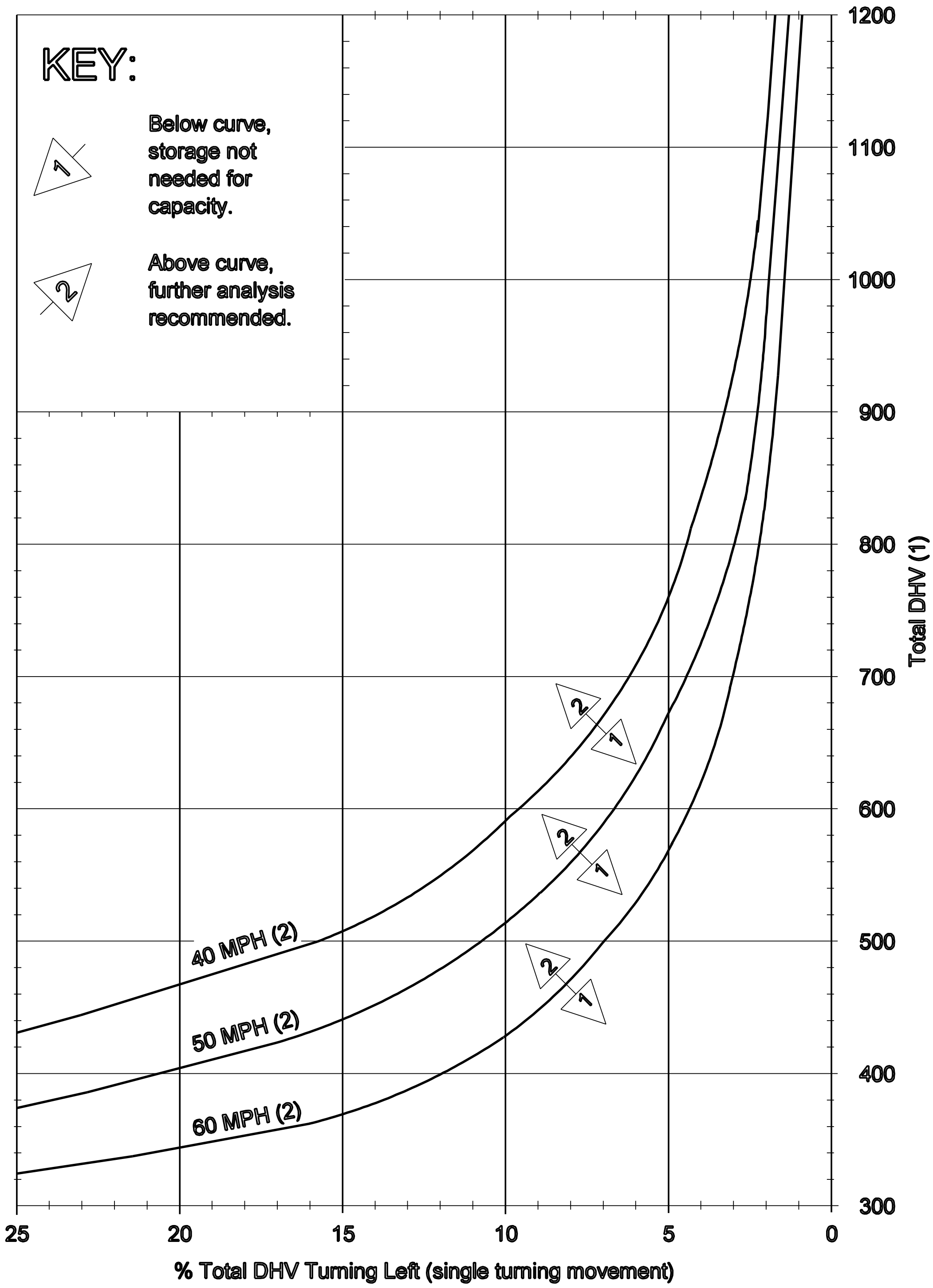
Vehicle	A	R	L_1 (1)	L_2 (1)	T	Vehicle	A	R	L_1 (1)	L_2 (1)	T
WB-67	60	85	11	22	7	WB-40	60	55	11	15	7.5
	75	75	11	21	8		75	55	11	15	7.5
	90	70	11	21	8		90	55	11	14	7.5
	105	55	11	24	7		105	45	11	16	7.5
	120	50	11	24	7		120	45	11	15	7.5
WB-50	60	55	11	19	6	SU & BUS	All	50	11	11	25
	75	55	11	18	6	P	All	35	11	11	25
	90	55	11	17	6						
	105	50	11	17	6						
	120	45	11	18	6						

(1) When available roadway width is less than 11 ft, widen at 25:1.

(2) Available roadway width includes the shoulder, less 2 ft clearance to a curb, and all same direction lanes of the exit leg at signalized intersections.

(3) All distances given in feet and angles in degrees.

Right-Turn Corner
Figure 910-7

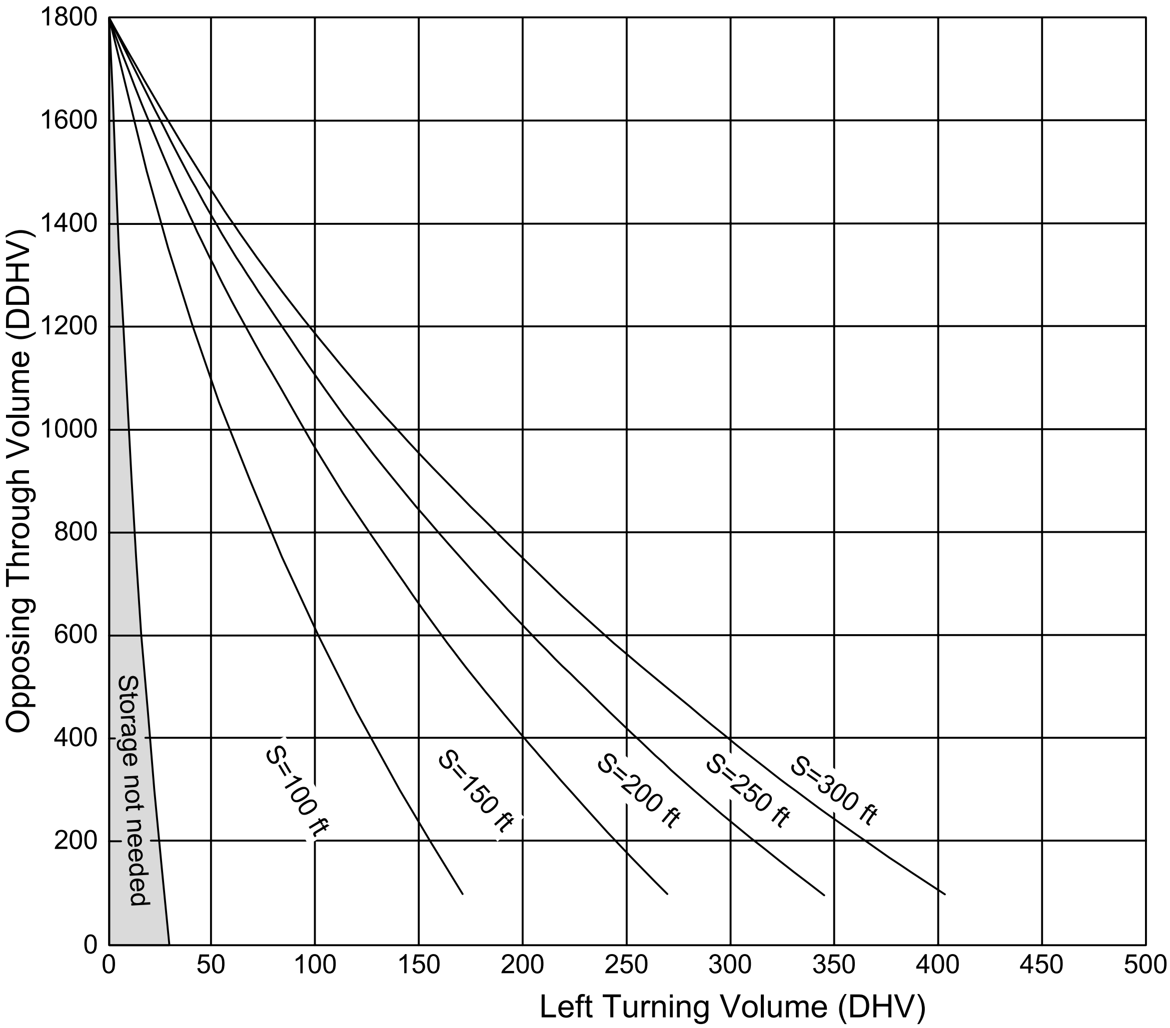


(1) DHV is total volume from both directions.

(2) Speeds are posted speeds.

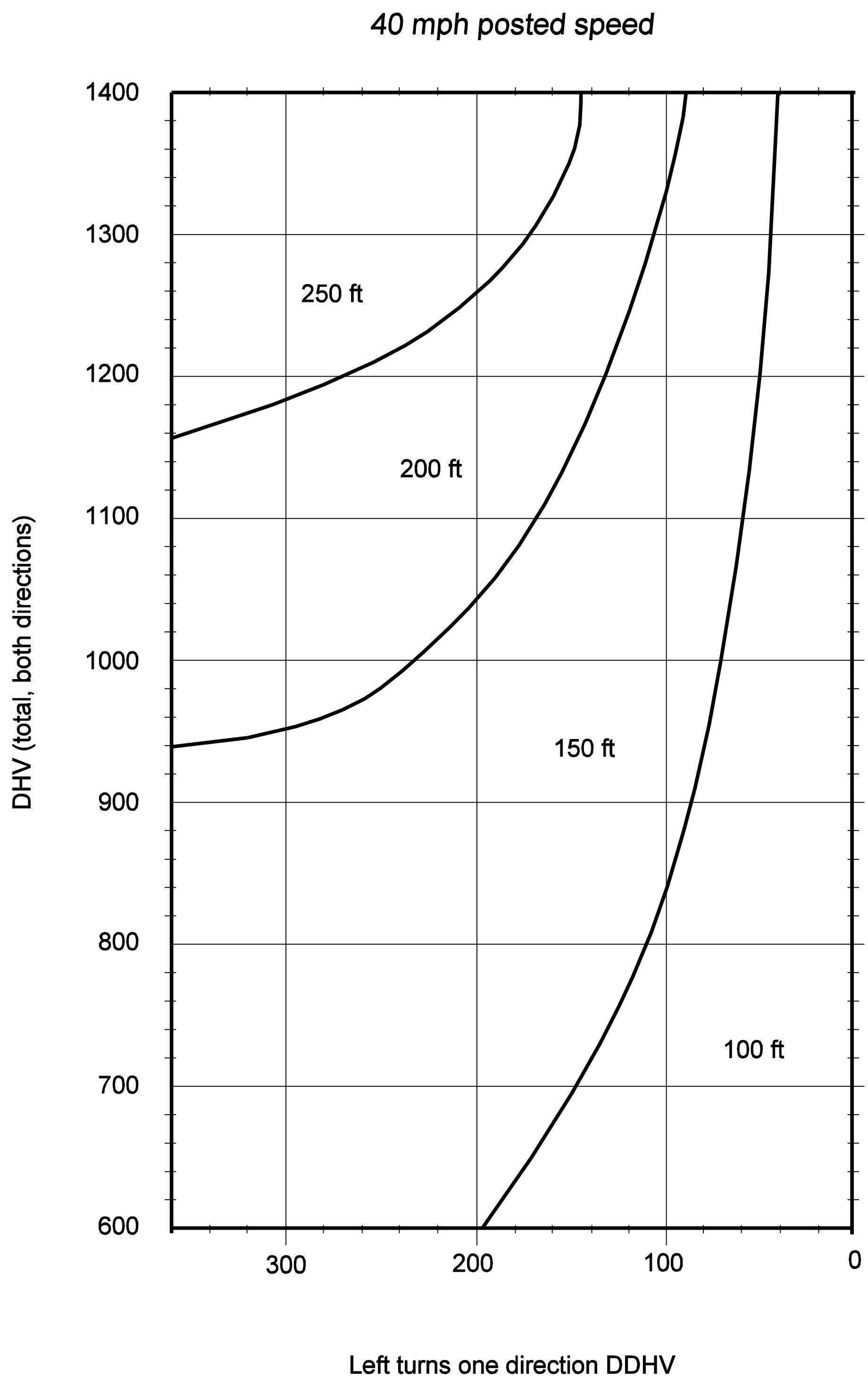
Left-Turn Storage Guidelines (Two-Lane, Unsignalized)

Figure 910-8a

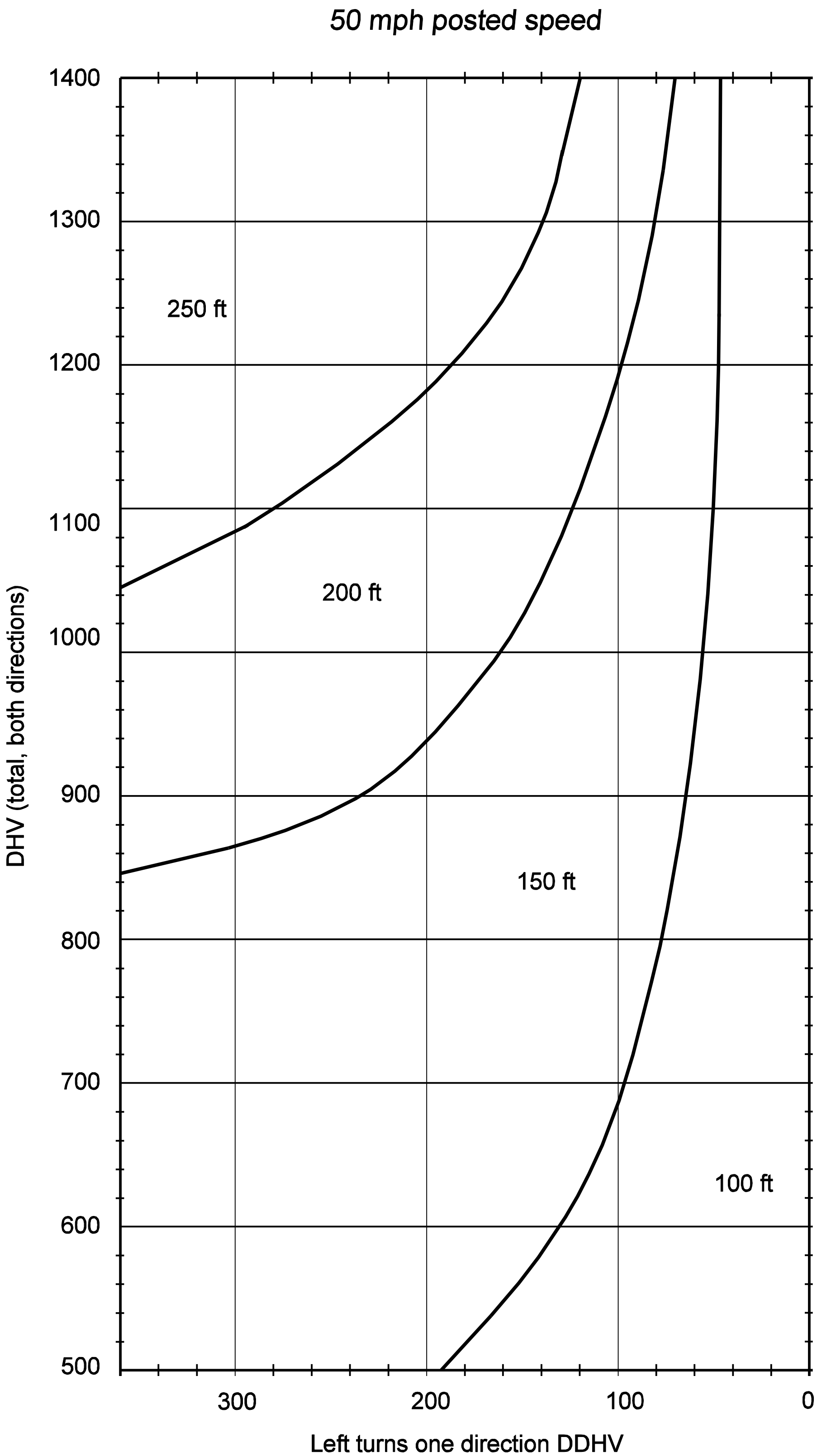


S = Left-Turn storage length

Left-Turn Storage Guidelines (Four-Lane, Unsignalized)
Figure 910-8b

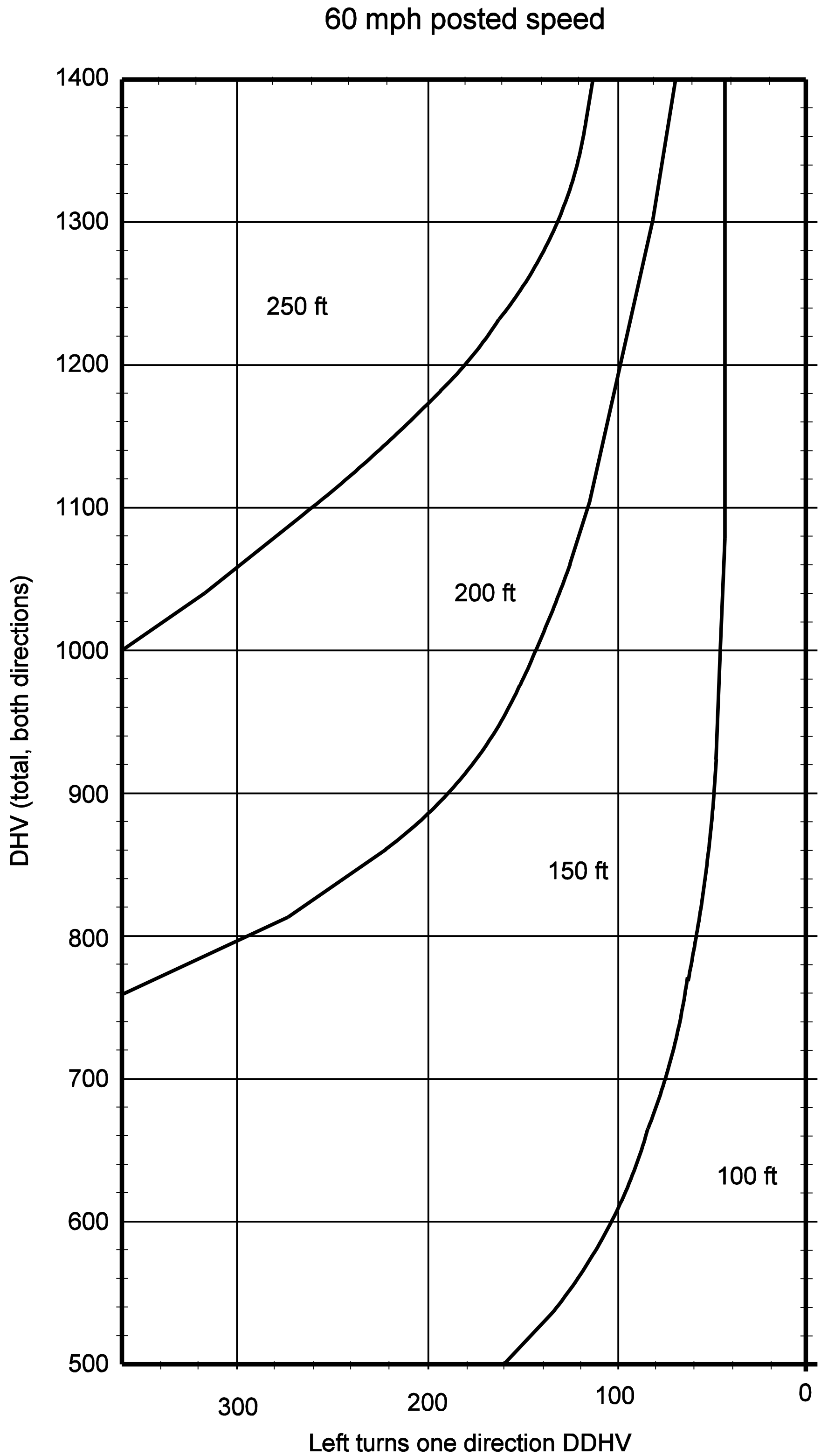


Left-Turn Storage Length (Two-Lane, Unsignalized)
Figure 910-9a

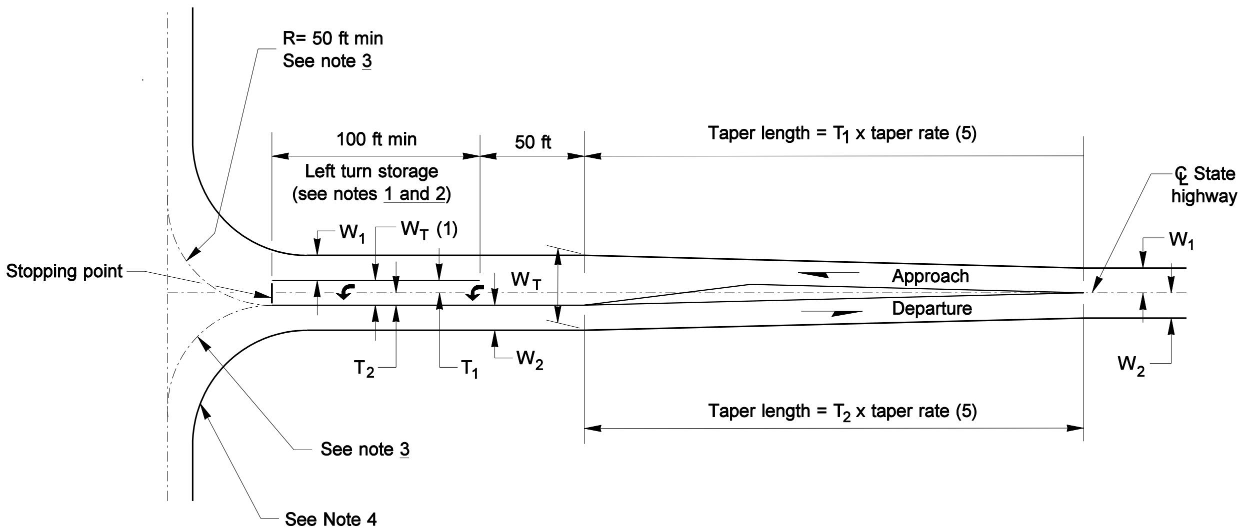


Left-Turn Storage Length (Two-Lane, Unsignalized)

Figure 910-9b



Left-Turn Storage Length (Two-Lane, Unsignalized)
Figure 910-9c



Notes:

(1) The minimum width of the left-turn storage lane (T_1+T_2) is 11 ft. The desirable width is 12 ft.

(2) For left-turn storage length, see Figures 910-8b for 4-lane roadways or 9a through 9c for 2-lane roadways.

(3) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.

(4) See Figure 910-7 for right-turn corner design.

(5) See Table 1 for desirable taper rates. With justification, taper rates from Table 2, Figure 910-10c, may be used.

(6) See Standard Plans and MUTCD for pavement marking details.

W_1 = Approaching through lane.

W_2 = Departing lane.

T_1 = Width of left-turn lane on approach side of center line.

T_2 = Width of left-turn lane on departure side of center line.

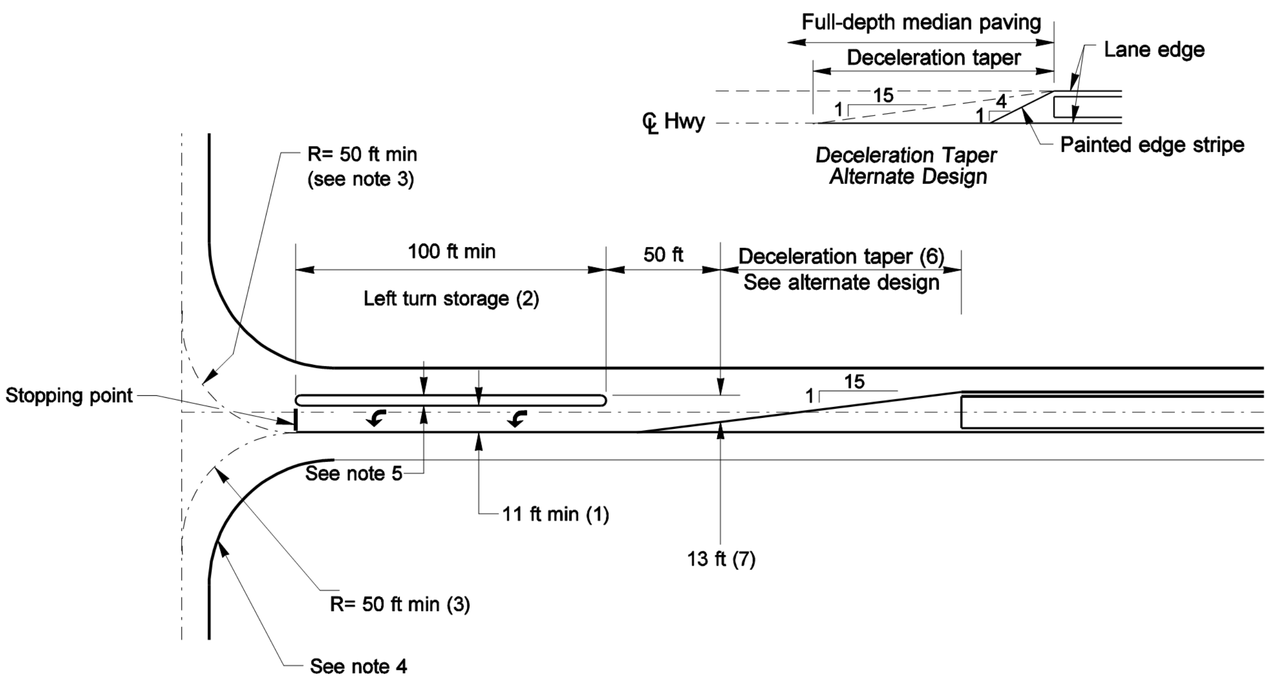
W_T = Total width of channelization. ($W_1+W_2+T_1+T_2$)

Posted Speed	Taper Rate
55 mph	55:1
50 mph	50:1
45 mph	45:1
40 mph	40:1
35 mph	35:1
30 mph	30:1
25 mph	25:1

Table 1

Median Channelization (Widening)

Figure 910-10a



Notes:

(1) Lane width of 13 ft is desirable.

(2) For left-turn storage length, see Figures 910-8b for 4-lane roadways or 9a through 9c for 2-lane roadways.

(3) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.

(4) See Figure 910-7 for right-turn corner design.

(5) For median widths greater than 13 ft, it is desirable to locate the left-turn lane adjacent to the opposing through lane with excess median width between the same direction through lane and the turn lane.

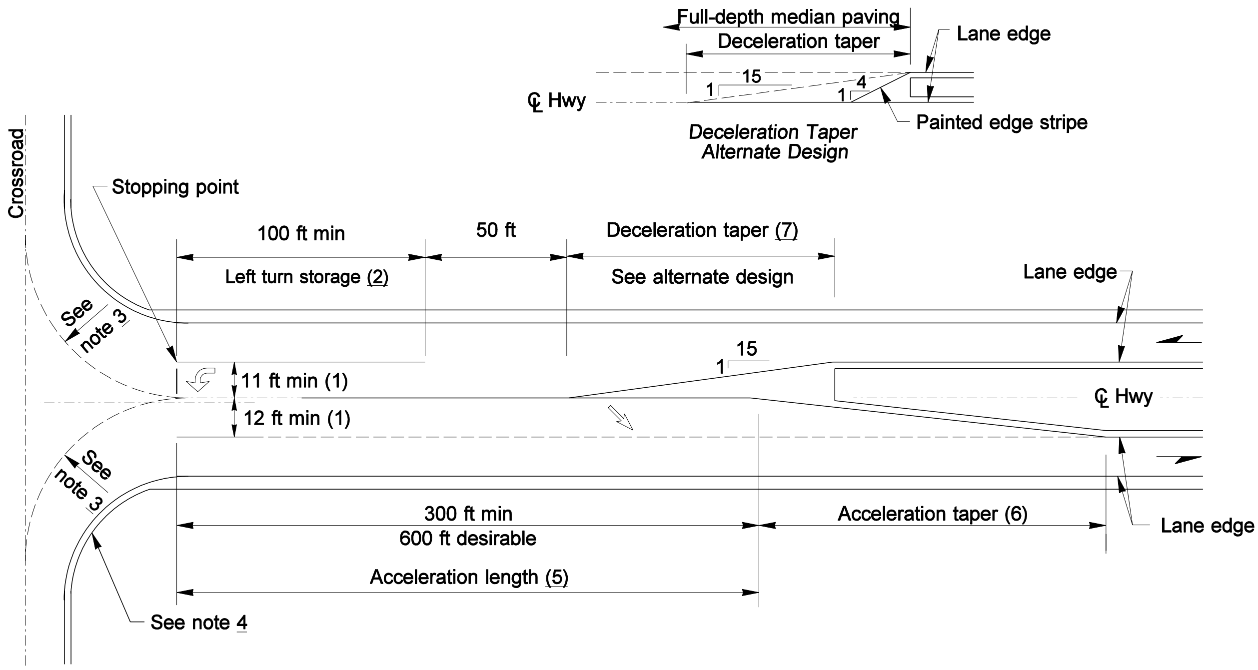
(6) For increased storage capacity, consider the left-turn deceleration taper alternate design.

<u>(7) Reduce to lane width for medians less that 13 ft wide.</u>

(<u>8</u>) See Standard Plans and MUTCD for pavement marking details.

Median Channelization (Median Width 11 ft or more)

Figure 910-10b



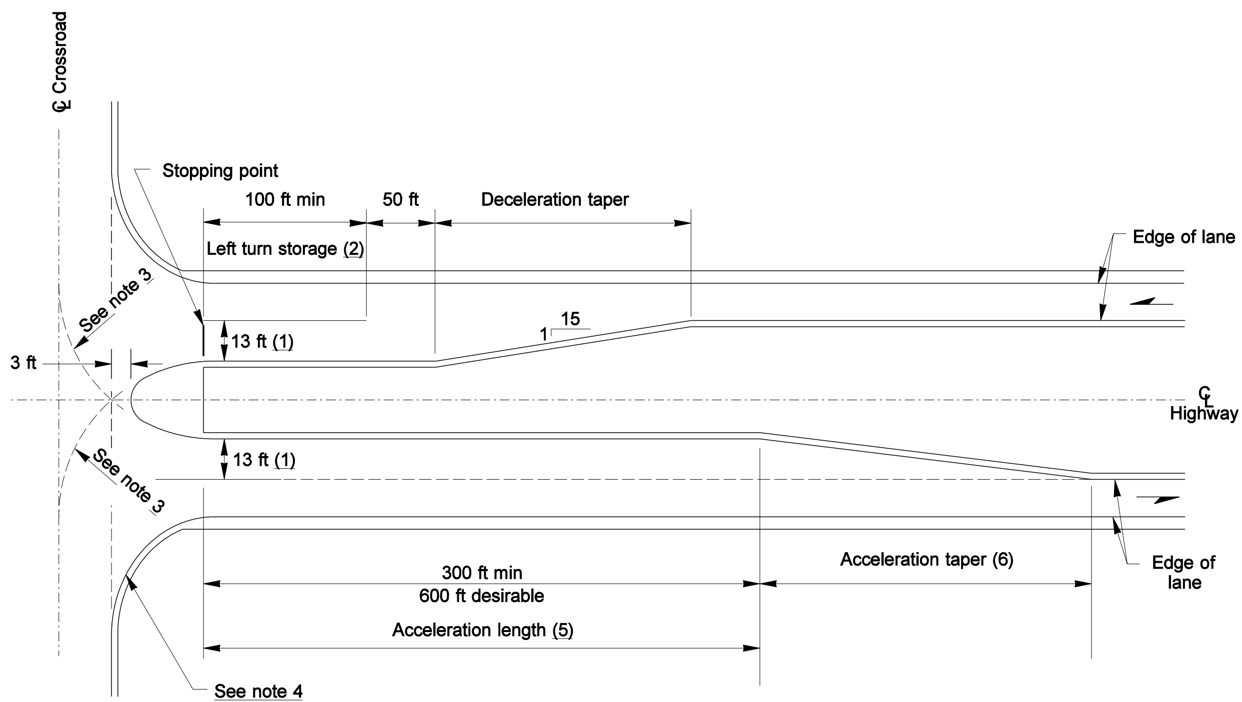
Notes:

(1) Lane widths of 13 ft are desirable for both the left-turn storage lane and the median acceleration lane.
(2) For left-turn storage length, see Figures 910-8b for 4-lane roadways or 9a throug9c for 2-lane roadways.
(3) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.
(4) See Figure 910-7 for right-turn corner design.
(5) The minimum total length of the median acceleration lane is shown in Figure 910-14.
(6) See Table 2, for acceleration taper rate.
(7) For increased storage capacity, consider the left-turn deceleration taper alternate design.
(8) See Standard Plans and MUTCD for pavement marking details.

Posted Speed	Taper Rate
55 mph	55:1
50 mph	50:1
45 mph	45:1
40 mph	27:1
35 mph	21:1
30 mph	15:1
25 mph	11:1

Table 2

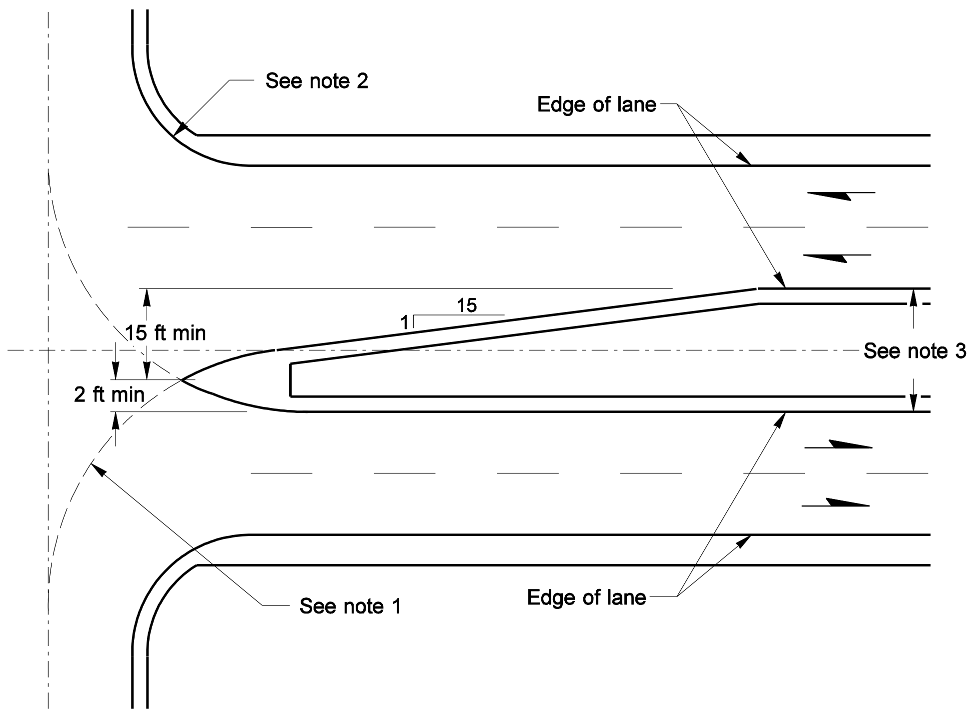
Median Channelization (Median Width 23 ft to 26 ft)
Figure 910-10c



Notes:

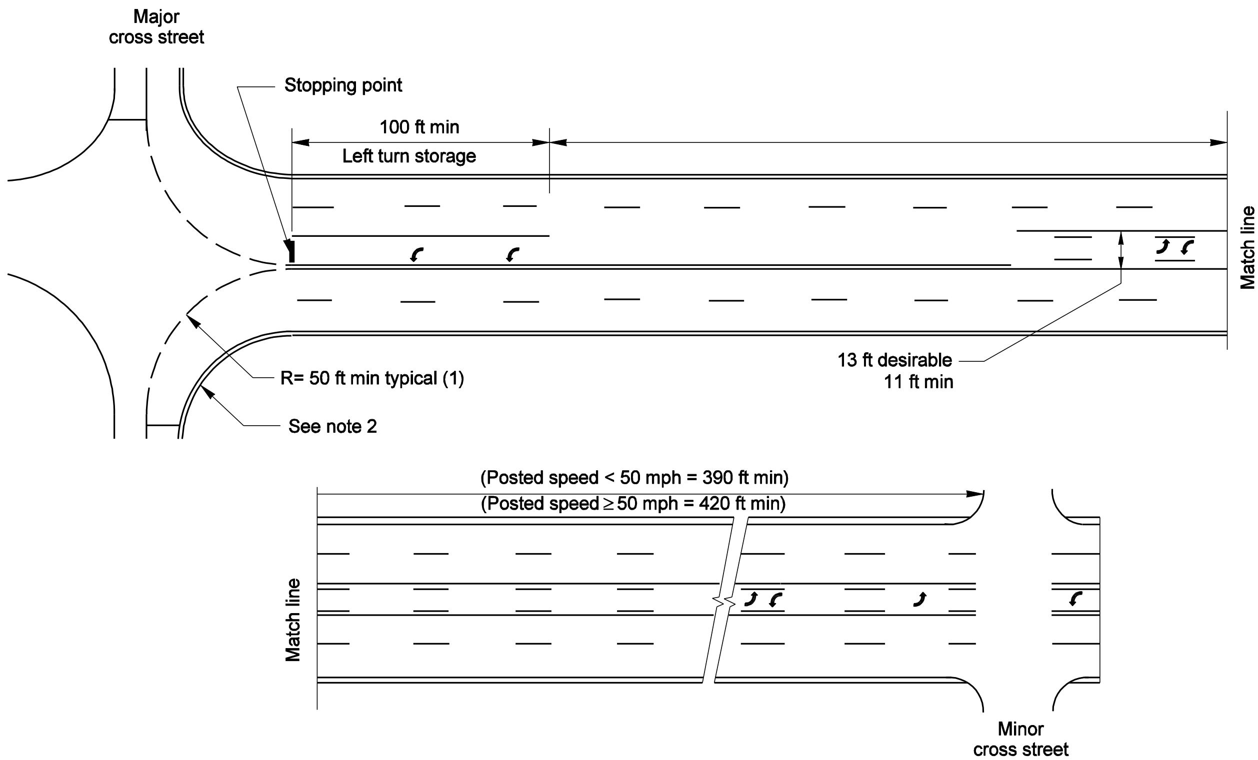
(1) May be reduced to 11 ft, with justification.
(2) For left-turn storage length, see Figures 910-8b for 4-lane roadways or 9a through 9c for 2-lane roadways.
(3) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.
(4) See Figure 910-7 for right-turn corner design.
(5) The minimum length of the median acceleration lane is shown in Figure 910-14.
(6) See Table 2 Figure 910-10c for acceleration taper rate.
(7) See Standard Plans and MUTCD for pavement marking details.

Median Channelization (Median Width of More Than 26 ft)
Figure 910-10d



Notes:
(1) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.
(2) See Figure 910-7 for right-turn corner design.
(3) For median width 17 ft or more. For median width less than 17 ft, widen to 17 ft or use Figure 910-10b.
(4) See Standard Plans and MUTCD for pavement marking details.

Median Channelization (Minimum Protected Storage)
Figure 910-10e



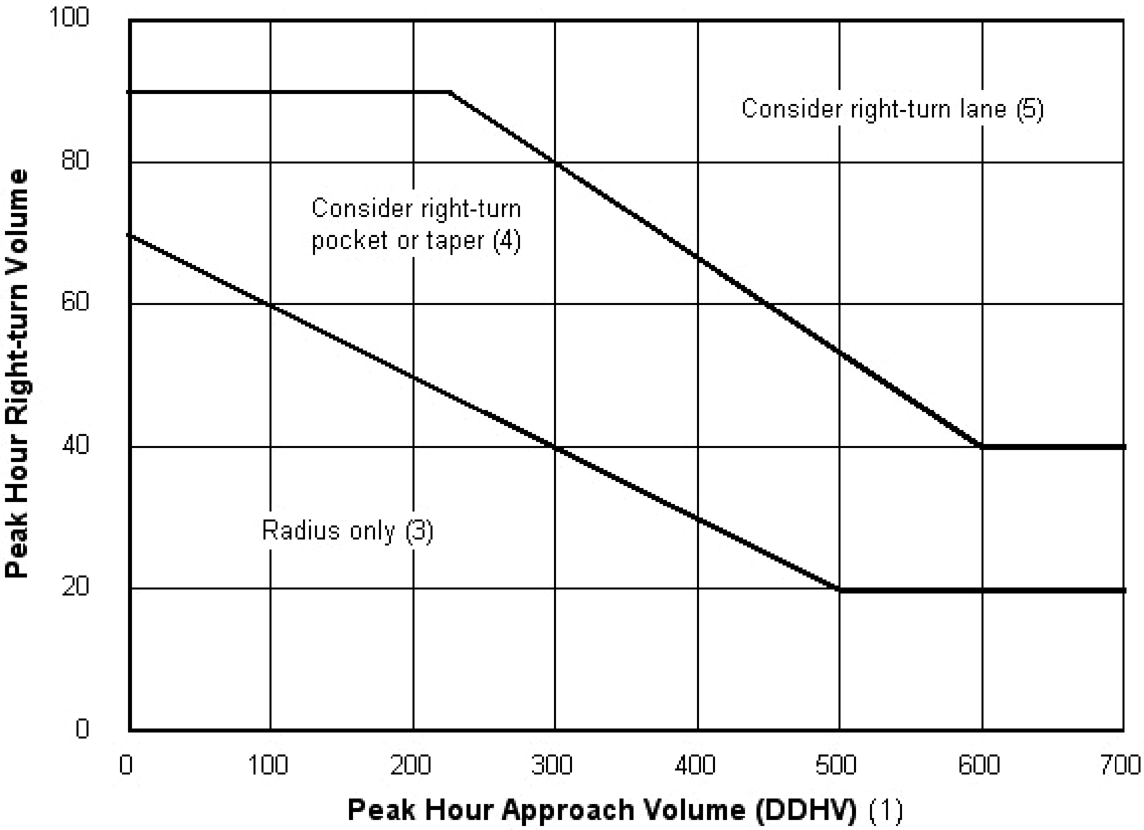
Notes:

(1) Desirable radius not less than 50 ft. Use templates to verify that the design vehicle can make the turn.

(2) See Figure 910-7 for right-turn corner design.

(3) See the Standard Plans and the MUTCD for pavement marking details and signing criteria.

Median Channelization (Two-way Left-Turn Lane)
Figure 910-10f



Notes:

(1) For two-lane highways, use the peak hour DDHV (through + right-turn).

For multilane, high speed highways (posted speed 45 mph or above), use the right-lane peak hour approach volume (through + right-turn).

(2) When all three of the following conditions are met, reduce the right-turn DDHV by 20.

- The posted speed is 45 mph or less.
- The right-turn volume is greater than 40 VPH.
- The peak hour approach volume (DDHV) is less than 300 VPH.

(3) See Figure 910-7 for right-turn corner design.

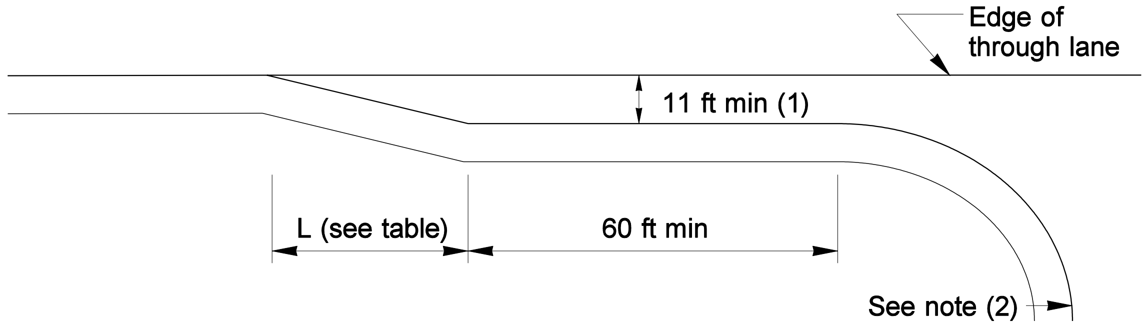
(4) See Figure 910-12 for right-turn pocket or taper design.

(5) See Figure 910-13 for right-turn lane design.

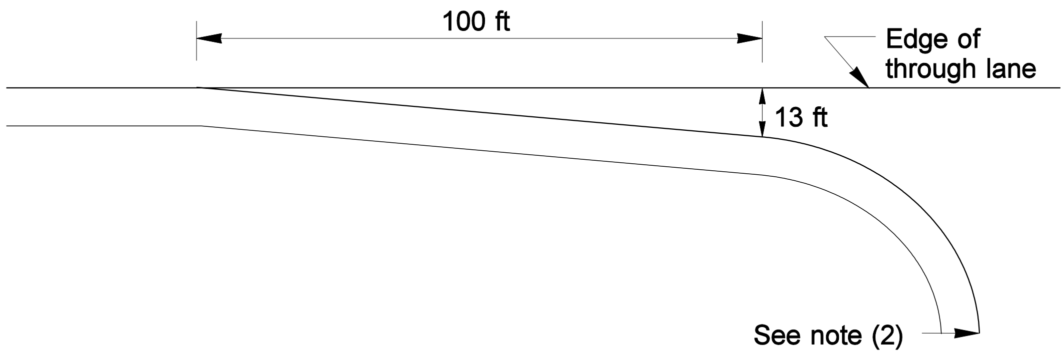
(6) For additional guidance, see 910.07(2) in the text.

Right-Turn Lane Guidelines (6)

Figure 910-11



Right-Turn Pocket



Right-Turn Taper

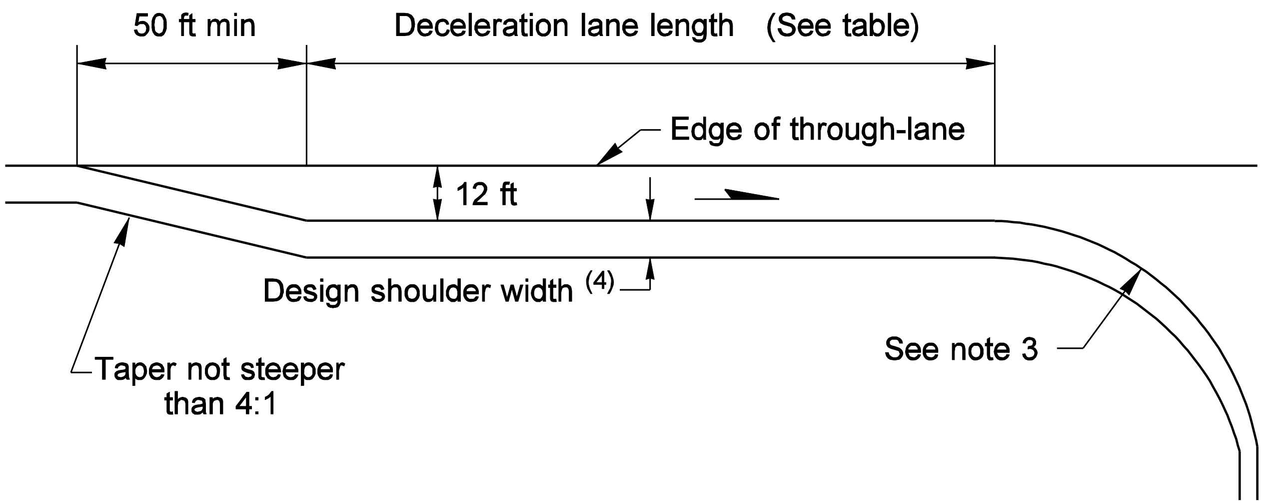
Posted speed limit	L
Below 40 mph	40 ft
40 mph or above	100 ft

Notes:

(1) 12 ft desirable.

(2) See Figure 910-7 for right-turn corner design.

Right-Turn Pocket and Right-Turn Taper
Figure 910-12



Highway Design Speed (mph)	Turning Roadway design speed (mph)		
	Stop(1)	15	20
30	235	200 (2)	170 (2)
35	280	250	210
40	320	295	265
45	385	350	325
50	435	405	385
55	480	455	440
60	530	500	480
65	570	540	520
70	615	590	570

Minimum Deceleration Lane Length (ft)

Grade	Upgrade	Downgrade
3% to less than 5%	0.9	1.2
5% or more	0.8	1.35

Adjustment Multiplier for Grades 3% or Greater

Notes:

(1) For use when the turning traffic is likely to stop before completing the turn. (For example, where pedestrians are present.)

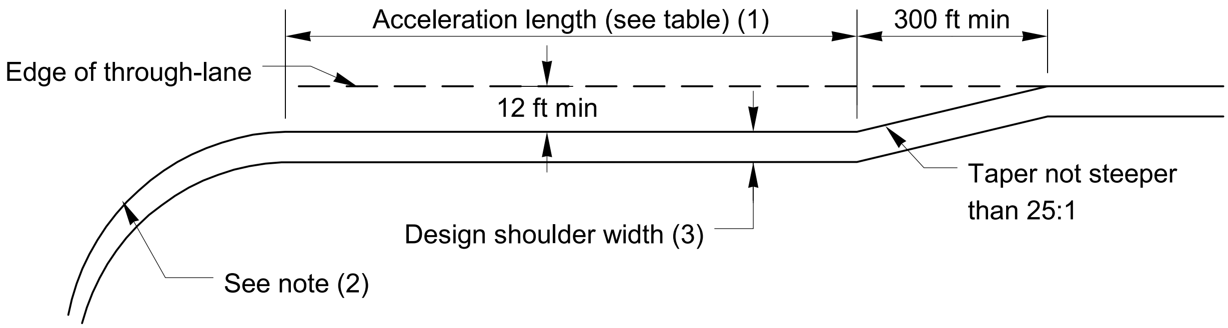
(2) When adjusting for grade, do not reduce the deceleration lane to less than 150 ft.

(3) See Figure 910-7 for right-turn corner design.

(4) May be reduced, see 910.07(4) in the text.

(5) See the Standard Plans and the MUTCD for pavement marking details.

Right-Turn Lane
Figure 910-13



Highway Design Speed (mph)	Turning Roadway Design Speed (mph)		
	Stop	15	20
30	180	140	
35	280	220	160
40	360	300	270
45	560	490	440
50	720	660	610
55	960	900	810
60	1200	1140	1100
65	1410	1350	1310
70	1620	1560	1520

Minimum Acceleration Lane Length (ft) (1)

Highway Design Speed (mph)	% Grade	Upgrade	Downgrade
40 50 60 70	3% to less than 5%	1.3 1.3 1.4 1.5	0.7 0.65 0.6 0.6
40 50 60 70	5% or more	1.5 1.5 1.7 2.0	0.6 0.55 0.5 0.5

Adjustment Multiplier for Grades 3% or Greater

Notes:

(1) At free-right turns (no stop required) and all left-turns, the minimum acceleration lane length is not less than 300 ft.

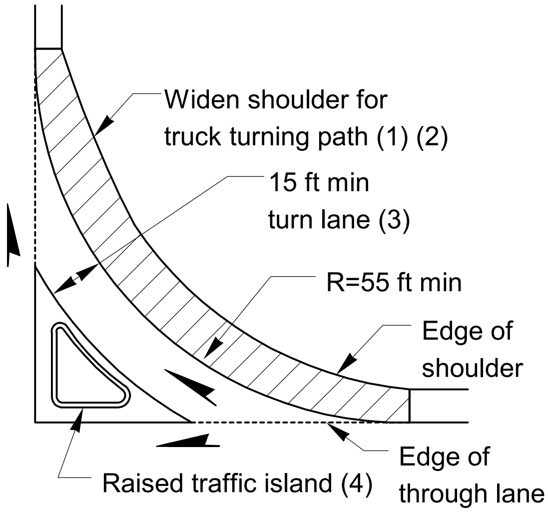
(2) See Figure 910-7 for right-turn corner design.

(3) May be reduced, see 910.07(4) in the text.

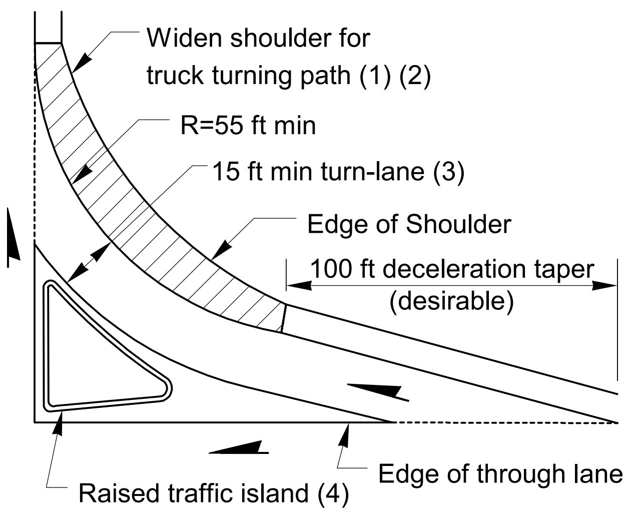
(4) See the Standard Plans and the MUTCD for pavement marking details.

Acceleration Lane

Figure 910-14



Small Traffic Island Design (5)



Large Traffic Island Design (5)

Notes:

(1) Widen shoulders when adequate right-turn radii or roadway width cannot be provided for large trucks. Design widened shoulder pavement the same depth as the right-turn lane.

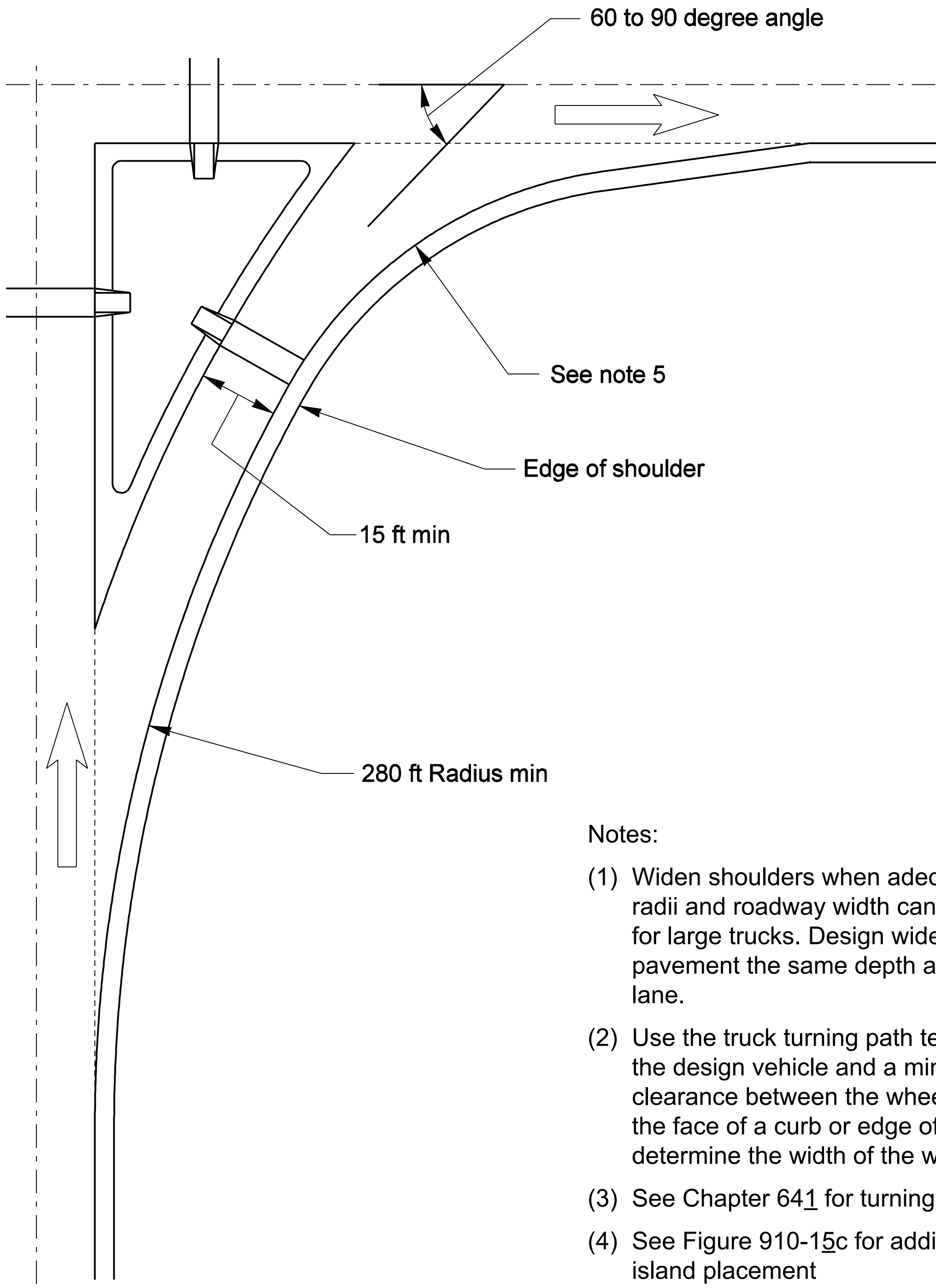
(2) Use the truck turning path templates for the design vehicle and a minimum of 2 ft clearance between the wheel paths and the face of a curb or edge of shoulder to determine the width of the widened shoulder.

(3) See Chapter 641 for turning roadway widths.

(4) See Figure 910-15c for additional details on island placement

(5) Small traffic islands have an area of 100 ft^2 or less; large traffic islands have an area greater than 100 ft^2.

Traffic Island Designs
Figure 910-15a



Notes:

(1) Widen shoulders when adequate right-turn radii and roadway width cannot be provided for large trucks. Design widened shoulder pavement the same depth as the right-turn lane.

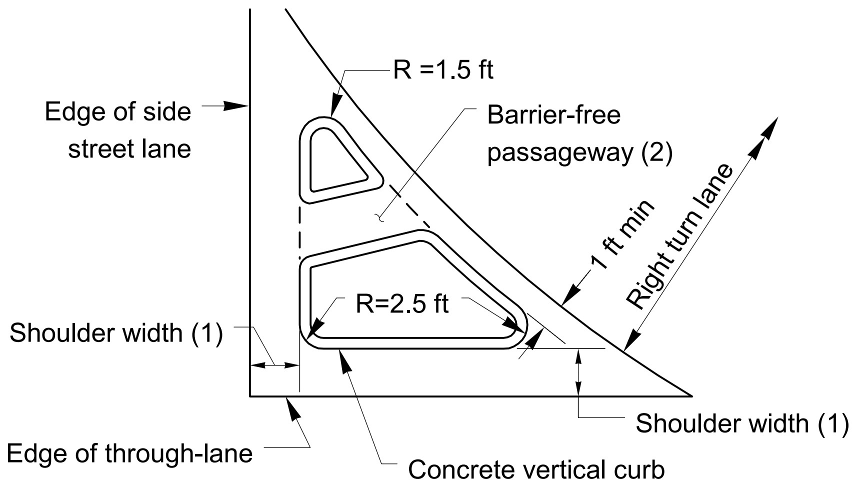
(2) Use the truck turning path templates for the design vehicle and a minimum of 2 ft clearance between the wheel paths and the face of a curb or edge of shoulder to determine the width of the widened shoulder.

(3) See Chapter 641 for turning roadway widths.

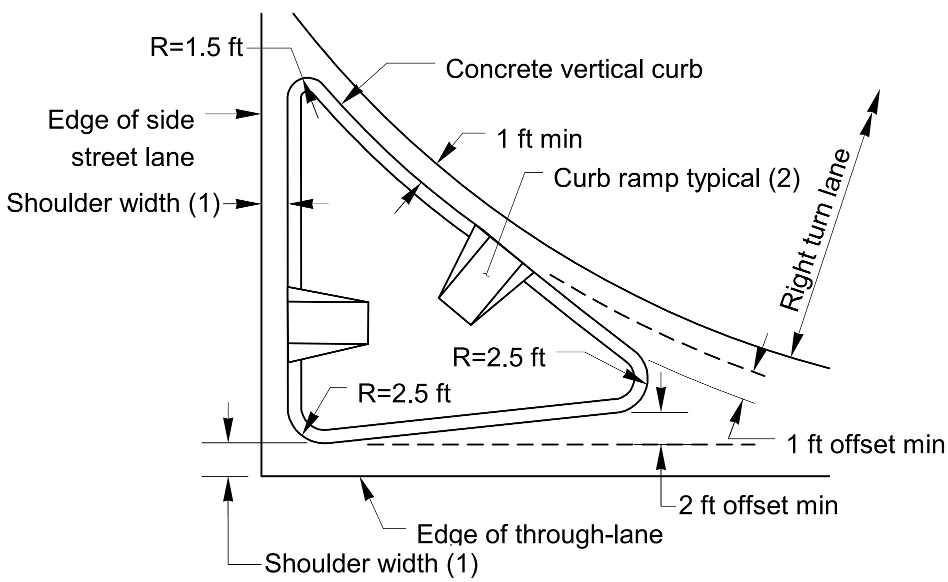
(4) See Figure 910-15c for additional details on island placement

(5) See Figure 910-7 for right-turn corner design.

Traffic Island Designs (Compound Curve)
Figure 910-15b



Small Raised Traffic Island (3)



Large Raised Traffic Island

Notes:

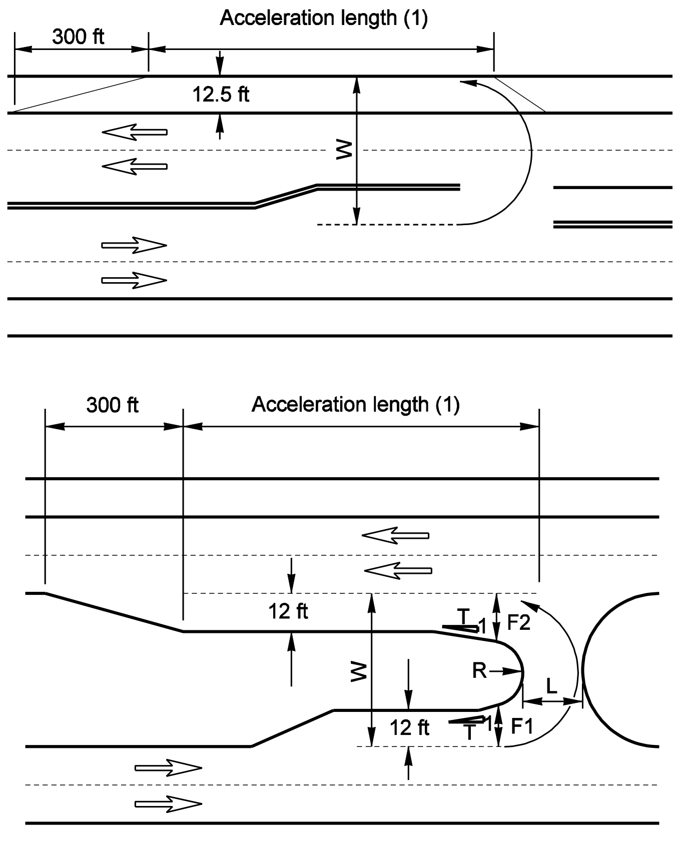
(1) See Chapter 440 for minimum shoulder width. See the text for additional information on shoulders at islands.

(2) Provide barrier-free passageways or curb ramps when required, see Chapter 1025.

(3) Small traffic islands have an area of 100 ft^2 or less; large traffic islands have an area greater than 100 ft^2.

Traffic Island Designs

Figure 910-15c



Vehicle	W	R	L	F1	F2	T
P	52	14	14	12	12	—
SU	87	30	20	13	15	10:1
BUS	87	28	23	14	18	10:1
WB-40	84	25	27	15	20	6:1
WB-50	94	26	31	16	25	6:1
WB-67	94	22	49	15	35	6:1
MH	84	27	20	15	16	10:1
P/T	52	11	13	12	18	6:1
MH/B	103	36	22	15	16	10:1

U-Turn Design Dimensions

Notes:

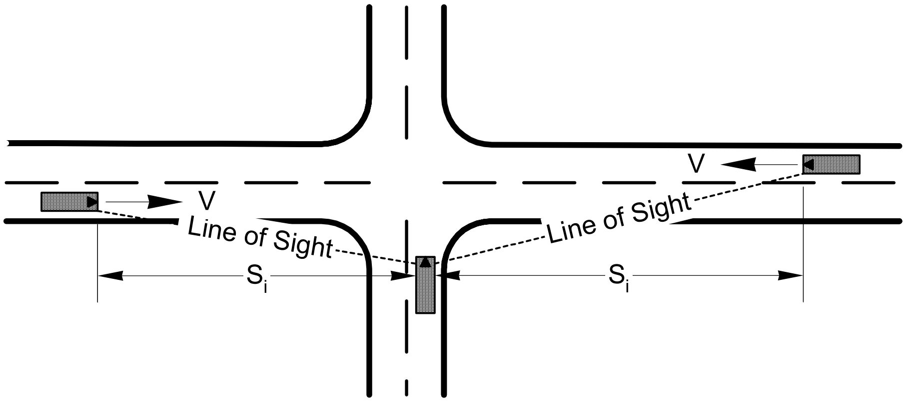
(1) The minimum length of the acceleration lane is shown in Figure 910-14. Acceleration lane may be eliminated at signal controlled intersections.

(2) All dimensions in feet.

(3) When U-turn uses the shoulder, provide 12.5 ft shoulder width and shoulder pavement designed to the same depth as the through lanes for the acceleration length and taper.

U-Turn Locations

Figure 910-16



$S_i = 1.47Vt_g$
Where: S_i = Intersection Sight Distance (ft) V = Design speed of the through roadway (mph) t_g = Time gap for the minor roadway traffic to enter or cross the through roadway (sec)

Intersection Sight Distance Equation
Table 1

Design Vehicle	Time Gap (t_g) in sec
Passenger car (P)	9.5
Single unit trucks and buses (SU & BUS)	11.5
Combination trucks (WB-40, WB-50, & WB-67)	13.5
Note: Values are for a stopped vehicle to turn left onto a two-lane two-way roadway with no median and grades 3% or less. Includes 2 sec for perception/reaction time.	

Intersection Sight Distance Gap Times (t_g)
Table 2

The t_g values listed in Table 2 require the following adjustments:

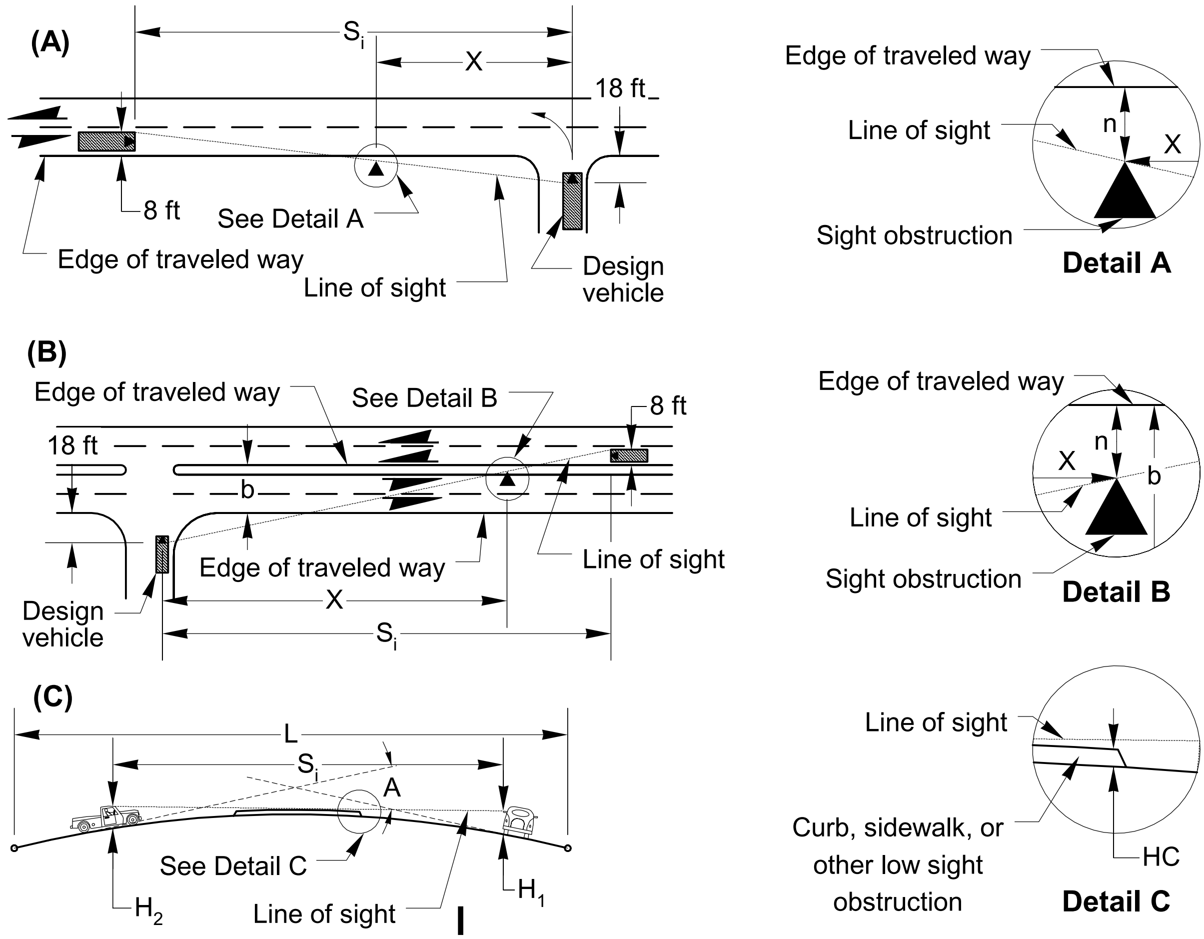
Crossing or right-turn maneuvers:
All vehicles subtract 1.0 sec

Multilane roadways:
Left-turns, for each lane in excess of one to be crossed and for medians wider than 4 ft:
Passenger cars add 0.5 sec
All trucks and buses add 0.7 sec
Crossing maneuvers, for each lane in excess of two to be crossed and for medians wider than 4 ft:
Passenger cars add 0.5 sec
All trucks and buses add 0.7 sec

Note: Where medians are wide enough to store the design vehicle, determine the sight distance as two maneuvers.

Crossroad grade greater than 3%:
All movements upgrade, for each percent that exceeds 3%:
All vehicles add 0.2 sec

Sight Distance at Intersections
Figure 910-17a



For sight obstruction driver cannot see over:

$$S_i = \frac{(26 + b)(X)}{(18 + b - n)}$$

Where:

S_i = Available intersection sight distance (ft).

n = Offset from sight obstruction to edge of lane (ft).

b = Distance from near edge of traveled way to near edge of lane approaching from right (ft). (b=0 for sight distance to the left.)

X = Distance from center line of lane to sight obstruction (ft).

For crest vertical curve over a low sight obstruction where S<L:

$$S = \sqrt{\frac{100L\left[\sqrt{2(H_1 - HC)} + \sqrt{2(H_2 - HC)}\right]^2}{A}}$$

$$L = \frac{AS^2}{100\left[\sqrt{2(H_1 - HC)} + \sqrt{2(H_2 - HC)}\right]^2}$$

Where:

S = Available sight distance (ft).

H_1 = Eye height (3.5 ft for passenger cars; 6 ft for all trucks).

H_2 = Object height (4.25 ft).

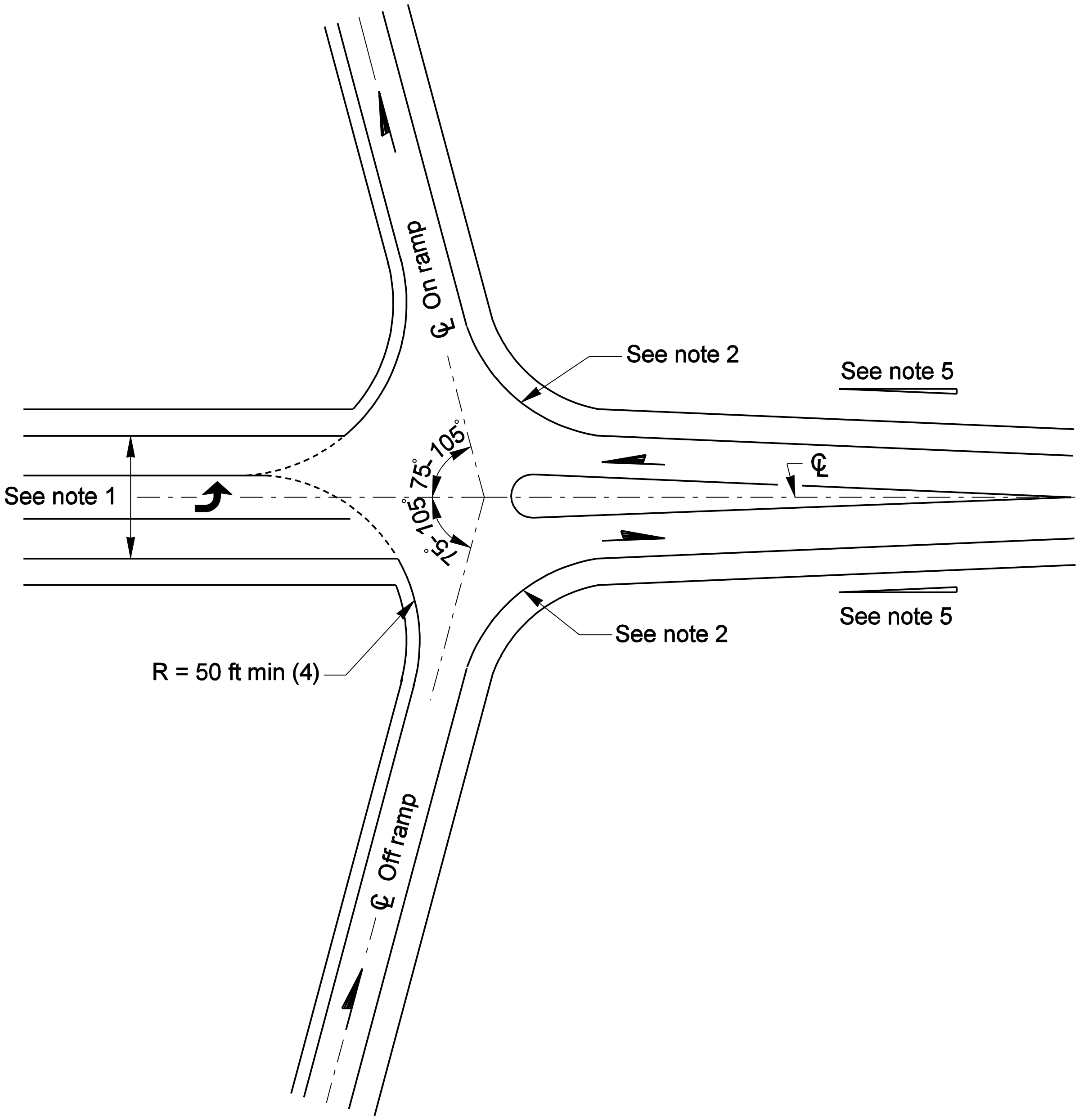
HC = Sight obstruction height (ft).

L = Vertical curve length (ft).

A = Algebraic difference in grades (%).

Sight Distance at Intersections

Figure 910-17b



Notes:

(1) 12 ft through-lanes and 13 ft left-turn lane desirable.

(2) For right-turn corner design see Figure 910-7.

(3) Intersections may be designed individually.

(4) Use templates to verify that the design vehicle can make the turn.

(5) See Figure 910-10a, Table 1 for taper rates.

Interchange Ramp Details

Figure 910-18

915.01 General

Modern roundabouts are circular intersections at grade. They can be an effective intersection type with fewer conflict points, lower speeds, and provide for easier decision making than conventional intersections. They require less maintenance than traffic signals. When well designed, they have been found to reduce fatal and severe injury accidents, traffic delays, fuel consumption, and air pollution. They also can have a traffic calming effect. For additional information and details on roundabouts, see *Roundabouts: An Informational Guide*.

Selection of a roundabout as the preferred intersection type is based on several factors including traffic volume, pedestrian and bicycle volume, space requirements, right of way availability, and traffic speeds. The safety benefits of a roundabout decrease with higher traffic volumes, particularly when pedestrians and bicycles are considered. Select a roundabout only when it is clearly the best intersection type.

Modern roundabouts differ from the old rotaries and traffic circles in three important respects: they have a smaller diameter that constrains circulating speeds; they have raised splitter islands that provide entry deflection, slowing down the entering vehicles; and they have yield at entry, which requires entering vehicles to yield, thus allowing circulating traffic free flow.

Old rotaries and traffic circles are characterized by a large diameter, often in excess of 300 ft. This large diameter typically results in travel speeds within the circulating roadway that exceed 30 mph. They typically provide little or no horizontal deflection of the paths of through traffic. These large diameters also create weaving areas that increase accidents in the circulating roadway. At times, traffic control was imposed on the circulating traffic, such as yield or stop signs that required circulating traffic to yield to entering traffic. In some cases, each entry was controlled with a traffic signal. Circular intersections with any of these features are not an approved intersection type.

(1) Locations Recommended for Roundabouts

Consider roundabouts at intersections:

- Where stop signs result in unacceptable delays for the crossroad traffic.
- With a high left-turn percentage on one or more legs.
- Where a disproportionately high number of accidents involve crossing or turning traffic.
- Where the major traffic movement makes a turn, for example where a state route or city arterial makes a turn.
- Where traffic growth is expected to be high and future traffic patterns are uncertain.
- Where it is not desirable to give priority to either roadway.
- Where major roads intersect at a wye (Y) or tee (T) intersection or with unusual geometry.

(2) Locations Where Roundabouts Need Additional Evaluation

The following conditions raise concerns that might make a roundabout less than desirable over other intersection types. With an evaluation that gives equal consideration to other intersection types, roundabouts may be considered:

- On a facility with a functional class of collector or above where any leg has a posted speed of 45 mph or higher.
- Where the grade for any leg exceeds 4%.
- Where traffic flows are unbalanced with higher volumes on one or more approaches.
- Where a major road intersects a minor road and a roundabout would result in unacceptable delays to the major road traffic.
- Where there is considerable pedestrian activity and, due to high traffic volumes, it would be difficult for pedestrians to cross either road. This includes special-need pedestrians such as large numbers of children or elderly.
- Where there is inadequate sight distance.
- Where there is considerable bicycle traffic.
- Where a downstream traffic control device could cause a queue that extends into the roundabout. Examples include traffic signals, signalized pedestrian crossings, railroad crossings, and drawbridges.
- Where a railroad will cross through the roundabout.
- With more than six approach legs.

(3) Locations Not Recommended for Roundabouts

Roundabouts are not recommended at intersections:

- Where a satisfactory geometric design (deflection, diameter, roadway width, or grade for example) cannot be provided.
- Where peak period reversible lanes are required.
- At a single intersection in a network of coordinated traffic signals and spacing prevents progression of the traffic signals.
- Where a signal interconnect system would provide a better level of service.
- Where it is desirable to be able to modify traffic movements via signal timings.
- Where volumes on the major roadway does not provide sufficient gaps for the minor roadway drivers, based on gap acceptance analysis model.

915.02 References

Americans with Disabilities Act of 1990 (ADA).

ADA Accessibility Guidelines (ADAAG), US Access Board, http://www.access-board.gov/adaag/html/adaag.htm

Revised Code of Washington (RCW) 47.05.021, Functional classification of highways.

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915.03 Definitions

approach roadway The lane or set of lanes for traffic approaching the roundabout. (See Figure 915-1.)

central island The area of the roundabout surrounded by the circulating roadway.

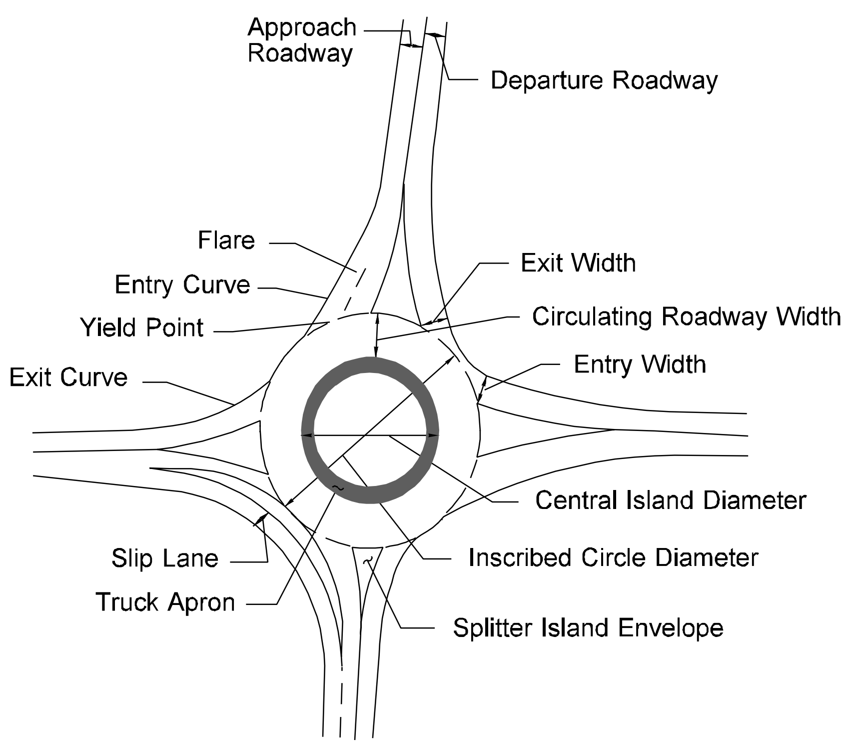
central island diameter The diameter of the central island, including the truck apron. (See Figure 915-1.)

circulating lane A lane used by vehicles circulating in the roundabout.

circulating roadway width The width of the area within the inscribed circle for vehicular movement measured from inscribed circle to the central island. (See Figure 915-1.)

conflict An event involving two or more road users in which the action of one user causes the other user to make an evasive maneuver to avoid a collision.

curb bulb A bulge in a curb line that reduces the width of the roadway.



Roundabout Elements
Figure 915-1

deflection The change in the path of a vehicle imposed by geometric features of a roundabout resulting in a slowing of vehicles. (See Figures 915-9a and 9b.)

departure roadway The lane or set of lanes for traffic leaving the roundabout. (See Figure 915-1.)

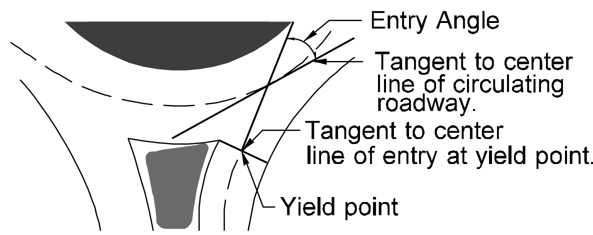
design speed The speed used to determine the various geometric design features of the roadway.

design vehicle A vehicle, the dimensions and operating characteristics of which are used to establish the layout geometry.

detectable warning surface A feature of a walking surface to warn visually impaired pedestrians of a hazard. Truncated domes are specified by The ADAAG.

double-lane roundabout A roundabout with the circulating roadway and one or more entry or exit legs designed as two lanes.

entry angle The angle between the entry roadway and the circulating roadway measured at the yield point. (See Figure 915-2.)



Entry Angle
Figure 915-2

entry curve The curve of the right curb that leads vehicles into the circulating roadway. (See Figure 915-1.)

entry width The width of an entrance leg at the inscribed circle. (See Figure 915-1.)

exit curve The curve of the right curb that leads vehicles out of the circulating roadway. (See Figure 915-1.)

exit width The width of an exit leg at the inscribed circle. (See Figure 915-1.)

flare The widening of the approach to the roundabout to increase capacity. (See Figure 915-1.)

functional classification The grouping of streets and highways according to the character of the service they are intended to provide as provided in RCW 47.05.021.

inscribed circle The entire area within a roundabout between all of the approaches and exits.

inscribed circle diameter The diameter of the inscribed circle. (See Figure 915-1.)

intersection angle The angle between any two intersection legs at the point that the center lines intersect.

intersection at grade The general area where a roadway or ramp terminal is met or crossed at a common grade or elevation by another roadway.

intersection leg Any one of the roadways radiating from and forming part of an intersection.

intersection sight distance The sight distance for the driver of a vehicle on the crossroad along the main roadway, as compared to the distance required for safe operation.

island A defined area within an intersection, between traffic lanes, for the separation of vehicle movements or for pedestrian refuge.

lane A strip of roadway used by a single line of vehicles.

lane width The lateral design width for a single lane, striped as shown in the Standard Plans and the Standard Specifications. The width of an existing lane is measured from the edge of traveled way to the center of the lane line or between the centers of successive lane lines.

roadway The portion of a state highway; a federal, county, or private road; or a city street, including shoulders, for vehicular use.

roundabout A circular intersection with yield control of all entering traffic, channelized approaches with raised splitter islands, counter-clockwise circulation, and appropriate geometric curvature to ensure that travel speeds on the circulating roadway are typically less than 30 mph.

sight distance The length of roadway visible to the driver.

single-lane roundabout A roundabout with the circulating roadway and all entry and exit legs designed as one lane.

shoulder The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and use by pedestrians and bicycles.

slip lane A lane that separates heavy right turn movements from the roundabout circulating traffic. (See Figure 915-1.)

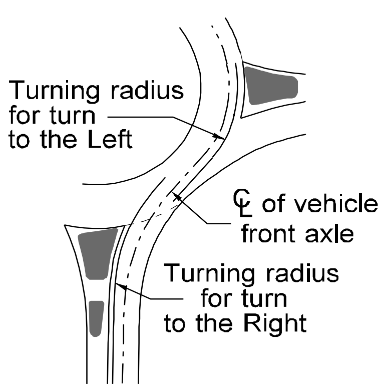
splitter island The raised island at each two-way leg between entering vehicles and exiting vehicles, designed primarily to deflect entering traffic.

splitter island envelope The raised splitter island and the painted channelization surrounding it. (See Figure 915-1.)

stopping sight distance The sight distance, as compared to the distance required to detect a hazard and safely stop a vehicle traveling at design speed.

superelevation The rotation of the roadway cross section in such a manner as to overcome part of the centrifugal force that acts on a vehicle traversing a curve.

rural area A nonurban area.



Turning Radius (R)
Figure 915-3

truck apron The optional, outer, mountable portion of the central island of a roundabout between the raised, nontraversable area of the central island and the circulating roadway. (See Figure 915-1.)

turning radius The radius that the front wheel of the design vehicle on the outside of the curve travels while making a turn. (See Figure 915-3.)

urban area One of the following areas:

- Within the federal urban area boundary as designated by FHWA.
- Characterized by intensive use of the land for the location of structures and receiving such urban services as sewers, water, and other public utilities and services normally associated with urbanized areas.
- With not more than twenty-five percent undeveloped land.

yield-at-entry The requirement that vehicles on all approaches yield to vehicles within the circulating roadway.

yield point The point of entry from an approach into the circulating roadway. If necessary, entering traffic must yield to circulating traffic at this point before entering the circulating roadway. (See Figure 915-1.)

915.04 Roundabout Categories

Roundabouts have been categorized according to size and environment to facilitate discussion of specific performance or design issues. There are six basic categories based on environment, number of lanes, and size:

- Mini roundabouts
- Urban compact roundabouts
- Urban single-lane roundabouts
- Urban double-lane roundabouts
- Rural single-lane roundabouts
- Rural double-lane roundabouts

Characteristics of the different roundabout categories are summarized on Figure 915-7. These categories and Figure 915-7 represent general characteristics of roundabouts, not design limits. Final design values may vary.

Separate categories have not been identified for suburban environments. Suburban settings combine higher approach speeds common in rural areas with multimodal activity that is more similar to urban settings. Therefore, generally, design suburban roundabouts as urban roundabouts but with the high-speed approach treatments recommended for rural roundabouts.

(1) Mini Roundabouts

Mini roundabouts are small roundabouts used in low-speed urban environments and are not suitable for use on a state route. They can be useful in low-speed urban environments, with average operating speeds of 35 mph or less, where a conventional roundabout is precluded by right of way constraints. In retrofit applications, mini roundabouts are relatively inexpensive because they typically require minimal additional pavement at the intersecting roads. They are mostly recommended when there is insufficient right of way for an urban compact roundabout. Because they are small, mini roundabouts are perceived as pedestrian friendly with short crossing distances and very low vehicle speeds on approaches and exits. The mini roundabout is designed to accommodate passenger cars without requiring them to drive over the central island. A mountable central island is recommended because larger vehicles might be required to cross over it. Provide speed control around the mountable central island in the design by requiring horizontal deflection. Capacity for this type of roundabout is expected to be similar to that of the urban compact roundabout. Permeable pavement might be appropriate in the mountable center island to offset any storm water impacts.

(2) Urban Compact Roundabouts

Urban compact roundabouts are also intended to be pedestrian and bicyclist friendly. Because of the smaller design vehicle, they are normally not suitable for use on a state route. Their perpendicular approach legs require very low vehicle speeds. All legs have single-lane entries. However, the urban compact treatment meets all the design requirements of effective roundabouts. The principal objective of this design is to enable pedestrians to have safe and effective use of the intersection. Consider urban compact roundabouts only where capacity is not a critical issue. The geometric design includes raised splitter islands that incorporate at-grade pedestrian storage areas, and a nonmountable central island. There is usually a truck apron surrounding the compact central island to accommodate large vehicles.

(3) Urban Single-Lane Roundabouts

Urban single-lane roundabouts are characterized as having single-lane entries at all legs and one circulating lane. They are distinguished from urban compact roundabouts by their larger inscribed circle diameters and more tangential entries and exits, resulting in higher capacities. Their design allows slightly higher speeds at the entry, on the circulating roadway, and at the exit. This roundabout design is focused on achieving consistent entering and circulating vehicle speeds. The geometric design includes raised splitter islands, a nonmountable central island, and (preferably) no apron. However, a truck apron might be necessary to allow large trucks to make left turns. When a truck apron is used, design the roundabout so that a bus will not need to use it.

(4) Urban Double-Lane Roundabouts

Urban double-lane roundabouts include all roundabouts in urban areas that have at least one entry with two lanes. They include roundabouts with entries on one or more approaches that flare from one to two lanes. These require wider circulating roadways to accommodate two vehicles traveling side by side. The speeds at the entry, on the circulating roadway, and at the exit are similar to those for the urban single-lane roundabouts. It is important that the vehicular speeds be consistent throughout the roundabout. Geometric design includes raised splitter islands, a nonmountable central island, and appropriate horizontal deflection.

Alternate routes may be provided for bicyclists who choose to bypass the roundabout. Delineate bicycle and pedestrian pathways clearly. Use sidewalks and landscaping to direct users to the appropriate crossing locations and alignment. Urban double-lane roundabouts located in areas with high pedestrian or bicycle volumes might have special design requirements.

When a double-lane roundabout is required for the design year but traffic projections indicate that one lane will be sufficient for 10 years or more, consider restricting it to one lane until traffic volumes require a double-lane roundabout.

(5) Rural Single-Lane Roundabouts

Rural single-lane roundabouts generally have high approach speeds. They require supplementary geometric and traffic control device treatments on approaches to encourage drivers to slow to an appropriate speed before entering the roundabout. Rural roundabouts may have larger diameters than urban roundabouts to allow slightly higher speeds at the entries, on the circulating roadway, and at the exits. This is possible if current and anticipated future pedestrian volumes are low.

Design rural roundabouts that might become part of an urban area with slower speeds and pedestrian treatments. However, in the interim, provide supplementary approach and entry features to achieve safe speed reduction. Supplemental geometric design elements include extended and raised splitter islands, a nonmountable central island, and adequate horizontal deflection.

The central island needs to have "target value" to give cues to approaching drivers that there is something that they must drive around. Designers will need to mound the planting area and plant native materials that are out of clear zone and provide "target value".

The geometric design includes a truck apron where necessary for WB-50 and larger trucks to use the roundabout. Design the roundabout so that a WB-40 will not be required to use the truck apron.

(6) Rural Double-Lane Roundabouts

Rural double-lane roundabouts have speed characteristics similar to rural single-lane roundabouts. They differ in having two entry lanes, or entries flared from one to two lanes, on one or more approaches. Consequently, many of the characteristics and design features of rural double-lane roundabouts mirror those of their urban counterparts. The main design differences are higher entry speeds and larger diameters, and recommended supplementary approach treatments. Design rural roundabouts that might become part of an urban area for slower speeds, with design details that fully accommodate pedestrians and bicyclists. However, in the interim, design approach and entry features to achieve safe speed reduction.

The central island needs to have "target value" to give cues to approaching drivers that there is something that they must drive around. Designers will need to mound the planting area and plant native materials that are out of clear zone and provide "target value".

When a double-lane roundabout is required for the design year but traffic projections indicate that one lane will be sufficient for at least 5 to 10 years, consider restricting it to one lane until traffic volumes require a double-lane roundabout.

915.05 Capacity Analysis

A capacity analysis is required for each proposed roundabout to compare it to other types of intersection control.

Design roundabouts so that the demand volume to capacity ratio is 0.85 or less and the anticipated delays are comparable to other types of intersection control.

There are two methods of performing the capacity analysis:

- An analysis based on gap acceptance (the Australian method). Use the method given in the *Austroad Guide* or the *Highway Capacity Manual*.
- An empirical formula based on measurements at a saturated roundabout (the British method). Use the method given in TRRL Report 942.

While each method has advantages, it is felt there is currently not enough United States performance data on which to base the empirical method analysis. Therefore, the gap acceptance method is preferred.

Figure 915-8 may be used to estimate the entry capacity of each roundabout entry leg; however, perform a capacity analysis using other methods to verify roundabout capacity.

915.06 Geometric Design

(1) Design Vehicle

The physical characteristics of the design vehicle are one of the elements that control the geometric design of a roundabout. See Chapter 910 for guidance on the selection of a design vehicle. As with other intersections, the design vehicle may differ for each movement. Use the largest vehicle selected for any movement as the design vehicle for the circulating roadway. For a roundabout on a state highway, this is the WB-50 vehicle. Design a roundabout so that the design vehicle can use it with 2 ft clearance from the turning radius to any curb face. The rear wheel of a semitrailer may encroach on the truck apron.

It is desirable to design the circulating roadway so that a BUS design vehicle in urban areas and a WB-40 in rural areas can use the roundabout without encroaching on the truck apron.

Design roundabouts on state routes so the WB-67 can use it without leaving the truck apron or encroaching on a curb. Use vehicle turning path templates to verify that this vehicle can make all state highway to state highway movements.

The vehicle path through a roundabout will normally contain reverse or compound curves. To check the roundabout for the design vehicles, a computer generated template for each path is recommended.

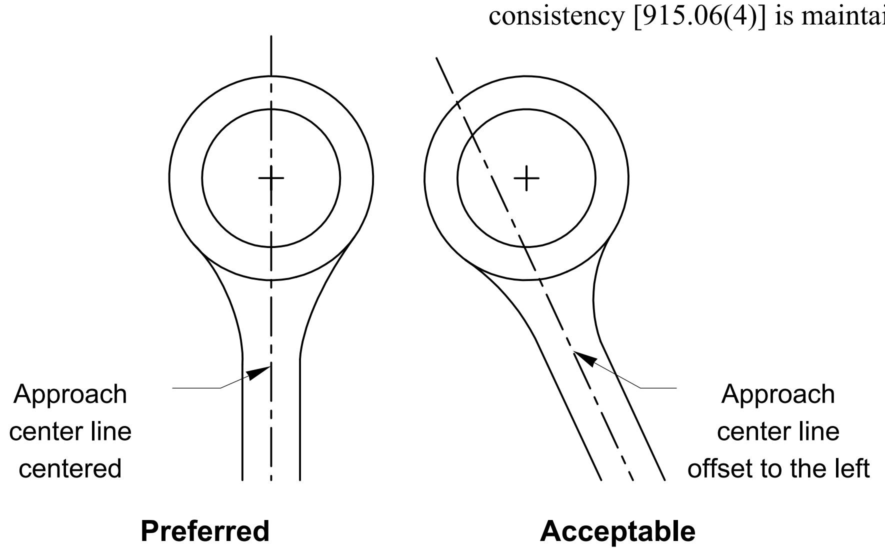
(2) Approach Alignment

The preferred alignment of an approach leg to a roundabout is with the centerline passing through the center of the inscribed circle. (See Figure 915-4.) This allows the roundabout to be designed so that vehicles will maintain slow speeds at both the entries and the exits. This alignment makes the central island more conspicuous to approaching drivers.

Where it is not possible to align an approach leg through the center of the inscribed circle, a slight offset to the left is acceptable. (See Figure 915-4.) This will allow adequate curvature at the entry, which is of greatest importance. In some cases, it may be beneficial to offset the approach slightly to the left to enhance the entry curvature. However, this will create a more tangential exit with increased exit speed and might increase the risk for pedestrians.

Approach alignment offset to the right of the roundabout's center point is unacceptable. This alignment <u>results in a more tangential approach allowing vehicles to enter the roundabout at a higher speed. This will normally result in a reduction in safety.</u>

It is desirable to equally space the angles between entries. This will optimize the separation between successive entries and exits. When site conditions make equal spacing impractical, spacing may be varied to a minimum of 40°. When reducing the angle between approaches, ensure that speed consistency [915.06(4)] is maintained.



Approach Leg Alignment
Figure 915-4

(3) Deflection and Design Speed

For a roundabout to work properly, it must be designed to reduce the relative speeds between conflicting traffic streams. The most significant feature that will control the speed is adequate deflection. The deflection is expressed as the radius of the center line of a vehicle path through the roundabout. Figures 915-9a and 9b illustrate the vehicle paths for determining deflection.

The vehicle path can be adjusted by:

- Changing the alignment and width of the entry and the shape, size, and position of the approach splitter island.
- Changing the central island size.
- Staggering alignment between entrance and exit.

The deflection design speed is controlled by the path radius and cross slope of the roadway. Figure 915-5 gives the deflection radii for design speeds for roadways that slope down to the outside of the curve (-2%), that are level (0%), and that slope down to the inside of the curve (2%). Use the following equation to make the final adjustments for speeds between those given:

$$V = \sqrt{\frac{R(c+f)}{6.69}}$$

Where:

V	=	Design speed in mph
R	=	The deflection radius in feet.
c	=	Slope of the roadway in percent
f	=	Side friction factor from Figure 915-5

Design roundabouts so that deflection limits the entry speed to 30 mph or less and achieves speed consistency. In areas with a large number of pedestrians or bicyclists, design roundabouts for a maximum speed of 15 to 20 mph.

Design Speed (mph)	Deflection Radius (ft) Cross Slope			Side Friction actor f
	-2%	0%	2%	
10	20	20	20	38
15	50	50	45	32
20	110	100	95	27
25	200	185	170	23
30	335	300	275	20
35	515	455	410	18

Deflection
Figure 915-5

(4) Speed Consistency

Speed consistency for all movements is an important element of roundabout design. Speed consistency is achieved when the differences between speeds of paths that merge, cross, or parallel each other do not exceed 12 mph.

Figure 915-10 shows five critical path radii to be checked for each leg. The entry path (R_1) is the minimum radius for through traffic approaching the yield point. The circulating path (R_2) is the minimum radius for through traffic around the central island. The exit path (R_3) is the minimum radius for through traffic into the exit. The left-turn path (R_4) is the minimum radius for the conflicting left-turn movement. The right-turn path (R_5) is the minimum radius for a right-turning vehicle. These vehicular path radii are determined as shown on Figures 915-9a and 9b.

Make R_1 smaller than or equal to R_2, and R_2 smaller than or equal to R_3 ($R_1 \leq R_2 \leq R_3$). This ensures that speeds will be reduced to their lowest at the roundabout entry reducing the likelihood of problems in the roundabout.

(5) Inscribed Diameter

The inscribed diameter is controlled by the space available, the design speed, design vehicle and the number of legs. The size of the inscribed diameter is a balance between designing for large vehicles and providing adequate deflection for the design speed. Select a diameter that will result in a speed at or below the desired design speed.

To meet the need to provide an adequate turning radius, the right-turn movement might require that the inscribed diameter be increased for roundabouts with more than four legs or with high skew angles. On state routes, make the turning radius 50 ft minimum with 2 ft clearance to the face of a curb.

The inscribed circle is not always circular, with a constant-radius circulating roadway; ovals and tear drops have been used. Noncircular shapes are allowed when the smaller turning radius is at least 50 ft. When a noncircular roundabout is used, where possible align it so that the heavier traffic uses the larger radius.

(6) Entry

Design the entry width to accommodate the design vehicles and required entry lanes while providing adequate deflection. Design the entry so that the entry angle is between 20° and 60°, preferably between 30° and 40°. Figure 915-11 provides additional guidance for entry design.

When the approach width, including shoulders and parking lanes, is wider than needed for the entry width, consider curb bulbs to reduce the width. For information on parking limitation at roundabouts, see 915.11.

When the roundabout is on a state route, the minimum turning radius is 50 ft to provide for large trucks. It is desirable for the entry radius to be smaller than both the circulating radius and the exit radius. This makes the speeds the lowest at the roundabout entry. It also helps to reduce the speed differential between entering and circulating traffic.

Design the entry radius, R_1 on Figure 915-10, to limit entry speeds to not more than 25 mph in urban areas and 30 mph in rural area.

At single-lane roundabouts, it is not difficult to reduce the value of the entry radius. The curb radius at the entry can be reduced or the alignment of the approach can be shifted to the left to achieve a slower entry speed. This is more difficult at double-lane roundabouts. When entry and exit curve radii are too small, the natural path of adjacent traffic can overlap. Path overlap occurs when the geometry leads a vehicle in the left lane to cross into the right lane to avoid the central island. (See Figure 915-12.) Path overlap can reduce capacity and increase accidents. Take care when designing double-lane roundabouts to avoid path overlap. For more information on path overlap, see *Roundabouts: An Informational Guide*.

Flaring is an effective means of introducing a double-lane roundabout without requiring as much right of way as a full lane addition. 130 ft is the optimum flare length to add a second lane at a double-lane roundabout. However, if right of way is constrained, shorter flare lengths may be used with decreased capacity.

At rural locations, consider the speed differential between the approaches and entries. If the posted speed of the approach is greater than 15 mph above the design speed of the entry curve, consider introducing speed reduction measures before the entry curve.

(7) Circulating Roadway

Keep the circulating width constant throughout the roundabout with the minimum width equal to or slightly wider (120%) than the maximum entry width.

At single-lane roundabouts, provide a circulating roadway width plus truck apron to just accommodate the design vehicle. Use appropriate vehicle-turning templates or a computer program to determine the swept path of the design vehicle through each turning movement. Provide a minimum clearance of 2 ft between the vehicle's tire track and all vertical curbs with a height of 6 in or more.

Design the circulating radius, R_2 on Figure 915-10, to be larger than the entry radius. In some cases where capacity is not a concern, it might not be possible for the circulating radius to be greater than the entry radius. In such cases, the entry radius may be greater than the circulating radius, provided the difference in speeds is less than 12 mph and preferably less than 6 mph.

(8) Exit

Design the exit width to accommodate the design vehicles while providing adequate deflection. Figure 915-11 provides additional guidance for exit design.

Generally, design the exit radius, R_3 on Figure 915-10, larger than both the entry radius (R_1) and the circulating radius (R_2). The larger exit curve radii improve the ease of exit and minimize the likelihood of congestion at the exits. This, however, is balanced by the need to maintain low speeds at the pedestrian crossing on exit. If the exit path radius is smaller than the circulating path radius, vehicles might be traveling too fast to negotiate the exit and crash into the splitter island or into oncoming traffic.

At single-lane roundabouts with pedestrian activity, design exit radii the same as or slightly larger than the circulating radius to minimize exit speeds. However, at double-lane roundabouts, additional care must be taken to minimize the likelihood of exit path overlap. Exit path overlap can occur when a vehicle on the left side of the circulating roadway exits into the right exit lane. Where no pedestrians are expected, make the exit radii large enough to minimize the likelihood of exiting path overlap. Where pedestrians are present, tighter exit curvature might be necessary to ensure low speeds at the pedestrian crossing.

When the departure roadway width, including shoulders and parking lanes, is wider than needed for the exit width, consider curb bulbs to reduce the width.

(9) Turning movements

Evaluate the left- and right-turn radii, R_4 and R_5 on Figure 915-10, to ensure that the maximum speed differential between entering and circulating traffic is no more than 12 mph. The left-turn movement is the lowest circulating speed. The left-turn radius can be determined by adding 5 ft to the central island radius.

(10) Sight Distance

The operator of a vehicle approaching a roundabout needs to have an unobstructed view of the splitter island, central island, yield point, and sufficient lengths of the intersecting roadways to permit recognition of the roundabout and to initiate the required maneuvers to maintain control of the vehicle and to avoid collisions. To do this, two aspects of the sight distance are necessary:

- **Stopping Sight Distance.** Provide the stopping sight distance given on Figure 915-6 at all points on the approach roadways, the circulating roadway, and the departure roadways. Check each vehicle path using the deflection speed. See Chapter 650 for additional information on stopping sight distance.

Speed (mph)	Stopping Sight Distance (ft)
10	47
15	77
20	113
25	153
30	198
35	248

Stopping Sight Distance for Roundabouts
Figure 915-6

- **Intersection Sight Distance.** For intersection sight distance at roundabouts, provide a clear view of traffic on the circulating roadway and approaching the roundabout on the leg to the left for a distance equal to that traveled in 4.5 seconds. The required gap is also a function of capacity and, at lower volumes, a larger gap may be required. However, do not use an intersection sight distance (Figure 915-13) less than the stopping sight distance (Figure 915-6).

  Because traffic is approaching a yield condition and might not be required to stop before entering a roundabout, provide the sight distance along the approach for 50 ft. Momentary sight obstructions that do not hide a vehicle, such as poles, sign posts, and narrow trees, are acceptable in the sight triangles including the central island. Guidance for intersection sight distance at a roundabout is shown on Figure 915-13.

Providing adequate sight distance will also provide clear zone for the central island.

(11) Islands

Raised islands are important for effective operation of a roundabout. Their primary purpose is to control deflection.

(a) **Central Island**. The central island is a raised, nontraversable area and may include a truck apron (Figure 915-14). The truck apron is the outer part of the central island, designed to allow for encroachment by the rear wheels of large trucks.

The primary control of the central island size is the inscribed diameter, the required circulating width, and the required deflection. When the required circulating width for the large vehicles results in a deflection radius larger than the maximum for the design speed, increase the central island diameter to achieve the desired deflection radius and provide a truck apron. Make the surfacing of the truck apron different from the circulating roadway. However, make the surfacing of the apron different from the sidewalks so that pedestrians are not encouraged to cross the circulating roadway. Use a 3 in mountable curb between the circulating roadway and the truck apron.

Use a 6 in or higher vertical curb between the truck apron and the nontraversable area. Landscape or mound the raised, nontraversable area to improve the visual impact of the roundabout to approaching drivers. When designing landscaping, consider sight distance and roadside safety. Also, consider maintenance needs for access to the landscaping in the central island.

When designing the landscaping for the central island, do not use items that might tempt people to take a closer look. Do not place street furniture or other objects that may attract pedestrian traffic to the central island, such as benches or monuments with small text. Design fountains or monuments in the central island in a way that will enable proper viewing from the perimeter of the roundabout. In addition, design and locate all objects in the center island to maintain sight distance, minimize driver distraction, and minimize the possibility of impact from an errant vehicle.

(b) **Splitter Island**. Splitter islands are built at each two-way leg. They serve to:

- Control the entry and exit speeds by providing deflection.
- Prevent wrong way movements.
- Provide pedestrian refuge.
- Provide a place to mount signs.

The desirable length of a splitter island envelope is equal to the stopping sight distance for the design speed of the roadway approaching the roundabout. (See Chapter 650.) Make the extensions of the curves that form the splitter islands tangent to the outside edge of the central island. The minimum width of the island at any crosswalk is 6.5 ft. Figure 915-15 gives guidance on the design of splitter islands.

For information on shoulders at islands, island nose radii, nose offsets, and other details, see Chapter 910.

(12) Grades and Superelevation

It is preferred that the grade on all of the intersecting roadways at a roundabout is 4% or flatter and that the grades be constant through the roundabout or that the roundabout be in a sag vertical curve. Grade in excess of 4% can result in reduces sight distance, increased difficulty slowing or stopping, and higher possibility of vehicle rollover.

When a roundabout must be built at or near the crest of a vertical curve on one of the roadways, pay special attention to the sight distances. For additional information on grades at roundabouts, see *Roundabouts: An Informational Guide*.

Do not use superelevation for the circulating roadway. It is desirable to maintain the normal 2% cross slope from the central island to the outside of the circle. (See Figure 915-5) This will improve drainage and help reduce the speed of circulating traffic.

(13) Right-Turn Slip Lane

Right-turn slip lanes may be used, with justification, when a right-turn movement is heavy enough to lead to a breakdown in roundabout operation and the radius produces a speed comparable to the speed through the roundabout.

For additional information on channelization for right-turn slip lanes, see right turn lanes at islands in Chapter 910 and *Roundabouts: An Informational Guide*.

(14) Design Clear Zone

For the right side of the circulating roadway, see Chapter 700 using the R_2 speed for the required design clear zone. Do not place light standards or other poles without breakaway features in splitter islands or on the right side just downstream of an exit point. When any approach leg has a posted speed of 45 mph or higher, place no fixed object, water features with a depth of 2 ft or more, or other hazards in the central island. At roundabouts with all approach legs posted at 40 mph or less, avoid water features with a depth of 2 ft or more in the central island. Avoid fixed objects in central islands when the island diameter is less than 65 ft. Within the central island, clear zone is desirable to provide both a recovery area for errant vehicles and sight distance. When necessary to protect features in the central island, provide a central island low profile barrier 18 in high or higher.

915.07 Pedestrians

Pedestrian crossings are unique at roundabouts in that the pedestrian is required to cross at a point behind the vehicles entering the roundabout. The normal crossing point at intersections is in front of these vehicles. For this reason, mark all pedestrian crosswalks at urban roundabouts and at rural roundabouts when pedestrian activity is anticipated. Position the crosswalk one car length, approximately 20 ft, from the yield point and use the raised splitter island as a pedestrian refuge. (See Figures 915-15 and 16.) Consider landscaping strips to discourage pedestrians crossing at undesirable locations.

Provide a barrier-free passageway at least 6 ft wide, 10 ft desirable, through this island for persons with disabilities. Whenever a raised splitter island is provided, also provide pedestrian refuge. This facilitates the pedestrian crossing in two separate movements.

Give special attention to assisting pedestrians who are visually impaired through design elements such as providing tactile cues through the installation of truncated domes at curb ramps, splitter islands, and any other pedestrian facility that might lead to conflicts with pedestrians and vehicular traffic. These pedestrians typically attempt to maintain their approach alignment to continue across a street in the crosswalk. A roundabout requires deviation from that alignment. Provide appropriate informational cues to pedestrians regarding the location of the sidewalk and the crosswalk.

See Chapter 1025 for sidewalk ramps and additional information on pedestrian needs.

915.08 Bicycles

The operating speed of vehicles within smaller low speed roundabouts is, in most cases, the same speed as that of bicyclists and both can use the same roadway without conflict or special treatment. Larger roundabouts with higher operating speeds can present problems for the bike rider and an alternate bike path, a shared use sidewalk, or warning signs might be necessary. If the bike riders are children, as in the case of a nearby elementary school, consider signing and pavement markings directing them to use the adjacent sidewalk. End all bicycle lanes before they enter a roundabout, with the bicycles either entering traffic to use the circulating roadway or leaving the roadway on a separate path or a shared use sidewalk. See Figure 915-16 for the recommended design for ending a bicycle lane with a shared use sidewalk at a roundabout.

915.09 Signing and Pavement Marking

Roundabouts, being a new concept in Washington State, require consistent signing and pavement markings to familiarize motorists with their intended operation.

Roundabout signing is shown on Figure 915-17. Locate signs where they have maximum visibility for road users but a minimal likelihood of obscuring other signs, pedestrians, or bicyclists. Use only signs contained in the MUTCD. A diagrammatic guide sign, as shown in the figure, can be used to provide the driver with destination information. Provide a route confirmation sign on all state routes shortly after exiting the roundabout.

Pavement markings are shown in the MUTCD. Optional lane lines between lanes within the circulating roadway may be used on multilane roundabouts. When evaluating whether or not to provide lane lines within the circulating roadway, consider the following potential impacts:

- Reduce confusion
- Reduce flexibility
- Improve lane alignment
- Reduce capacity
- Provide a more normal situation
- Might require advanced signing for proper lane usage at the entry

When lane lines are to be used, include the striping plan with the roundabout approval request.

915.10 Illumination

For a roundabout to operate satisfactorily, a driver must be able to enter, move through, and exit the roundabout in a safe and efficient manner. To accomplish this, a driver must be able to see the layout and operation in time to make the appropriate maneuvers. Adequate lighting is needed for this at night.

Provide illumination for roundabouts with any one of the following:

- At least one leg is a state route or ramp terminal.
- It is necessary to improve the visibilityof pedestrians and bicyclists.
- One or more of the legs are illuminated.
- An illuminated area in the vicinity can distract the driver's view.
- Heavy nighttime traffic is anticipated.

Provide illumination for each of the conflict points between circulating and entering traffic in the roundabout and at the beginning of the raised splitter islands. Figure 915-18 depicts the light standard placement for a four-legged roundabout. See Chapter 840 for additional information and requirements on illumination. A single light source located in the central island is not acceptable. When one or more of the legs are illuminated, provide a light level within the roundabout approximately 50% higher than the highest level on any leg. Use a high pressure sodium vapor luminaire with a medium or short cut-off light distribution for the light source. Position the luminaire over the outside edge of the roundabout to use the "house side" lighting to illuminate the pedestrian crosswalks.

915.11 Access, Parking, and Transit Facilities

No road approach connections to the circulating roadway are allowed at roundabouts, unless it is designed as a leg to the roundabout appropriate for the traffic volume using the approach. Road approach connections to the circulating roadway are allowed only when no other reasonable access is available. It is preferred that road approaches not be located on the approach or departure legs within the length of the splitter island. The minimum distance from the circulating roadway to a road approach is controlled by the corner clearance using the circulating roadway as the crossroad. (See Chapter 1435.)

Parking is not allowed in the circulating roadway or on the approach roadway past the crosswalk. It is also desirable that no parking be allowed on the approach or departure legs for the length of the splitter island. See Chapter 1025 for additional information on parking limitations near a crosswalk.

Transit stops are not allowed in the circulating roadway or on the approach roadway past the crosswalk. Locate transit stops on departure legs in a pullout or where the pavement is wide enough that a stopped bus will not block the through movement of traffic. Locate transit stops on approach or departure legs where they will not obstruct sight distance.

915.12 Procedures

(1) Selection

Use the following steps when selecting a roundabout for intersection control:

(a) Consider the context. Are there constraints that must be addressed? Are there site-specific and community impact reasons why a roundabout of a particular size would not be a good choice?

(b) Determine the roundabout category (Figure 915-7) and a preliminary lane configuration (Figure 915-8) based on capacity requirements.

(c) Identify the justification category. See 915.12(2). This establishes why a roundabout might be the preferred choice and determines the need for specific information.

(d) Perform the analysis appropriate to the selection category. If the selection is to be based on operational performance, use the appropriate comparisons with alternative intersections

(e) Determine the right of way requirements and feasibility.

(f) If additional right of way must be acquired or alternative intersection forms are viable, an economic evaluation will be useful.

(g) Contact all approving authorities to obtain concurrence that a roundabout is an acceptable concept at the proposed location. On state routes this includes the HQ Design Office.

(2) Justification

Consider roundabouts only when fulfilling one or more of the following justification categories:

(a) **Safety Improvement.** At high accident location intersections, a roundabout might be a method of reducing accidents by reducing the number of conflict points. At conventional intersections, many accidents involve left-turning or crossing vehicles; with roundabouts these movements are eliminated. With the low operating speeds and low entry angles, accidents at roundabouts are generally less severe.

Roundabouts in this category require an accident analysis that shows high accidents of a type that a roundabout can reduce in number or severity. In the analysis, consider any potential shift of accidents to another accident type.

(b) **Improve Intersection Capacity.** A roundabout may be analyzed as an alternative to traditional traffic control options to increase the capacity of an intersection. With traffic signals, alternating traffic streams through the intersection can cause a loss of capacity when the intersection clears between phases. In a roundabout, vehicles may enter available gaps simultaneously from multiple approaches. This can result in an advantage in capacity. This advantage becomes greater when the volume of left turning vehicles is high.

Justify roundabouts in this category with a capacity analysis showing that it can provide the required capacity comparable to the optimum design for a conventional intersection. Discuss the effects on “off-peak” traffic.

(c) **Queue Reduction.** Roundabouts can improve operations at locations where the space for queuing is limited. Roadways are often widened for queuing at traffic signals, but the reduced delays and continuous flows at roundabouts allow the use of fewer lanes. Possible applications are at interchanges where left turn volumes are high. Roundabouts at ramp terminals can improve capacity without widening a structure.

Roundabouts in this category require an analysis showing that the roundabout will eliminate the need to build additional lanes or widen a structure without additional impacts to the main line operations.

(d) **Special Conditions.** The special conditions where a roundabout might be preferred over a conventional intersection include locations with unusual geometrics; right of way limitations; closely spaced intersections; wye (Y) intersections; and, on nonstate routes, for traffic calming. Roundabouts might be better suited for intersections with unusual geometrics; such as high skew angle and offset legs. Roundabouts can provide adequate levels of operation without significant realignment or complicated signing or signal phasing.

Roundabouts can avoid the need to obtain additional right of way along the intersection legs. Roundabouts can shift any required right of way from the roadway between the intersections to the area of the intersection.

Roundabouts can eliminate closely spaced intersections, and any associated operational problems, by combining them into one intersection. The ability of roundabouts to serve high turning volumes make them a practical design at wye (Y) or tee (T) intersections.

Roundabouts proposed for a special condition require documentation indicating what the condition is and how the roundabout will address it.

(3) Approval

A proposal to install a roundabout on any route, either NHS or non-NHS, with a posted speed limit of 45 mph or higher requires an analysis of alternatives. See Chapter 910 for requirements.

HQ Design Office approval of the design is required when a roundabout is to be used on a state highway. Submit to the HQ Design Office:

- Supporting engineering data.
- Concurrence that a roundabout is an acceptable concept 915.12(1)(g).
- An intersection plan.
- Roundabout justification from 915.12 (2).
- A comparison of the roundabout to alternative intersection types with an explanation as to why the roundabout is the preferred alternative.
- A traffic analysis of the roundabout and alternative intersection types, including a discussion of any loss in level of service or increase in delay. Include the effects on "off-peak" traffic and discuss any adverse impacts of the roundabout.
- An analysis of pedestrian and bicycle activities.
- An approved analysis of alternatives for roundabouts on any state route with a posted speed of 45 mph or higher.
- The approval of the State Design Engineer or designee for roundabouts within the limits of limited access control.
- The calculated design speeds for the entry path, the circulating path, the exit path, the left-turn path, and the right-turn path for each leg of the roundabout.
- A corridor and network analysis.
- Current or projected traffic control or safety problems at the roundabout.
- Demonstration that the proposed configuration can be implemented and that it will provide adequate capacity on all approaches.
- All potential complicating factors, their relevance to the location, and any mitigation efforts that might be required.
- An economic analysis, indicating that a roundabout compares favorably with lternative control modes from a benefit-cost perspective.

915.13 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

	Design Element	Mini (1)	Urban (2) Compact	Urban Single-Lane	Urban Double-Lane	Rural Single-Lane	Rural Double-Lane
General	Number of Lanes	1	1	1	2	1	2
	Typical max. (3) ADT	12,000	15,000	20,000	40,000	20,000	40,000
	Splitter Island Treatment	Painted, raised if possible	Raised	Raised	Raised	Raised extended	Raised extended
	Max. Design(4) Vehicle	SU	SU/BUS	WB-50	WB-50	WB-67	WB-67
Circulating	Inscribed Circle Diameter	45'-80'	80'-100'(5)	100'-130'(6)	150'-180'	115'-130'(6)	180'-200'
	Circulating Roadway Design Speed	15-18 mph	16-20 mph	20-25 mph	22-28 mph	22-27 mph	25-30 mph
	Circulating Roadway Width	14'-19'	14'-19'	14'-19'	29'-32'	14'-19'	29'-32'
Entry	Max. Entry Design Speed	15 mph	15 mph	20 mph	25 mph	25 mph	30 mph
	Entry Radius	25'-45'	25'(7)-100'	35'(7)-100'	100'-200'	40'(7)-120'	130'-260'
	Entry Lane Widths	14'-16'	14'-16'	14'-16'	25'-28'	14'-16'	25'-28'

(1) Mini roundabouts are not suitable for use on a state route.

(2) Urban compact roundabouts are normally not suitable for use on a state route.

(3) Total ADT entering a 4-leg roundabout with 33% of the volume on the minor roadway. Multiply by 1.2 for 4-leg roundabouts with equal volume on both roadways. Multiply by 0.9 for 3-leg roundabouts.

(4) See Chapter 910 for selecting a design vehicle on a state route.

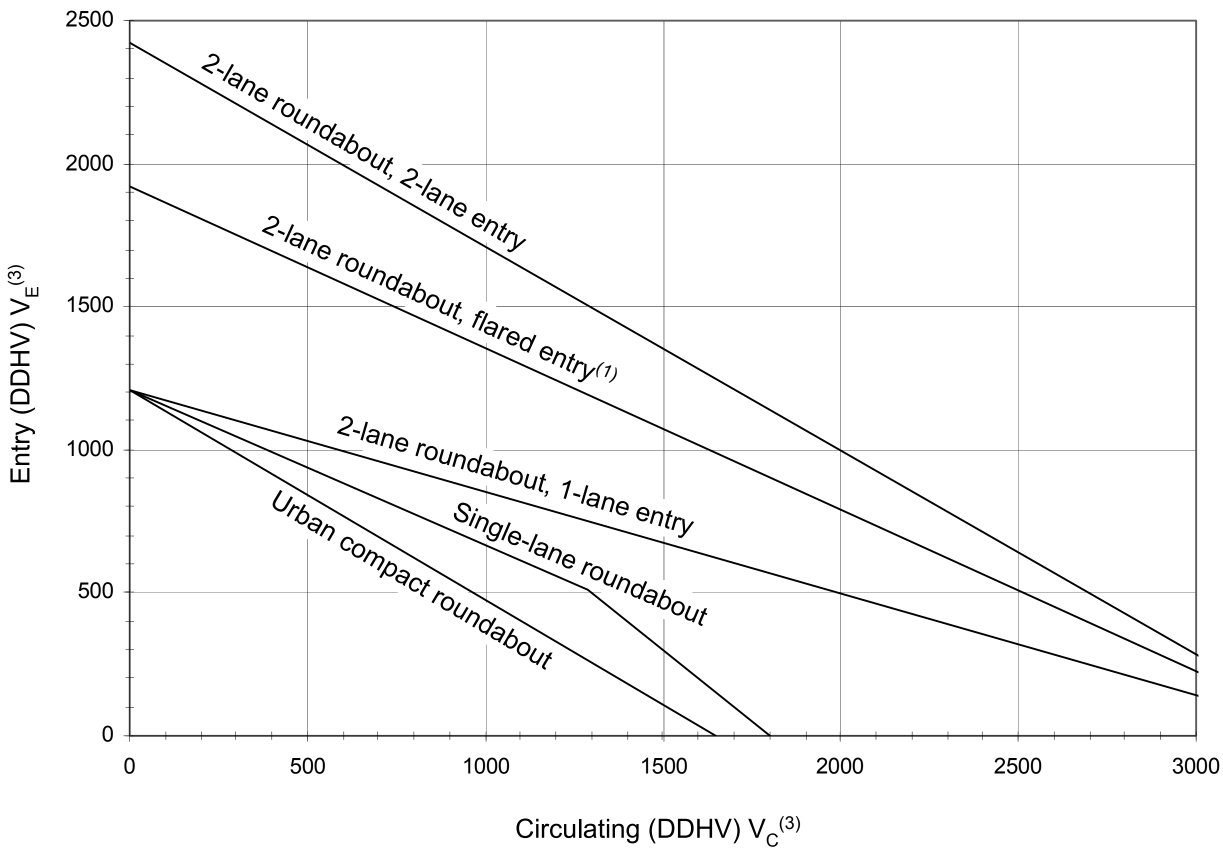
(5) Use 100 ft minimum on state routes.

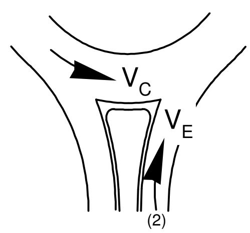
(6) When roundabout might be expanded to a double-lane roundabout, consider using a double-lane roundabout diameter.

(7) Use 50 ft minimum on state routes.

Note:
The values given in this figure are approximate. They are intended for planning and preliminary design. Final design values may vary.

Roundabout Categories Design Characteristics
Figure 915-7





Note:

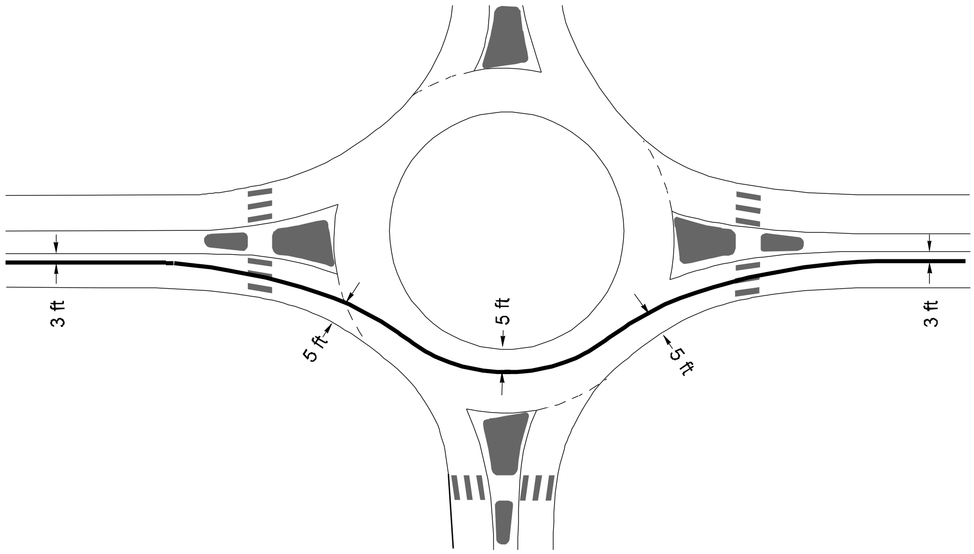
(1) Entry flared with 2 vehicle storage lane.

(2) Check for each entry.

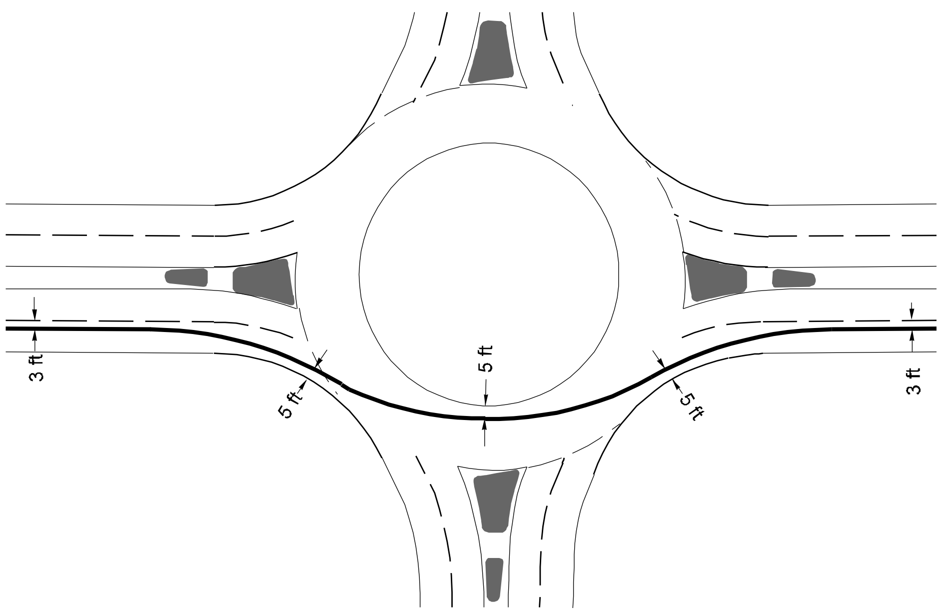
(3) DDHV in passenger car equivalents.

Vehicle Type	Passenger Car Equivalent
Car	1.0
SU or BUS	1.5
Other truck	2.0
Bicycle or Motorcycle	0.5

Approximate Entry Capacity
Figure 915-8

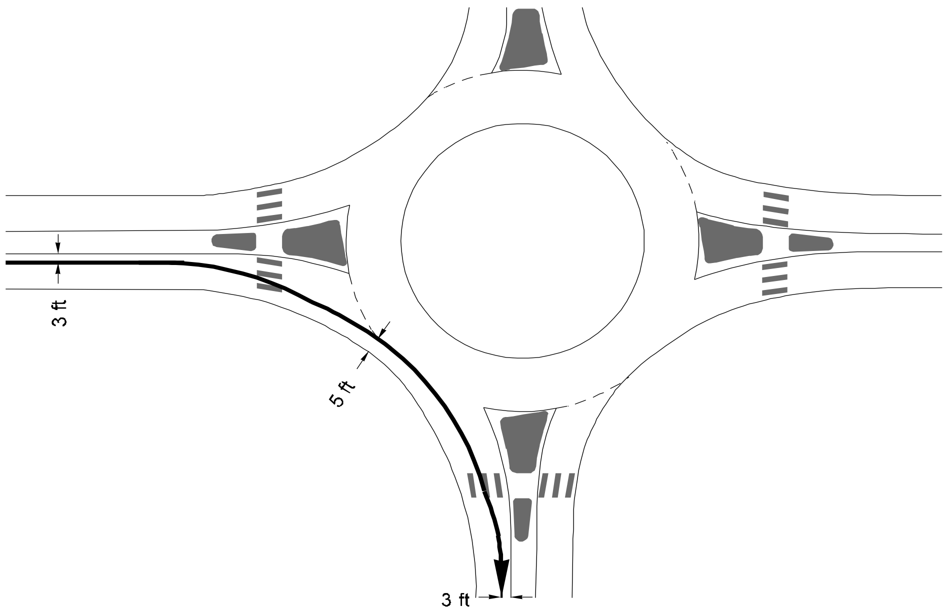


Single-Lane Roundabout

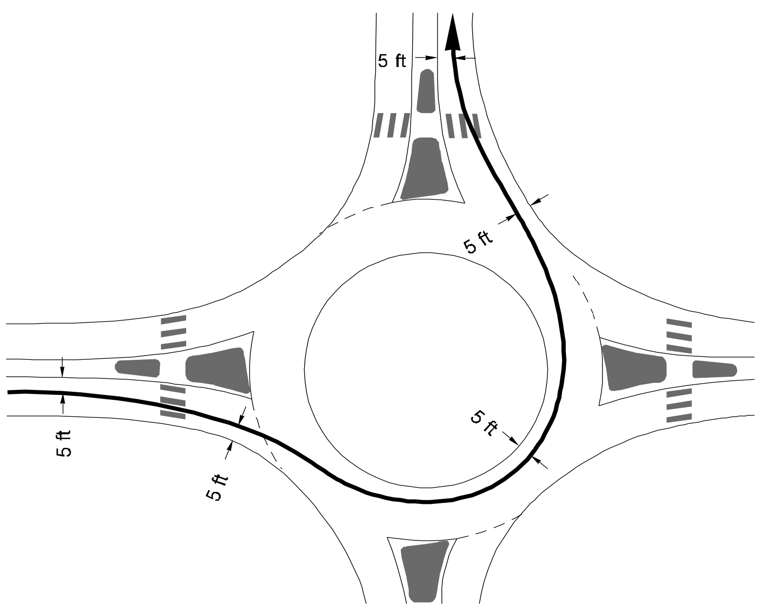


Double-Lane Roundabout

Deflection Path
Figure 915-9a



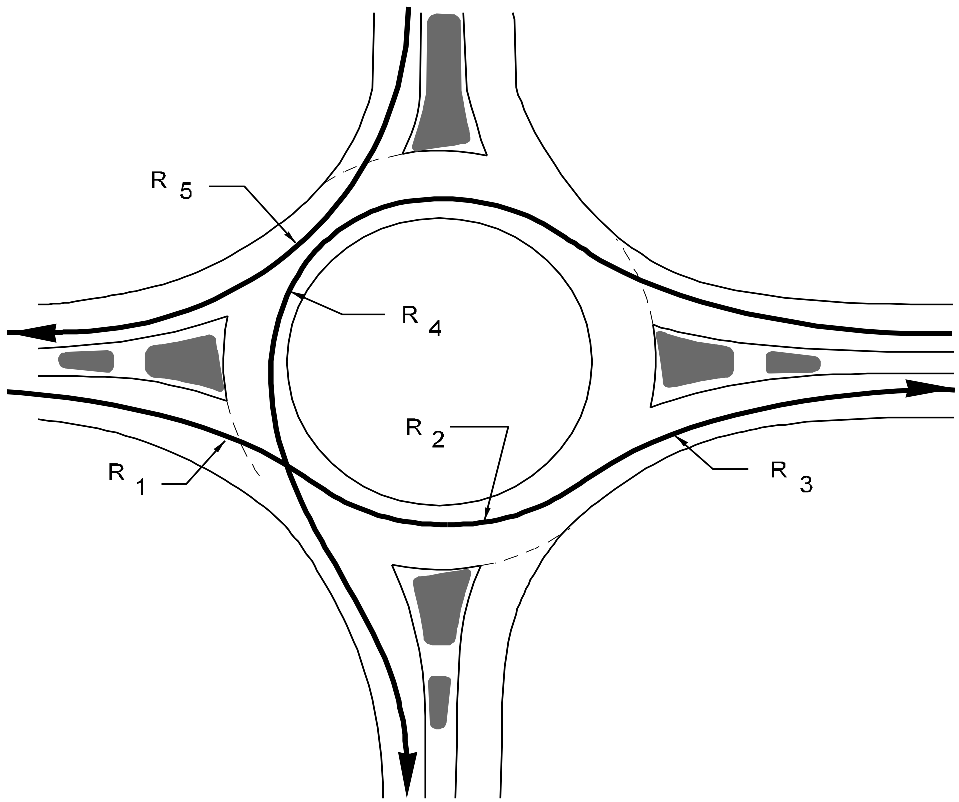
Right-Turn Movement



Left-Turn Movement

Deflection Path

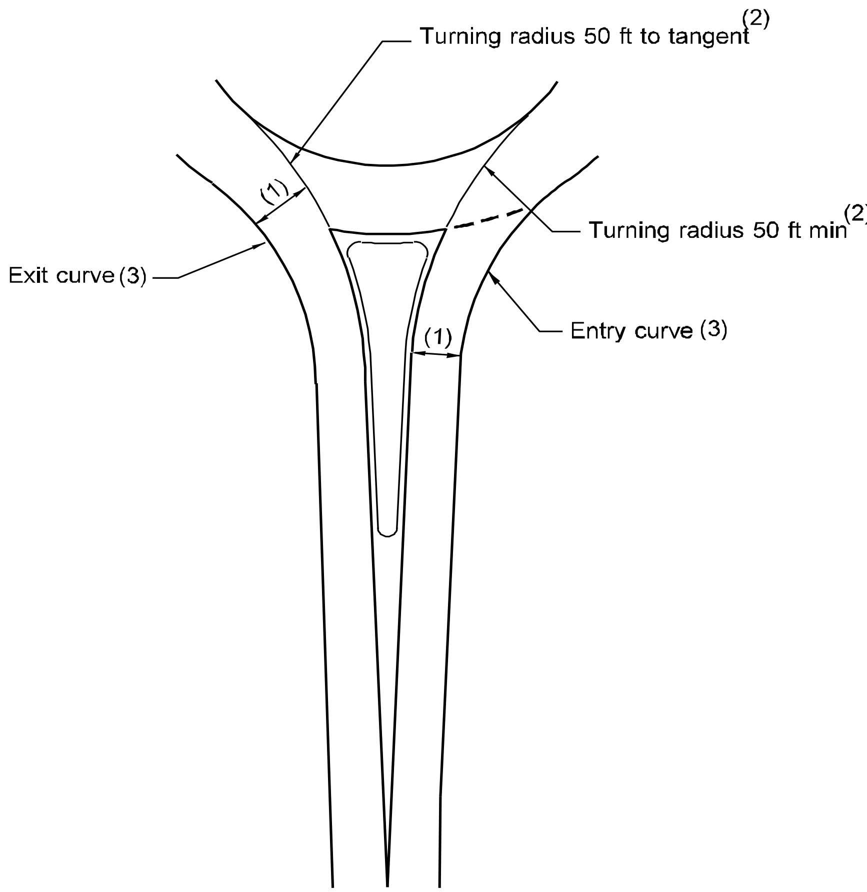
Figure 915-9b



Where:

R_1 = entry path radius.
R_2 = circulating path radius.
R_3 = exit path radius.
R_4 = left-turn path radius.
R_5= right-turn path radius.

Deflection Path Radius
Figure 915-10



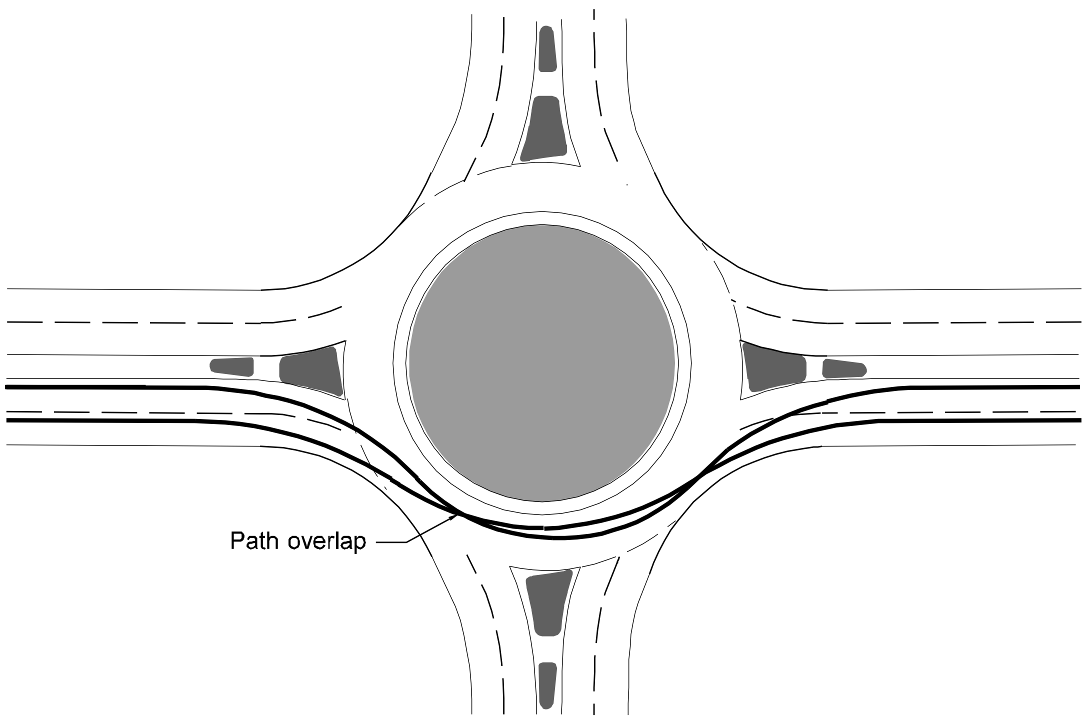
Notes:

(1) Minimum width is 15 ft for 1-lane and 25 ft for 2-lane. Entry and exit widths based on capacity needs (see Figure 915-8) and design vehicle requirements (see Chapter 641 or use templates).

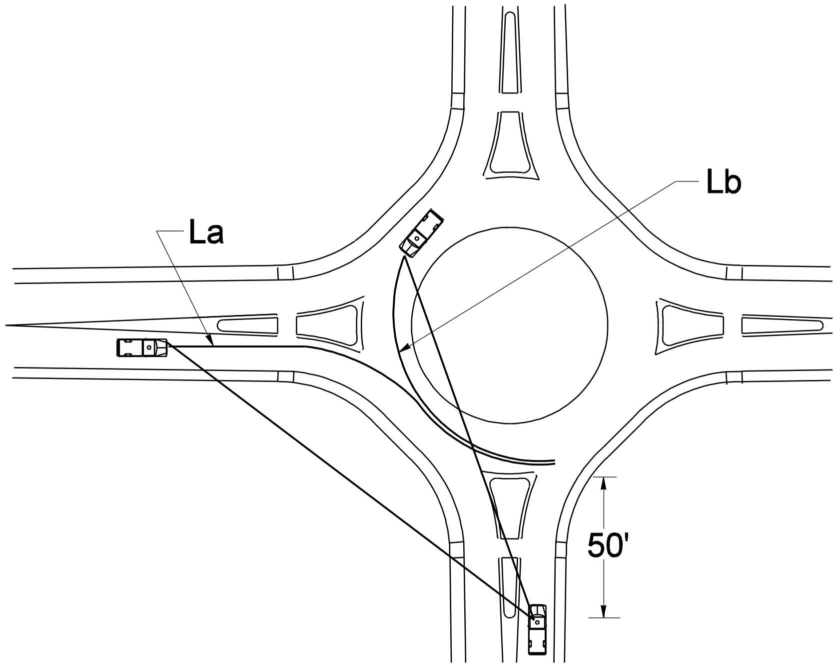
(2) Continuation of splitter island envelope curve tangential to central island.

(3) Entry and exit curves tangential to outside edge of circulating roadway.

Entry and Exit
Figure 915-11



Path Overlap
Figure 915-12



Speed (mph)	Gap Acceptance Length (min), L (ft)
15	115
20	150
25	185
30	225
35	260

Where:

La = Sight distance, measured from the yield point, along approach roadway to the left, the minimum gap acceptance length (L) using the average of the entry speed (R_1) and the circulating speed (R_2).

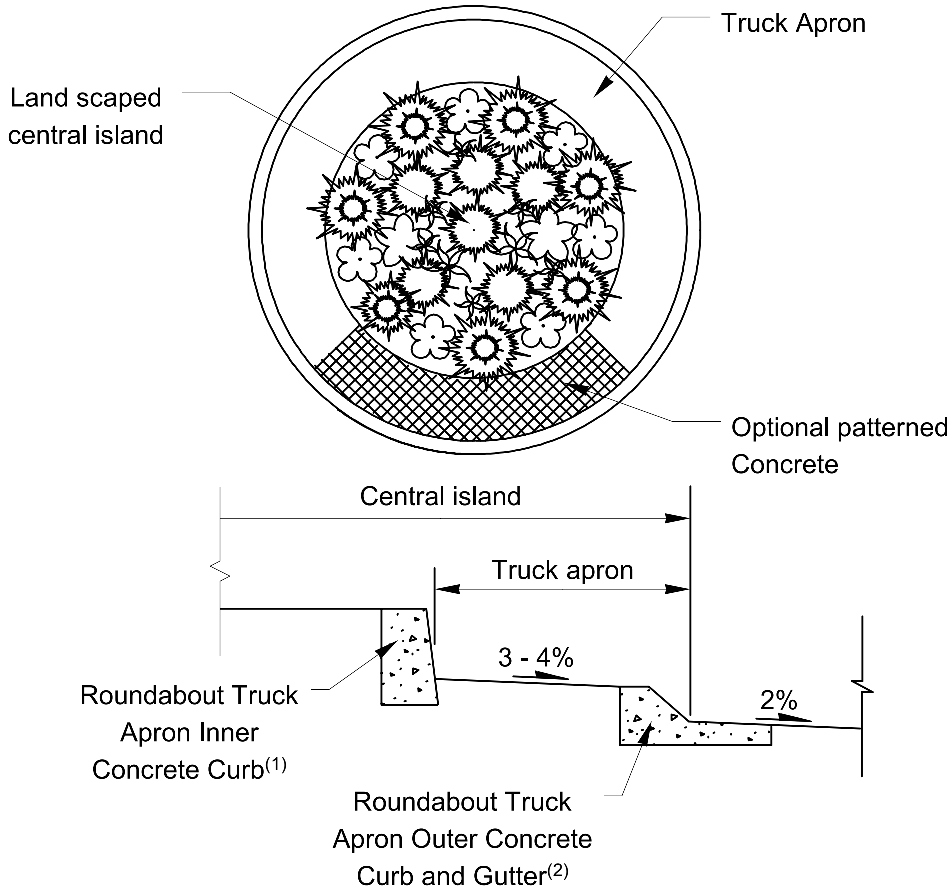
Lb = Sight distance, from the yield point, along the circulating roadway, the minimum gap acceptance Length (L) using the left-turning vehicle speed (R_4).

Note:

See 915.06(2) and Figures 915-9a and 9b for information on determining R_1, R_2, and R_4 speeds.

Roundabout Intersection Sight Distance

Figure 915-13

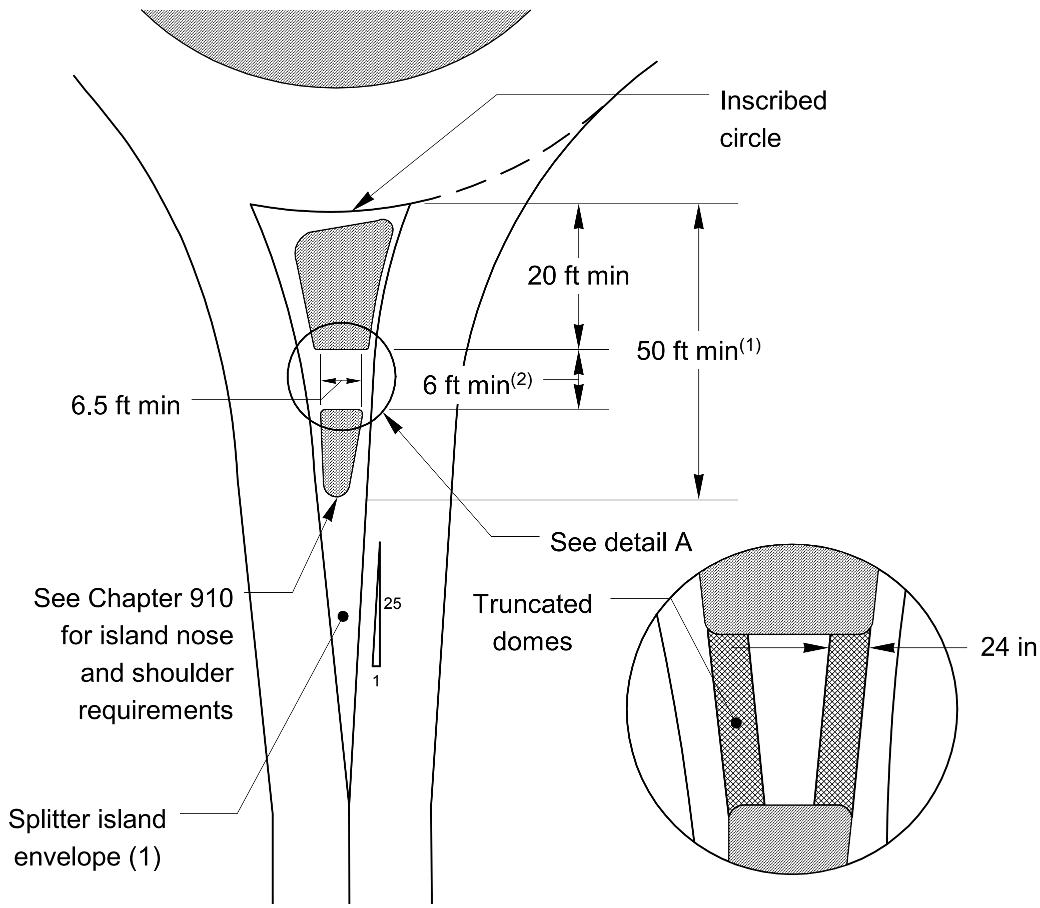


Notes:

(1) See Standard Plans for Roundabout Truck Apron Inner Concrete Curb details.

(2) See Standard Plans for Roundabout Truck Apron Outer Concrete Curb details. Other mountable curbs, with a maximum height of 3 in, may be used.

Central Island
Figure 915-14

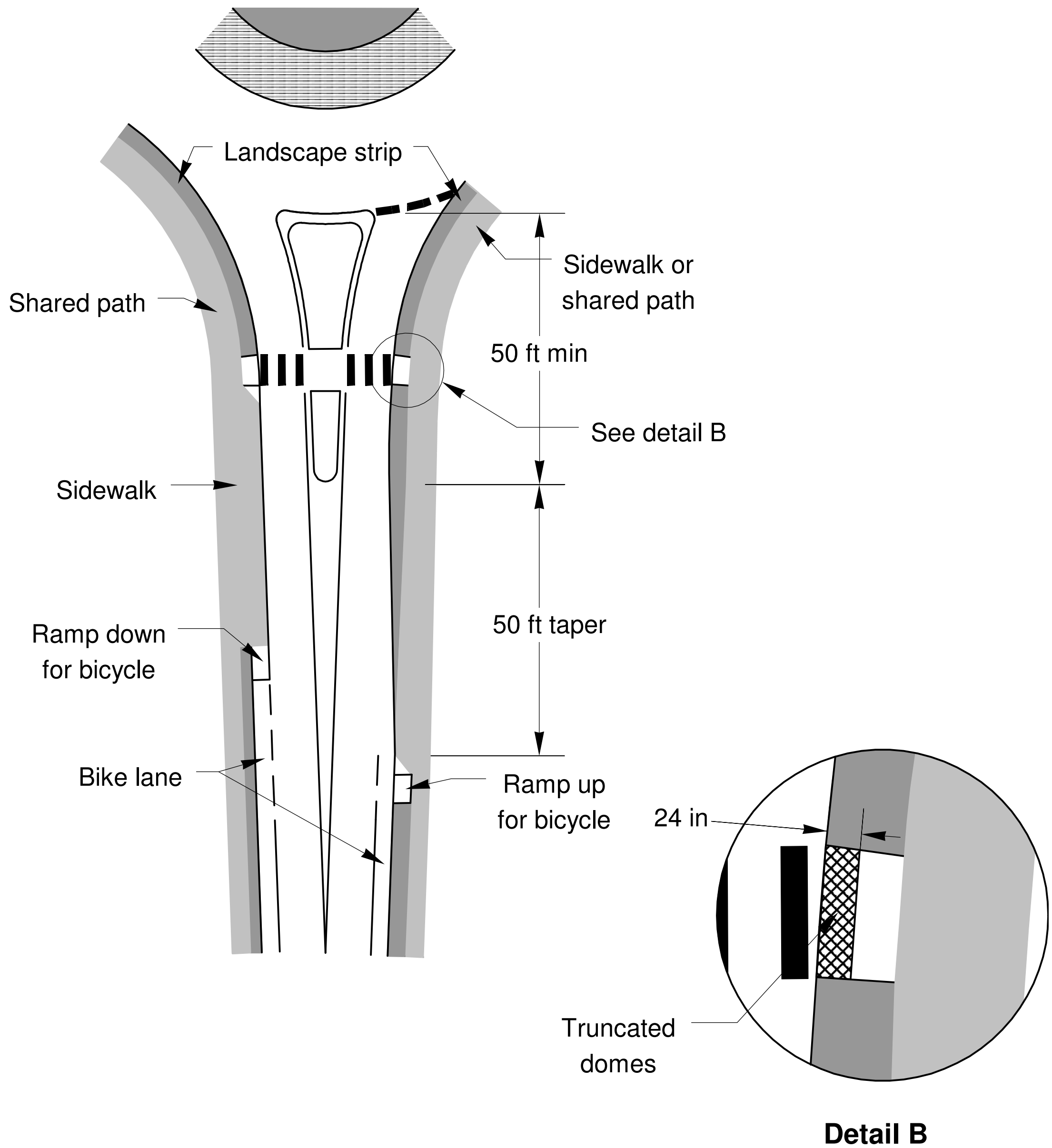


Notes:

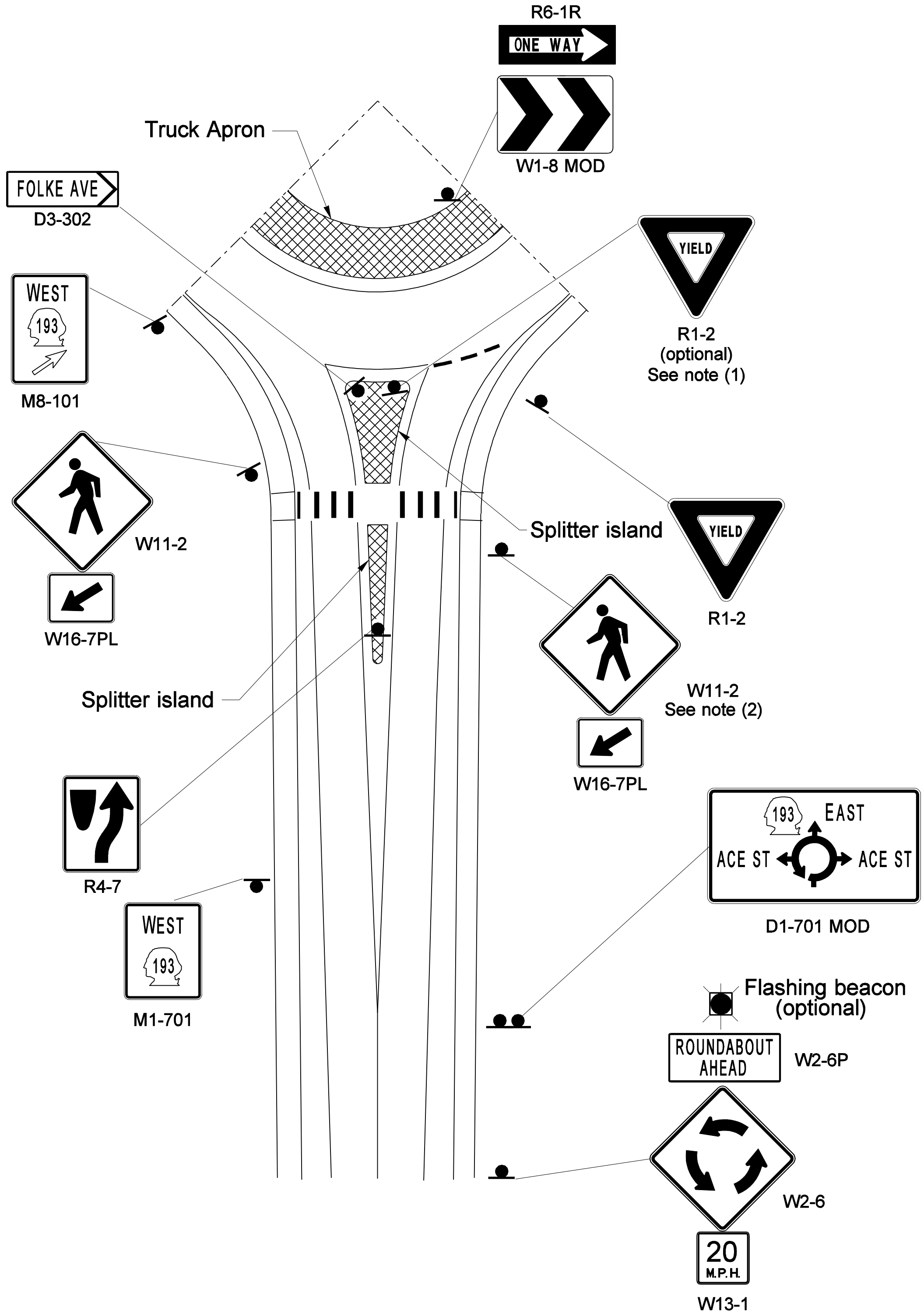
(1) Stopping sight distance desirable for length of splitter island envelop.

(2) A 10 ft width to accommodate full crosswalk width is desirable.

Splitter Island
Figure 915-15



Shared Use Sidewalk
Figure 915-16



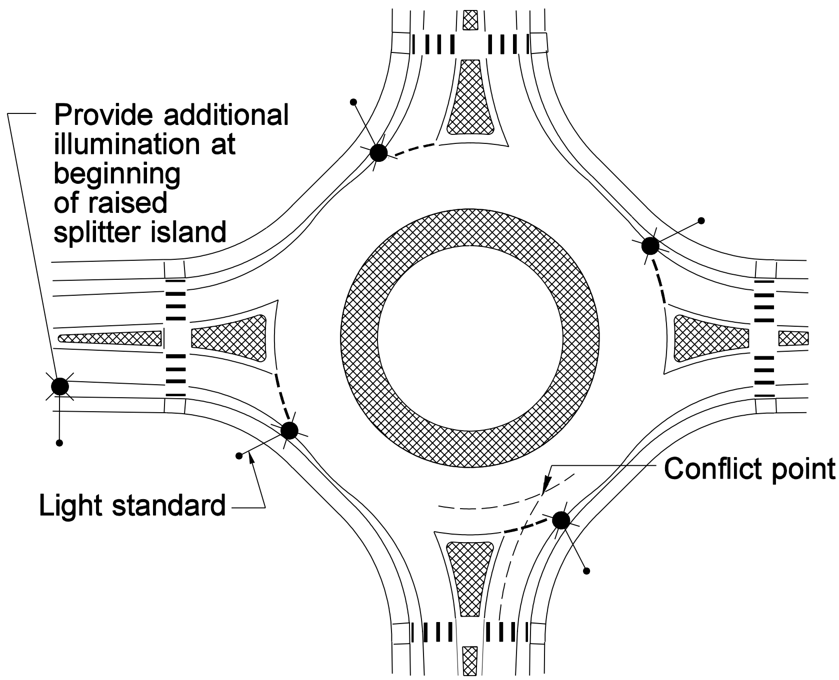
Notes:

(1) Required on two-lane entries, consider when view of right side sign might become obstructed.

(2) Locate in such a way as to not obstruct view of yield sign.

(3) See Chapter 820 for additional information on sign installation.

Roundabout Signing
Figure 915-17



Note:

Consider additional lighting for walkways and crosswalks to provide visibility for pedestrians.

Roundabout Illumination
Figure 915-18

920.01 General

Every owner of property that abuts the state highway system where limited access rights have not been acquired has a right to reasonable access to the state highway system. For considerations, requirements, and restrictions concerning road approaches on state highways where limited access rights have not been acquired, see Chapters 1420 and 1435.

For considerations, requirements, and restrictions concerning road approaches on state highways where limited access rights have been acquired from the abutting property owners, see Chapters 1420 and 1430.

Road approaches are designed and built on the state highway system to provide access at the locations provided for in Chapters 1430 and 1435. This chapter applies to road approaches on state highways in unincorporated areas and within incorporated areas where limited access rights have been acquired. Road approaches on state highways within incorporated areas where limited access rights have not been acquired are the jurisdiction of the local agency, but conformance to the requirements of this Chapter is required by statute (RCW 47.50.030).

920.02 References

Revised Code of Washington (RCW) 47.32.150, "Approach roads, other appurtenances — Permit"

RCW 47.32.160, "Approach roads, other appurtenances — Rules — Construction, maintenance of approach roads"

RCW 47.32.170, "Approach roads, other appurtenances — Removal of installations from right of way for default"

RCW 47.50, "Highway Access Management"

Washington Administrative Code (WAC) 468-51, "Highway Access Management Access Permits — Administrative Process"

WAC 468-52, "Highway Access Management — Access Control Classification System And Standards"

WAC 468-58, "Limited Access Highways"

Right of Way Manual, M 26-01, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

920.03 Definitions

access connection An access point, other than a public road/street, that permits access to or from a managed access highway on the state highway system.

approach An access point, other than a public road/street, that allows access to or from a limited access highway on the state highway system.

average weekday vehicle trip ends (AWDVTE) The estimated total of all trips entering plus all trips leaving a road approach on a weekday for the final stage of development of the property served by the road approach.

intersection at grade The general area where a state highway or ramp terminal is met or crossed at a common grade or elevation by another state highway, a county road, or a city street.

legal road approach A road approach that complies with the requirements of Chapter 1430 for limited access facilities and Chapter 1435 for managed access facilities.

limited access highway All highways where the rights of direct access to or from abutting lands have been acquired from the abutting land owners.

managed access highway All highways where the rights of direct access to or from abutting lands have not been acquired from the abutting land owners.

nonconforming road approach A road approach that does not meet current requirements for location, quantity, spacing, sight distance, or geometric elements.

road approach A road or driveway providing private access to or from the state highway system.

road approach design template The design geometric standards for a road approach based on the usage, types of vehicles, and the traffic volume.

920.04 Design Considerations

Review all existing road approaches within the limits of a project to verify their legality. (See Chapters 1420, 1430, and 1435.) Restore or replace all legal road approaches impacted by a highway project. Evaluate road approaches that will not comply with access control requirements for ways to bring them into compliance.

New road approaches or upgrades to existing road approaches, requested by the property owner, may be included in the project at the expense of the property owner.

Design road approaches at transit facilities in accordance with Chapter 1060.

920.05 Road Approach Design Template

The road approach design template is dependent upon the usage, types of vehicles, and the traffic volume.

Figure 920-1 lists the road approach design templates, the road approach usage, and the design vehicle that Figures 920-3 through 5 provide for. When a larger design vehicle is required, use the turning path templates in Chapter 910, or from another source, to determine what adjustments to make.

Design Template	Property Usage	Design Vehicle
A	Residential	P
B	Farm	SU & BUS
C	Utility and special use	SU & BUS
D	Commercial	varies*
* See Figure 920-5.		

Road Approach Design Templates
Figure 920-1

The road approach templates are divided by allowable access movement. Figure 920-2 gives the movements allowed for each road approach access design.

Category	Access Allowed
1	Full access
2	Right in right out
3	Right in only
4	Right out only

Road Approach Access Category
Figure 920-2

When designating a road approach template include the access category. For example, a residential road approach with full access would be Design Template A1.

(1) Road Approach Design Template A – Residential

A Road Approach Design Template A is used for a noncommercial road approach to provide access for residential units. It is designed for low traffic volumes of primarily passenger cars. Design road approaches to fit the conditions within the limits shown in Figure 920-3.

(a) **Limited Access Facilities** Use Road Approach Design Template A when a Type A approach is specified.

(b) **Managed Access Facilities** Use Road Approach Design Template A for connections to single family residences, duplexes, or other small multifamily complexes. When the connection provides access to more than 10 dwelling units, consider a commercial road approach (Design Template D).

(2) Road Approach Design Template B – Farm

A Road Approach Design Template B is used for a road approach for the normal operation of a farm, but not for retail marketing. It is designed for the larger vehicles normal for farm operations. If there is a predominance of semitrailer traffic, modify the design to accommodate larger vehicles. Design road approaches to fit the conditions within the limits shown in Figure 920-4.

(a) **Limited Access Facilities** Use Road Approach Design Template B when a Type B approach is specified.

(b) **Managed Access Facilities** Use Road Approach Design Template B for connections to farms and other agricultural facilities that do not include retail marketing.

(3) Road Approach Design Template C – Utility and Special Use

A Road Approach Design Template C is used to provide access to facilities owned by a utility for the purpose of maintenance of that facility and operation of the utility. Template C may also be used for other special agreed upon uses. If there is a predominance of semitrailer traffic, modify the design to accommodate larger vehicles. Design road approaches to fit the conditions within the limits shown in Figure 920-4.

(a) **Limited Access Facilities** Use Road Approach Design Template C when a Type C or Type F approach is specified.

(b) **Managed Access Facilities** Use Road Approach Design Template C for connections to utility facilities, wireless communication sites, and other locations where an agreement has been reached for a special purpose.

(4) Road Approach Design Template D – Commercial

A Road Approach Design Template D is used for all commercial road approaches to provide access to businesses, farms with retail marketing, and other high volume road approaches.

Determine the predominant type of vehicle and design the commercial road approach in accordance with Figure 920-5. If the width of the frontage precludes such a road approach, use the turning path templates in Chapter 910, or from another source, to determine what adjustments may be made to provide safe and efficient access and to avoid encroachment upon the frontage of abutting property.

Commercial road approaches must not cause undue interference or hazard to the free movement of highway traffic and, when not joint use road approaches, they must not infringe on the frontage of adjoining property.

Where traffic volumes are heavy, such as for a shopping center or an industrial park, design the road approach as an intersection. (See Chapter 910.)

(a) **Limited Access Facilities** Use Road Approach Design Template D when a Type D approach is specified.

(b) **Managed Access Facilities** Use Road Approach Design Template D for businesses, farms with retail marketing, and other high volume road approaches.

920.06 Sight Distance

The driver of a vehicle entering a roadway from a road approach needs obstruction-free sight triangles in order to see enough of the roadway to safely enter before an approaching vehicle can reach the road approach.

Locate the road approach where the sight distances shown on Figure 920-6 are available.

920.07 Road Approach Location

Locate road approaches as determined in Chapter 1430 for limited access facilities and Chapter 1435 for managed access facilities.

920.08 Drainage Requirements

In a roadway section with a drainage ditch, a culvert pipe is placed under the road approach. The road approach is graded as shown in Figure 920-5. Be careful that roadway runoff is not a problem.

Design foreslopes not steeper than 6H:1V. Bevel the culvert ends in accordance with Chapter 700.

Locate culverts as far from the traveled way as possible. Minimum distances are shown in Figures 920-3 through 5.

A turnpike section (a standard roadway section with a shallow V-shaped paved gutter at the shoulder edge) may be used. Consider continuing the turnpike section throughout the area between the shoulder and the backslope. In the profile controls on Figure 920-5, if the grade from the edge of shoulder to the right of way line is a flat or minus grade and roadway runoff is a consideration, curb may be placed as shown.

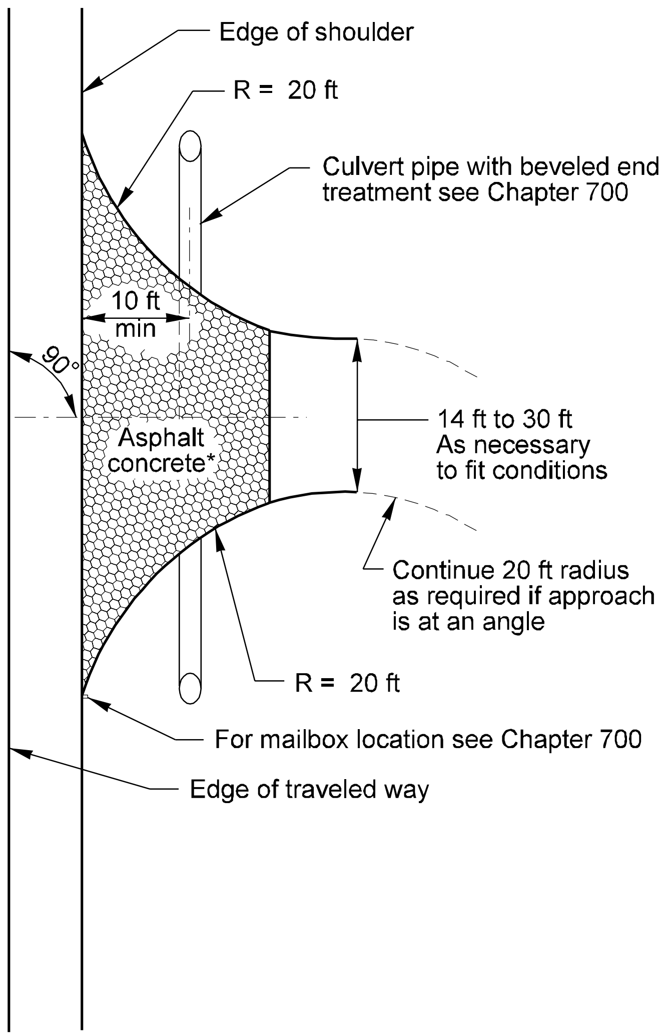
Road approaches and related areas must be constructed so they do not impair drainage within the right of way or alter the stability of the roadway subgrade.

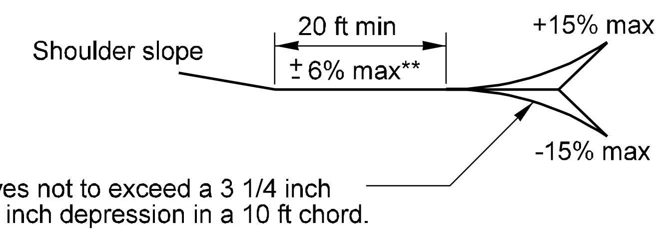
920.09 Procedures

Verify the legality of all road approaches. (See Chapters 1420, 1430, and 1435.) Show on a plan or a list the location and template, for all road approaches. Where road approaches are to be included in a project, consider location and function as early as possible, preferably in the preliminary planning stage.

920.10 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http//www.wsdot.wa.gov/eesc/design/projectdev/



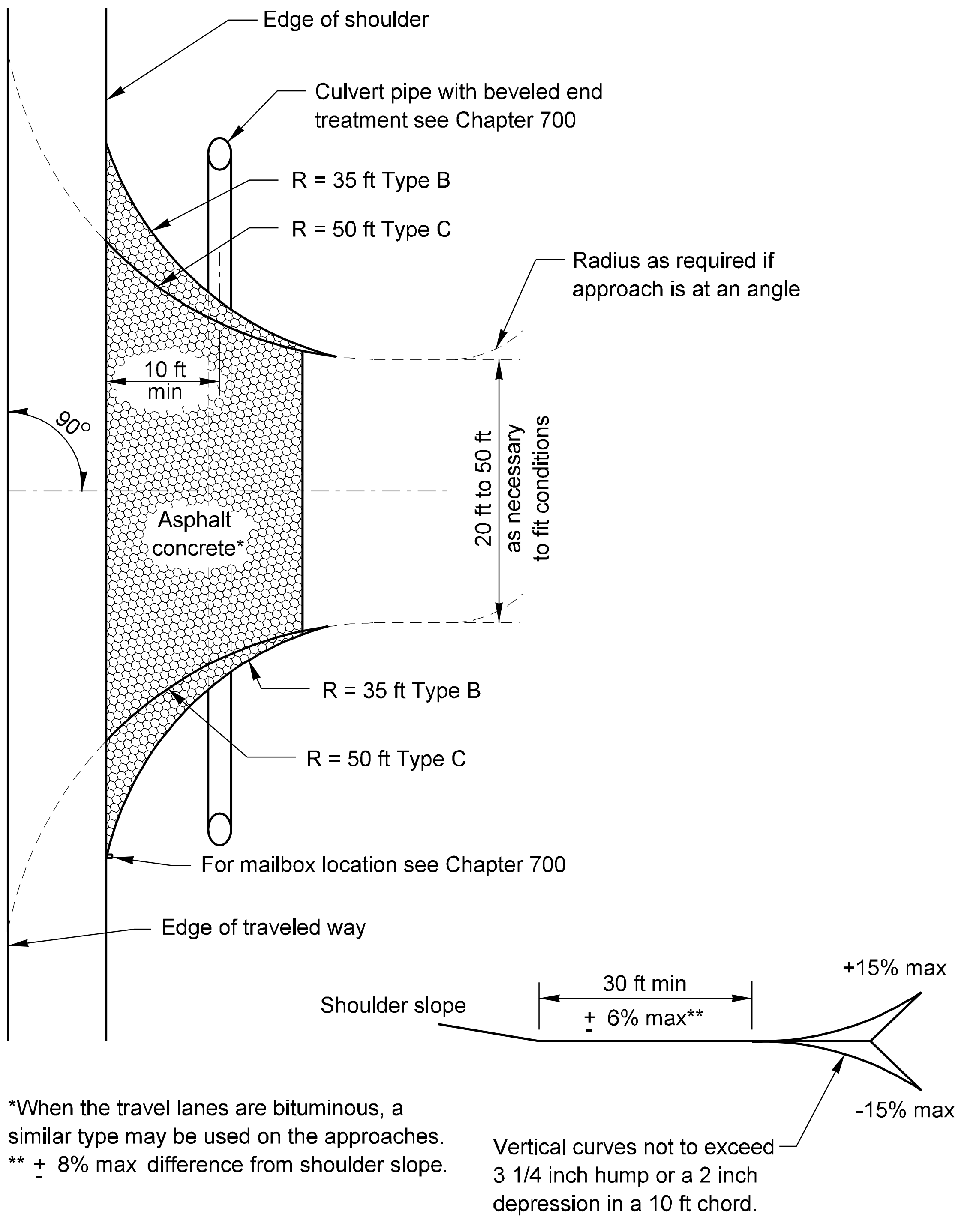


*When the travel lanes are bituminous, a similar type may be used on the approaches.

** ± 8% max difference from shoulder slope.

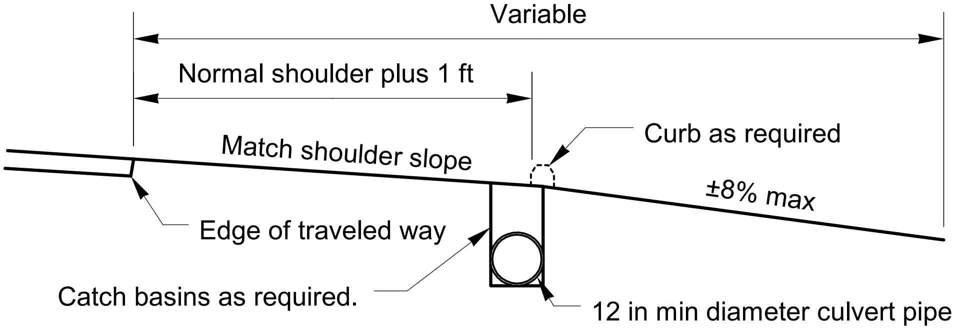
Road Approach Design Template A1

Figure 920-3

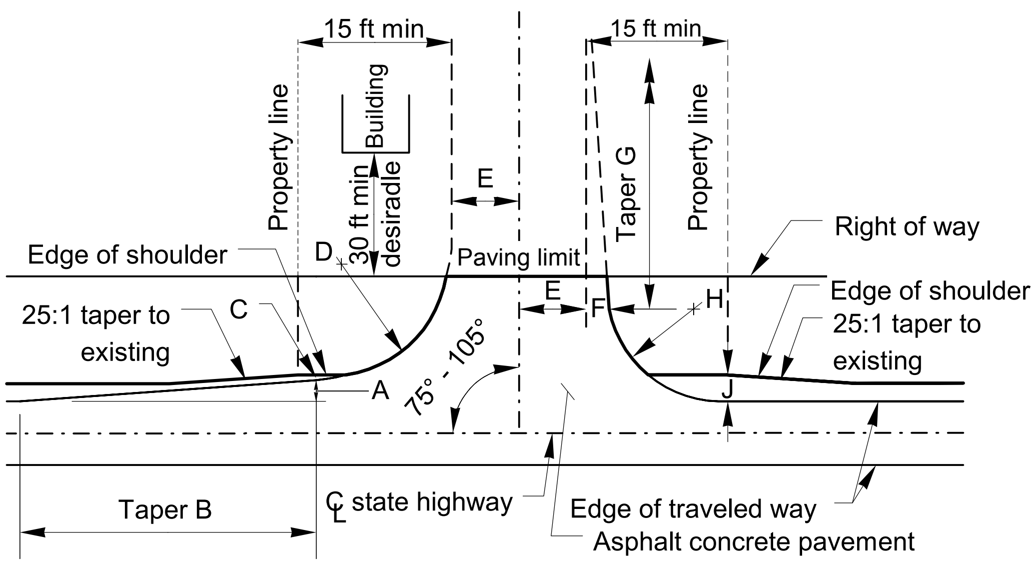


Road Approach Design Templates B1 and C1

Figure 920-4



Profile Controls



Condition	A	B	C	D	E	F	G	H	J
Primary SU and less	—	—	(2)	30	15	—	—	30	(2)
Primary combination Vehicle WB 40	—	—	(2)	65	15	—	—	55	(2)
	4	25	(3)	50	15	7	25	45	(2)
Primary combination Vehicle WB 50 and doubles	—	—	(2)	70	20	—	—	50	(2)
	4	25	(3)	55	20	—	—	50	(2)

Notes:

(1) All values in ft.

(2) Normal shoulder width. (See Chapter 440.)

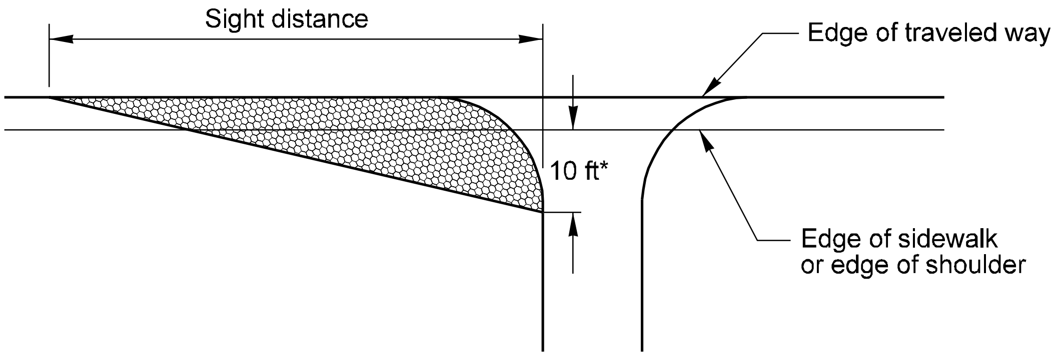
(3) Normal shoulder width less A.

(4) For larger vehicles, use turning templates. (See Chapter 910.)

(5) Vertical curves between the shoulder slope and the road approach grade not to exceed a 3¼ in hump or a 2 in depression in a 10 ft cord.

Road Approach Design Template D1

Figure 920-5



* Not to exceed 18 ft from the edge of traveled way.

Posted Speed Limit (mph)	25	30	35	40	50	60	70
AWDVTE 100 or less	155	200	230	295	395	525	625
AWDVTE 100 to 1500	155	200	250	305	425	570	645
Road Approach Sight Distance (ft)							

These distances require an approaching vehicle to reduce speed or stop to prevent a collision.

Design road approach sight distance for road approaches with AWDVTE over 1500 as an intersection, see Chapter 910.

Provide decision sight distance (Chapter 650) for through traffic at all utility and special use road approaches on facilities with full access control.

For road approaches where left turns are not allowed, a sight triangle need only be provided to the left, as shown.

For road approaches where left turns are allowed, provide a sight triangle to the right in addition to the one to the left. The sight distance to the right is measured along the center line of the roadway.

For additional information on calculating the sight triangle, see Chapter 910.

Road Approach Sight Distance
Figure 920-6

930.01 General

Most railroads in Washington were in operation long before our system of roads was developed and generally have prescriptive rights and underlying property interests that supersede those of road authorities. In general, right of way is not acquired in fee from a railroad company. Rather than selling property, railroads typically convey easements, access rights, and construction permits. Therefore, most roads exist on railroad property by easement from the railroads. Any widening or realignment of an existing roadway, construction upon, over or under, or installation of wires or pipes on railroad property requires permission from the railroad in the form of a permit or an agreement.

Projects that require the railroad to do work, or for which they are to be reimbursed or compensated will require an agreement. It is not unusual for a railroad agreement to take 6 months or more to be developed, reviewed and executed, therefore, it is important for the designer to establish early contact with the HQ WSDOT Railroad Liaison in the Design Office.

Agreements are developed and negotiated by the WSDOT Railroad Liaison. Permits are typically acquired directly from the railroad or its property manager by the Region. Contact your Regional Utilities Engineer or the HQ Railroad Liaison for assistance. Include copies of any executed permits or agreements in the Design Documentation Package. Include a copy of the "Notice to Proceed" (required in the agreement to authorize the railroad to commence work) in the Project file.

Railroad grade crossings are, in effect, intersections with two legs of rail traffic that never stop. Due consideration must be given by the roadway designer to the traffic control for the rail crossing. Grade crossing traffic controls (railroad signals, gates, pavement markings, signs, and controllers) are typically located within the area of railroad property. Railroad signal and gate maintenance is the responsibility of the railroad. Railroads are also responsible for the maintenance of crossing surfaces for the 12 inches outside the edge of rail (WAC 480-62-225). Most railroads will insist on designing and constructing their own signals, gates, and crossing surfaces.

The Washington Utilities and Transportation Commission (WUTC) has statutory authority over grade crossing safety in Washington State. Any changes to a grade crossing or the associated safety appurtenances require initial approval by the WUTC. This is accomplished by submitting a Petition to the WUTC. The Railroad Liaison has copies of WUTC forms and can help with their preparation. The WUTC will review the Petition and issue an Order granting or denying the Petition with or without conditions, depending on situation. Include a copy of any Petition or Order in the Design Documentation Package.

930.02 References

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA, including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Railroad-Highway Grade Crossing Handbook, FHWA TS-86-215

Guidance On Traffic Control Devices At Highway-Rail Grade Crossings, HIGHWAY/RAIL GRADE CROSSING TECHNICAL WORKING GROUP (TWG), FHWA, November 2002 (http://safety.fhwa.dot.gov/media/twgreport.htm#2)

Agreements Manual, WSDOT M22-99

Traffic Control Devices Handbook, ITE, 2001.

A Policy on Geometric Design of Highways and Streets, AASHTO, 2001

Revised Code of Washington (RCW) 81.53 Railroad Crossings

Washington Administrative Code (WAC) 480-62-150 Grade crossing petitions

930.03 Plans

Include plans for state constructed improvements to existing crossings and any new crossings within the normal process. In addition to basic roadway dimensions, signs, and markings, indicate angle of the crossing, number of tracks, location of signals and other railway facilities (e.g., electrical and communications lines, control boxes). Also indicate railroad stationing at the point where highway centerline crosses the center of the tracks.

For any project proposing to alter the horizontal or vertical alignment at a grade crossing (including grade separations), show the alignment and profile for both the railroad and the roadway for a minimum of 500 feet on all legs of the crossing. Show all other important features that might affect the safety, operation, and design of the crossing such as nearby crossroads, driveways or entrances, buildings, and highway structures on the plans.

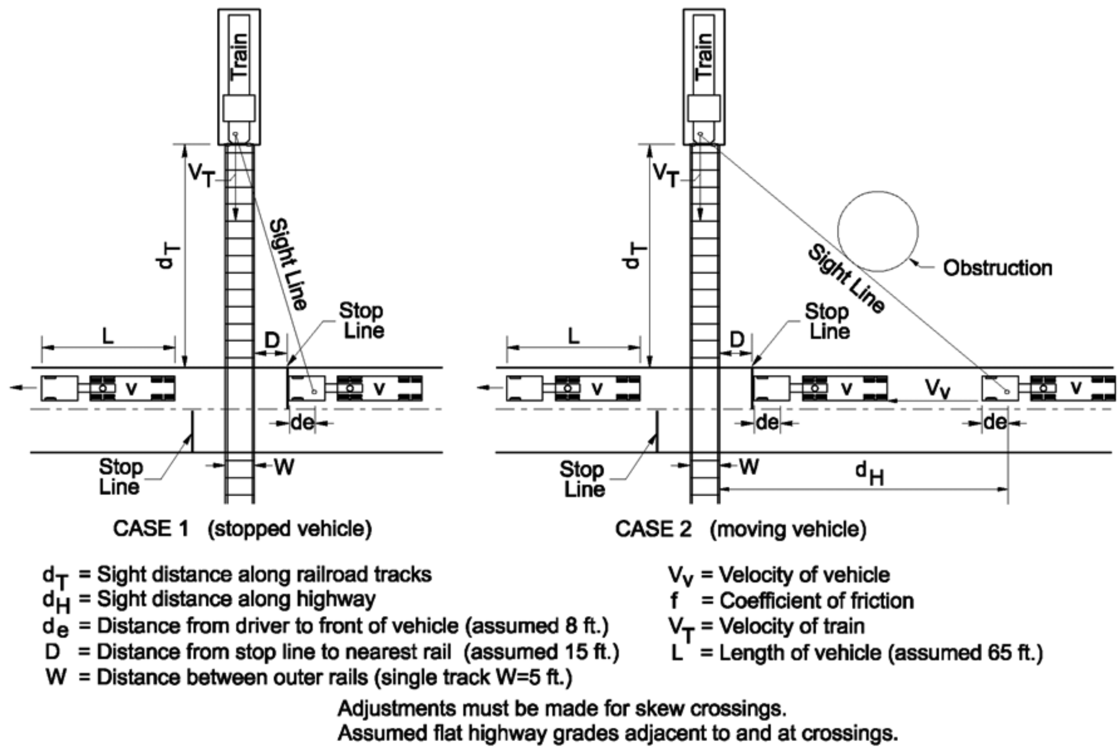
Sight distance is a primary consideration at grade crossings. A railroad grade crossing is comparable to the intersection of two highways where a sight triangle must be kept clear of obstructions or it must be protected by a traffic control device. The desirable sight distance allows an approaching driver to see an approaching train at such a distance that the vehicle can stop well in advance of the crossing if signals or gates and signals are not present. See Figures 930-1, Case 2 and 930-2. Sight distances of the order shown are desirable at any railroad grade crossing not controlled by railroad signal lights or gates (active warning devices).. Their attainment, however, is often difficult and impracticable due to topography and terrain. Even in flat open terrain, the growth of crops or other seasonal vegetation can create a permanent or seasonal sight distance obstruction. Furthermore, the properties upon which obstructions might exist are commonly owned by the railroad or others. Evaluate installation of active devices at any location where adequate sight distances cannot be assured. Include communication with the railroad and Washington Utilities and Transportation Commission in your evaluation.

The driver of a vehicle stopped at a crossing with signal lights but no gates needs to be able to see far enough down the tracks from the stop bar to be able to safely cross the tracks before a train, approaching at maximum allowable speed, reaches the crossing. See Figures 930-1, Case 1 and 930-2.

In some cases lights and gates alone will not provide adequate safety for motorists whose impatience may encourage them to drive around a gate. Evaluate train and traffic volumes and accident history to assess the feasibility of installing a median separator to prevent vehicles from driving around gates. Close call incident logs are sometimes available from the railroad or WUTC, these too can provide an indication of need for additional active control devices. Consult with the railroad or the HQ Railroad Liaison since the railroad may have information on numbers of gate violators at the crossing. Where sufficient space is available, median separators should be at least 60 feet in length.

Construct highway grades so that low-slung vehicles will not hang-up on tracks or damage them. See Chapter 630 for information on vertical alignment at railroad grade crossings. Whenever possible design the roadway to cross grade crossings at right angles. If bicycle traffic uses the crossing (this can be assumed for most roads), provide a shoulder through the grade crossing at least as wide as the approach shoulder width. If a skew is unavoidable, wider shoulders may be necessary to permit bicycles to maneuver to cross the tracks at right angles. See Chapter 1020 for information on bikeways crossing railroad tracks.. Consider installation of advance warning signs indicating the presence of a skewed crossing for crossings where engineering judgment suggests a benefit.

Include any engineering studies or sight distance measurements in the Design Documentation Package.



Sight Distance at Railroad Crossing
Figure 930-1

Case 1 Departure from stop		Case 2 Moving Vehicle						
		Vehicle Speed (mph) V_V						
Train Speed (mph) V_T	0	10	20	30	40	50	60	70
		F=0.40	0.40	0.35	0.32	0.30	0.29	0.28
		Distance Along Railroad from Crossing d_T(ft)						
10	240	150	100	100	100	110	120	130
20	480	290	210	200	210	220	240	270
30	720	440	310	300	310	340	370	400
40	960	580	410	390	410	450	490	540
50	1200	730	520	490	520	560	610	670
60	1440	870	620	590	620	670	730	810
70	1880	1020	720	690	720	790	860	940
80	1920	1160	830	790	830	900	980	1070
90	2160	1310	930	890	930	1010	1100	1210
		Distance Along Highway from Crossing d_H(ft)						
		69	135	220	324	447	589	751
Required design sight distance for combination of highway and train vehicle speeds; 65 ft truck crossing a single set of tracks at 90°. (AASHTO)								

Sight Distance at Railroad Crossing
Figure 930-2

930.04 Traffic Control Systems

Traffic control systems permit safe and efficient operation of railroad-highway traffic crossings. These systems may include one or more of the following:

(a) Passive Elements

(1) Signing elements are shown in Part 8, *Traffic Control for Highway-Rail Grade Crossings*, of the MUTCD and include one or more of the following:

a. Railroad Crossing Sign (crossbuck). The railroad is responsible for maintenance of the crossbucks.

b. Railroad Crossing Auxiliary Sign (Inverted "T" sign). This sign is mounted below the crossbuck to indicate the number of tracks when 2 or more tracks are involved -- Railroad Responsibility.

c. Railroad Advance Warning Sign. Road Authority installs and maintains.

d. Exempt Crossing Sign. This is a supplemental sign that, when authorized by the WUTC, may be mounted below the crossbuck. When this sign is approved, certain classes of vehicles, otherwise required to stop before crossing the tracks, may proceed without stopping, provided no train is approaching. Road Authority installs and maintains.

e. Do Not Stop On Tracks Sign. Road Authority Responsibility.

(2) Pavement Markings on all paved approaches are the responsibility of the road authority and consist of RR Crossing markings per the Standard Plans, no passing markings and pullout lanes as appropriate.

(3) Consider the installation of illumination at and adjacent to railroad crossings where an engineering study determines that better nighttime visibility of the train and the grade crossing is needed. For example:

- where a substantial amount of railroad operations are conducted at night.
- where grade crossings are blocked for long periods at night by slow speed trains.
- where crash history indicates that drivers experience difficulty seeing trains during hours of darkness.

(b) Active Elements

(1) Railroad Signals and gates. Maintenance of these devices is the responsibility of the railroad. Funding for installation and upgrades to these devices, commonly comes from the road authority.

(2) Repeater Signals (also known as "pre-signals"). These are traffic signals installed in advance of a railroad grade crossing when the grade crossing is adjacent to a parallel roadway with a far side traffic signal. They are installed and maintained by the road authority and used to discourage traffic from stopping on the tracks.

(3) Locomotive Horn. By law, trains are required to sound their horn in advance of grade crossings. In some locations this can be a problem for adjacent residents or businesses. This requirement may be waived provided current Federal Railroad Administration (FRA) requirements are met. (See Federal Register Vol 68, Number 243, Dec. 18, 2003) and (http://www.fra.dot.gov/Content3.asp?P=1318).

(4) Traffic signal interconnects (also known as "railroad pre-emption") provide linkage between the railroad signals and adjacent traffic signals to prevent vehicles from getting trapped at a traffic signal as a train approaches. These are typically funded by the road authority and require cooperation with the railroad for installation. Include copies of any signal pre-emption timings or calculations in the Project File.

In general, passive controls notify drivers that they are approaching a grade crossing and should be on the lookout for trains. Passive controls are typically found at low (train) volume and (train) speed crossings.

For crossings of state highways with low to moderate train speeds and volumes or for crossings with limited sight distance per Figure 930-1 Case 2 consider active controls. For crossings without adequate stopped vehicle sight distance per Figure 930-2, Case 1, consider including gates.

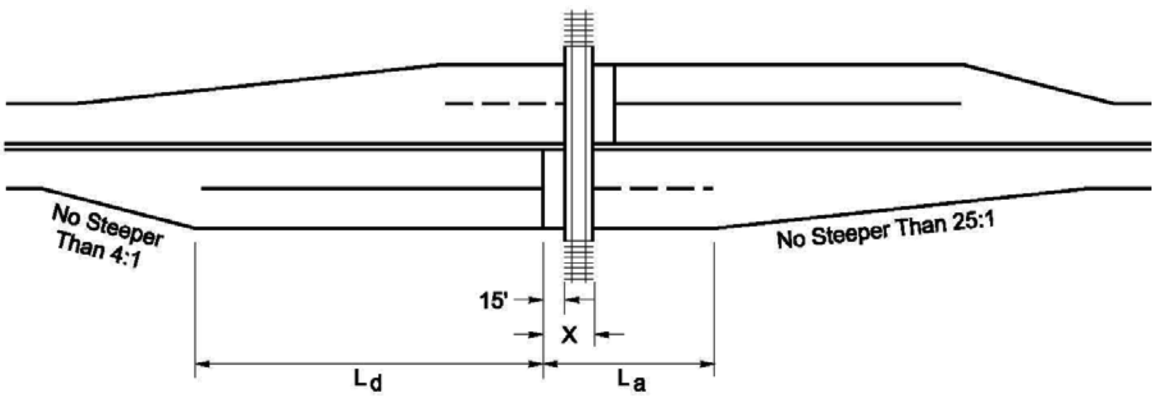
At the time of this writing no National or State warrants have been developed for installation of traffic controls at grade crossings. Furthermore, due to the large number of significant variables that must be considered, there is no single standard system of active traffic control devices universally applicable for grade crossings. Base the determination of the appropriate type of traffic control system on an engineering and traffic investigation including input from the railroad and the WUTC. Significant factors to consider are train and highway volumes and speeds, pedestrian volume, accident history, and sight distance restrictions.

Evaluate railroad signal supports and gate mechanisms as roadside hazards. Use traffic barrier or impact attenuators as appropriate per Division 7 of this manual.

930.05 Pullout Lanes

Per RCW 46.61.350 certain vehicles are required to stop at all railroad crossings without signals or not posted with an “Exempt” sign. Consider the installation of "pullout lane" when grade crossings have no active protection. Some school districts have a policy that school buses must stop at all grade crossings regardless of the type of control. Consider the installation of pullout lanes at any public grade crossing used regularly by school buses and for which the school buses must stop.

Design pullout lane geometrics in accordance with Figure 930-3. The minimum shoulder width adjacent to the pullout lane is 3 feet.



L_d = Total length of pullout lane, approach
L_a = Total length of pullout lane, exit
X = Distance from stopping point to downstream side of crossing surface

Approach Length of Pullout Lane, L_d		Downstream Length of Pullout Lane, L_a	
Vehicle Speed (mph)	Length (ft)	Vehicle Speed (mph)	Length (ft)
30	175	30	0
40	265	40	80
50	385	50	460
60	480	60	870

Typical Pullout Lane at Railroad Crossing
Figure 930-3

930.06 Crossing Surfaces

Railroads are responsible for the maintenance of crossing surfaces up to 12 inches outside the edge of rail (WAC 480-62-225). Crossing surfaces can be constructed of a number of different materials including asphalt, concrete, steel, timber, rubber, or plastic. The most common surface types used on state highway crossings are asphalt, precast concrete, and rubber. Timbered crossings are frequently used for low volume roads and temporary construction crossings.

The life of a crossing surface depends on the volume and weight of highway and rail traffic using it. Highway traffic not only dictates the type of crossing surface but also has a major influence on the life of the crossing. Rough crossing surfaces impact the motoring public far more than the railroad. Therefore, when a highway project passes through a railroad grade crossing consider the condition of the crossing surface. While the existing condition might not warrant railroad investment in replacing it, the surface might have deteriorated sufficiently to increase vehicle operating costs and motorist inconvenience. In such cases it may be effective to partner with the railroad to replace the crossing as part of the highway project. Such partnerships typically consist of the state reimbursing the railroad for all or a portion of the cost of the work.

930.07 Crossing Closure

The MUTCD states, "Any highway-rail grade crossing which cannot be justified should be eliminated". Coordination with the appropriate railroad and the Washington Utilities and Transportation Commission is required before any changes can be made to track structure or railroad signal systems. If a state route grade crossing appears unused, consult the Headquarters Railroad Liaison Engineer before taking any action. At-grade crossings which are replaced by grade separations should be closed.

930.08 Traffic Control During Construction And Maintenance

Work Zone Traffic Control at highway-rail grade crossings is required as in any other project with the addition of the need to provide protection from train traffic. When highway construction or maintenance activities will affect a railroad crossing, the railroad company must be notified at least ten days before performing the work (WAC 480-62-305 (4)). Furthermore, any time highway construction or maintenance crews or equipment are working within 25 feet of an active rail line or grade crossing, consult the railroad to determine if a railroad flagger is required to ensure work zone safety. Current contact numbers for railroads may be obtained by contacting your Regional Utilities Engineer. Railroad flaggers differ from highway flaggers in that they have information on train schedules and can generally communicate with trains by radio. When flaggers are required, the railroad generally sends the road authority a bill for the cost of providing this service.

Work zone traffic must never be allowed to stop or queue up on a nearby rail-highway grade crossing unless railroad flaggers are present. Without proper protection, vehicles might be trapped on the tracks when a train approaches. See the MUTCD for more detailed guidance.

For projects requiring temporary access across a set of railroad tracks, contact the Headquarters Railroad Liaison Engineer early in the design process since a Railroad Agreement will likely be required.

930.09 Railroad Grade Crossing Petitions And WUTC Orders

The Washington Utilities and Transportation Commission (WUTC) is authorized by statute (Title 81 RCW) with regulatory authority over railroad safety at grade-crossings. Any modifications to grade crossings or safety equipment including grade separations, widening, realignment, and profile must be approved by the WUTC (WAC 480-62-150). This is accomplished by submitting a formal Petition to the WUTC for which they will issue a formal Order. Provide Section, Township, & Range; posted speed limit;

ADT, percentage of trucks; number of daily school bus trips; and a 20 year projection of the ADT, truck percentage, and school bus trips. The Headquarters Railroad Liaison Engineer can help in the preparation and submittal of this petition. Include a copy of the Petition and WUTC Findings and Order in the Design Documentation Package.

930.10 Section 130 Grade Crossing Improvement Projects

WSDOT Highway and Local Programs administers the Section 130 Grade Crossing safety improvement program. Project proposals are submitted by local agencies, railroads, and WSDOT. Funding is provided from the Surface Transportation 10 percent "Safety Set Aside" authorized by the TEA-21.

Eligibility: All public railroad grade crossing safety improvements are eligible for funding. Project types include signing and pavement markings; active warning devices; illumination; crossing surfaces; grade separations (new and reconstructed); sight-distance improvements; geometric improvements to the roadway approaches; and closing and/or consolidating crossings. Section 130 funds are generally available at a 90 percent Federal share and up to 100% for signing; pavement markings; active warning devices; elimination of hazards; and crossing closures.

Most Section 130 projects on state highways are low cost grade crossing signal upgrades entirely within existing railroad right of way. Work is typically done by the railroad under agreement and generally takes a very short time. Consider Section 130 grade crossing signal upgrade projects, constructed by the railroad or its contractor, which are not part of a larger state highway project to be Minor Operational Enhancements funded under Program Q barring extenuating circumstances.

Contact the Railroad Liaison in the HQ Design Office for more information.

930.11 Light Rail

Light Rail, also known as streetcars, is developing in some urban areas of the state. For the most part, criteria for light rail are very similar to those for freight and passenger rail with the exception of locations where light rail shares a street right of way with motor vehicles. The MUTCD now includes a chapter devoted exclusively to Light Rail. Consult this reference as the situation warrants http://mutcd.fhwa.dot.gov/HTM/2003/part10/part10-toc.htm.

930.12 Documentation

A list of the documents that are required to be preserved in the Design Documentation Package (DDP) and the Project File (PF) is on the following website:

http://www.wsdot.wa.gov/eesc/design/projectdev/

940.01 General

The primary purpose of an interchange is to eliminate conflicts caused by vehicle crossings and to minimize conflicting left-turn movements. Interchanges are provided on all Interstate highways, freeways, other routes on which full access control is required, and at other locations where traffic cannot be controlled safely and efficiently by intersections at grade.

See the following chapters for additional information:

Chapter	Subject
640	Ramp Sections
641	Turning Widths
642	Superelevation
910	Intersections
1050	HOV Lanes
1055	HOV Direct Access Connections
1420	Access Control
1425	Interchange Justification Report
1430	Limited Access

940.02 References

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

A Policy on Design Standards - Interstate System, 1991, AASHTO

Highway Capacity Manual (Special Report 209), Transportation Research Board

Procedure for Analysis and Design of Weaving Sections, A User's Guide, October 1985, Jack E. Leisch

940.03 Definitions

auxiliary lane The portion of the roadway adjoining the traveled way for parking, speed change, turning, storage for turning, weaving, truck climbing, passing, and other purposes supplementary to through traffic movement

basic number of lanes The minimum number of general purpose lanes designated and maintained over a significant length of highway.

collector distributor road (C-D road) A parallel roadway designed to remove weaving from the main line and to reduce the number of main line entrances and exits.

decision sight distance The sight distance required for a driver to detect an unexpected or difficult-to-perceive information source or hazard, interpret the information, recognize the hazard, select an appropriate maneuver, and complete it safely and efficiently.

frontage road An auxiliary road that is a local road or street located on the side of a highway for service to abutting properties and adjacent areas, and for control of access.

gore The area downstream from the intersection of the shoulders of the main line and exit ramp. Although generally the area between a main line and an exit ramp, the term may also be used to refer to the area between a main line and an entrance ramp.

intersection at grade The general area where a state highway or ramp terminal is met or crossed at a common grade or elevation by another state highway, a county road, or a city street.

Interstate System A network of routes selected by the state and the FHWA under terms of the federal aid acts as being the most important to the development of a national transportation system. The Interstate System is part of the principal arterial system.

lane A strip of roadway used for a single line of vehicles.

median The portion of a divided highway separating the traveled ways for traffic in opposite directions.

outer separation The area between the outside edge of traveled way for through traffic and the nearest edge of traveled way of a frontage road.

painted nose The point where the main line and ramp lanes separate.

physical nose The point, upstream of the gore, with a separation between the roadways of 16 to 22 ft. See Figures 940-11a and 11b.

ramp A short roadway connecting a main lane of a freeway with another facility for vehicular use such as a local road or another freeway.

ramp connection The pavement at the end of a ramp, connecting it to a main lane of a freeway.

ramp meter A traffic signal at a freeway entrance ramp that allows a measured or regulated amount of traffic to enter the freeway.

ramp terminal The end of a ramp at a local road.

roadway The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.

sight distance The length of highway visible to the driver.

shoulder The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and (where permitted) use by bicyclists and pedestrians.

stopping sight distance The sight distance required to detect a hazard and safely stop a vehicle traveling at design speed.

traffic interchange A system of interconnecting roadways, in conjunction with one or more grade separations, providing for the exchange of traffic between two or more intersecting highways or roadways.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

940.04 Interchange Design

(1) General

All freeway exits and entrances, except HOV direct access connections, are to connect on the right of through traffic. Deviations from this requirement will be considered only for special conditions.

HOV direct access connections may be constructed on the left of through traffic when they are designed in accordance with Chapter 1055.

Provide complete ramp facilities for all directions of travel wherever possible. However, give primary consideration to the basic traffic movement function that the interchange is to fulfill.

Few complications will be encountered in the design and location of rural interchanges that simply provide a means of exchanging traffic between a limited access freeway and a local crossroad. The economic and operational effects of locating traffic interchanges along a freeway through a community requires more careful consideration, particularly with respect to local access, to provide the best local service possible without reducing the capacity of the major route or routes.

Where freeway to freeway interchanges are involved, do not provide ramps for local access unless they can be added conveniently and without detriment to safety or reduction of ramp and through-roadway capacity. When exchange of traffic between freeways is the basic function and local access is prohibited by access control restrictions or traffic volume, it may be necessary to provide separate interchanges for local service.

(2) Interchange Patterns

Basic interchange patterns have been established that can be used under certain general conditions and modified or combined to apply to many more. Alternatives must be considered in the design of a specific facility, but the conditions in the area and on the highway involved must govern and rigid patterns must not be indiscriminately imposed.

Selection of the final design must be based on a study of projected traffic volumes, site conditions, geometric controls, criteria for intersecting legs and turning roadways, driver expectancy, consistent ramp patterns, continuity, and cost.

The patterns most frequently used for interchange design are those commonly described as directional, semidirectional, cloverleaf, partial cloverleaf, diamond, and single point (urban) interchange. (See Figure 940-4.)

(a) **Directional** A directional interchange is the most effective design for connection of intersecting freeways. The directional pattern has the advantage of reduced travel distance, increased speed of operation, and higher capacity. These designs eliminate weaving and have a further advantage over cloverleaf designs in avoiding the loss of sense of direction drivers experience in traveling a loop. This type of interchange is costly to construct, commonly using a four-level structure.

(b) **Semidirectional** A semidirectional interchange has ramps that loop around the intersection of the highways. This requires multiple single-level structures and more area than the directional interchange.

(c) **Cloverleaf** The full cloverleaf interchange has four loop ramps that eliminate all the left-turn conflicts. Outer ramps provide for the right turns. A full cloverleaf is the minimum type interchange that will suffice for a freeway-to-freeway interchange. Cloverleaf designs often incorporate a C-D road to minimize signing difficulties and to remove weaving conflicts from the main roadway.

The principal advantage of this design is the elimination of all left-turn conflicts with one single-level structure. Because all movements are merging movements, it is adaptable to any grade line arrangement.

The cloverleaf has some major disadvantages. The left-turn movement has a circuitous route on the loop ramp, the speeds are low on the loop ramp, and there are weaving conflicts between the loop ramps. The cloverleaf also requires a large area. The weaving and the radius of the loop ramps are a capacity constraint on the left-turn movements.

(d) **Partial Cloverleaf (PARCLO)** A partial cloverleaf has loop ramps in one, two, or three quadrants that are used to eliminate the major left-turn conflicts. These loops may also serve right turns for interchanges that have one or two quadrants that must remain undeveloped. Outer ramps are provided for the remaining turns. Design the grades to provide sight distance between vehicles approaching these ramps.

(e) **Diamond** A diamond interchange has four ramps that are essentially parallel to the major arterial. Each ramp provides for one right and one left-turn movement. Because left-turns are made at grade across conflicting traffic on the crossroad, intersection sight distance is a primary consideration.

The diamond design is the most generally applicable and serviceable interchange configuration and usually requires less space than any other type. Consider this design first when a semidirectional interchange is required unless another design is clearly dictated by traffic, topography, or special conditions.

(f) **Single Point (Urban)** A single point urban interchange is a modified diamond with all of its ramp terminals on the crossroad combined into one signalized at-grade intersection. This single intersection accommodates all interchange and through movements.

A single point urban interchange can improve the traffic operation on the crossroad with less right of way than a <u>typical</u> diamond interchange; however, a larger structure is required.

(3) Spacing

To avoid excessive interruption of main line traffic, consider each proposed facility in conjunction with adjacent interchanges, intersections, and other points of access along the route as a whole.

The minimum spacing between adjacent interchanges is 1 mi in urban areas and 2 mi in rural areas. In urban areas, spacing less than 1 mi may be used with C-D roads or grade separated (braided) ramps. Generally, the average interchange spacing is not less than 2 mi in urban areas and not less than 4 mi in suburban areas. Interchange spacing is measured along the freeway center line between the center lines of the crossroads.

The spacing between interchanges may also be dependent on the spacing between ramps. The minimum spacing between the noses of adjacent ramps is given on Figure 940-5.

Consider either frontage roads or C-D roads when it is necessary to facilitate the operation of near-capacity volumes between closely spaced interchanges or ramp terminals. C-D roads may be required where cloverleaf loop ramps are involved or where a series of interchange ramps requires overlapping of the speed change lanes. Base the distance between successive ramp terminals on capacity requirements and check the intervening sections by weaving analysis to determine whether adequate capacity and sight distance and effective signing can be ensured without the use of auxiliary lanes or C-D roads.

(4) Route Continuity

Route continuity refers to the providing of a directional path along the length of a route designated by state route number. Provide the driver of a through route a path on which lane changes are minimized and other traffic operations occur to the right.

In maintaining route continuity, interchange configuration may not always favor the heavy traffic movement, but rather the through route. In this case, design the heavy traffic movements with multilane ramps, flat curves, and reasonably direct alignment.

(5) Drainage

Avoid interchanges located in proximity to natural drainage courses. These locations often result in complex and unnecessarily costly hydraulic structures.

The open areas within an interchange can be used for storm water detention facilities when these facilities are required.

(6) Uniformity of Exit Pattern

While interchanges are of necessity custom designed to fit specific conditions, it is desirable that the pattern of exits along a freeway have some degree of uniformity. From the standpoint of driver expectancy, it is desirable that each interchange have only one point of exit, located in advance of the crossroad.

940.05 Ramps

(1) Ramp Design Speed

The design speed for a ramp is based on the design speed for the freeway main line.

It is desirable for the ramp design speed at the connection to the freeway be equal to the free-flow speed of the freeway. Meet or exceed the upper range values from Figure 940-1 for the design speed at the ramp connection to the freeway. Transition the ramp design speed to provide a smooth acceleration or deceleration between the speeds at the ends of the ramp. However, do not reduce the ramp design speed below the lower range speed of 25 mph. For loop ramps, use a design speed as high as practical, but not less than 25 mph.

These design speed guidelines do not apply to the ramp in the area of the ramp terminal at-grade intersection. In the area of the intersection, a design speed of 15 mph for turning traffic or 0 mph for a stop condition is adequate. Use the allowed skew at the ramp terminal at-grade intersection to minimize ramp curvature.

For freeway-to-freeway ramps and C-D roads, the design speed at the connections to both freeways is the upper range values from Figure 940-1; however, with justification, the midrange values from Figure 940-1 may be used for the remainder of the ramp. When the design speed for the two freeways is different, use the higher design speed.

Existing ramps meet design speed requirements if acceleration or deceleration requirements are met (figure 940-8 or 940-10) and superelevation meets or will be corrected to meet the requirements in Chapter 642.

Main Line Design Speed mph		50	55	60	65	70	80
Ramp Design Speed (mph)	Upper Range	45	50	50	55	60	70
	Midrange	35	40	45	45	50	60
	Lower Range	25	25	25	25	25	25

Ramp Design Speed
Figure 940-1

(2) Sight Distance

Design ramps in accordance with provisions in Chapter 650 for stopping sight distances.

(3) Grade

The maximum grade for ramps for various design speeds is given in Figure 940-2.

Ramp Design Speed (mph)	25-30	35-40	45 and above
Desirable Grade (%)	5	4	3
Maximum Grade (%)	7	6	5
On one-way ramps down grades may be 2% greater.			

Maximum Ramp Grade
Figure 940-2

(4) Cross Section

Provide the minimum ramp widths given in Figure 940-3. Ramp traveled ways may require additional width to these minimums as one-way turning roadways. See Chapters 640 and 641 for additional information and roadway sections.

Number of Lanes		1	2
Traveled Way(1)		15(2)	25(3)
Shoulders	Right	8	8
	Left	2	4
Medians(4)		6	8

(1) See Chapter 641 for turning roadway widths. See Chapter 1050 for additional width when an HOV lane is present.
(2) May be reduced to 12 ft on tangents.
(3) Add 12 ft for each additional lane.
(4) The minimum median width is not less than that required for traffic control devices and their respective clearances.

Ramp Widths (ft)
Figure 940-3

Cross slope and superelevation requirements for ramp traveled way and shoulders are as given in Chapters 640 and 642 for roadways.

Whenever feasible, make the ramp cross slope at the ramp beginning or ending station equal to the cross slope of the through lane pavement. Where space is limited and superelevation runoff is long or when parallel connections are used, the superelevation transition may be ended beyond (for on-ramps) or begun in advance of (for off-ramps) the ramp beginning or ending station, provided that the algebraic difference in cross slope at the edge of the through lane and the cross slope of the ramp does not exceed 4%. In such cases, ensure smooth transitions for the edge of traveled way.

(5) Ramp Lane Increases

When off-ramp traffic and left-turn movement volumes at the ramp terminal at-grade intersection cause congestion, it may be desirable to add lanes to the ramp to reduce the queue length caused by turning conflicts. Make provision for the addition of ramp lanes whenever ramp exit or entrance volumes, after the design year, are expected to result in poor service. See Chapter 620 for width transition design.

(6) Ramp Meters

Ramp meters are used to allow a measured or regulated amount of traffic to enter the freeway. When operating in the "measured" mode, they release traffic at a measured rate to keep downstream demand below capacity and improve system travel times. In the "regulated" mode, they break up platoons of vehicles that occur naturally or result from nearby traffic signals. Even when operating at near capacity, a freeway main line can accommodate merging vehicles one or two at a time, while groups of vehicles will cause main line flow to break down.

The location of the ramp meter is a balance between the storage and acceleration requirements. Locate the ramp meter to maximize the available storage and so that the acceleration lane length, from a stop to the freeway main line design speed, is available from the stop bar to the merging point. With justification, the average main line running speed during the hours of meter operation may be used for the highway design speed to determine the minimum acceleration lane length from the ramp meter. See 940.06(4) for information on the design of on-connection acceleration lanes. See Chapter 860 for additional information on the design of ramp meters.

Driver compliance with the signal is required for the ramp meter to have the desired results. Consider enforcement areas with ramp meters.

Consider HOV bypass lanes with ramp meters. See Chapter 1050 for design data for ramp meter bypass lanes.

940.06 Interchange Connections

Provide uniform geometric design and uniform signing for exits and entrances, to the extent possible, in the design of a continuous freeway. Do not design an exit ramp as an extension of a main line tangent at the beginning of a main line horizontal curve.

Provide spacing between interchange connections as given by Figure 940-5.

Avoid on-connections on the inside of a main line curve, particularly when the ramp approach angle is accentuated by the main line curve, the ramp approach requires a reverse curve to connect to the main line, or the elevation difference will cause the cross slope to be steep at the nose.

Keep the use of mountable curb at interchange connections to a minimum. Justification is required when it is used adjacent to traffic expected to exceed 40 mph.

(1) Lane Balance

Design interchanges to the following principles of lane balance:

(a) At entrances, make the number of lanes beyond the merging of two traffic streams not less than the sum of all the lanes on the merging roadways less one. (See Figure 940-6a.)

(b) At exits, make the number of approach lanes equal the number of highway lanes beyond the exit plus the number of exit lanes less one. (See Figure 940-6a.) Exceptions to this are at a cloverleaf or at closely spaced interchanges with a continuous auxiliary lane between the entrance and exit. In these cases the auxiliary lane may be dropped at a single-lane, one lane reduction, off-connection with the number of approach lanes being equal to the sum of the highway lanes beyond the exit and the number of exit lanes. Closely spaced interchanges have a distance of less than 2,100 ft between the end of the acceleration lane and the beginning of the deceleration lane.

Maintain the basic number of lanes, as described in Chapter 620, through interchanges. When a two-lane exit or entrance is used, maintain lane balance with an auxiliary lane. (See Figure 940-6b.) The only exception to this is when the basic number of lanes is changed at an interchange.

(2) Main Line Lane Reduction

The reduction of a basic lane or an auxiliary lane may be made at a two-lane exit or may be made between interchanges. When a two-lane exit is used, provide a recovery area with a normal acceleration taper. When a lane is dropped between interchanges, drop it 1,500 to 3,000 ft from the end of the acceleration taper of the previous interchange. This will allow for adequate signing but not be so far that the driver will become accustomed to the number of lanes and be surprised by the reduction. (See Figure 940-7.)

Reduce the traveled way width of the freeway by only one lane at a time.

(3) Sight Distance

Locate off-connections and on-connections on the main line to provide decision sight distance for a speed/path/direction change as described in Chapter 650.

(4) On-Connections

On-connections are the pavement at the end of on-ramps, connecting them to the main lane of a freeway. They have two parts, an acceleration lane and a taper. The acceleration lane allows entering traffic to accelerate to the freeway speed and evaluate gaps in the freeway traffic. The taper is for the entering vehicle to maneuver into the through lane.

On-connections are either taper type or parallel type. The tapered on-connection provides direct entry at a flat angle, reducing the steering control needed. The parallel on-connection adds a lane adjacent to the through lane for acceleration with a taper at the end. Vehicles merge with the through traffic with a reverse curve maneuver similar to a lane change. While the taper requires less steering control, the parallel is narrower at the end of the ramp and has a shorter taper at the end of the acceleration lane.

(a) Provide the minimum acceleration lane length, given on Figure 940-8, for each ramp design speed on all on-ramps. When the average grade of the acceleration lane is 3% or greater, multiply the distance from the Minimum Acceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

For existing ramps that do not have significant accidents in the area of the connection with the freeway, the freeway posted speed may be used to calculate the acceleration lane length for preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the acceleration lane.

Document existing ramps to remain in place with an acceleration lane length less than to the design speed as a design exception. Also, include the following documentation in the project file: the ramp location, the acceleration length available, and the accident analysis that shows that there are not significant accidents in the area of the connection.

The acceleration lane is measured from the last point designed at each ramp design speed (usually the PT of the last curve for each design speed) to the last point with a ramp width of 12 ft. Curves designed at higher design speeds may be included as part of the acceleration lane length.

(b) For parallel type on-connections, provide the minimum gap acceptance length (L_g) to allow entering traffic to evaluate gaps in the freeway traffic and position the vehicle to use the gap. The length is measured beginning at the point that the left edge of traveled way for the ramp intersects the right edge of traveled way of the main line to the ending of the acceleration lane. (See Figures 940-9b and 9c.) The gap acceptance length and the acceleration length overlap with the ending point controlled by the longer of the two.

(c) Single-lane on-connections may be either taper type or parallel type. The taper type is preferred; however, the parallel may be used with justification. Design single-lane taper type on-connections as shown on Figure 940-9a and single lane parallel type on-connections as shown on Figure 940-9b.

(d) For two-lane on-connections, the parallel type is preferred. Design two-lane parallel on-connections as shown on Figure 940-9c. A capacity analysis will normally be the basis for determining whether a freeway lane or an auxiliary lane is to be provided.

When justification is documented, a two-lane tapered on-connection may be used. Design two-lane tapered on-connections in accordance with Figure 940-9d.

(5) Off-Connections

Off-connections are the pavement at the beginning of an off-ramp, connecting it to a main lane of a freeway. They have two parts, a taper for maneuvering out of the through traffic and a deceleration lane to slow to the speed of the first curve on the ramp. Deceleration is not assumed to take place in the taper.

Off-connections are either taper type or parallel type. The taper type is preferred because it fits the path preferred by most drivers. When a parallel type connection is used, drivers tend to drive directly for the ramp and not use the parallel lane. However, when a ramp is required on the outside of a curve, the parallel off-connection is preferred. An advantage of the parallel connection is that it is narrower at the beginning of the ramp.

(a) Provide the minimum deceleration lane length given on Figure 940-10 for each design speed for all off-ramps. Also, provide deceleration lane length to the end of the anticipated queue at the ramp terminal. When the average grade of the deceleration lane is 3% or greater, multiply the distance from the Minimum Deceleration Lane Length table by the factor from the Adjustment Factor for Grades table.

For existing ramps that do not have significant accidents in the area of the connection with the freeway, the freeway posted speed may be used to calculate the deceleration lane length for preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the deceleration lane.

Document existing ramps to remain in place with a deceleration lane length less than to the design speed as a design exception. Also, include the following documentation in the project file: the ramp location, the deceleration length available, and the accident analysis that shows that there are not significant accidents in the area of the connection.

The deceleration lane is measured from the point where the taper reaches a width of 12 ft to the first point designed at each ramp design speed (usually the PC of the first curve for each design speed). Curves designed at higher design speeds may be included as part of the deceleration lane length.

(b) Gores, Figures 940-11a and 11b, are decision points that must be clearly seen and understood by approaching drivers. In a series of interchanges along a freeway, it is desirable that the gores be uniform in size, shape, and appearance.

The paved area between the physical nose and the gore nose is the reserve area. It is reserved for the installation of an impact attenuator. The minimum length of the reserve area is controlled by the design speed of the main line. (See Figures 940-11a and 11b.)

In addition to striping, raised pavement marker rumble strips may be placed for additional warning and delineation at gores. See the Standard Plans for striping and rumble strip details.

The accident rate in the gore area is greater than at other locations. Keep the unpaved area beyond the gore nose as free of obstructions as possible to provide a clear recovery area. Grade this unpaved area as nearly level with the roadways as possible. Avoid placing obstructions such as heavy sign supports, luminaire poles, and structure supports in the gore area.

When an obstruction must be placed in a gore area, provide an impact attenuator (Chapter 720) and barrier (Chapter 710). Place the beginning of the attenuator as far back in the reserve area as possible, preferably after the gore nose.

(c) For single-lane off-connections, the taper type is preferred. Use the design shown on Figure 940-12a for tapered single-lane off-connections. When justification is documented, a parallel single-lane off-connection, as shown on Figure 940-12b, may be used.

(d) The single-lane off-connection with one lane reduction, Figure 940-12c, is only used when the conditions from lane balance for a single lane exit, one lane reduction, are met.

(e) The tapered two-lane off-connection design shown on Figure 940-12d is preferred where the number of freeway lanes is to be reduced, or where high volume traffic operations will be improved by the provision of a parallel auxiliary lane and the number of freeway lanes is to be unchanged.

The parallel two-lane off-connection, Figure 940-12e, allows less operational flexibility than the taper, requiring more lane changes. Use a parallel two-lane off-connection only with justification.

(6) Collector Distributor Roads

A C-D road can be within a single interchange, through two closely spaced interchanges, or continuous through several interchanges. Design C-D roads that connect three or more interchanges to be two lanes wide. All others may be one or two lanes in width, depending on capacity requirements. Consider intermediate connections to the main line for long C-D roads. See Figure 940-13a for designs of collector distributor outer separations. Use Design A, with concrete barrier, when adjacent traffic in either roadway is expected to exceed 40 mph. Design B, with mountable curb, may be used only when adjacent traffic will not exceed 40 mph.

(a) The details shown in Figure 940-13b apply to all single-lane C-D road off-connections. Where conditions require two-lane C-D road off-connections, a reduction in the number of freeway lanes, the use of an auxiliary lane, or a combination of these, design it as a normal off-connection per 940.06(5).

(b) Design C-D road on-connections as required by Figure 940-13c.

(7) Loop Ramp Connections

Loop ramp connections at cloverleaf interchanges are distinguished from other ramp connections by a low speed ramp on-connection followed closely by an off-connection for another low speed ramp. The loop ramp connection design is shown on Figure 940-14. The minimum distance between the ramp connections is dependent on a weaving analysis. When the connections are spaced far enough apart that weaving is not a consideration, design the on-connection per 940.06(4) and off-connection per 940.06(5).

(8) Weaving Sections

Weaving sections are highway segments where one-way traffic streams cross by merging and diverging. Weaving sections may occur within an interchange, between closely spaced interchanges, or on segments of overlapping routes. Figure 940-15 gives the length of the weaving section for preliminary design. The total weaving traffic is the sum of the traffic entering from the ramp to the main line and the traffic leaving the main line to the exit ramp in equivalent passenger cars. For trucks, a passenger car equivalent of two may be estimated. Use the *Highway Capacity Manual* for the final design of weaving sections.

Because weaving sections cause considerable turbulence, interchange designs that eliminate weaving or remove it from the main roadway are desirable. Use C-D roads for weaving between closely spaced ramps when adjacent to high speed highways. C-D roads are not required for weaving on low speed roads.

940.07 Ramp Terminal Intersections at Crossroads

Design ramp terminal intersections at grade with crossroads as intersections at grade. (See Chapter 910.) Whenever possible, design ramp terminals to discourage wrong way movements. Review the location of ramp intersections at grade with crossroads to ensure signal progression if the intersection becomes signalized in the future. Provide intersection sight distance as described in Chapter 910.

In urban and suburban areas, match design speed at the ramp terminal to the speed of the crossroad. Provide steeper intersection angles between the ramp terminal and crossroad to slow motor vehicle traffic speeds and reduce crossing distances for bicyclists and pedestrians.

The intersection configuration requirements for ramp terminals is normally the same as for other intersections. One exception to this is an angle point is allowed between an off ramp and an on ramp. This is because the through movement of traffic getting off the freeway, going through the intersection, and back on the freeway is minor.

Another exception is at ramp terminals where the through movement is eliminated (for example at a Single Point interchange). For ramp terminals that have two wye connections, one for right turns and the other for left turns and no through movement, the intersection angle has little meaning and does not need to be considered.

940.08 Interchanges on Two-Lane Highways

Occasionally, the first stage of a conventional interchange will be built with only one direction of the main roadway and operated as a two-lane two-way roadway until the ultimate roadway is constructed.

The design of interchanges on two-lane two-way highways may vary considerably from traditional concepts due to the following conditions:

- The potential for center-line-crossing related accidents due to merge conflicts or motorist confusion.
- The potential for wrong way or U-turn movements.
- Future construction considerations.
- Traffic type and volume.
- The proximity to multilane highway sections that might influence the driver's impression that these roads are also multilane.

The deceleration taper is required for all exit conditions. Design the entering connection with either the normal acceleration taper or a "button hook" type configuration with a stop condition before entering the main line. Consider the following items:

- Design the stop condition connection in accordance with the requirements for a Tee intersection in Chapter 910. Use this type of connection only when an acceleration lane is not possible. Provide decision sight distance as described in Chapter 650.
- Since each design will probably vary from project to project, analyze each project for most efficient signing placement such as one way, two way, no passing, do not enter, directional arrows, guide posts, and traffic buttons.
- Prohibit passing through the interchange area on two lane highways by means of signing, pavement marking, or a combination of both. A 4 ft median island highlighted with raised pavement markers and diagonal stripes is the preferred treatment. When using a 4 ft median system, extend the island 500 ft beyond any merging ramp traffic acceleration taper. The width for the median can be provided by reducing each shoulder 2 ft through the interchange. (See Figure 940-16.)
- Inform both the entering and through motorists of the two-lane two-way characteristic of the main line. Include signing and pavement markings.
- Use as much of the ultimate roadway as possible. Where this is not possible, leave the area for future lanes and roadway ungraded.
- Design and construct temporary ramps as if they were permanent unless second stage construction is planned to rapidly follow the first. In all cases, design the connection to meet the safety needs of the traffic. (See Figure 940-16.)

940.09 Interchange Plans

Figure 940-17 is a sample showing the general format and data required for interchange design plans.

Compass directions (W-S Ramp) or crossroad names (E-C Street) may be used for ramp designation to realize the most clarity for each particular interchange configuration and circumstance.

Include the following as applicable:

- Classes of highway and design speeds for main line and crossroads (Chapter 440).
- Curve data on main line, ramps, and crossroads.
- Numbers of lanes and widths of lanes and shoulders on main line, crossroads, and ramps.

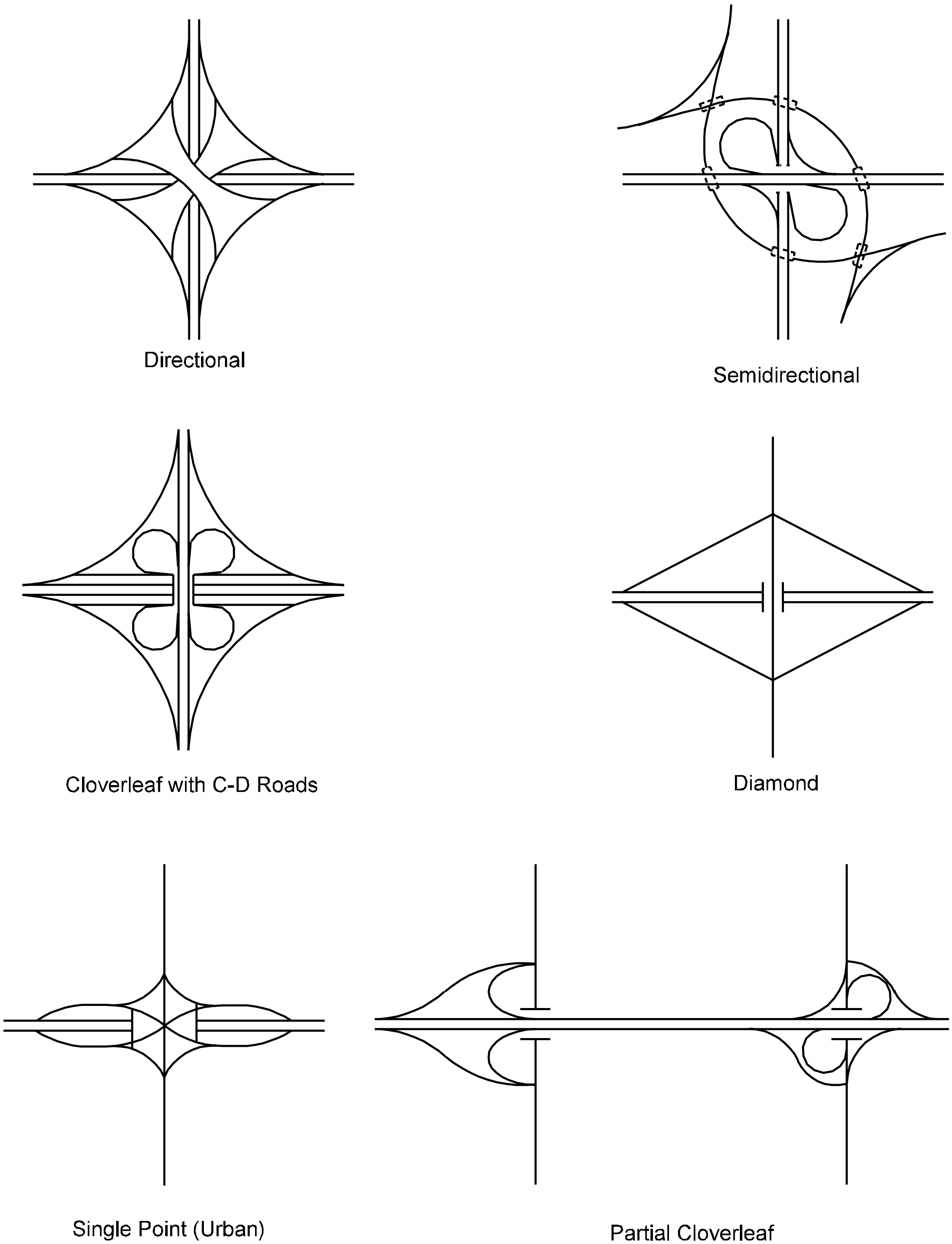
- Superelevation diagrams for the main line, the crossroad, and all ramps (may be submitted on separate sheets).
- Channelization (Chapter 910).
- Stationing of ramp connections and channelization.
- Proposed right of way and access control treatment (Chapters 1410, 1420, and 1430).
- Delineation of all crossroads, existing and realigned (Chapter 910).
- Traffic data necessary to justify the proposed design. Include all movements.
- For HOV direct access connections on the left, include the statement that the connection will be used solely by HOVs or will be closed.

Prepare a preliminary contour grading plan for each completed interchange. Show the desired contours of the completed interchange including details of basic land formation, slopes, graded areas, or other special features. Coordinate the contour grading with the drainage design and the roadside development plan.

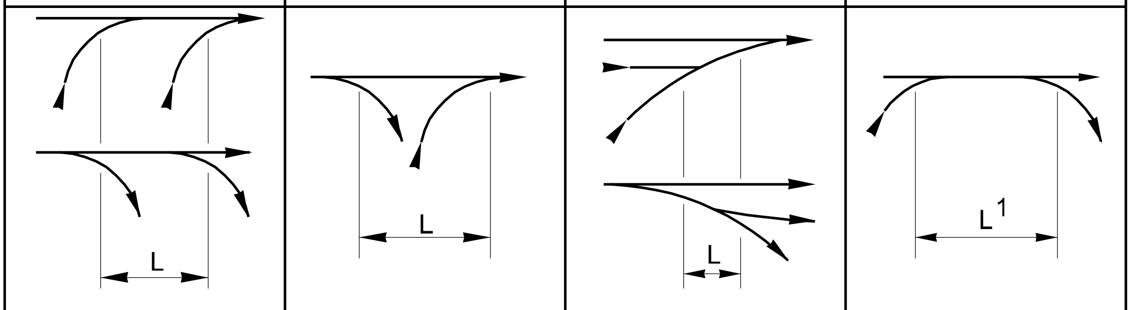
Alternative designs considered, studied, and rejected may be shown as reduced scale diagrams with a brief explanation of the advantages and disadvantages of the alternative designs, including the recommended design.

940.10 Documentation

A list of documents that are to be presereved [in the Design Documentation Package (DDP) or the project File (PF) is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/



Basic Interchange Patterns
Figure 940-4



On - On or Off - Off		Off - On		Turning Roadways		On - Off (weaving)			
Freeway	C-D Road	Freeway	C-D Road	System Interchange[2]	Service Interchange[3]	A	B	C	D
1000	800	500	400	800	600	2000	1600	1600	1000

L = Minimum distance in feet from nose to nose. The nose is the beginning of the unpaved area within the gore for an exit and the ending of the unpaved area for an entrance.

A Between two interchanges connected to a freeway, a system interchange[2] and a service interchange[3].

B Between two interchanges connected to a C-D road, a system interchange[2] and a service interchange[3].

C Between two interchanges connected to a freeway, both service interchanges[3].

D Between two interchanges connected to a C-D road, both service interchanges[3].

Notes:

These recommendations are based on operational experience, need for flexibility, and adequate signing. Check them in accordance with Figure 940-15 and the procedures outlined in the *Highway Capacity Manual* and use the larger value.

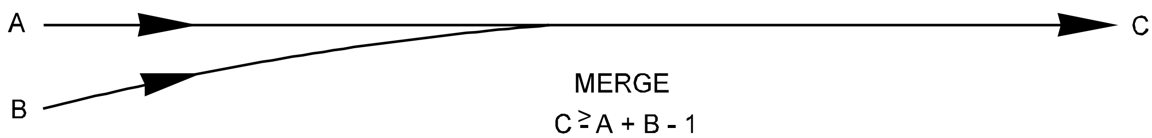
(1) With justification, these values may be reduced for cloverleaf ramps.

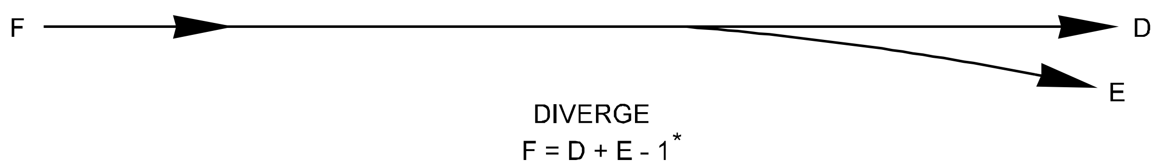
(2) A system interchange is a freeway to freeway interchange.

(3) A service interchange is a freeway to local road interchange.

Minimum Ramp Connection Spacing

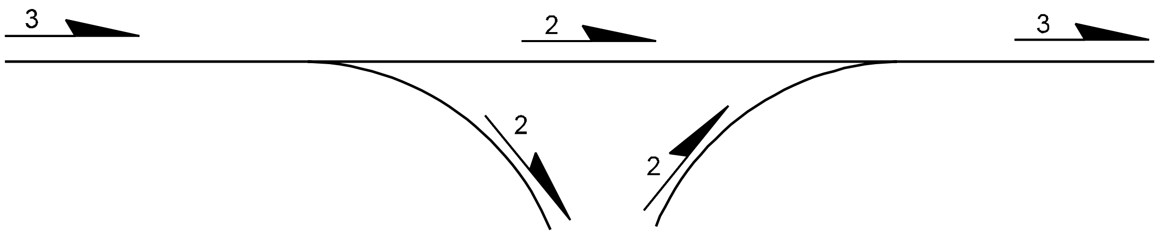
Figure 940-5



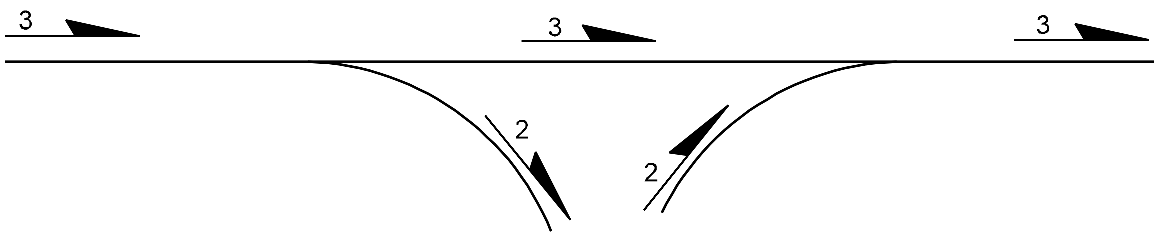


* Number of lanes, F, may be more by one lane only, provided the lane dropped is an auxiliary lane between closely spaced entrance and exit ramps.

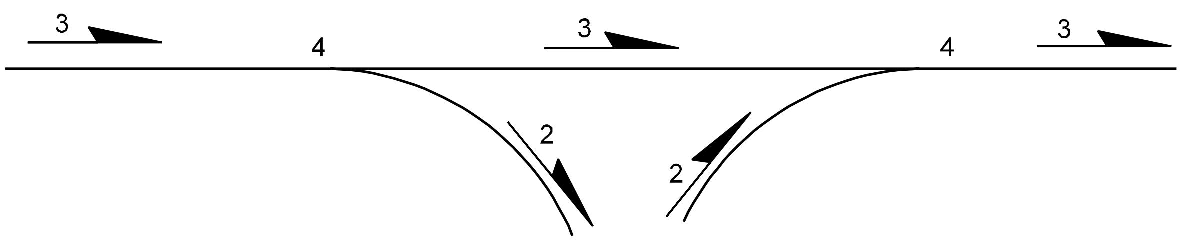
Lane Balance
Figure 940-6a



UNDESIRABLE Lane balance but no compliance with basic number of lanes.

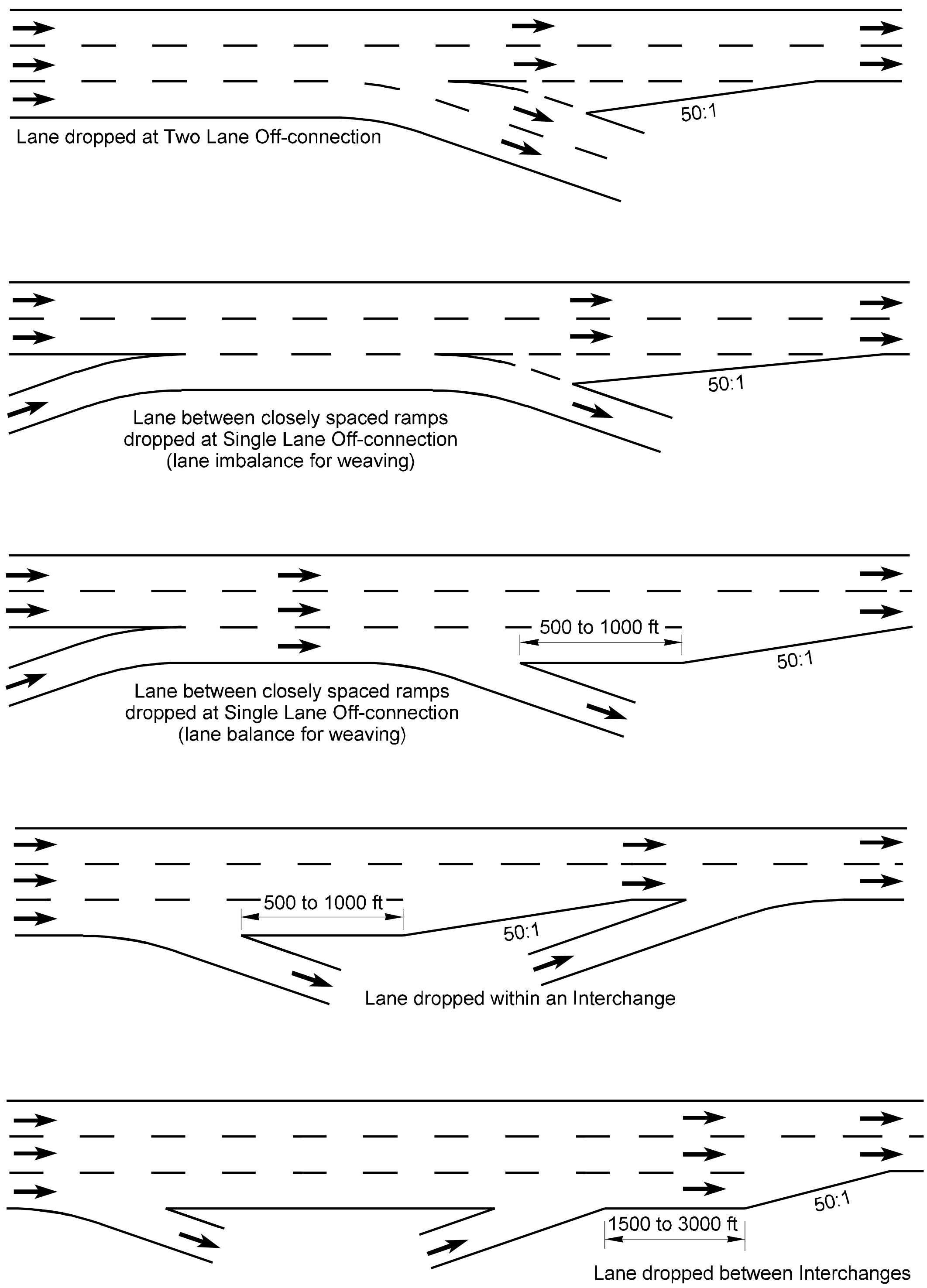


UNDESIRABLE No lane balance but compliance with basic number of lanes.

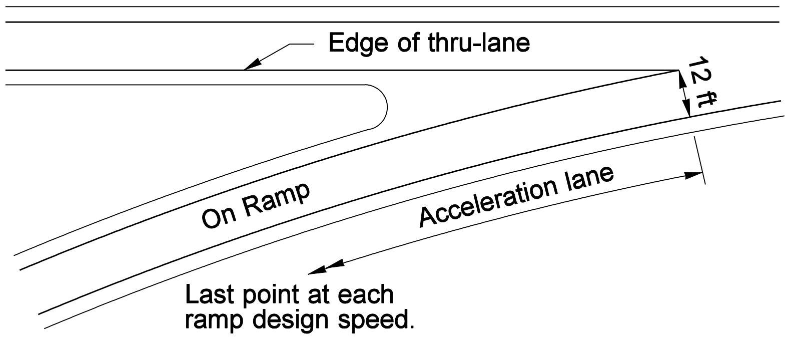


DESIRABLE Compliance with both lane balance and number of lanes.

Lane Balance
Figure 940-6b



Main Line Lane Reduction Alternatives
Figure 940-7



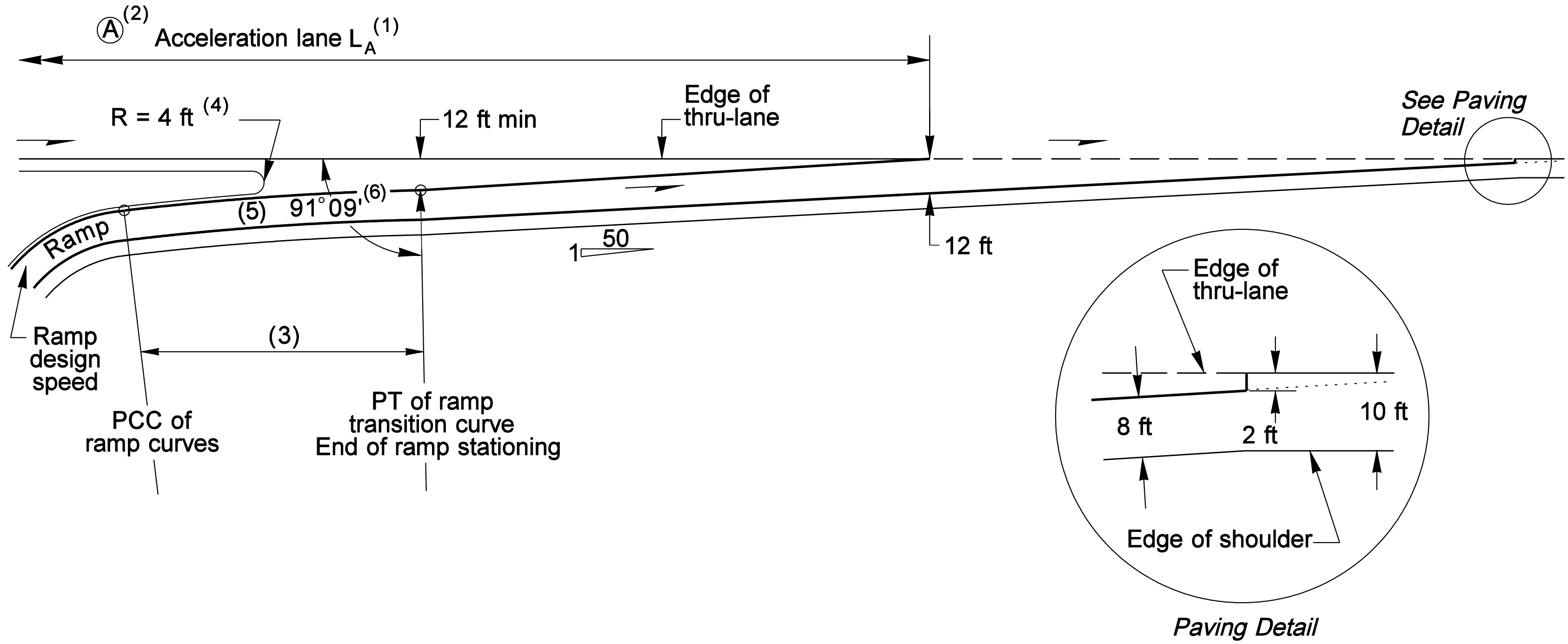
Highway Design Speed (mph)	Ramp Design Speed (mph)										
	0	15	20	25	30	35	40	45	50	60	70
30	180	140									
35	280	220	160								
40	360	300	270	210	120						
45	560	490	440	380	280	160					
50	720	660	610	550	450	350	130				
55	960	900	810	780	670	550	320	150			
60	1200	1140	1100	1020	910	800	550	420	180		
65	1410	1350	1310	1220	1120	1000	770	600	370		
70	1620	1560	1520	1420	1350	1230	1000	820	580	210	
80	2000	1950	1890	1830	1730	1610	1380	1200	970	590	210

Minimum Acceleration Lane Length (ft)

Highway Design Speed (mph)	Grade	Up Grade				Down Grade
		Ramp Design Speed				All Ramp Design Speeds
		20	30	40	50	
40	3% to less than 5%	1.3	1.3			0.70
45		1.3	1.35			0.675
50		1.3	1.4	1.4		0.65
55		1.35	1.45	1.45		0.625
60		1.4	1.5	1.5	1.6	0.60
70		1.5	1.6	1.7	1.8	0.60
40	5% or more	1.5	1.5			0.60
45		1.5	1.6			0.575
50		1.5	1.7	1.9		0.55
55		1.6	1.8	2.05		0.525
60		1.7	1.9	2.2	2.5	0.50
70		2.0	2.2	2.6	3.0	0.50

Adjustment Factors for Grades Greater than 3%

Acceleration Lane Length
Figure 940-8



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point A is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

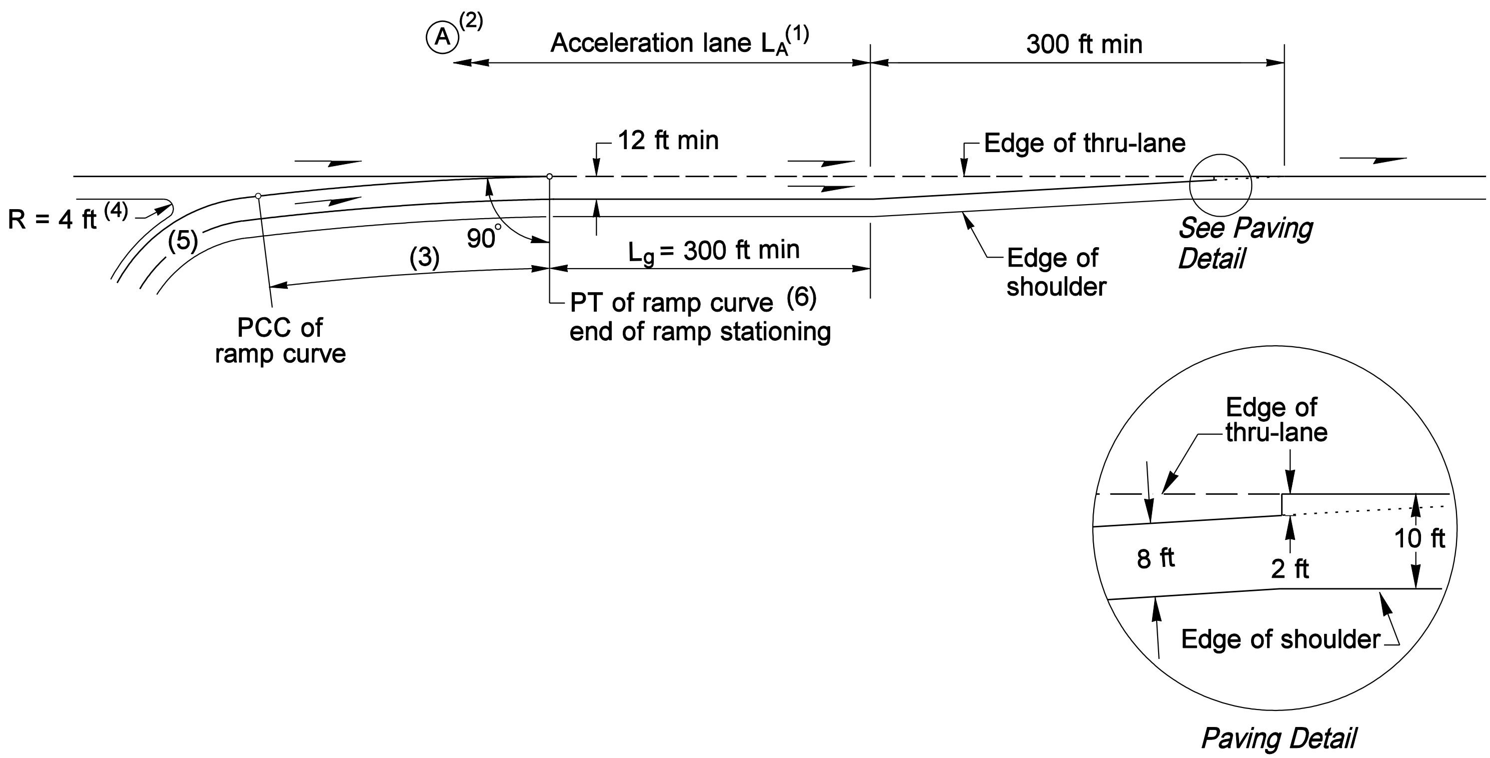
(4) Radius may be reduced when concrete barrier is placed between the ramp and main line.

(5) For ramp lane and shoulder widths, see Figure 940-3.

(6) Approximate angle to establish ramp alignment.

(7) For Striping, see the Standard Plans.

On-Connection (Single-Lane, Taper Type)
Figure 940-9a



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point (A) is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line. <u>The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.</u>

(4) <u>Radius may be reduced when concrete barrier is placed between the ramp and main line.</u>

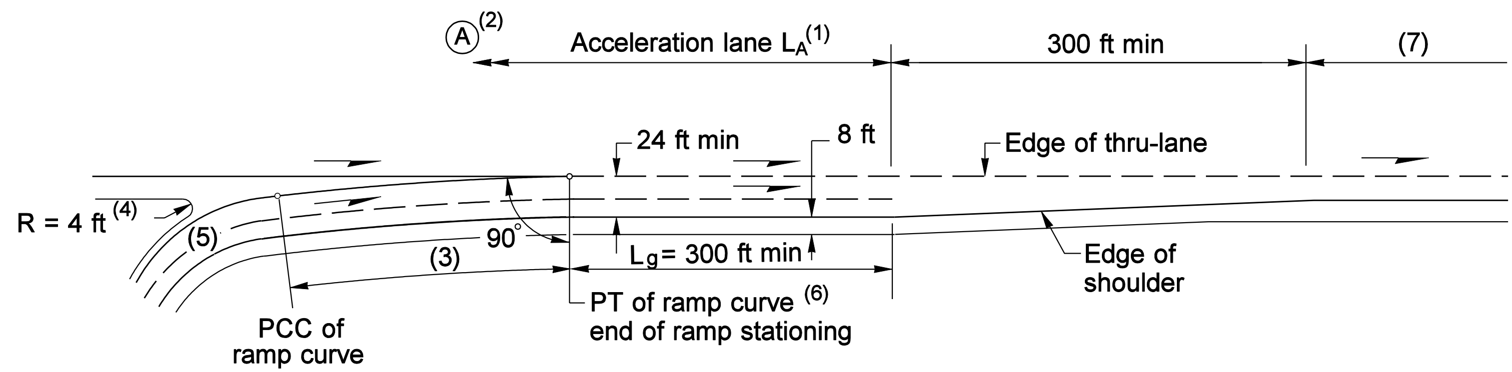
(5) For ramp lane and shoulder widths, see Figure 940-3.

(6) <u>Ramp stationing may be extended to accommodate superelevation transition.</u>

(7) For striping, see the Standard Plans.

On-Connection (Single-Lane, Parallel Type)

Figure 940-9b



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point (A) is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line. <u>The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.</u>

(4) <u>Radius may be reduced when concrete barrier is placed between the ramp and main line.</u>

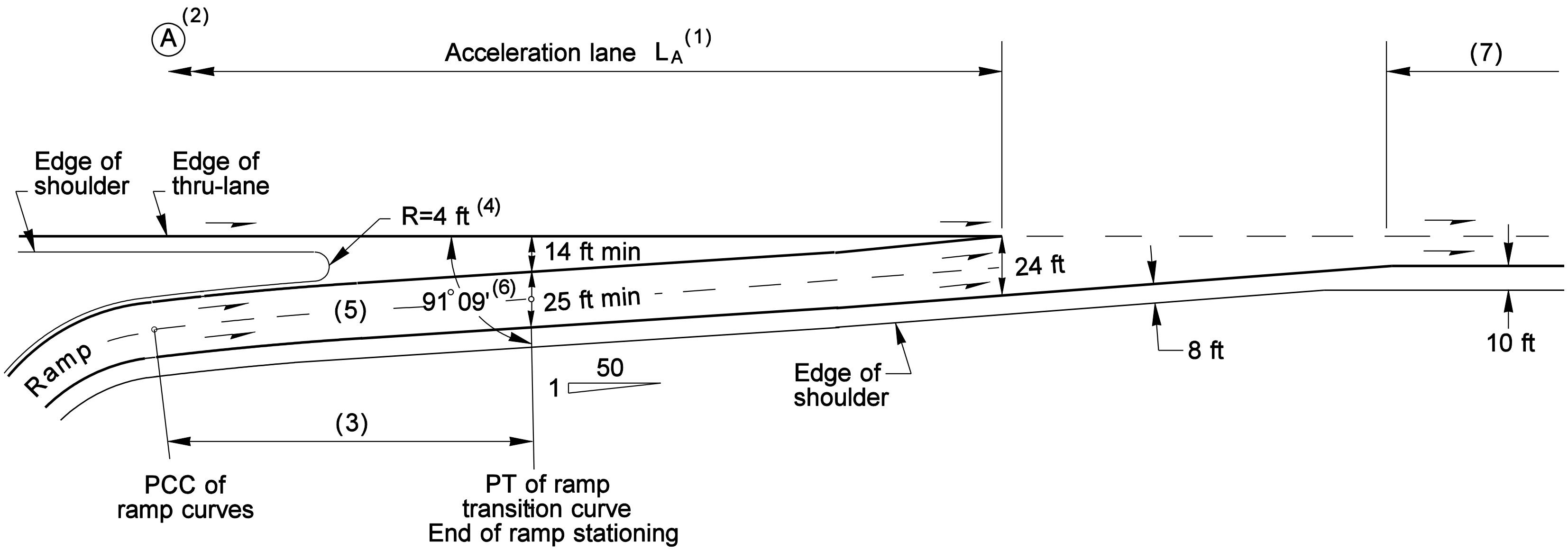
(5) For ramp lane and shoulder widths, see figure 940-3.

(6) <u>Ramp stationing may be extended to accommodate superelevation transition.</u>

(7) Added lane or 1,500 ft auxiliary lane plus 600 ft taper.

(8) For striping, see the Standard Plans.

On-Connection (Two-Lane, Parallel Type)
Figure 940-9c



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point (A) is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

(4) <u>Radius may be reduced when concrete barrier is placed between the ramp and main line.</u>

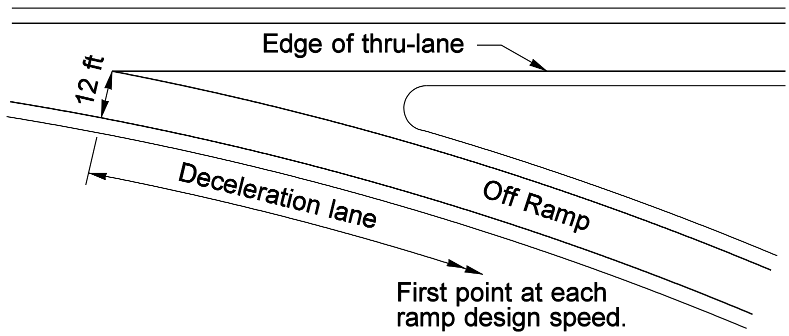
(5) For ramp lane and shoulder widths, see figure 940-3.

(6) Approximate angle to establish ramp alignment.

(7) Added lane or 1,500 ft auxiliary lane plus 600 ft taper.

(8) For striping, see the Standard Plans.

On-Connection (Two-Lane, Taper Type)
Figure 940-9d



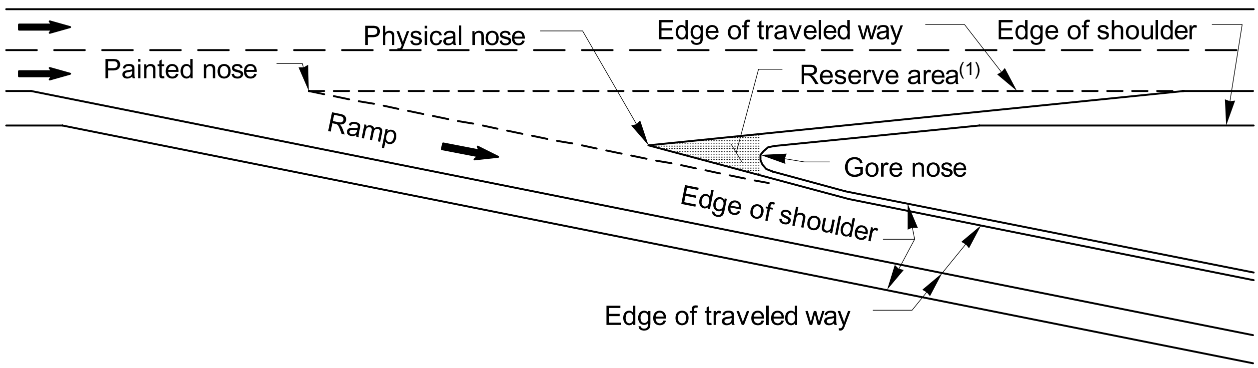
Highway Design Speed (mph)	Ramp Design Speed (mph)										
	0	15	20	25	30	35	40	45	50	60	70
30	235	200	170	140							
35	280	250	210	185	150						
40	320	295	265	235	185	155					
45	385	350	325	295	250	220	155				
50	435	405	385	355	315	285	225	175			
55	480	455	440	410	380	350	285	235	180		
60	530	500	480	460	430	405	350	300	240		
65	570	540	520	500	470	440	390	340	280	185	
70	615	590	570	550	520	490	440	390	340	240	
80	735	710	690	670	640	610	555	510	465	360	265

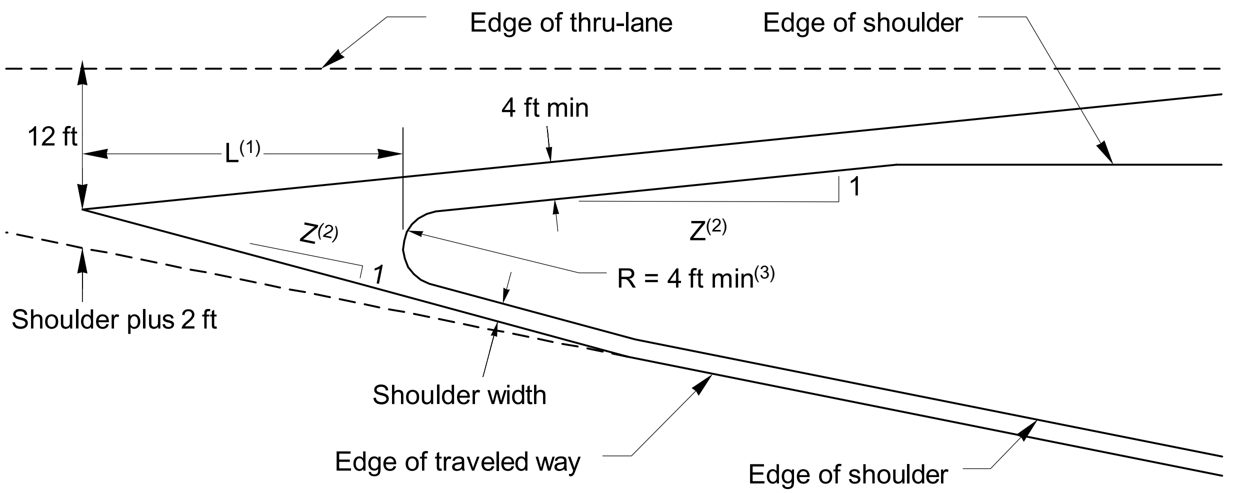
Minimum Deceleration Length (ft)

Grade	Up Grade	Down Grade
3% to less than 5%	0.9	1.2
5% or more	0.8	1.35

Adjustment Factors for Grades Greater than 3%

Deceleration Lane length
Figure 940-10





Notes:

(1) The reserve area length (L) is not less than:

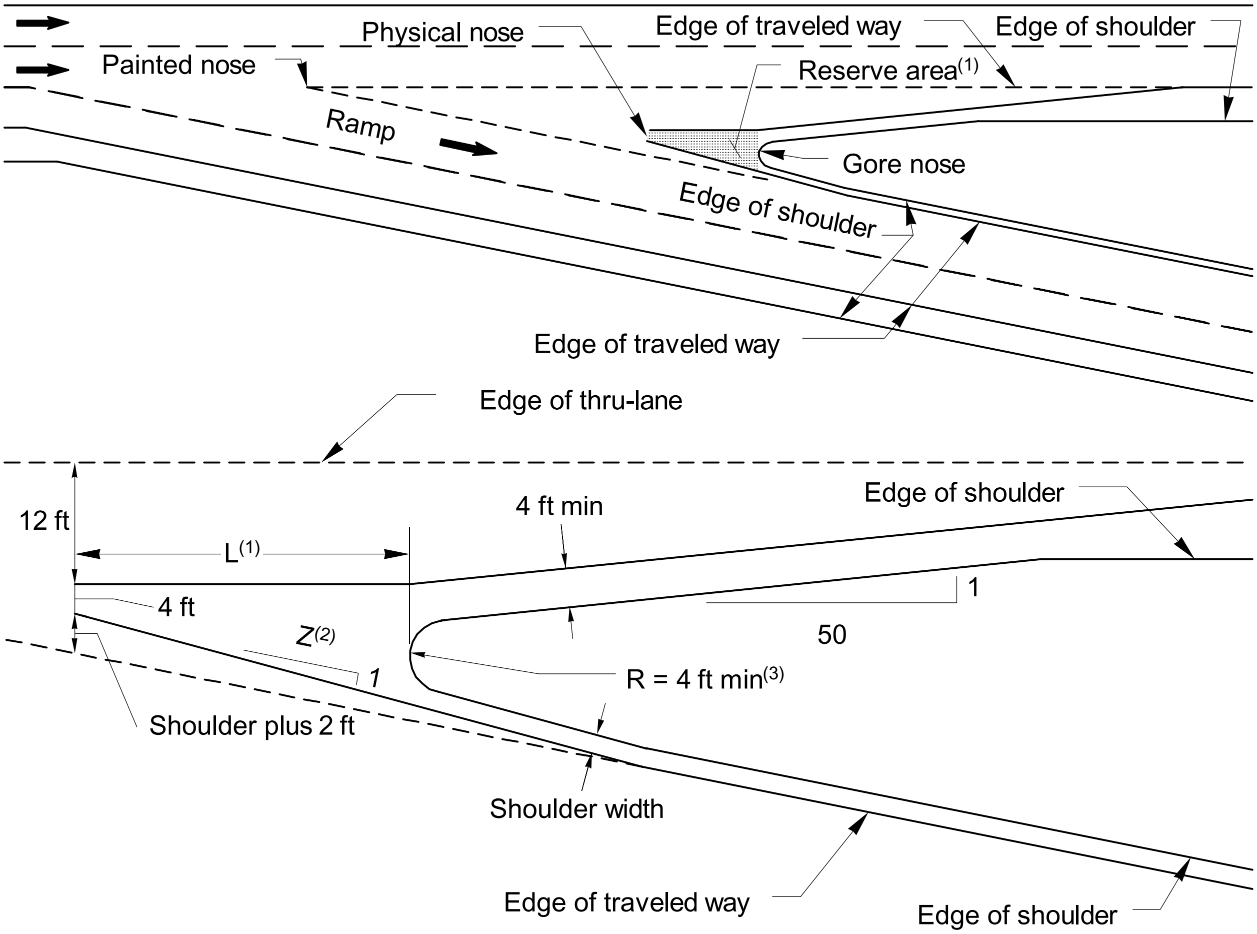
Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

(2) $Z = \frac{\text{Design Speed}}{2}$, Design speed is for the main line.

(3) R may be reduced, when protected by an impact attenuator.

Gore Area Characteristics

Figure 940-11a



Notes:

(1) The reserve area length (L) is not less than:

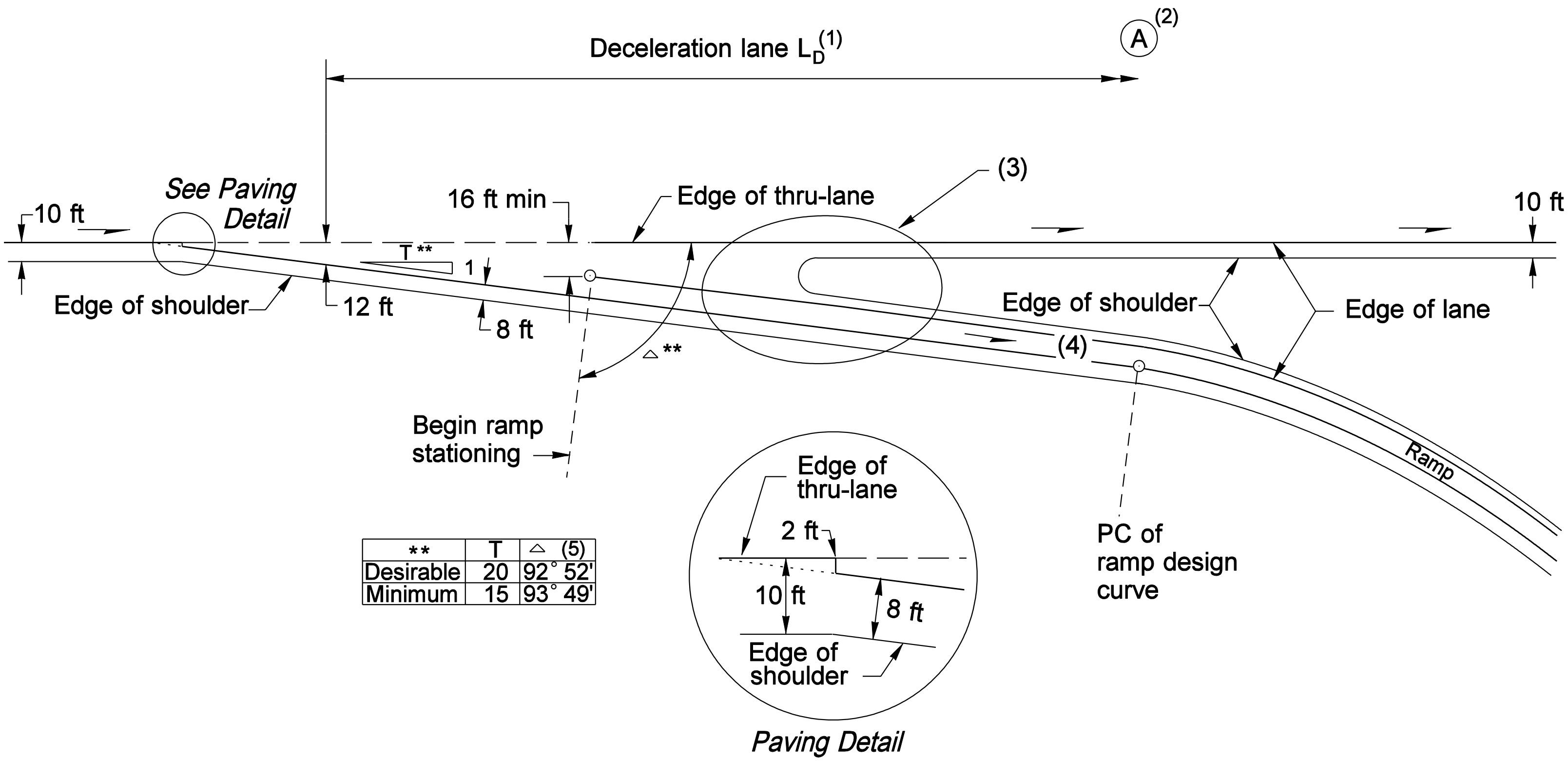
Main Line Design Speed (mph)	40	45	50	55	60	65	70	80
L (ft)	25	30	35	40	45	50	55	70

(2) $Z=\frac{\text{Design Speed}}{2}$, Design speed is for the main line.

(3) R may be reduced, when protected by an impact attenuator.

Gore Area Characteristics

Figure 940-11b



**	T	△ (5)
Desirable	20	92° 52'
Minimum	15	93° 49'

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point A is the point controlling the ramp design speed.

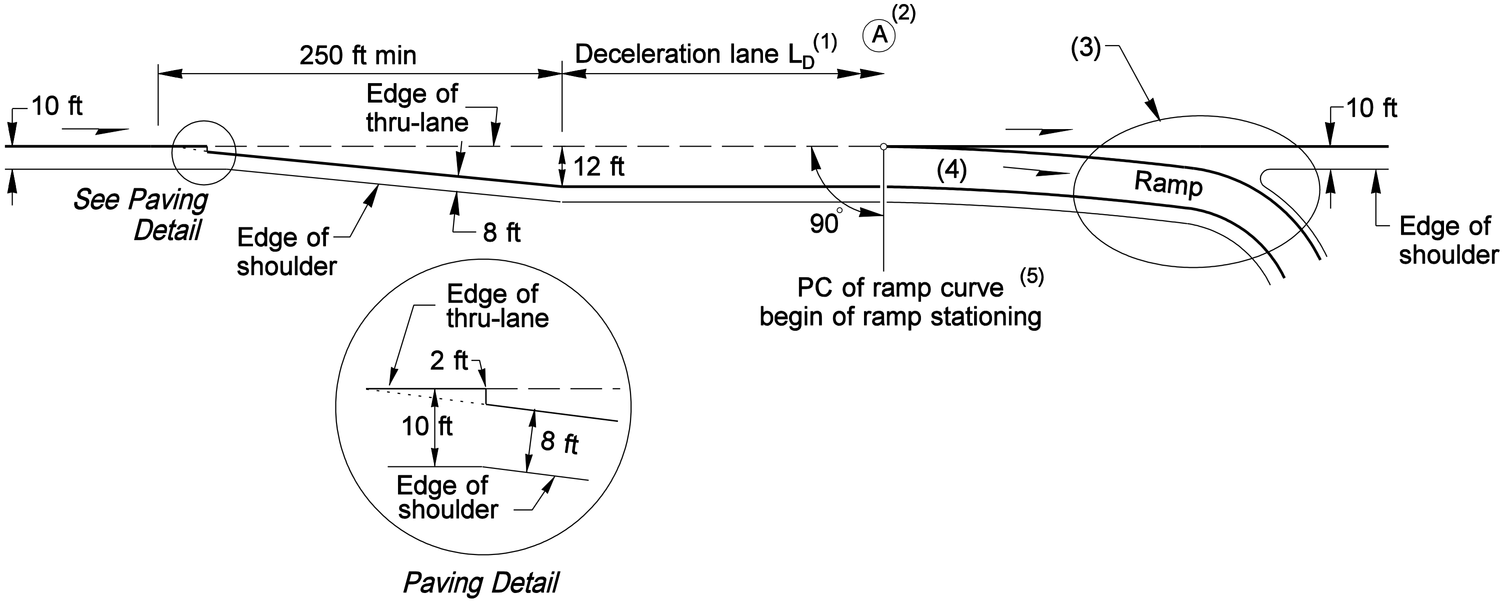
(3) See Figure 940-11a for gore details.

(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish ramp alignment.

(6) For striping, see the Standard Plans.

Off-Connection (Single-Lane, Taper Type)
Figure 940-12a



Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the ramp design speed.

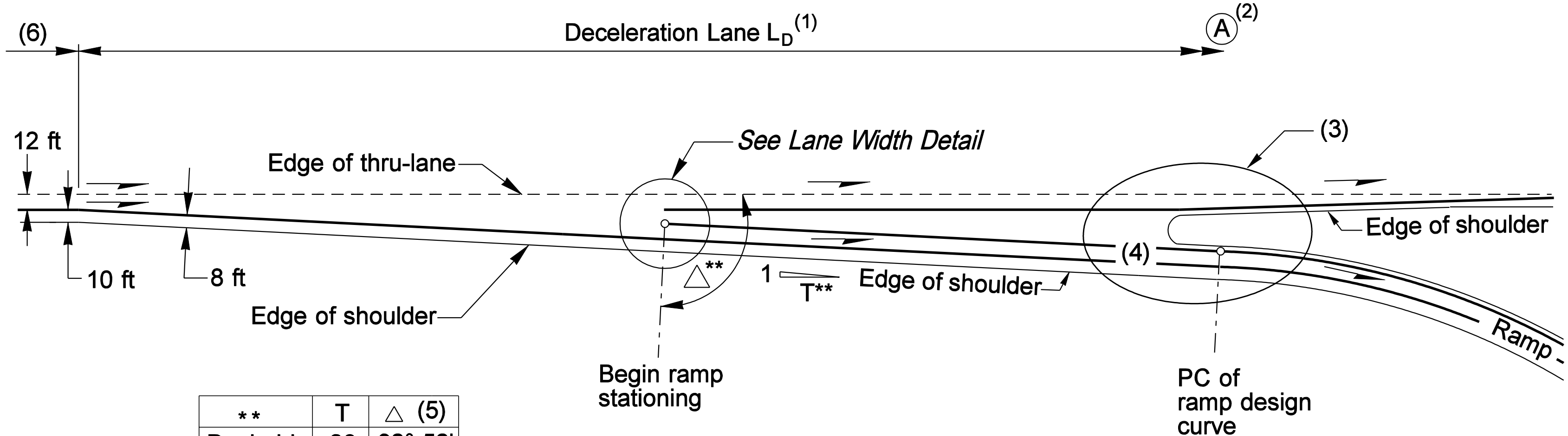
(3) <u>See Figure 940-11a for gore details.</u>

(4) For ramp lane and shoulder widths, see Figure 940-3.

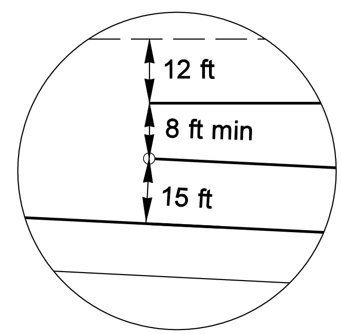
(5) <u>Ramp Stationing may be extended to accommodate superelevation transition.</u>

(6) For striping, see the Standard Plans.

Off-Connection (Single-Lane, Parallel Type)
Figure 940-12b



**	T	△ (5)
Desirable	20	92° 52'
Minimum	15	93° 49'



Lane Width Detail

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point A is the point controlling the ramp design speed.

(3) <u>See Figure 940-11b for gore details.</u>

(4) For ramp lane and shoulder widths, see Figure 940-3.

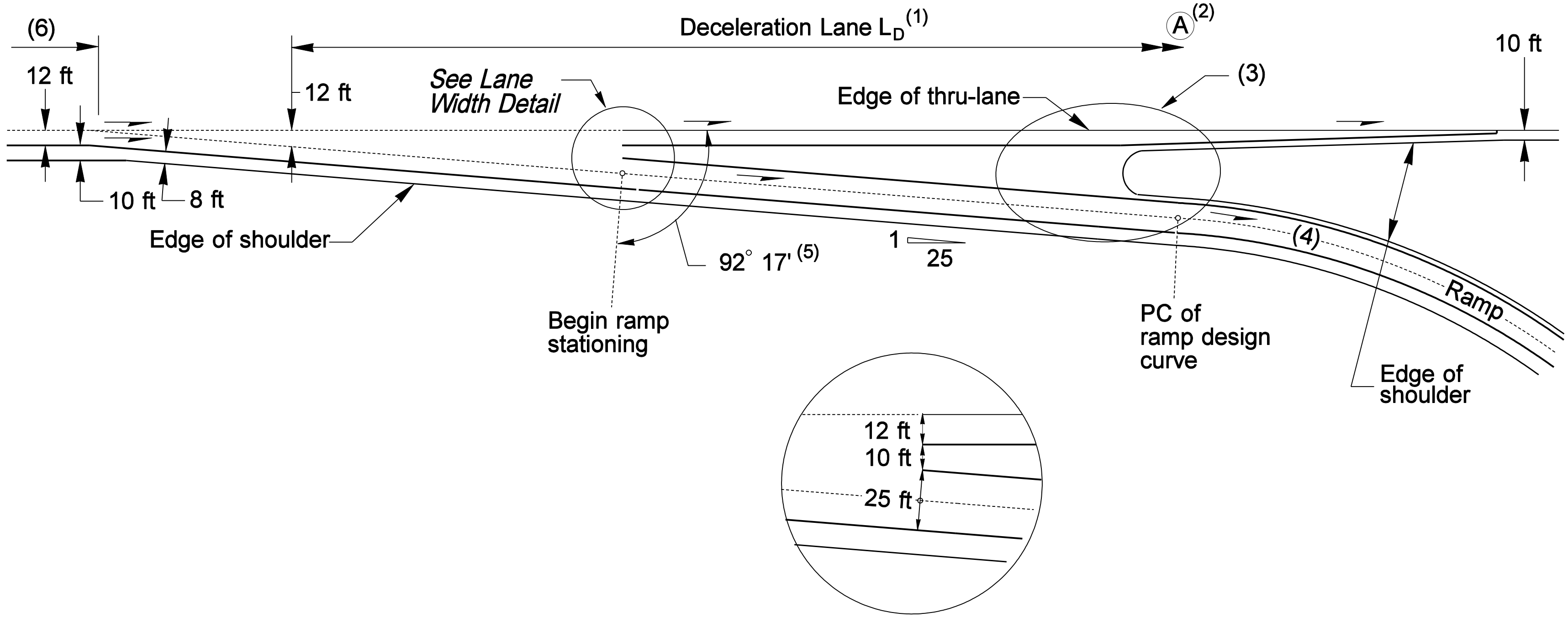
(5) Approximate angle to establish ramp alignment.

(6) Auxiliary lane between closely spaced interchanges to be dropped.

(7) For striping, see the Standard Plans.

Off-Connection (Single-Lane, One-Lane Reduction)

Figure 940-12c



Lane Width Detail

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the ramp design speed.

(3) See Figure 940-11b for gore details.

(4) For ramp lane and shoulder widths, see Figure 940-3.

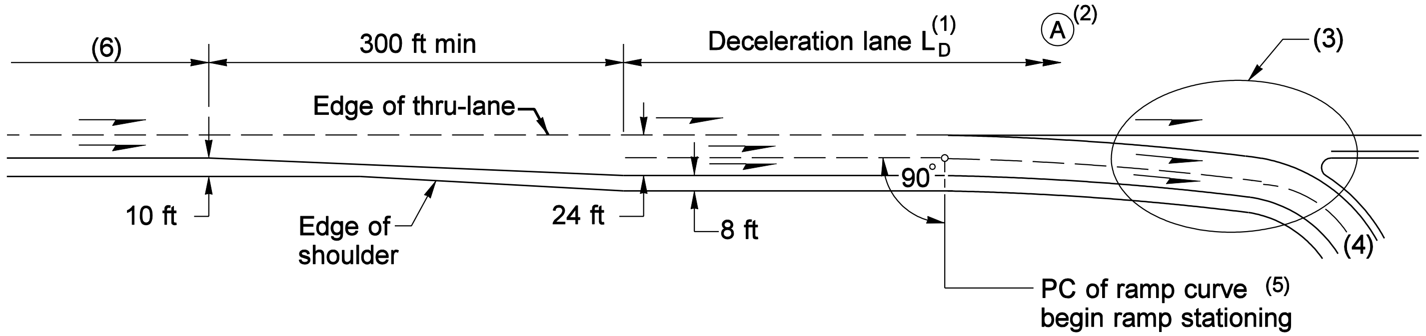
(5) Approximate angle to establish ramp alignment.

(6) Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300 ft taper.

(7) For striping, see the Standard Plans.

Off-Connection (Two-Lane, Taper Type)

Figure 940-12d



Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) See Figure 940-11b for gore details.

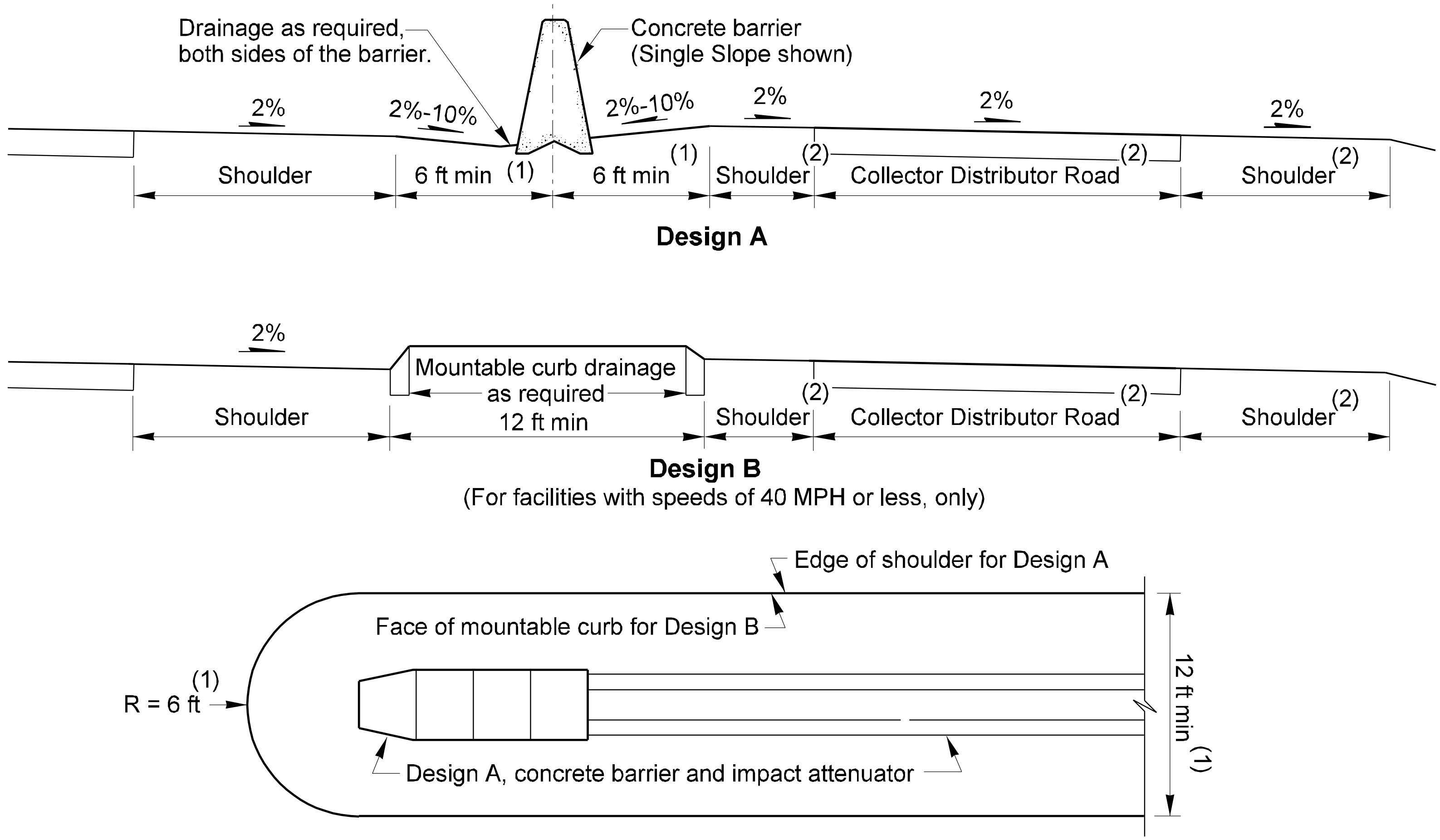
(4) For ramp lane and shoulder widths, see Figure 940-3.

(5) Ramp stationing may be extended to accommodate superelevation transition.

(6) Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300 ft taper.

(7) For striping, see the Standard Plans.

Off-Connection (Two-Lane, Parallel Type)
Figure 940-12e

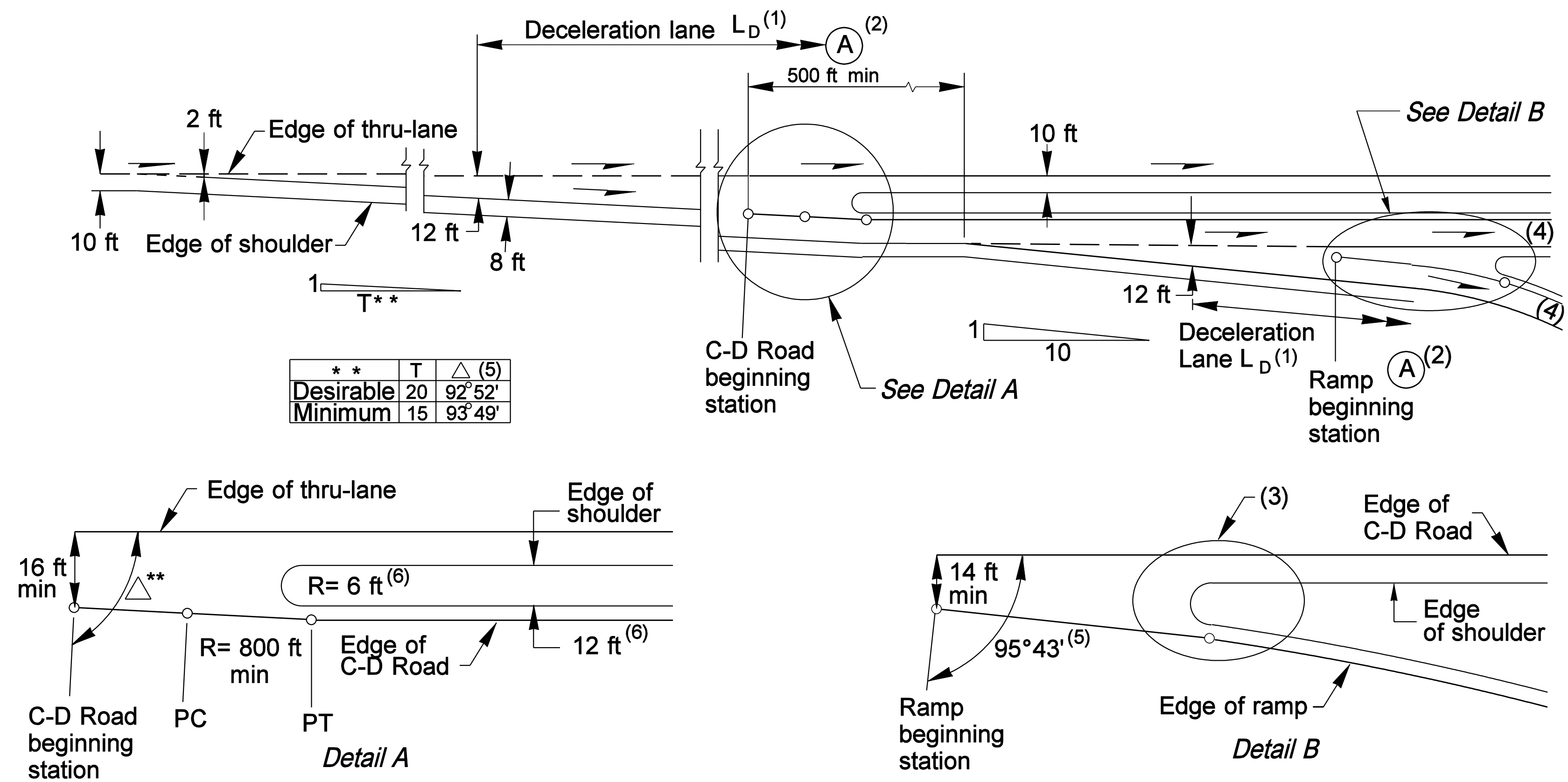


Notes:

(1) With justification, the concrete barrier may be placed with 2 ft <u>between</u> the edge of either shoulder <u>and</u> the face of barrier. The minimum width between the edge of through-shoulder and the edge of C-D road shoulder will be reduced to 6 ft, and the radius at the nose will be reduced to 3 ft.

(2) For collector distributor road lane and shoulder widths, see ramp lane and shoulder widths, Figure 940-3.

Collector Distributor (Outer Separations)
Figure 940-13a



**	T	Δ (5)
Desirable	20	92°52'
Minimum	15	93°49'

Notes:

(1) See Figure 940-10 for deceleration lane length L_D.

(2) Point (A) is the point controlling the <u>C-D road or</u> ramp design speed.

(3) <u>See Figure 940-11a for gore details.</u>

(4) For C-D road and ramp lane and shoulder widths, see Figure 940-3.

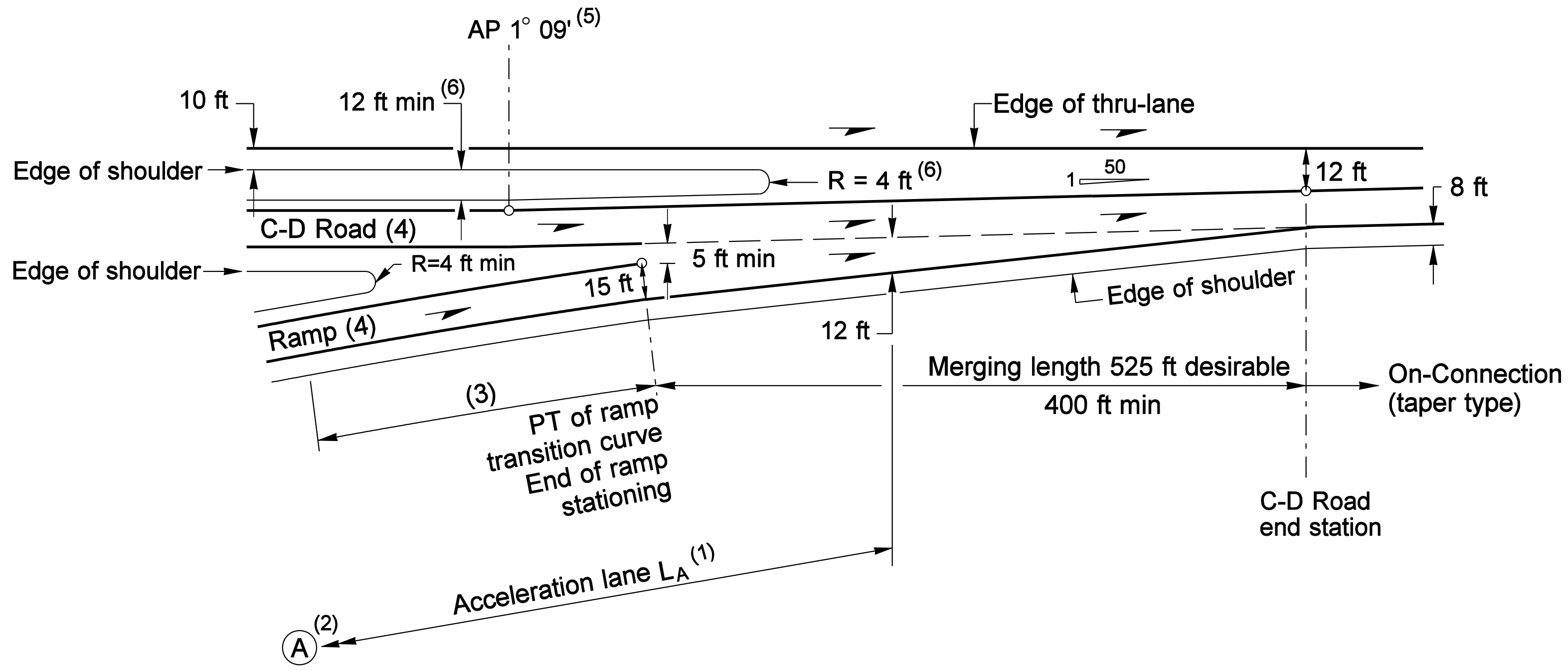
(5) Approximate angle to establish alignment.

(6) May be reduced with justification. <u>(See Figure 940-13a.)</u>

(7) For striping, see the Standard Plans.

Collector Distributor (Off-Connections)

Figure 940-13b



Notes:

(1) See Figure 940-8 for acceleration lane length L_A.

(2) Point Ⓐ is the point controlling the ramp design speed.

(3) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the C-D road is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the C-D road.

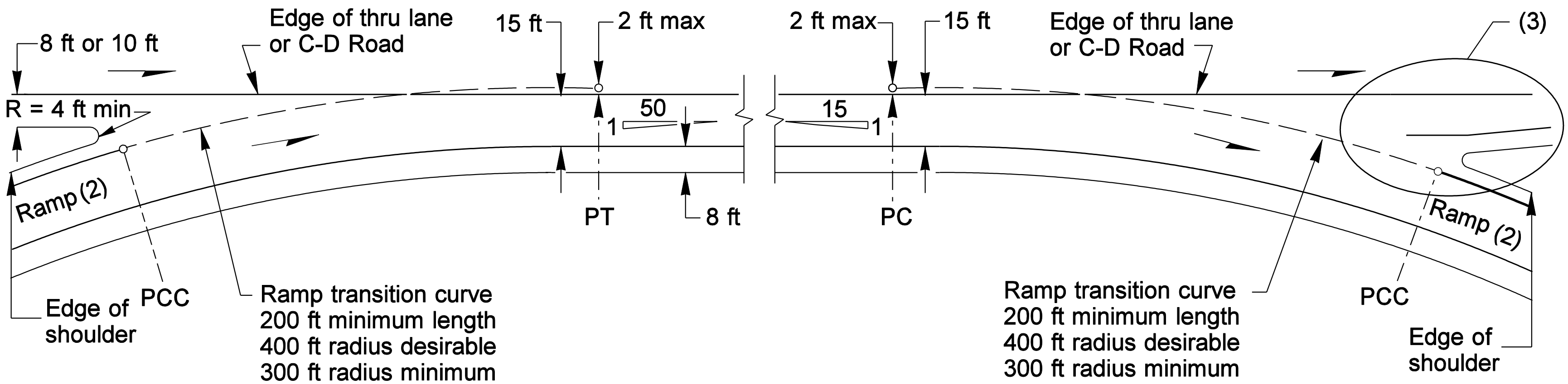
(4) For C-D road and ramp lane and shoulder widths, see Figure 940-3.

(5) Approximate angle to establish alignment.

(6) May be reduced with justification. (See Figure 940-13a.)

(7) For striping, see the Standard Plans.

Collector Distributor (On-Connections)
Figure 940-13c



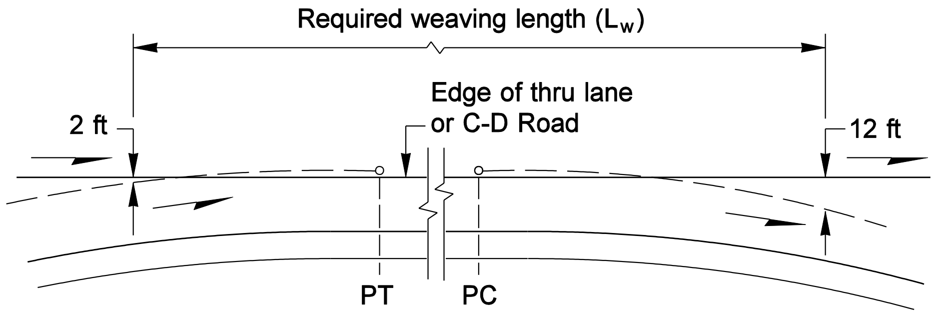
Notes:

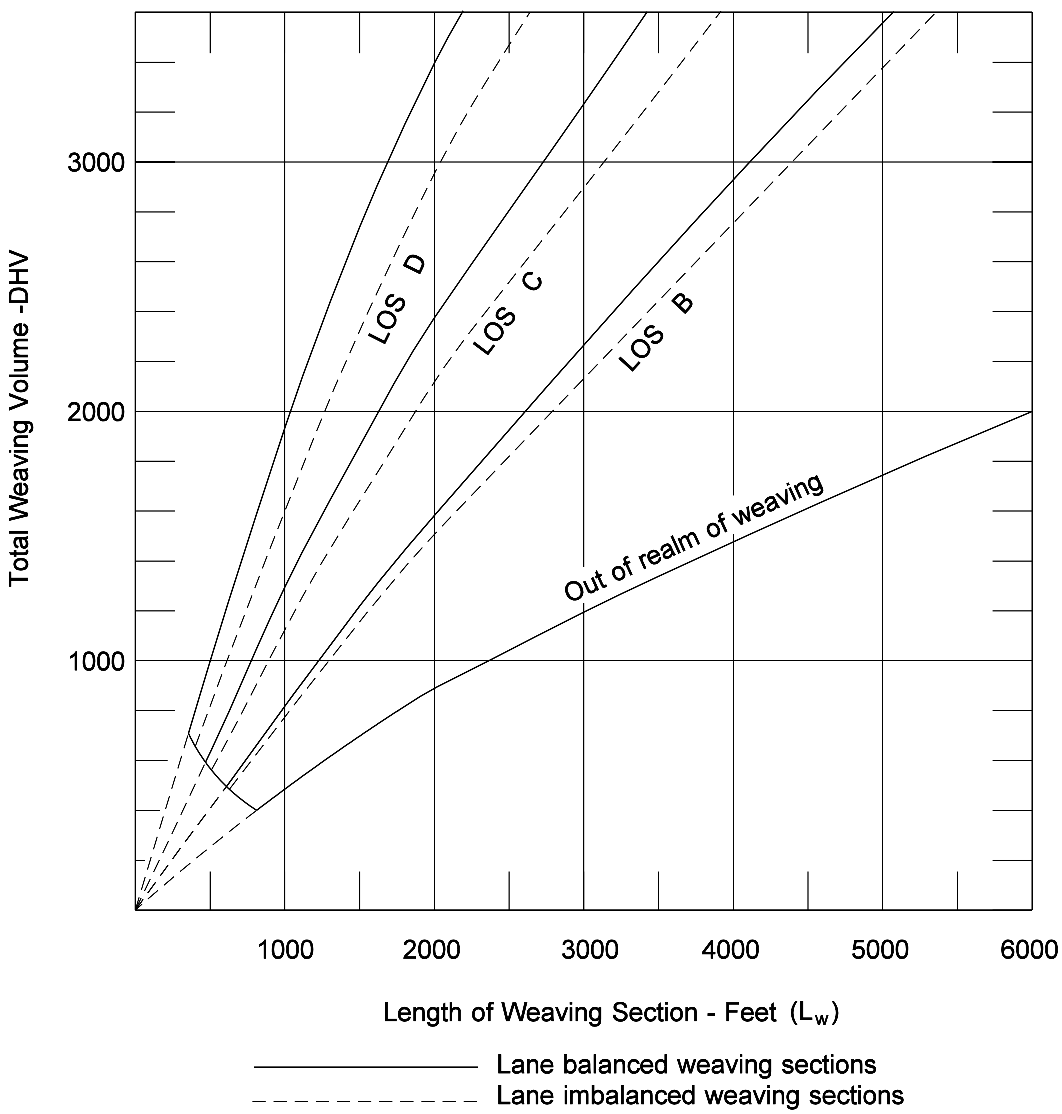
(1) See Figure 940-15 for required minimum weaving length.

(2) For minimum ramp lane and shoulder widths, see Figure 940-3.

(3) See Figure 940-11b for gore details.

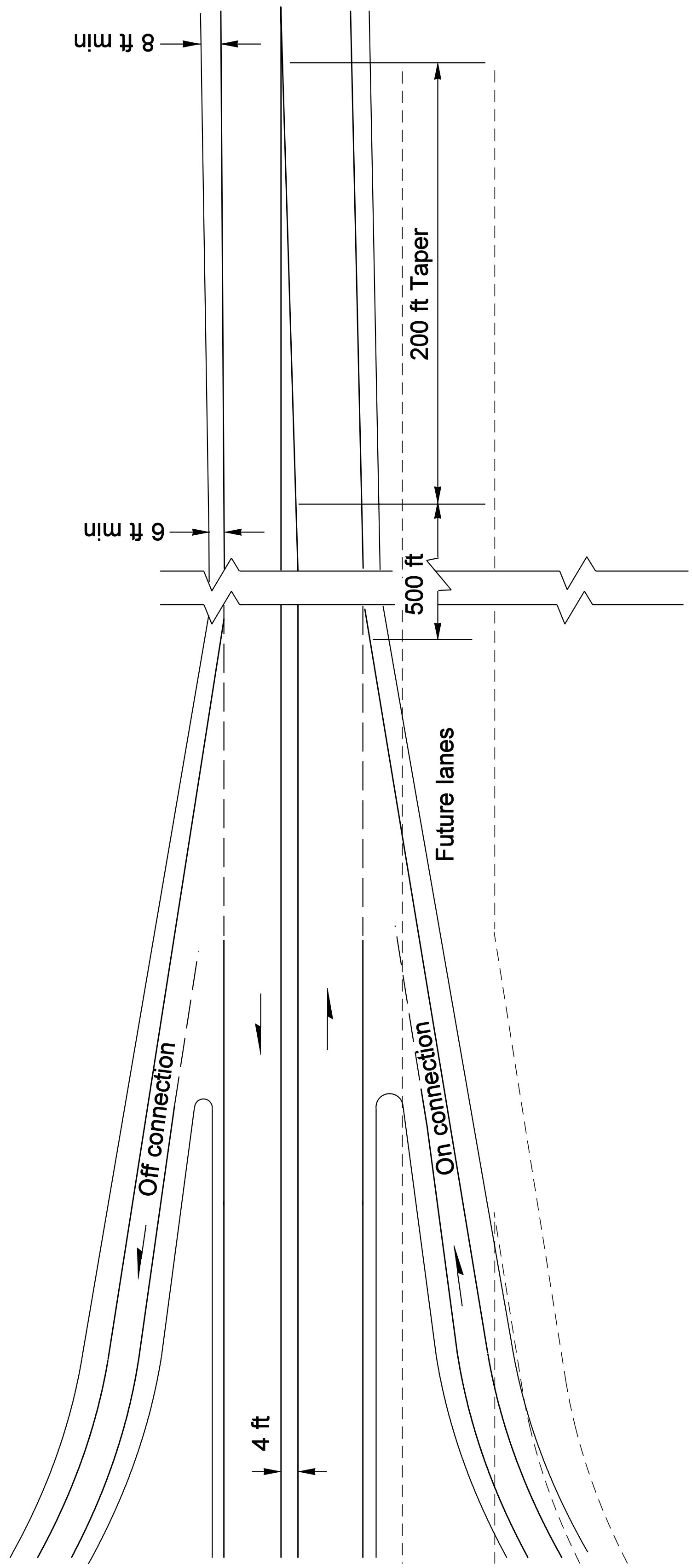
Loop Ramps Connections
Figure 940-14



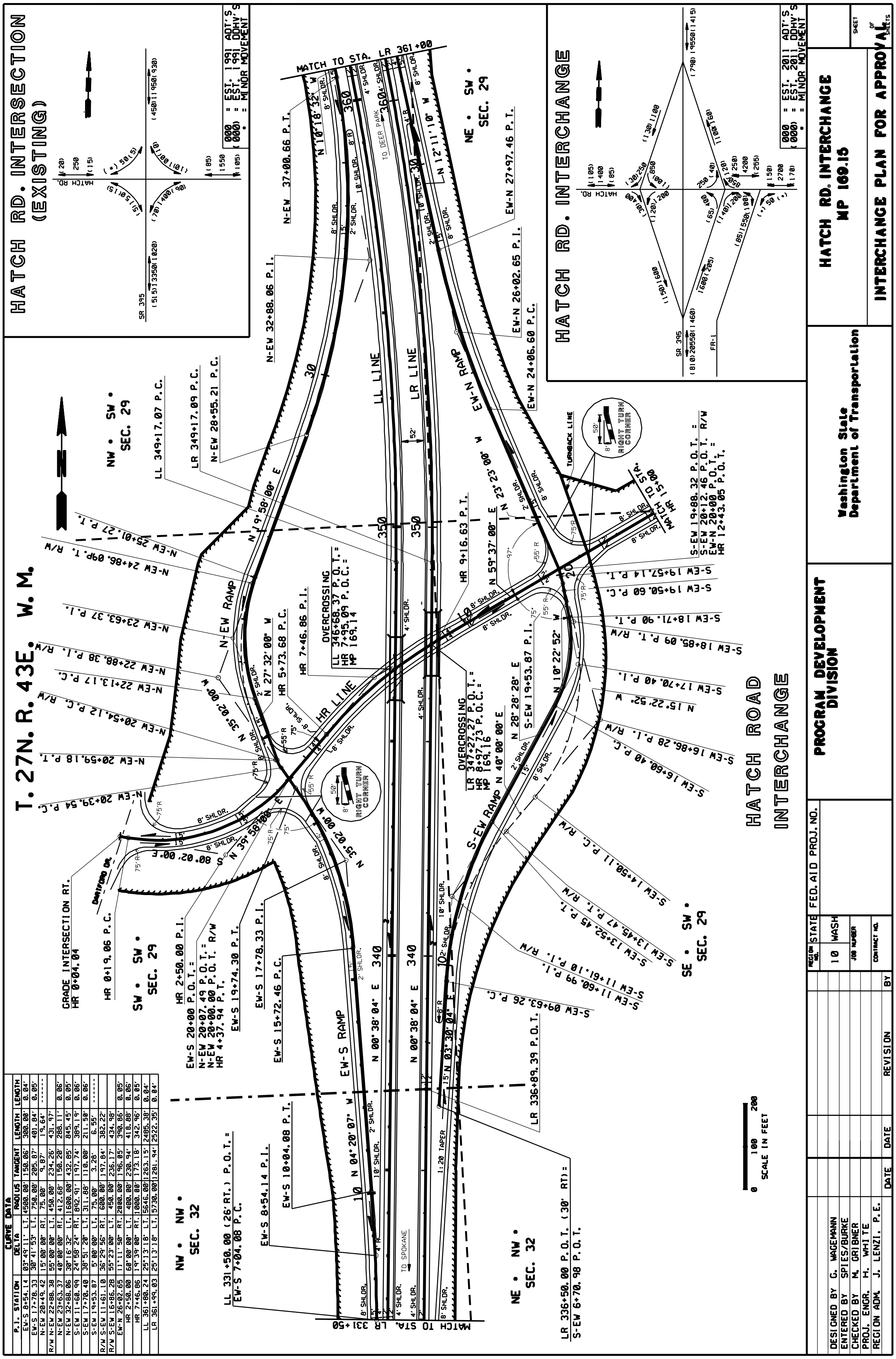


See Figure 940-7 to determine
whether or not lane balance exists

Length of Weaving Sections
Figure 940-15



Temporary Ramps
Figure 940-16



Interchange Plan
Figure 940-17

960.01 General

This chapter provides guidance for locating and designing median crossovers.

Median crossovers are provided at selected locations on divided highways for crossing by maintenance, traffic service, emergency, and law enforcement vehicles. The use of any median crossover is restricted to the users noted above.

Crossovers may be provided:

- Where analysis demonstrates that access through interchanges or intersections is not practical
- As part of region maintenance operations
- As necessary for law-enforcement functions

For median openings to provide turning movements for public access to both sides of the roadway, see Chapter 910, Intersections At Grade.

960.02 Analysis

A list of existing median crossovers is available from the Headquarters (HQ) Access and Hearings Unit. The Statewide Master Plan for Median Crossovers can be found at: http://www.wsdot.wa.gov/eesc/design/access/1MasterPlanXoversHistory.pdf.

The general categories of vehicles recognized as legitimate users of median crossovers are: law enforcement and official services vehicles, these include emergency, traffic service, and maintenance vehicles.

In both urban and rural areas, crossovers may be necessary for law enforcement operations. In urban areas with a high occupancy vehicle lane adjacent to the median, crossovers may be considered for law enforcement. See Chapter 1050.

In areas where there are three or more miles between access points, providing an unobtrusive crossover can improve emergency service or improve efficiency for traffic service and maintenance forces.

Where crossovers are justified and used for winter maintenance operations such as snow and ice removal, the recommended minimum distance from the ramp merge or diverge point should be 1,000 feet to accommodate future ramp improvements. This distance may be decreased to improve winter maintenance efficiency based on an operational analysis. Include an operational analysis in the Design Documentation Package.

960.03 Design

Utilize the following design criteria for all median crossovers, while taking into consideration the intended vehicle usage. Some of the criteria below may not apply to crossovers intended primarily for law enforcement:

- Adequate median width at the crossover location is required to allow the design vehicle to complete a U-turn maneuver without backing. Use of the shoulder area is allowed for the execution of the U-turn maneuver. The typical design vehicles for this determination are a passenger car and a single unit truck.
- Consider the type of vehicles using the median crossover.
- The minimum recommended throat width is 30 feet.
- Use grades and radii that are suitable for all authorized user vehicles. (See Chapter 920)
- Ten-foot inside shoulders are adequate for most cases. Consider full ten-foot shoulders for a distance of 450 feet upstream of the crossover area to accommodate deceleration, and extend downstream of the crossover area for a distance of 600 feet to allow acceleration prior to entering the travel lane. Where inside shoulders can be constructed wide enough

to allow vehicle deceleration and acceleration to occur off the travel lanes, documentation is not required.

- Provide adequate stopping sight distance for vehicles approaching the crossover area. Because of the unexpected maneuvers associated with these inside access points and higher operating speeds commonly experienced in the inside travel lanes, use conservative values for stopping sight distance. (See Chapter 650.)
- Provide adequate intersection sight distance at crossover locations where authorized user vehicles must encroach on the travel lanes. (See Chapter 910.)
- For the crossing, use side slopes no steeper than 10H:1V. Grade for a relatively flat and gently contoured appearance that is inconspicuous to the public.
- Consider impacts to existing drainage.
- Do not use curbs or pavement markings.
- Flexible guide posts may be provided for night reference, as shown in the Standard Plans.
- Consider the terrain and locate the crossover to minimize visibility to the public.
- Vegetation may be used to minimize visibility. Low vegetation, with a 3-foot year-round maximum height is recommended for this purpose. (See Chapter 1300).
- In locations where vegetation cannot be used to minimize visibility to the traveling public and there is a high incidence of unauthorized use; appropriate signing such as “No U-Turns” may be used to discourage unauthorized use.
- A stabilized all-weather surface is required. Urban crossovers for a high occupancy vehicle enforcement plan are usually paved. Paving at other types of crossovers may be paved when justified. Paving of crossings is determined on a case-by-case basis.

960.04 Approval

All approved crossover locations will be designated on the Statewide Master Plan for Median Crossovers. A committee consisting of the Assistant Regional Administrator for Operations or Project Development, the Washington State Patrol Assistant District Commander, the HQ Access Engineer and the FHWA Area Engineer or their designees, will be responsible for establishing and updating this plan as appropriate. Contact the Access and Hearings Unit for interim review and approvals for the following: proposed new crossings, relocation of previously approved crossings, or removal of crossings that are no longer necessary.

To expedite the team process, provide pictures of the existing crossings and the interchanges on a strip map. Include MP locations and spacing between existing and planned crossings and interchanges. The use of SR view at the team meeting helps the members determine which crossings may remain, which need to be relocated, and which to eliminate.

Regional Administrators or their designee, are responsible for the design and construction of median crossovers. Prior to construction of the opening, submit the documentation of the crossover need and the design data (together with a right of way plan showing the opening in red) to the State Design Engineer for right of way or limited access plan approval. Construction may not proceed prior to approval. (Refer to the DDP checklist.)

After notification of approval, the HQ Right of Way Plans Section sends the region a revised reproducible right of way or limited access plan which includes the approved crossover location.

960.05 Documentation

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

Chapter 1010 Auxiliary Lanes

1010.01 General

Auxiliary lanes are used to comply with capacity requirements; to maintain lane balance; to accommodate speed change, weaving, and maneuvering for entering and exiting traffic; or to encourage carpools, vanpools, and the use of transit.

For signing of auxiliary lanes, see the Traffic Manual and the MUTCD.

Although slow-vehicle turnouts, shoulder driving for slow vehicles, and chain-up areas are not auxiliary lanes they are covered in this chapter because they perform a similar function.

For additional information, see the following chapters:

Chapter	Subject
910	turn lanes
910	speed change lanes at intersections
940	speed change lanes at interchanges
940	collector-distributor roads
940	weaving lanes
1050	high occupancy vehicle lanes

1010.02 References

Laws – Federal and state laws and codes that may pertain to this chapter include:

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, Chapter 468-95 WAC, (MUTCD) http://wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Revised Code of Washington (RCW) 46.61, Rules of the Road

Design Guidance – Design guidance included by reference within the text includes:

Traffic Manual, M 51-02, WSDOT

Supporting Information – Other resources used or referenced in this chapter include:

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2001

Emergency Escape Ramps for Runaway Heavy Vehicles, FHWA-T5-79-201, March 1978

Highway Capacity Manual (Special Report 209), Transportation Research Board

NCHRP Synthesis 178, *Truck Escape Ramps*, Transportation Research Board

1010.03 Definitions

auxiliary lane The portion of the roadway adjoining the through lanes for parking, speed change, turning, storage for turning, weaving, truck climbing, passing, and other purposes supplementary to through-traffic movement.

climbing lane An auxiliary lane used for the diversion of slow traffic from the through lane.

design speed The speed used to determine the various geometric design features of the roadway.

emergency escape ramp A roadway leaving the main roadway designed for the purpose of slowing and stopping out-of-control vehicles away from the main traffic stream.

lane A strip of roadway used for a single line of vehicles.

lateral clearance The distance from the edge of traveled way to a roadside object.

operating speed The speed at which drivers are observed operating their vehicles during free-flow conditions. The 85th percentile of the distribution of observed speeds is most frequently used.

posted speed The maximum legal speed as posted on a section of highway using regulatory signs.

passing lane An auxiliary lane on a two-lane highway used to provide the desired frequency of safe passing zones.

roadway The portion of a highway, including shoulders, for vehicular use.

shoulder The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and use by pedestrians and bicycles.

slow-moving vehicle turnout A widened shoulder area to provide room for a slow-moving vehicle to pull safely out of the through traffic, allow vehicles following to pass, and return to the through lane.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

warrant A minimum condition for which an action is authorized. Meeting a warrant does not attest to the existence of an unsafe or undesirable condition. Further justification is required.

1010.04 Climbing Lanes

(1) General

Climbing lanes normally are associated with truck traffic, but they may also be considered in recreational or other areas that are subject to slow-moving traffic. Climbing lanes are designed independently for each direction of travel.

Generally, climbing lanes are provided when the requirements of two warrants speed reduction and level of service are exceeded. The requirements of either warrant may be waived if, for example, slow-moving traffic is demonstrably causing a high accident rate or congestion that could be corrected by the addition of a climbing lane. However, under most conditions, climbing lanes are built when the requirements of both warrants are satisfied.

(2) Warrant No. 1 - Speed Reduction

Figure 1010-2a shows how the percent and length of grade affect vehicle speeds. The data are based on a typical truck.

The maximum entrance speed, as reflected on the graphs, is 60 miles per hour. This is the maximum value regardless of the posted speed of the highway. When the posted speed is above 60 miles per hour, use 60 miles per hour in place of the posted speed. Examine the profile at least 1/4 mile preceding the grade to obtain a reasonable approach speed.

If a vertical curve makes up part of the length of grade, approximate the equivalent uniform grade length.

Whenever the gradient causes a 10 mile per hour speed reduction below the posted speed limit a for typical truck for either two-lane or multilane highways, the speed reduction warrant is satisfied (see Figure 1010-2b for an example).

(3) Warrant No. 2 - Level of Service (LOS)

The level of service warrant for two-lane highways is fulfilled when the upgrade traffic volume exceeds 200 vehicles per hour and the upgrade truck volume exceeds 20 vehicles per hour. On multilane highways, use Figure 1010-3.

(4) Design

When a climbing lane is justified, design it in accordance with Figure 1010-4. Provide signing and delineation to identify the presence of the auxiliary lane. Begin climbing lanes at the point where the speed reduction warrant is met and end them where the warrant ends for multilane highways and 300 feet beyond for two-lane highways. Consider extending the auxiliary lane over the crest to improve vehicle acceleration and sight distance.

Design climbing lane width equal to that of the adjoining through lane and at the same cross slope as the adjoining lanes. When ever possible, maintain the shoulder width for the class of highway. However, on two-way two-lane highways, the shoulder may be reduced to 4 feet, with justification.

1010.05 Passing Lanes

(1) General

Passing lanes are desirable where a sufficient number and length of safe passing zones do not exist and the speed reduction warrant for a climbing lane is not satisfied. Figure 1010-5 may be used to determine whether a passing lane is recommended.

(2) Design

When a passing lane is justified, design it in accordance with Figure 1010-6. Make the lane long enough to permit several vehicles to pass. Passing lanes longer than 2 miles can cause the driver to lose the sense that the highway is basically a two-lane facility. Where practicable, locate passing lanes on an upgrade to increase their efficiency.

Passing lanes are preferably four-lane sections; however, a three-lane section may be used. When a three-lane section is used, alternate the direction of the passing lane at short intervals to ensure passing opportunities for both directions and to discourage illegal actions of frustrated drivers.

Make the passing lane width equal to the adjoining through lane and at the same cross slope. Full-width shoulders for the highway class are preferred; however, with justification, the shoulders may be reduced to 4 feet. Provide adequate signing and delineation to identify the presence of an auxiliary lane.

1010.06 Slow-Moving Vehicle Turnouts

(1) General

On a two-lane highway where passing is unsafe, a slow-moving vehicle is required (See RCW 46.61.427) to turn off the through lane wherever a safe turnout exists, in order to permit the vehicles following to proceed. A slow-moving vehicle is one that is traveling at a speed less than the normal flow of traffic, behind which five or more vehicles are formed in a line.

A slow-moving vehicle turnout is not an auxiliary lane. Its purpose is to provide sufficient room for a slow-moving vehicle to safely pull out of through traffic and stop if necessary, allow vehicles following to pass, then return to the through lane. Generally, a slow-moving vehicle turnout is provided on existing roadways where passing opportunities are limited, where slow-moving vehicles such as trucks and recreational vehicles are predominant, and where the cost to provide a full auxiliary lane would be prohibitive.

(2) Design

Base the design of a slow-moving vehicle turnout primarily on sound engineering judgment and Figure 1010-7. Design may vary from one location to another. A minimum length of 100 feet provides adequate storage, since additional storage is provided within the tapers and shoulders. The maximum length is 1/4 mile including tapers. Surface turnouts with a stable unyielding material such as BST or HMA with adequate structural strength to support the heavier traffic.

Locate slow-moving vehicle turnouts where at least design stopping sight distance (See Chapter 650) is available, decision sight distance is preferred, so that vehicles can safely reenter the through traffic. Sign slow-moving vehicle turnouts to identify their presence.

When a slow-moving vehicle turnout is to be built, document the need for the turnout, the location of the turnout, and why it was selected over a passing or climbing lane.

1010.07 Shoulder Driving for Slow Vehicles

(1) General

For projects where climbing or passing lanes are justified, but are not within the scope of the project, or where meeting the warrants for these lanes is borderline, the use of a shoulder driving section is an alternative.

Review the following when considering a shoulder driving section:

- Horizontal and vertical alignment
- Character of traffic
- Presence of bicycles
- Clear zone (See Chapter 700)

(2) Design

When designing a shoulder for shoulder driving, locate where full design stopping sight distance (speed/path/direction decision sight distance is desirable) and a minimum length of 600 feet are available. Where practicable, avoid sharp horizontal curves. The minimum shoulder width is 10 feet, with 12 feet preferred. When barrier or other roadside objects are present, the minimum width is 12 feet. The shoulder width depends on the vehicles that will be using the shoulder. Where trucks will be the primary vehicle using the shoulder, use a 12-foot width; when passenger cars are the primary vehicle, a 10-foot width may be used. Shoulder driving and bicycles are not compatible. When the route has been identified as a local, state, or regional significant bike route, shoulder driving for slow vehicles is undesirable. Adequate structural strength for the anticipated traffic is necessary and may require reconstruction. Select locations where the side slope meets the requirements of Chapter 640 for new construction and Chapter 430 for existing roadways. When a transition is required at the end of a shoulder driving section, use a 50:1 taper.

Signing for shoulder driving is required. Install guideposts when shoulder driving is to be permitted at night.

Document the need for shoulder driving and why a lane is not being built.

1010.08 Emergency Escape Ramps

(1) General

Consider an emergency escape ramp whenever long, steep down grades are encountered. In this situation, the possibility exists of a truck losing its brakes and going out of control at a high speed. Consult local maintenance personnel and check traffic accident records to determine if an escape ramp is justified.

(2) Design

(a) ***Type.*** Escape ramps include the following types:

- Gravity escape ramps are ascending grade ramps paralleling the traveled way. They are commonly built on old roadways. Their long length and steep grade can present the driver with control problems, not only in stopping, but with rollback after stopping. Gravity escape ramps are the least desirable design.
- Sand pile escape ramps are piles of loose, dry sand dumped at the ramp site, usually not more than 400 feet in length. The deceleration is usually high and the sand can be affected by weather conditions; therefore, they are less desirable than arrester beds. However, where space is limited they may be suitable.
- Arrester beds are parallel ramps filled with smooth, free-draining gravel. They stop the out-of-control vehicle by increasing the rolling resistance. Arrester beds are commonly built on an up grade to add the benefit of gravity to the rolling resistance. However, successful arrester beds have been built on a level or descending grade.
- *The Dragnet Vehicle Arresting Barrier.* (See Chapter 710 for additional information.)

(b) ***Location.*** The location of an escape ramp will vary depending on terrain, length of grade, and roadway geometrics. The best locations include in advance of a critical curve, near the bottom of a grade, or before a stop. It is desirable that the ramp leave the roadway on a tangent at least 3 miles from the beginning of the down-grade.

(c) ***Length.*** Lengths will vary depending on speed, grade, and type of design used. The minimum length is 200 feet. Calculate the stopping length using the following equation:

$$L = \frac{V^2}{0.3(R \pm G)}$$

Where:

L = stopping distance (ft)
V = entering speed (mph)
R = rolling resistance (see Figure 1010-1)
G = grade of the escape ramp (%)

Speeds of out-of-control trucks rarely exceed 90 mph; therefore, an entering speed of 90 mph is preferred. Other entry speeds may be used when justification and the method used to determine the speed are documented.

Material	R
Roadway	1
Loose crushed aggregate	5
Loose noncrushed gravel	10
Sand	15
Pea gravel	25

Rolling Resistance (R)
Figure 1010-1

(d) ***Width.*** The width of each escape ramp will vary depending on the needs of the individual situation. It is desirable for the ramp to be wide enough to accommodate more than one vehicle. The desirable width of an escape ramp to accommodate two out-of-control vehicles is 40 feet and the minimum width is 26 feet.

(e) The following items are additional considerations in the design of emergency escape ramps:

- If possible, at or near the summit, provide a pull-off brake-check area. Also, include informative signing about the upcoming escape ramp in this area.
- A free-draining, smooth, noncrushed gravel is preferred for an arrester bed. To assist in smooth deceleration of the vehicle, taper the depth of the bed from 3 inches at the entry to a full depth of 18 to 30 ininches in not less than 100 feet.
- Mark and sign in advance of the ramp. Discourage normal traffic from using or parking in the ramp. Sign escape ramps in accordance with the guidance contained in the MUTCD for runaway truck ramps.
- Provide drainage adequate to prevent the bed from freezing or compacting.
- Consider including an impact attenuator at the end of the ramp if space is limited.
- A surfaced service road adjacent to the arrester bed is needed for wreckers and maintenance vehicles to remove vehicles and make repairs to the arrester bed. Anchors are desirable at 300-foot intervals to secure the wrecker when removing vehicles from the bed.

A typical example of an arrester bed is shown in Figure 1010-8.

Include justification, all calculations, and any other design considerations in the documentation of an emergency escape ramp documentation.

1010.09 Chain-Up Areas

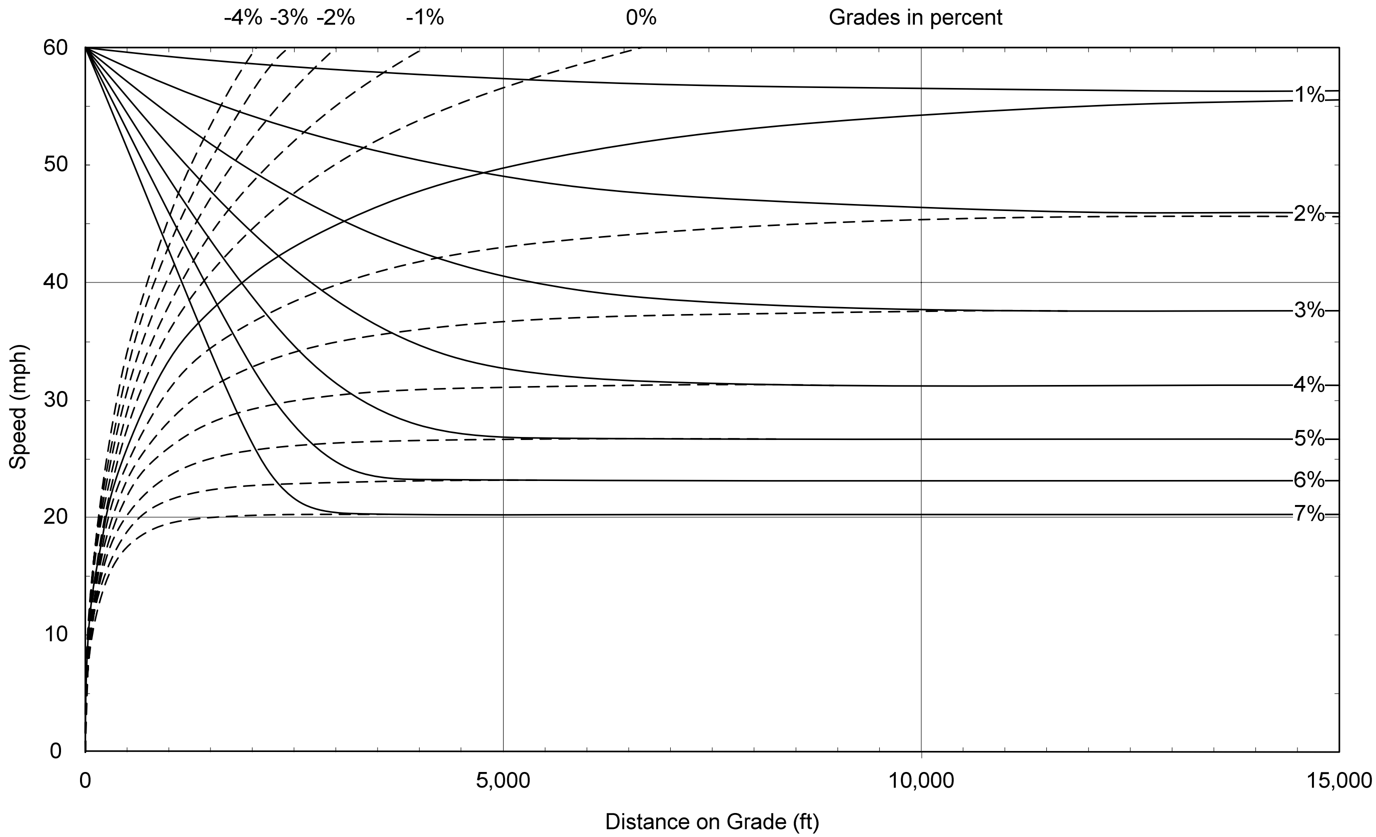
Provide chain-up areas to allow chains to be put on vehicles out of the through lanes at locations where traffic enters chain enforcement areas. Provide chain-off areas to remove chains out of the through lanes for traffic leaving chain enforcement areas.

Chain-up or chain-off areas are widened shoulders, designed as shown in Figure 1010-9. Locate chain-up and chain-off areas where the grade is 6% or less and preferably on a tangent section.

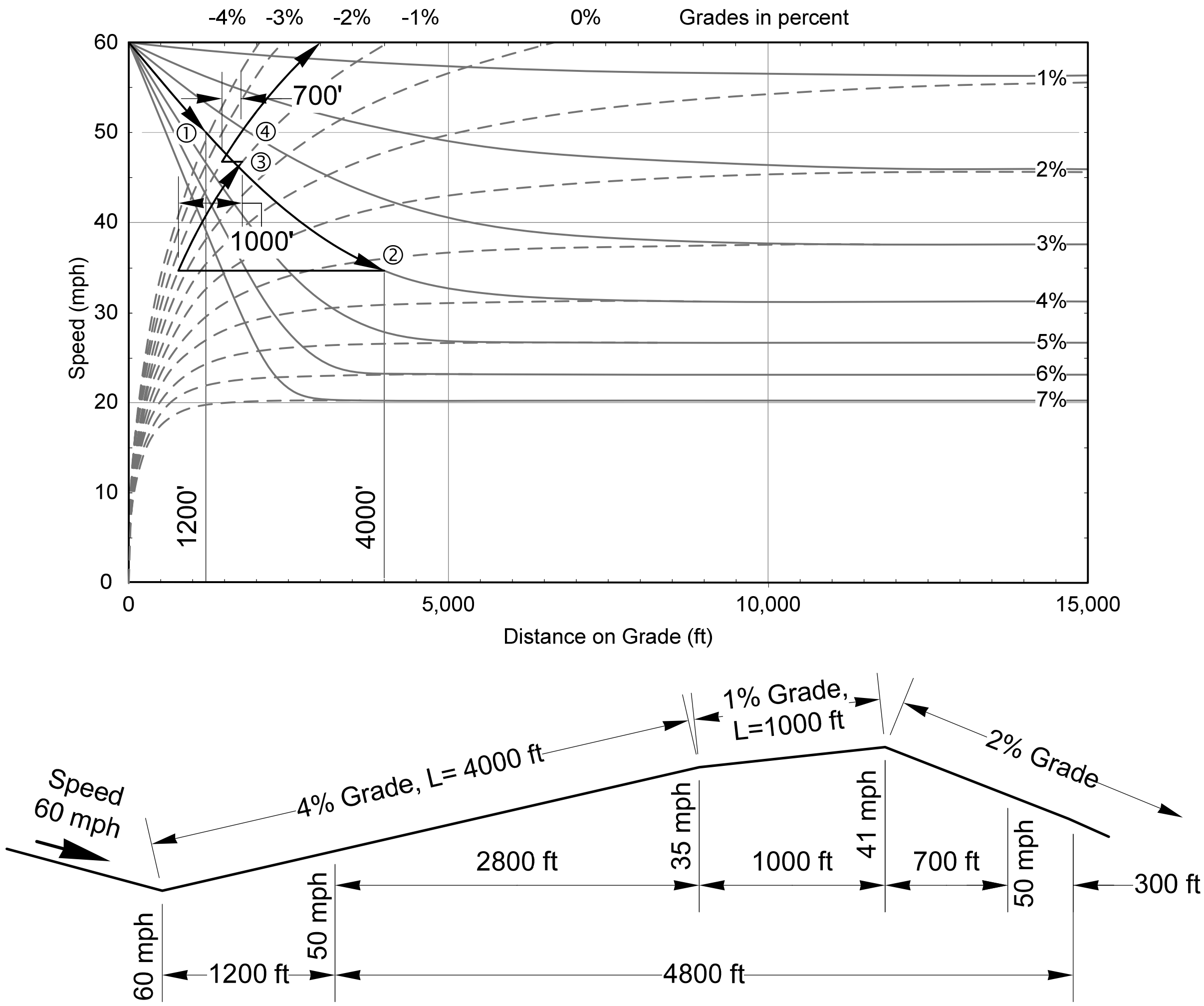
Consider illumination for chain-up and chain-off areas on multilane highways. When deciding whether or not to install illumination, consider traffic volumes during the hours of darkness and the availability of power.

1010.10 Documentation

The list of documents required to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/



Speed Reduction Warrant (Performance for Trucks)
Figure 1010-2a



Given:

A two-lane highway meeting the level of service warrant, with the above profile, and a 60 mph posted speed.

Determine:

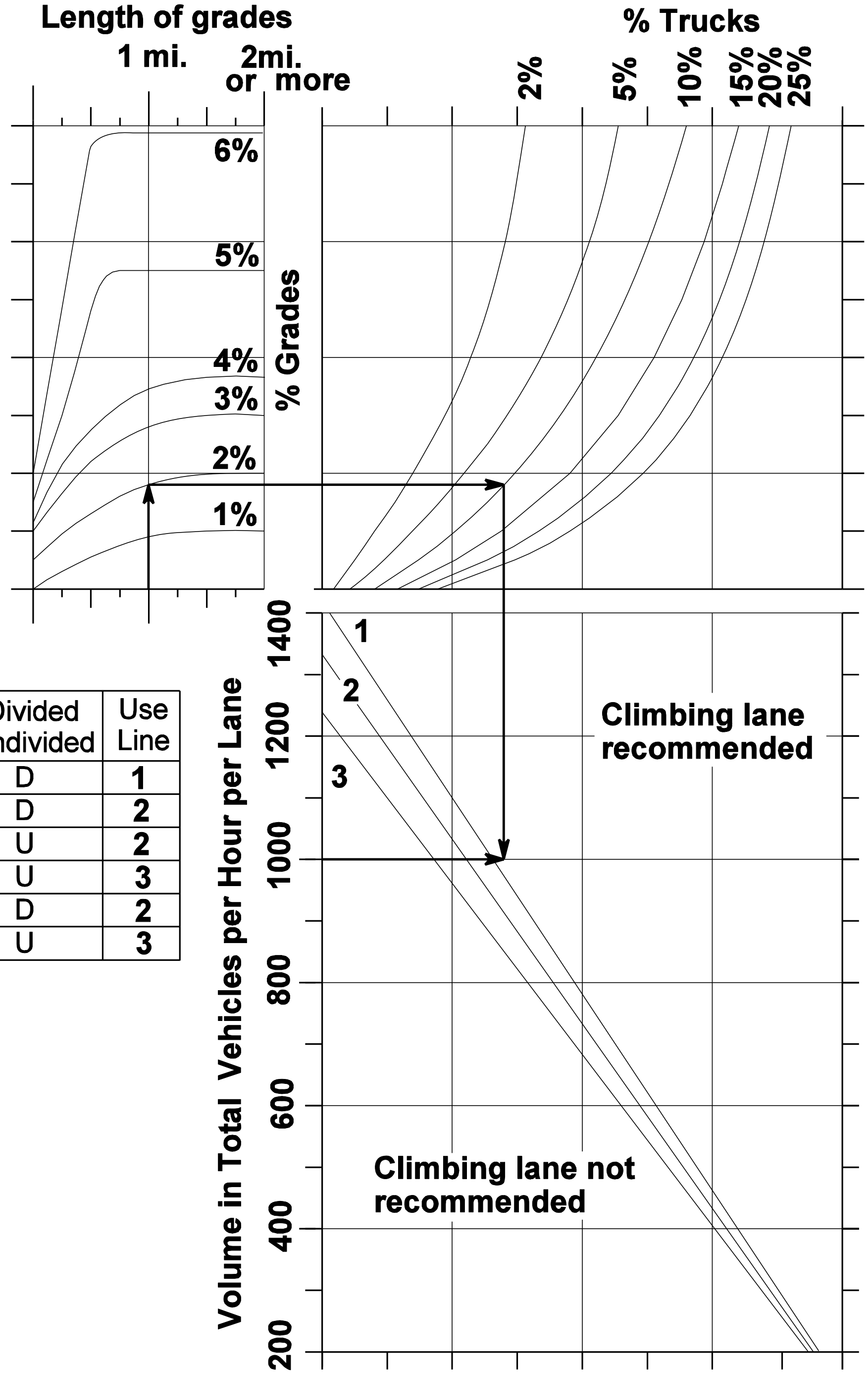
Is the climbing lane warranted and, if so, what length?

Solution:

1. Follow the 4% grade deceleration curve from a speed of 60 mph to a speed of 50 mph at 1,200 feet. The speed reduction warrant is met and a climbing lane is needed.
2. Continue on the 4% grade deceleration curve to 4,000 feet. Note that the speed at the end of the 4% grade is 35 mph.
3. Follow the 1% grade acceleration curve from a speed of 35 mph for 1,000 feet. Note that the speed at the end of the 1% grade is 41 mph.
4. Follow the -2% grade acceleration curve from a speed of 41 mph to a speed of 50 mph, ending the speed reduction warrant. Note the distance required is 700 feet.
5. The total auxiliary lane length is (4,000-1,200)+1,000+700+300=4,800 feet. 300 feet is added to the speed reduction warrant for a two-lane highway. (See the text and Figure 1010-4.)

Speed Reduction Warrant (Example)

Figure 1010-2b

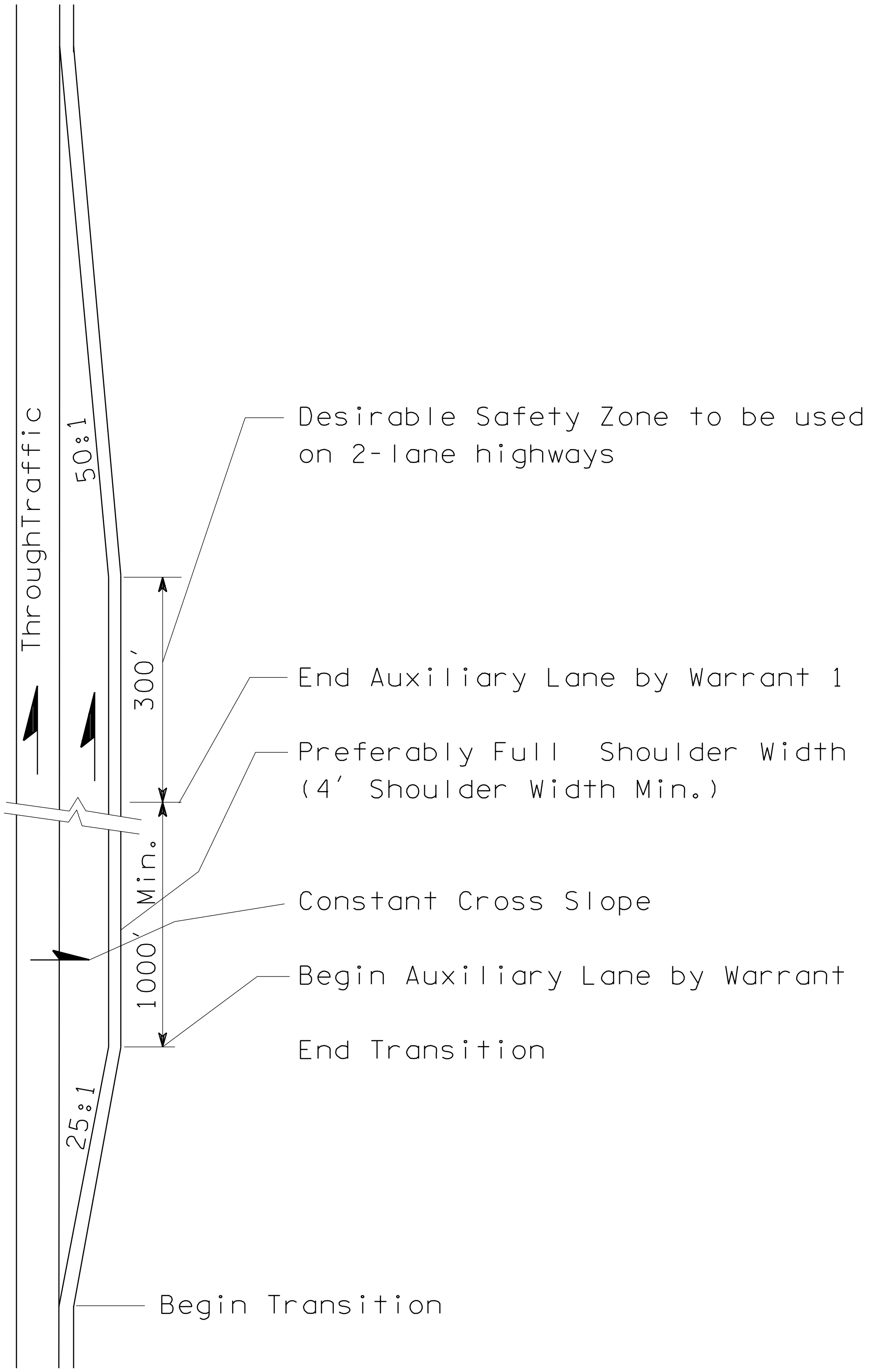


Lane Width	Lateral Clearance	Divided Undivided	Use Line
12	≥ 6	D	**1**
12	< 6	D	**2**
12	≥ 6	U	**2**
12	< 6	U	**3**
11	All	D	**2**
11	All	U	**3**

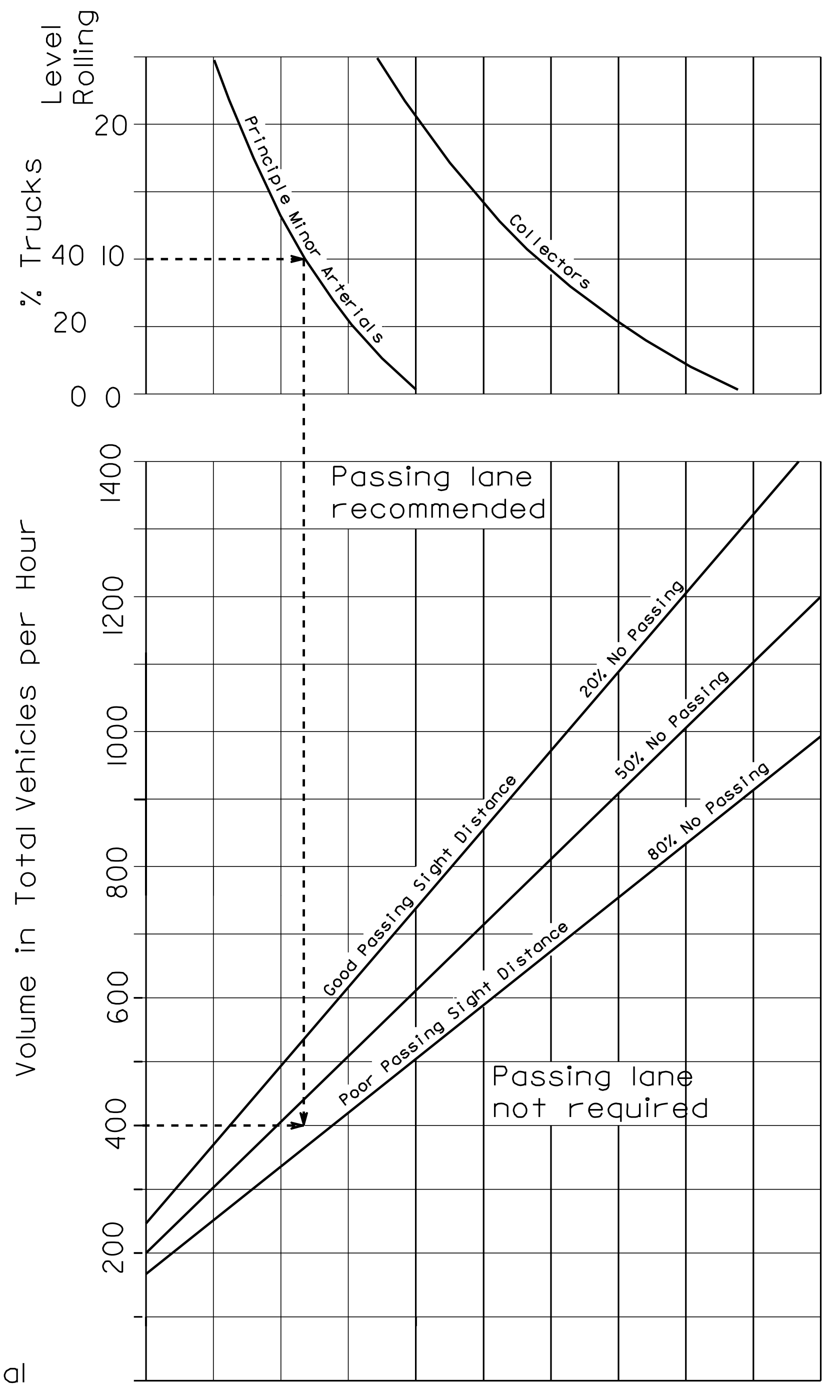
Example

2% grade for 1 Mile
10% Trucks
12' Lanes
Lateral Clearance
≥ 6'
4 Lane, Divided
DDHV = 2000
From the chart,
climbing lane
is recommended

Level of Service Warrant - Multilane
Figure 1010-3



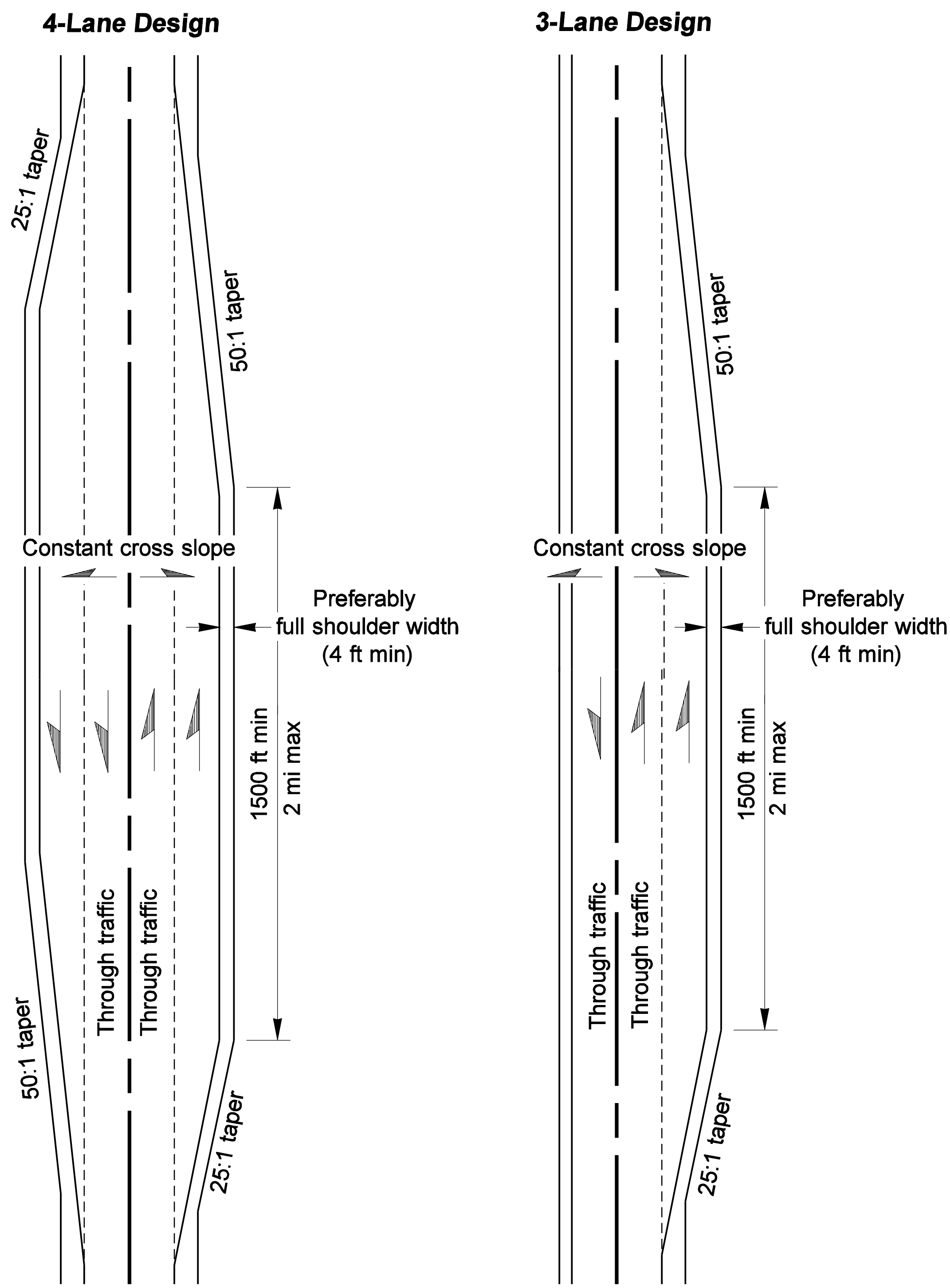
Auxiliary Climbing Lane
Figure 1010-4



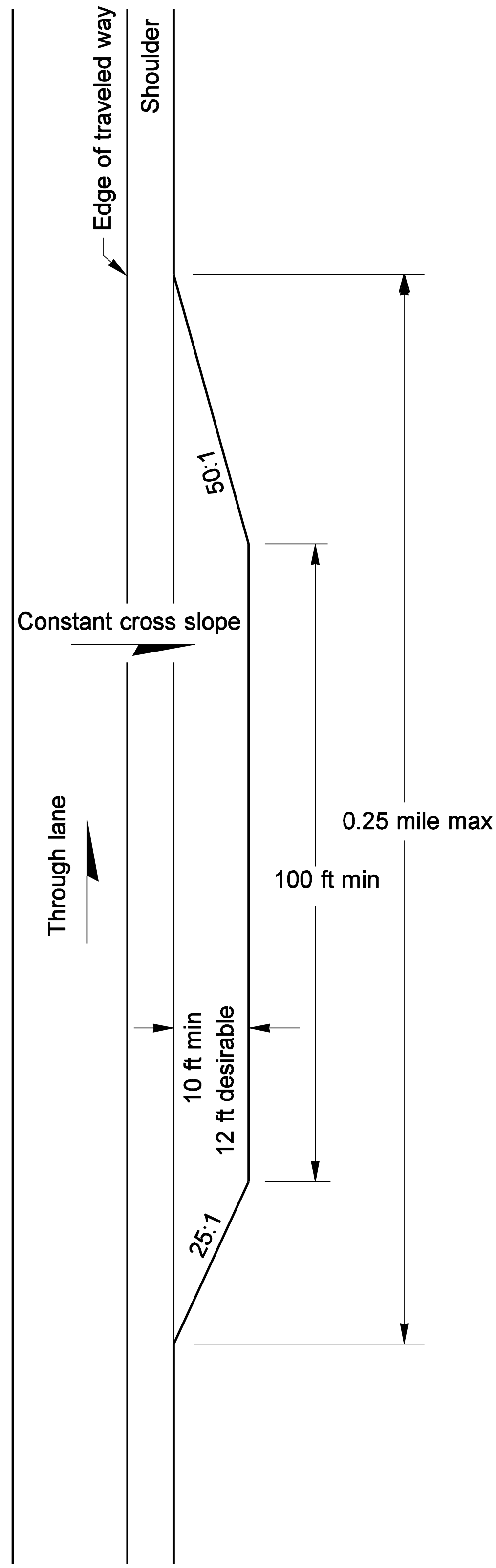
EXAMPLE

For a Minor Arterial
Given: DHV=400 VPH
10% Trucks
50% No Passing Zones
Rolling Terrain
From the Chart, Passing Lane NOT Required.

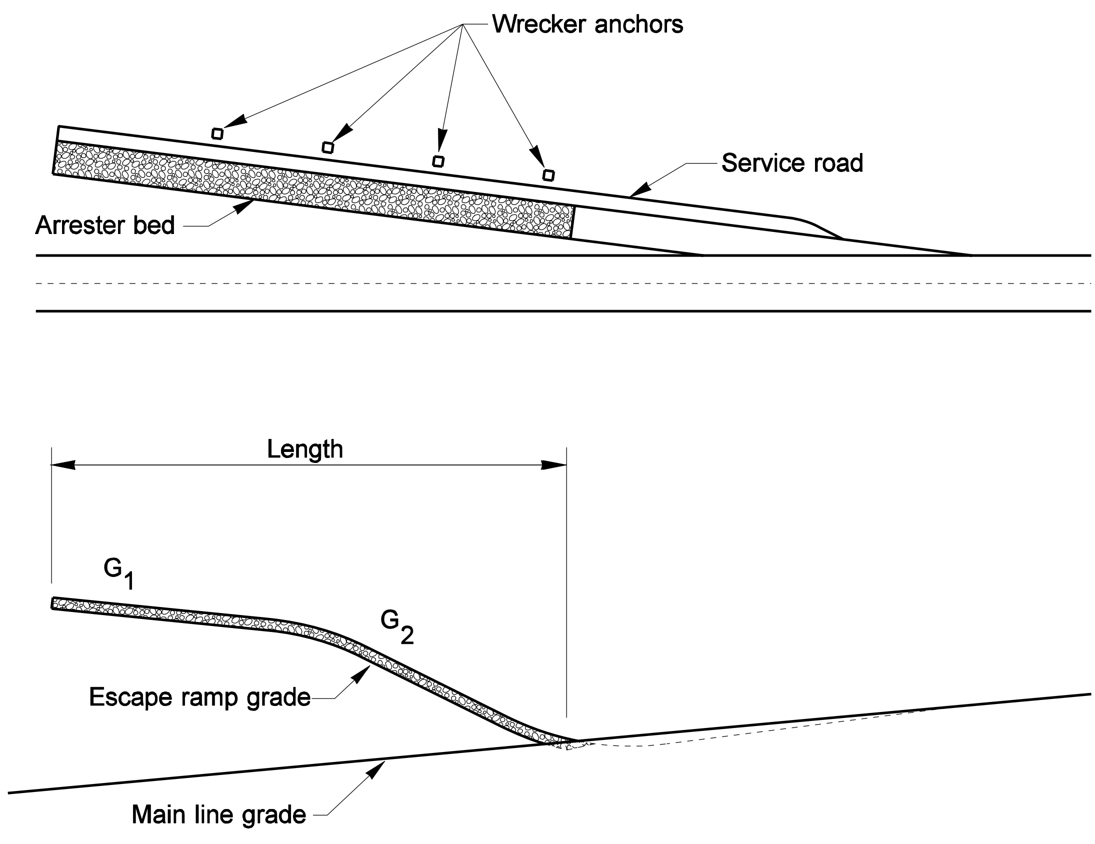
Warrant for Passing Lanes
Figure 1010-5



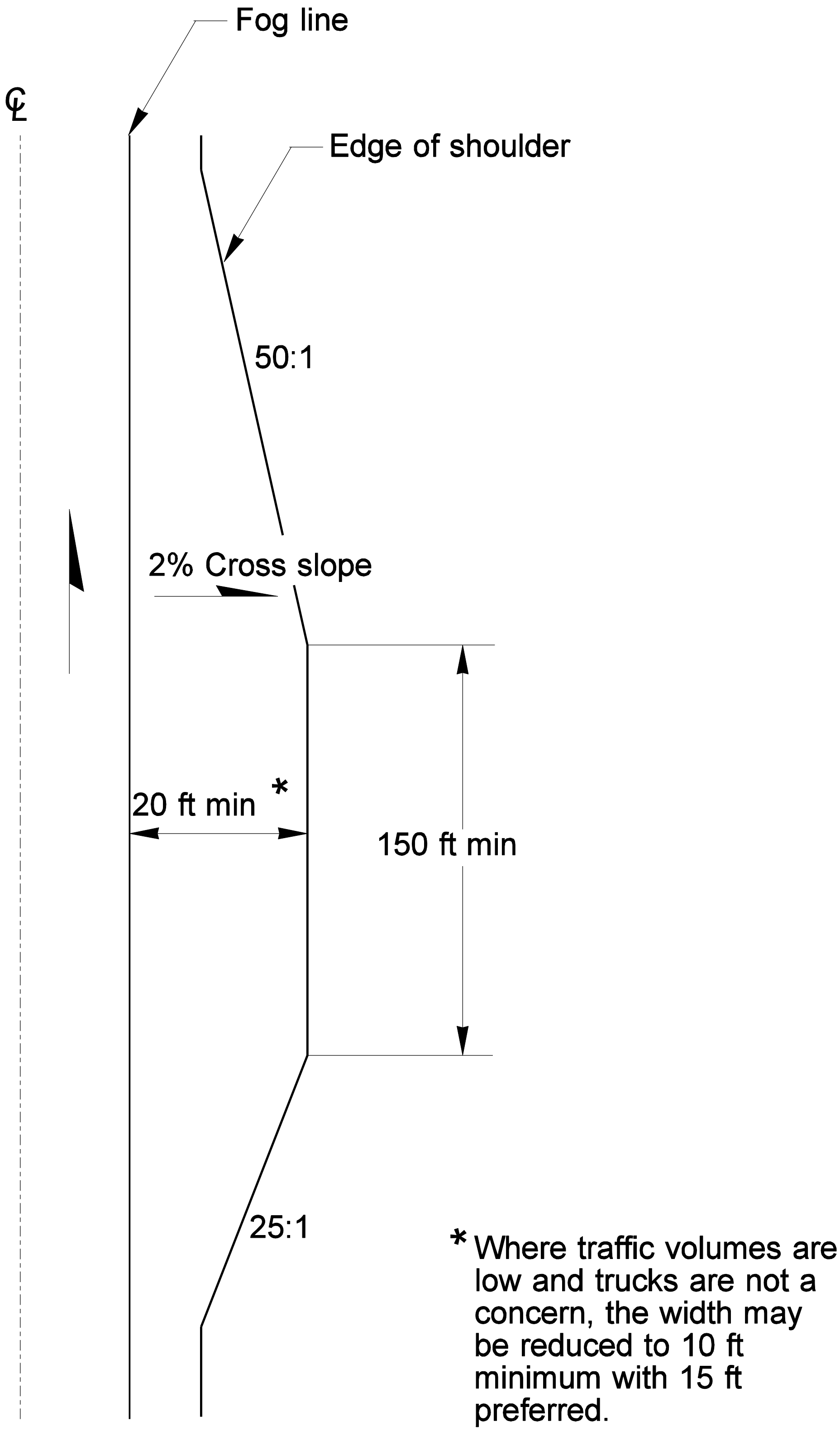
Auxiliary Passing Lane
Figure 1010-6



Slow-Moving Vehicle Turnout
Figure 1010-7



Typical Emergency Escape Ramp
Figure 1010-8



Chain Up/Chain Off Area
Figure 1010-9

Chapter 1020 Bicycle Facilities

1020.01 General

The Washington State Department of Transportation (WSDOT) encourages bicycle use on its facilities, except where prohibited by law. Bicycle facilities or improvements for bicycle transportation are included in the project development and highway programming processes.

This chapter is to serve as a guide for designing the most useful, cost-effective, and safe bicycle facilities when the design matrices (see Chapter 325) indicate full design level for bicycle and pedestrian design elements. These guidelines apply to normal situations encountered during project development. Unique design problems are resolved on a project-by-project basis using guidance from the region's Bicycle Coordinator or bicycle and pedestrian expert.

State law (RCW 46.61.710) prohibits the operation of mopeds on facilities specifically designed for bicyclists, pedestrians, and equestrians. Mopeds and other motorized personal assistive mobility devices (excluding power wheelchairs) are not considered in the design process for the purposes of this chapter.

In general, do not mix equestrian and bicycle traffic on a shared-use path. Consider designing an equestrian trail that is separate from the shared-use path in common equestrian corridors.

1020.02 References

Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA)

23 Code of Federal Regulations (CFR) Part 652, Pedestrian and Bicycle Accommodations and Projects

Revised Code of Washington (RCW), Chapter 35.75, Streets – Bicycles – Paths

Chapter 46.04 RCW, Definitions

Chapter 46.61 RCW, Rules of the Road

RCW 46.61.710, Mopeds, electric-assisted bicycles – General requirements and operation

RCW 47.26.300, Bicycle routes – Legislative declaration

Washington Administrative Code (WAC) Chapter 468-95, "Manual on uniform traffic control devices for streets and highways" (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Design Guidance

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by WAC 468-95

Selecting Roadway Design Treatments to Accommodate Bicycles, USDOT, Federal Highway Administration (FHWA), 1994

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT http://www.wsdot.wa.gov/eesc/design/designstandards/

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005 http://www.wsdot.wa.gov/eesc/design/Urban/Default.htm

Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2004

Designing Sidewalks and Trails for Access, Part I of II, FHWA, 2001

Guide for the Development of Bicycle Facilities, AASHTO, 1999

1020.03 Definitions

bicycle Every device propelled solely by human power upon which a person or persons may ride, having two tandem wheels, either of which is 16 inches or more in diameter, or three wheels, any one of which is more than 20 inches in diameter.

bicycle route A system of facilities that are used or have a high potential for use by bicyclists or that are designated as such by the jurisdiction having the authority. A series of bicycle facilities may be combined to establish a continuous route and may consist of any or all types of bicycle facilities.

bike lane A portion of a highway or street identified by signs and pavement markings as reserved for bicycle use.

shared roadway A roadway that is open to both bicycle and motor vehicle travel. This may be an existing roadway, a street with wide curb lanes, or a road with paved shoulders.

signed shared roadway A shared roadway that has been designated by signing as a route for bicycle use.

shared-use or multiuse path A facility physically separated from motorized vehicular traffic within the highway right of way or on an exclusive right of way with minimal crossflow by motor vehicles. It is designed and built primarily for use by bicycles, but is also used by pedestrians, joggers, skaters, wheelchair users (both nonmotorized and motorized), equestrians, and other nonmotorized users.

wye (Y) connection An intersecting one-way roadway, intersecting at an angle less than 60°, in the general form of a "Y."

1020.04 Facility Selection

(1) Facility Location

Provide bicycle facilities on routes that have been identified as a local, state, or regional significant bike route. Fill gaps in the existing network of bicycle facilities when the opportunity is available. For all other roadways, provide full design level shoulders for bicycle needs, unless:

- Bicyclists are prohibited by law from using the facility.
- The cost is excessively disproportionate to the need or probable use.
- Other factors indicate there is no need.

For additional information, see *Understanding Flexibility in Transportation Design – Washington*.

(2) Selection of the Type of Facility

Selection of the facility type includes consideration of community needs and safe and efficient bicycle travel. A generalized method of assessing the type of bicycle facility needed can be found in Figure 1020-1.

Roadway Classification, Land Use, Speed, and ADT	Facility Recommendation
Rural and suburban highways and streets (less than 4 dwelling units per acre), speeds above 25 mph, and ADT above 2000.	Full design level shoulder (see Chapter 440) on both sides (4 ft minimum width), or shared-use path.
Major arterial in residential area; school zones; streets in commercial or industrial areas.	Bike lanes on both sides (see 1020.07), or shared-use path.
Local street in residential area where speed is 25 mph or less, or ADT is 2000 or less. Rural highways and streets where sight distance is adequate for passing, and speed is 25 mph or less or ADT is 2000 of less. Collector or minor arterial where speed is 25 mph or less, or ADT is 2000 or less.	Shared roadway.

Bike Facility Selection
Figure 1020-1

An important consideration is route continuity. Change facility types at logical locations.
For additional information, see *Understanding Flexibility in Transportation Design – Washington*.

1020.05 Project Requirements

For urban bicycle mobility improvement projects (see Bike/Ped connectivity projects in the matrices, Chapter 325), apply the guidance in this chapter to the bicycle facility.

For highway design elements affected by the project, apply the appropriate design level from the matrices (see Chapter 325) and as found in the applicable chapters.

For highway design elements not affected by the project, no action is required.

1020.06 Shared-Use Path Design

When designing shared-use paths (see Figure 1020-2), accommodate all users and minimize conflicts. When equestrians are present, a separate bridle trail along a shared-use path is recommended to minimize conflicts with horses. Some common locations are along rivers, streams, ocean beachfronts, canals, utility rights of way, and abandoned railroad rights of way; within college campuses; and within and between parks. Another common application of shared-use paths is to close gaps in the bicycle network. There might also be situations where such facilities can be provided as part of planned developments.

Shared-use paths often provide recreational opportunities. They also serve to minimize motor vehicle interference by providing direct bicycle commute routes.

Shared-Use Path
Figure 1020-2

(1) Widths

The desirable width of a shared-use path is 12 feet. The minimum width is 10 feet. Use 12 to 14 feet when maintenance vehicles use a shared-use path as an access road for utilities. Use of 12- to 14-foot paths is recommended when there will be substantial use by bicyclists, or joggers, skaters, and pedestrians. Contact the region's Bicycle Coordinator for bicycle use information. (See Figures 1020-11a and 11b for additional information and cross sections.)

An existing path with a width of 8 feet may remain when all the following conditions apply:

- Bicycle traffic is expected to be low
- Pedestrian use is not expected to be more than occasional
- The horizontal and vertical alignment adequately provide safe and frequent passing opportunities
- Normal maintenance activities can be performed without damaging the pavement edge

For path width on structures, see 1020.06(14).

(2) Horizontal Clearance to Obstructions

The desirable horizontal clearance from the edge of pavement to an obstruction (such as bridge piers or guardrail) is at least 2 feet. Where this clearance cannot be obtained, install signs and pavement markings to warn bicyclists of the condition. (For pavement marking details, see the MUTCD and the Standard Plans.)

Where a shared-use path is adjacent to canals, ditches, fill slopes steeper than 3H:1V, or where hazards exist at the bottom of an embankment, consider a minimum 5-foot separation from the edge of the pavement. A physical barrier, such as dense shrubbery, railing, or chain link fence, is needed at the top of a high embankment. When barrier or railing is installed, see 1020.06(6).

(3) Vertical Clearance

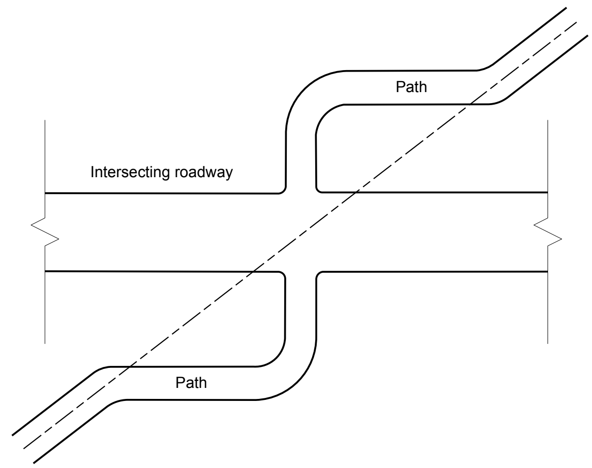
Provide a vertical clearance of 10 feet or more from bikeway pavement to overhead obstructions. The vertical clearance may be reduced to an 8-foot minimum, with justification. A 10-foot or higher vertical clearance is needed for the passage of equestrians and for maintenance and emergency vehicles.

(4) Intersections With Roadways

Shared-use path and roadway intersections must clearly define who has the right of way and provide adequate sight distance for all users. There are three types of shared-use path/roadway at-grade intersection crossings: adjacent path, midblock, and complex. Only at-grade adjacent and midblock crossings are addressed here. Complex intersections involve special designs that must be considered on a case-by-case basis. Contact the region's Bicycle Coordinator for assistance.

Adjacent path crossings are located adjacent to the at-grade intersections of two roadways. These crossings are normally placed with pedestrian crossings, where motorists can be expected to stop. If alternate intersection locations for a shared-use path are available, select the one with the greatest sight distance.

Midblock crossings are located between roadway intersections. They are the least complex of the crossing types. When possible, locate the path crossings far enough away from intersections to minimize conflicts between the path crossing and the intersection motor vehicle traffic. A 90° crossing is preferable; however, a 75° angle is acceptable. A 45° angle is the minimum acceptable to minimize right of way requirements. A diagonal midblock crossing can be altered as shown in Figure 1020-3. (See the MUTCD and the Standard Plans for signing and pavement marking requirements, and Chapter 1025 for pedestrian and ADA requirements.)



Note: Path and highway signing and markings are given in the MUTCD and the Standard Plans.

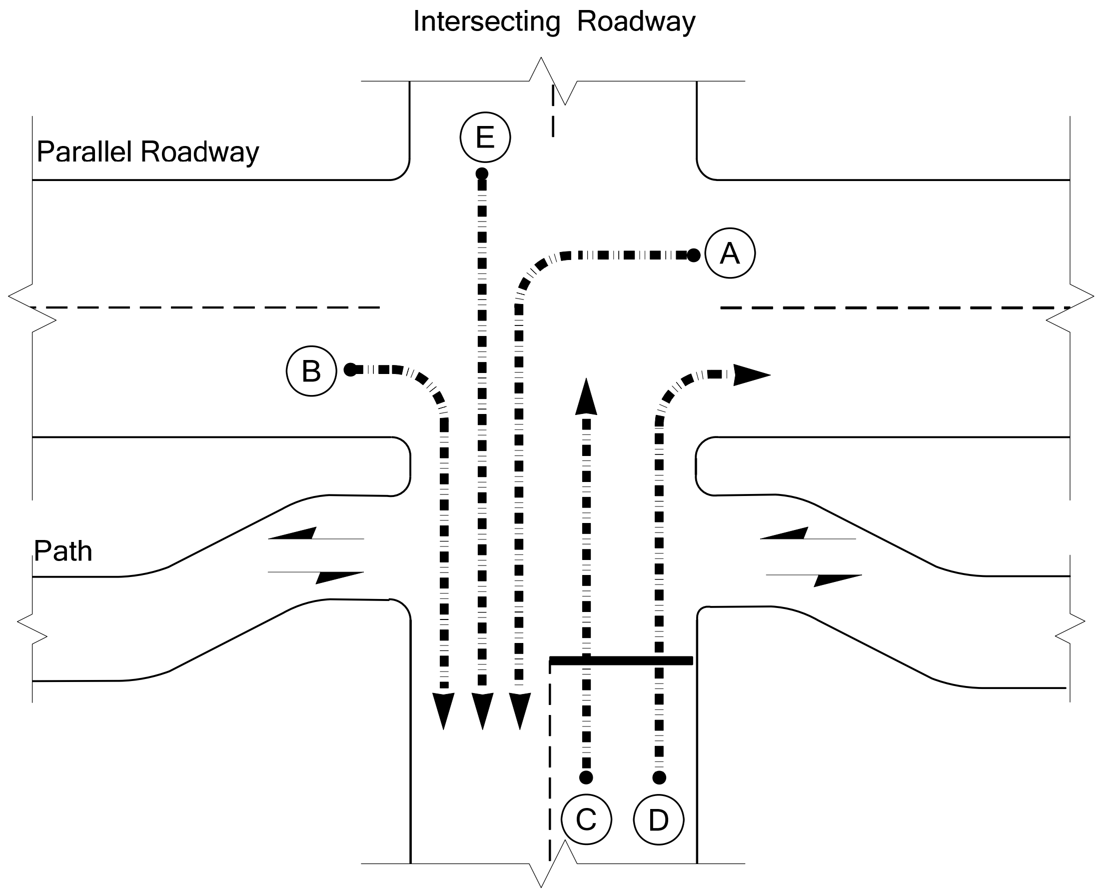
Typical Redesign of a Diagonal Midblock Crossing
Figure 1020-3

There are other considerations when designing midblock crossings, including traffic right of way assignments, traffic control devices, sight distances for both bicyclists and motor vehicle operators, refuge island use, access control, and pavement markings.

Adjacent path crossings occur where a path crosses an existing intersection of two roadways, a T intersection (including driveways), or a four-way intersection, as shown in Figure 1020-4. It is preferable to integrate this type of crossing close to an intersection so that motorists and path users recognize one another as intersecting traffic. The path user faces potential conflicts with motor vehicles turning left (A) and right (B) from the parallel roadway, and on the crossed roadway (C, D, and E).

Complex intersection crossings are all other types of path/roadway or driveway junctions. These include a variety of configurations where the path crosses directly through an existing intersection of two or more roadways and where there can be any number of motor vehicle turning movements.

Improvements to complex crossings must be considered on a case-by-case basis. Suggested improvements include: move the crossing, install a signal, change signalization timing, or provide a refuge island and make a two-step crossing for path users.



Note: Signing requirements are given in the MUTCD and the Standard Plans.

Adjacent Shared-Use Path Intersection
Figure 1020-4

The major road might be either the parallel or the crossed roadway. Important elements that greatly affect the design of these crossings are traffic right of way assignments, traffic control devices, and the separation distance between path and roadway.

Other roadway/path intersection design considerations include:

- **Traffic Signals/Stop Signs.** Determine the need for traffic control devices at all path/roadway intersections by using MUTCD warrants and engineering judgment. Bicycles are considered vehicles in Washington State, and bicycle path traffic can be classified as vehicular traffic for MUTCD warrants. Ensure that traffic signal timing is set for bicycle speeds.
- **Signal Actuation Mechanisms.** Place the manually operated signal button in a location that complies with ADA requirements. For additional information, see Chapters 850 and 1025. A detector loop in the path pavement may be provided in addition to the manually operated signal button. Consider MUTCD bicycle detector symbol pavement marking when a detector loop is placed in the path.
- **Signing.** Sign type, size, and location must be in accordance with the MUTCD. Place path stop or yield signs as close to the intended stopping point as possible. Do not place the shared-use path signs where they will confuse motorists or place roadway signs where they will confuse bicyclists. For additional information on signing, see the MUTCD and Chapter 820.

- **Approach Treatments.** Design shared-use path and roadway intersections with flat grades and adequate sight distances. Provide adequate advance warning signs and pavement markings (see the MUTCD) that alert and direct bicyclists to yield or stop before reaching the intersection, as appropriate, especially on downgrades. Provide unpaved shared-use paths with paved aprons extending a minimum of 10 feet from the paved road surfaces. Do not use speed bumps or other similar surface obstructions intended to cause bicyclists to slow down.
- **Sight Distance.** Sight distance is a principal element of roadway and path intersection design. At a minimum, provide stopping sight distance for both the roadway and the path at the crossing. Decision sight distance is preferred for the roadway traffic. (See Chapter 650 for stopping sight distance for the roadway and 1020.06(9) for shared-use path stopping sight distance.)
- **Transition Zones.** Integrate the shared-use path into the roadway where the path terminates. Design these terminals to transition the bicycle traffic into a safe merging or diverging condition. Appropriate signing is necessary to warn and direct both bicyclists and motorists.
- **Curb Ramp Widths.** Design curb ramps with a width equal to the shared-use path width. Curb ramps and barrier-free passageways are to provide a smooth transition between the shared-use path and the roadway. Consider a 5-foot radius or flare to facilitate right turns for bicycles. This same consideration applies to the intersections of two shared-use paths. Curb ramps at path/roadway intersections must meet the requirements for sidewalk curb ramp at a crosswalk. For design requirements, see Chapter 1025, and for curb ramp treatments at roundabouts, see Chapter 915.
- **Refuge Islands.** Consider refuge islands when one or more of the following applies: high motor vehicle traffic volume and speeds; wide roadways; or the crossing will be used by the elderly, children, the disabled, or other slow-moving users. (See Figure 1020-12 for details.)

(5) At-Grade Railroad Crossings

Whenever a bikeway crosses railroad tracks, continue the crossing at least as wide as the approach bikeway. Use special construction and materials to keep the flangeway depth and width to a minimum. Wherever possible, design the crossing at right angles to the rails. (See Figure 1020-13.) For on-street bikeways where a skew is unavoidable, widen the shoulder (or bike lane) to permit bicyclists to cross at right angles. (See Figure 1020-13.)

For signing and pavement marking for a shared-use path crossing a railroad track, see the MUTCD and the Standard Plans.

(6) Separation, Barrier, and Fencing

When possible, provide a wide separation between a shared-use path and the roadway's traveled way where the path is located near a roadway. (See 1020.06(2).)

If the shared-use path is inside the Design Clear Zone, provide a concrete traffic barrier. (See Figure 1020-11b.) A concrete barrier presents less of a hazard to bicyclists than beam guardrail and is preferred. However, if the edge of the path is farther than 10 feet from the barrier, a beam guardrail is also acceptable. For Design Clear Zone guidance, see Chapter 700, and for barrier location and deflection, see Chapter 710.

All barrier and railing adjacent to a shared-use path must meet the requirements for pedestrians. (See Chapter 1025.) When the edge of the path is within 5 feet of a barrier or railing, provide a taller barrier (a minimum of 42 inches) to reduce the potential for bicyclists falling over the barrier. For barrier between the path and a roadway, if the roadway shoulder is 6 feet or wider, additional barrier height is not required. The 42-inch height applies to railing required per 1020.06(2). (See Figures 1020-14a and 14b.)

Where the path is to be located next to a limited access facility, provide an access barrier. Where space permits, provide fencing as described in Chapter 1460, in conjunction with a normal height barrier. Otherwise, provide a taller barrier (54-inch minimum height).

Fencing between a shared-use path and adjacent property may also be necessary to restrict access to the private property. Discuss the need for fencing and the appropriate height with the property owners during project design.

On structures, the bridge railing type and height are part of the structure design. Contact the Headquarters (HQ) Bridge and Structures Office for additional information. (See Chapter 1120 for further considerations.)

Evaluate the impacts of barriers and fencing on sight distances.

(7) Design Speed

The design speed for a shared-use path is dependent on the expected conditions of use and on the terrain. Design the path to encourage bicycles to maintain speeds at or below the speeds shown in Figure 1025-5. Higher speeds are inappropriate in a mixed-use setting.

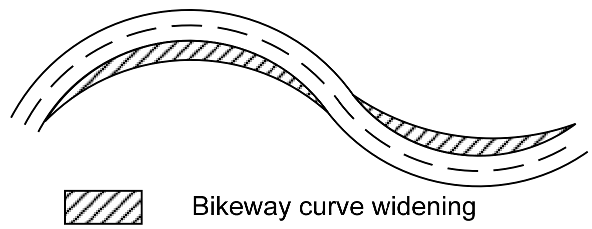
Conditions	Design Speed (mph)	Min. Curve Radius (ft)
Open country (level or rolling); shared-use path in urban areas	20	90
Long downgrades (steeper than 4% and longer than 500 ft)	30	260

Bicycle Design Speeds
Figure 1020-5

(8) Horizontal Alignment and Cross Section

On tangent path sections, the recommended cross slope is 2%. The maximum superelevation is also 2%. A greater superelevation can cause maneuvering difficulties for adult tricyclists and wheelchair users. (See Figures 1020-11a and 11b.)

When radii less than given in Figure 1020-5 are required, increase pavement width by up to 4 feet on the inside of a curve to compensate for bicyclist lean. (See Figure 1020-6.) For sharp curves on two-way facilities, consider providing centerline pavement markings.



Radius (ft)	Additional Pavement Width (ft)
0 – 25	4
25 – 50	3
50 – 75	2
75 – 100	1
100 +	0

Bikeway Curve Widening
Figure 1020-6

(9) Stopping Sight Distance

Figure 1020-15 gives the minimum stopping sight distances for various design speeds and grades.

(10) Sight Distance on Crest Vertical Curves

Figure 1020-16 gives the minimum lengths of crest vertical curves for varying design speeds. The values are based on a 4.5-foot eye height for the bicyclist and a 0-foot height for the object (roadway surface).

(11) Sight Distance on Horizontal Curves

Figure 1020-17 indicates the minimum clearances to line-of-sight obstructions for sight distance on horizontal curves. Calculate the required lateral clearance based on the sum of stopping sight distances from Figure 1020-15 for bicyclists traveling in both directions and the proposed horizontal curve radius. Where this minimum clearance cannot be obtained, provide curve warning signs and use centerline pavement markings in accordance with the MUTCD.

(12) Grades

Some pedestrians, people with disabilities, and bicyclists are unable to negotiate long, steep grades. The maximum grade recommended for a shared-use path is 5%. It is desirable that sustained grades (800 feet or longer) be limited to 2% to accommodate a wide range of users. When shared-use paths must be made steeper, minimize the lengths of segments greater then 5% and keep them free of other access barriers. It is desirable that the total running slope not exceed 8.3% for 30% or more of the path. A shared-use path must meet the grade and resting area requirements for a sidewalk on an independent alignment. (See Chapter 1025.)

Grades steeper than 3% might not be feasible for shared-use paths with crushed stone or other unpaved surfaces for both bicycle handling and traction, and for drainage and erosion reasons.

Options to mitigate steep grades are:

- When using a steeper grade, add an additional 4 to 6 feet of width to permit slower-speed maneuverability and to provide a place where bicyclists can dismount and walk.
- Use signing in accordance with the MUTCD to alert bicyclists of the steep downgrades and the need to control their speeds.
- Provide adequate stopping sight distance.
- Increase horizontal path side clearances (4 to 6 feet is recommended), and provide adequate recovery area or railing.

(13) Pavement Structural Section

Design the pavement structural section of a shared-use path in the same manner as a highway, considering the quality of the subgrade and the anticipated loads on the bikeway. Design loads will normally be from maintenance and emergency vehicles. Provide a smooth pavement surface to address safety and comfort issues.

Unless otherwise justified, use hot mix asphalt (HMA) pavement or Portland cement concrete pavement in the construction of a shared-use path. The desirable minimum HMA thickness is 0.20 feet. Design the final pavement structural section as recommended by the region's Materials Engineer.

Contact the HQ Materials Laboratory for determination of the subgrade R value.

R Value	Subsurfacing Thickness (ft)
< 40	0.35
40 to 65	0.25
> 65	0.20

R Values and Subsurfacing Needs
Figure 1020-7

(14) Structures

Structures intended to carry a shared-use path only are designed using pedestrian loads and emergency and maintenance vehicle loading for live loads. Provide the same minimum clear width as the approach paved shared-use path, plus the graded clear areas. (See Figures 1020-11a and 11b.)

Carrying full widths across all structures has two advantages:

- The clear width provides a minimum horizontal shy distance from the railing or barrier
- It provides needed maneuvering room to avoid pedestrians and other bicyclists

Undercrossings and tunnels require a minimum vertical clearance of 10 feet from the bikeway pavement to the structure. This allows access by emergency, patrol, and maintenance vehicles on the shared-use path.

Consult the region's Maintenance Office and the HQ Bridge Preservation Office to verify that the planned path width is adequate for their needs. If not, widen to their specifications.

Provide a smooth, nonskid surface for bicycles to traverse bridges with metal grid bridge decking. A sidewalk meeting the width requirement of a shared-use path may be used for a bicycle facility on a bridge with this type of decking when no other practical alternative exists, or signs may be placed instructing the bicyclist to dismount and walk for the length of the bridge.

Use bicycle-safe expansion joints for all decks with bicycle facilities.

On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for further information. (See Chapter 1120 for additional considerations.)

(15) Drainage

Sloping the pavement surface to one side usually simplifies longitudinal drainage design and surface construction, and is the preferred practice. (See 1020.06(8) for cross slope requirements.) Generally, surface drainage from the path will be adequately dissipated as it flows down the side slope. However, a shared-use path constructed on the side of a hill might require a drainage ditch on the uphill side to intercept the hillside drainage. Where necessary, install catch basins with drains to carry intercepted water under the path. (See Chapter 1210 for other drainage criteria.)

Locate drainage inlet grates and manhole covers off the pavement of shared-use paths. If manhole covers are needed on a path, install them to minimize the effect on bicyclists. Design manhole covers level with the surface of the path.

Drainage inlet grates on bicycle facilities must have openings narrow enough and short enough to ensure that bicycle tires will not drop into the grates. Replace existing grates that are not bicycle-safe with grates designed for bicycles (a WSDOT vaned grate, herringbone grate, or other grate with an opening perpendicular to the direction of travel, 4 inches or less center to center).

(16) Bollards

Install bollards at entrances to shared-use paths to prevent motor vehicles from entering. When locating such installations, ensure that barriers are well marked and visible to bicyclists, day or night. Do not use bollards to divert or slow path traffic. (For bollard designs, see the Standard Plans, and for pavement markings at bollards, see the MUTCD.)

A single bollard installed in the middle of the path reduces a user’s confusion. When multiple posts are required, use a 5-foot spacing to permit passage of bicycle-towed trailers, wheelchairs, and adult tricycles, and to ensure adequate room for safe bicycle passage without dismounting. Use removable bollards (Bollard Type 1) to permit access by emergency and service vehicles. Ensure that the bollard sleeve is flush with the pavement surface. Nonremovable bollards (Bollard Type 2) may be used where access is not required.

(17) Signing and Pavement Markings

For guidance and directions regarding signing and pavement markings on bicycle facilities, see the MUTCD. Consider centerline markings to separate opposing directions of travel where there is heavy use, on curves where there is restricted sight distance, and where the path is unlighted and nighttime riding is expected. An edge line helps to delineate the path if nighttime use is expected.

(18) Lighting

The level of illumination required on a bicycle facility is dependent upon the amount of nighttime use expected and the nature of the area surrounding the facility. Provide illumination at intersections. (See Chapter 840 for guidance on bicycle facility illumination.)

1020.07 Bike Lane Design

Bike lanes are established along streets in corridors where there is current or anticipated bicycle demand and where it would be unsafe for bicyclists to ride in the travel lane. Provide bike lanes where it is desirable to delineate available road space for preferential use by bicyclists. Consider bike lanes in and around schools, parks, libraries, and other locations where young cyclists are present. (See Figure 1020-8.) Bike lanes delineate the rights of way assigned to bicyclists and motorists and provide for movements that are more predictable by each. Bike lanes can be provided by reducing the number or width of lanes or prohibiting parking, if an analysis shows that traffic will not be unduly degraded and adjacent businesses will not be excessively impacted by the loss of parking.

Bike Lane
Figure 1020-8

Where street improvements are not possible, improve the bicyclist's environment by providing shoulder sweeping programs and special signal facilities.

(1) Widths

The minimum width for a bike lane is 4 feet. Some typical bike lane configurations are illustrated in Figure 1020-18 and are described below:

- **Figure 1020-18, Design A,** depicts bike lanes on an urban-type curbed street where parking stalls (or continuous parking stripes) are marked. Locate bike lanes between the parking area and the traffic lanes. Minimum widths are shown. When the combined width of the bike lane and the parking lane is less than 15 feet, an increased probability of bicycle/car door collisions exists. When wider widths are not available, consider eliminating bike lane marking and signing.

  Do not place bike lanes between the parking area and the curb. Such facilities create hazards for bicyclists, such as the opening of car doors and poor visibility at intersections. Also, they prevent bicyclists from leaving the bike lane to turn left and they cannot be effectively maintained.
- **Figure 1020-18, Design B,** depicts bike lanes on an urban-type curbed street where parking is permitted without pavement markings between the bike lane and the parking lane. Establish bike lanes in conjunction with the parking areas. 12 feet (15 feet preferred) is the minimum total width of the bike lane and parking lane. This design is satisfactory where parking is not extensive and where the turnover of parked cars is infrequent. However, an additional width of 1 to 2 feet is recommended if parking is substantial or the turnover of parked cars is high. Delineated parking lanes are preferred.
- **Figure 1020-18, Design C,** depicts bike lanes along the outer portions of a roadway, with and without curb, where parking is prohibited. This configuration eliminates potential conflicts (such as the opening of car doors) with motor vehicle parking. Minimum widths are shown. Both the 5-foot width with curb or barrier and the 3 feet between a gutter and the traveled way must be achieved. With curb, guardrail, or barrier, the minimum bike lane width is 5 feet. When a gutter is present, a minimum width of 3 feet is required from the edge of the gutter. Additional width is desirable, particularly where motor vehicle operating speeds exceed 40 miles per hour. Prohibit parking when necessary.

High-speed truck, bus, and recreational vehicle traffic can cause problems along a bike lane because of aerodynamic effects and vehicle widths. Increase shoulder widths to accommodate large vehicles and bicycle traffic when truck, bus, or recreational vehicle traffic makes up 5% or more of the daily traffic.

Bike lanes are not advisable on long, steep downgrades where bicycle speeds greater than 30 miles per hour can be expected. As grades increase, downhill bicycle speeds will increase, which increases the handling problems if bicyclists are riding near the edge of the roadway. In such situations, bicycle speeds can approach those of motor vehicles, and experienced bicyclists will generally move into the motor vehicle lanes to increase sight distance and maneuverability. However, this situation might place other bicyclists in a hazardous position. When steep downgrades are unavoidable, provide full design-level shoulder width and signing in accordance with the MUTCD to alert bicyclists of the grade and the need to control their speeds.

Bike lanes are usually placed on the right side of one-way streets. Consider placing the bike lane on the left side when it produces fewer conflicting movements between bicycles and motor vehicles.

(2) Intersection Design

Design bike lanes at intersections in a manner that will minimize confusion for motorists and bicyclists and will permit both users to operate in accordance with the Rules of the Road (see RCW 46.61).

Figure 1020-19 illustrates a typical intersection of multilane streets, with bike lanes on all approaches. Some common movements of motor vehicles and bicycles are shown.

Figures 1020-20a and 20b illustrate two design options where bike lanes cross off- and on-ramps or wye connections. Option 1 provides a defined crossing point for bicyclists who want to stay on their original course. This option is desirable when bicyclists do not have a good view of traffic. Use Option 2 where bicyclists normally have a good view of traffic entering or exiting the roadway and will adjust their path to cross ramp traffic. A bike-crossing sign to warn motorists of the possibility of bicyclists crossing the roadway is recommended.

Figure 1020-21 illustrates the recommended options where bike lanes cross a channelized right-turn-only lane. When approaching such intersections, bicyclists will have to merge with right-turning motorists. Since bicyclists are typically traveling at speeds less than motorists, they can signal and merge where there is a sufficient gap in right-turning traffic, rather than at any predetermined location. For this reason, it is most effective to end bike lane markings at the approach of the right-turn lane or to extend a single, dotted bike lane line across the right-turn lane. Parallel lines (delineating a bike lane crossing) to channelize the bike merge are not recommended, as they encourage bicyclists to cross at predetermined locations. In addition, some motorists might assume they have the right of way and neglect to yield to bicyclists continuing straight.

A dotted line across the right-turn-only lane is not recommended where there are double right-turn-only lanes. For these types of intersections, drop all pavement markings to permit judgment by the bicyclists to prevail.

For signing and pavement marking requirements, see the MUTCD and the Standard Plans.

(3) Traffic Signals

At signalized intersections, consider bicycle traffic needs and intersection geometry when timing the traffic signal cycle and when selecting the method of detecting the presence of the bicyclist. Contact the region's Bicycle Coordinator for assistance in determining the timing criteria. Consider the installation of effective loop detectors or other methods of detecting a bicycle within the bike lane (in advance of the intersection) and turn lanes, in addition to push button actuators. Select loop detectors sensitive enough to detect bicycles. Bicyclists generally prefer not to use push button actuators, as they must go out of their way to actuate the signal. For additional guidance on signal design, see Chapter 850.

(4) Signing and Pavement Markings

Use the MUTCD and the Standard Plans for signing and pavement marking criteria. (See Chapter 820 for additional information on signing and Chapter 830 for information on pavement markings.)

(5) Drainage Grates and Manhole Covers

Locate drainage inlet grates and manhole covers to avoid bike lanes. When drainage grates or manhole covers are located in a bike lane, minimize the effect on bicyclists. A minimum of 3 feet of lateral clearance is needed between the edge of a drainage inlet grate and the shoulder stripe. Install and maintain grates and manhole covers level with the surface of the bike lane.

For additional information on drainage, see 1020.06(15).

1020.08 Shared Roadway Design

Generally, lower-speed/lower-volume streets are adequate for bicycle travel, so additional signing and pavement markings for bicycle use are unnecessary. (See Figure 1020-9.)

Shared Roadway
Figure 1020-9

The region's Traffic Engineer is responsible for determining which sections of state highways are inappropriate for bicycle traffic. The State Traffic Engineer, after consultation with the Bicycle Advisory Committee, prohibits bicycling on sections of state highways through the traffic regulation process. Contact the region Traffic Operations Office for further information.

Bicyclists traveling between cities or on recreational trips may use many rural highways. Providing and maintaining paved shoulders, with or without an edge stripe, can significantly improve safety and convenience for bicyclists and motorists along such routes.

A shared roadway bike route with improvements for bicycles can offer a greater degree of service to bicyclists than other roadways. Improvements on shared roadways to facilitate better bicycle travel include widening the shoulders to full design level width (a minimum of 4 feet); adding pavement markings; improving roadside maintenance (including periodic sweeping); and removing surface hazards such as drain grates not compatible with bicycle tires.

Where public transport and cycling facilities meet, an integrated design that ensures neither mode inconveniences the other is desirable. When buses and bicyclists share the same roadway, consider the following recommendations:

- Where bus speeds and volumes are high, separate facilities for buses and bicyclists are desirable
- Where bus speeds and volumes are low, consider a shared-use bus/bicycle lane

Consider providing bicycle parking facilities near public transportation stops.

1020.09 Signed Shared Roadway

Signed shared roadways are shared roadways that have been identified as preferred bike routes by posting bike route signs. (See Figure 1020-10.) Provide connections for continuity to other bicycle facilities. Designate preferred routes through high bicycle-demand corridors. As with bike lanes, signing shared roadways as bike routes is an indication to bicyclists that there are advantages to using these bike routes, as compared with alternative routes. (Signing also alerts motor vehicle operators that bicycles are present.) Provide improvements to make these routes suitable as bike routes, and maintain in a manner consistent with the needs of bicyclists.

Signed Shared Roadway (Designated Bike Route)
Figure 1020-10

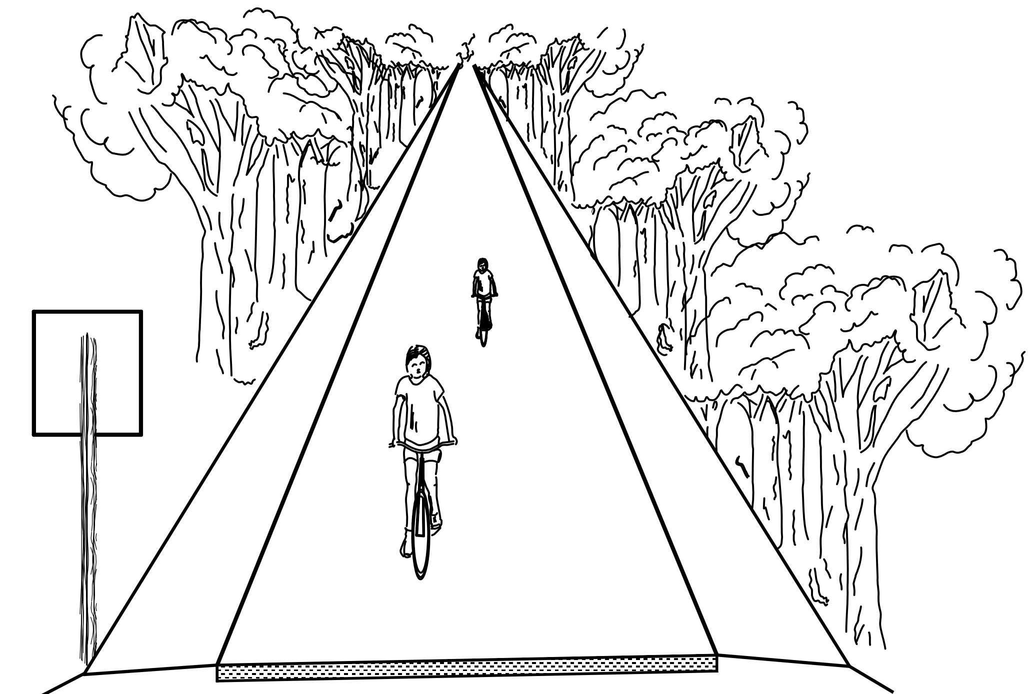
Use the following criteria to aid in determining whether or not to designate and sign a bike route:

- The route offers a higher degree of service than alternative streets
- The route provides for through and direct travel in bicycle corridors
- The route connects bicycle facilities
- Traffic control devices have been adjusted to accommodate bicyclists
- Street parking is prohibited for improved safety where lane width is critical
- Surface hazards to bicyclists have been corrected
- Maintenance of the route is at a higher level than comparable streets, such as more frequent street sweeping and repair

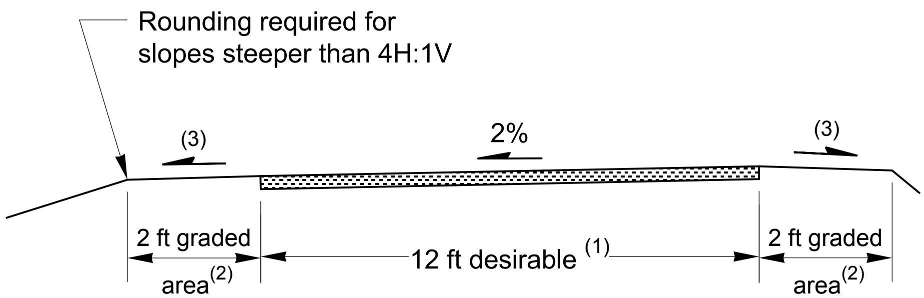
Establish a signed shared roadway bike route by placing the MUTCD Bicycle Route signs or markers along the roadways. When the signed shared roadway designates an alternate route, consider destination signing.

1020.10 Documentation

The list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/



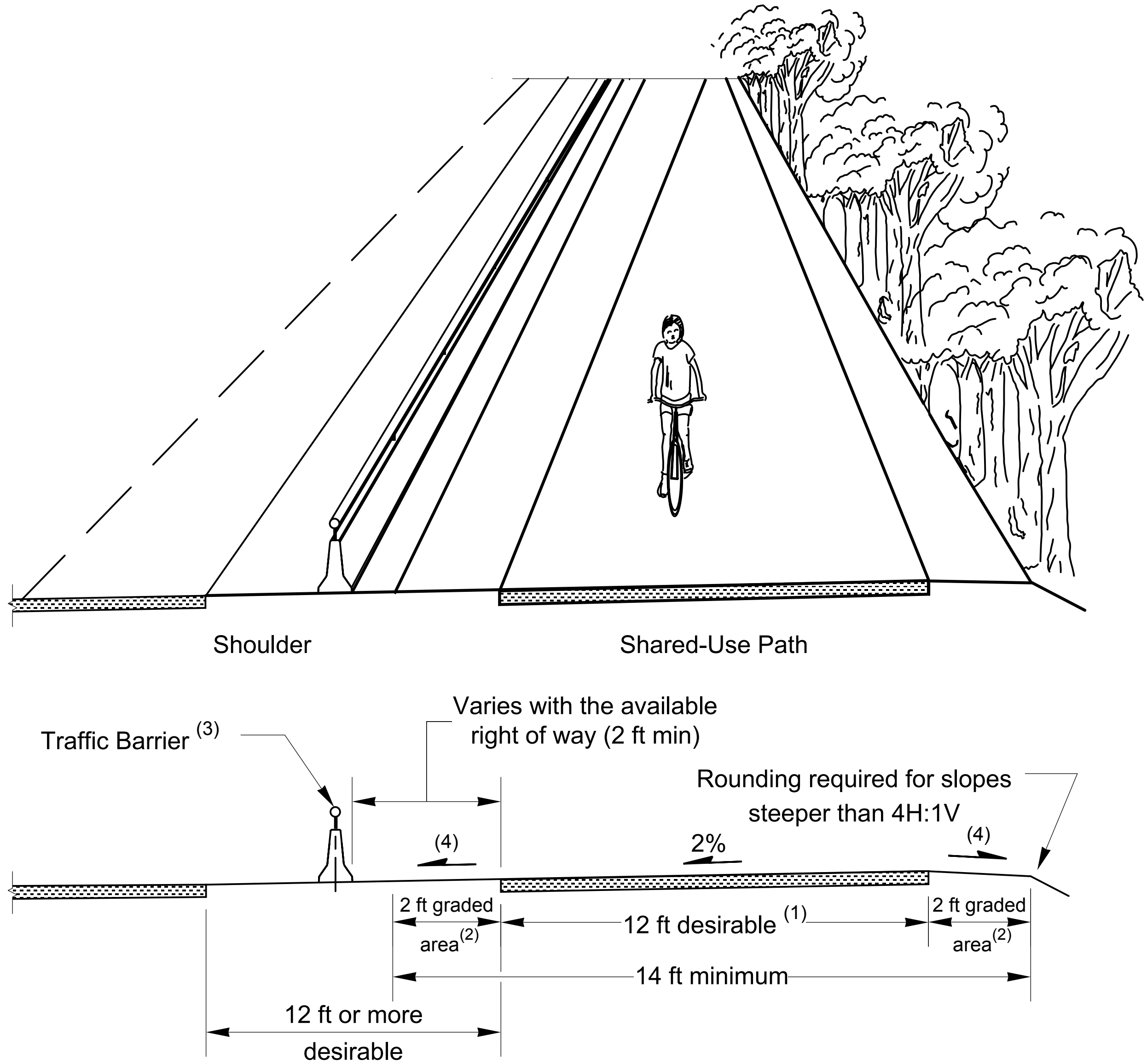
Shared-Use Path



Notes:

(1) For further discussion on bicycle path widths, see 1020.06(1).
(2) Where the paved width is wider than 10 feet, the graded area may be reduced accordingly.
(3) Not steeper than 6H:1V.

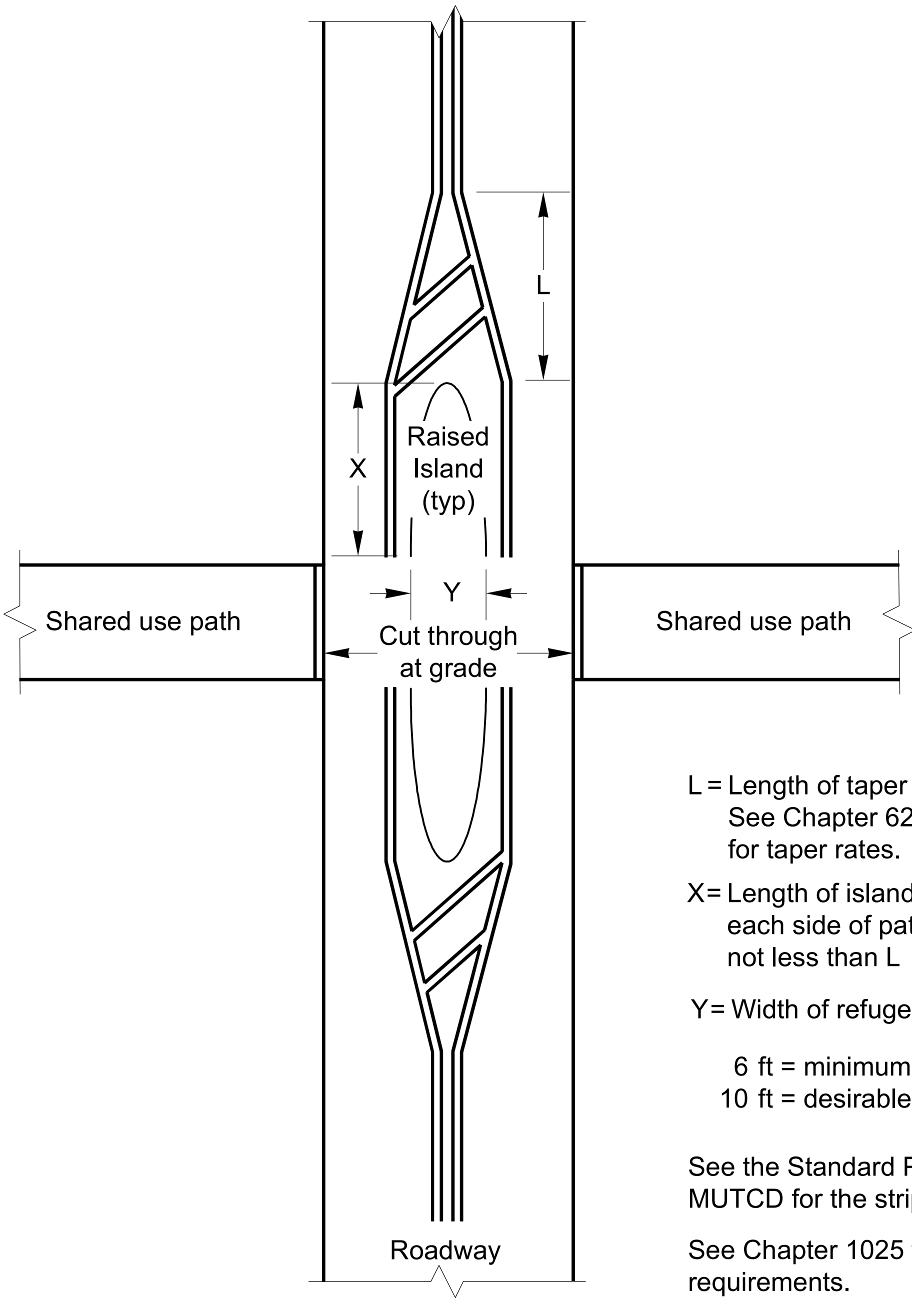
Two-Way Shared-Use Path
(Separate Right of Way)
Figure 1020-11a



Notes:

(1) For further discussion on bicycle path widths, see 1020.06(1).
(2) Where the paved width is wider than 10 feet, the graded area may be reduced accordingly.
(3) For selecting barriers between bicycle path and shoulder, and for determining the need for fencing on limited access roadways, see 1020.06(6).
(4) Not steeper than 6H:1V.

Two-Way Shared-Use Path (Adjacent to Roadway)
Figure 1020-11b



L = Length of taper
See Chapter 620
for taper rates.

X = Length of island
each side of path
not less than L

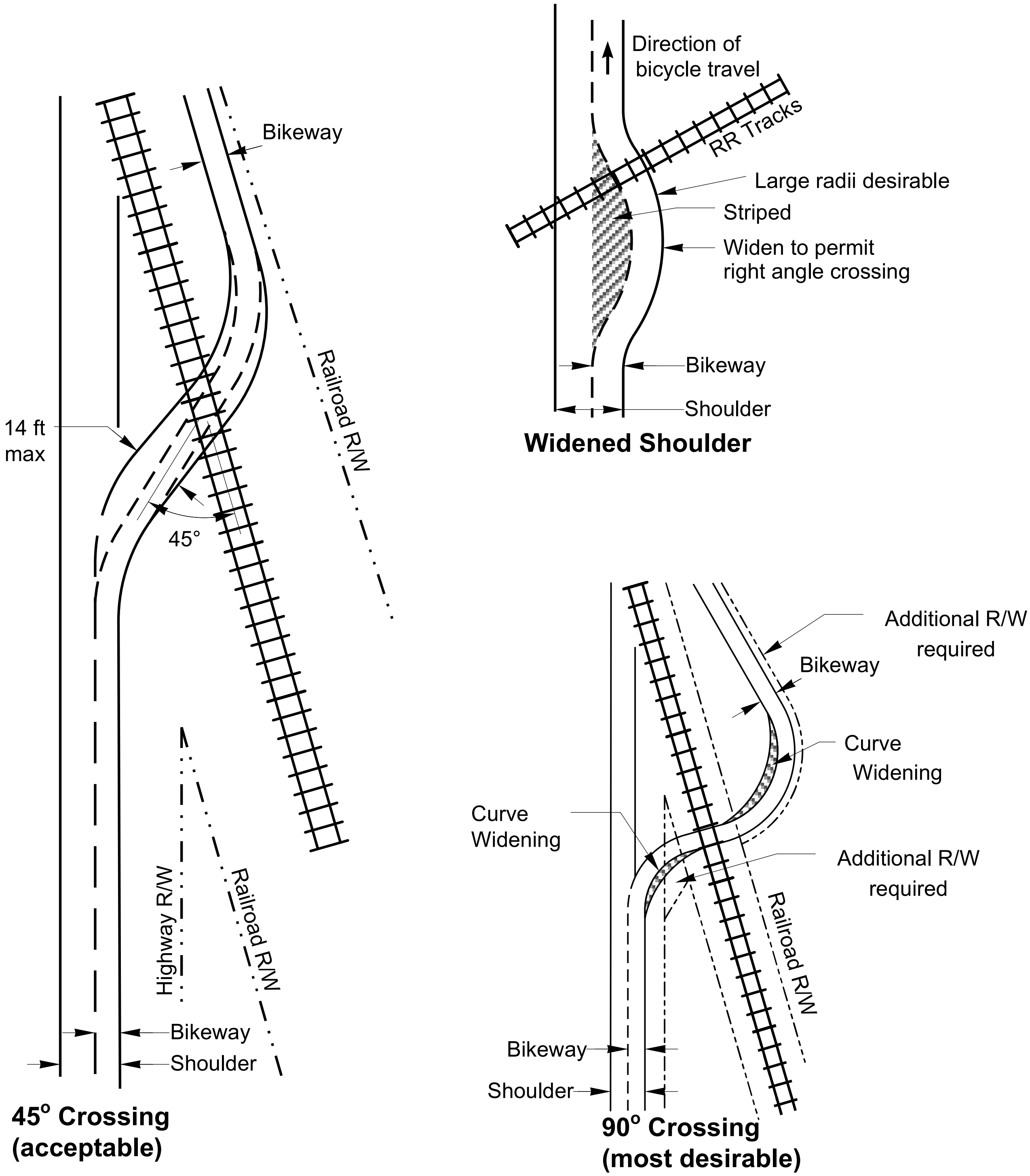
Y = Width of refuge

6 ft = minimum
10 ft = desirable

See the Standard Plans and the MUTCD for the striping details.

See Chapter 1025 for ADA requirements.

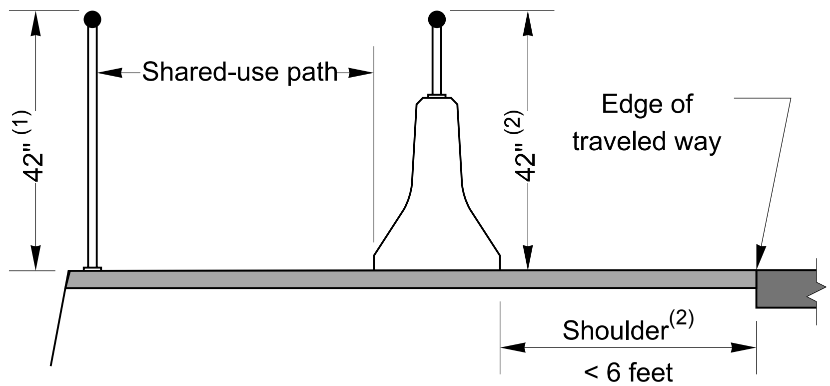
Refuge Area
Figure 1020-12



Note:

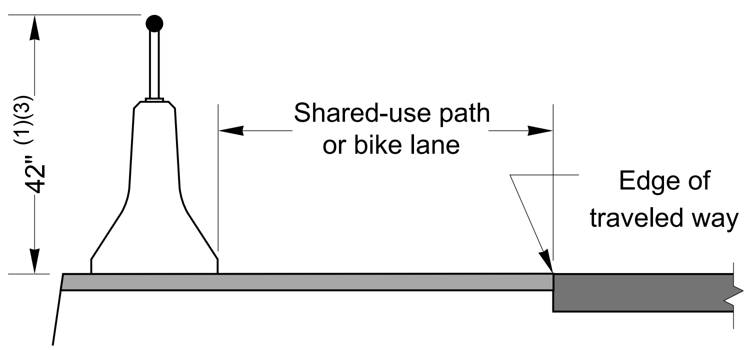
Provide additional width to a maximum total width of 14 feet at railroad crossing to allow bicyclists to choose their own crossing routes.

At-Grade Railroad Crossings
Figure 1020-13



Separated (shared-use paths)

Bicyclists and pedestrians use a path separated from the roadway with barrier.



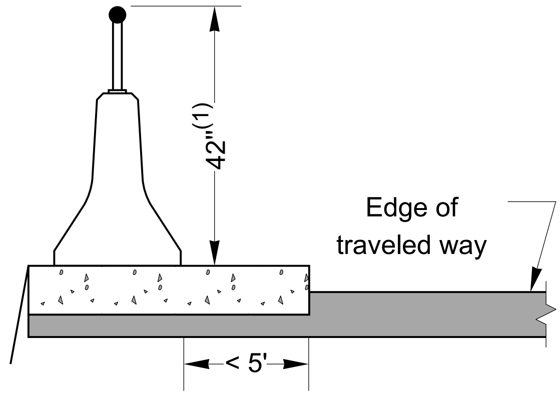
Unseparated (bike lanes)[4]

Bicyclists use the shoulder/bike lane between the edge of traveled way and the barrier.

Notes:

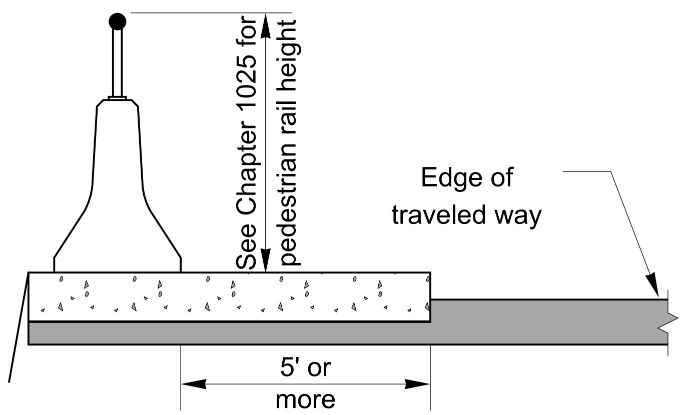
(1) Height does not apply to bridge rail. On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for additional information.
(2) When shoulder width is 6 feet or more, additional height for bicycles is not required. (See 1020.06(6) for additional information.)
(3) Applies to bike lanes. Additional height is not required for shared-use roadways.
(4) Includes exceptional conditions where sidewalks are used by bicyclists.

Barrier Adjacent to Bicycle Facilities
Figure 1020-14a



**Unseparated bike lanes with a sidewalk
less than 5 ft wide**

Bicyclists use the shoulder between the edge of traveled way and the sidewalk.



**Unseparated bike lanes with a sidewalk
5 ft or more wide**

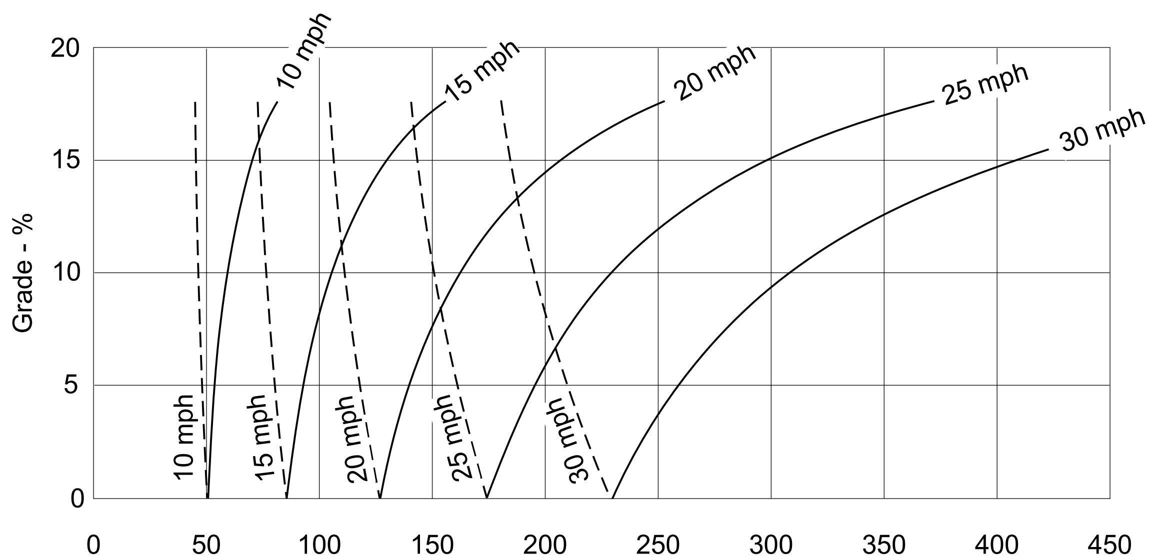
Bicyclists use the shoulder between the edge of traveled way and the sidewalk.

Note:

(1) Height does not apply to bridge rail. On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for additional information.

Barrier Adjacent to Bicycle Facilities

Figure 1020-14b



Stopping sight distance (ft)
(Based on 2.5 sec reaction time)

Downgrade (-G) ————

Upgrade (+G) – – – – – – –

$$S = \frac{V^2}{0.30\,(f \pm G)} + 3.67V$$

Where:
S = Stopping sight distance (ft)
V = Speed (mph)
f = Coefficient of friction (use 25)
G = Grade (%)

Stopping Sight Distance
Figure 1020-15

A (%)	Stopping Sight Distance, S (ft)													
	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2	3	3	3	3	3	3	3	3	3	3	30	70	110	150
3	3	3	3	3	3	3	20	60	100	140	180	220	260	300
4	3	3	3	3	15	55	95	135	175	215	256	300	348	400
5	3	3	3	20	60	100	140	180	222	269	320	376	436	500
6	3	3	10	50	90	130	171	216	267	323	384	451	523	600
7	3	3	31	71	111	152	199	252	311	376	448	526	610	700
8	3	8	48	88	128	174	228	288	356	430	512	601	697	800
9	3	20	60	100	144	196	256	324	400	484	576	676	784	900
10	3	30	70	111	160	218	284	360	444	538	640	751	871	1000
11	3	38	78	122	176	240	313	396	489	592	704	826	958	1100
12	5	45	85	133	192	261	341	432	533	645	768	901	1045	1200
13	11	51	92	144	208	283	370	468	578	699	832	976	1132	1300
14	16	56	100	156	224	305	398	504	622	753	896	1052	1220	1400
15	20	60	107	167	240	327	427	540	667	807	960	1127	1307	1500
16	24	64	114	178	256	348	455	576	711	860	1024	1202	1394	1600
17	27	68	121	189	272	370	484	612	756	914	1088	1277	1481	1700
18	30	72	128	200	288	392	512	648	800	968	1152	1352	1568	1800
19	33	76	135	211	304	414	540	684	844	1022	1216	1427	1655	1900
20	35	80	142	222	320	436	569	720	889	1076	1280	1502	1742	2000
21	37	84	149	233	336	457	597	756	933	1129	1344	1577	1829	2100
22	39	88	156	244	352	479	626	792	978	1183	1408	1652	1916	2200
23	41	92	164	256	368	501	654	828	1022	1237	1472	1728	2004	2300
24	43	96	171	267	384	523	683	864	1067	1291	1536	1803	2091	2400
25	44	100	178	278	400	544	711	900	1111	1344	1600	1878	2178	2500
Minimum Length of Vertical Curve, L (ft)														

$L = \frac{AS^2}{900}$ when S <L

$L = 2S - \frac{900}{A}$ when S >L

Shaded area represents S≤L.

Where:
S = Stopping sight distance (ft)
A = Algebraic difference in grade (%)
L = Minimum vertical curve length (ft)
Based on an eye height of 4.5 ft and an object height of 0 ft.

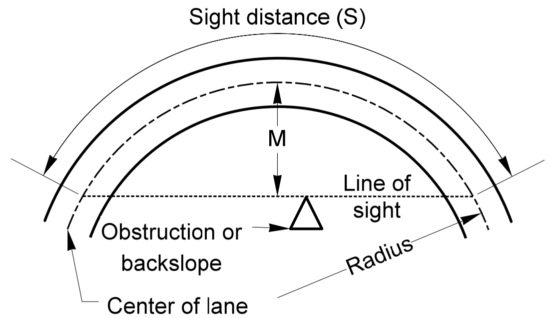
Sight Distances for Crest Vertical Curves
Figure 1020-16

Height of eye: 4.50 ft
Height of object: 0.0 ft
Line of sight at the M distance is normally 2.25 ft above centerline of inside lane at point of obstruction, provided no vertical curve is present in horizontal curve.

$$M = R\left(1 - \cos\frac{28.65S}{R}\right)$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R - M}{R}\right)\right]$$

$S \leq$ Length of curve
Angle is expressed in degrees.



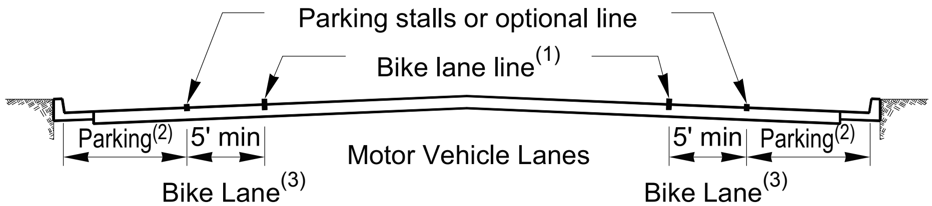
Where:
S = Sight distance (ft)
R = Centerline radius, of inside lane (ft)
M = Distance from inside lane centerline (ft)

R (ft)	Stopping Sight Distance, S (ft)(1)													
	40	60	80	100	120	140	160	180	200	220	240	260	280	300
25	7.6	15.9												
50	3.9	8.7	15.2	23.0	31.9	41.5								
75	2.7	5.9	10.4	16.1	22.7	30.4	38.8	47.8	57.4	67.2				
95	2.1	4.7	8.3	12.9	18.3	24.6	31.7	39.5	47.9	56.9	66.2	75.9	85.8	
125	1.6	3.6	6.3	9.9	14.1	19.1	24.7	31.0	37.9	45.4	53.3	61.7	70.5	79.7
150	1.3	3.0	5.3	8.3	11.8	16.0	20.8	26.2	32.1	38.6	45.5	52.9	60.7	69.0
175	1.1	2.6	4.6	7.1	10.2	13.8	18.0	22.6	27.8	33.4	39.6	46.1	53.1	60.4
200	1.0	2.2	4.0	6.2	8.9	12.1	15.8	19.9	24.5	29.5	34.9	40.8	47.0	53.7
225	0.9	2.0	3.5	5.5	8.0	10.8	14.1	17.8	21.9	26.4	31.2	36.5	42.2	48.2
250	0.8	1.8	3.2	5.0	7.2	9.7	12.7	16.0	19.7	23.8	28.3	33.0	38.2	43.7
275	0.7	1.6	2.9	4.5	6.5	8.9	11.6	14.6	18.0	21.7	25.8	30.2	34.9	39.9
300	0.7	1.5	2.7	4.2	6.0	8.1	10.6	13.4	16.5	19.9	23.7	27.7	32.1	36.7
350	0.6	1.3	2.3	3.6	5.1	7.0	9.1	11.5	14.2	17.1	20.4	23.9	27.6	31.7
400	0.5	1.1	2.0	3.1	4.5	6.1	8.0	10.1	12.4	15.0	17.9	20.9	24.3	27.8
500	0.4	0.9	1.6	2.5	3.6	4.9	6.4	8.1	10.0	12.1	14.3	16.8	19.5	22.3
600	0.3	0.7	1.3	2.1	3.0	4.1	5.3	6.7	8.3	10.1	12.0	14.0	16.3	18.7
700	0.3	0.6	1.1	1.8	2.6	3.5	4.6	5.8	7.1	8.6	10.3	12.0	14.0	16.0
800	0.2	0.6	1.0	1.6	2.2	3.1	4.0	5.1	6.2	7.6	9.0	10.5	12.2	14.0
900	0.2	0.5	0.9	1.4	2.0	2.7	3.6	4.5	5.5	6.7	8.0	9.4	10.9	12.5
1000	0.2	0.4	0.8	1.2	1.8	2.4	3.2	4.0	5.0	6.0	7.2	8.4	9.8	11.2
Minimum Lateral Clearance, M (ft)														

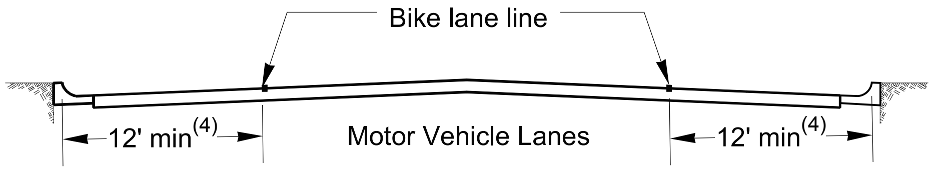
Note:
(1) S is the sum of the distances (from Figure 1020-15) for bicyclists traveling in both directions.

Lateral Clearance on Horizontal Curves

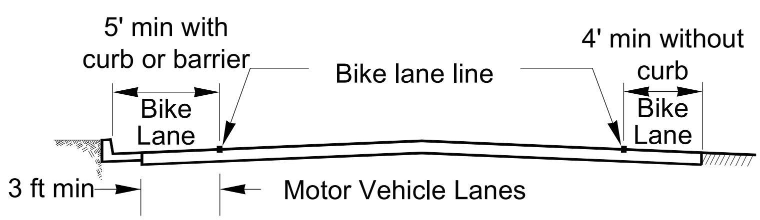
Figure 1020-17



Design A marked parking



Design B parking permitted without parking line or stall



Design C parking prohibited

Post NO PARKING signs as required

Notes:

(1) The optional line between the bike lane and the parking lane might be advisable where stalls are unnecessary (because parking is light), but there is concern that motorists might misconstrue the bike lane to be a traffic lane. (See the MUTCD and the Standard Plans for pavement marking requirements.)

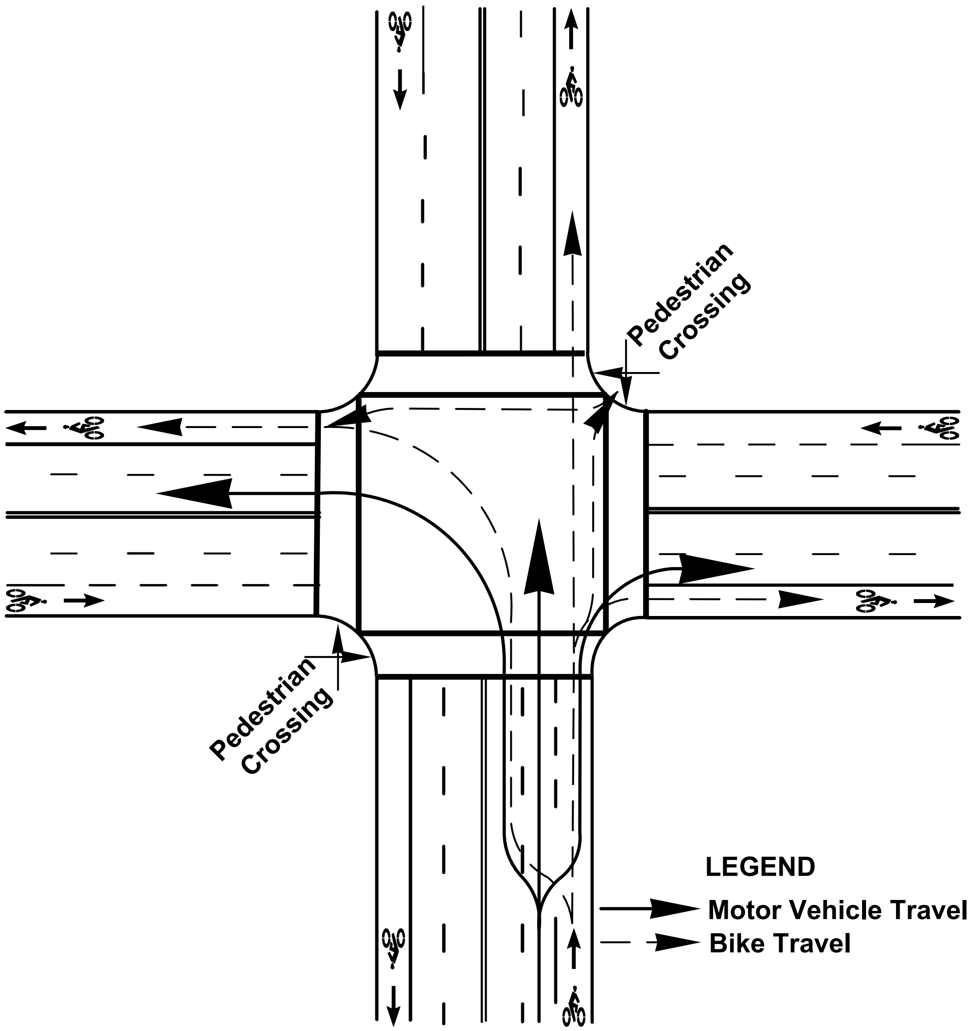
(2) For parking lane width, see Chapter 440. Consider a combined bike lane/parking lane width of 15 feet to reduce the risk of bicycle/car door collisions.

(3) 6 feet is the minimum width when parking lane is less than 10 feet.

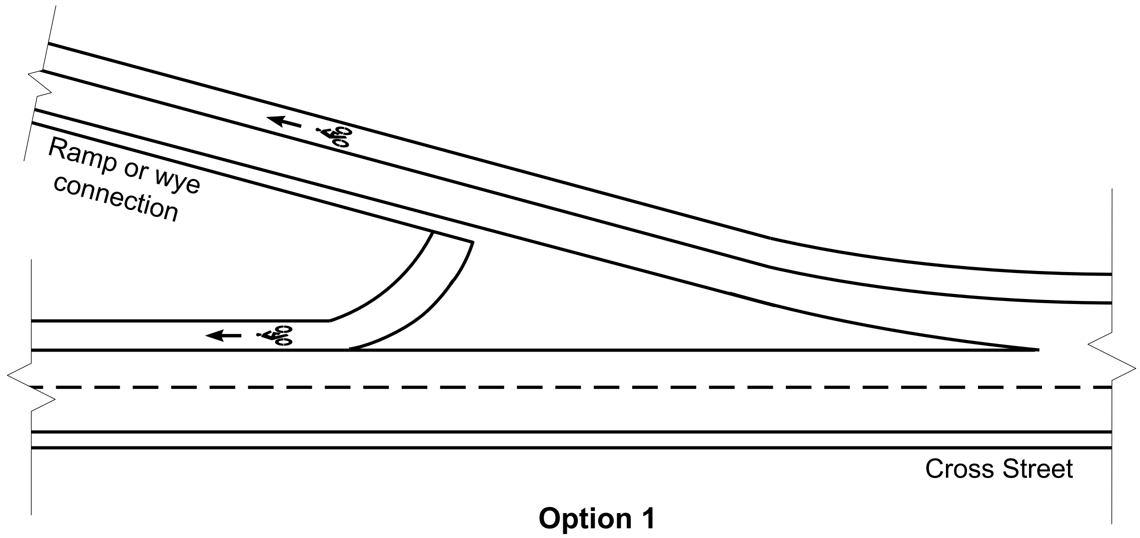
(4) 13–14 feet is recommended where there is substantial parking or the turnover of parked cars is high. Consider a width of 15 feet to reduce the risk of bicycle/car door collisions.

Typical Bike Lane Cross Sections

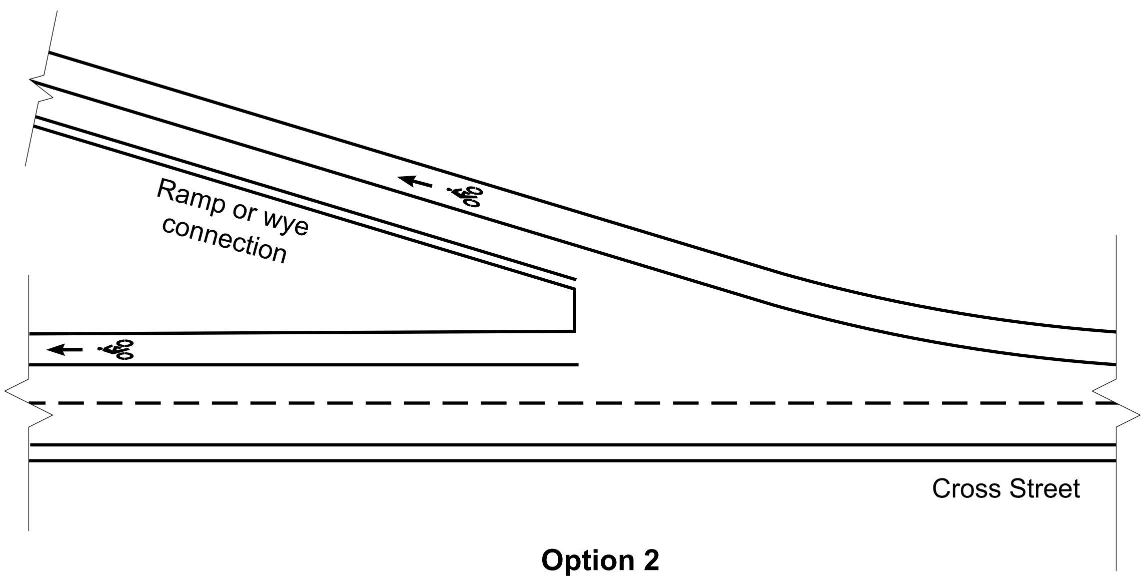
Figure 1020-18



Typical Bicycle/Auto Movements at Intersection of Multilane Streets
Figure 1020-19

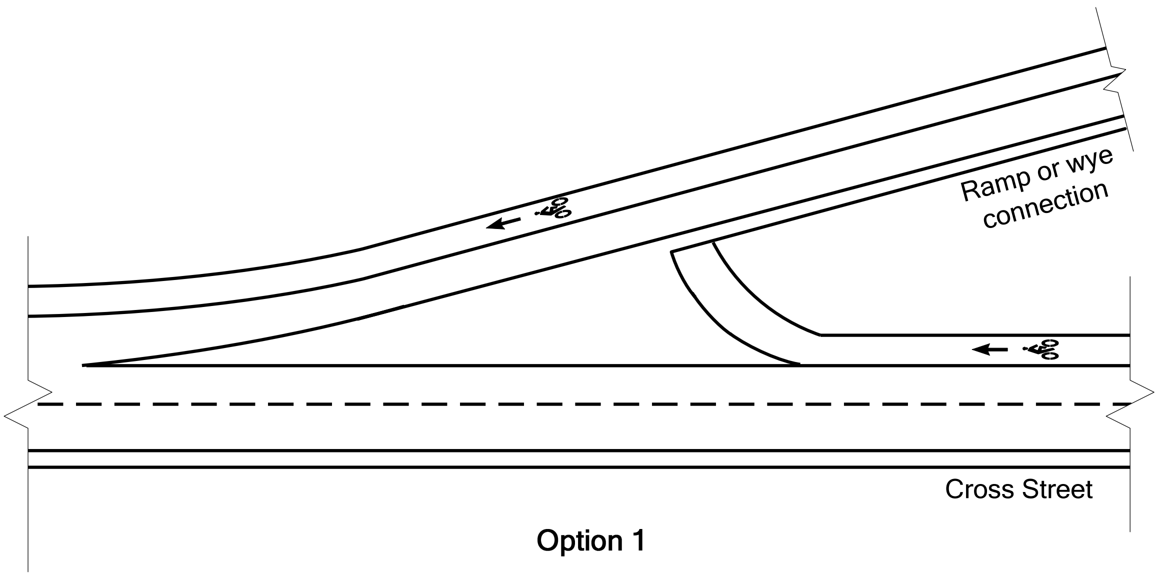


Option 1

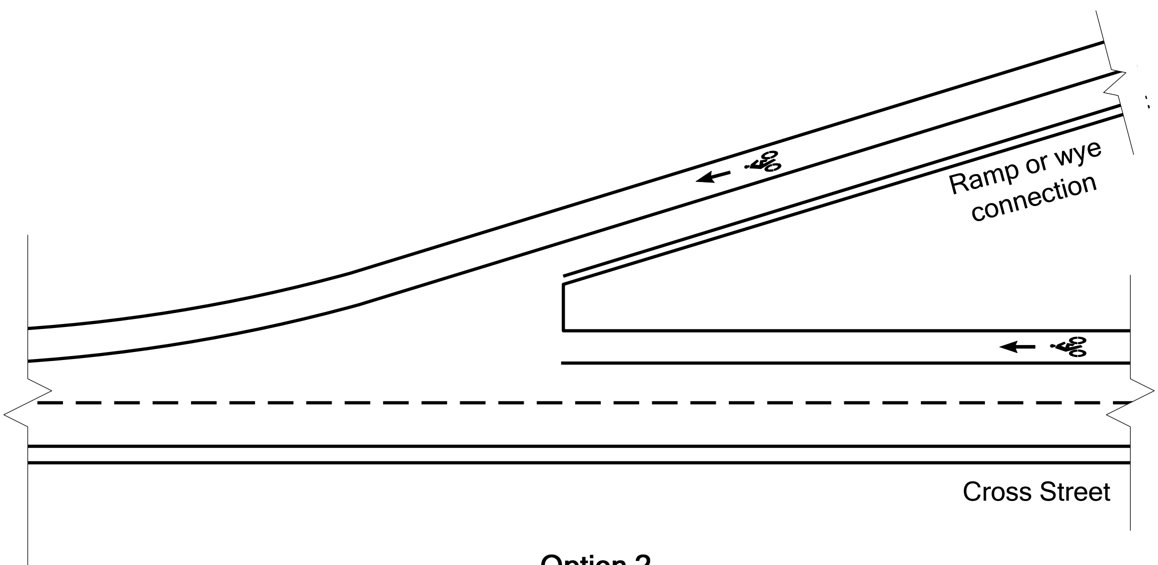


Option 2

Bicycle Crossing of Interchange Ramp
Figure 1020-20a

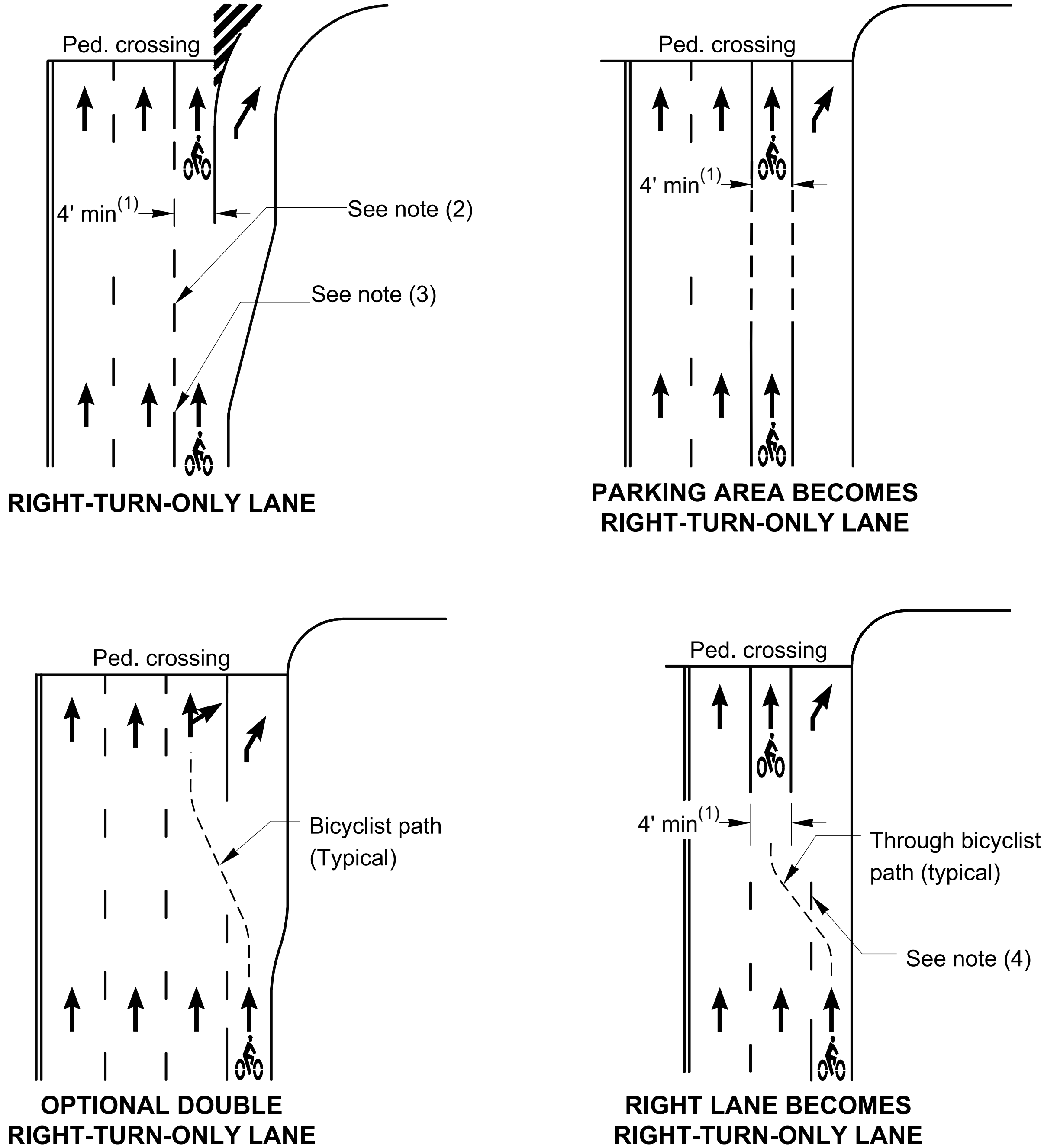


Option 1



Option 2

Bicycle Crossing of Interchange Ramp
Figure 1020-20b



Notes:
(1) If space is available.
(2) Optional dashed line. Not recommended where a long right-turn-only lane or double turn lanes exist.
(3) When optional dashed line is not used, drop all bike lane delineation at this point.
(4) Drop bike lane line where right-turn-only is designated.

Bike Lanes Approaching Motorists' Right-Turn-Only Lanes
Figure 1020-21

Chapter 1025 Pedestrian Design Considerations

1025.01 General

Pedestrians are present on most highways and transportation facilities, yet their travel mode differs vastly and sometimes is in conflict with the requirements for vehicular travel. Pedestrian travel is a vital transportation mode. It is used at some point by nearly all citizens and is the main link to everyday life for many others. Pedestrians vary in their physical abilities; this variation must be accommodated in design to allow near universal access. Keep the pedestrian space free of obstacles. In areas of heavy snowfall, avoid using the pedestrian space for snow storage. The challenge is to provide safe and efficient facilities that address these two interests within a limited amount of right of way.

1025.02 References

(1) Law

Laws and codes (both federal and state) that may pertain to this chapter include the following:

23 *Code of Federal Regulations* (CFR) Part 652

28 CFR Part 35

28 CFR Part 36, Appendix A, as revised July 1, 1994

49 CFR Part 27 (Authority: Section 504 of the Rehabilitation Act of 1973, as amended – 29 USC 794)

Manual on Uniform Traffic Control Devices, USDOT, FHWA; including the *Washington State Modifications* to the MUTCD, Chapter 468-95 WAC, (MUTCD).
http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Revised Code of Washington (RCW) 35.68, “Sidewalks, Gutters, Curbs and Driveways – All Cities and Towns”

RCW 35.78, “Streets – Classification and Design Standards”

RCW 46.04.160, “Crosswalk”

RCW 46.61.235, “Crosswalk”

RCW 46.61.240, “Crossing at other than crosswalks”

RCW 46.61.261, “Sidewalks, Crosswalks – Pedestrians, Bicycles”

RCW 47.24.010, City streets as part of state highways, “Designation – Construction,

maintenance – Return to city or town”

RCW 47.24.020, City streets as part of state highways, “Jurisdiction, control”

RCW 47.30.030, “Facilities for Non-Motorized Traffic”

RCW 47.30.050, “Expenditures for Paths and Trails”

(2) Design Guidance

The following contain guidance that is included by reference within the text:

Roadside Manual, M 25-30, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005

(3) Supporting Information

The following were used in the development of this chapter or contain additional information:

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2001

Accessible Rights-of-Way; A Design Guide, U.S. Access Board, Washington D.C.

Building a True Community: Accessible Public Rights-of-Way (Draft,) U.S. Access Board, Washington D.C.

Design Guidance, Accommodating Bicycle and Pedestrian Travel. A Recommended Approach, USDOT Policy Statement, 2001

Designing Sidewalks and Trails for Access Part II of II: Best Practices Design Guide, USDOT, FHWA, 2001

Guide for the Planning, Design, and Operation of Pedestrian Facilities, AASHTO, 2004

Highway Capacity Manual, Transportation Research Board (TRB), 2000

Pedestrian Facilities Users Guide – Providing Safety and Mobility, FHWA, 2002

Pedestrian Facilities Guidebook: Incorporating Pedestrians into Washington's Transportation System, OTAK, 1997

1025.03 Definitions

accessible route A continuous unobstructed pedestrian route that connects accessible elements and spaces of a building or facility. Exterior accessible routes include parking access aisles, sidewalks, sidewalk ramps, and crosswalks at vehicular ways, walkways, ramps, paths, trails, and lifts.

ADA An abbreviation for the Americans with Disabilities Act of 1990. The ADA is a civil rights law that identifies and prohibits discrimination based on disability. The ADA requires public entities to design new facilities or alter existing facilities, including sidewalks and trails that are accessible to people with disabilities.

ADAAG ADA Accessibility Guidelines. The guidelines contain requirements that apply to new construction and alterations. Refer to the following web site:
http://www.access-board.gov/prowac/guide/PROWGuide.htm

Bituminous Surface Treatment (BST) A bituminous surface treatment, also known as a seal coat or chip seal, is a thin protective wearing surface that is applied to a pavement or base course. BSTs can provide a waterproof layer to protect the underlying pavement; increased skid resistance; a fill for existing cracks or raveled surfaces; an anti-glare surface during wet weather; and an increased reflective surface for night driving. BSTs are primarily used for preventative maintenance and waterproofing of the existing pavement.

crosswalk A crosswalk is defined as:

1. The portion of the roadway between the intersection area and a prolongation or connection of the farthest sidewalk line or, in the event there are no sidewalks, then between the intersection area and a line ten feet therefrom, except as modified by a marked crosswalk (RCW 46.04.160).

2. (a) That part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or in the absence of curbs, from the edges of the traversable roadway, and in the absence of a sidewalk on one side of the roadway, the part of the roadway included within the extension of the lateral lines of the sidewalk at right angles to the center line. (b) Any portion of a roadway at an intersection or elsewhere distinctly indicated as a pedestrian crossing by lines on the surface, which may be supplemented by contrasting pavement texture, style, or color. (MUTCD, 2003)

curb extension A curb and sidewalk bulge or extension out into the parking lane, or shoulder used to decrease the length of a pedestrian crossing and increase visibility.

detectable warning A tactile surface that can be detected by vision-impaired pedestrians. The detectable warning signals a change in the pedestrian environment, where the pedestrian is moving into a vehicular traffic area, railroad crossing, or vertical drop-off at a transit loading facility. The only acceptable warnings are truncated domes. The detectable warning must contrast with the surrounding surface.

flangeway gap The space between the inner edge of a rail and the crossing surface. The gap is of sufficient space to permit a rail car wheel to pass through; approximately 3 inches. If there is insufficient space, a derailment is possible.

landing A level area, 4 feet by 4 feet (not steeper than 2% slope in any direction), at the top and bottom of a pedestrian ramp.

midblock pedestrian crossing A marked pedestrian crossing located between intersections.

pedestrian facilities Walkways such as sidewalks, highway shoulders, walking and hiking trails, shared-use paths, pedestrian grade separations, crosswalks, and other improvements provided for the benefit of pedestrian travel. Pedestrian facilities are intended to be accessible routes.

pedestrian refuge island A raised area between traffic lanes that provides a place for pedestrians to wait to cross the roadway. Wheelchair access (cut-through) must be provided in all pedestrian refuge islands.

raised median A raised island in the center of a road used to restrict vehicle left turns and side street access. Pedestrians often use this median as a place of refuge when crossing a roadway. Raised medians must include wheelchair access (cut through).

rural area An area that meets none of the conditions to be an urban area.

suburban area A term for the area at the boundary of an urban area. Suburban settings may combine the higher speeds common in rural areas with activities that are more similar to urban settings.

traffic calming A set of self-enforcing engineered techniques designed to reduce the speed and aggressiveness of traffic. Strategies include lane narrowing, sidewalk extensions, surface variations, and visual clues in the vertical plane.

train dynamic envelope The clearance required for a train and its cargo overhang due to any combination of loading, lateral motion, or suspension failure.

truncated domes Truncated domes are small raised protrusions of between 7/8 inch and 1 7/16 inch in diameter and 3/16 inch in height arranged in a distinctive pattern that is readily detected and recognized by a vision-impaired person using a cane for guidance. The Standard Plans show the appropriate pattern and dimensions.

urban area An area defined by one or more of the following:

- An area including and adjacent to a municipality or other urban place having a population of 5000 or more, as determined by the latest available published official federal census (decennial or special), within boundaries to be fixed by a state highway department, subject to the approval of the FHWA.
- Within the limits of an incorporated city or town.
- Characterized by intensive use of the land for the location of structures and receiving such urban services as sewer, water, and other public utilities and services normally associated with an incorporated city or town.
- With not more than 25% undeveloped land.

1025.04 Policy

(1) General

Pedestrian facilities are required along and across sections of state routes and city streets, and are an integral part of the transportation system. FHWA policy (23 CFR 652.5) suggests that safe bicycle and pedestrian facilities be given full consideration on all federal aid highway improvement projects. Provide ADA-compliant pedestrian facilities on highway projects unless one or more of the three conditions below are met:

- Pedestrians are prohibited by law from using the facility.
- The cost of the improvements is excessive and disproportionate to the original need or probable use (as a guide, more than 20% of the project estimate). In these instances, evaluate options to modify the scope of the pedestrian improvements or investigate funding for a separate pedestrian project. Any improvement must comply with ADA accessibility requirements. Include documentation of the results of the investigation for funding a separate pedestrian project.
- Low population density or other factors (such as a lack of pedestrian generators within a quarter-mile radius of the project) indicate there is no need.

Consider whether the project is within a city or an urban growth area that is intended to be ultimately developed as an urban density area, which will be served by urban services including transit. Inside incorporated cities, design pedestrian facilities in accordance with the city design standards adopted in accordance with RCW 35.78.030. Exceptions to adopted design standards require a deviation approved by the designated authority identified in Chapter 330.

(2) Jurisdiction

When city streets form a part of the state highway system within the corporate limits of cities and towns, the city has full responsibility for and control over any such street beyond the curbs and, if no curb is installed, beyond that portion of the highway used for highway purposes. (See RCW 47.24.020.) Proposed projects that will damage or remove existing sidewalks or other walkways within the city's jurisdiction must include reconstruction of these facilities. This jurisdictional distinction does not relieve the agency (or agencies) initiating a project from addressing ADA compliance.

The title to limited access facilities within incorporated cities and towns remains with the state. Within these areas the state maintains full jurisdiction, responsibility, and control as provided in RCW 47.24.20.

(3) Full Access Control

Walking and hiking trails and shared-use paths within the right of way are separated from vehicular traffic with physical barriers. These facilities can connect with other facilities outside the right of way once proper documentation has been obtained. Contact HQ Real Estate Services to determine the required documentation. Grade separations are provided when the trail crosses the highway.

(4) Partial or Modified Access Control

Walking trails and shared-use paths may be located between the access points of interchanges or intersections. Pedestrian crossings are usually either at grade with an intersecting crossroad or a grade separation. Consider midblock pedestrian crossings at pedestrian generators when the roadway has the characteristics associated with an urban area and appropriate operational and geometric characteristics that allow for a crossing.

Consider providing sidewalks at signalized intersections. Evaluate extending sidewalks on a project-by-project basis.

(5) Managed Access Control

In rural areas, paved shoulders are usually used for pedestrian travel. When pedestrian activity is high, separate walkways may be provided. Sidewalks are used in urban growth areas where there is an identified need for pedestrian facilities.

Consider providing sidewalks at signalized intersections. Evaluate extending sidewalks on a project-by-project basis.

Trails and paths, separated from the roadway alignment, are used to connect areas of community development. Pedestrian crossings are typically at grade.

(6) ADA Compliance

Detectable warnings are required on all vehicular roadway and railroad crossings intended for pedestrian use.

Improvement projects address the construction of a new roadway or produce major modifications to an existing roadway. In these projects, the pedestrian's needs are assessed and included, when applicable. Develop the pedestrian facilities consistent with the requirements listed in Figure 1025-2, using the ADA Standards for Improvement Projects column.

Preservation projects on state highways (except for BSTs) are considered alterations of the roadway. Address pedestrian needs and include, to the maximum extent feasible, access for persons with disabilities. If an existing sidewalk ramp adjacent to the roadway meets the ADA minimums for preservation projects in the Preservation Projects column in Figure 1025-2, no further action is required. If an existing ramp does not meet the ADA minimums, then it will need to be removed and constructed or modified to meet the standards for improvement projects, unless installing truncated domes would meet requirements.

It is not always feasible or even possible to build pedestrian facilities to full ADA standards (as shown in the column ADA Standards for Improvement Projects) in preservation projects or alterations. When this is the case, the ADA minimums for preservation projects are applicable.

In these circumstances, the alteration shall provide the maximum physical accessibility feasible. Any altered features of the facility that can be made accessible shall be made accessible.

When a preservation project is going through an area with pedestrian facilities that meet these requirements, no other action is necessary at this time. The agency (or agencies) initiating the project is responsible for funding this work.

1025.05 Pedestrian Facility Design

(1) Facilities

The type of pedestrian facility provided is based on local transportation plans, the roadside environment, pedestrian volumes, user age group, safety-economic analysis, and continuity of local walkways along or across the roadway. Sidewalks can be either immediately adjacent to streets and highways or separated from them by a buffer.

The type of walkway also depends on the access control of the highway as follows:

(2) Pedestrian Travel Along Streets and Highways

(a) ***General.*** Examples of various types of pedestrian walkways are shown in Figures 1025-3a and 3b. A generalized method of assessing the need for and adequacy of pedestrian facilities can be found in Figure 1025-4. These guidelines do not establish minimum requirements. Consider a study which addresses roadway classification, traffic speed, crash data, pedestrian generators, school zones, transit routes, and land use designation to assist in facility choices.

The minimum clear width for an ADA-accessible route is 4 feet. Utility poles and other fixtures located in the sidewalk can be obstacles for pedestrians with disabilities. To the maximum extent possible, provide a continuous unobstructed route for pedestrians with disabilities. When an unobstructed route is not feasible, provide an ADA-compliant route around these obstructions. When relocation of these utility poles and other fixtures is necessary in a project, determine the impact of their new location on any pedestrian walkways. Utility vaults and junction boxes with special lids are used for installations in sidewalks to reduce tripping hazards. Improvement projects might provide opportunities to eliminate existing utilities that are obstructions in the pedestrian route.

Hanging or protruding objects within the walkway present obstacles for pedestrians with visual impairments. The minimum vertical clearance for objects overhanging a walkway, including signs, is 7 feet. Objects that protrude more than 4 inches into the walkway are considered to be obstacles, and warning devices are necessary. Wall-mounted and post-mounted objects that protrude 4 inches or more into the walkway between 27 inches and 80 inches above the sidewalk shall be equipped with warning devices detectable by persons with impaired vision using a cane.

Where the walkway is located behind guardrail, cut off protruding guardrail bolts or install a rub rail to prevent snagging on the bolts. Specify these construction requirements in the contract.

Provide a smooth finish to vertical concrete surfaces adjacent to a pedestrian facility to prevent snagging or abrasive injuries from accidental contact with the surface.

(b) ***Shoulders.*** Paved shoulders are an acceptable pedestrian facility along rural roadways. Pedestrian activity is usually minimal along rural roadways. Determine if the roadway's shoulders are of sufficient width and condition to permit safe travel for pedestrians. In urban areas, a shoulder can provide a buffer between the vehicle and the pedestrian facility. Paved shoulders are preferable for an all-weather walking surface and for ADA compliance. A 4-foot-wide shoulder is acceptable where pedestrian activity is minor. Wider shoulders, up to 8 or 10 feet, are desirable along high-speed highways, particularly when truck volumes are high or pedestrian activities are high. Longitudinal travel along shoulders with cross slopes greater than 2% can be difficult for people with mobility disabilities. Horizontal curves are usually superelevated and can have cross slopes steeper than 2%. The shoulders on these curves often have the same cross slope as the roadway. In rural areas, the probability of a shoulder being used by someone in a wheelchair is remote. However, if pedestrians use the shoulder frequently, consider flattening the shoulder cross slope or provide a separate pedestrian route. (See Chapter 640 when flattening the shoulder slope.)

(c) ***Shared-Use Paths.*** Shared-use paths are used by pedestrians and bicyclists. Shared-use paths that function as sidewalks must comply with ADA sidewalk requirements. Pedestrian facilities differ from bicycle facilities in their design requirements and goals, and they are not always compatible. When it is determined that a shared-use path is in the best interests of both groups, see Chapter 1020, "Bicycle Facilities."

(d) **Walking Trails.** Walking trails are considered on a project-by-project basis. Trails that function as sidewalks are required to meet ADA standards, and they may be unpaved. Unpaved trails, to the maximum extent possible, shall be firm and stable allowing potential wheelchair accessibility. (See Figure 1025-1 for trail width, vertical clearance, and grade guidelines.) The clear area is the cross-sectional area of the trail that is cleared of limbs, exposed roots, brush, and other obstacles that might be obstructions.

	Clear Area	Trail Width	Maximum Grade
Walking Trail	8' high & 6' wide	4'	10%

*** Note:**
When grades of 5% or more are used, provide 5-foot-square resting areas adjacent to the trail every 200 feet.

Walking Trail Guidelines
Figure 1025-1

(e) ***Sidewalks.*** Details for raised sidewalks are shown in the *Standard Plans*. Wherever appropriate, make sidewalks continuous and provide access to side streets. The most desirable installation for the pedestrian is a sidewalk separated from the traveled way by a planted buffer strip. Consider buffer strips of 4 feet for collector routes and 6 feet for arterial routes. If trees or shrubs are included, make sure they do not limit the visibility of motorists or pedestrians or pose hazards for persons with disabilities. (See Chapter 920.) Shoulders, bike lanes, and on-street parking can also be used to provide an adequate buffer zone for pedestrian facilities. The minimum clear width for the sidewalk is 5 feet. (See the *Standard Plans*.) Where a sidewalk is separated from the traveled way with only a curb, the minimum sidewalk width is 6 feet. Wider sidewalks are preferable in areas of high pedestrian traffic, such as a central business district (CBD), and along parks, schools and other major pedestrian generators. Sidewalks 10 to 15 feet wide may be more appropriate at these locations. Coordinate with the city for appropriate sidewalk width and participation.

In areas with heavy snowfall, consider wider sidewalks or a sidewalk with a buffer to provide snow storage and to minimize the disruption to pedestrian travel. Sidewalks and trails must be maintained to ADA requirements; thus, ensure that maintenance access is not obstructed. Consider limiting or consolidating driveways (vehicle access points). Driveways are to be constructed in accordance with ADA requirements, or provide an ADA-accessible route.

(See Chapter 1420 for access control information, and the *Standard Plans* for vehicle approach details and ADA requirements.)

Consider sidewalk enhancements such as unobstructed visibility for both motorists and pedestrians to encourage walkway use and increase pedestrian comfort.

A grade of 8.33% or less is required when the sidewalk is on an independent alignment and does not follow an adjacent roadway grade. Sidewalks located adjacent to a street or highway shall not exceed that facility's grade. On roadways with prolonged severe grades, provide railings and, to the maximum extent possible, level landings adjacent to the sidewalk at approximately 200-foot intervals as resting areas for people with physical disabilities. Design sidewalks with cross slopes no more than 2%. Steeper cross slopes are difficult for people in wheelchairs to negotiate.

The side slope adjacent to the sidewalk is a critical design element. (See Figures 1025- 3a and 3b.) On embankment slopes of 4H:1V or flatter, provide a 1-foot widening at the back of the sidewalk. On steeper embankment slopes, provide a 4-foot embankment widening or use a sidewalk design with a 2-foot widening and a raised 4-inch-high lip at the back edge of the sidewalk. When the adjacent roadway has a posted speed of 35 mph or less and there is a vertical drop-off of 2 feet 6 inches or more directly behind the sidewalk, provide a pedestrian railing when embankment widening is not possible. (See Figure 1025-3b.) Pedestrian railings are not always designed to withstand vehicular impacts or redirect errant vehicles. When a vertical drop- off is present on a higher-speed roadway, the Design Clear Zone is the primary consideration and a crash-worthy traffic barrier is required if within the Design Clear Zone. (See Chapter 700.) Where the walkway is adjacent to a vertical drop-off and is separated from the roadway, consider installing the traffic barrier between the traveled way and the walkway. The pedestrian railing is then installed between the walkway and the vertical drop-off.

(f) ***Vehicle Bridges and Underpasses.*** Provide provisions for pedestrians on vehicle bridges and underpasses where pedestrians are not prohibited; contact the HQ Bridge and Structures Office. Provide either raised sidewalks or ramps on the approaches to bridges when there are raised sidewalks on the bridge. The ramp is constructed of either asphalt or cement concrete and has a slope of 20H:1V or flatter. These ramps can also be used as a transition from a raised sidewalk down to a paved shoulder. The ramp provides pedestrian access and mitigates the raised, blunt end of the concrete sidewalk.

In underpasses where pedestrians are not prohibited, providing sidewalks and maintaining the full shoulder width is desirable. When bridge columns are placed on either side of the roadway, consider placing the walkway between the roadway and the columns for pedestrian visibility and security. Adequate lighting and drainage are important for pedestrian safety and comfort.

(g) ***Railroad Crossings.*** Crossing railroad tracks can be difficult or even impossible for a person who requires a wheelchair, crutches, or walking aids for mobility. The concrete or rubber railroad crossings required to permit vehicle travel are extended into the shoulders of the roadway to enhance pedestrian travel. When a raised sidewalk is adjacent to the roadway, provide ramps to bring the pedestrian walkway down to the same grade as the roadway. Whenever possible, make crossings perpendicular to the tracks. In this type of installation, the truncated domes are placed at the outside edges of the train's dynamic envelope and are not placed at the bottom of the sidewalk ramp. Keep flangeway gaps to no more then 2.5 or 3 inches.

(3) Pedestrian Crossings At Grade

(a) ***General.*** The chart in Figure 1025-5 provides recommendations for determining pedestrian markings based on vehicular traffic volume and speed. Minimum lighting requirements and additional requirements are also recommended in this chart.

Pedestrian crossings are permitted along the length of most highways. Pedestrian crossing of all legs of an intersection is also permitted. An illegal pedestrian crossing only occurs when signs prohibit a particular crossing at an intersection or the crossing occurs between two adjacent signalized intersections. (See RCW 46.61.240.) When considering prohibiting a pedestrian crossing, ensure a reasonable alternative crossing is provided.

(b) ***Crosswalks.*** Crosswalks, whether marked or not, exist at all intersections. An unmarked crosswalk is the 10-foot-wide area across the intersection behind a prolongation of the curb or edge of the through traffic lane. (See RCW 46.04.160.) A marked crosswalk is required when the intended pedestrian route is different than that cited in the RCW. (See Figure 1025-5.) At roundabouts and intersections with triangular refuge islands or offset legs, the desired pedestrian crossings might not be consistent with the definition of an unmarked crosswalk and markings become necessary. Inside city limits where the population exceeds 22,500, the decision to mark crosswalks resides with the city subject to approval by WSDOT of the installation and type. In unincorporated areas and within cities with populations less than 22,500, WSDOT has decision authority.

Crosswalk lines are not to be used indiscriminately. Perform an engineering study before installing crosswalks away from highway traffic signals or stop signs. Evaluate the following factors at a minimum. Consider unmarked crossings as candidates for marking if:

- The crosswalk would serve 20 pedestrians per hour during the peak hour, 15 elderly and/or children per hour, or 60 pedestrians total for the highest consecutive 4-hour period.
- The crossing is on a direct route to or from a pedestrian generator, such as a school (see the MUTCD), library, hospital, senior center, community center, shopping center, park, employment center, or transit center. Generators in the immediate proximity of the highway are of primary concern. Pedestrian travel distances greater than 1/4 mile generally do not attract many pedestrians.
- The comprehensive plan includes the development of pedestrian facilities in the project vicinity.
- The location is 300 feet or more from another crossing.
- The location has decision sight distance and/or sight distance will be improved prior to marking the crossing. (See Chapter 650, "Decision Sight Distance.")
- Safety considerations do not preclude a crosswalk.

A significant pedestrian accident history may also warrant the installation or marking of a crosswalk.

For marked crosswalks, the standard crosswalk marking consists of a series of wide white lines aligned with the longitudinal axis of the roadway. Crosswalk widths of at least 6 feet and 10 feet are preferred in central business districts. The lines are positioned at the edges and centers of the traffic lanes to place them out of the normal wheel path of vehicles. This type of crosswalk is a longitudinal pattern known as a Ladder Bar and is shown in the Standard Plans. Designers are encouraged to set back stop and yield lines to ensure visibility. Stop and yield line dimensions and placement shall conform to the MUTCD.

Communities sometimes request specially textured crosswalks (consisting of colored pavement, bricks, or other materials) in community enhancement projects. These crosswalks do not always fall within the legal definition of a marked crosswalk and parallel white crosswalk lines might be necessary to define the crosswalk. (See the MUTCD or Local Agency Crosswalk Options web site, http://www.wsdot.wa.gov/eesc/design/designstandards/psl/PM-2/pm-2.htm.) Provide a non-slip surface, appropriate for wheelchair use.

When locating crosswalks at intersections, consider the visibility of the pedestrian from the motorist's point of view. Shrubbery, signs, parked cars, and other roadside appurtenances can block the motorist's view of the pedestrian. Figure 1025-7a illustrates these sight distance problems.

When designing crosswalks and pedestrian signals, consider the needs of older pedestrians and pedestrians with disabilities, as they might walk at a significantly slower pace than the average pedestrian. Include countdown clocks where appropriate to assist older and disabled pedestrians to determine the time remaining to cross. Determine if there are pedestrian generators in the project vicinity that might attract older and disabled pedestrians. Consult with the region's Maintenance Office regarding maintenance requirements for these devices.

Consider the use of ADAAG-compliant audible pedestrian signals where suitable for pedestrian safety. Determine if there are pedestrian generators in the project vicinity that might attract hearing-impaired pedestrians for which audible signals are appropriate. Consult with the region's Maintenance Office regarding maintenance requirements for these devices. (See Chapter 850 and the MUTCD for additional information.)

Wide, multilane streets are often difficult for pedestrians to cross, particularly when there are insufficient gaps in vehicular traffic because of heavy volumes. Consider the use of raised medians with cut-throughs on roadways with the following conditions:

- Two-way arterial street with high speeds and high average daily traffic (ADT), and large pedestrian volumes
- The crossing distance exceeds 60 feet
- Complex or irregularly shaped intersections

The minimum width of a raised median refuge area is 4 feet to accommodate people in wheelchairs. Raised medians that exceed the minimum are encouraged. Raised medians are usually too narrow to allow the installation of ramps and a level landing. When the median is 16 feet or less in width, provide a passageway wide enough to accommodate wheelchairs through the median. This passageway connects with the two separate roadways and cannot exceed a grade of 5%. Truncated domes are required on both sides of a median cut-through.

Design ramp terminals for both off-ramps and on-ramps as at-grade intersections. (See Chapters 910 and 940.)

For pedestrian safety, design turn lanes to ensure that turning speeds are kept low and sight distance is not compromised. Consider the following measures to help reduce conflict:

- Reduce turning radii
- Prohibit right turns on red
- Place crosswalks so they are visible and adjacent to the pedestrian facility
- Use a separate left-turn phase in conjunction with a "WALK/DON'T WALK" signal
- Restrict left turns at certain times
- Shorten crossing distance
- Use a raised median
- Use pedestrian signals
- Use signage
- Place crosswalks as close as practicable to the traveled way
- Provide pedestrian-level lighting

The island used for channelized right-turn slip lanes can provide a pedestrian refuge, but may promote faster turning speeds. To reduce conflicts, keep the lane as narrow as practical and attempt to maintain a 90º intersection angle. (See Chapter 910 for more information about turn lanes, Chapter 940 for more information about interchange ramps, and Chapter 915 for information about pedestrian accommodations in roundabouts.)

(c) ***Managing Traffic Speed and Flow.*** Curb extensions are a traffic calming measure that, when used appropriately, may increase pedestrian safety. In urban areas where vehicle speeds are in the range of 25 to 35 mph, a sidewalk curb extension is sometimes used as a traffic calming measure to help reduce traffic speeds. Parked cars can be a safety hazard for pedestrians by limiting driver visibility. Curb extensions can improve safety by placing the pedestrian at a more visible location, shortening the length of the pedestrian crossing, and reducing the pedestrian's exposure time. Curb extensions can also increase the effective sidewalk width at intersections. Extend the curb to the width of the parking lane. Consider low-level landscaping that does not create a sight obstruction and an approach nose. At intersections with traffic signals, the curb extension can be used to reduce pedestrian signal timing. Examples of sidewalk curb extensions are shown in Figure 1025-7b and 1025-8.

The right turn path of the design vehicle or the vehicle most likely to make this turn is a critical element in determining the size and shape of the curb extension. Sidewalk curb extensions tend to restrict the width of the roadway and can make right turns difficult for large trucks. Avoid interrupting bicycle traffic with curb extensions. If the route is identified as a local, state, or regional significant bike route, provide a minimum shoulder width of 4 feet. (See Chapter 1020 for additional information.) Do not use curb extensions in any of the following circumstances on state highways:

- The Design Vehicle is required to encroach on curbs, opposing lanes, or same-direction lanes (see the *Design Vehicle* section in Chapter 910)
- Shoulder parking is not present
- The posted speed is above 35 mph

Plantings that obstruct neither pedestrian's nor driver's vision may be used as traffic calming measures by creating the illusion of narrow streets. Consider motorist and pedestrian visibility and Design Clear Zone requirements. (See Chapter 700.)

Traffic signal progressions can be used to address traffic speeds.

Consider narrower lane widths on portions of non-NHS two-lane routes to reduce the expanse of visible pavement to the motorist and help slow traffic when the following conditions exist:

- Within incorporated cities
- High pedestrian use

For minimum lane widths, see Chapters 430 and 440.

(d) ***Midblock Crossings.*** On roadways with pedestrian crossing traffic caused by nearby pedestrian generators, consider a midblock pedestrian crossing. (See 1025.05 (3)(b) for crosswalk criteria and Figure 1025-5 for marked crosswalk recommendations at unsignalized intersections.) The installation of a midblock pedestrian crossing on a state highway, however, is a design deviation that requires approval and documentation. An example of a midblock crossing is shown in Figure 1025-9.

Conditions that might favor a midblock crossing include:

- Significant pedestrian crossings and substantial pedestrian and vehicle conflicts occur.
- The proposed crossing can concentrate or channel multiple pedestrian crossings to a single location.
- The crossing is at an approved school crossing on a school walk route.
- The adjacent land use creates high concentrations of pedestrians needing to cross the highway.
- The pedestrians fail to recognize the best or safest place to cross along a highway and there is a need to delineate the optimal location.
- There is adequate sight distance for motorists and pedestrians.

Midblock pedestrian crossings on state highways are not desirable at the following locations:

- Immediately downstream (less than 300 feet) from an existing traffic signal where motorists do not expect a pedestrian to cross.
- Within 600 feet of another pedestrian crossing.
- Where pedestrians must cross three or more lanes of traffic in the same direction.

(4) Sidewalk Ramps

Sidewalk curb ramps are required at all intersections, unless pedestrians are prohibited from crossing the roadway and on midblock crossings where sidewalks are present. These ramps provide an easily accessible connection from a raised sidewalk down to the roadway surface. To comply with ADA requirements, these ramps are at least 4 feet wide and have slopes 12H:1V or flatter and a cross slope of not greater then 2%. Curb ramp flares do not exceed 10%. Examples of sidewalk curb ramps are shown in the Standard Plans.

The lower terminus of the sidewalk ramp is always located at the beginning of a marked or unmarked crosswalk when separate ramps are used for each direction. A separate sidewalk ramp is preferred for each crossing because the crossing distance is shorter and people with vision impairments or in wheelchairs have fewer difficulties with this arrangement. A single diagonal ramp, serving two crossings, is sometimes necessary where right of way constraints make the installation of separate ramps infeasible. The use of a diagonal ramp requires the approval of the region's Traffic Engineer. If inside an incorporated city, the city must approve the use of a diagonal ramp. In all cases, detectable warning strips are to be installed.

Surface water runoff from the roadway can flood the lower end of a sidewalk ramp. Determine the grades along the curb line and provide catch basins or inlets to prevent the flooding of the ramps. Figure 1025-10 shows examples of how drainage structures are located. Verify that the drainage structure will not be in the path of a wheelchair user.

A level landing is necessary at the top and bottom of a sidewalk ramp. The top landing is provided to allow a person in a wheelchair room to maneuver into a position to use the ramp or to bypass it. The lower landing allows a wheelchair user to transition from the ramp to the roadway crossing. In preservation projects, the landings must be at least 3 feet square. In new construction, a 4-foot-square landing is required. When right of way constraints are not an issue, provide a larger 5-foot-square landing. If the landing is next to a vertical wall, a 5-foot-wide clear area is desirable to allow a person in a wheelchair more room to maneuver.

At signalized intersections, pedestrian push buttons are located near the sidewalk ramps for ADA accessibility. (See Chapter 850, "Traffic Control Signals," for information on pedestrian requirements at traffic signal locations.)

(5) Pedestrian Grade Separations

(a) ***General.*** In extreme cases where pedestrian need is high, consider providing a pedestrian grade separation along freeways and other high-speed facilities. When considering a pedestrian structure, determine if the conditions that require the crossing are permanent. If there is a likelihood that the pedestrian activity generator might not exist in the near future, consider less costly solutions. Locate the grade-separated crossing where pedestrians are most likely to cross the roadway. A crossing might not be used if the pedestrian is required to deviate significantly from a more direct route. A structure might be underutilized if the additional average walking distance for 85% of pedestrians exceeds 1/4 mile. It is sometimes necessary to install fencing or other physical barriers to channel the pedestrians to the structure and reduce the possibility of undesired at-grade crossings. The Bridge and Structures office is responsible for the design of pedestrian structures.

Consider grade-separated crossings under the following conditions:

- Where there is moderate to high pedestrian demand to cross a freeway or expressway
- Where there are large numbers of young children, particularly on schools routes, who regularly cross high-speed or high-volume roadways
- On streets with high vehicular volumes and high pedestrian crossing volumes, and the crossings are extremely hazardous for pedestrians

(b) ***Pedestrian Bridges.*** Pedestrian grade-separation bridges are more effective when the roadway is below the natural ground line as in a "cut" section. Elevated grade separations, where the pedestrian is required to climb stairs or use long approach ramps, tend to be underutilized. Pedestrian bridges require adequate right of way to accommodate accessible ramps.

For the minimum vertical clearance from the bottom of the pedestrian structure to the roadway beneath, see Chapter 1120. This minimum height requirement can affect the length of the pedestrian ramps to the structure. To comply with ADA requirements, a ramp cannot have a grade exceeding 8.33%, and landings for resting areas are required every 2 feet 6 inches of rise or every 30 feet. Landings are a minimum of 5 feet long and shall not be less than the ramp width. When ramps are not feasible, provide both elevators and stairways. Stairways are designed in accordance with the Standard Plans.

Railings are provided on pedestrian bridges. Protective screening is sometimes necessary to prevent objects from being thrown from an overhead pedestrian structure. (See Chapter 1120, "Bridges.") Consider a clear width of 14 feet when a pedestrian bridge is enclosed or shared with bicycles.

(c) ***Pedestrian Tunnels.*** Tunnels are an effective method of providing crossings for roadways located in embankment sections. When possible, design the tunnel with a nearly level profile to provide complete vision from portal to portal. Pedestrians are reluctant to enter a tunnel with a depressed profile because they are unable to see whether the tunnel is occupied. Police officers also have difficulty patrolling depressed profile tunnels. Provide vandal-resistant daytime and nighttime illumination within the pedestrian tunnel. Installing gloss-finished tile walls and ceilings can also enhance light levels within the tunnel. The minimum overhead clearance for a tunnel is 10 feet. Provide a tunnel width between 12 and 18 feet depending on usage and the length of the tunnel.

(6) Transit Stops

The location of transit stops is an important consideration in providing appropriate pedestrian facilities. (Contact the local transit provider for additional information.) Newly constructed transit stops must conform to ADA requirements. (See Chapter 1060, "Transit Benefit Facilities.") Ensure that the transit stop is accessible from the sidewalk or paved shoulder. A transit stop on one side of a street usually has a counterpart on the opposite side because transit routes normally function in both directions on the same roadway. Provide adequate crossing facilities for pedestrians.

When locating transit stops consider the following:

- ADT
- Traffic speed
- Crossing distance
- Accident history
- Sight distance

If any of these suggest an undesirable location for a pedestrian crossing, consider a controlled crossing or another location for the transit stop.

When analyzing high pedestrian accident locations, consider the presence of nearby transit stops and opportunities for pedestrians to safely cross the street. At-grade midblock pedestrian crossings are effective at transit stop locations on roadways with lower vehicular volumes.

Pedestrian grade separations are appropriate at midblock locations when vehicular traffic volumes prohibit pedestrian crossings at grade. (See Figure 1025-5 for recommendations for marked crosswalks at unsignalized intersections.)

(7) School Bus Stops

School bus stops are typically adjacent to sidewalks in urban areas and along shoulders in rural areas. Determine the number of children using the stop and provide a waiting area that allows the children to wait safely for the bus. Children, because of their smaller size, might be difficult for motorists to see at crossings or stops. Determine whether utility poles, vegetation, and other roadside features interfere with the motorist's ability to see the children. When necessary, relocate the obstructions or move the bus stop. Parked vehicles can also block visibility and parking prohibitions might be necessary near the bus stop.

(8) Illumination and Signing

In Washington State, the highest number of collisions between vehicles and pedestrians occur during November through February, when there is poor visibility and fewer daylight hours. Illumination of pedestrian crossings and other walkways is an important design consideration, because lighting has a major impact on a pedestrian's safety and sense of security. Illumination provided solely for vehicular traffic is not always effective in lighting parallel walkways for pedestrians. Consider pedestrian-level lighting (mounted at a lower level) for walkways, intersections, and other pedestrian crossing areas with high nighttime pedestrian activity such as shopping districts, transit stops, schools, community centers, and other major pedestrian generators or areas with a history of pedestrian accidents. Design guidance for illumination is in Chapter 840. (See Chapter 820 and the MUTCD for pedestrian-related signing.)

(9) Work Zone Pedestrian Considerations

Providing access and mobility for pedestrians through and around work zones is an important design concern. In work zones, consider:

- Separating pedestrians from conflicts with work zone equipment and operations.
- Separating pedestrians from traffic moving through or around the work zone.
- Providing pedestrians with a safe, accessible, and convenient travel path that duplicates, as closely as possible, the characteristics of sidewalks or footpaths.

Ensure that walkways are clearly marked, pedestrian barriers are continuous, nonbendable, and detectable to persons with impaired vision using a cane, keep the pedestrian head space clear. Keep walkways free from pedestrian hazards such as holes, debris, and abrupt changes in grade or terrain. Keep wheelchair access along sidewalks clear of construction traffic control signs.

Temporary pedestrian facilities within the work zone shall be detectable and include accessibility features consistent with the features present in the existing pedestrian facility.

Consider the use of flaggers if pedestrian generators such as schools are in the work zone vicinity.

Provide advance notification of sidewalk closures.

Where transit stops are affected or relocated because of work activity, access to temporary transit stops shall be provided.

For further information or guidance on work zone pedestrian considerations, see the MUTCD.)

1025.06 Documentation

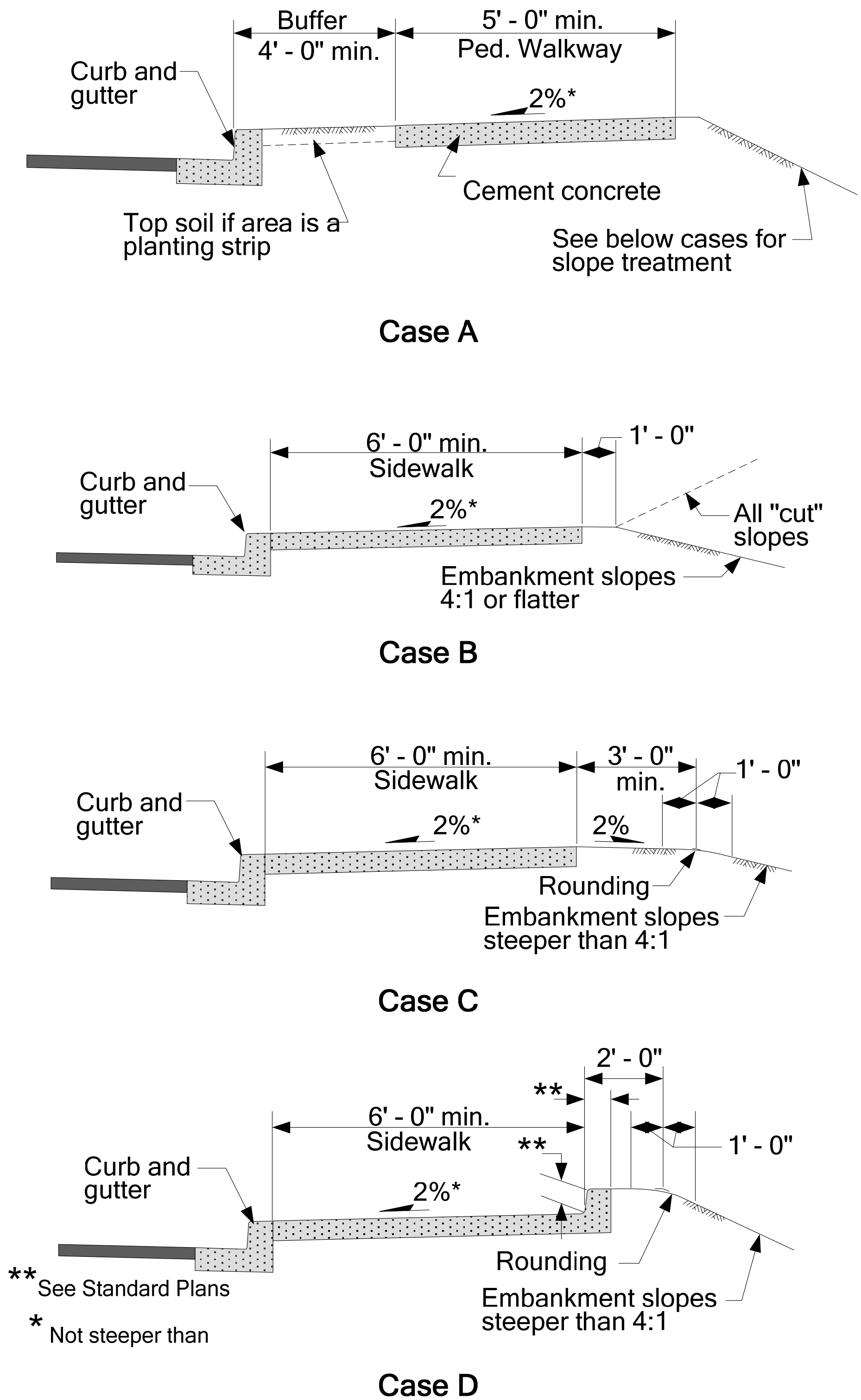
A list of documents that are required to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

Item	ADA Standards for Improvement Projects (New, Reconstruction, or Modification)	ADA Minimums for Evaluating Existing Facilities on Preservation Projects (Resurfacing or Paving)
Sidewalk Ramps		
Truncated Domes	Bottom 2 feet of ramp	Bottom 2 feet of ramp
Contrasting Colors	Yes	Yes
Landings[1]	48 inches square Min.[2]	36 inches Min.[2]
Longitudinal Slopes	12H:1V (8%)	8H:1V[3]
Cross Slopes	48H:1V (2%)	Minimum feasible
Width	48 inches[2]	36 inches[2]
Flare Side Slopes	10H:1V[4]	10H:1V
Accessible Routes		
Width	48 inches[5]	36 inches
Longitudinal Slopes	20H:1V (5%)[6,7]	20H:1V(5%)[6,7]
Cross Slopes	48H:1V (2%)	Minimum feasible
Ramps [8, 9]		
Landings[10] (Length)	60 inches[2]	60 inches[2]
Longitudinal Slopes	12H:1V (8%)6	8H:1V[3]
Cross Slopes	48H:1V (2%)	Minimum feasible
Width	44 inches	36 inches
Max. Rise Btwn. Landings	30 inches	30 inches

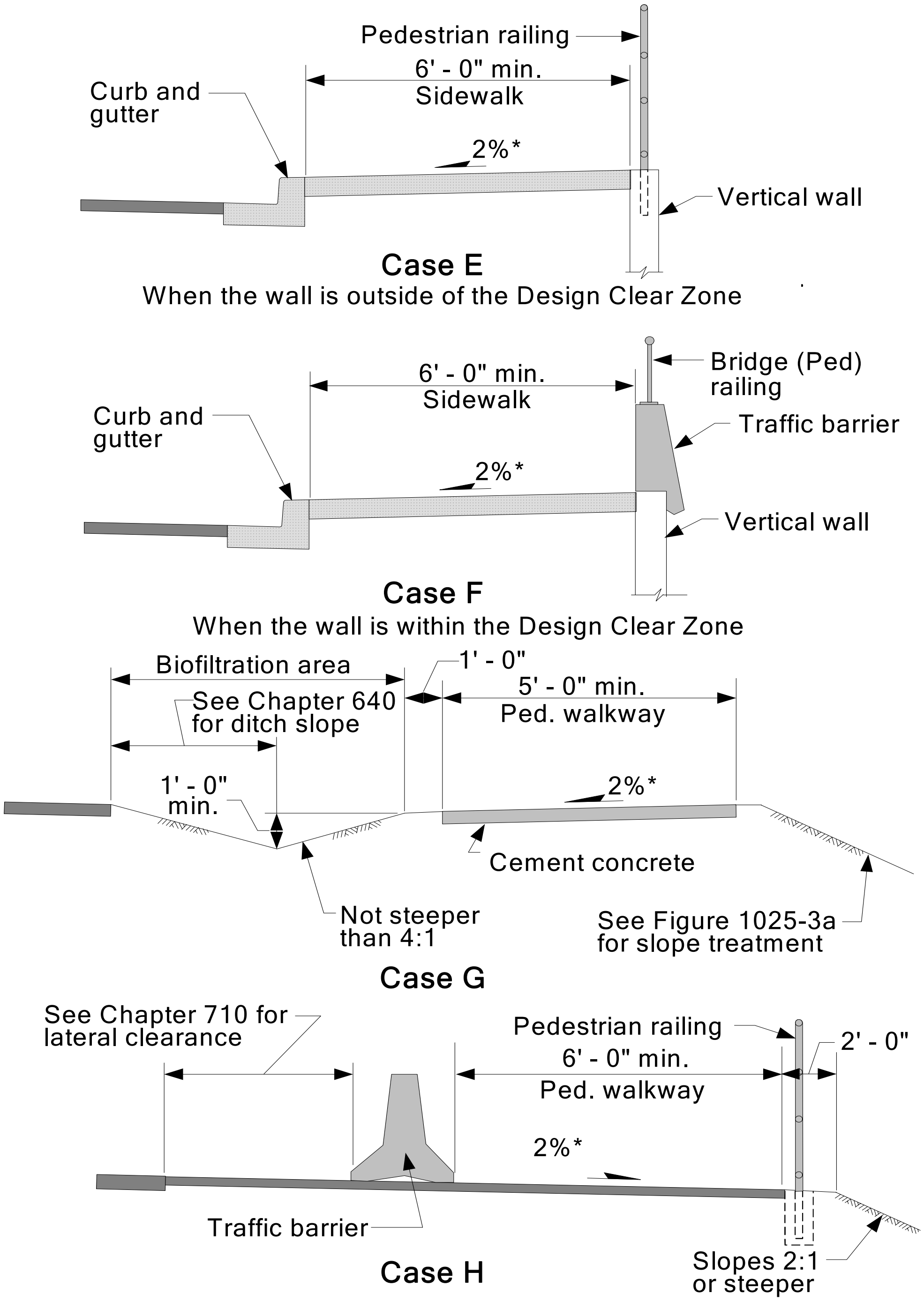
Notes:

1. The slope of the gutter pan or roadway surface at the bottom of ramp cannot exceed 20H: 1V.
2. The width of the landing shall not be less than the ramp width. Provide a 60 inch x 60 inch landing when a change of direction is required at the landing.
3. 10H:1V to 12H:1V is allowed for rises up to 6 inches; 8H:1V to 10H:1V is allowed for rises up to 3 inches.
4. Exception: Where the width of the walking surface at the top of the ramp and parallel to the run is less than 48 inches, the maximum side slope shall be 12H:1V.
5. If the width is less than 60 inches, passing spaces at least 60 inches x 60 inches shall be provided at intervals not to exceed 200 feet.
6. If accessible route is adjacent to a roadway, then the slope is allowed to match the profile of the road.
7. Slopes exceeding 5% must meet the requirements for ramps when accessible route is on a separate alignment and does not abut a roadway.
8. A ramp in this context is on a walkway on a separate alignment and does not abut a roadway. These ramps have slopes greater than 20H:1V.
9. Ramps shall have handrails, with the exception of curb ramps.
10. Landings required at top and bottom of ramp.

ADA Requirements
Figure 1025-2



Pedestrian Walkways
Figure 1025-3a



* Not steeper than

Pedestrian Walkways
Figure 1025-3b

Roadway Classification & Land Use Designation	Sidewalk Recommendations
Rural highways (outside urban growth areas)	No sidewalk recommended. 4-foot-wide shoulders adequate.
Suburban highways (one or less dwelling unit per acre)	Sidewalk on one side desirable. 4-foot-wide shoulders adequate.
Suburban highway (two to four dwelling units per acre)	Sidewalks on both sides of roadway desirable. Sidewalk on one side recommended.
Major arterial in residential area	Sidewalks on both sides of roadway recommended.
Collector or minor arterial in residential area	Sidewalks on both sides of roadway recommended.
Local street in residential area with less than one dwelling unit per acre	Sidewalk on one side desirable. 4-foot- wide shoulders adequate.
Local street in residential area with one to four dwelling units per acre	Sidewalks on both sides of roadway desirable. Sidewalk on one side recommended.
Local street in residential area with more than four dwelling units per acre	Sidewalks on both sides of roadway recommended.
Streets in commercial area	Sidewalks on both sides of roadway recommended.
Streets in industrial area	Sidewalks on both sides of roadway desirable. Sidewalk on one side recommended.

Sidewalk Recommendations

Figure 1025-4

		Roadway Type			
Traffic Volume(ADT)	**Posted Speed**	**2 lanes**	**2 lanes, raised median**[a]	**4 lanes, raised median**[a,g]	**6 lanes, raised median** [a,g]
Less than or equal to 9,000	**30 mph and slower**	Marked crosswalk	Marked crosswalk	Additional enhancement	
	35 mph to 40 mph	Marked crosswalk	Marked crosswalk	Additional enhancement	
	45 mph and higher	Additional enhancement	Additional enhancement	Active enhancement	
9,000 to 15,000	**30 mph and slower**	Marked crosswalk	Marked crosswalk	Additional enhancement	
	35 mph to 40 mph	Marked crosswalk	Marked crosswalk	Additional enhancement	
	45 mph and higher	Additional enhancement	Additional enhancement	Active enhancement	
15,000 to 30,000	**30 mph and slower**	Additional [b] enhancement	Additional enhancement	Additional [b] enhancement	Active [d] enhancement
	35 mph to 40 mph	Additional [b] enhancement	Additional enhancement	Active enhancement	Active [d] enhancement
	45 mph and higher	Active [e] enhancement	Active enhancement	See note ‘C’.	See note ‘C’.
Greater than 30,000	**45 mph and lower**	Active [e] enhancement	Active enhancement	Pedestrian [f] traffic signal	Pedestrian [f] traffic signal

* Inside city limits where the population exceeds 22,500, the decision to mark crosswalks resides with the city, subject to approval by WSDOT of the installation and type.

Notes:

a Raised refuge island, minimum 4 feet wide and 6 feet long. A TWLTL is not considered a median.
b Consider active enhancement treatment for roadways exceeding 20,000 ADT.
c Provide alternate routes for pedestrian crossings or construct a grade-separated facility.
d Location may be approaching the need for a controlled crossing. A pedestrian signal may be appropriate, based on engineering analysis.
e Raised refuge island required.
f Refer to region’s Traffic Engineer for approval and design of a pedestrian traffic signal.
g Facilities with four or more lanes that meet the crossing warrants require a raised median.

Minimum Requirements (additive for each level)

“marked crosswalk”

- Marked and signed in accordance w/MUTCD Section 3B.17 & 2C.41 (signed @ crossing only)
- Pedestrian-view warning signs
- Illumination

“additional enhancement”

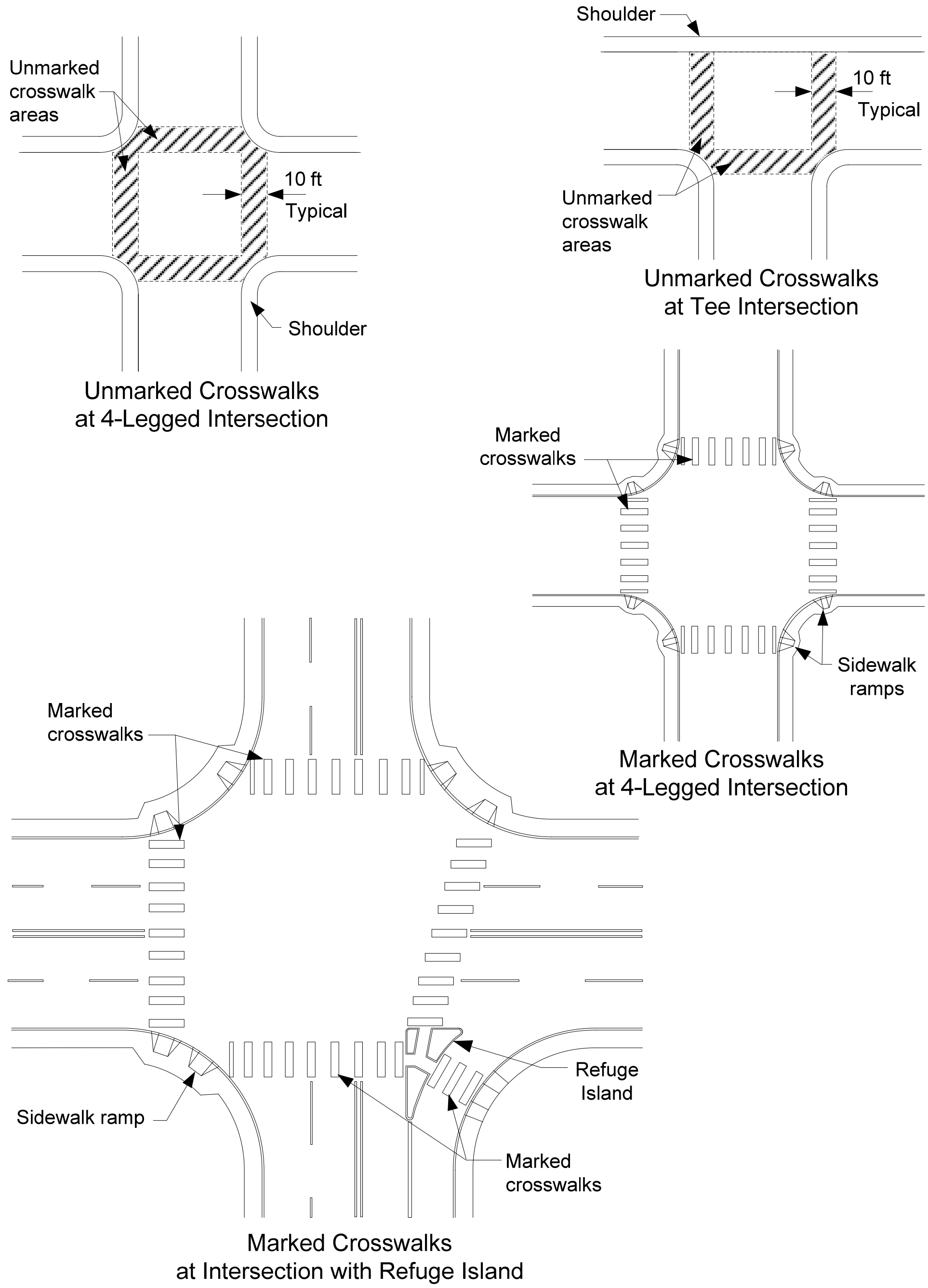
- Minimum requirements listed under “marked crosswalk”
- Stop line in accordance w/MUTCD Section 3B.16
- Advance signing in accordance w/MUTCD Section 2C.41

“active enhancement”

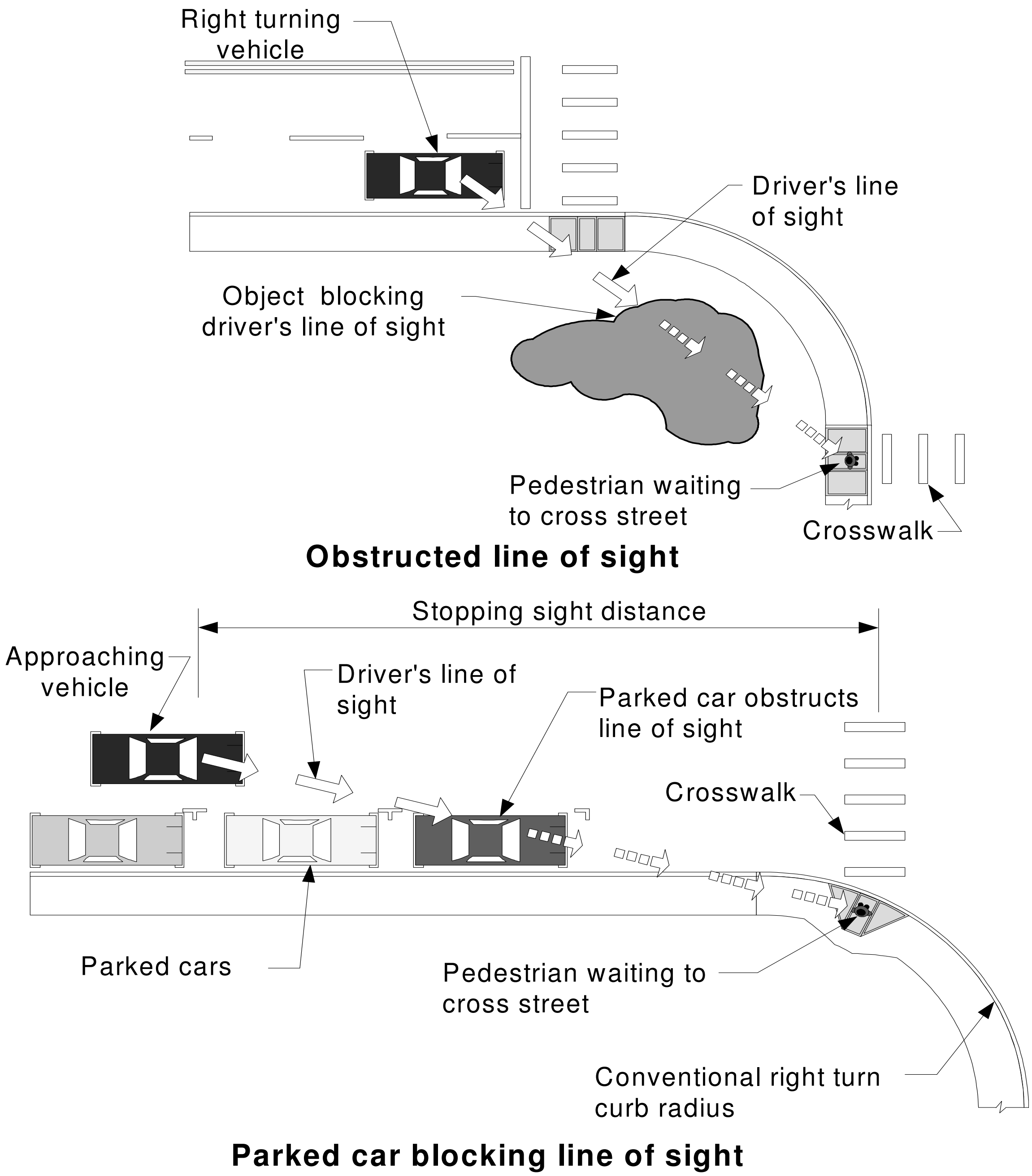
- Minimum requirements listed under “additional enhancement”
- Pedestrian-actuated warning beacons; overhead for roadway w/4 or more lanes

Note: For additional considerations that may be appropriate based on a site-specific engineering analysis, see *Design Manual*, 1025.05(3).

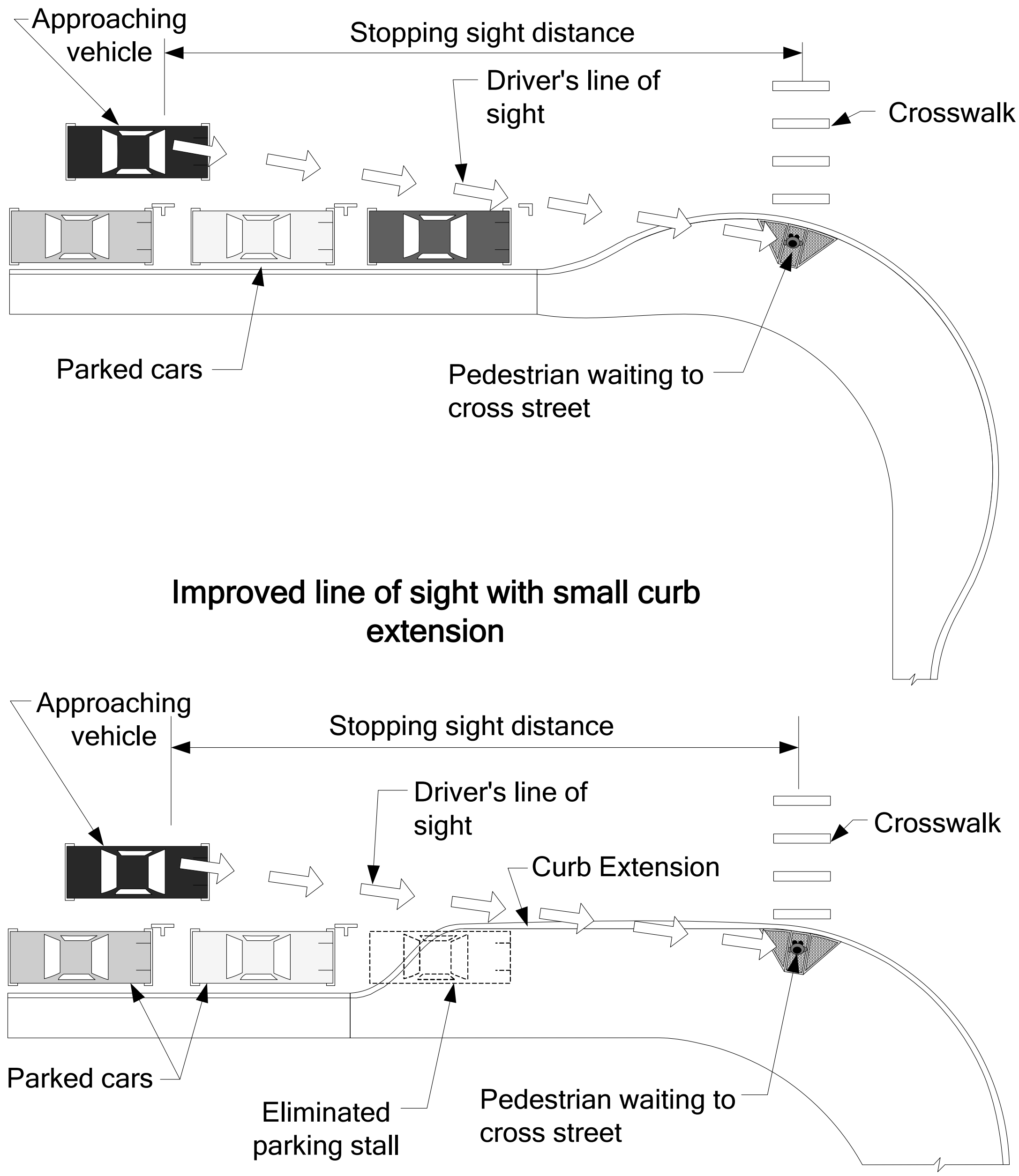
Marked Crosswalk Recommendations at Unsignalized Crossings
Figure 1025-5



Crosswalk Locations
Figure 1025-6



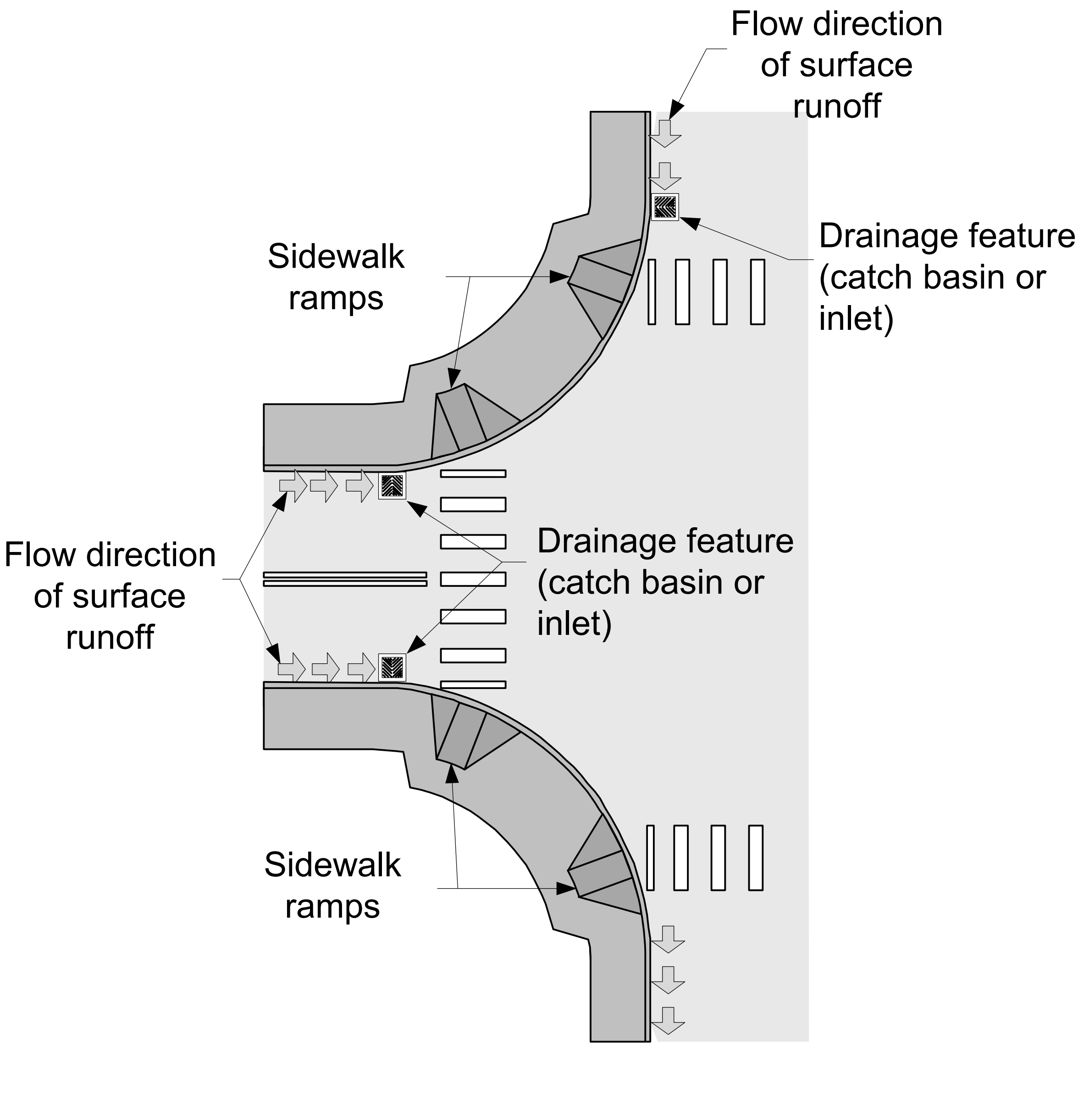
Sight Distance at Intersections
Figure 1025-7a



Sight Distance at Intersections
Figure 1025-7b

Curb Extension
Figure 1025-8

Midblock Pedestrian Crossing
Figure 1025-9



Sidewalk Ramp Drainage
Figure 1025-10

Chapter 1030 Safety Rest Areas and Traveler Services

1030.01 General

The Washington State Department of Transportation (WSDOT) has developed a statewide system of traveler services on Interstate highways and state routes. This system includes safety rest areas, roadside parks, points of interest, and traveler information centers. These traveler services provide the opportunity for rest and orientation. Benefits include improved safety, reduced driver fatigue, refuge from adverse driving conditions, and increased tourism.

Traveler services are planned and designed by a multidisciplinary team lead through the Safety Rest Area Program Planner in HQ Maintenance and Operations.

Safety rest areas and roadside parks are spaced approximately every 60 miles on the National Highway System and on Scenic and Recreational Highways. Use the *Safety Rest Area and Roadside Park Master Plan* as a guide when selecting a site location.

See the *Roadside Manual*, Division 6, for detailed information on planning, design, construction, and maintenance of safety rest areas and other traveler services.

1030.02 References

42 United States Code (USC) Section 12101et seq. Americans with Disabilities Act of 1990

23 Code of Federal Regulations (CFR) 1.23 Rights-of-Way

23 CFR 752 Landscape and roadside development

Revised Code of Washington (RCW) 46.16.063 Additional fee for recreational vehicles

RCW 46.68.170 RV account — Use for sanitary disposal systems

RCW 47.06.040 State-wide multimodal transportation plan

RCW 47.28.030 Contracts — State Forces

RCW 47.38 Roadside Areas — Safety Rest Areas

RCW 47.39 Scenic and Recreational Highway Act of 1967

Washington Administrative Code (WAC) 51-40 Uniform Building Code Requirements for Barrier-Free Accessibility

Roadside Manual, M 25-30, WSDOT

Highway Runoff Manual, M 31-16, WSDOT

Highway System Plan, WSDOT

Hydraulics Manual, M 23-03, WSDOT

Maintenance Manual, M 51-01, WSDOT

Right of Way Manual, M 26-01, WSDOT

Roadside Classification Plan, M 25-31, WSDOT

Traffic Manual, M 51-02, WSDOT

Safety Rest Area and Roadside Park Master Plan

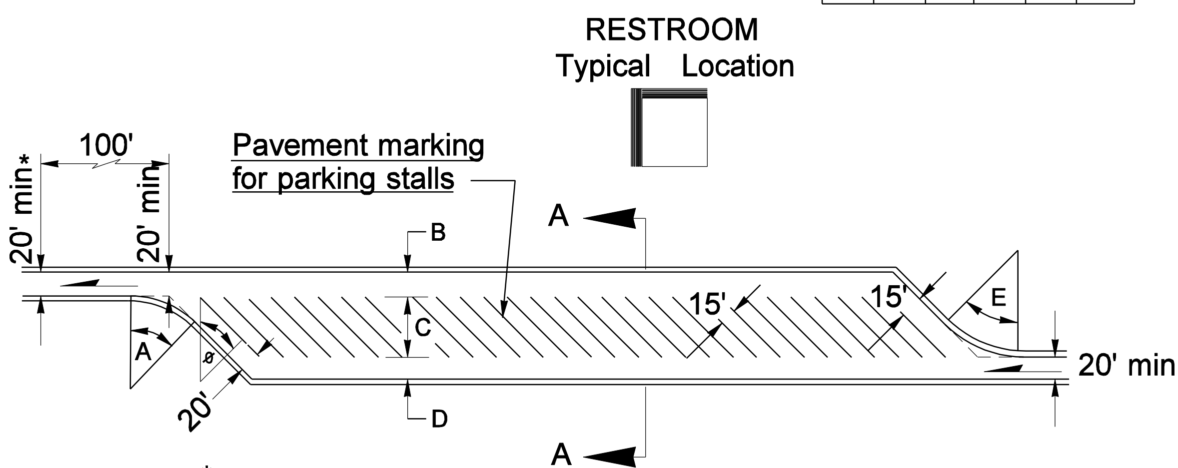
Manual on Uniform Traffic Control Devices USDOT, Washington DC, including the *Washington State Modifications to the MUTCD,* WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

"Safety Rest Areas: Planning, Location and Design," USDOT, FHWA, 1981

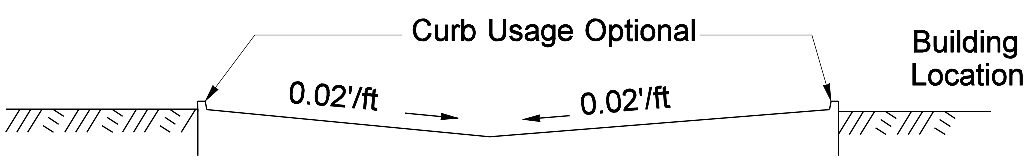
1030.03 Documentation

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

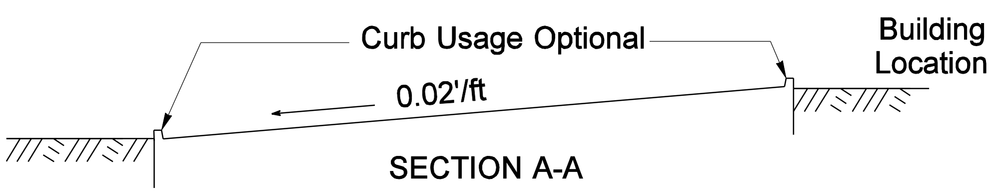
	Variables (feet)				
Ø	A	B	C	D	E
30°	85	30	50	30	100
35°	90	35	55	35	105
40°	95	35	60	35	110
45°	100	45	65	45	115



* Note:
If exit ramp is tangent
or has curve radii greater
than 1000', this width may be
reduced to 14'.

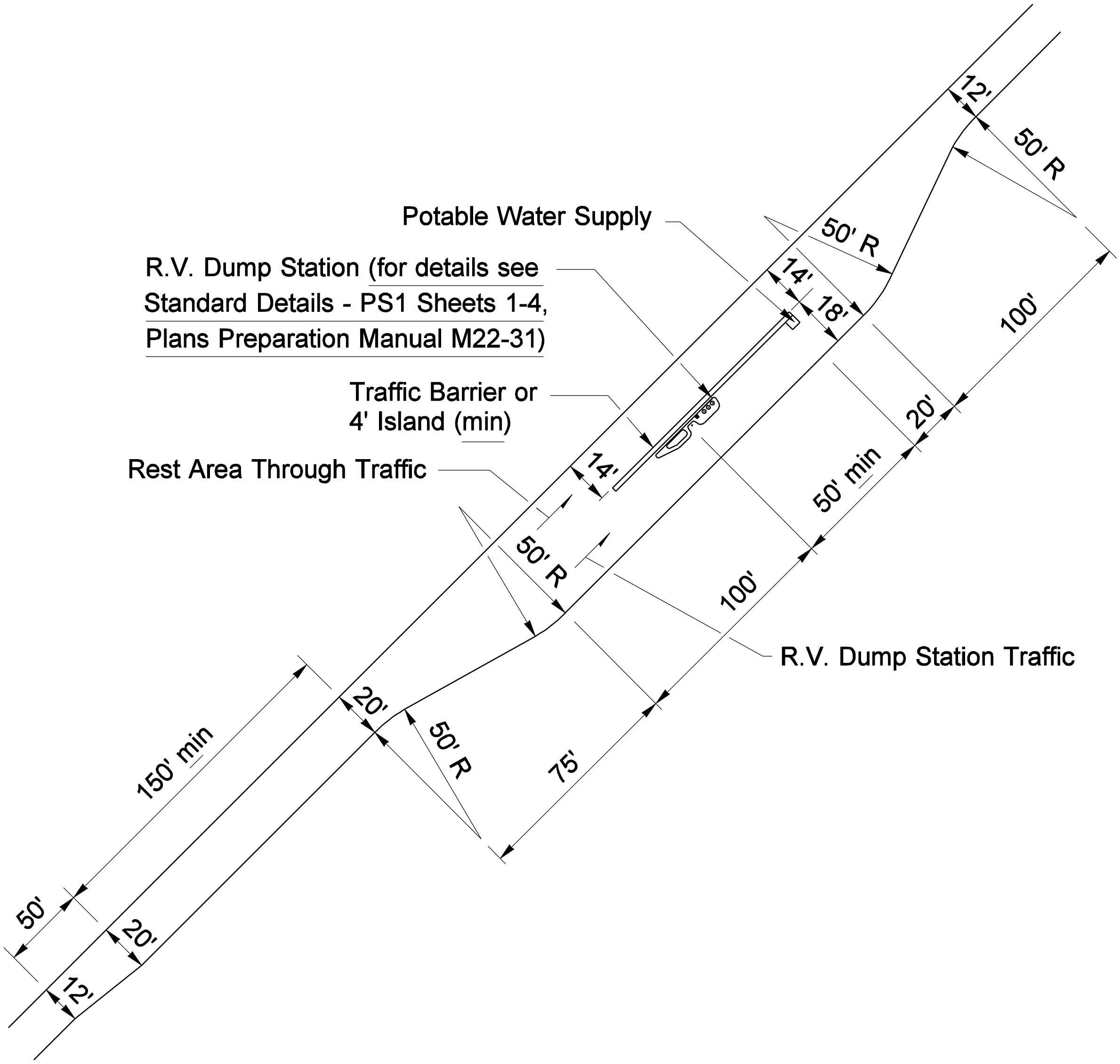


SECTION A-A

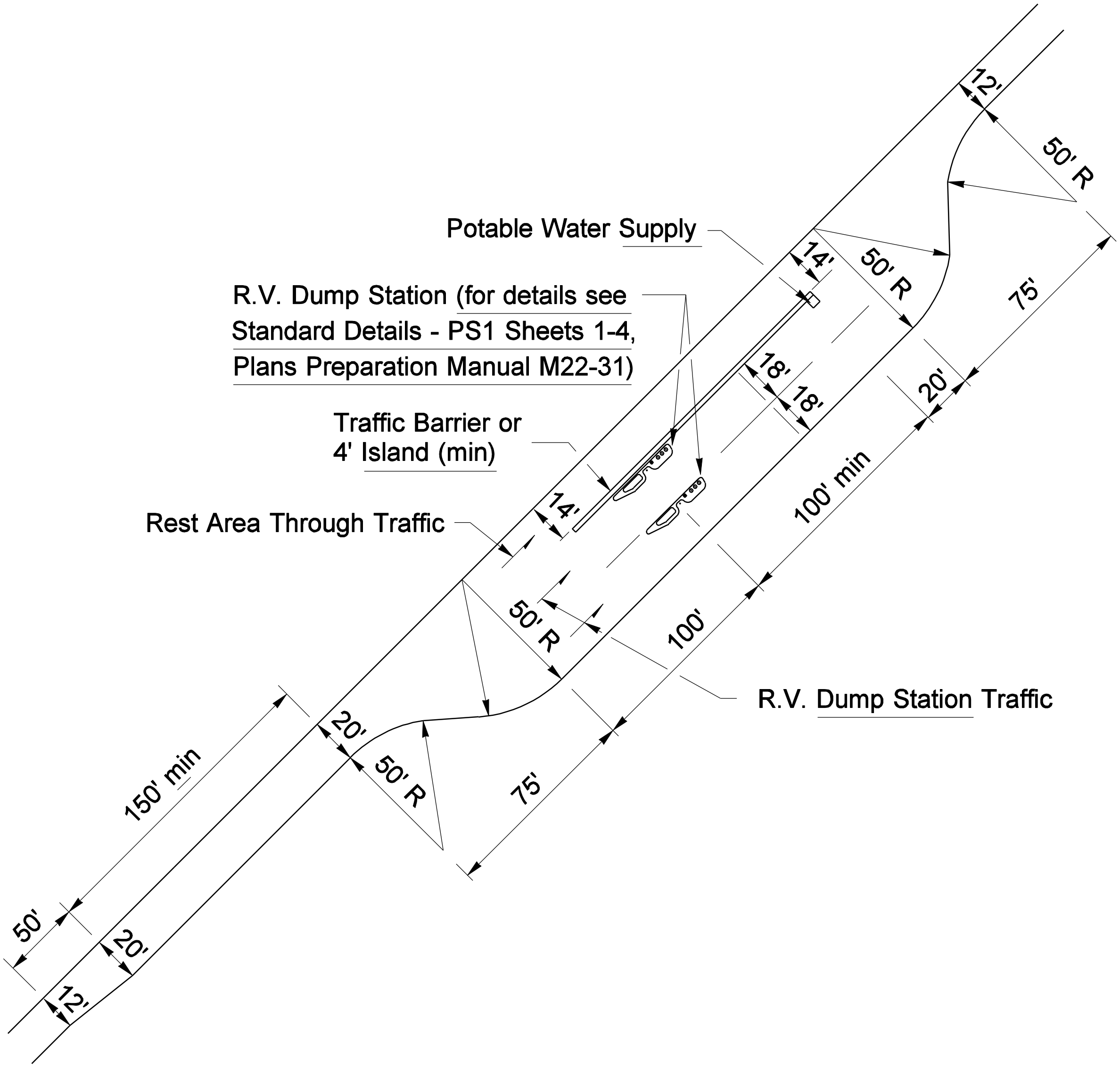


SECTION A-A
Alternate

Typical Truck Storage
Figure 1030-1



Typical Single RV Dump Station Layout
Figure 1030-2



Typical Two RV Dump Station Layout
Figure 1030-3

1040.01 General

Truck weighing facilities are needed to protect state highways from overweight vehicles, to provide for vehicle safety inspection, and to provide a source of data for planning and research. The development, construction, and maintenance of these facilities is a cooperative effort between the Washington State Department of Transportation (WSDOT) and the Washington State Patrol (WSP).

1040.02 Definitions

Commercial Vehicle Information Systems and Networks (CVISN) A network that links intelligent transportation systems (ITS) to share information on commercial vehicles. When in operation at a weigh site it can enable commercial vehicles to clear the facility without stopping.

decision sight distance The sight distance required for a driver to detect an unexpected or difficult-to-perceive information source or hazard, interpret the information, recognize the hazard, and select and complete an appropriate maneuver safely and efficiently.

functional classification The grouping of streets and highways according to the character of the service they are intended to provide. (See Chapter 440.)

frontage road An auxiliary road that is a local road or street located beside a highway for service to abutting property and adjacent areas and for control of access.

lane A strip of roadway used for a single line of vehicles.

median The portion of a divided highway separating the traveled ways for traffic in opposite directions.

outer separation The area between the outside edge of traveled way for through traffic and the nearest edge of traveled way of a frontage road.

roadway The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.

sight distance The length of roadway visible to the driver.

shoulder The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and use by pedestrians and bicycles.

static scale A scale that requires a vehicle to stop for weighing.

stopping sight distance The sight distance required to safely stop a vehicle traveling at design speed.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

usable shoulder The width of the shoulder that can be used by a vehicle for stopping.

weigh in motion (WIM) A scale facility capable of weighing a vehicle without the vehicle stopping.

1040.03 Planning, Development, and Responsibilities

The WSP works with the WSDOT's Planning and Programming Service Center to develop a prioritized list of weigh facility needs for each biennium. The list includes:

- New permanent facilities
- New portable facilities
- New shoulder sites

- WIM equipment
- Vehicle inspection facilities
- Scale approach slab reconstruction

The WSP provides Program Management a project definition, that includes:

- A statement of need, the purpose of the project, and the type of work
- The general location of the project

Program Management sends this information to the region for preparation of a Project Summary. The region works with the WSP to identify the specific location of the facility, prepares a design decision estimate, and submits it to Program Management.

The region negotiates and the Regional Administrator executes any formal agreements with the WSP required for the design, construction, or maintenance of vehicle weighing and inspection facilities.

The Memorandum of Understanding Related to Vehicle weighing and Equipment Inspection Facilities on State Highways, Figure 1040-8, contains details about the various responsibilities of the WSDOT and the WSP.

1040.04 Permanent Facilities

Permanent truck weighing facilities have permanent scales and may have buildings. When these facilities are in operation, trucks are required stop. However, when Weigh In Motion (WIM) and Commercial Vehicle Information Systems and Networks (CVISN) capabilities have been installed, the driver may be notified to continue without stopping. The notification to continue may be through the use of signs or transponders.

(1) Site Locations

The exact location of a truck weighing facility is generally controlled by topography, highway alignment, and geometrics. It is also desirable to select a site where adequate right of way is already available. Select the most economical site to minimize site preparation, expense, or impact on the environment. Water, electricity availability, and sewage treatment and disposal are other considerations for site selection.

Locate the facility so that its operation will not hinder the operation of the highway or other related features such as intersections and interchanges.

To the extent possible, locate the facility to prevent truck traffic avoiding the facility on other roadways and the type and volume of truck traffic using the highway.

An Access Point Decision Report is required for weigh sites on multilane divided highways with access control. (See Chapter 1425.)

(2) Design Features

On multilane highways, provide standard off- and on-connections, as shown in Chapter 940. Figure 1040-1 is the minimal design of a weigh site on multilane highways.

Design weigh facilities on two-lane highways to best fit the existing conditions, with particular consideration given to the matter of access to and from the site. Standard off- and on-connections, as shown in Chapter 940, are preferred; however, with justification on-connections may be designed as intersections. (See Chapter 910.) Figure 1040-2 is a guide for the design of weigh sites on two-lane highways.

The following special design features apply:

- Level cement concrete approach slabs are required at both ends of the scales.

  Asphalt concrete pavement approach slabs will be allowed only when adequate soil conditions exist, projected truck volume is light, and benefit/cost analysis justifies the use of asphalt concrete pavement based on the small percentage of time the scales will be in operation.

  The approach slabs must be level and in the same plane as the scale.

- Provide adequate parking and storage to ensure that trucks do not impede the mainline through traffic. The WSDOT Regional Administrator and the WSP agree on the area to be provided.

- On multilane divided highways, install illuminated electronically controlled “open” and “closed” message signs that can be operated from the scale house or the control cabinet. Provide permanent signing for the facility, as requested by the WSP.
- The need for a vehicle safety inspection facility at any site is identified by the WSP. Figure 1040-3 is a guide for a site plan for a single bay vehicle inspection facility. Additional bays and site adaptation will be on a site by site basis. The WSDOT Regional Administrator and the WSP agree on the area to be provided.
- The need for some form of approach protective treatment for the scale house or a protective fence between the scale and roadway is identified by the WSP and agreed upon by the WSDOT Regional Administrator and the WSP. The need for the device is to protect the scale house from errant vehicles. See Chapter 700 for additional clear zone considerations.
- The need for WIM or CVISN capabilities is identified by the WSP. Design the in-place facilities to provide the ability to notify drivers whether to continue on or to stop for further investigation before they reach the exit for the static scale. The design is agreed upon by the WSDOT Regional Administrator and the WSP.
- Where WIM and CVISN are not included in the project, provide conduit for their future installation.
- With justification, at locations where space is limited, the depressed outer separation between the weigh facility and the through lanes may be replaced with concrete traffic barrier. (See Collector Distributor Outer Separations, Chapter 940.)
- Provide a clear view of the entire weigh site for the facility’s operator and the driver of an approaching vehicle.
- Asphalt concrete pavement is acceptable for use on the ramp and storage areas. Design the depth in accordance with the surfacing report.
- To optimize scale efficiency, make the storage area flat; however, to facilitate drainage, the slope may be up to 2%.
- Provide illumination when requested by the WSP. Illumination is required if the facility is to be operated during the hours of darkness and may be desirable at other locations to deter unauthorized use of the facility. See Chapter 840 for additional information on illumination.

1040.05 Portable Facilities

Portable truck weighing facilities have no permanent scales or buildings. When these facilities are in operation, they operate in the same manner as permanent facilities.

(1) Site Locations

Design portable truck weighing facilities located on two-lane and multilane roadways to best fit the existing conditions. Minor portable scale sites, as shown on Figure 1040-4, are used with two-way traffic and on multilane highways with low traffic volumes. Major portable scale sites, Figure 1040-5, are for use on expressways, freeways, and where traffic volumes are high.

Locate the weighing facility so that its operation will not hinder the operation of the highway or other related features such as an intersection.

An Access Point Decision Report is required for weigh sites on multilane divided highways with access control. (See Chapter 1425.)

(2) Design Features

The following special design features apply:

- Off- and on-connections, as shown in Figures 1040-4 and 5, are preferred; however, with justification on highways with no access control, on-connections may be designed as intersections. (See Chapter 910.)
- With justification, at locations where space is limited, the depressed outer separation between the weigh facility and the through lanes may be replaced with concrete traffic barrier. See the collector distributor outer separation figure in Chapter 940.

- Provide adequate parking and storage to ensure that trucks do not impede the mainline through traffic. The WSDOT Regional Administrator and the WSP agree on the area to be provided.
- Asphalt concrete pavement is acceptable for use on the ramp and storage areas. Design the depth in accordance with the surfacing report.
- To optimize portable scale efficiency, make the storage area flat; however, to facilitate drainage, the slope may be up to 2%.
- Provide permanent signing for the facility, as requested by the WSP.
- Provide illumination when requested by the WSP. Illumination is required if the facility is to be operated during the hours of darkness and may be desirable at other locations to deter unauthorized use of the facility. See Chapter 840 for additional information on illumination.

1040.06 Shoulder Sites

Shoulder sites are used by the WSP to pull a truck over for inspection and weighing with portable scales.

(1) Site Locations

Design shoulder sites to best fit the existing conditions. Small shoulder sites (Figure 1040-6) are for use on lower volume roadways (ADT 5,000 or less) with two-way traffic. Large shoulder sites (Figure 1040-7) are to be used with higher volume two-way roadways and multilane highways.

Locate the weighing facility so that its operation will not hinder the operation of the highway or other related features such as an intersection.

(2) Design Features

Shoulder sites are designed in coordination with the WSP. Input from the local WSP Commercial Vehicle Enforcement personnel will ensure that the proposed site will meet their needs without over-building the facility. Obtain written concurrence from the WSP for the length, width, and taper rates before the design is finalized.

When the ADT is 1,500 or less and with the written approval of the WSP, the tapers at small shoulder sites may be eliminated. The shoulders on either side of the site may be used as acceleration and deceleration lanes, whether or not they were designed for this use. Therefore, provide adequate strength to support truck traffic.

Asphalt concrete pavement is acceptable for use on all shoulder sites. Design the depth in accordance with the surfacing report. Design the shoulder pavement at this depth for a length not less than the deceleration lane length before, and the acceleration lane length after, the site (Chapter 940).

When the shoulders are designed to be used for deceleration and acceleration lanes, the minimum width is 12 ft with full pavement depth for the deceleration/acceleration lane lengths (Chapter 940).

Use a maximum of 2% slope in order to optimize portable scale efficiency and to facilitate drainage.

1040.07 Federal Participation

Federal funds appropriate to the system being improved may be used for the acquisition of right of way and the construction of truck weighing facilities and vehicle inspection facilities. This includes, but is not limited to on and off ramps, deceleration and acceleration lanes, passing lanes, driveways, parking areas, scale approach slabs, vehicle inspection facilities, roadway illumination, and signing.

1040.08 Procedures

Prepare site plans for all truck weigh facilities that include:

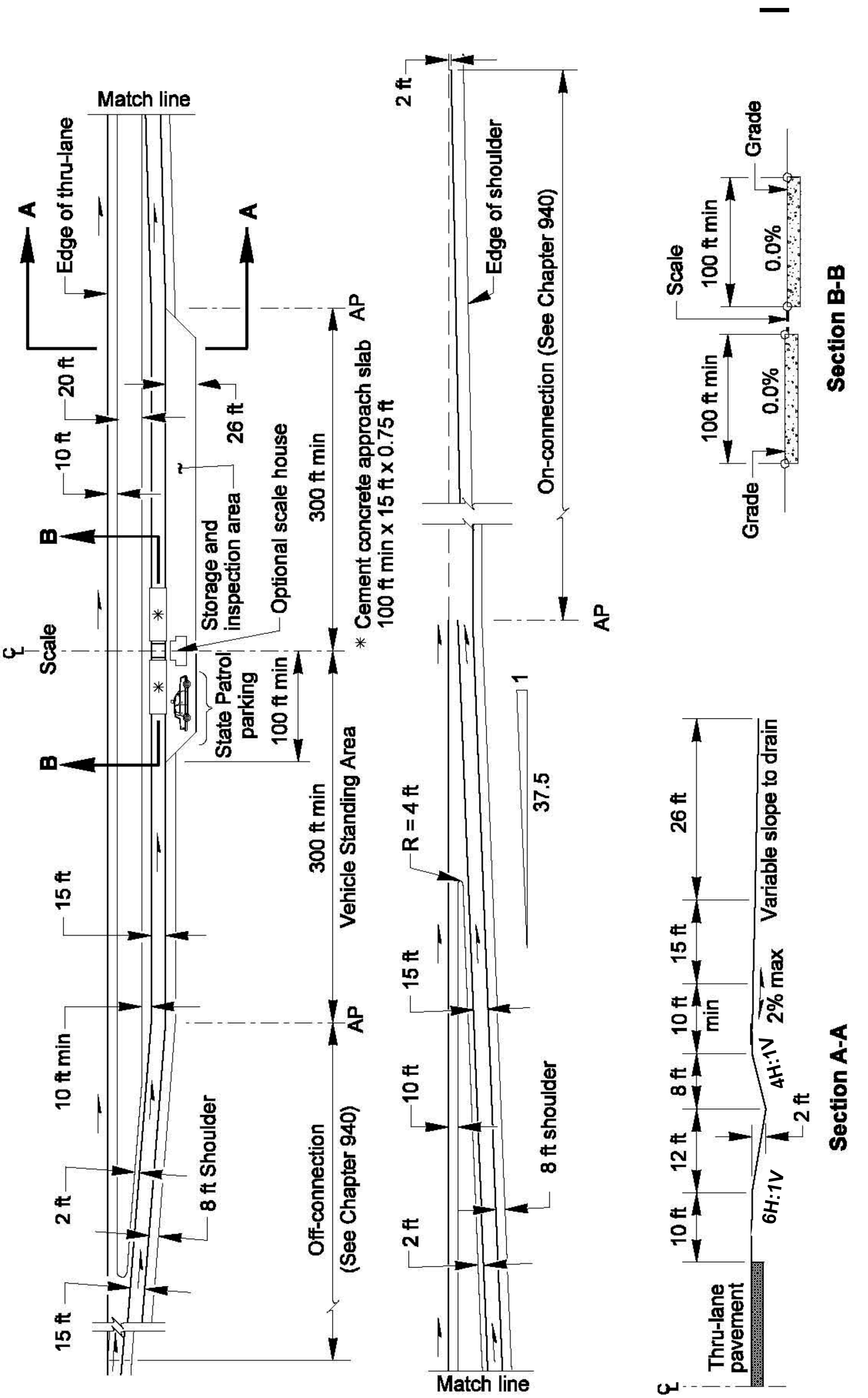
- Class of highway and design speed for main line (Chapter 440).
- Curve data on main line and weigh site.
- Numbers of lanes and widths of lanes and shoulders on main line and weigh site.
- Superelevation diagrams for the main line and weigh site.
- Stationing of ramp connections and channelization.

- Illumination.
- Signing.
- Water supply and sewage treatment.
- Roadside development.

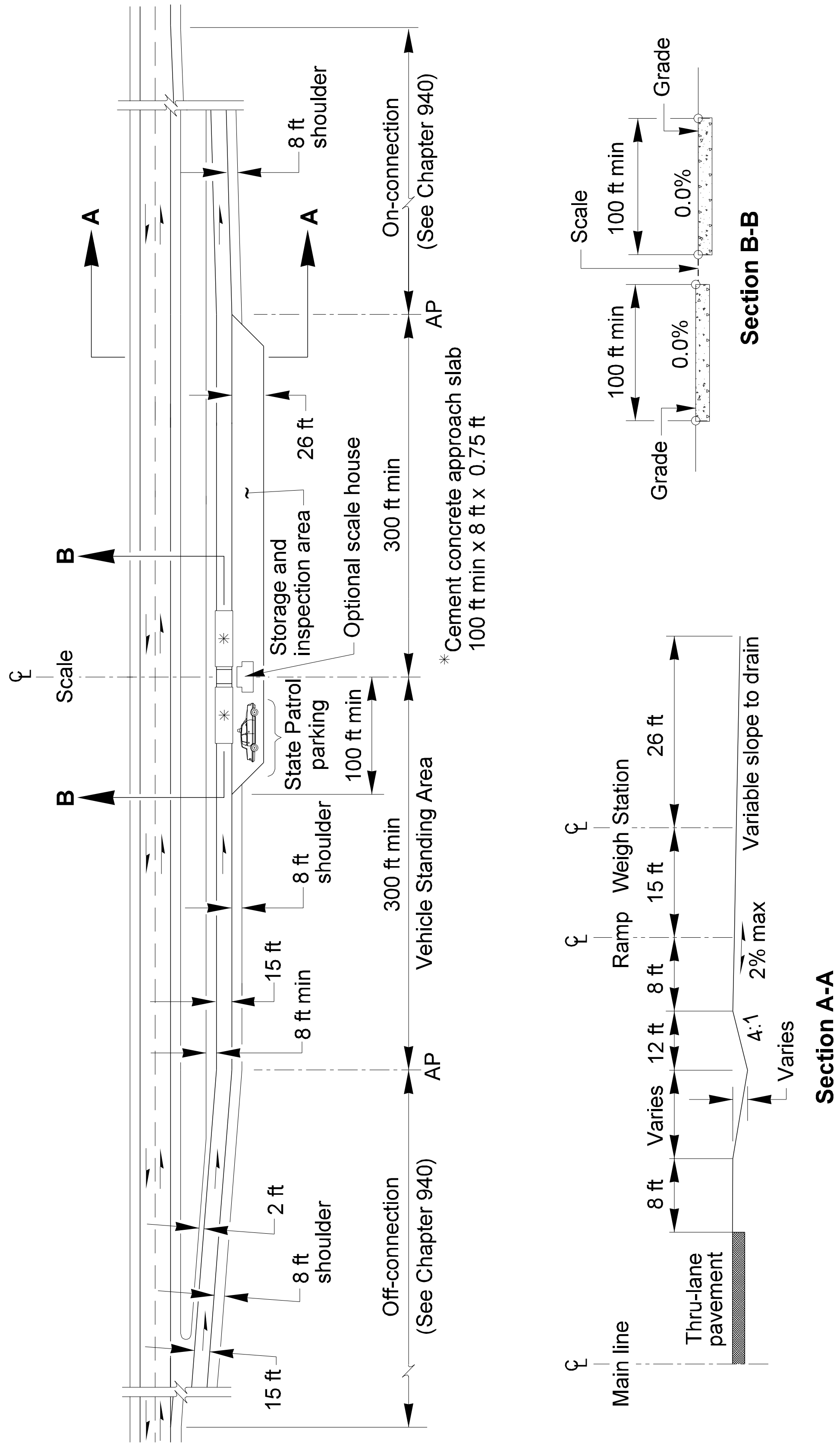
Get WSP approval of the site plans before the final plan approval.

1040.09 Documentation

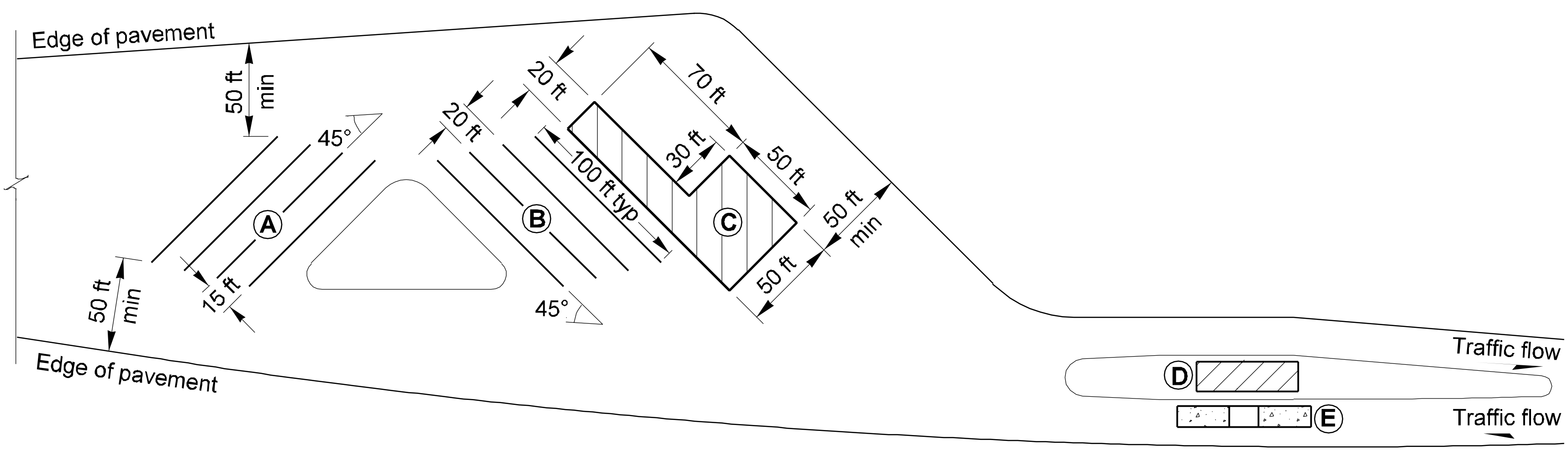
A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/



Truck Weigh Site (Multilane Highways)
Figure 1040-1



Truck Weigh Site (Two Lane Highways)
Figure 1040-2



Ⓐ Truck storage and parking

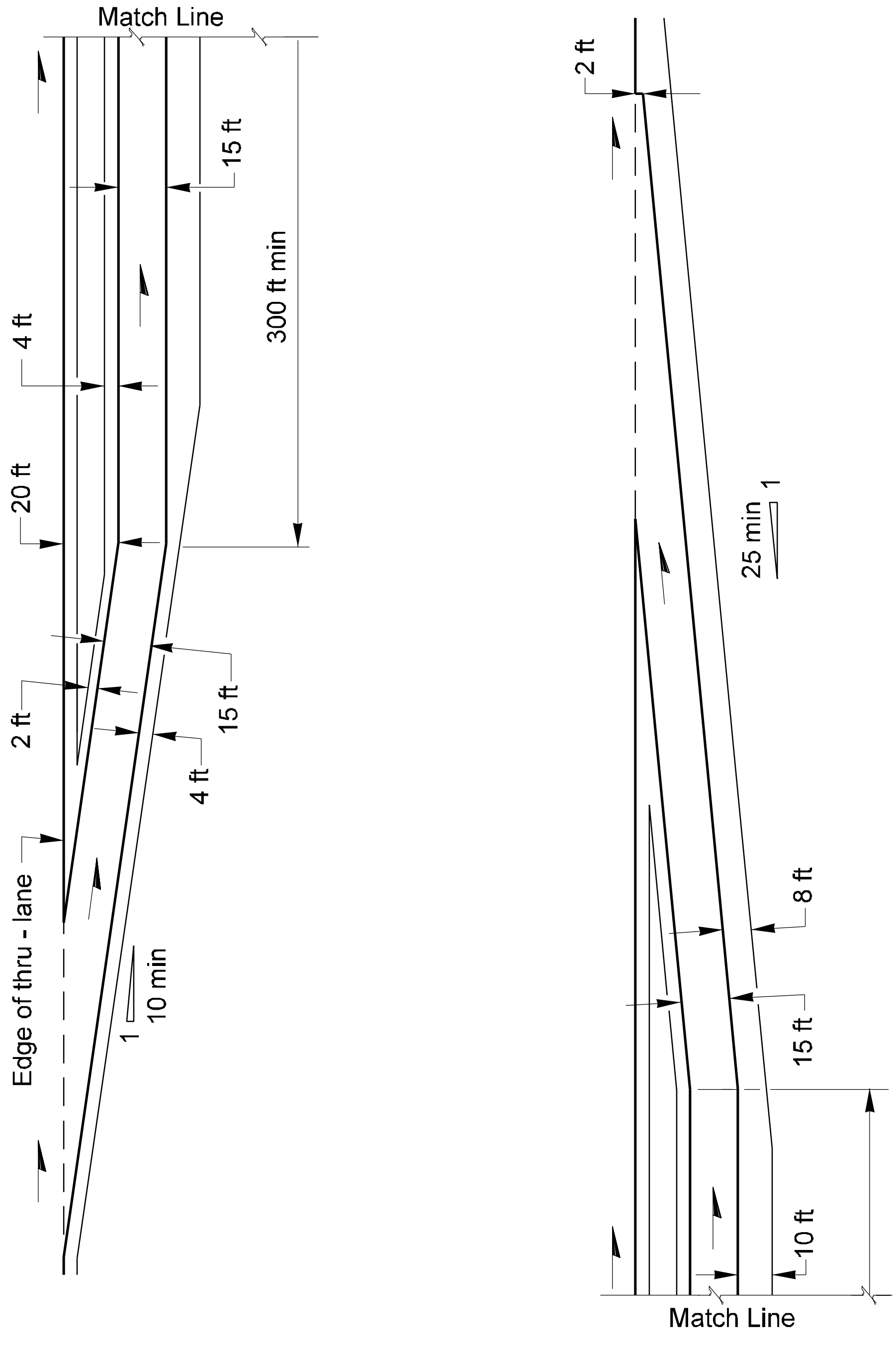
Ⓑ Outside truck inspection and parking

Ⓒ Truck inspection building

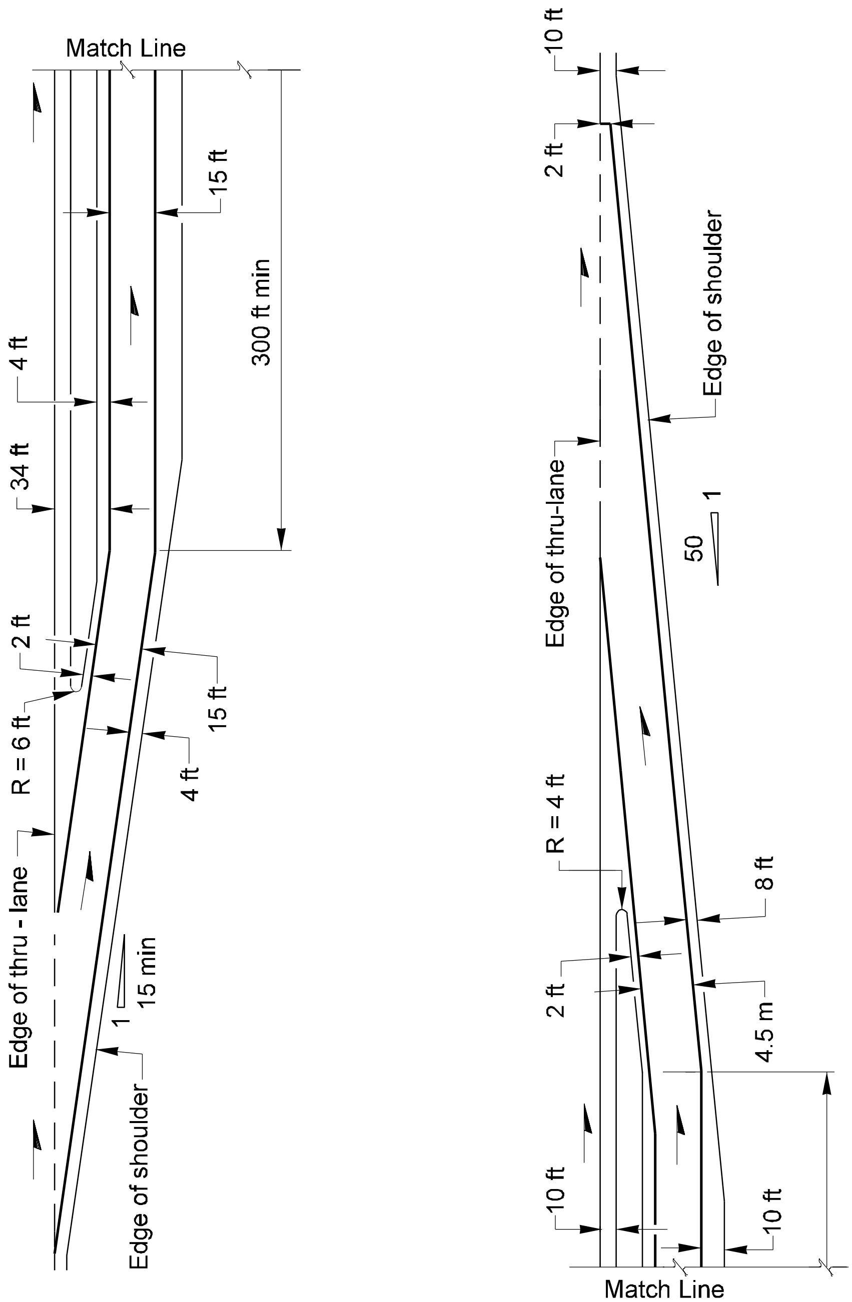
Ⓓ Scalehouse

Ⓔ Scale

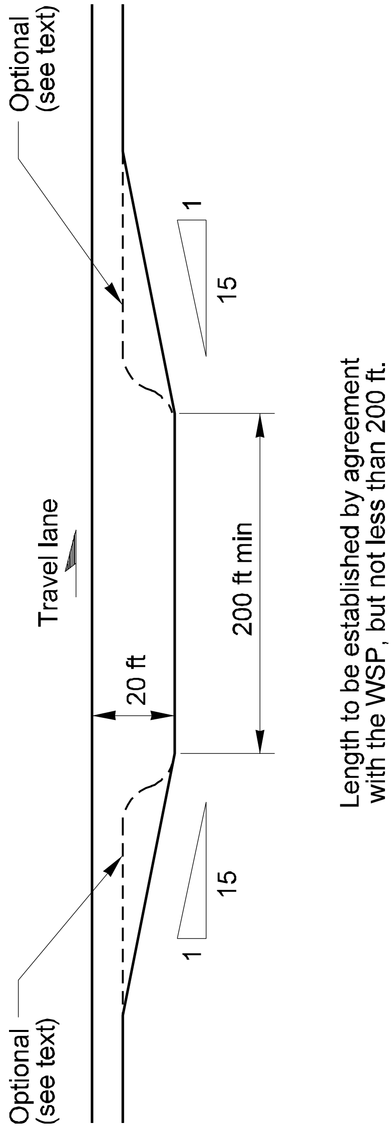
Vehicle Inspection Installation
Figure 1040-3



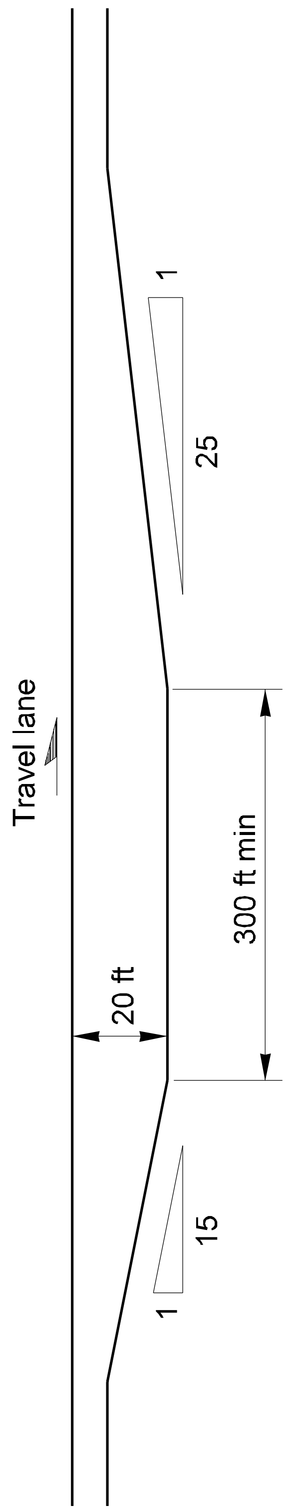
Minor Portable Scale Site
Figure 1040-4



Major Portable Scale Site
Figure 1040-5



Small Shoulder Site
Figure 1040-6



Large Shoulder Site
Figure 1040-7

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Memorandum of Understanding

Related to Vehicle Weighing and
Equipment Inspection Facilities on State Highways

This Memorandum of Understanding by and between the Washington State Department of Transportation hereinafter called the "Department of Transportation," and the Washington State Patrol, hereinafter called the "State Patrol," establishes procedures for coordinating and delineating the responsibilities for the location, design, construction, maintenance, signing, and other matters related to vehicle weighing and equipment inspection facilities and the state highway improvements needed as a result of these facilities.

It is mutually recognized that:

The Department of Transportation is responsible for planning, designing, constructing, and perpetuating public highways of the State Highway system for the safety and benefit of the traveling public;

The State Patrol is responsible for enforcement of the laws of the state of Washington regarding vehicle weight enforcement programs and vehicle safety inspection programs;

Nothing in this agreement is to be construed as conflicting with existing laws, regulations, and prescribed responsibilities, and

In recognition of the responsibilities, interest, and limitations set forth above and of the mutual benefits of established procedures to facilitate agreement on specific matters, the Department of Transportation and the State Patrol mutually agree as follows:

I. Planning

A. The State Patrol will work with the Department of Transportation's Planning and Programming Service Center to develop a prioritized list of weigh station needs at each biennium. The list will include:

- New permanent facilities
- New portable facilities
- Weigh-in-Motion (WIM) equipment
- Vehicle inspection facilities
- Scale approach slab construction

B. The State Patrol will provide the Planning and Programming Service Center with a project definition for each project, which will include statement of need, purpose of project, type of work, and general location of the project.

C. The Planning and Programming Center will send the information to the Regional Administrator for preparation of a project summary. The Regional Administrator will work with the State Patrol to identify the specific location of the facility, prepare a design decision estimate, and submit it to the Planning and Programming Service Center for inclusion in the biennial program.

D. The Regional Administrator will negotiate and execute any formal agreements required for design, construction, or maintenance of vehicle weighing and inspection sites.

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways

Figure 1040-8a

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II. Responsibilities

Vehicle weighing and equipment inspection facilities shall meet highway standards for acceleration and deceleration lanes, on and off ramps, illumination, and other related equipment. These facilities will be provided through the cooperative efforts of the State Patrol and Department of Transportation as needed on state highways.

A. The State Patrol will:

1. Initiate the action and submit recommendations for the addition of a new facility or expansion of an existing facility or the relocation of an existing facility, and negotiate agreements, e.g. siting of a new facility, etc. with the Department of Transportation through the appropriate region and the Olympia Service Center.

2. Perform the preliminary engineering and submit the design and PS&E documents for the scale, WIM, scalehouse, and inspection facility to the Department of Transportation for review and processing for approval with the Federal Highway Administration (FHWA), if applicable, at the State Patrol's expense.

3. Construct, operate, and maintain the weigh station scale, WIM, scalehouse, and equipment inspection facility with all related equipment thereto including lighting, water, heat, telephone, and toilet facilities at the State Patrol's expense.

4. For WIM facilities and for facilities deploying Commercial Vehicle Information Systems and Networks (CVISN), select sites in cooperation with DOT that minimize the need for pavement reconstruction, and, at the State Patrol's expense, install, operate, and maintain any weigh-in-motion signs and related equipment, purchase and install all WIM hardware and software, and provide electrical conduit and an equipment storage room within the scale facility.

5. In the event the State Patrol cannot fulfill the responsibilities specified above for preliminary engineering (design and PS&E documents), construction, or maintenance, they may request that the Department of Transportation perform the work on the basis of a written agreement that includes reimbursement to the Department of Transportation for the costs.

6. Construct the CVISN roadside apparatus at the same time as WIM equipment is installed, e.g.; cantilevered mounting poles, guard rail, conduit/raceway installation at DOT expense. All construction in the state or interstate right-of-way will be under the responsibility of a DOT region engineer.

B. The Department of Transportation will:

1. Initiate action for the relocation of an existing installation when necessary because of the relocation of a highway or expansion of an existing highway, and obtain concurrence of the State Patrol.

2. Negotiate agreements with the State Patrol regarding addition, expansion, and relocation of facilities.

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways

Figure 1040-8b

C990477GSC

3. On all newly located or existing highways, at Department of Transportation expense, acquire the necessary right of way, construct and maintain the required acceleration and deceleration lanes, on and off ramps, driveways, passing lanes, scale approach slabs, and parking areas, including the surfacing thereof, excavate the scale pit, and construct and maintain the inspection, parking, and roadway illumination and standard signing at approved locations.

4. For WIM facilities and for facilities deploying Commercial Vehicle Information Systems and Networks (CVISN), at Department of Transportation's expense, construct the special approaches, provide maintenance of CVISN hardware and software located within the facility, and provide traffic control for installation of the scale and, when closure of any lane is required, for maintenance of the scale.

5. For facilities deploying Commercial Vehicle Information Systems and Networks (CVISN), at WSDOT's expense install mainline hardware (Automated Vehicle Identification equipment) and software for conformance with CVISN standards and provide maintenance of CVISN hardware and software located within the facility.

6. Upon request of the State Patrol, in accordance with a written agreement and on a reimbursement basis, perform other preliminary engineering, construction, and maintenance, which is the sole responsibility of the State Patrol.

Additionally, the State Patrol and the Department of Transportation agree to follow the Federal Highway Administration's *Guidance for Local Agency Roadway Projects within Interstate Rights-of-Way*, as outlined in Attachment A.

III. Conclusions and Approvals

A. The Regional Administrators for the Department of Transportation and the Commercial Vehicle Division Commander for the State Patrol are encouraged to consult with each other and to agree on such matters that fall within their scope of responsibility.

B. This memorandum may be amended or supplemented by mutual agreement between the signers or their successors.

C. Either party may terminate this MOU upon thirty- (30) days' written notification. If this MOU is so terminated, the terminating party shall be liable only for performance in accordance with the terms of the MOU for performance rendered prior to the effective date of the termination.

D. In the event a dispute arises under this MOU, it shall be resolved as follows: The Secretary of WSDOT and the Chief of the WSP shall each appoint a member, not affiliated with either agency, to a conflict resolution board. Then these two members shall appoint a third member. The decision made by this board shall be final and binding on the parties to the MOU.

E. In the event funding from state, federal, or other sources is withdrawn, reduced, or limited in any way after the effective date of this MOU and prior to normal completion, the WSDOT or WSP may terminate the MOU under the TERMINATION clause, subject to renegotiation under those new funding limitations and conditions.

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways

Figure 1040-8c

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F. We have read the foregoing and agree to accept and abide by the procedures herein.

Annette M. Sandberg, Chief
Washington State Patrol

12/16/99
Date

Sid Morrison, Secretary
Washington State
Department of Transportation

3/9/'00
Date

APPROVED AS TO FORM:

Assistant Attorney General

9/7/99
Date

Washington State Patrol
Budget and Fiscal Services

12/27/99
Date

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways
Figure 1040-8d

C99047 / GSC

ATTACHMENT A

Guidance for Local Agency Roadway Projects within Interstate Rights-of-Way

Since all projects within the Interstate rights-of-way (ROW) have the potential to impact safety and operations on the Interstate route, they must incorporate Interstate design criteria and construction quality. It is the Federal Highway Administration's (FHWA) policy that the Washington State Department of Transportation (WSDOT) should administer all projects within the Interstate ROW. However, given the scope and extent of non-Interstate projects within the Interstate ROW, it is recognized that local agency administration of some projects may be desirable.

Whenever a local agency proposes a project within the Interstate ROW, they must develop an agreement with WSDOT that clearly outlines their duties and responsibilities to maintain the integrity of the Interstate facility, from both the safety and quality perspectives. The agreement must be executed prior to beginning design and must incorporate the following requirements:

Responsibilities: WSDOT and the local agency must each assign a responsible Project Engineer.

Design: WSDOT must review and approve all highway plans, profiles, deviations structural plans false-work plans, shoring plans, and traffic control plans for any work within the Interstate ROW.

Plans, specification and estimates: WSDOT must review and approve the plans and specifications for any work within Interstate ROW.

Advertising and aware: The local agency must confer with the WSDOT Project Engineer on any pre-aware issues affecting the quality and timing of the contract.

Construction: All construction, materials, and quality control requirements contained in the current editions of the WSDOT Standard Specifications and Construction Manual must be incorporated into the agreement.

Contract changes: All contract changes affecting work within the Interstate ROW must have the prior concurrence of the WSDOT Project Engineer.

Final inspection: The final inspection of the project must be performed by WSDOT Olympia Service Center and must evidence their approval.

Only local agencies with full certification acceptance authority may enter into such an agreement with the WSDOT.

The agreement must be submitted to FHWA for approval. FHWA reserves the right to assume full oversight of the project.

MOU Related to Vehicle Weighing and Equipment Inspection Facilities on State Highways

Figure 1040-8e

1050.01 General

High occupancy vehicle (HOV) facilities include separate HOV roadways, HOV lanes, transit lanes, HOV direct access ramps, and flyer stops. The objectives for the HOV facilities are:

- Improve the capability of corridors to move more people by increasing the number of people per vehicle.
- Provide travel time savings and a more reliable trip time to HOV lane users.
- Provide safe travel options for HOVs without adversely affecting the safety of the general-purpose lanes.

Plan, design, and construct HOV facilities that ensure intermodal linkages. Give consideration to future highway system capacity needs. Whenever possible, design HOV lanes so that the level of service for the general-purpose lanes will not be degraded.

In urban corridors that do not currently have planned or existing HOV lanes, complete an analysis of the need for HOV lanes before proceeding with any projects for additional general-purpose lanes. In corridors where both HOV and general-purpose facilities are planned, construct the HOV lane before or simultaneously with the construction of new general-purpose lanes.

See the following chapters for additional information:

Chapter	Subject
430	general-purpose roadway widths for modified design level
440	general-purpose roadway widths for full design level
640	other cross section data
641	general-purpose turning roadway widths
1055	HOV Direct Access

1050.02 References

Revised Code of Washington (RCW) 46.61.165, High-occupancy vehicle lanes

RCW 47.52.025, Additional powers — Controlling use of limited access facilities — High-occupancy vehicle lanes

Washington Administrative Code (WAC) 468-510-010, High occupancy vehicles (HOVs)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, Washington State Department of Transportation (WSDOT)

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), 2000, U.S. Department of Transportation, Federal Highway Administration; including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT

Traffic Manual, M 51-02, WSDOT

Guide for the Design of High Occupancy Vehicle Facilities, American Association of State Highway and Transportation Officials (AASHTO)

Design Features of High Occupancy Vehicle Lanes, Institute of Traffic Engineers (ITE)

High-Occupancy Vehicle Facilities: Parsons Brinkerhoff, Inc.

NCHRP Report 414, *HOV Systems Manual*

1050.03 Definitions

buffer-separated HOV lane An HOV lane that is separated from the adjacent same direction general-purpose freeway lanes by a designated buffer.

bus rapid transit (BRT) An express rubber tired transit system operating predominantly in roadway managed lanes. It is generally characterized by separate roadway or buffer-separated HOV lanes, HOV direct access ramps, and a high occupancy designation (3+ or higher).

business access transit (BAT) lanes A transit lane that allows use by other vehicles to access abutting businesses.

enforcement area A place where vehicles may be stopped for ticketing by law enforcement. It also may be used as an observation point and for emergency refuge.

enforcement observation point A place where a law enforcement officer may park and observe traffic.

flyer stop A transit stop inside the limited access boundaries.

high occupancy toll (HOT) lane A managed lane that combines a high occupancy vehicle lane and a toll lane.

high occupancy vehicle (HOV) A vehicle that fits one of the following:

(1) Rubber tired municipal transit vehicles.

(2) Buses with a carrying capacity of sixteen or more persons, including the operator.

(3) Motorcycles.

(4) Recreational vehicles that meet the occupancy requirements of the facility.

(5) All other vehicles that meet the occupancy requirements of the facility, except trucks in excess of 10,000 lb gross vehicle weight.

HOV direct access ramp An on or off ramp exclusively for the use of HOVs that provides access between a freeway HOV lane and a street, transit support facility, or another freeway HOV lane without weaving across general-purpose lanes.

HOV facility A priority treatment for HOVs.

level of service A qualitative measure describing operational conditions within a traffic stream, incorporating factors of speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

managed lane A lane that increases efficiency by packaging various operational and design actions. Lane management operations may be adjusted at any time to better match regional goals.

nonseparated HOV lane An HOV lane that is adjacent to and operates in the same direction as the general-purpose lanes with unrestricted access between the HOV lane and the general-purpose lanes.

occupancy designation The minimum number of occupants required for a vehicle to use the HOV facility.

separated HOV facility An HOV roadway that is physically separated from adjacent general-purpose lanes by a barrier, median, or on a separate right of way.

single occupant vehicle (SOV) Any motor vehicle other than a motorcycle carrying one occupant.

transit lane A lane for the exclusive use of transit vehicles.

violation rate The total number of violators divided by the total number of vehicles on an HOV facility.

1050.04 Preliminary Design and Planning

(1) Planning Elements for Design

In order to determine the appropriate design options for an HOV facility, the travel demand and capacity must first be established; identify suitable corridors, evaluate the HOV facility location and length, and estimate the HOV demand. A viable HOV facility will satisfy the following criteria:

- Be part of an overall transportation plan.
- Have the support of the community and public.

- Respond to demonstrated congestion or near-term anticipated congestion: Level of Service E or F for at least one hour of peak period (traffic approaching a capacity of 1,700 to 2,000 vehicles per hour per lane) or average speeds less than 30 mph during peak periods over an extended distance.
- Except for a bypass of a local bottleneck, be of sufficient length to provide a travel time saving of at least 5 minutes during the peak periods.
- Have sufficient numbers of HOV users for a cost-effective facility and to avoid the perception of under utilization. (HOV volumes of 400 to 500 vehicles per hour on nonseparated lanes and 600 to 800 on separated facilities.)
- Provide a safe, efficient, and enforceable operation.

A queue or bottleneck bypass can be effective without satisfying all of the above. An isolated bypass can be viable when there is localized, recurring traffic congestion, and such treatment will provide a travel time saving to an adequate number of HOV users.

The efficiency of the HOV facility can be affected by the access provisions. Direct access between park and ride/transit facilities and an HOV lane is the most desirable, but it is also an expensive alternative. Direct access options are discussed in Chapter 1055.

Document the need for the HOV lane and how the proposed lane will meet those needs.

(2) HOV Facility Type

Make a determination as to the type of HOV lane. The three major choices are separated roadway, buffer-separated lane, and nonseparated HOV lane.

(a) **Separated Roadway.** The separated roadway can be either a one-way reversible or a two-way operation. The directional split in the peak periods, space available, and operating logistics are factors to be considered. A separated HOV roadway may be located in the median of the freeway, next to the freeway, or on an independent alignment. Separated HOV facilities are more effective for:

- Large HOV volumes.
- Large merging and weaving volumes.
- Long-distance HOV travel.

Reversible, separated roadways operate effectively where there are major directional splits during peak periods. Consider potential changes in this traffic pattern and designing the facility to accommodate possible conversion to two-way operation. The separated roadway is normally more efficient, provides for the higher level of safety, and is more easily enforced. However, it is generally the most expensive type of HOV facility to implement.

(b) **Buffer-Separated.** A buffer-separated HOV lane is similar to a freeway nonseparated HOV lane on the left, but with a buffer between the HOV lane and the general-purpose lanes. The addition of a buffer provides better delineation between the lanes and controls access between the HOV lane and general-purpose lanes to improve operation.

(c) **Nonseparated.** Nonseparated HOV lanes operate in the same direction and immediately adjacent to the general-purpose lanes. They are located either to the left (preferred) or to the right of the general-purpose lanes. Nonseparated HOV lanes are normally cheaper, easier to implement, and provide more opportunity for frequent access. However, the ease of access can create more problems for enforcement and a higher potential for conflicts.

(3) Freeway Operational Alternatives

For an HOV lane on a limited access facility, consider the following operational alternatives:

- Inside (preferred) or outside HOV lane.
- Lane conversion.
- Use of existing shoulder (not recommended for permanent operations).
- HOV direct access ramps.
- Queue bypasses.
- Flyer stops.
- Hours of operation.

When evaluating alternatives, consider a combination of alternatives to provide the best solution for the corridor. Also, incorporate flexibility into the design in order not to preclude potential changes in operation, such as outside-to-inside lane and reversible to two-way operations. Access, freeway-to-freeway connections, and enforcement will have to be accommodated for such changes. Document the operational alternatives.

(a) **Inside Versus Outside HOV Lane.** System continuity and consistency of HOV lane placement along a corridor are important and influence facility development decisions. Other issues include land use, trip patterns, transit vehicle service, HOV volume, ramp volume, congestion levels, safety, enforcement, and direct access to facilities.

The inside (left) HOV lane is most appropriate for a corridor with long distance trip patterns, such as a freeway providing mobility to and from a large activity center. These trips are characterized by long distance commuters and express transit service. Maximum capacity for an effective inside HOV lane is approximately 1,500 vehicles per hour. When the HOVs weaving across the general-purpose lanes cause severe congestion, consider implementing HOV direct access ramps, separated HOV roadways, or a higher occupancy designation. Inside lanes are preferred for HOV lanes on freeways.

The outside (right) HOV lane is most appropriate for a corridor with shorter, widely dispersed trip patterns. These trip patterns are characterized by transit vehicle routes that exit and enter at nearly every interchange. The maximum capacity for an effective outside HOV lane is reduced and potential conflicts are increased by heavy main line congestion and large entering and exiting general-purpose volumes.

(b) **Conversion of a General-Purpose Lane.** The use of an existing general-purpose lane for an HOV lane is not a preferred option; however, conversion of a lane to an HOV lane might be justified when the conversion provides greater people-moving capability on the roadway. Use of an existing freeway lane as an HOV lane will be considered only with a deviation.

Given sufficient existing capacity, converting a general-purpose lane to an HOV lane will provide for greater people moving capability in the future without significantly affecting the existing roadway operations. The fastest and least expensive method for providing an HOV lane is through conversion of a general-purpose lane. Restriping and signing are sometimes all that is needed. Converting a general-purpose lane to HOV use will likely have environmental benefits. This method, however, is controversial from a public acceptance standpoint. Public support might be gained through an effective public involvement program. See Chapter 210, Public Involvement and Hearings.

Lane conversion of a general-purpose lane to an HOV lane must enhance the corridor's people moving capacity. It is critical that an analysis be conducted that includes:

- Public acceptance of the lane conversion.
- Present and long-term traffic impacts on the adjacent general-purpose lanes and the HOV lane.
- Impacts to the neighboring streets and arterials.
- Legal, environmental, and safety impacts.

(c) **Use of Existing Shoulder.** When considering the alternatives in order to provide additional width for an HOV lane, the use of the existing shoulder is not a preferred option. Use of the shoulder on a freeway or freeway ramp as an HOV lane will be considered only with a deviation.

Consider shoulder conversion to an HOV lane when traffic volumes are heavy and the conversion is a temporary measure. Another alternative is to use the shoulder as a permanent measure to serve as a transit-only or queue bypass lane during peak hours and then revert to a shoulder in off peak hours. The use of the shoulder creates special signing, operational, and enforcement problems. An agreement is required with the transit agency to ensure that transit vehicles will only use the shoulder during peak hours. The use of the shoulder must be clearly defined by signs. Institute special operations to ensure the shoulder is clear and available for the designated hours.

The existing shoulder pavement is often not designed to carry heavy volumes of vehicles, especially transit vehicles. As a result, repaving and reconstruction of the shoulder might be required.

(d) **HOV Direct Access Ramps.** To improve the efficiency of an HOV system, exclusive HOV access connections for an inside HOV lane may be considered. See Chapter 1055 for information on HOV direct access connections. Direct access reduces the need for HOVs to cross the general-purpose lanes from right side ramps. Transit vehicles will be able to use the HOV lane and provide service to park and ride lots, flyer stops, or other transit stops by the HOV direct access ramps.

(e) **Queue Bypass Lanes.** A queue bypass lane allows HOVs to save time by avoiding congestion at an isolated bottleneck. An acceptable time saving for a queue bypass is one minute or more. Typical locations for queue bypasses are at ramp meters, signalized intersections, toll plaza or ferry approaches, and locations with isolated main line congestion. By far the most common use is with ramp metering. Queue bypass lanes can be built along with a corridor HOV facility or independently. In most cases, they are relatively low cost and easily implemented. Where practical, include HOV bypasses on ramp metering sites or make provisions for their future accommodation, unless specific location conditions dictate otherwise.

(f) **Flyer Stops.** Flyer stops reduce the time required for express transit vehicles to serve intermediate destinations. However, passengers must travel greater distances to reach the loading platform. For information on flyer stops, see Chapter 1055.

(g) **Hours of Operation.** HOV designation on freeway HOV lanes 24 hours a day provides benefits to users during off peak periods, minimizes potential confusion, makes enforcement easier, and simplifies signing and striping. However, 24-hour operation also might result in a lane not used during off peak periods, negative public opinion, and the need for full time enforcement.

(4) Arterial Street Operational Alternatives

Arterial street HOV lanes also have a variety of HOV alternatives to be considered. Some of these alternatives are site specific or have limited applications. Arterial HOV lanes differ from freeway HOV lanes in slower speeds, little access control (turning traffic can result in right angle conflicts), and traffic signals. Arterial HOV lanes are occasionally designated for transit vehicles only, especially in cities with a large concentration of transit vehicles. When evaluating alternatives consider traffic signal queues and managed access highway class. The alternatives include:

- Type of lane.
- Left side or right side HOV lane.
- Hours of operation.
- Spot treatments.
- Bus stops.

When evaluating alternatives, consider a combination of alternatives to provide the best solution for the corridor. Also, incorporate flexibility into the design in order not to preclude potential changes in operation. Document the operational alternatives.

(a) **Type of lane.** Lanes can be transit only or include all HOVs. Transit only lanes are desirable where bus volumes are high with a high level of congestion. They will increase the speed of transit vehicles through congested areas and improve the reliability of the transit service. Lanes that allow use by all HOVs are appropriate on corridors with high volumes of carpools and vanpools. They can collect carpools and vanpools in business and industrial areas and connect them to the freeway system.

(b) **Left side or right side HOV lane.** Continuity of HOV lane location along a corridor is an important consideration when making the decision whether to locate an arterial street HOV lane on the left or right side of the street. Other issues include land use, trip patterns, transit vehicle service, safety, enforcement, and presence of parking.

The right side is the preferred location for arterial street HOV lanes on transit routes with frequent stops. It is the most convenient for passenger boarding at transit stops. It is also the most common location for HOV lanes on arterial streets. General-purpose traffic must cross the HOV lane to make a right-turn at intersections and to access driveways. These turns across the HOV lane can create conflicts. Minimizing access points that create these conflict locations is recommended. Other issues to consider are on street parking, stopping area for delivery vehicles, and enforcement areas.

Left side arterial street HOV lanes are less common than right side lanes. HOV lanes on the left eliminate the potential conflicts with driveway access, on street parking, and stopping area for delivery vehicles. The result is fewer delays and higher speeds making left side arterial street HOV lanes appropriate for longer distance trips. Disadvantages are the difficulty providing transit stops and the need to provide for left turning general-purpose traffic.

(c) **Hours of operation.** An arterial street HOV lane can either operate as an HOV lane 24 hours a day or during peak hours only. Factors to consider in determining which to use include type of HOV lane, level of congestion, continuity, and enforcement.

HOV lanes operating 24 hours a day are desirable when congestion and HOV demand exists for extended periods throughout the day. The 24 hour operation provides benefits to users during off peak periods, minimizes potential confusion, makes enforcement easier, and simplifies signing and striping. Disadvantages are negative public opinion if the lane is not used during off peak periods, the need for full time enforcement, and the loss of on street parking.

Peak period HOV lanes are appropriate for arterial streets with HOV demand or congestion existing mainly during the peak period. Peak period HOV lanes provide HOV priority at the critical times of the day, lessen the negative public perception of the HOV lane, and allow on street parking or other shoulder uses at other times. The disadvantages include possible confusion to the drivers, more difficult enforcement, increased signing, and the need to institute special operations to ensure the shoulder or lane is clear and available for the designated period.

(d) **Spot Treatments.** A spot HOV treatment is used to give HOVs priority around a bottleneck. It can provide time savings, travel time reliability, and improve access to other facilities. Examples include a short HOV lane to provide access to a freeway on-ramp, one lane of a dual turn-lane, a priority lane at ferry terminals, and priority at traffic signals.

Signal priority treatments that alter the sequence or duration of a traffic signal are techniques for providing preferential treatment for transit vehicles. The priority treatments can range from timing and phasing adjustments to signal preemption. Consider the overall impact on traffic. Preemption would normally not be an appropriate treatment where traffic signal timing and coordination are being utilized or where there are high volumes on the cross streets.

(e) **Bus stops.** Normally, with arterial HOV lanes, there is not a shoulder suitable for a bus to use while stopped to load and unload passengers without blocking the lane. Therefore, bus stops are either in-lane or in a pullout. In-lane bus stops are the simplest type of bus stop. However, stopped buses will block the HOV lane; therefore, in-lane bus stops are only allowed in transit lanes. Bus pullouts provide an area for buses to stop without blocking the HOV lane. Disadvantages include higher cost, reduced width for the sidewalk or other roadside area, and possible difficulty reentering the HOV lane. See Chapter 1060 for additional information on bus stop location and design.

1050.05 Operations

(1) Vehicle Occupancy Designation

Select the vehicle occupancy designation to provide the maximum movement of people in a corridor, provide free-flow HOV operations, reduce the empty lane perception, provide for the ability to accommodate future HOV growth within a corridor, and be consistent with the regional transportation plan and the policies adopted by the metropolitan planning organization (MPO).

An initial occupancy designation must be established. It is WSDOT policy to use the 2+ designation as the initial occupancy designation. Consider a 3+ occupancy designation if it is anticipated during initial operation that the volumes will be 1,500 vehicles per hour for a left-side HOV lane, or 1,200 vehicles per hour for a right-side HOV lane, or that a 45 mph operating speed cannot be maintained for more than 90 percent of the peak hour.

(2) Enforcement

Enforcement is necessary for the success of an HOV facility. Coordination with the Washington State Patrol (WSP) is critical when the operational characteristics and design alternatives are being established. This involvement ensures that the project is enforceable and will receive their support.

Provide both enforcement areas and observation points for all high-speed HOV lanes and ramp facilities.

Barrier-separated facilities, because of the limited access, are the easiest facilities to enforce. Shoulders provided to accommodate breakdowns may also be used for enforcement. Reversible facilities have ramps for the reverse direction that may be used for enforcement. Gaps in the barrier may be needed so emergency vehicles can access barrier-separated HOV lanes.

Buffer-separated and nonseparated HOV lanes allow violators to easily enter and exit the HOV lane. For this reason, providing strategically located enforcement areas and observation points is essential.

Consider the impact on safety and visibility for the overall facility during the planning and design of enforcement areas and observation points. Where HOV facilities do not have enforcement areas, or where officers perceive that the enforcement areas are inadequate, enforcement on the facility will be difficult and less effective.

(3) Intelligent Transportation Systems

The objective of intelligent transportation systems (ITS) is to make more efficient use of our transportation network. This is done by collecting data, managing traffic, and relaying information to the motoring public.

It is important that an ITS system is incorporated into the HOV project and that the HOV facility fully utilize the ITS features available. This includes providing a strategy of incident management since vehicle breakdowns and accidents have a significant impact on the efficient operation of the HOV facilities. See Chapter 860 for more information on ITS.

1050.06 Design Criteria

(1) Design Procedures

See the design matrices (Chapter 325) for the required design level for the elements of an HOV project.

(2) Design Considerations

HOV lanes are designed to the same criteria as the facilities they are attached. Design nonseparated and buffer-separated HOV lanes to match the vertical alignment, horizontal alignment, and cross slope of the adjacent lane. A deviation is required when any proposed or existing design element does not meet the applicable design level for the project.

(3) Adding an HOV Lane

The options for adding an HOV lane are reconstruction, restriping, combined reconstruction and restriping, and possibly lane conversion.

Reconstruction involves creating roadway width. Additional right of way may be required. Restriping involves reallocating the existing paved roadway to create enough space to provide an additional HOV lane. Restriping of lane or shoulder widths to less than for the design level and functional class of the highway is a design deviation and approval is required.

Reconstruction and restriping can be combined to maximize use of the available right of way. For example, a new lane can be created through a combination of median reconstruction, shoulder reconstruction, and lane restriping. Each project will be handled on a case by case basis. Generally consider the following reductions in order of preference:

(a) Reduction of the inside shoulder width, provided the enforcement and safety mitigation issues are addressed. (Give consideration not to preclude future HOV direct access ramps by over reduction of the available median width.)

(b) Reduction of the interior general-purpose lane width to 11 ft.

(c) Reduction of the outside general-purpose lane width to 11 ft.

(d) Reduction of the HOV lane to 11 ft.

(e) Reduction of the outside shoulder width to 8 ft.

If lane width adjustments are necessary, old lane markings must be thoroughly eradicated. It is desirable that longitudinal joints (new or existing) not conflict with tire track lines. If they do, consider overlaying the roadway before restriping.

(4) Design Criteria for Types of HOV Facilities

(a) **Separated Roadway HOV Facilities.** The separated HOV facility can be single lane or multilane and directional or reversible. (See Figure 1050-2.)

1. **Lane Widths.** See Figure 1050-1 for traveled way width (W_R) on turning roadways.

2. **Shoulder Widths.** The shoulder width requirements are as follows:

- The minimum width for the sum of the two shoulders is 12 ft for one-lane facilities and 14 ft for two-lane facilities.
- One of the shoulders must have a width of at least 10 ft for disabled vehicles. The minimum for the other shoulder is 2 ft for one-lane facilities and 4 ft for two-lane facilities.
- The wider shoulder may be on the left or the right as needed to best match the conditions. Maintain the wide shoulder on the same side throughout the facility.

3. **Total Widths.** To reduce the probability of blocking the HOV facility, make the total width (lane width plus paved shoulders) wide enough to allow an A-BUS to pass a stalled A-BUS. For single lane facilities, the traveled way widths (W_R), given in Figure 1050-1, plus the 12 ft total shoulder width will provide for this passing for radii (R) 100 ft or greater. For R of 75 ft, a total roadway width of 33 ft is needed and for R of 50 ft, a total roadway width of 41 ft is needed to provide for the passing.

R (ft)(1)	W_R (ft)	
	1-Lane	2-Lane
3001 to Tangent	13(2)	24
3000	14	24
2000	14	25
1000	15	26
500	15	27
300	15	28
200	16	29
150	17	31
100	18	34
75	19	37
50	22	45

(1) Radius (R) is on the outside edge of traveled way on 1-lane and center line on 2-lane roadways.
(2) May be reduced to 12 ft on tangent.

Minimum Traveled Way Widths for Articulated Buses
Figure 1050-1

(b) **Nonseparated Freeway HOV Lanes.** For both inside and outside HOV lanes, the minimum lane width is 12 ft and the minimum shoulder width is 10 ft. (See Figure 1050-2.)

When a left shoulder less than 10 ft wide is proposed for distances exceeding 1.5 mi, enforcement and observation areas must be provided at 1- to 2-mi intervals. See 1050.06(7).

Where left shoulders less than 8 ft wide are proposed for lengths of roadway exceeding 0.5 mi, safety refuge areas must be provided at 0.5- to 1-mi intervals. These can be in addition to or in conjunction with the enforcement areas.

Allow general-purpose traffic to cross HOV lanes at on-and off-ramps.

(c) **Buffer-Separated HOV lanes.** Design buffer-separated HOV lanes the same as for inside nonseparated HOV lanes, except for a buffer 2 to 4 ft in width or 10 ft or greater in width with pavement marking, with supplemental signing, to restrict crossing. For buffer-separated HOV lanes with a buffer at least 4 ft wide, the left shoulder may be reduced to 8 ft. Buffer widths between 4 and 10 ft are not desirable since they may be used as a refuge area for which the width is not adequate. Provide gaps in the buffer to allow access to the HOV lane.

(d) **Arterial Street HOV Lanes.** The minimum width for an arterial street HOV lane is 12 ft. Allow general-purpose traffic to cross the HOV lanes to turn at intersections and to access driveways. (See Figure 1050-2.)

For right side HOV lanes adjacent to curbs, provide a 4 ft shoulder between the HOV lane and the face of curb. The shoulder may be reduced to 2 ft with justification.

For HOV lanes on the left, a 1 ft left shoulder between the HOV lane and the face of curb is required. When concrete barrier is adjacent to the HOV lane, the minimum shoulder is 2 ft.

(e) **HOV Ramp Meter Bypass.** The HOV bypass may be created by widening an existing ramp, construction of a new ramp where right of way is available, or reallocation of the existing pavement width provided the shoulders are full depth.

Ramp meter bypass lanes may be located on the left or right of metered lanes. Typically, bypass lanes are located on the left side of the ramp. Consult with local transit agencies and the region's Traffic Office for direction on which side to place the HOV bypass.

Consider the existing conditions at each location when designing a ramp meter bypass. Design a single lane ramp with a single metered lane and an HOV bypass as shown on Figure 1050-4a. Make the total width of the metered and bypass lanes equal to a 2-lane ramp (Chapters 641 and 940). Design a ramp with two metered lanes and an HOV bypass as shown on Figure 1050-4b. Make the width of the two metered lanes equal to a 2-lane ramp (Chapters 641 and 940) and the width of the bypass lane as shown on Figure 1050-3. The design shown on Figure 1050-4b requires that the ramp operate as a single lane ramp when the meter is not in operation.

Both Figures 1050-4a and 4b show an observation point/enforcement area. Document any other enforcement area design as a design exception. One alternative (a design exception) is to provide a 10-ft outside shoulder from the stop bar to the main line.

(5) HOV Direct Access Ramps

HOV direct access ramps provide access between an HOV lane and another freeway, a local arterial street, a flyer stop, or a park and ride facility. Design HOV direct access ramps in accordance with Chapter 1055.

(6) HOV Lane Termination

Locate the beginning and end of an HOV lane at logical points. Provide decision sight distance, signing, and pavement markings at the termination points.

The preferred method of terminating an inside HOV lane is to provide a straight through move for the HOV traffic, ending the HOV restriction and dropping a general-purpose lane on the right. However, analyze volumes for both the HOV lanes and general-purpose lanes, and the geometric conditions, to optimize the overall operational performance of the facility.

(7) Enforcement Areas

Enforcement of the inside HOV lane can be done with a minimum 10 ft inside shoulder. For continuous lengths of barrier exceeding 2 mi, a 12 ft shoulder, for the whole length of the barrier, is recommended.

For inside shoulders less than 10 ft, locate enforcement and observation areas at 1- to 2-mi intervals or based on the recommendations of the WSP. These areas can also serve as safety refuge areas for disabled vehicles. See Figures 1050-5a and 5b.

Provide observation points approximately 1300 ft before enforcement areas. They can be designed to serve both patrol cars and motorcycles or motorcycles only. Coordinate with the WSP during the design stage to provide effective placement and to ensure utilization of the observation points. Median openings give motorcycle officers the added advantage of being able to quickly respond to emergencies in the opposing lanes. (See Figure 1050-5b.) The ideal observation point places the motorcycle officer 3 ft above the HOV lane and outside the shoulder so the officer can look down into a vehicle.

Locate the enforcement area on the right side for queue bypasses and downstream from the stop bar so the officer can be an effective deterrent (Figures 1050-4a and 4b).

An optional signal status indicator for enforcement may be placed at HOV lane installations that are metered. The indicator faces the enforcement area so that a WSP officer can determine if vehicles are violating the ramp meter. The indicator allows the WSP officer to simultaneously enforce two areas, the ramp meter and the HOV lane. Consult with the WSP for use at all locations.

See the *Traffic Manual* regarding HOV metered bypasses for additional information on enforcement signal heads.

(8) Signs and Pavement Markings

(a) **Signs.** Provide post-mounted HOV preferential lane signs next to the HOV lane or overhead mounted over the HOV lane. Make the sign wording clear and precise, stating which lane is restricted, the type of HOVs allowed, and the HOV vehicle occupancy designation for that section of road. The sign size, location, and spacing are dependent upon the conditions under which the sign is used. Roadside signs can also be used to convey other HOV information such as the HERO program, carpool information telephone numbers, and violation fines. Some situations may call for the use of variable message signs.

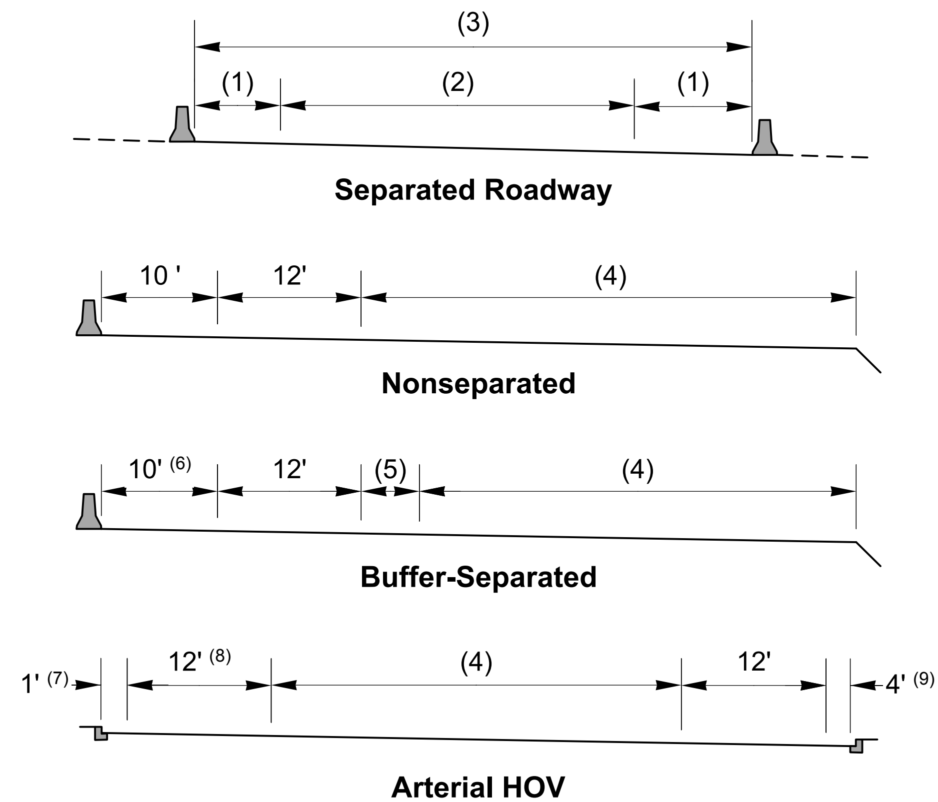
Place overhead signs directly over the HOV lane to provide maximum visibility. Use a sequence of overhead signs at the beginning and end of all freeway HOV facilities. Overhead signs can also be used in conjunction with roadside signs along the roadway.

(b) **Pavement Markings.** Provide pavement markings that conform to the *Traffic Manual* and the Standard Plans.

(c) **Interchanges.** In the vicinity of interchange on and off connections where merging or exiting traffic crosses an HOV lane, make provisions for general-purpose traffic using the HOV lane. These provisions include signing and striping that clearly show the changes in HOV versus general traffic restrictions. See the Standard Plans for pavement markings and signing.

1050.07 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/



Notes:

(1) The sum of the two shoulders is 12 ft for one-lane and 14 ft for two-lane facilities. One of the shoulders must have a width of at least 10 ft for disabled vehicles. The wider shoulder may be on the left or the right as needed to best match the conditions. Maintain the wide shoulder on the same side throughout the facility. See 1050.06(4)(a)2.

(2) 12 ft minimum for single lane, 24 ft minimum for two lanes. Wider width is required on curves. See 1050.06(4)(a)1. and Figure 1050-1.

(3) For total width requirements see 1050.06(4)(a)3.

(4) Width as required for the design level, functional class, and the number of lanes.

(5) Buffer 2 to 4 ft or 10 ft or more.

(6) When buffer width is 4 ft or more, may be reduced to 8 ft.

(7) 2 ft when adjacent to concrete barrier.

(8) Arterial HOV lanes on the left operate in the same direction as the adjacent general-purpose lane.

(9) May be reduced to 2 ft with justification.

Typical HOV Lane Sections

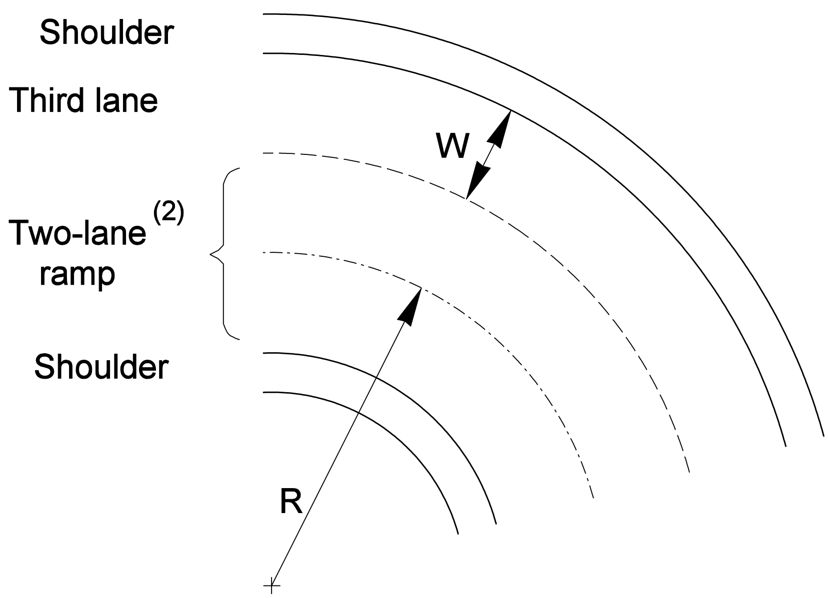
Figure 1050-2

Radius of Two-Lane Ramp R (ft)	Design Width of Third Lane(1) W (ft)
1000 to Tangent	12
999 to 500	13
499 to 250	14
249 to 200	15
199 to 150	16
149 to 100	17

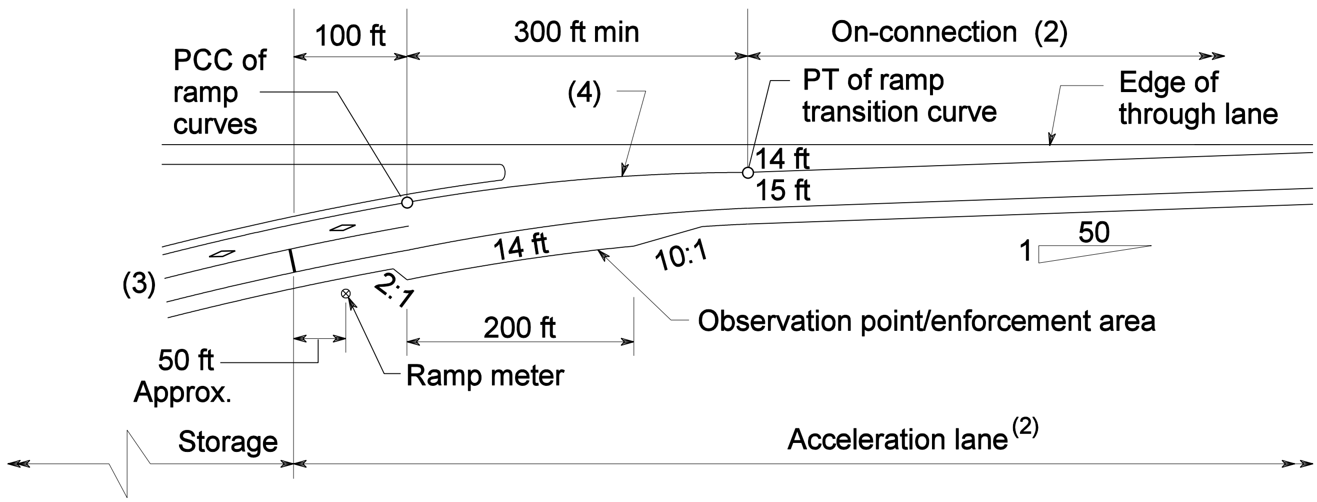
Notes:

(1) Apply additional width to 2-lane ramp widths.

(2) See traveled way width for two-lane one-way turning roadways in Chapter 641 for turning roadway widths.



Roadway Widths for Two-Lane Ramps with an HOV Lane
Figure 1050-3



Notes:

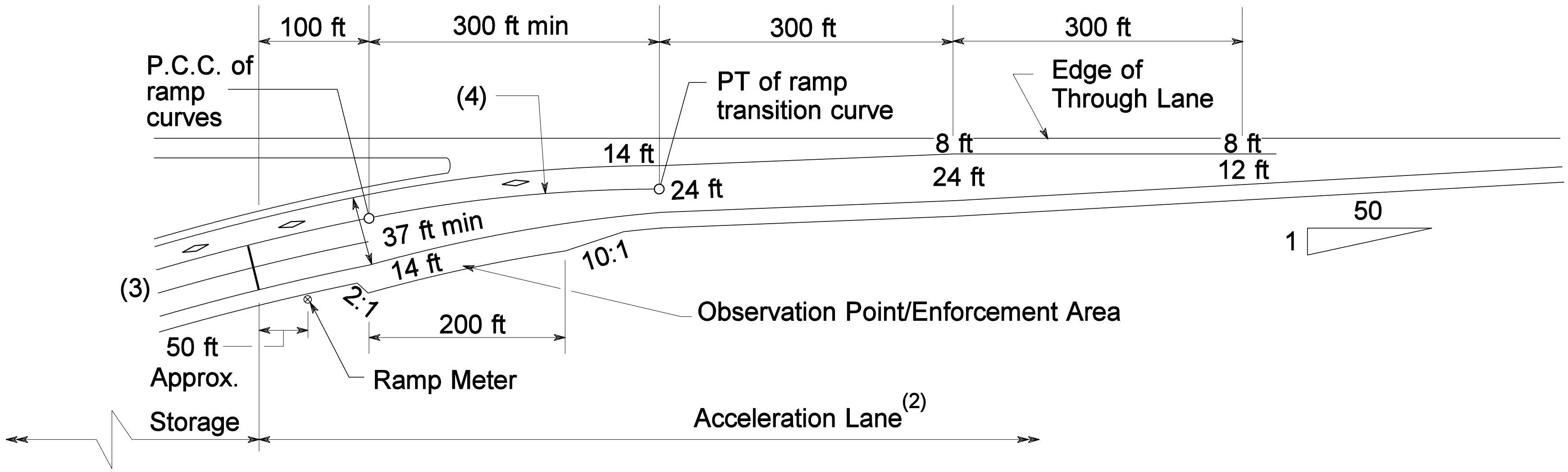
(1) See Standard Plans for striping details.

(2) See Chapter 940 for on-connection details and for acceleration lane length.

(3) See Chapters 940 & 641 for ramp lane and shoulder widths for a 2-lane ramp.

(4) A transition curve with a minimum radius of 3,000 ft is desirable. The minimum length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

Single-Lane Ramp Meter With HOV Bypass
Figure 1050-4a



NOTES

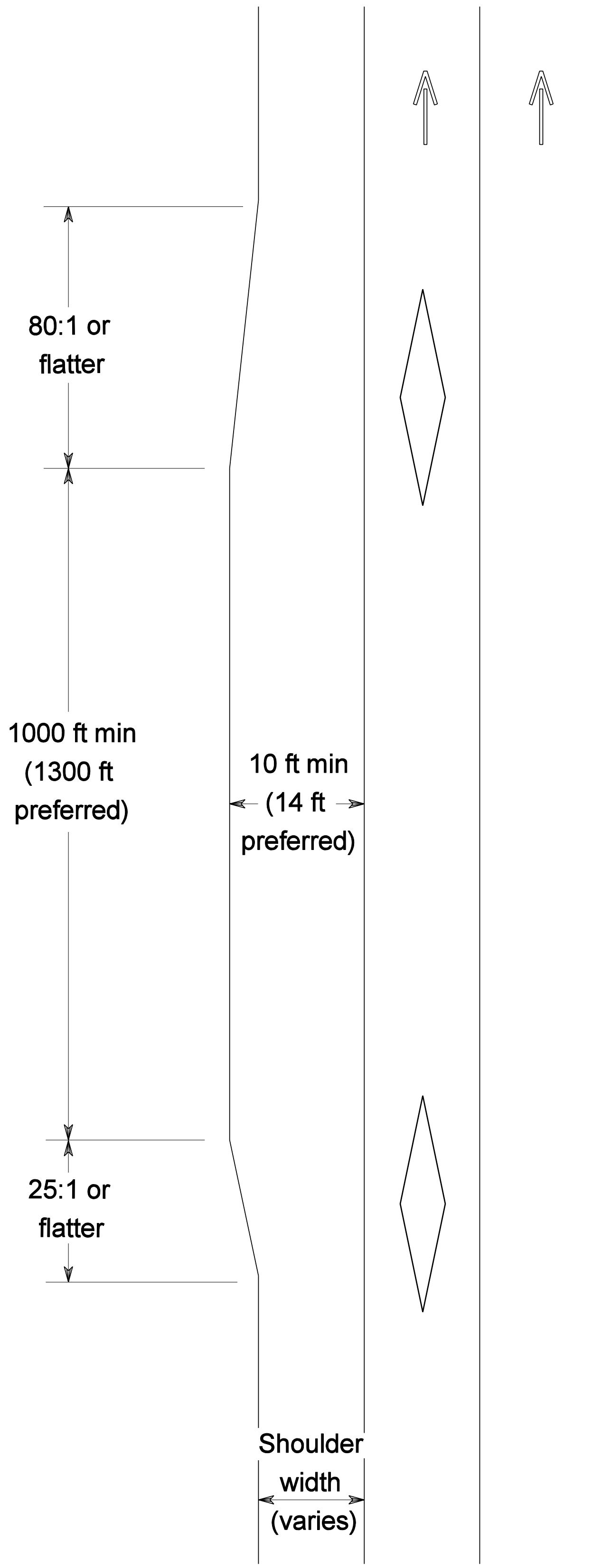
(1) See Standard Plans for Striping Details.

(2) See Chapter 940 for acceleration lane length.

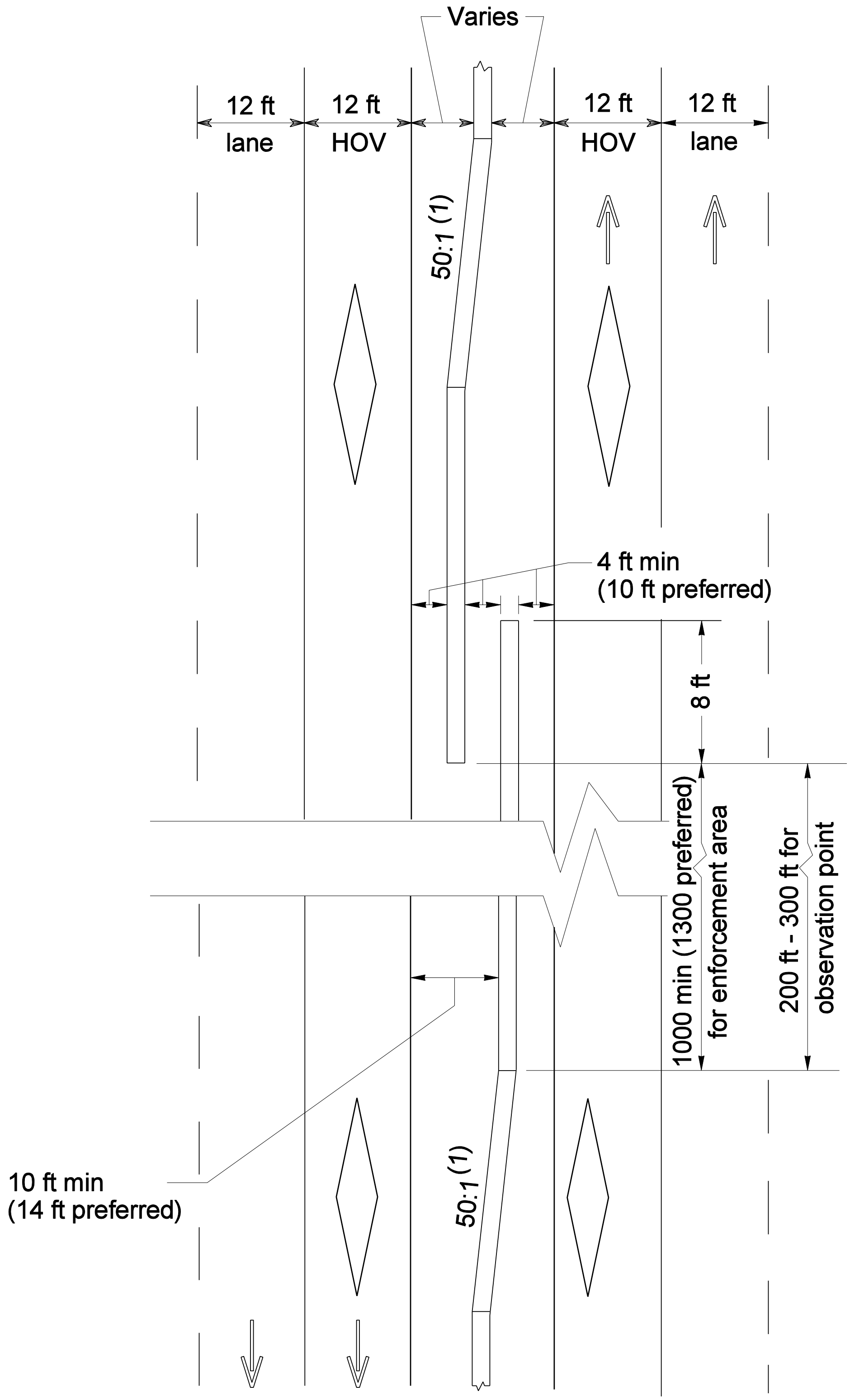
(3) See Chapters 940 & 641 for 2-lane ramp lane and shoulder widths. See Figure 1050-3 for 3rd lane width.

(4) A transition curve with a minimum radius of 3,000 ft is desirable. The minimum length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

Two-Lane Ramp Meter With HOV Bypass
Figure 1050-4b



Enforcement Area (One Direction Only)
Figure 1050-5a



Notes:

(1) See Chapter 620 for median width transition.

Enforcement Area (Median)
Figure 1050-5b

Chapter 1055 HOV Direct Access

1055.01 General

This Chapter provides design guidance for left-side direct access facilities for high occupancy vehicles (HOVs) between freeway HOV lanes and public-transportation passenger facilities within the freeway right of way and facilities outside of the right of way. Design right-side HOV only access facilities per Chapter 940.

Direct access eliminates the HOV user crossing the general-purpose lanes from left-side HOV lanes to the right-side general-purpose ramps. Also, transit vehicles will be able to use the HOV lane and provide service to the HOV direct access facility.

Providing the HOV user access to the inside HOV lane without mixing with the general-purpose traffic saves the user additional travel time and aids in safety, enforcement, incident handling, and overall operation of the HOV facility.

Locations for direct access ramps include HOV facilities on intersecting routes, park and ride lots, flyer stops, and locations with a demonstrated demand. Coordination with the local transit agencies will result in the identification of these key locations. Give priority to locations that serve the greatest number of transit vehicles and other HOVs.

(1) Existing Facilities

When designing an HOV direct access facility, the existing general-purpose facilities must not be degraded. However, there may be opportunities to improve existing geometrics. These opportunities can be identified during the project definition phase.

When an HOV direct access facility project includes work on the existing facilities, apply the new/reconstruction row of the Interstate Design Matrices and the HOV row of the other matrices in Chapter 325.

(2) Reviews, Studies, and Reports

The normal project development process is to be followed when developing an HOV direct access project. Most facets of the project development process remain unchanged despite the unusual nature of the projects that are the focus of this chapter. For example, early coordination with others is always a vital part of developing a project. There are also environmental considerations, public involvement, and Value Engineering studies (Chapter 315). These are all necessary to ensure appropriate scope and costs.

There may also be reviews, studies, and reports required by agreements with regional transit authorities or other agencies.

An Access Point Decision Report (Chapter 1425) is required when there is a proposal to add, delete, or change an access point. Provide the operational analysis from the report for all flyer stops. For left-side connections, include the commitment that the connection will be used solely by HOVs or will be closed.

Throughout the project development phase, ensure that the:

- Project definition and cost estimate are correct.
- Project development process is on schedule.
- Project documents are biddable.
- Project will be constructible.
- Project will be maintainable.

Constructibility of HOV direct access facilities is an important consideration during the design phase. These facilities will typically be constructed on existing highways with traffic maintained on-site. Key goals are to:

- Ensure that the project can be built.
- Plan a construction strategy.
- Provide a safe work zone.
- Minimize construction delays.

Access to these facilities by maintenance crews must be considered. Avoid items that require a significant maintenance effort and might result in lane closure for routine maintenance or repair.

(3) Left-Side Connections

Left-side connections are allowed only when they serve HOVs only and connect to an HOV lane. The higher traffic volume associated with general-purpose traffic is not acceptable for left-side connections. If the demand for an HOV direct access decreases to the point that the HOV direct access connection is no longer desirable, the connection must be closed.

1055.02 References

Americans with Disabilities Act of 1990 (ADA).

ADA Accessibility Guidelines (ADAAG), The Access Board, http://www.access-board.gov/adaag/html/adaag.htm.

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, Chapter 468-95 WAC, (MUTCD).

Sign Fabrication Manual, M 55-05, WSDOT.

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT.

High-Occupancy Vehicle Facilities A Planning, Design, and Operation Manual, Parsons Brinkerhoff Inc.

FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe (CD ROM), USDOT, FHWA and Parsons Brinkerhoff Inc.

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO.

Guide for the Design of High Occupancy Vehicle Facilities, AASHTO.

Transit Implications of HOV Facility Design, WA-RD 396.1, September 1996, WSDOT and USDOT, Federal Transit Administration.

NCHRP 155, *Bus Use of Highways, Planning and Design Guidelines*.

NCHRP 414, *HOV Systems Manual*.

1055.03 Definitions

flyer stop a transit stop inside the limited access boundaries.

high occupancy vehicle (HOV) Vehicles that fit one of the following:

- Rubber tired municipal transit vehicles.
- Buses with a carrying capacity of sixteen or more persons, including the operator.
- Motorcycles.
- Recreational vehicles that meet the occupancy requirements of the facility.
- All other vehicles that meet the occupancy requirements of the facility, except trucks in excess of 10,000 lb gross vehicle weight.

HOV direct access facility a ramp and its connection directly to an HOV lane, exclusively for the use of high occupancy vehicles to move between the ramp and the HOV lane without weaving across general-purpose lanes.

intelligent transportation systems (ITS) a system of advanced sensor, computer, electronics, and communication technologies and management strategies - in an integrated manner – to increase the safety and efficiency of the surface transportation system.

ramp a short roadway connecting a main lane of a highway with another facility, such as a road, parking lot, or transit stop, for vehicular use.

ramp connection the pavement at the end of a ramp, connecting to a main lane of a highway.

ramp terminal the end of a ramp at a local street or road, transit stop, or park and ride lot.

transit stop a facility for loading and unloading passengers that is set aside for the use of transit vehicles only.

transit vehicle a bus or other motor vehicle that provides public transportation (usually operated by a public agency).

1055.04 HOV Access Types and Locations

To provide direct access for high occupancy vehicles from the HOV lane to a passenger loading facility, there are many options and many constraints. Following are some of the options (selected as being usable on Washington's freeways) and constraints to their use.

To select an option, it is necessary to first establish the need, choose possible locations, evaluate site features (such as terrain, existing structures, median widths), and evaluate existing HOV information (such as lanes, park and ride facilities, transit routes and schedules, and origin and destination studies). The chosen location must meet access point spacing requirements and must be proven not to degrade traffic operations on the main line.

Important constraints to transit stop designs are that passenger access routes and waiting areas must be separated from freeway traffic, passenger access to a bus is on its right side only, and passenger access to a loading platform must accommodate the disabled.

(1) Freeway Ramp Connection Locations

(a) **Spacing**

For minimum ramp connection spacing see Chapter 940. Include only left-side connections, in this evaluation.

However, traffic operations can be degraded by the weaving caused by a left-side on-connection followed closely by a right-side off-connection (or a right-side on-connection followed by a left-side off-connection). As a general rule, if the spacing between the HOV direct access ramp and the general-purpose ramp is less than one gap acceptance length [1055.05(6)(c)] per lane, make the HOV lane buffer separated. (See Chapter 1050.)

Conduct an analysis to ensure that the new ramp will not degrade traffic operations. See Chapter 1425 for the studies and report required for a new access point.

When an off-connection follows an on-connection, provide full speed-change lane lengths and tapers or at least sufficient distance for full speed-change lanes that connect at full width with no tapers. See 1055.05(6) and 1055.05(7). An auxiliary lane can be used to connect full-width speed-change lanes if there is not sufficient distance for both tapers.

(b) **Sight Distance**

Locate both on- and off-connections to the main line where decision sight distance exists on the main line. (See Chapter 650.)

(2) Ramp Terminal Locations

(a) **Local Streets and Roads**

Access to the HOV lane can be provided by a ramp that terminates at a local street or road. The local street or road may incorporate HOV lanes, but they are not required. See 1055.07 for signing and pavement markings.

Consider traffic operations on the local road. Locate the terminal where:

- It will have the least impact on the local road.
- Intersection spacing requirements are satisfied.
- Queues from adjacent intersections will not block the ramp.
- Queues at the ramp will not block adjacent intersections.
- Wrong way movements are discouraged.

When off-ramps and on-ramps are opposite each other on the local road, consider incorporating a transit stop with the intersection.

(b) **Park and Ride Lots**

HOV direct access ramps that connect the HOV lane with a park and ride lot provide easy access for express transit vehicles between the HOV lane and a local service transit stop at the park and ride facility. Other HOV traffic using the access ramp must enter through the park and ride lot, which can create operational problems.

(c) **Flyer Stops**

Median flyer stops do not provide general access to the HOV lane. Access is from the HOV lane to the transit stop and back to the HOV lane. No other vehicle access is provided. Ramps to and from the flyer stops are restricted to transit vehicles only.

(3) Ramp Types

(a) **Drop Ramps**

Drop ramps are generally straight, staying in the median, and connecting the HOV lane with a local road or flyer stop (Figure 1055-3).

(b) **T Ramps**

A T ramp is a median ramp, serving all four HOV access movements, that comes to a T intersection within the median, usually on a structure. The structure then carries the HOV ramp over the freeway to a local road or directly to a park and ride lot (Figure 1055-4). Through traffic is not permitted at the T; therefore, flyer stops are not allowed.

(c) **Flyover Ramps**

A flyover ramp is designed to accommodate high speed traffic by using flat curves as the ramp crosses from the median over one direction of the freeway to a local road, a park and ride lot, or an HOV lane on another freeway (Figure 1055-5).

(4) Transit Stops

(a) **Flyer Stops**

Flyer stops are transit stops inside the limited access boundaries for use by express transit vehicles using the freeway. They may be located in the median at the same grade as the main roadway or on a structure, on a ramp, or on the right-side of the main line.

The advantage of a median flyer stop is that it reduces the time required for express transit vehicles to serve intermediate destinations. A disadvantage is that passengers must travel greater distances to reach the loading platform.

With left-side HOV lanes, flyer stops located on the right side will increase the delay to the express transit vehicles by requiring them to cross the general-purpose lanes. However, these stops improve passenger access from that side of the freeway.

See Chapter 1060 for additional design information.

1. **Side-Platform Flyer Stops** Side-platform flyer stops are normally located in the median (Figure 1055-6) and have two passenger loading platforms, one on each side between the bus loading lane and the through HOV lane. This design provides the most direct movement for the express transit vehicle and is the preferred design for median flyer stops.

This design is relatively wide. Where space is a concern, consider staggering the loading platforms longitudinally.

Consider tall barrier to divide the directions of travel or staggering the loading platforms to prevent unauthorized at-grade movement of passengers from one platform to the other. (See 1055.07(1).)

2. **At-Grade Passenger Crossings** This design is similar to the side-platform flyer stop, except that passengers are allowed to cross, from one platform to the other, at-grade (Figure 1055-7). This design might eliminate the need for passenger access to one of the loading platforms with a ramp or an elevator and simplifies transfers. The passenger crossing necessitates providing a gap in the barrier for the crosswalk.

Only transit vehicles are allowed. Passenger/pedestrian accommodations must comply with the ADA.

Consider an at-grade passenger crossing flyer stop only when passenger volumes are expected to be low. Design at-grade passenger crossing flyer stops as the first stage of the stop, with the ultimate design being side-platform flyer stops with grade separated access to both platforms.

3. **Ramp Flyer Stops** When ramp flyer stops are located on an HOV direct access drop ramp (Figure 1055-8), the delay for the express transit vehicle will not be much more than that for a median stop, and passenger access and connectivity to local service transit routes, on the local street or road, are improved. A flyer stop on a right-side ramp works well with right-side HOV lanes and diamond interchanges in which express transit vehicles can use the off-ramp to connect with a bus route on the local road and the on-ramp to return to the HOV lane. However, a stop on a general-purpose right-side ramp with a

left-side HOV lane will increase the delay by requiring the express transit vehicle to use the general-purpose lanes and possibly degrade main line traffic operations by increasing weaving movements.

(b) **Off-Line Transit Stops**

1. **Park and Ride Stops** Transit stops located at park and ride lots provide transfer points between the express transit system and the local transit system, and there is convenient passenger access to the park and ride lot. When a direct access ramp is provided, express transit delays from the HOV lane to the stop are reduced. These delays can be reduced more by providing a median flyer stop with passenger access facilities connecting the park and ride lot to the flyer stop; however, this might be more inconvenient for the passengers.

2. **Stops at Flyer Stop Passenger Access Points** To minimize the distance a passenger must travel between express and local service transit stops, locate local system transit stops near passenger access facilities for the flyer stops (Figure 1055-9).

(5) Enforcement Areas

For HOV facilities to function as intended, it is necessary to enforce the vehicle occupancy requirement. Law enforcement officers need areas for observation that are near pull-out areas where both the violator and the officer can pull safely out of the traffic flow.

Consider locating observation and pull-out areas near any point where violators can enter or exit an HOV direct access facility. Examples of potential locations are:

- Freeway on- and off-connections for HOV direct access ramps.
- HOV direct access ramp terminals at parking lots.

For freeway HOV lanes, locate enforcement areas on the adjacent shoulders so officers and violators are not required to cross several lanes of traffic.

Enforcement area guidance and designs are in Chapter 1050.

1055.05 Direct Access Geometrics

HOV direct access ramps are different from other ramps because they are frequently on the left-side of the through lanes and they have a high percentage of buses. Design right-side HOV direct access using the procedures given in Chapter 940. The following procedures are for the design of left-side HOV direct access.

Because left-side ramps are rare and are therefore less expected, signing is an important issue. (See 1055.07(2), for signing requirements.)

When the bus percentage is high, there are several needs to be met.

- When a bus enters the through lanes from the left, the driver has a relatively poor view of the through traffic.
- A bus requires a longer distance to accelerate than other vehicles.
- A bus requires a longer deceleration length for passenger comfort.

For these reasons, use the following design values when designing left-side HOV direct access facilities.

(1) Design Vehicles

Use AASHTO's A-BUS vehicle for horizontal design.

Use AASHTO's BUS vehicle for vertical clearance 13.5 ft.

Use AASHTO's P vehicle for stopping sight distance.

See Chapters 910 and 1060 for vehicle descriptions, dimensions, and turning templates.

(2) Design Speeds

See Chapter 940 for the design speeds for the ramps. Use the design speed of the general-purpose lanes for the main line design speed.

(3) Sight Distance

Provide stopping sight distance per Chapter 650. This provides sight distance for an automobile. The longer distance required for a bus to stop is compensated for by the greater eye height of the driver with the resulting vertical curve length requirement about equal to that for an automobile.

Sag vertical curves may be shortened where necessary. See Chapter 630 for guidance.

(4) Grades

Grades for ramps are covered in Chapter 940. Deviations will be considered for:

- Downgrade on-ramps with grades increased by an additional 1%.
- Upgrade off-ramps with grades increased by an additional 2%.

These increased grades help when geometrics are restricted and assist transit vehicles with the acceleration when entering and the deceleration when exiting the freeway.

(5) Ramp Widths

(a) **Lane Widths**

Use widths for separated roadway HOV facilities, see Minimum Traveled Way Widths for Articulated Buses, in Chapter 1050.

On tangents, the minimum lane width may be reduced to 12 ft.

(b) **Shoulder Widths**

Ramp shoulder width requirements are modified as follows:

- The minimum width for the sum of the two shoulders is 10 ft for one-lane ramps and 12 ft for two or more lanes.
- One of the shoulders must have a width of at least 8 ft for disabled vehicles. The minimum for the other shoulder is 2 ft. See Chapter 710 for shy distance requirements at barrier.
- The wider shoulder may be on the left or the right as needed to best match the conditions. Maintain the wide shoulder on the same side throughout the ramp.

(c) **Total Ramp Widths**

Make the total width of the ramp (lane width plus shoulders) wide enough to allow an A-BUS to pass a stalled A-BUS. This width has two components:

- The vehicle width (U = 8.5 ft on tangent) for each vehicle.
- Lateral clearance (C = 2 ft) for each vehicle.

The vehicle width and the lateral clearance are about the width of an A-BUS from edge of mirror to edge of mirror.

Figure 1055-1 gives the minimum ramp width (W_R) at various radii (R) for an articulated bus. For ramp locations on a tangent section or on a curve with a radius greater than 150 ft, consider the W_R width when requesting a reduced lane or shoulder width. For ramp curves with a radius less than 150 ft, check the total ramp width and, if necessary, widen the shoulders to provide the W_R width.

R (ft)*	W_R (ft)
Tangent	21
500	23
400	23
300	24
200	26
150	27
100	30
75	34
50	40

* R is to the curve inside edge of traveled way

Minimum Ramp Widths for Articulated Buses
Figure 1055-1

(6) On-Connections

(a) **Parallel On-Connections**

For left-side on-connections, use the parallel on-connection. See Figure 1055-10.

A parallel on-connection adds a parallel lane that is long enough for the merging vehicle to accelerate in the lane and then merge with the through traffic. This merge is similar to a lane change and the driver can use side and rear view mirrors to advantage.

(b) **Acceleration Lanes**

Figure 1055-11 gives the minimum acceleration lane length (L_A) for left-side HOV direct access on-connections.

The numerous buses using HOV direct access ramps must merge with high speed traffic. Acceleration lanes that are longer than normally required are needed.

For left-side on-connections, provide at least the normal 10 ft (14 ft preferred) wide left shoulder for the main line for a minimum length of 500 ft (1000 ft preferred) beyond the end of the on-connection taper. This gives additional room for enforcement, merging, and erratic maneuvers.

(c) **Gap Acceptance Length**

Gap acceptance length is a minimum distance traveled while a merging driver finds a gap in the through traffic and begins the merge. For left-side parallel on-connections the gap acceptance length is added to the acceleration length. The L_g values are given in Figure 1055-2. These values are larger than for right-side on-connections to account for drivers' visibility constraints.

Highway Posted Speed (mph)	Gap Acceptance Length L_g (ft)
45	550
50	625
55	700
60	775
65	850
70	925

Gap Acceptance Length for Parallel On-Connections
Figure 1055-2

(d) **Design of Urban On-Connections**

Design left-side HOV direct access on-connections in urban areas as follows:

1. Use the parallel design for all left-side on-connections.

2. Add the Gap Acceptance Length for Parallel On-Connections (Figure 1055-2) for a freeway speed of 60 mph to the acceleration length.

3. Use Acceleration Length for Buses (Figure 1055-11) with a 60 mph freeway speed and the ramp design speed [1055.05(2)] for acceleration length.

(e) **Design of Rural On-Connections**

Design left-side HOV direct access on-connections in rural areas using a freeway design speed as determined using Chapter 440.

(7) Off-Connections

(a) **Parallel Off-Connection**

The parallel off-connection (Figure 1055-12) is preferred for left-side direct access off-connections. For freeway to freeway off-connections, provide a parallel lane with a length sufficient for signing and deceleration. The desirable minimum length is not less than the gap acceptance length (Figure 1055-2).

(b) **Tapered Off-Connection**

The tapered off-connection may be used for off-connections with justification. See Chapter 940 for the design of tapered off-connections.

(c) **Deceleration Lanes**

Bus passenger comfort requires longer deceleration lanes. Use the deceleration lane lengths from Figure 1055-14 for HOV direct access facilities.

(d) **Design of Urban Off-Connections**

Design left-side HOV direct access off-connections in urban areas as follows:

1. Either the parallel (preferred) or the taper (with justification) design may be used.

2. Use the longer deceleration length of: the Deceleration Length for Buses (Figure 1055-14) from a 60 mph freeway speed to the ramp design speed [1055.05(2)], or the Minimum Deceleration Length given in Chapter 940 from the freeway design speed to the ramp design speed.

(e) **Design of Rural Off-Connections**

Design left-side HOV direct access off-connections in rural areas using a freeway design speed as determined using Chapter 440.

(8) Vertical Clearance

Vertical clearance for a structure over a road is measured from the lower roadway surface, including the usable shoulders, to the bottom of the overhead structure.

See Chapter 1120 for information on vertical clearance. For a new structure and for a new ramp under an existing structure, the minimum vertical clearance is 16.5 ft. A deviation will be considered for 14.5 ft minimum vertical clearance for a new HOV direct access ramp under an existing bridge.

The minimum vertical clearance for a pedestrian grade separation over any road is 17.5 ft.

(9) Flyer Stops

Design flyer-stop-ramp on-connections as given in 1055.05(6) and design off-connections as given in 1055.05(7). Flyer stop connections are included in the access point spacing discussed in 1055.04(1)(a).

Design the ramp to the flyer stop per 1055.05(3), 1055.05(4), and 1055.05(5).

The minimum width for the roadway at a flyer stop is 24 ft.

When a flyer stop is in the median, provide enough median width for the flyer stop roadway, the passenger facilities, and barrier separation without reducing the width of the through lanes or shoulders. (See 1055.06.)

The approval of a flyer stop requires the operational analysis portion of the Access Point Decision Report (Chapter 1425).

(10) T Ramps

A T ramp example and design is given on Figure 1055-15

1055.06 Passenger Access

When designing transit stops, accessibility (compliance with the ADA), safety, and the comfort of the passengers must be included. Minimize pedestrian/vehicle conflict points. Design the whole facility with security in mind by keeping lines of sight as open as possible. Traffic barriers, fencing, illumination, landscaping, seating, windscreens, shelters, enclosed walkways, telephones, and posted schedules are examples of factors that contribute to passenger safety and well-being. See Chapter 1060 for passenger amenities at transit stops.

(1) Passengers

To encourage use of the passenger access facility for an express transit stop, provide a route that is the shortest distance to travel from the park and ride lot, or local transit stop. Failure to do so might generate the use of undesirable shortcuts. To encourage local use of the passenger access facilities, provide direct access from surrounding neighborhoods.

To access a transit stop in the median or to move about within the facility, grade separations are required for all flyer stop designs except the at-grade crossing flyer stop. Consider stairways, ramps, elevators, and escalators, but provide at least one access for the disabled at every loading platform, as required by the American Disabilities Act of 1990. See Chapter 1025 for guidance when designing pedestrian grade separations.

The ADA Accessibility Guidelines for Buildings and Facilities includes: "Platform edges bordering a drop-off and not protected by platform screens or guard rails shall have a detectable warning … 24 inches wide running the full length of the platform drop-off." See the Standard Plans for the detectable warning pattern.

In transit stops, at-grade crosswalks are only permitted in the at-grade crossing flyer stop layout described in 1055.04(4)(a)2. Use traffic calming techniques, such as horizontal alignment, textured pavement and crosswalk markings, barrier openings, and other treatments, to channelize pedestrian movements and slow the transit vehicle movements. Illuminate transit stop crosswalks. (See Chapter 840.)

Where at-grade crosswalks are not permitted, steps must be taken to minimize unauthorized at-grade crossings. Fencing, taller concrete traffic barrier, enclosed walkways, and ramps are examples of steps that may be taken.

(2) Bicycles

Bike lanes on nearby streets and separate trails encourage people to bicycle from surrounding neighborhoods. Provide these bicyclists direct access to passenger access facilities.

For bike-bus-bike commuter access to a transit facility, design bicycle access facilities in conjunction with the access for the disabled. (See Chapters 1020 and 1025.)

Locate bicycle parking outside of the passenger walkways. See Chapter 1060.

Locations near colleges and universities and locations with good bicycle access, especially near trails, will attract bicyclists. Contact the region Bicycle Coordinator for information on the predicted number of bicycle parking spaces needed and the types of bicycle racks available.

1055.07 Traffic Design Elements

Traffic design elements are critical to the safe and efficient use of HOV direct access facilities. The following discusses the elements of traffic design that might be different for HOV direct access facilities.

(1) Traffic Barriers

Separate the main line from the HOV direct access facilities with a traffic barrier. Whenever possible, separate opposing traffic lanes in the facility by using traffic barrier. (See Chapter 710.) This is especially important in areas where opposing traffic is changing speeds to or from main line speeds. Concrete barrier is generally preferable on these facilities due to lower maintenance requirements.

The approach ends of traffic barriers must have crashworthy end treatments. In areas where the operating speed is greater than 35 mph, an impact attenuator is required. (See Chapter 720.) Consider concrete barrier and low maintenance impact attenuators, such as the REACT 350 or QuadGuard Elite, where there is a potential for frequent impacts, such as in gore areas.

When the operating speed is 25 mph or less, and where an at-grade pedestrian crossing transit stop has an opening in a concrete barrier, a sloped-down end as shown in the Standard Plans is acceptable.

When a break in the barrier is required for turning maneuvers, consider the sight distance requirements when determining the location for stopping the barrier. (See Chapter 650.)

In areas where headlight glare is a concern, consider glare screens, such as taller concrete barrier. Other glare screen options that mount on the top of a barrier tend to be high maintenance items and are discouraged.

Taller barrier might also be desirable in areas where pedestrian access is discouraged such as between opposing flyer stops and between a flyer stop and the main line.

(2) Signing

It is essential that the design and placement of HOV signing clearly indicate whether the signs are intended for motorists in the HOV lane or the general-purpose lanes. The purposes of the signs include:

- To enhance safety.
- To convey the message that HOV lanes are restricted to HOVs.
- To provide clear directions for entrances and exits.
- To define vehicle occupancy requirements or other restrictions.

Because HOV facilities are not found in many regions, the signing not only considers the commuter but also the occasional user of the facility who might be unfamiliar with the HOV facility and its operation.

(a) **Safety**

Much of HOV signing relates to enhancing safety for the motorists. Not only are geometrics often minimized due to the lack of right of way, but there are unusual operational characteristics such as the differential speed between the HOV vehicle and the adjacent general purpose traffic. The lack of passing opportunities in the HOV lane and the necessity for frequent merging and weaving actions require designers to use messages that are clear and concise, and use symbols wherever possible.

Because left-side off-connections are unusual, advance warning signing that an exit is on the left becomes more important.

For T ramps, provide traffic control at the T to assign priority to one of the conflicting left-turn movements and to avert wrong way movements.

(b) **Diamond Symbols**

The diamond symbol is used to designate all HOV facilities where carpools are allowed. For all signs, whether regulatory, guide, or warning, the symbol is always white on a black background to convey the restrictive nature of the HOV lane and to make the signs more uniformly recognizable. The use of the symbol with all HOV signs also informs drivers that the message is intended for HOVs. The diamond symbol is only for HOV lanes where carpools are allowed, not used for bus, taxi, or bicycle preferential lanes.

(c) **Selection and Location**

The signing details, Figures 1055-16 through 17b, provide for the HOV geometric configurations used within the right of way. Signing for other types of HOV facilities (such as those used for reversible-flow, and HOV direct access between freeways and temporary HOV lanes used during construction) is designed on a case-by-case basis requiring consultation with the appropriate Headquarters and region traffic personnel. The design of signing for HOV direct access between freeways will include HOV guide signs, both advance and action, in addition to the normal regulatory signs.

(d) **Regulatory Signs**

Regulatory signs for HOV facilities follow the normal regulatory signing principles; black legend with a white reflective background on a rectangular panel. Keep in mind that messages conveyed by the HOV signs (such as signs concerning violations and those indicating the beginning of an HOV lane downstream) are not necessarily intended only for the HOV vehicle. Therefore, it might be prudent to place additional signs on the right side of the freeway where this conforms to sound engineering practice.

(e) **Guide Signs**

Guide signs for the HOV facilities are generally used at intermediate on and off locations to inform HOV motorists of upcoming freeway exits and the appropriate location to exit the HOV lane. For HOV direct access to and from arterials, guide signs are used in a fashion similar to normal arterial interchange signing practice. The guide signs for HOV facilities have a black nonreflective legend on a white reflective background. The exception is the diamond, where the white reflective symbol is on a black nonreflective background. For all HOV related guide signs, the diamond is placed in the upper left-hand corner of the sign.

(3) Lighting

Illumination of HOV direct access facilities is required for ramps, loading platforms at transit stops, major parking lots, and walkways as defined in Chapter 840.

(4) Intelligent Transportation Systems

Intelligent transportation systems (ITS) are used to collect traffic data, maintain freeway flow, and disseminate traveler information. Transit information systems for passengers and transit facility surveillance are not normally a part of WSDOT's ITS system, but implementation of these components may be considered for some locations.

Design of HOV direct access facilities, like all HOV facilities, should fully utilize available ITS elements. Need for ITS elements vary depending on project features, such as facility design and operation, and whether the site has existing ITS components.

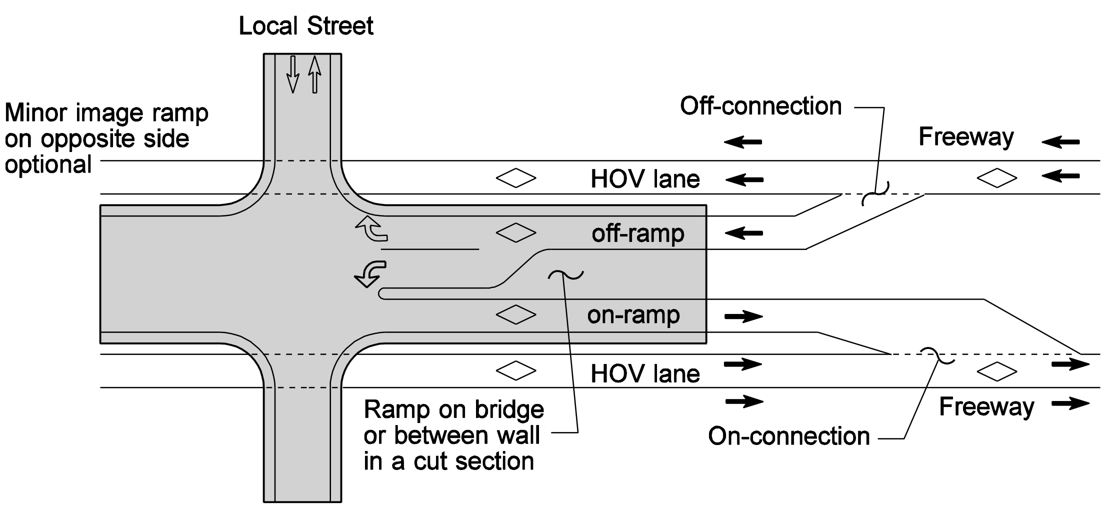
ITS elements that might be applicable to HOV direct access facilities include: closed circuit television surveillance, ramp metering, data collection, exit queue detection and override, dynamic signing, transit signal priority, and automatic vehicle identification and location.

Guidance on the development of ITS elements is found in Chapter 860. Include the region's Traffic Office, transit operator, and affected local agency in the coordination for design and implementation of ITS elements.

1055.08 Documentation

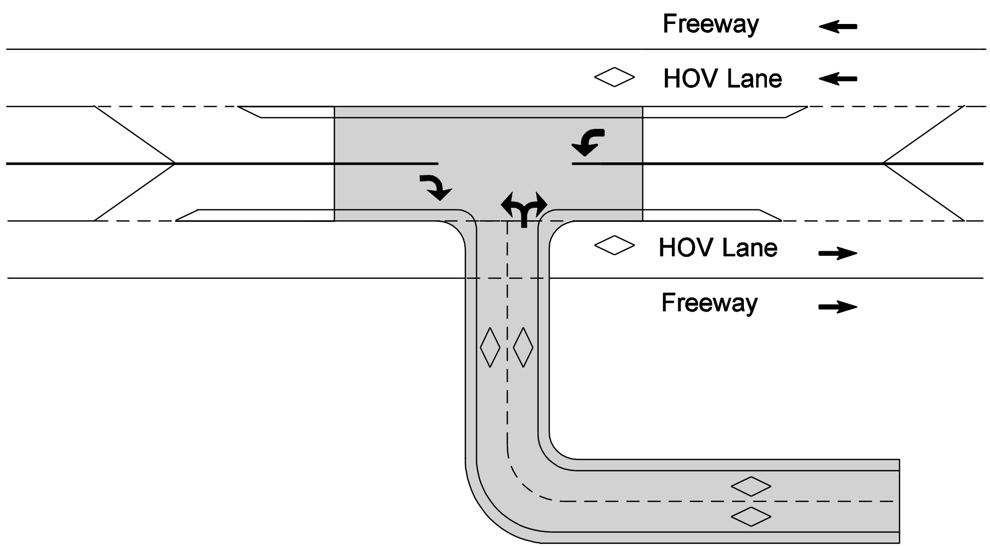
A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http://www.wsdot.wa.gov/eesc/design/projectdev/

Photograph from *FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe*



Drop Ramp

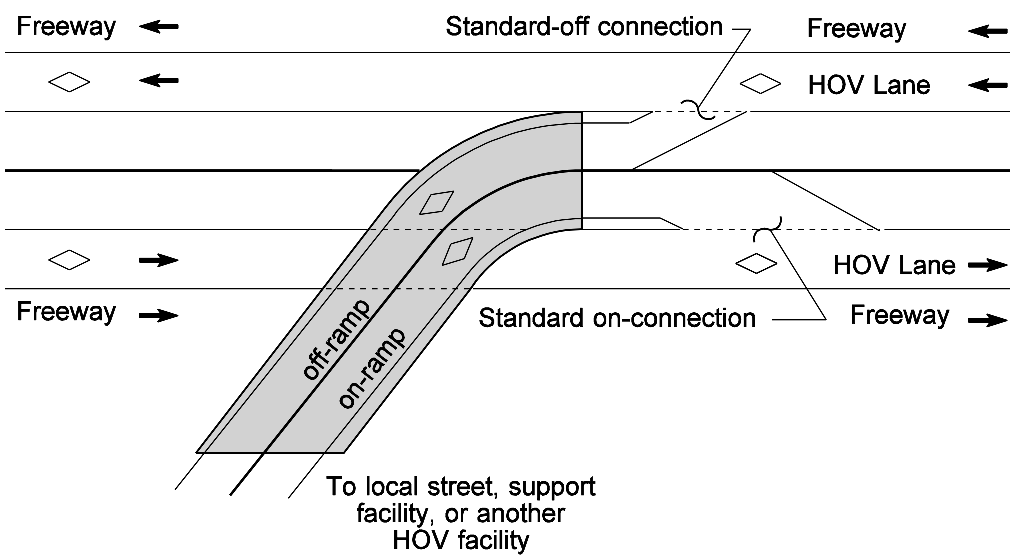
Figure 1055-3



See Figure 1055-15 for additional design information.

T Ramp
Figure 1055-4

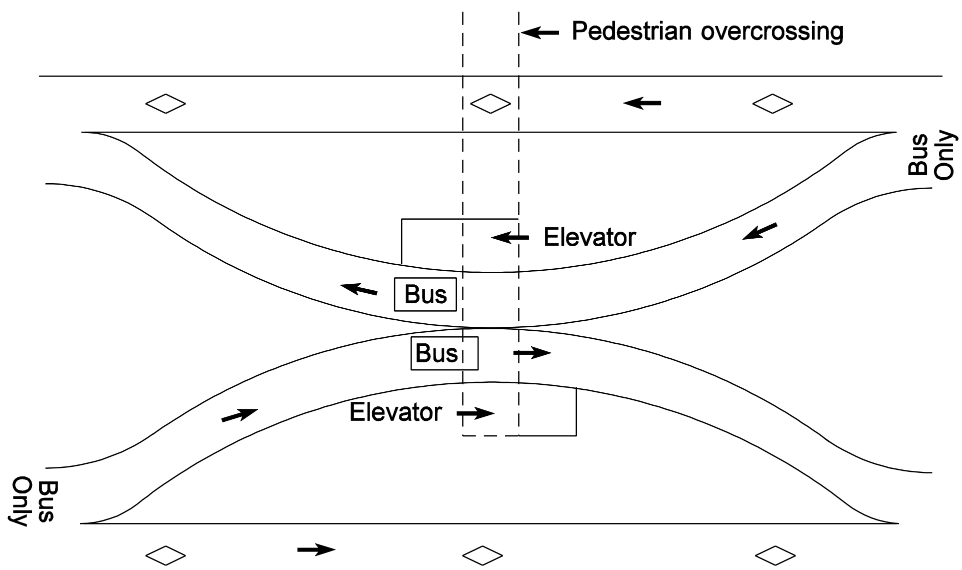
Photograph from *FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe*



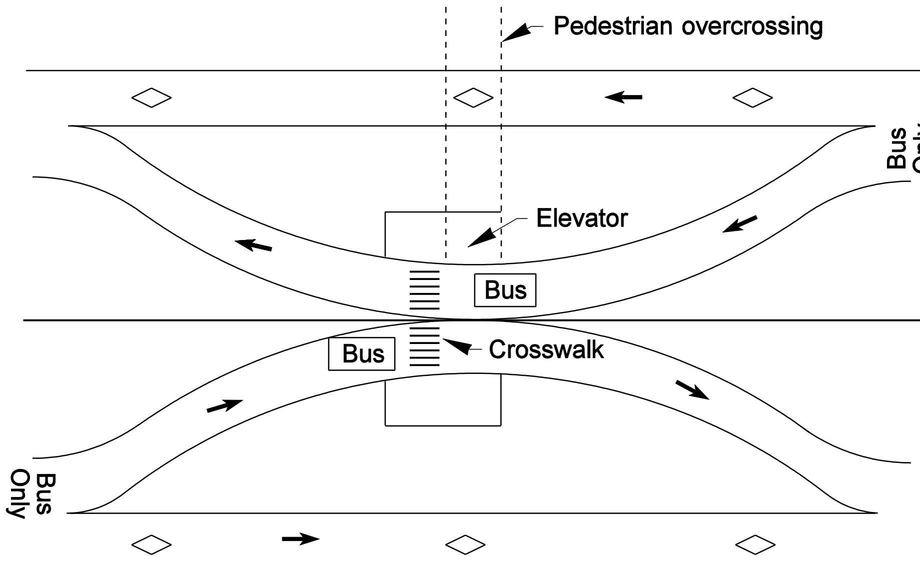
Flyover Ramp
Figure 1055-5

Photograph from *FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe*

The side platform flyer stop with grade separated access to each platform is the preferred design.



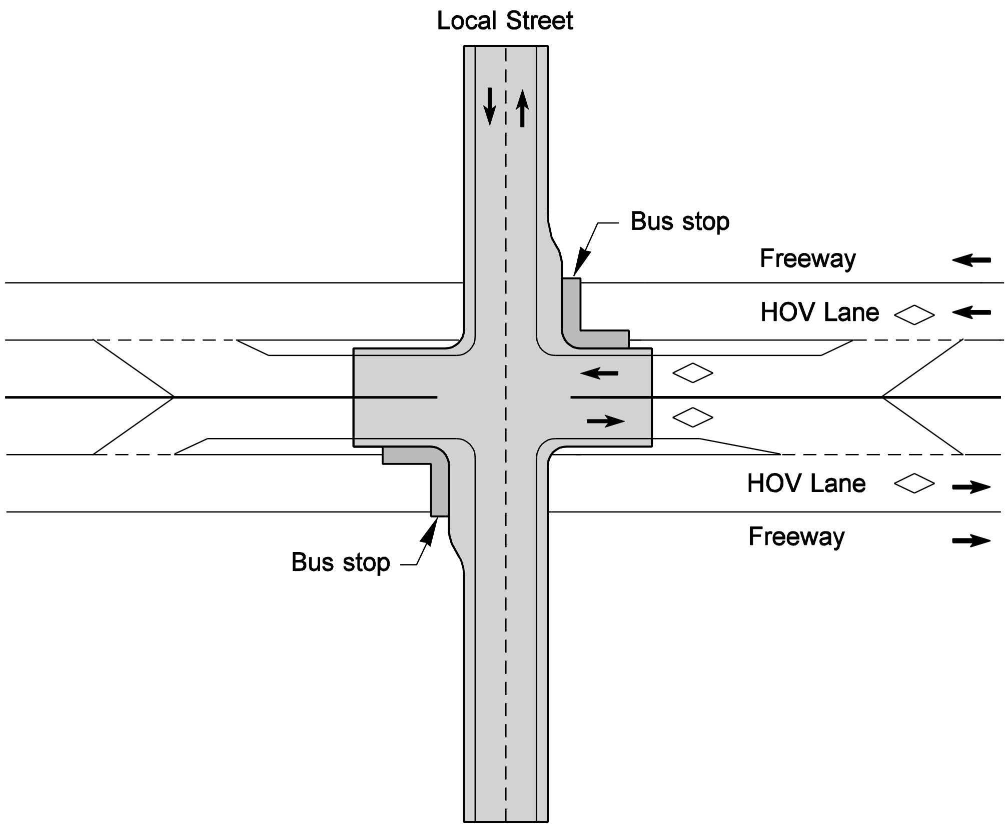
Side Platform Flyer Stop
Figure 1055-6



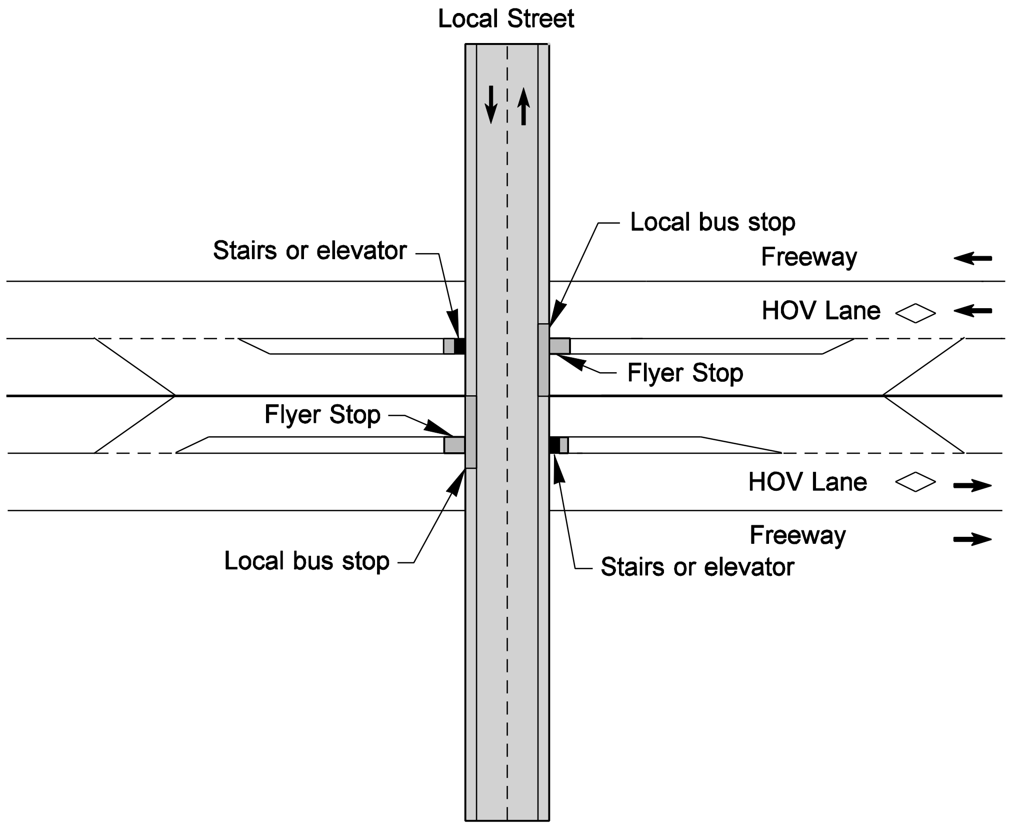
Consider flyer stops with at-grade pedestrian crossing only when anticipated volumes are low. The design must allow for the future addition of grade separated access to both platforms. See side platform flyer stop design, Figure 1055-6.

Photograph from *FHWA/PB HOV Interactive 1.0 High Occupancy Vehicle Data Base from the U.S., Canada and Europe*

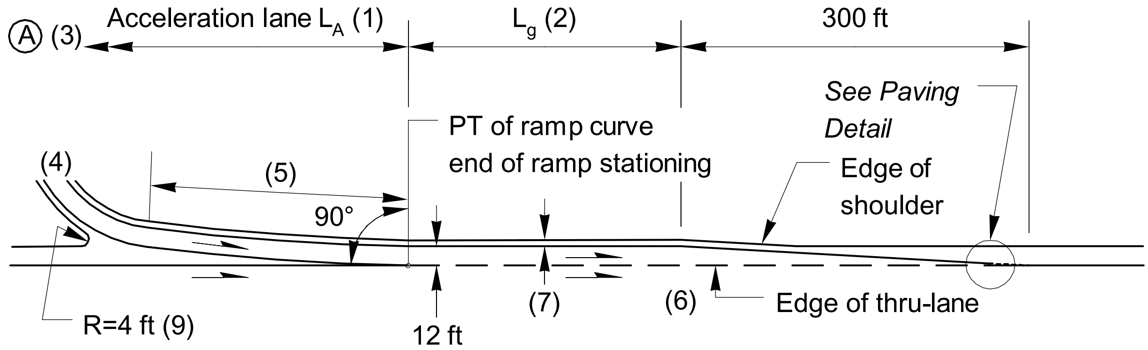
At-Grade Crossing Flyer Stop
Figure 1055-7

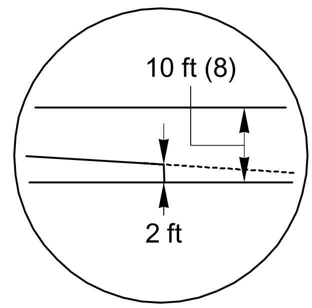


Transit Stops at Ramps
Figure 1055-8



Other Transit Stops
Figure 1055-9





Paving Detail

Notes:

(1) See Figure 1055-11 for acceleration lane length L_A.
Check L_A for each ramp design speed.

(2) L_g is the gap acceptance length. Begin L_g at the beginning of the parallel lane, as shown, but not before the end of the acceleration lane L_A. See Figure 1055-2 for the length L_g.

(3) Point A is the point controlling the ramp design speed or the end of the transit stop zone or other stopping point.

(4) See 1055.05(5) for ramp lane and shoulder widths.

(5) A transition curve with a minimum radius of 3,000 ft is desirable. The desirable length is 300 ft. When the main line is on a curve to the right, the transition may vary from a 3,000 ft radius to tangent to the main line. The transition curve may be replaced by a 50:1 taper with a minimum length of 300 ft.

(6) Angle point for width transitions, when required. See Chapter 620 for pavement transitions.

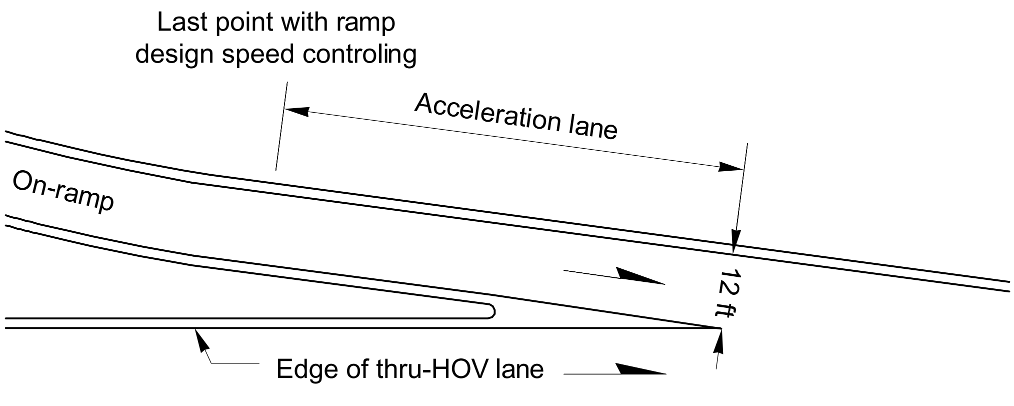
(7) See 1055.05(5)(b) for ramp shoulder width.

(8) The 10 ft left shoulder is the minimum width; 14 ft is preferred. Maintain this shoulder width for at least 500 ft; 1,000 ft is preferred.

(9) Radius may be reduced when concrete barrier is placed between the ramp and main line.

(10) For striping, see the Standard Plans.

Single Lane Parallel On-Connection
Figure 1055-10

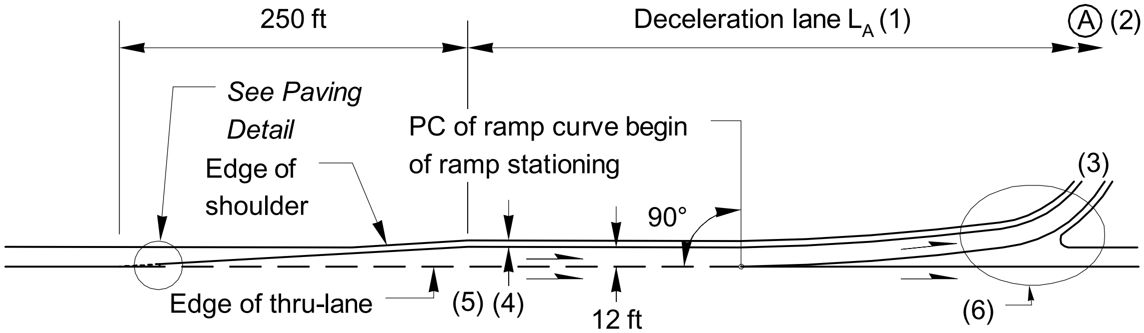


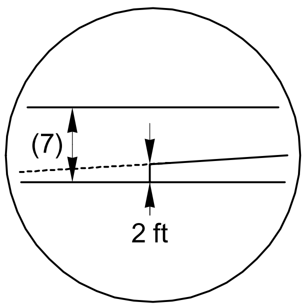
Freeway Speed (mph)	Ramp Design Speed								
	0	15	20	25	30	35	40	45	50
40	555	480	420	340	185				
45	835	760	700	615	470	290			
50	1230	1160	1100	1020	865	685	310		
55	1785	1715	1655	1575	1420	1235	875	410	
60	2135	2085	2040	1985	1875	1735	1440	995	460
70	3045	3015	2985	2945	2860	2745	2465	2050	1515
80	4505	4465	4420	4370	4250	4095	3745	3315	2780

Acceleration Length (L_A) for Buses (ft)

For the adjustment factors for grade, see Acceleration lane length in Chapter 940.

HOV Direct Access Acceleration Lane Length
Figure 1055-11





Paving Detail

Notes:

(1) See Figure 1055-14 for deceleration lane length L_D.
Check L_D for each ramp design speed.

(2) Point Ⓐ is the point controlling the ramp design speed or the end of the transit stop zone or other stopping point.

(3) See 1055.05(5) for ramp lane and shoulder widths.

(4) See 1055.05(5)(b) for ramp shoulder width.

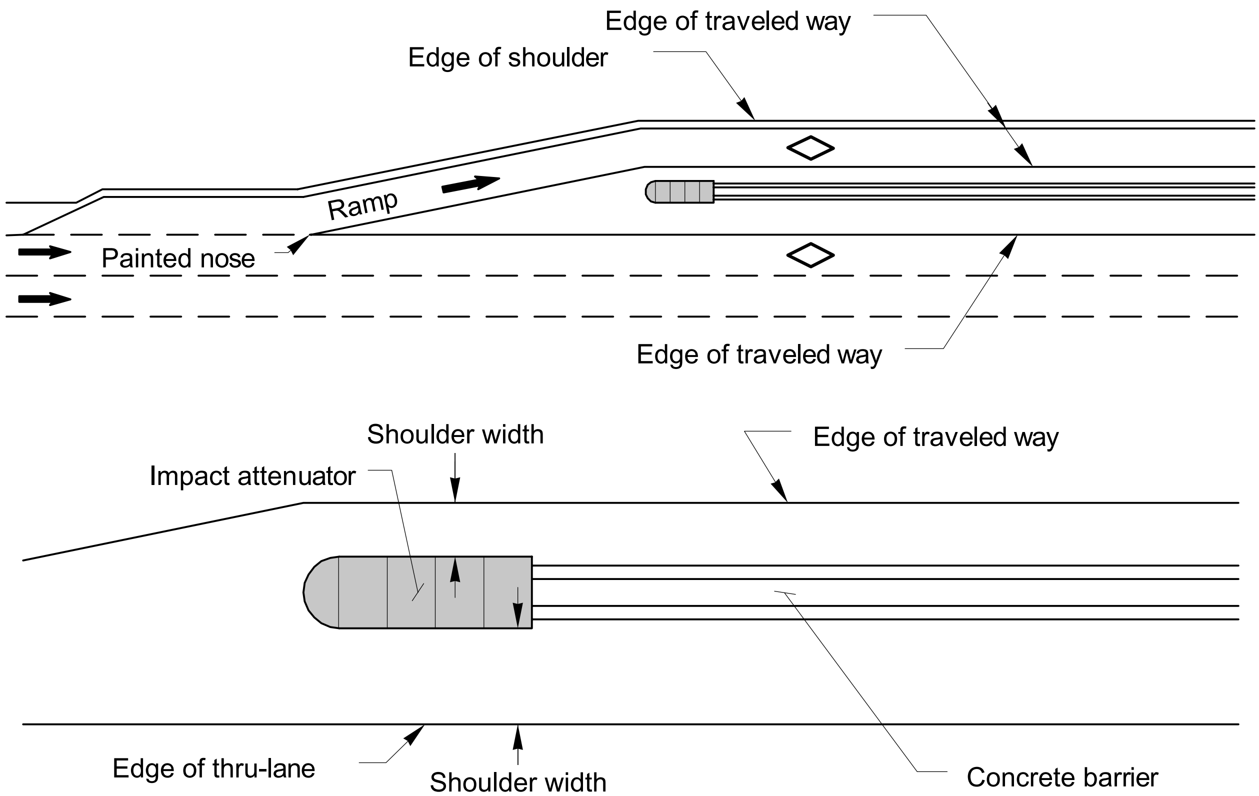
(5) Angle point for width transitions, when required. See Chapter 620 for pavement transitions.

(6) Gore area details at drop ramp connections (Figure 1055-3) are shown on Figure 1055-13. See Chapter 940 for gore details at other connection types.

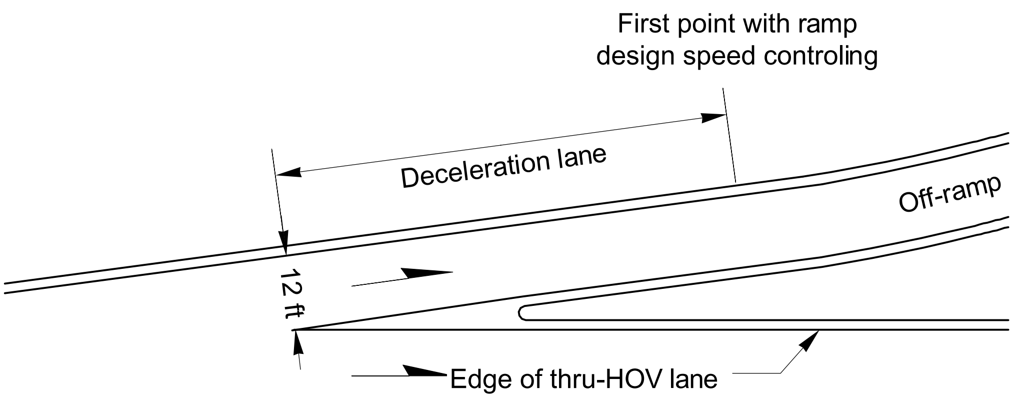
(7) The desirable shoulder width is 10 ft.

(8) For striping, see the Standard Plans.

Single Lane Parallel Off-Connection
Figure 1055-12



Drop Ramp Gore Area Characteristics
Figure 1055-13

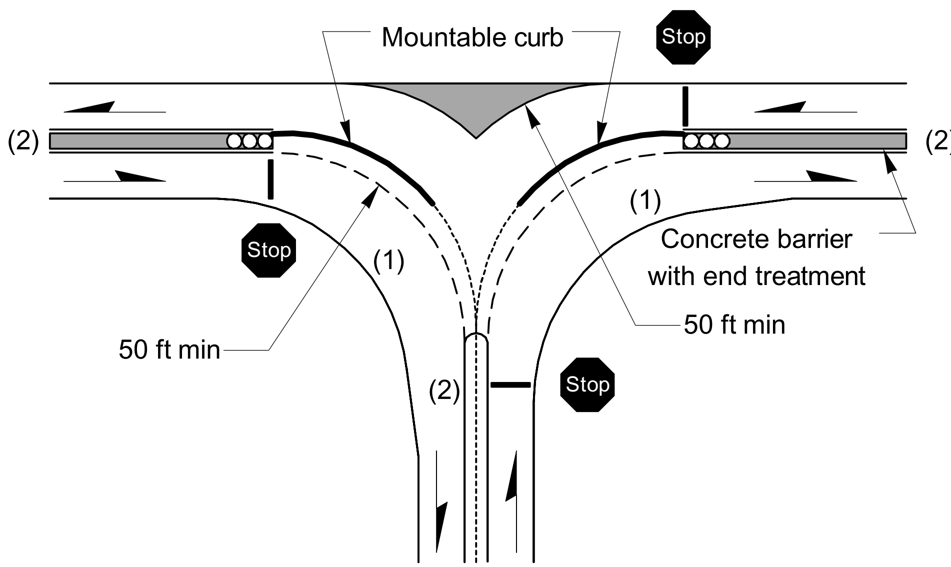


Highway Speed (mph)	Ramp Design Speed (mph)								
	0	15	20	25	30	35	40	45	50
40	390	330	290	240	170	100			
45	470	420	380	330	260	190	90		
50	570	520	480	430	360	290	190	100	
55	680	620	590	540	470	400	300	210	110
60	800	740	700	660	580	520	420	330	230
70	990	930	900	850	780	710	610	520	420
80	1210	1150	1110	1060	990	920	830	740	640

Deceleration Length (LD) for Buses (ft)

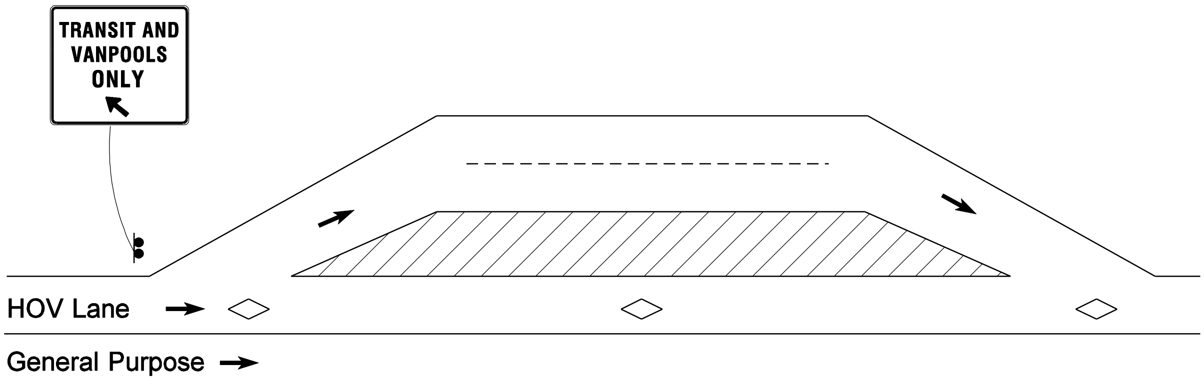
For the adjustment factors for grade, see deceleration lane length in Chapter 940.

Deceleration Lane Length for Buses
Figure 1055-14

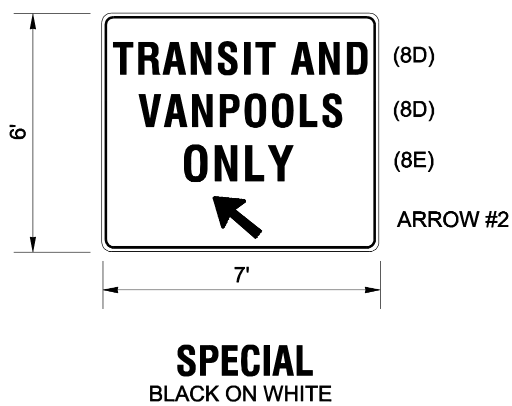


Notes:
(1) See Chapter 910 for intersection corner design. Use the right-turn corner design for the WB-40 for both the left and right turns.
(2) See 1055.05(5) for ramp lane and shoulder widths.

T Ramp Design
Figure 1055-15

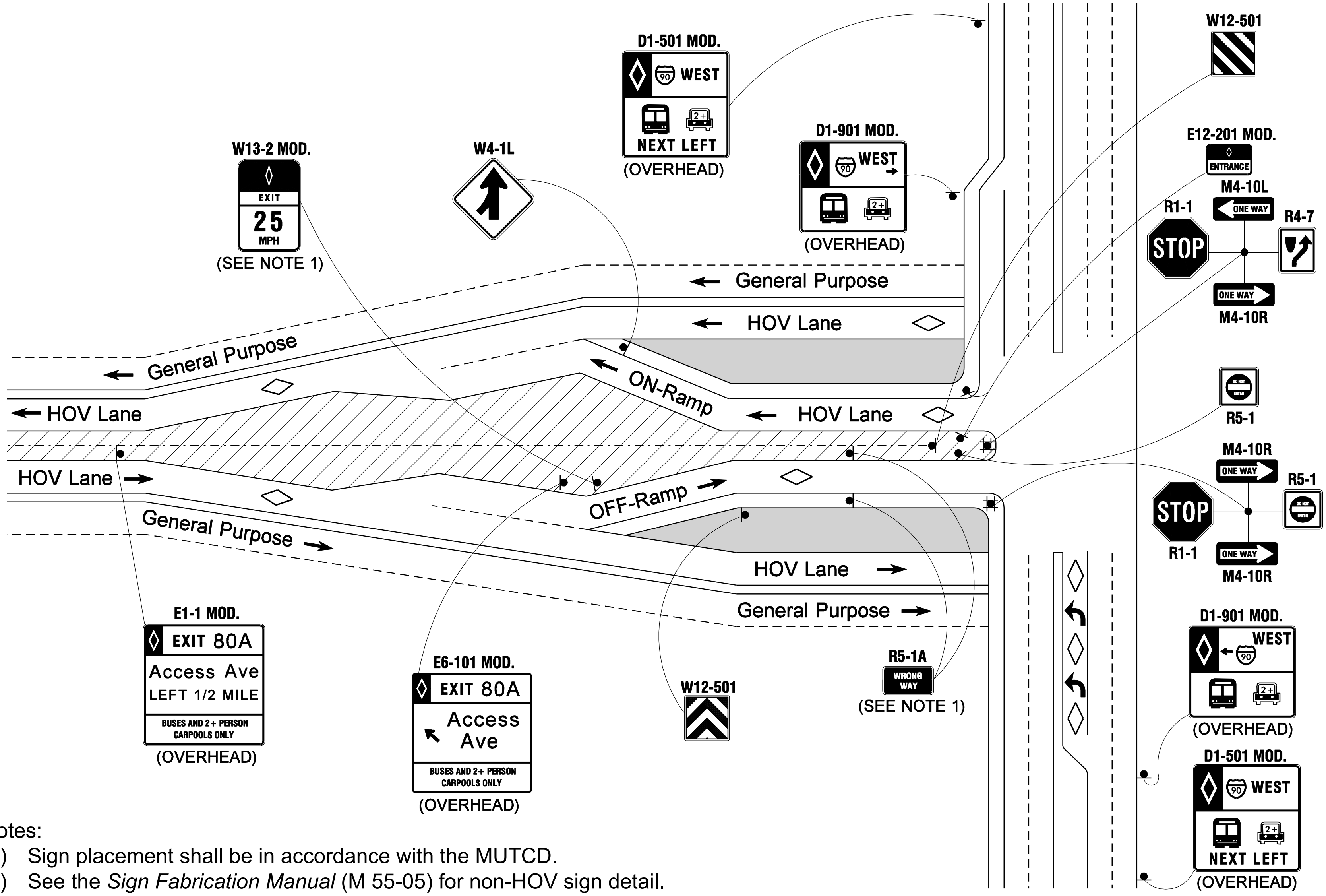


Typical Signing for Flyer Stop



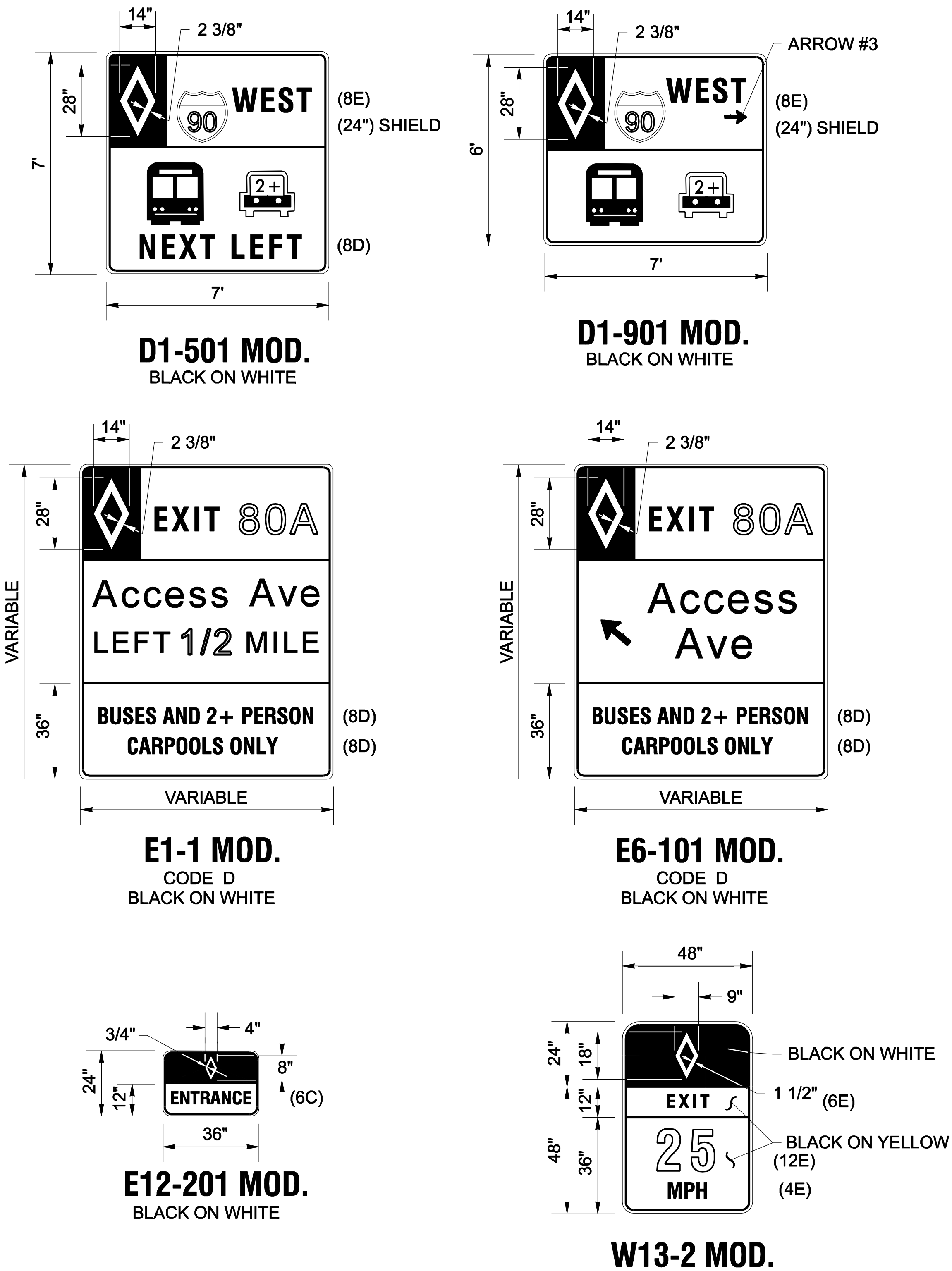
Special Flyer Stop Sign

Flyer Stop Signing
Figure 1055-16



Notes:
(1) Sign placement shall be in accordance with the MUTCD.
(2) See the *Sign Fabrication Manual* (M 55-05) for non-HOV sign detail.
(3) See Figure 1055-17b for modified sign details.

HOV Direct Access Signing
Figure 1055-17a



HOV Direct Access Signing

Figure 1055-17b

1060
TRANSIT BENEFIT FACILITIES

1060.01 INTRODUCTION

(1) Purpose of Chapter

The purpose of this chapter is to provide operational guidance and information for designing transit benefit facilities for WSDOT, local agencies, and developers on public or private property within Washington.

The design criteria presented represent recognized principles based mainly upon criteria developed by AASHTO. The information presented should not substitute for sound engineering judgement. It must be recognized that some situations encountered will be beyond the scope of this section, since it is not a comprehensive textbook on public transportation engineering.

Private development, which incorporates transit benefit facilities into its design, should use this section as a guide at the direction of staff from the appropriate public jurisdiction.

Coordination between agencies in the location and design of transit benefit facilities has often been catch-as-catch-can" at best. Where transit benefit facilities have been required as a condition of development, there has been some confusion as to what design criteria apply. This chapter, along with the referenced "A Guide to Land Use and Public Transportation," provides guidance for the design and location of transit benefit facilities.

The design information which follows can help WSDOT, local jurisdictions, and developers assure that transit provides efficient and cost effective service to the public and the community.

1060.02 DEFINITIONS

articulated bus a two-section bus that is permanently connected at a joint. An articulated bus is 50 percent longer than a standard bus, has three axles, and can bend around corners.

bus pull-out a dedicated parking area for in-service coaches on specified routes, where coaches do not have independent pull-in and pull-out areas.

bus shelter a facility which provides seating and protection from the weather for passengers waiting for a bus.

bus stop a place where passengers wait to board a bus.

car/vanpool a group of people who share the use and cost of a car or van for transportation, on a regular basis.

feeder service bus service providing connections with other bus or rail services.

high occupancy vehicle (HOV) a vehicle which carries a specified minimum number of persons (Chapter 1050).

kiss and ride when patrons of a park and ride lot are dropped off or picked up by private auto or taxi. These are sometimes called drop and ride.

public transportation passenger transportation services available to the public, including buses, ferries, rideshare, and rail transit.

sawtooth berth a series of bays that are off-set from one another by connecting curblines. They are constructed at an angle from the bus bays. This configuration minimizes the amount of space needed for vehicle pull-in and pull-out.

standard bus a bus that is approximately 40 feet in length.

transit a general term applied to passenger rail and bus service used by the public.

transit benefit facility capital facilities, along with the necessary design considerations, which improve the efficiency of public transportation or encourage the use of public transportation and other HOVs.

1060.03 PARK AND RIDE LOTS

(1) General

Park and ride lots provide parking for people who wish to transfer from private vehicles to public transit or carpools/vanpools. These lots are intended to increase highway efficiency, reduce energy demands, and increase highway safety by reducing traffic congestion. Most park and ride lots located within urban areas are served by transit; however, the smaller lots may only have local transit service. Smaller leased lots, usually at churches or shopping centers, may have no bus service, and only serve carpools and vanpools. Park and ride lots, located in rural areas not served by buses, also serve carpools and vanpools.

Early and continuous coordination with the local transit authority and local government agencies is critical. When a memorandum of understanding (MOU) exists, which outlines design, funding, maintenance and operations of the lot program, it must be checked for requirements for new lots. If the requirements cannot be met, the MOU must be renegotiated.

(2) Site Selection

Present and future needs are the main considerations in determining the location of a park and ride lot. Public input is a valuable tool. The demand for and the size of a park and ride lot is dependent on a number of factors. Many of these factors vary with the state of the economy, energy availability and cost, perceived congestion, and public attitude, and are somewhat difficult to predict. Therefore, consider sizing the facility to allow for a conservative first-stage construction with expansion possibilities. As a rule of thumb, one acre can accommodate approximately 90 vehicles in a park and ride lot. This allows about 40 percent of the area for borders, landscaping, passenger amenities, bus facilities for larger lots, and future expansion.

Primary concerns during the design stage include:

- Safe and efficient traffic flows, both on and adjacent to the site, for all modes: transit, carpools, vanpools, pedestrians, and bicycles.
- Adequate lighting and good visibility to enhance security and surveillance of the facility to reduce criminal activity.
- Adequate number of parking spaces.
- Comfortable and attractive facilities.
- Facilities that accommodate use by elderly and disabled users and meet state barrier free design codes.

Local transit authority input is critical because, in some cases, the need for a park and ride lot and its location may already have been determined in the development of their comprehensive transit plan. Failure to obtain transit input could result in a site which does not work well for transit vehicle access.

A list of potential sites should be developed. This can be simplified by the use of existing aerial photos, detailed land use maps, or property maps. The goal is to identify properties which can most readily be developed for parking and which have suitable access.

Factors influencing site selection and design of a park and ride facility include:

- Local transit authority master plan.
- Regional transportation plan.
- Local public input.
- Need.
- Traffic.
- Commuter distance.
- Local government zoning.
- Economic, social, and environmental impacts.
- Cost and cost effectiveness.
- Access by all modes of travel.
- Security and appearance.
- Maintenance.
- Available utilities.
- Existing right of way or sundry site.
- Capability for future expansion.

Purchasing or leasing property increases costs substantially. Therefore, state-owned right of way should be the first choice, assuming the other selection criteria are favorable. The use of city or county-owned right of way should also receive prime consideration. The site selected should not jeopardize the present and future integrity of the highway facility.

Each potential site should be further investigated in the field. The field survey serves to confirm or revise impressions gained from the office review. Consider the following when making the review:

- Physical characteristics of the site.
- Current use of surrounding area (zoning).
- Whether the site is visible from adjacent street(s) to enhance security and surveillance of the facility.
- Potential for additional expansion.
- Accessibility for motorists and other modes of travel including transit.
- Proximity of any existing parking facilities, such as church or shopping center parking lots, that are underutilized during the day.
- Potential for joint use of facilities with businesses or land uses compatible with park and ride patrons, such as day care centers or dry cleaners.
- Congestion problems and other design considerations.

After establishing the best potential sites, public meetings and environmental procedures should be completed prior to preparing the design report. Follow environmental procedures as outlined in Chapter 220.

The design report should address the public meetings and environmental processes completed, as well as the preferred and alternate sites considered.

(3) Design

A design report (Chapter 330) is required for all federally funded projects and for WSDOT facilities that are to be paved.

Design features must be in compliance with applicable design standards, specifications, and operating procedures and with any local requirements that may apply. In some cases, variances to local design standards may be necessary to ensure the safety and security of facility users.

Design components may include:

- Geometric design of access points.
- Internal and external circulation.
- Parking space layout.
- Pavements.
- Shelters.
- Exclusive High Occupancy Vehicle (HOV) facilities.
- Bicycle facilities.
- Motorcycle facilities.
- Traffic control devices, including signs, signals, and permanent markings.
- Illumination.
- Drainage and erosion control.
- Security of facility users and vehicles.
- Environmental mitigation.
- Landscape preservation and development.
- Restroom facilities.
- Telephone booths.
- Trash receptacles.
- Traffic data.
- Barrier free design for the disabled.

The degree to which the desirable attributes of any component are sacrificed to obtain the benefits of another component can only be dealt with on a site specific basis.ˇHowever, these guidelines present the optimum requirements of each factor.

Large park and ride lots use private automobiles as the primary collector distributor mode and transit buses as the line haul mode. The basic principles are also used in designing smaller park and ride lots used primarily for carpools and vanpools with limited or no bus service.

(a) Access. Six basic transportation modes are used to arrive at and depart from park and ride lots: walking, bicycle, motorcycle, private automobile including carpools, vanpools, and bus. All these modes should be provided for.

Access to a park and ride lot should not increase congestion on the facility it serves. For this reason, direct access by private automobiles to a freeway or ramp should be avoided. However, direct access for transit is often desirable as long as this access does not add a major conflict point. Often the most efficient access point to a park and ride lot will be on an intersecting collector or local street. If the intersection is already signalized, excellent access can often be provided. Entrances and exits should be located with regard to adjacent intersections, so that signal control at these intersections can be reasonably installed at a later time, if necessary. Storage for vehicles entering the lot and adequate storage for exiting vehicles should be planned. Ease of access will encourage use of the facility.

When it is necessary to provide direct access to an arterial, the location must be carefully considered. It should be located to avoid queues from nearby intersections. Field observation of traffic patterns and queuing at the site is recommended prior to establishing an access point.

The facility should be located to allow the most users possible to make a right turn into the lot, thus reducing the hazard of crossing opposing traffic.

Entrances and exits should be at least 150 feet apart and not closer than 150 feet to a public intersection, all measured curb to curb (minimum standard): 350ˇfeet is desirable. Where the capacity of the parking area does not exceed 150 stalls, the above spacings may be reduced to 100 feet.

Park and ride lots located along one-way couplets should be located between the two one-way streets with access from both streets. When access cannot be provided directly to both streets, it may be necessary to provide additional signing to guide users to and from the facility.

When a park and ride lot has more than 300 parking stalls, at least two entrances and two exits should be provided. The volume per entrance or exit should not exceed 300 vehicles per hour. With lot sizes larger than 500 stalls, two lane exits with traffic signals should be considered for exits onto heavy volume two-way streets. It is desirable for park and ride lots with capacities greater than 1,000 parking stalls to have entrance and exit points to two or more adjacent streets in order to avoid congestion. Entrances should be located so that a vehicle approaching the site from any direction could miss one entrance and find a second one without circuitous routing.

Entrances and exits that will be used by buses should have a minimum width of 15 feet per lane. See Section 1060.08 for corner radii requirements for buses. See Chapter 920 and the standard plans for design of other access points.

All entrances and exits should conform to WSDOT design standards or other published design standards used by the local agency.

The transit route from the freeway or arterial to a park and ride lot, circulation patterns within the lot, and return route should be designed to minimize transit travel time. Exclusive ramp connections for buses and vanpools, both to and from the freeway or street, may be justified by time savings to riders and reduced transit costs. All transit routing should be coordinated with the transit authority.

(b) Internal Circulation. Major circulation routes within a park and ride lot should be located at the periphery of the parking area to minimize vehicle-pedestrian conflicts. Circulation within the lot should accommodate all modes using that part of the facility. Care should be taken to see that an internal intersection is not placed too close to a street intersection. A separate loading area, with priority parking areas, should be considered for vanpools. Whenever possible, buses should not be mixed with cars. Bus circulation routes should be designed to provide for easy movement, with efficient terminal operations and convenient passenger transfers. A one-way roadway with two lanes to permit passing of stopped buses is desirable, with enough curb length and/or saw-tooth type loading areas to handle the number of buses that will be using the facility under peak conditions (see Section 1060.04). Close coordination with the local transit authority is critical in the design of internal circulation for buses and vanpools.

The passenger waiting area should be located either:

1. In a central location with parking for the various user modes surrounding the waiting area, or
2. Located near the end of the facility with parking for the various user modes extending radially from the waiting area.

Large lots may require more than one waiting area.

In shared-type lots, such as shopping centers and churches, the waiting area should be located away from main building(s) so pedestrian and vehicle traffic from the lot will not interfere with the other facility activities.

In an undersized or odd-shaped lot, circulation may have to be compromised in order to maximize utilization of the lot. The general design for the individual user modes should be based on the priority sequence of pedestrians, bicycles, feeder buses, and park and ride area. Traffic circulation should be designed to minimize vehicular travel distances, conflicting movements, and number of turns. Vehicular movements within the parking area should be dispersed by strategic location of entrances, exits, and aisles. Aisles should be aligned to facilitate convenient pedestrian movement toward the bus loading zone.

Any of the internal layout that will be used by buses, including entrance and exit driveways, must be designed to the turning radius of the bus. Additional considerations for internal circulation are:

- All users (auto, pedestrian, bicycle, and bus) should be able to understand how the lot works.
- Drivers should not be confronted with more than one decision at a time.
- Adequate capacity should be provided at entrances and exits.
- Signing should be clear.
- Flexibility to adjust to changes in transit volume and operations should be provided.

(c) Stall Size. Internal circulation should be two-way with 90-degree parking. However, due to geometrics of smaller lots, one-way aisles with angled parking may be advantageous. Automobile stall dimensions should be 8.5 feet x 18 feet. When space for vehicle overhang is provided, some of the stalls may be 8.5 feet x 16 feet when parking at 90 degrees. When justified, some of the stalls may be designed for compact cars, 8 feet x 16 feet minimum. Include justification of the percentage of compact stalls.

For additionally information on parking stall size requirements for the disabled, see Section 1060.09.

If possible, aisle lengths should not exceed 400 feet. The greatest efficiency can generally be obtained by placing aisles and rows of parking parallel to the long dimension of the site. All parking should be head-in only. Vehicles and other objects should be excluded from corners where it is necessary to provide adequate intersection sight distances. It is also desirable to have parking on both sides of the aisle. This provides the most efficient design in terms of land use.

(d) Pedestrian Movement. Pedestrian movement in parking areas is normally by way of the aisles. Additional provision for pedestrian movement by means of walkways is desirable and could be required in certain situations, as described below. A pedestrian path from any parking stall to the loading zone should be as direct as possible.

Pedestrian walkways should be provided to minimize pedestrian use of a circulation road or an aisle, and to minimize the number of points at which pedestrians cross a circulation road. Where pedestrians originate from an outlying part of a large parking lot and use aisles or circulation roads to approach the loading zone, they will have to travel along an irregular path for a considerable distance. In such cases, consideration should be given to the provision of a walkway which extends toward the loading zone in a straight line.

The maximum distance a pedestrian will have to walk from his car to a loading zone should be in the range of 600 to 800 feet. Longer walking distances require consideration of centrally located or additional loading zones.

Pedestrian crossings should have good visibility both for pedestrians and drivers. Pedestrian walkways and crossings shall be clearly marked.

Facilities for disabled patrons must also be included. All pedestrian walkways shall have curb cuts, built in accordance with the Standard Plans, at all curbs or other sudden elevation changes. The sidewalk grade should be 12:1 or less. For additional disabled accessibility information, see Section 1060.09.

Sidewalks intended for use by pedestrians should have a minimum width of 5 feet. When it is anticipated that both pedestrians and bicycles will use the sidewalks, the minimum width is 8 feet. They should be compatible with existing sidewalks in the area and follow local codes.

The minimum width of a sidewalk adjacent to a loading zone should be 12 feet or the adjacent sidewalk width plus 7 feet, whichever is greater. Pedestrian barriers should be provided where unusual hazards or unreasonable interference with vehicular traffic would result. The barriers may be railings, berms, fencing, walls, or landscaping. These barriers should be installed with sight distance in mind. Minimum horizontal clearance between a barrier and vehicle should be 2 feet. A good parking lot design will minimize the need for pedestrian barriers.

(e) Bicycle Facilities. Encouraging the bicycle commuter is important. Each bicycle used to commute to the park and ride lot potentially frees up one parking space. An evaluation should be made to determine if the lot is going to be used by bicyclists and, if bicycles are expected, bicycle lockers or locking racks should be provided. All paved lots that are accessible by bicycle and are served by public transit should have lockers or a rack for a minimum of three bicycles. The bike parking area should be located relatively close to the transit loading area, separated from motor vehicles by curbing or other physical barriers, and have a direct route from the feeding streets. The bicycle parking area should be designed to prevent pedestrians from inadvertently walking into it and tripping. For bicycles, the layout normally consists of stalls 2 feet x 6 feet, at 90 degrees to aisles, with a minimum aisle width of 5 feet. For additional information on bicycle facilities, see Chapter 1020.

(f) Motorcycle Facilities. Motorcycle stalls should be 4 feet x 7 feet. Motorcycle storage should be on a Portland cement concrete slab to prevent stands from sinking into the asphalt pavement. Motorcycle stalls should be located relatively close to the transit loading areas.

(g) Drainage. Ponding of water in a lot is undesirable both for vehicles and pedestrians. Therefore, adequate slope should be provided for surface drainage. This is particularly true in cold climates where freezing may create icy spots. Recommended grade is 2 percent (0.02 ft/ft). Curb, gutter, and surface drains and grates should be installed where needed. Drainage grates with short, narrow openings, placed perpendicular to traffic direction, should be used in traffic areas to allow safe passage over the grate. Drainage design should be coordinated with the local agency to ensure that appropriate codes are followed (Chapter 1210).

Raised islands shall be held to a minimum so as not to hinder cleaning and snow removal.

(h) Pavement Design. Pavement design shall conform to state design specification for each of the different uses and loadings that a particular portion of a lot or roadway is expected to handle. The surfacing typeˇshall have the concurrence of the Materials Laboratory (Chapterˇ520).

(i) Traffic Control. Control of traffic movement can be greatly improved by proper pavement markings. Typically, reflectorized markings for center lines, lane lines, channelizing lines, and lane arrows will be necessary to guide or separate patron traffic and transit traffic. Signing and pavement markings shall conform to Chapters 820 and 830 and to the MUTCD. Park and Ride identification signs should be installed.

(j) Shelters. Pedestrian shelters should be considered in areas where the magnitude of transit service and environmental conditions warrant. Consider shelters when 50 or more riders per day are anticipated. Shelters may be individually designed or selected from a variety of commercially available designs to satisfy local needs. The following features should be considered in selecting shelter designs:

- Select open locations with good visibility to minimize potential for criminal activity.
- If enclosed, the open side should be away from nearby vehicle splashing.
- Doors are not recommended, unless need dictates otherwise, because of maintenance and vandalism potential.
- Allow for a small air space below side panels to permit air circulation and prevent the collection of debris.
- Optional features that may be provided are lighting, heat, telephone, travel information (schedules), and trash receptacles.
- Ease of field assembly and repair of components. Contact WSDOT's Architecture Office or local transit agency for shelter designs. Shelters are usually provided by the serving transit authority with the state providing only the shelter pad. Coordination with the local transit authority is essential in shelter design and placement.
- Design shelters to accommodate the disabled.
- See Section 1060.06, Passenger Amenities, for additional information on this subject.

(k) Illumination. Adequate lighting is important from a safety standpoint and as a deterrent to criminal activity in both the parking area and the shelters. Illumination should be considered for all park and ride lots (Chapter 840). Only security lighting is provided during hours of low usage. Locate poles so that vehicle movements and parking are not obstructed. If raised islands are used to separate adjacent parking rows, place the poles on the islands. In determining the locations of luminaire poles, plan for future expansion of the facility.

(l) **Landscape Preservation and Development.** Selective preservation of existing vegetation is often a cost-effective means to provide a balanced environment for the park and ride lot user. Preservation may reduce environmental impacts and give "instant" results. Landscaping of park and ride lots is desirable for aesthetic as well as ecological reasons and should consist of plantings that will be compatible with the operation of the facility. Landscaping shall be cost-effective, comply with the local requirements, and satisfy the functional needs of the park and ride lot. The type of plantings and their placements should not interfere with:

- Adequate lighting for the area, thus resulting in a potential safety hazard to the patron.
- Adequate sight distance for cars and transit vehicles, especially at intersections and pedestrian crossings.
- The proper placement of the traffic control devices.
- The ability of pedestrians, bicyclists, and the disabled to use the facility.
- Security of patrons and their property.

Trees provide shade and visual interest, reduce glare, and are less costly to maintain than shrubs and ground cover. Therefore, trees should be the dominant plant material. Trees should be placed only where they will not block sight distance for cars or buses and proper clearances can be maintained as they mature. Landscaping should be designed in such a manner that hiding places for vandals are minimized. Landscaping can provide an effective means for establishing pedestrian paths and walking patterns within the site. In parking zones, sufficient setback must be provided for all plants so the front or rear overhang of cars does not damage them. Earth forms, such as berms, mounds, and swales are a good design tool to provide for low-cost screening, delineation, visual interest, and drainage. Landscaping should be designed so that security patrols can see into the lot from adjacent streets without entering. Landscape design shall keep maintenance requirements to a minimum.

It is desirable that one tree be planted per 12 parking stalls so that no parking stall is farther than 75 feet from a tree. These trees provide luminaire light diffusion for adjacent property owners.

Irrigation also needs to be addressed in the landscape design.

(m) **Fencing.** See Chapter 1460 for guidelines for fencing.

(n) **Maintenance.** A comprehensive maintenance plan should be developed as per established state policy either as part of a memorandum of understanding with the local authority or for use by state maintenance forces. Maintenance of park and ride lots outside state right of way shall be the responsibility of the local transit authority. It is encouraged that park and ride lots inside state right of way should also be maintained by the local transit authority. Agreements for maintenance by others shall be negotiated during the design phase and documented in the design report (Chapter 330).

Maintenance cost estimates, funding source, and legal responsibilities for accidents and security are to be addressed in the maintenance plan and documented in the design report. The location and type of site (new or existing), and method of performing maintenance, will generally determine the extent of the maintenance program.

The following maintenance activities should be considered:

- Periodic inspection.
- Pavement repair.
- Traffic control devices (signs and pavement markings).
- Lighting.
- Mowing.
- Cleaning of drainage structures.
- Sweeping/trash pickup.
- Landscaping.
- Shelters.
- Snow and ice control.

A sound maintenance program should be established well ahead of the date a park and ride lot is placed into operation.

1060.04 TRANSFER/TRANSIT CENTERS

(1) Introduction

Transfer centers are essentially large bus stops where buses on a number of routes converge to allow riders the opportunity to change buses. Transfer centers are of particular importance in many transit systems, since riders in many areas are served by a "feeder" route; to travel to area destinations not served by the feeder, residents must transfer.

Transit centers are frequently associated with a major activity center. In this case, the activity is beyond simply a transfer between buses but also involves the center as a destination point.

This section provides general design considerations of transfer and transit centers. The development of a particular center requires consideration of such features as passenger volume, number of buses on site at one time, and local auto and pedestrian traffic levels. These factors will dictate the particular requirements of each center.

(2) Bus Berths

Where several transit routes converge and where buses congregate, multiple bus berths or spaces are sometimes required. Parallel and shallow sawtooth designs are the options available when considering multiple berths.

An important aspect in multiple bus berthing is proper signing and marking for the bus bays. Each bay should clearly delineate the route served. In addition, the pavement should be marked with striping to indicate correct stopping positions.

Consideration should be given to using Portland Cement Concrete Pavement where pedestrians will walk for ease of cleaning.

Where buses are equipped with a bicycle rack, the design should provide for loading and unloading of bicycles.

Figure 1060-1 shows typical parallel and sawtooth designs for parking standard 40-foot buses for loading and unloading passengers at a transfer center. The sawtooth design does not require buses to arrive or depart in any order. The parallel design shown requires that the buses either arrive or depart in order.

Where space is a consideration, the sawtooth design can be used for independent arrival but dependent departure. Figure 1060-2 is an example of a sawtooth transit center. In an in-line berthing design, space requirements are excessive if this same access is to be provided. More commonly, in an in-line design, buses pull into the forward-most available berth. Buses must then leave in the order of arrival. The local transit authority should be involved throughout the design process and must concur with the final design.

In the design of parallel bus berths, additional roadway width is required for swing-out maneuvers if shorter bus loading platforms are utilized. The roadway width and amount of lineal space at the bus loading platform are directly related where designs allow departing buses to pull out from the platform around a standing bus. For example, a 40-foot bus with a 16-foot forward clearance requires 22 feet of roadway width for its pull-out maneuver. This condition requires a roadway width of at least 24 feet and a total minimum berth length of 56 feet for each bus. Thus, five buses would require 264 feet of linear distance. The shorter the berth length allowed, the wider the roadway must be.

Considerable linear space is necessary in a parallel design to permit a bus to overtake and pull into a platform ahead of a parked bus. For example, a 40-foot bus requires approximately 92 feet to pull in, assuming the rear end of the bus is 1 foot out from the platform curb and 56 feet when a 5-foot "tailout" is permitted.

Parallel designs, even if signed properly, require strict parking enforcement, since they give the appearance of general curbside parking areas. Pavement marking is most critical for parallel design. Sawtooth designs offer the advantage of appearing more like a formal transit facility, which tends to discourage unauthorized parking.

(3) Flow/Movement Alternatives

Two primary alternatives for vehicle and passenger movement are possible for transfer centers, regardless of the type of bus berths used. As shown in Figure1060-3, all buses may line up along one side of the transfer center. This type of arrangement is generally only suitable for a limited number of buses, due to walking distances required for transferring passengers. For a larger number of buses, an arrangement similar to Figure 1060-4 can minimize transfer time requirements by consolidating the buses in a smaller area.

1060.05 BUS STOPS AND PULLOUTS

(1) Introduction

The bus stop is the point of contact between the passenger and the transit services. The simplest bus stop is a location by the side of the road. The highest quality bus stop is an area that provides passenger amenities such as a bench and protection from the weather.

Bus pullouts allow the transit vehicle to pick up and discharge passengers in an area outside the traveled way. The interference between buses and other traffic can be reduced by providing bus pullouts.

(2) Bus Stops Designation and Location

The location of bus stops should be standardized within the system to avoid undue confusion. However, standardization should not be a substitute for sound judgement whenever conditions render standard practice inappropriate. It is imperative that bus stops be of adequate length and located so that the adverse effect on traffic (including pedestrians) is kept to a minimum.

The following should be considered when locating bus stops:

- Bus stop placement requires the consent of the jurisdiction having authority over the affected right of way and the local transit authority.
- The physical location of any bus zone should be primarily determined by the following considerations: maximizing safety, operational efficiency, minimizing adjacent property impacts, and user destination points.
- Public transportation agencies are typically responsible for maintenance of transit facilities within the public right of way.

These elements are discussed in the following subsections.

The proper spacing for bus stops represents a trade-off between passenger convenience and bus operating speed. Closer spacing reduces passenger walking distance, while longer spacing permits faster and less expensive bus operations. The proper spacing in any specific area depends on the nature and layout of adjoining land uses and the number of passengers expected. Bus stops should˘be as close as possible to passenger origins and destinations.

If activity along the bus route is uniform, the typical bus stop spacing should be about 1,000 feet. A general minimum spacing should be 500 to 600 feet within the central business district (every 2 to 3 blocks). In this range, stops should be provided where streets intersect or where walkways from the surrounding areas reach the main street. Evaluation of pedestrian walking distances as a design issue in subdivision layout may yield short walking distances to bus stops and encourage transit use.

In suburban areas (mostly single-family housing with pockets of open space and undeveloped land), bus stops should be located approximately every 1,250 feet (four per mile). Stops are generally not provided where residential density drops below four units per acre.

If commercial, residential, or industrial activity along the bus route is not clustered, bus stops need not be located uniformly along routes, but can be sited at the activity nodes. Greater spacings, 1,500 to 2,500 feet (approximately two to four per mile), may be possible in these circumstances.

In order to evaluate a new route and build ridership, placement of bus zones may initially depart from the above guidelines.

(3) Bus Stop Placement

Where traffic volume is low, on-street parking is prohibited, and a stopped bus will not impede traffic, the bus stop may simply be a designated location where the bus can pull up to the curb or to the edge of the roadway. The location will be dictated by patronage, the intersecting bus routes or transfer points, security of the rider, and the need for convenient service.

The specific bus stop location is influenced not only by convenience to patrons, but also by the design characteristics and operational considerations of the highway or street. Bus stops are usually located in the immediate vicinity of intersections. Where blocks are exceptionally long, or where bus patrons are concentrated well removed from intersections, midblock bus stops, along with midblock crosswalks, may be used.

Bus stop capacity of one bus will typically be adequate for up to 30 buses per hour.

Where on-street auto parking is permitted, a designated area where the bus can pull in, stop, and pull out must be provided. Figure 1060-5 illustrates several types of bus stops.

- Far-side, with a stop located just past an intersection;
- Near-side, with a stop located just prior to an intersection; and
- Mid-block, with a stop located away from any intersections.

In general, a far-side stop is preferred, however, examine each case separately and determine the most suitable location giving consideration to such things as service to patrons, efficiency of transit operations, and traffic operation in general. Near-side and mid-block bus stops may be suitable in certain situations. Bus stops should utilize sites which discourage unsafe pedestrian crossings, offer proximity to activity centers, and satisfy the general spacing requirements discussed previously. Following are descriptions of the advantages and disadvantages of each type of site.

(a) Far-Side Bus Stops. Advantages:

- Right turns can be accommodated with less conflict.
- A minimum of interference is caused at locations where traffic is heavier on the approach side of the intersection.
- Will cause less interference where the cross street is one-way street from left to right.
- Stopped buses do not obstruct sight distance for vehicles entering or crossing from a side street.
- At a signalized intersection, buses can find a gap to enter the traffic stream without interference, except where there are heavy turning movements into the street with the bus route.
- Waiting passengers assemble at less-crowded sections of the sidewalk.
- Buses in the bus stop will not obscure traffic control devices or pedestrian movements at the intersection.

Disadvantages:

- Intersections may be blocked if other vehicles park illegally in the bus stop, or if the stop is too short for occasional heavy demand.
- Stops on a narrow street or within a traffic lane may block the intersection.

(b) Near-Side Bus Stops. Advantages:

- A minimum of interference is caused at locations where traffic is heavier on the leaving side than on the approach side of the intersection.
- Will cause less interference where the cross street is one-way from right to left.
- Passengers generally exit the bus close to crosswalk.

- There is less interference with traffic turning into the bus route street from a side street.

Disadvantages:

- Heavy vehicular right turns can cause conflicts, especially where a vehicle makes a right turn from the left of a stopped bus.
- Buses often obscure sight distance stop signs, traffic signals, or other control devices, as well as pedestrians crossing in front of the bus.
- Where the bus stop is too short for occasional heavy demand, the overflow will obstruct the traffic lane.

(c) **Mid-Block Bus Stops.** Advantages:

- Buses cause a minimum of interference with sight distance of both vehicles and pedestrians.
- Stops can be located adjacent to major bus passenger generators.
- Waiting passengers assemble at less-crowded sections of the sidewalk.

Disadvantages:

- Pedestrian jaywalking is more prevalent.
- Patrons from cross streets must walk farther.
- Buses may have difficulty re-entering the flow of traffic.

Some general guidelines for the location of bus stops are:

- At intersections controlled by signals, stop, or yield signs, when transit is critical but traffic and parking are not critical, a near-side stop is preferable.
- At intersections where heavy left or right turns occur, a far-side bus stop should be used. If a far-side bus stop is impractical, the stop should be moved to an adjacent intersection or to a mid-block location in advance of the intersection.
- It is important that the bus stop be clearly marked as a no parking zone with signs and/or curb painting.
- For safety and accessibility, all loading and unloading should be made from the curb, not in the street/traffic lane.
- At intersections where bus routes and heavy traffic movements diverge, a far-side stop can be used to advantage.
- Mid-block stop areas are recommended under the following conditions: (1) where traffic or physical street characteristics prohibit a near or far-side adjacent to an intersection; or (2) where large factories, commercial establishments, or other large bus passenger generators exist. A mid-block stop should be located at the far-side of a pedestrian crosswalk (if one exists) so that standing buses will not block an approaching motorist's view of pedestrians in the crosswalk.
- Sight distance conditions generally favor far-side bus stops, especially at unsignalized intersections. A driver approaching a cross street on the through lanes can see any vehicles approaching from the right. With near-side stops the view to the right may be blocked by a stopped bus. Where the intersection is signalized, the bus may block the view of one of the signal heads.
- For security purposes the availability of adequate off-street lighting is an important consideration.

(4) Bus Pullouts

Bus pullouts are generally most appropriate when one or more of the following situations exits:

- Traffic in the curb lane exceeds 250 vehicles during the peak hour.
- Passenger volume at the stop exceeds 20 boardings an hour.
- Traffic speed is greater than 45 miles per hour.
- Accident patterns are recurrent.

The separation of transit and passenger vehicles is critical in cases of high bus or traffic volumes or high speeds. Bus stops in the travel lane may be unsafe or impede the free flow of traffic. Bus pullouts should also be considered at locations with high bus passenger loading volumes that cause traffic to back up behind the stopped bus.

To be fully effective, the pullout should incorporate a deceleration lane or taper, adequate staging area for all anticipated buses, and a merging lane or taper. As roadway operating speeds increase, the taper length should increase accordingly. Many times, high traffic volumes will not allow sufficient gaps for the bus operator to returnˇthe vehicle safely to the traffic stream. When this happens, the operator may opt not to use the turnout.

Figure 1060-6 illustrates the dimensions and design features of bus pullouts associated with near-side, far-side, and mid-block bus pullouts.

There are no absolute criteria for locating bus pullouts. Where a pullout is being considered, the transit agency must be involved. Factors controlling the appropriate location and eventual success of a pullout include:

- Operating speed.
- Traffic volume.
- Number of passenger boardings.
- Available right of way.
- Roadway geometrics (horizontal and vertical).
- Construction costs.
- Location of curb ramps.

Figure 1060-7 illustrates the dimension and design requirements of far-side bus zones and pullouts where buses will stop after making a right turn. Adherence to these designs should allow safe stopping of buses with minimal interference with legally parked vehicles.

It is important in the design of bus pullouts to consider the need to provide structurally adequate pavement for the bus pullout (Chapter 520), otherwise the surfacing may be damaged by the weight of the buses.

1060.06 PASSENGER AMENITIES

(1) Introduction

Providing an attractive, pleasant setting for the walk and wait are important elements in attracting bus users.

A passenger arriving at a bus stop desires a comfortable place to wait. Important elements of a bus stop are:

- Safety from passing traffic.
- Adequate lighting.
- Security.
- Paved surface.
- Protection from the environment.
- A seat (if the wait may be long).
- Information about the routes serving the stop.

Providing safety from passing traffic involves locating stops where there is adequate space, so passengers can wait away from the edge of the traveled roadway. The buffering distance required from the roadway increases with traffic speed and traffic volume. Three to 5 feet is adequate where vehicle speeds are 30 miles per hour. A heavy volume arterial with speeds of 45 miles per hour can require a distance of 8 to 10 feet for passenger comfort.

Passengers arriving at bus stops, especially infrequent riders, want information and reassurance. Information provided should include the numbers or names of routes serving the stop. Other important information may include a system route map, the hours and days of service, schedules, and a phone number for information. The information provided and format used is typically the responsibility of the local transit system.

At busier stops, including park and ride lots, a public telephone should be provided. For all paved park and ride lots, a desirable site for a public telephone should be selected and conduit provided whether or not a telephone is currently planned. Where shelters are not provided, a bus stop sign and, depending on weather conditions, passenger bench are desirable. The sign indicates to passengers where to wait and can provide some basic route information.

(2) Passenger Shelters

Passenger shelters should provide protection for waiting transit users. In accomplishing this task, the shelter itself must be located conveniently for users without creating hazards — such as blocking the line of sight of automobile drivers or blocking the sidewalk. Figure 1060-8 illustrates a clear sight triangle that will permit shelter siting withˇminimal impact on sight distances at urban arterial intersections without traffic controls. The dimensions may vary by local jurisdiction — check local zoning ordinances or with appropriate officials.

State Motor Vehicle Funds cannot be used for design or construction of shelters, except for the concrete pad. Funding of shelters must be handled by the transit agency or some other local agency.

Adequate lighting is necessary to enhance passenger security. Lighting makes the shelter visible to passing traffic and allows waiting passengers to read information provided. General street lighting is usually adequate. Where street lights are not in place, additional street lights or transit shelter lights should be considered.

A properly drained, paved surface is necessary so that passengers will not traverse puddles and mud in wet weather. Protection from the environment is typically provided by a shelter that provides shade from the sun, protection from rain and snow, and a wind break. Shelters can range from simple to elaborate. The latter type may serve as an entrance landmark for a residential development or employment complex and be designed to carry through the architectural theme of the complex. If a nonpublic transportation entity shelter is provided, its design and siting must be approved by the local transit operator. The reasons for this approval requirement include safety, barrier-free design and long-term maintenance concerns.

Simple shelters, such as that illustrated in Figure 1060-9, may be designed and built by the transit agency or purchased from commercial vendors. The WSDOT Architecture Office may be contacted for more complex designs.

If resources permit, shelter placement should be considered at most bus stops in new commercial and office developments and in places where large numbers of elderly and disabled persons may wait, i.e., hospitals, senior centers, etc. In residential areas, shelters are placed only at the highest volume stops.

1060.07 ROADWAY AND VEHICLE DESIGN CRITERIA CHARACTERISTICS

(1) Paving Sections

The pavement design (type and thickness) of a transit benefit project, whether initiated by a public transportation agency or a private entity, must be coordinated with WSDOT or the local agency public works department depending on highway, street, or road jurisdiction. These agencies play a major role in determining the paving section for the particular project. Early and frequent coordination is required.

Paving section design is determined by the volume and type of traffic, design speed, soil characteristics, availability of materials, construction costs, and maintenance cost. Important characteristics of good pavement design are the ability to retain shape and dimensions, the ability to drain, and the ability to maintain adequate skid resistance.

See Chapterˇ510 "Investigation of Soils and Surfacing Materials" and Chapterˇ520 "Design of Pavement Structure" for guidance in the design of pavements.

(a) Grades. Roadway grades refer to the maximum desirable slope or grade, or the maximum slope based upon the minimum design speed that a standard 40-foot transit bus can negotiate safely. Guidance on roadway grades is in Chapterˇ440 or in the *Local Agency Guidelines*. Public transportation agencies or private developers should coordinate their needs with WSDOT or the appropriate local agency.

Speed of buses on grades is directly related to the weight/horsepower ratio. Grades should be selected to permit uniform operation at an affordable cost. In cases where the roadway is steep, a climbing lane for buses and trucks may be needed. Abrupt changes in grade should be avoided due to bus overhangs and ground clearance requirements.

(b) Lane Widths. Roadway and lane widths are generally regulated by WSDOT or the *Local Agency Guidelines*, based upon the functional class of highway or road under their respective jurisdiction.

Private developers should contact these agencies early in the design process to ensure that roadway and lane widths are consistent with applicable standards.

Roadway capacity is directly affected by lane width. As lanes narrow, anticipated capacity is lowered. Controls determining adequate lane width include design speed, anticipated traffic volume, types of user vehicles, available right of way, and roadside obstructions, i.e., retaining walls, light poles, and street furniture.

For lanes to be used by High Occupancy Vehicles (HOV), buses, vanpools, and carpools, the recommended width is 12 feet. Lane widths should not be less than 12 feet when transit volumes are high. Chapter 1050 provides additional information on HOV facilities.

(2) Vehicle Characteristics/Specifications

Most transit agencies operate several types of buses within their system. Vehicle sizes range from the articulated bus to passenger vans operated for specialized transportation purposes and vanpooling.

Each manufacturer within each of the general classifications may vary dimensions such as wheelbase, height, and vehicle overhang. The total gross vehicle weight rating (GVWR) varies considerably among manufacturers for the type of general vehicle classification. Because of these differences, more specific design information should be obtained from the local transit authority.

The principal dimensions affecting design are the minimum turning radius, the tread width, the wheelbase, and the path of the inner rear tire. Effects of driver characteristics and the slip angle of the wheels are minimized by assuming that the speed of the vehicle for the minimum radius (sharpest) turn is less than 10 miles per hour.

(a) Large Transit Buses. These traditional urban transit service vehicles are typically 40 feet long and have a wheelbase of approximately 25 feet. Many agencies operate 35-foot buses which have a 19-foot wheelbase.

Many of these vehicles are equipped with either front or rear door wheelchair lifts, or a front "kneeling" feature that reduces the step height for mobility impaired patrons.

(b) Articulated Transit Bus. Because articulated buses are hinged between two sections, these vehicles can turn on a relatively short radius. Articulated buses are typically 60 feet in length with a wheelbase of 19 feet from the front axle to mid-axle and 24 feet from the mid-axle to the rear axle.

(c) Small Transit Buses. Some of the smaller transit agencies operate 26 to 30-foot transit coaches which are designed for use in low volume situations. Modified vans are used for transportation of the elderly and disabled persons and shuttle services. Passenger vans are a third type of small bus, used for specialized transportation and vanpooling. Some of these vans have been modified to provide special seating arrangements. Since the vehicle specifications vary so widely within this category, consult the local transit authority or bus manufacturer for specifications of the particular vehicle in question.

1060.08 INTERSECTION RADII

A fundamental characteristic of transit accessible development is safe, convenient access and circulation for transit vehicles. It is important that radii at intersections be designed to accommodate turning buses. Adequate radii will reduce conflicts between automobiles and buses, reduce bus travel time, and provide maximum comfort for the passengers.

The following major factors should be taken into consideration in designing intersection radii:

- Right of way availability.
- Angle of intersection.
- Width and number of lanes on the intersecting streets.
- Design vehicle turning radius.

- Parking at the intersection.
- Allowable bus encroachment.
- Operating speed and speed reductions.
- Pedestrians.
- Bicycles.

Because of space limitations and generally lower operating speeds in urban areas, curve radii for turning movements may be smaller than those normally used in rural areas. It is assumed that buses making turns are traveling at speeds of less than 10 miles per hour. Figures 1060-10 and 11 illustrate the Turning Templates and design vehicle specifications for a standard 40-foot bus and an articulated bus.

Figure 1060-12 illustrates appropriate radii at intersections for four types of parking configurations which may be associated with an intersection. Radii less than minimum result in encroachment into adjoining lanes or curbs. As intersection radii increase, pedestrian crossing distances increase.

To ensure efficient transit operation on urban streets, it is desirable to provide corner radii of from 35 to 50 feet (based on the presence of curb parking on the streets) for right turns to and from the through lanes. Where there are curb parking lanes on both of the intersecting streets and parking is restricted for some distance from the corner, the extra width provided thereby serves to increase the usable radius.

Angle of intersection also influences the turning path of the design vehicle. Figure 1060-13 shows the effect of the angle of intersection on the turning path of the design vehicle on streets without parking. Figure 1060-13 also illustrates different cases; when a vehicle turns from proper lane and swings wide on the cross street, and when the turning vehicle swings equally wide on both streets.

1060.09 DISABLED ACCESSIBILITY

(1) Introduction

Public transportation providers have an obligation under both state and federal laws to create and operate capital facilities and vehicles that are usable by the wide variety of residents in the service area. A major need arising from this obligation is to provide transportation service to the transit dependent, among whom are disabled individuals.

According to the report titled "Persons of Disability in Washington State — A Statistical Profile 1970-1980" by the Washington State Employment Security Department, the percentage of persons with disabilities within the state in the working age years of 16 to 64 was 8.7 percent in 1980. The number of elderly people with disabilities that affect mobility is far higher.

Federal law requires all new or significantly rehabilitated buses to be accessible to the disabled. Transit agencies are also required to provide demand response service comparable with the fixed route service.

Barrier-free design means more than just accommodating wheelchairs. Care needs to be given not to create hazards or barriers for people who have vision or hearing impairments. They key is to design clear pathways without obstacles and signs that are simple with large print.

Transit Benefit facilities are designed for accessibility aspects under the Uniform Federal Accessibility Standards (UFAS) and/or, Chapter 51-10 WAC "Washington State Regulations for Barrier-Free Facilities" or local agency standards where applicable.

(2) Park and Ride Lots

Parking stalls for the disabled should be located in close proximity to the transit loading and unloading area. Stalls shall be at least 8 feet wide with a 5-foot adjacent loading aisle on each side with sidewalk curb cuts (see Standard Plans). Two accessible parking stalls may share a common access aisle. Provide disabled stalls according to the following table:

Total Parking Stalls in Lot	Required Disabled Parking Stalls
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1,000	2% of total
1,001 and over	20 plus 1 for each 100 over 1,000

No more than two of these stalls need be striped and signed for disabled use at the time of initial operation. The remaining stalls may be striped for standard usage, but the curb cuts for wheelchair ramps should be provided for each future stall. Additional stalls shall be made available for use by disabled patrons when demand indicates the need.

A parking stall for disabled persons shall be signed according to the requirements of RCW 46.61.581.

- Disabled facilities should be in accordance with the following:
- Disabled patrons should not have to cross access roads enroute to the bus loading zone.
- Disabled patrons should not be forced to travel behind parked cars (in their circulation path).
- Wheelchair ramps shall be provided to facilitate the movement of physically disabled patrons.

- Parking stalls and access aisles shall be level with surface slopes not exceeding 2 percent.

(3) Bus Stops and Shelters

In order to use buses which are accessible, bus stops must also be accessible to disabled persons. The nature and condition of streets, sidewalks, passenger loading pad, curb ramps, and other bus stop facilities can constitute major obstacles to mobility and accessibility. State, local, public and private agencies need to work closely with public transportation officials to enhance accessibility for people with disabilities. A significant component of bus stop accessibility is in the provision of "pads" for the deployment of wheelchair lifts. The terrain where a wheelchair pad is located should be level. The pad should be constructed of cement concrete, asphalt concrete pavement, or a similar impervious surface. The approach to the pad should not consist of grass, gravel, or any surface where a wheelchair might lose traction. The pad should have a minimum slope toward the curb sufficient for drainage purpose. The stop pad should measure at least 10 feet in length and 8 feet in width. When right of way or other limitations restrict the pad size, a smaller pad may be provided, but it must be able to accommodate a wheelchair.

The local public transit agency should be involved in the pad design to help ensure that lifts can actually be deployed at this site.

In order to access a bus stop, it is important that the path to these facilities also be accessible by the use of sidewalks with curb ramps. The Standard Plans contain design and construction information for cement concrete sidewalks and curb ramps. A continuous curb ramp is used for accessibility of disabled park and ride users as part of the accessible path to the bus stop and shelter.

In the design of bus stops and/or shelters the following should be considered:

- Inclusion of bus stop disabled access as a critical factor in the selection of locations for pedestrian improvements within the safety component of the state's or local agency capital improvement program.
- Ensure that curb ramps are properly sloped and sized for safe wheelchair usage and that they have textured surfaces to warn blind persons (see the Standard Plans).
- Identification of places that require sidewalks.
- Encouragement that property owners keep existing sidewalks in a good state of repair.
- Encouragement and continued emphasis of standards requiring all new street construction or reconstruction to include sidewalk or pedestrian walkway and curb ramps.
- Bus stop should be identified with curb painting and/or bus stop signs. Both disabled and nondisabled persons will benefit from this.
- All bus stops that can be made accessible should be made accessible, whether or not the paths to them are accessible, as future improvements may make the paths accessible.
- All bus stop signs along a route served by accessible vehicles should be marked with the blue international accessibility symbol conforming to the requirements of RCW 70.92.120 for easier identification by users.
- Existing as well as future park and ride locations must, by state law, include reserved parking for disabled persons, marked with signs as outlined in RCW 46.61.581.

1060.10 REFERENCES

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Performance Criteria and Design Standards for Park and Ride Lots, Metro Guidelines, April 1974.

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Design Guidelines for Bus Facilities, Orange County Transit District, Garden Grove, California, November 1987.

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A Policy on Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials, 1984.

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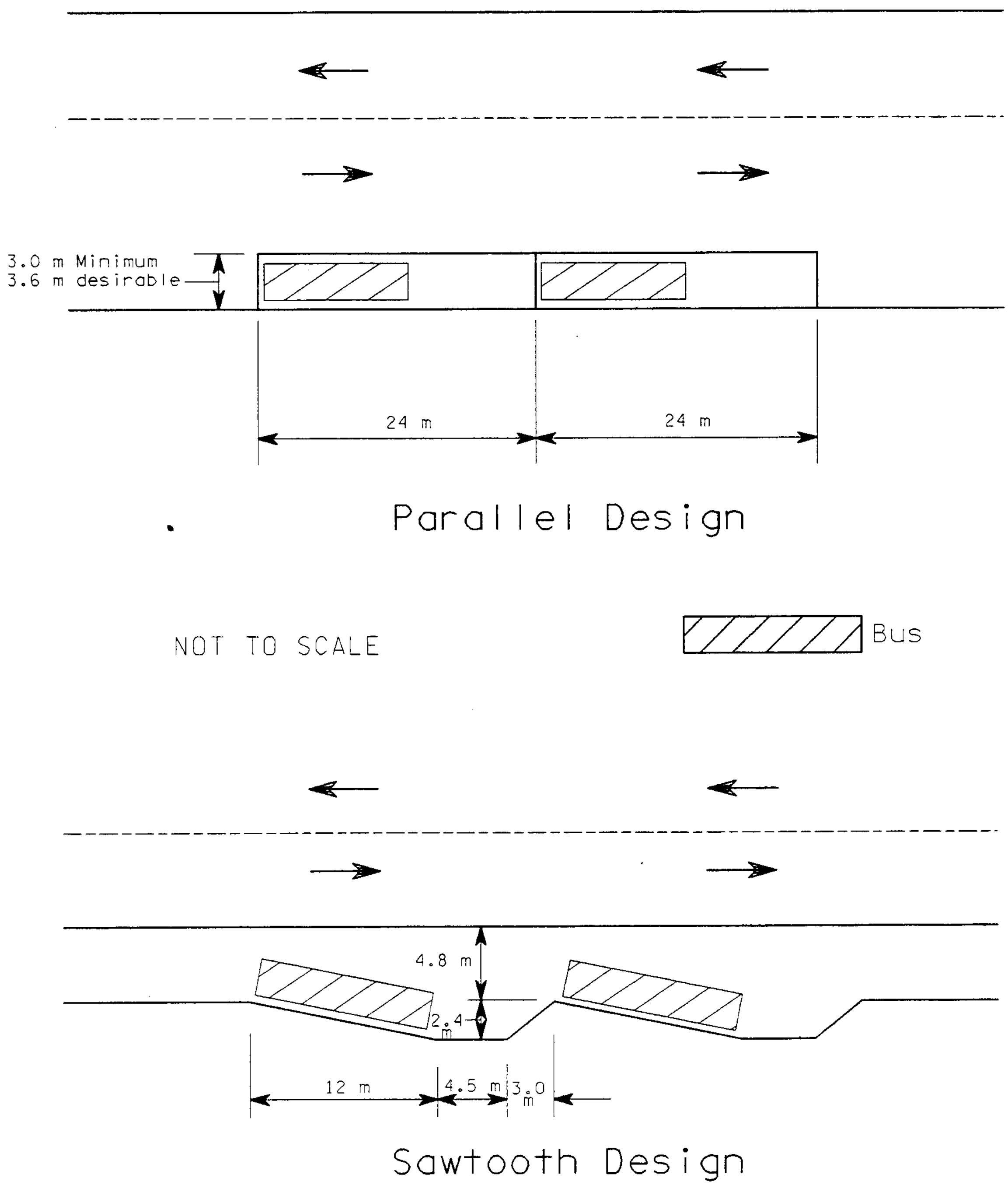
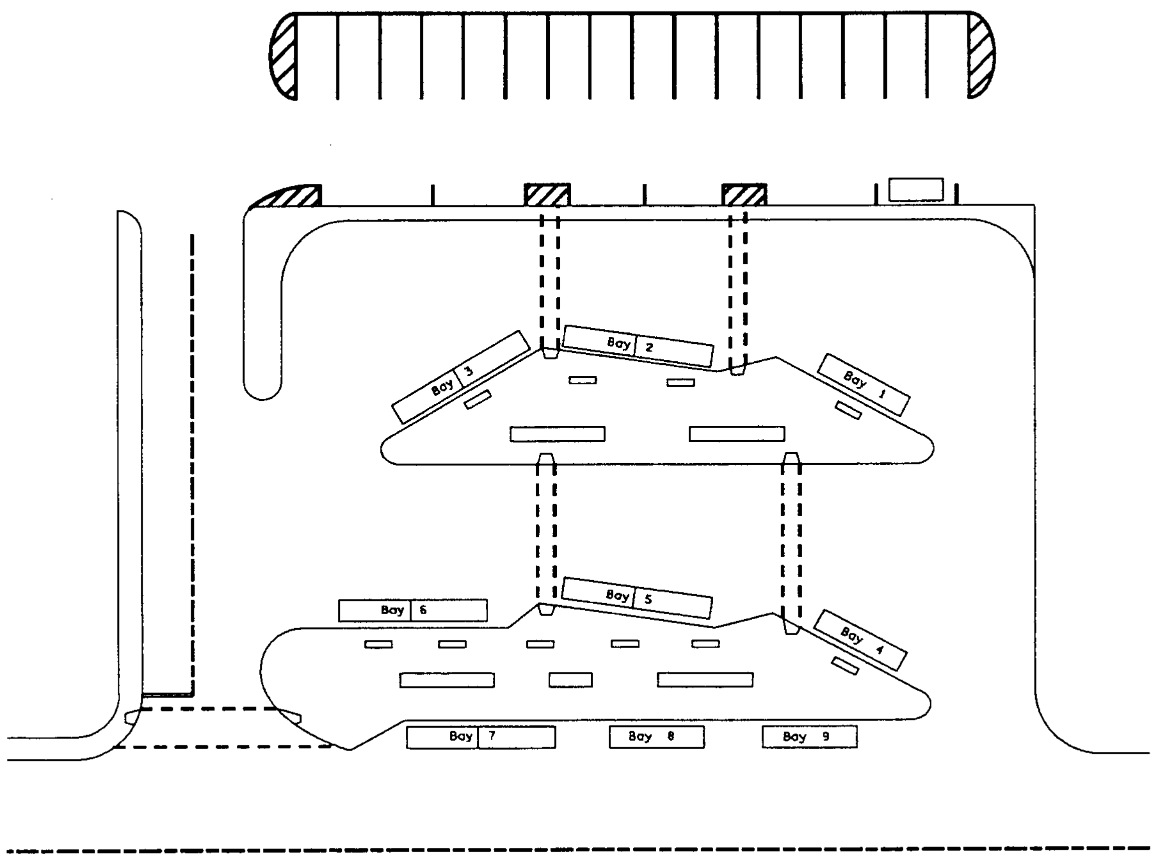
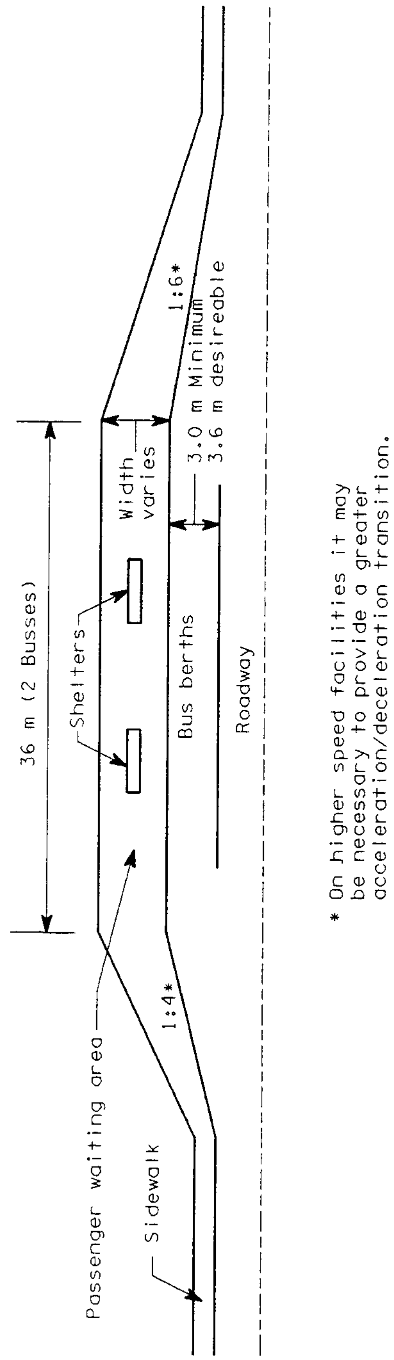


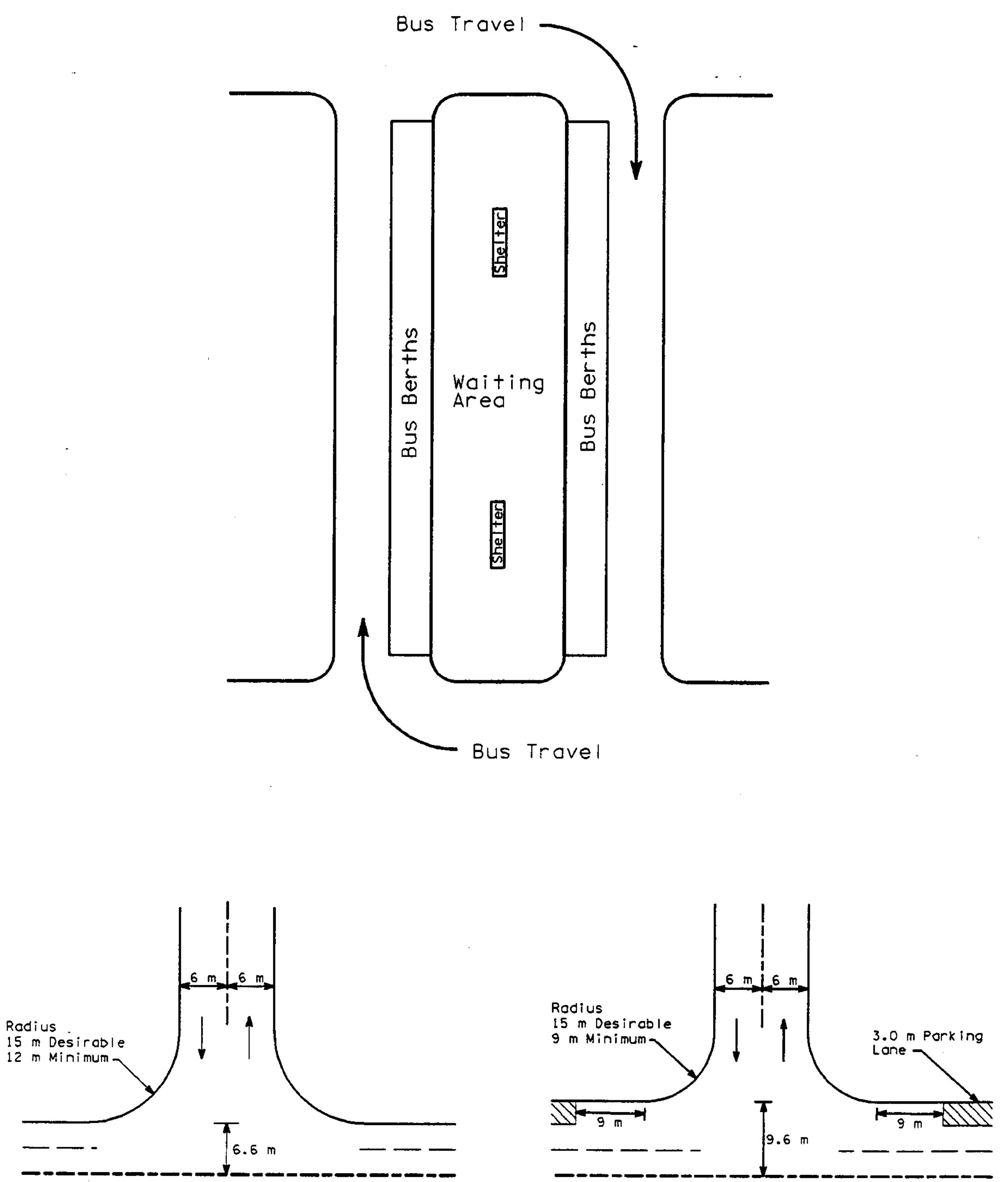
BUS BERTH DESIGNS
Figure 1060-1
(Metric)



TRANSIT CENTER
SAWTOOTH BUS BERTH
DESIGN EXAMPLE
Figure 1060-2

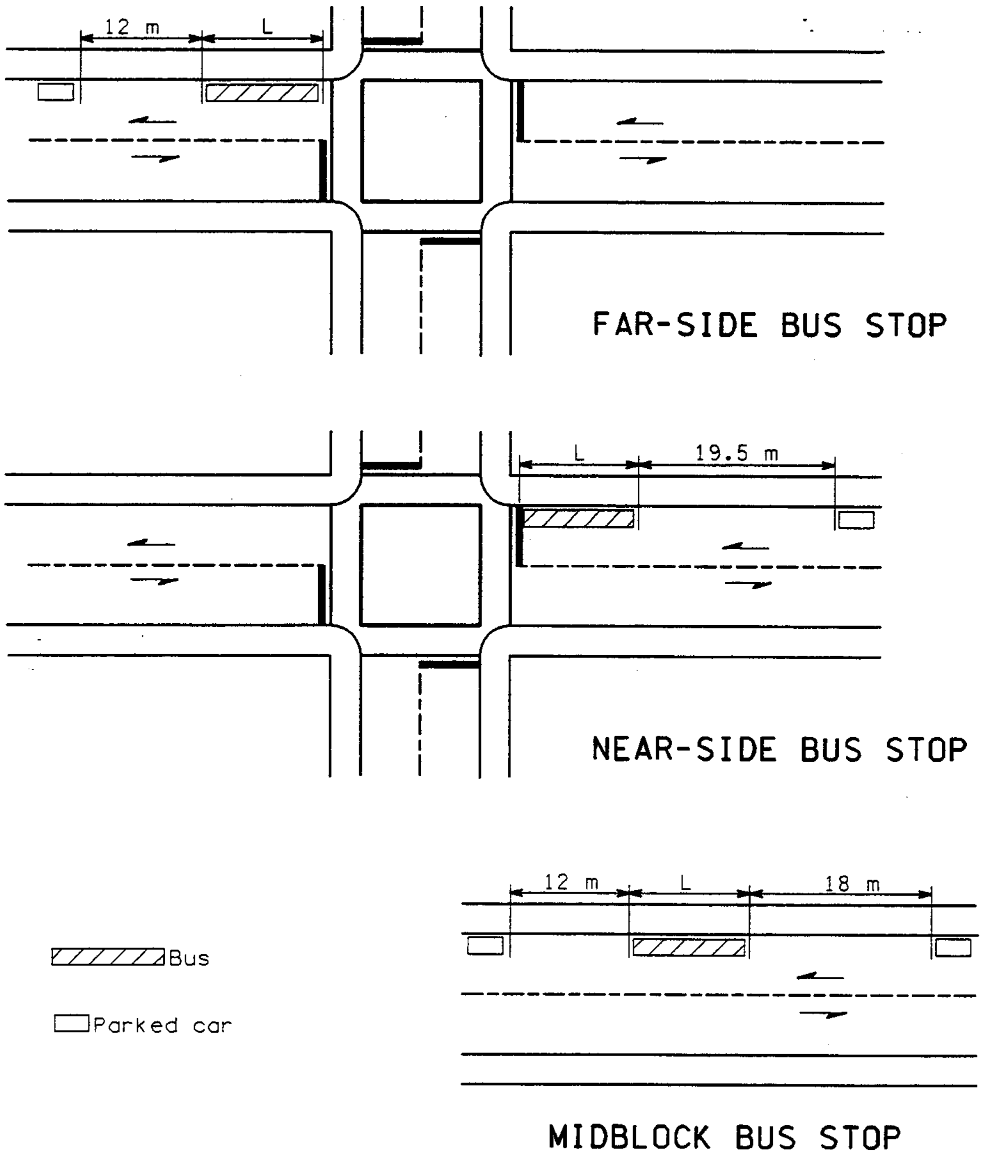


BUS TURNOUT TRANSFER CENTER
Figure 1060-3
(Metric)



OFF-STREET TRANSFER CENTER

Figure 1060-4
(Metric)



Minimum Lengths for Bus Curb Loading Zones (L)[1]

	Loading Zone Length (meters)					
	One Bus Stop			Two Bus Stops		
Approx. Bus Length(L)	Near Side[2,3]	Far Side[2]	Mid Block	Near Side[2,3]	Far Side[2]	Mid Block
7.5	27	19.5	37.5	36	27	45
9	28.5	21	39	39	30	48
10.5	30	22.5	40.5	42	33	51
12	31.5	24	42	45	36	54
18	37.5	30	48	57	48	66

[1]Based on bus 0.3 m from curb. When bus is 0.15 m from curb, add 6.0 m near side, 4.5 m far side, and 6.0 m midblock. Based on streets 12.0 m wide, add 4.5 m when 10.5 m wide and 9.0 m when 9.6 m wide.

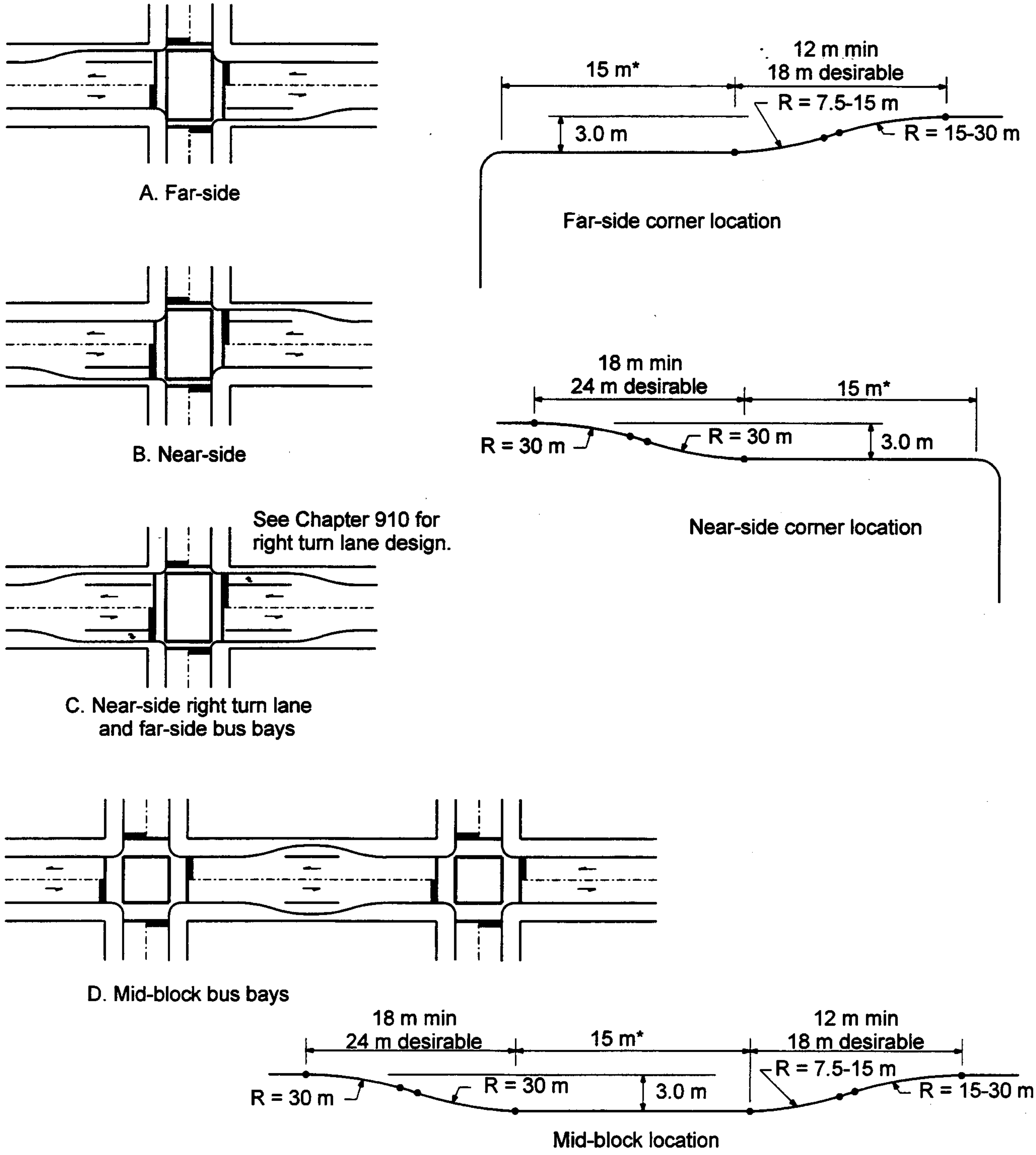
[2]Measured from extension of building line or established stop line. Add 4.5 m where buses make a right turn.

[3]Add 9.0 m where right turn volume is high for other vehicles.

MINIMUM BUS ZONE DIMENSIONS

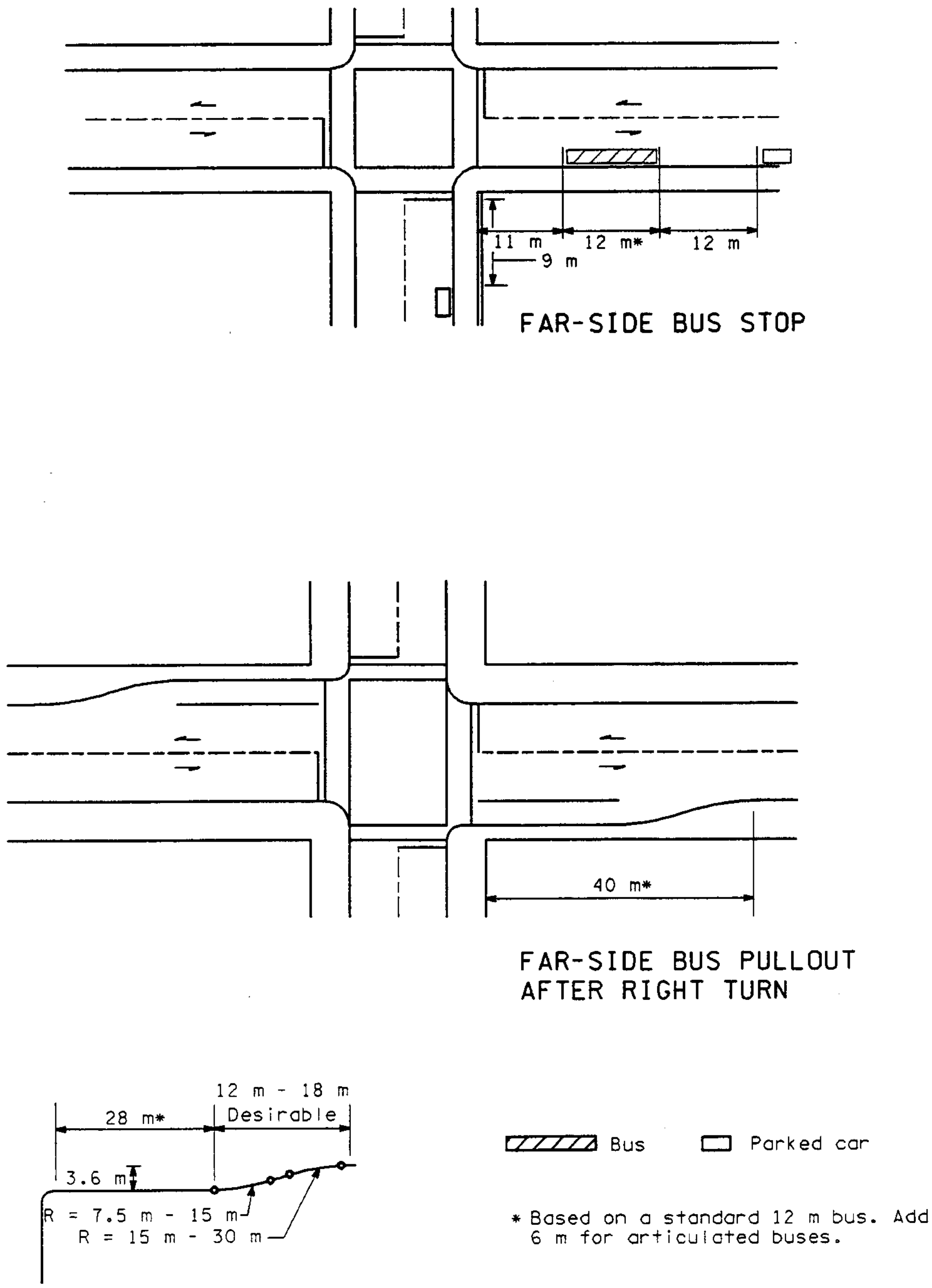
Figure 1060-5

(Metric)



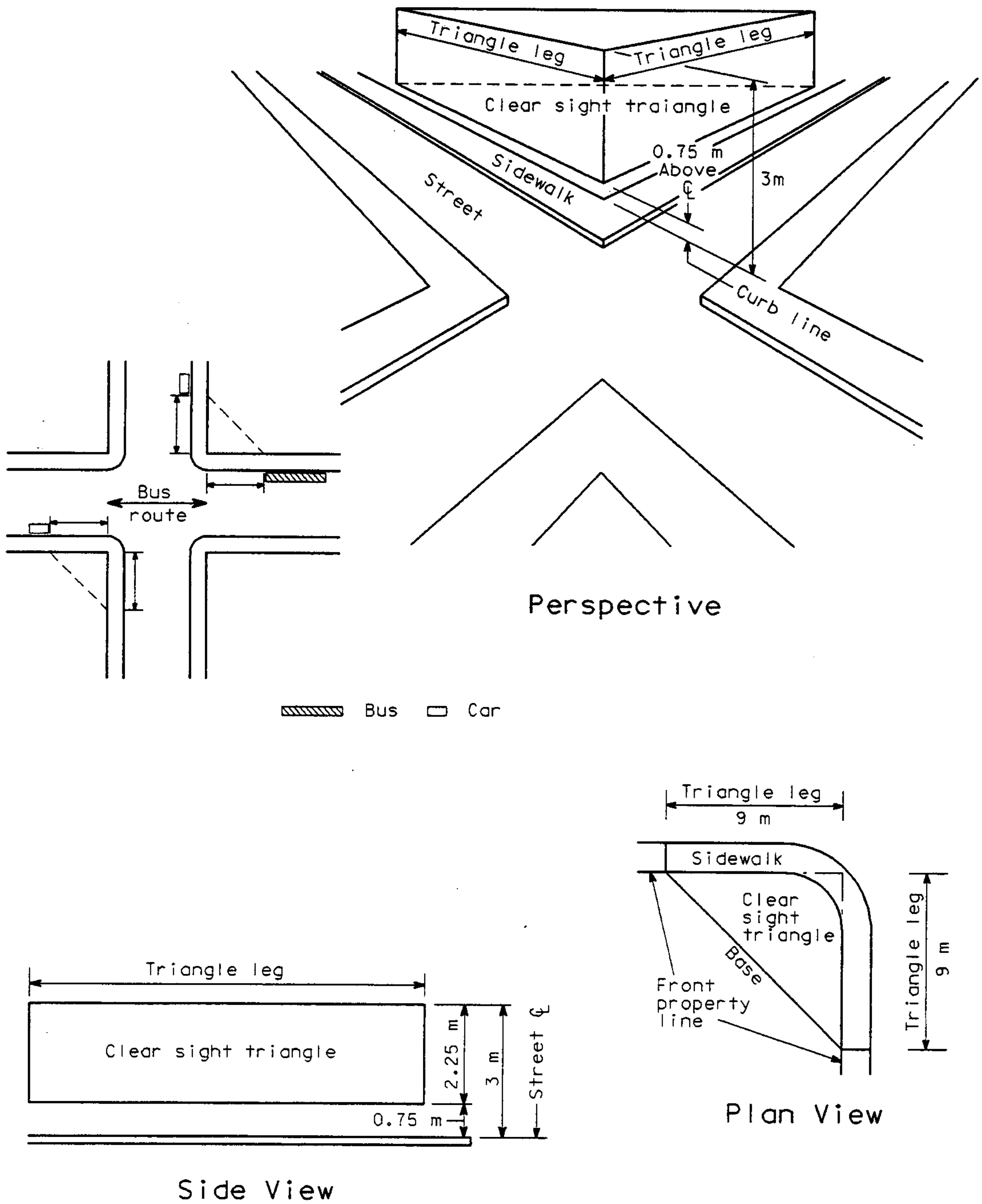
* 15 m Bay is for one standard 12 m bus.
Add 13.5 m for each additional standard bus.
Articulated buses require 21 m bays, with
19.5 m for each additional.

Bus Stop Pullouts, Arterial Streets
Figure 1060-6
(Metric)

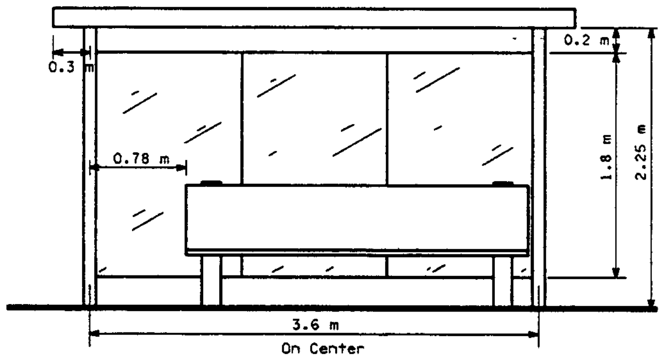


MINIMUM BUS ZONE AND PULLOUT AFTER RIGHT TURN DIMENSIONS

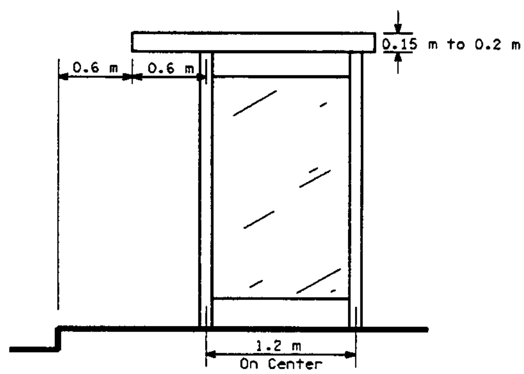
Figure 1060-7
(Metric)



SHELTER SITING
Figure 1060-8
(Metric)

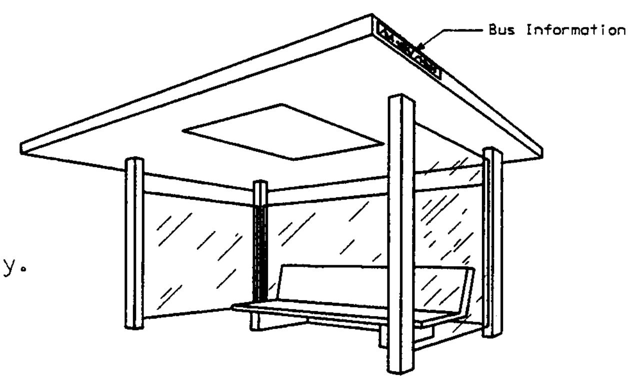


Front View

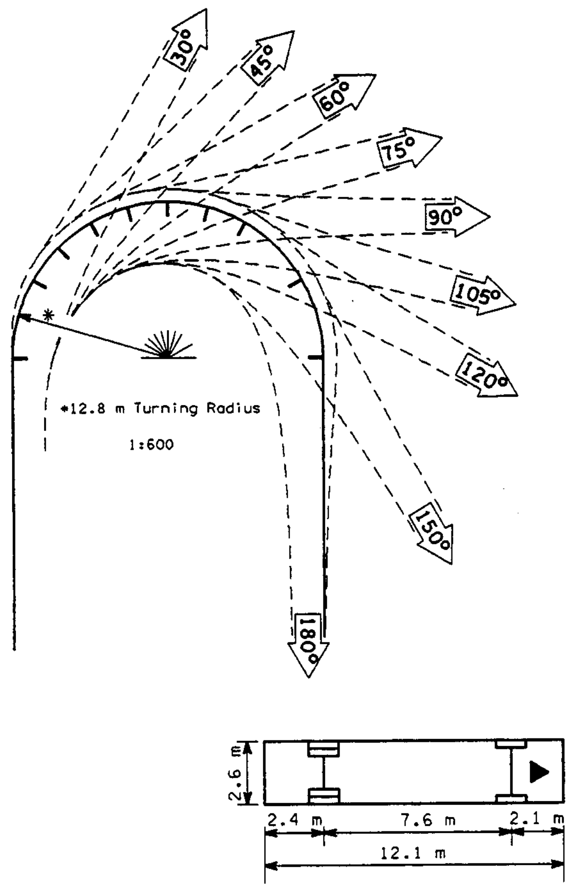


Side View

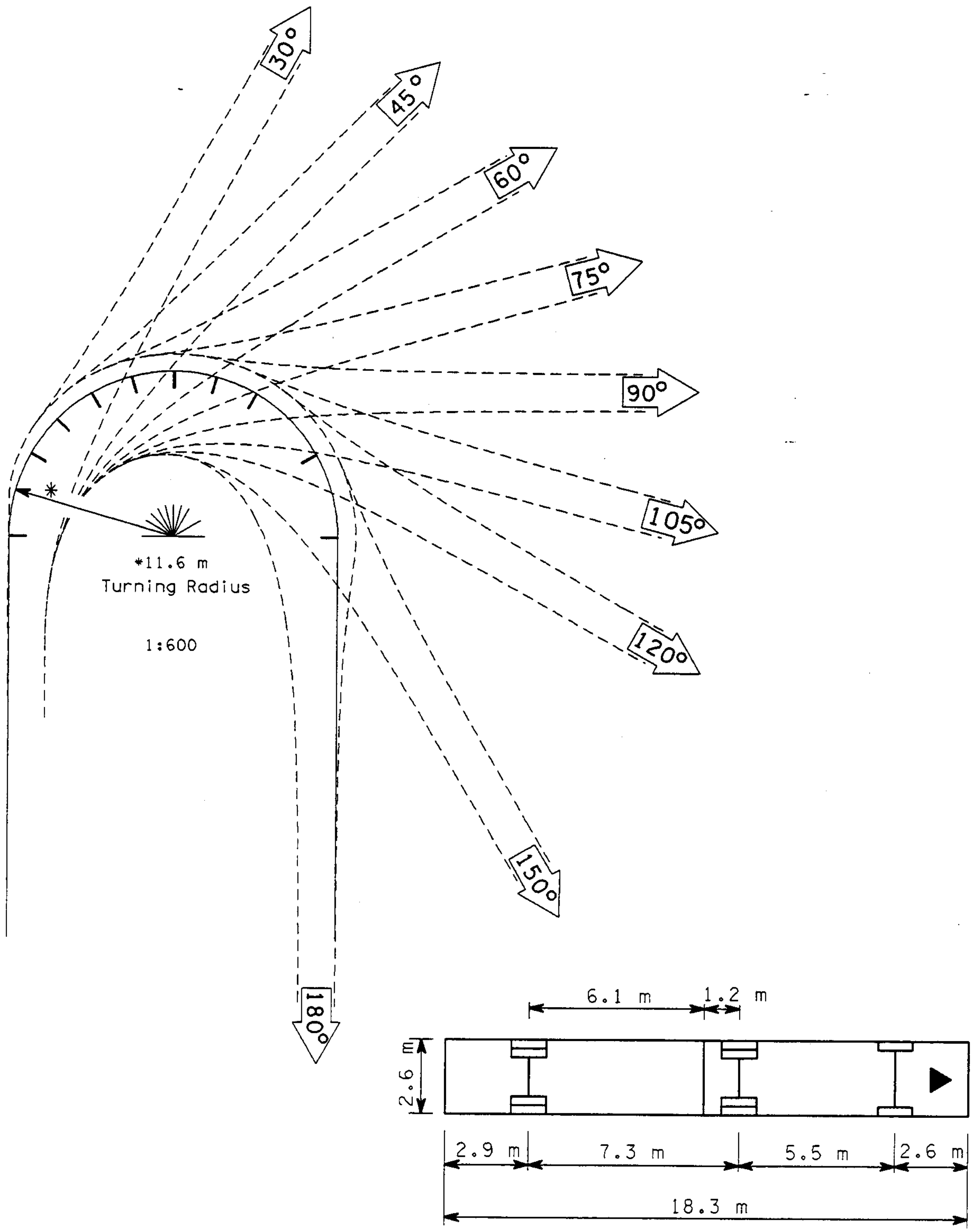
Note: Bench style can vary.



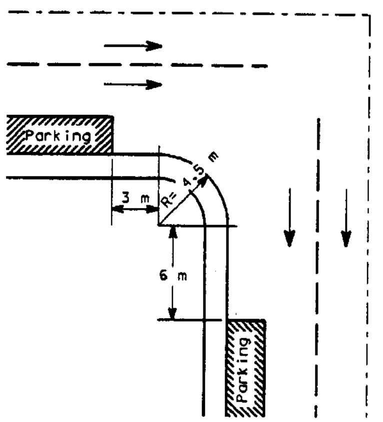
TYPICAL BUS SHELTER DESIGN
Figure 1060-9
(Metric)



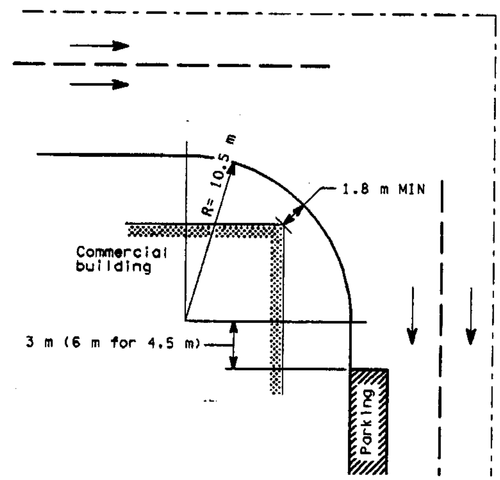
Design Vehicle Turning Movements
Figure 1060-10
(Metric)



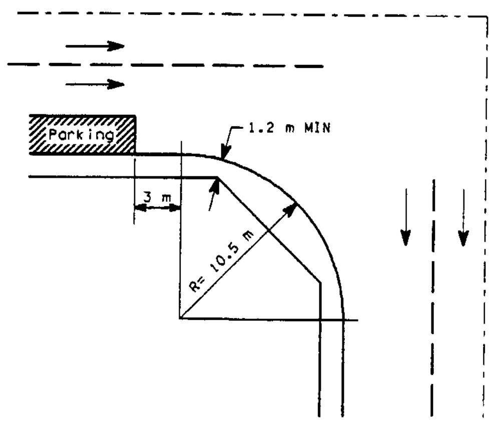
Turning Template for Articulated Bus
Figure 1060-11
(Metric)



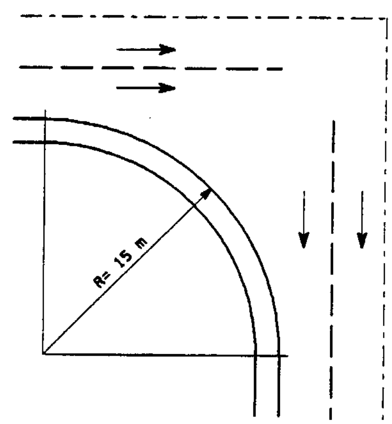
On Street Parking Before and After Turn



On Street Parking After Turn



On Street Parking Before Turn

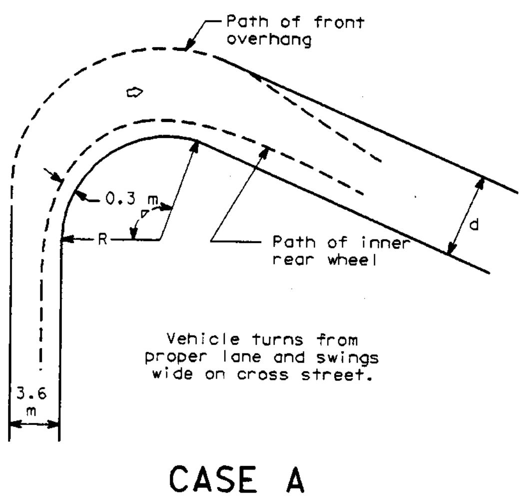


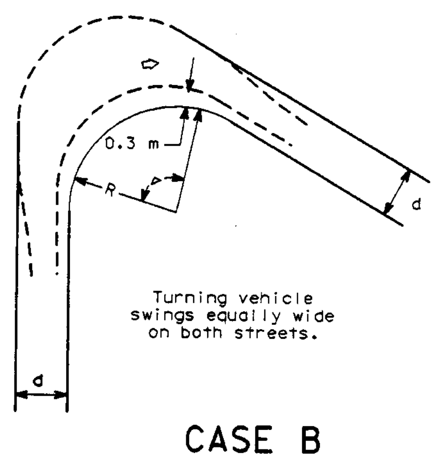
No On Street Parking

INTERSECTION DESIGN

Figure 1060-12
(Metric)

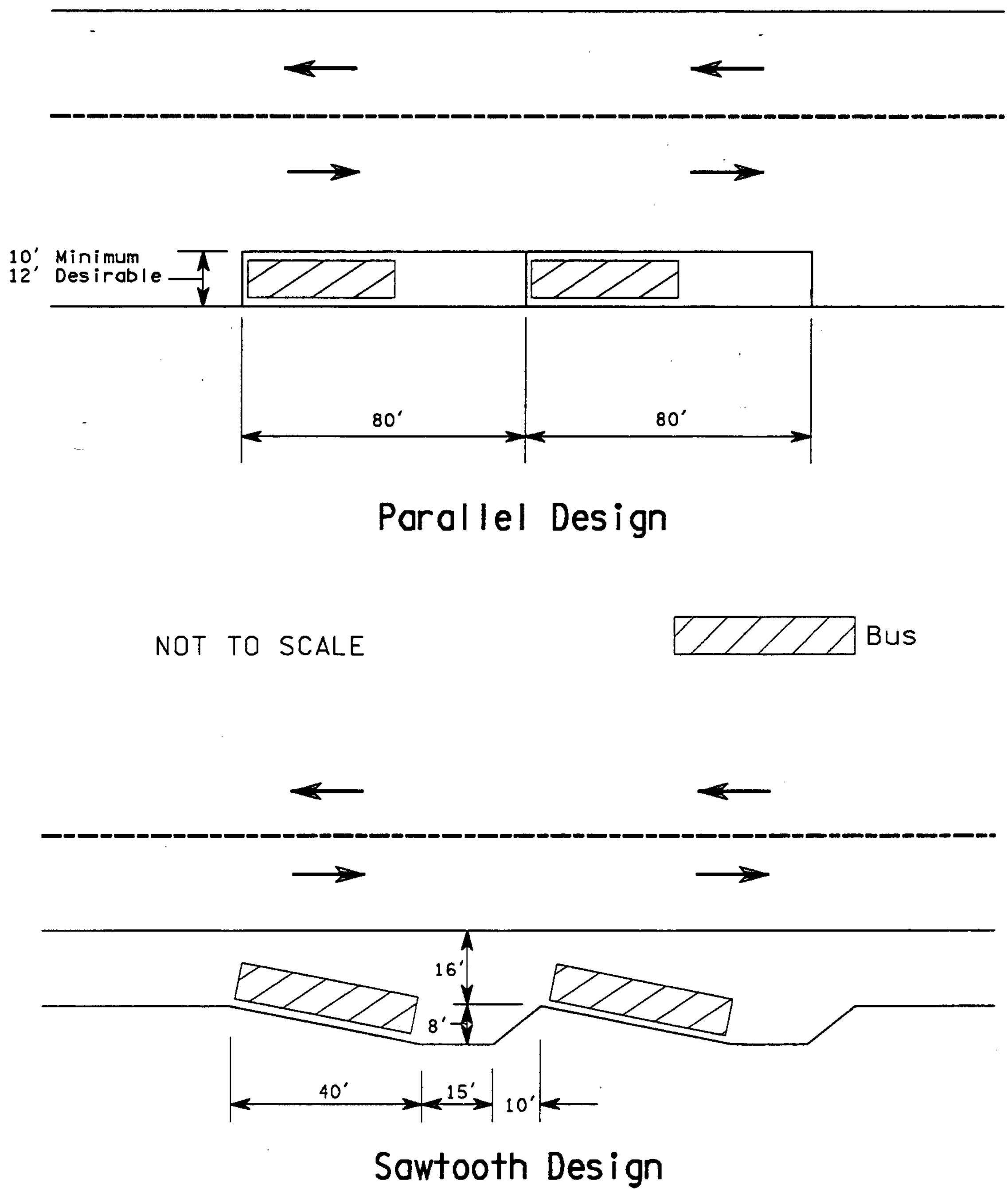
△ Design Vehicle	d (m) for Clases A and B Where:									
	R = 4.5 m		R = 6 m		R = 7.5 m		R = 9 m		R = 12 m	
	A	B	A	B	A	B	A	B	A	B
30°	6.6	5.1	5.7	5.1	5.7	5.1	5.7	5.1	5.4	5.1
60°	8.4	6.3	7.8	6.0	7.2	6.0	6.9	5.7	6.6	5.4
90°	11.4	6.9	9.9	6.6	9.0	6.6	7.5	6.3	6.3	5.4
120°	13.8	8.4	12.0	7.5	9.6	6.9	7.8	5.7	5.7	5.4
150°	14.4	8.4	12.0	7.5	9.6	6.9	6.6	5.4	5.1	4.8





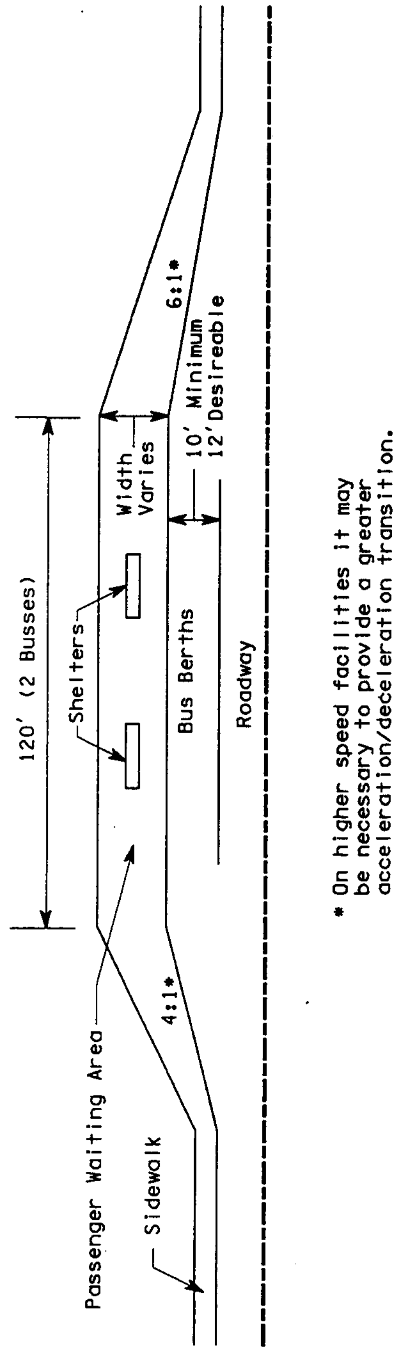
CROSS-STREET WIDTH OCCUPIED BY TURNING VEHICLE FOR VARIOUS ANGLES OF INTERSECTION AND CURB RADII

Figure 1060-13
(Metric)



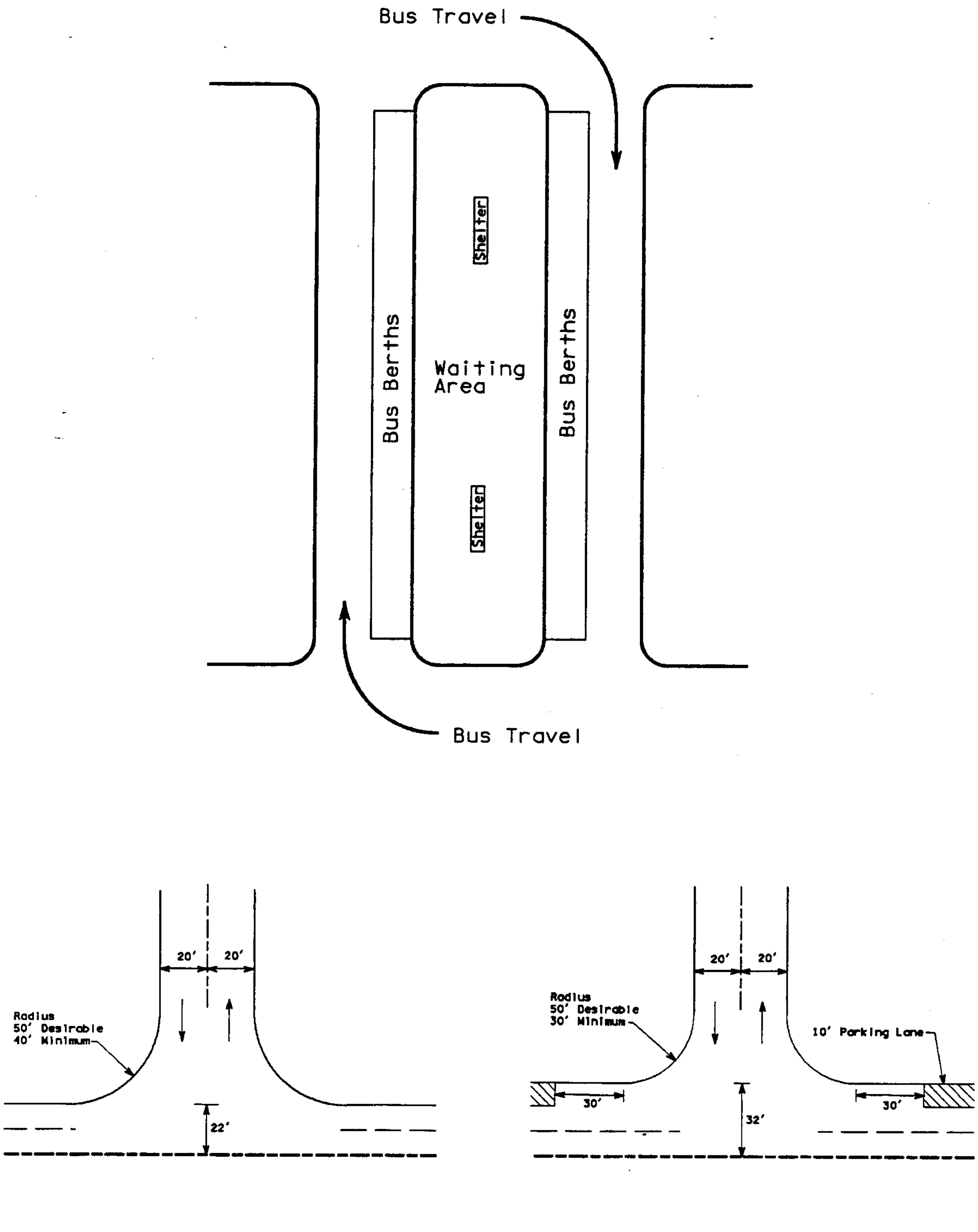
BUS BERTH DESIGNS

Figure 1060-1

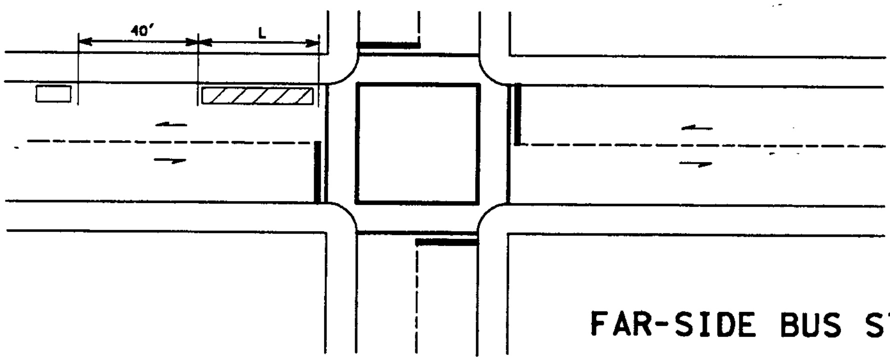


BUS TURNOUT TRANSFER CENTER

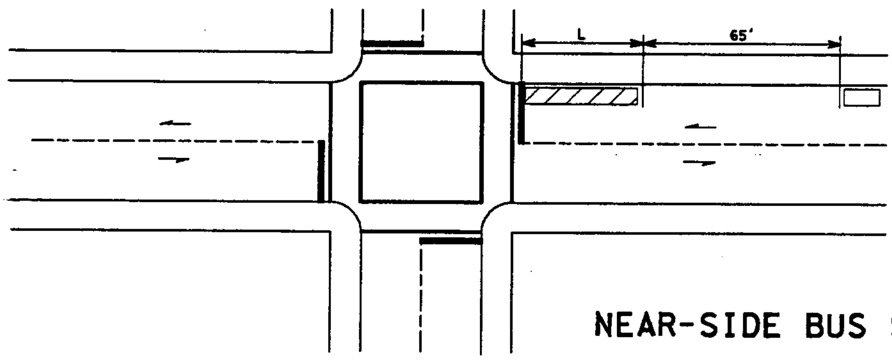
Figure 1060-3



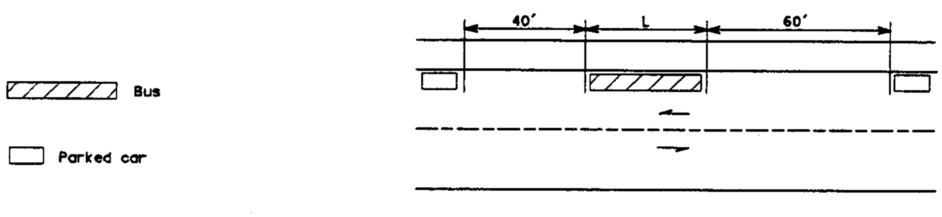
OFF-STREET TRANSFER CENTER
Figure 1060-4



FAR-SIDE BUS STOP



NEAR-SIDE BUS STOP



MIDBLOCK BUS STOP

Minimum Lengths for Bus Curb Loading Zones (L)[1]

Approx. Bus Length(L)	Loading Zone Length (feet): One Bus Stop, Near Side[2,3]	One Bus Stop, Far Side[2]	One Bus Stop, Mid Block	Two Bus Stops, Near Side[2,3]	Two Bus Stops, Far Side[2]	Two Bus Stops, Mid Block
25	90	65	125	120	90	150
30	95	70	130	130	100	160
35	100	75	135	140	110	170
40	105	80	140	150	120	180
60	125	100	160	190	160	220

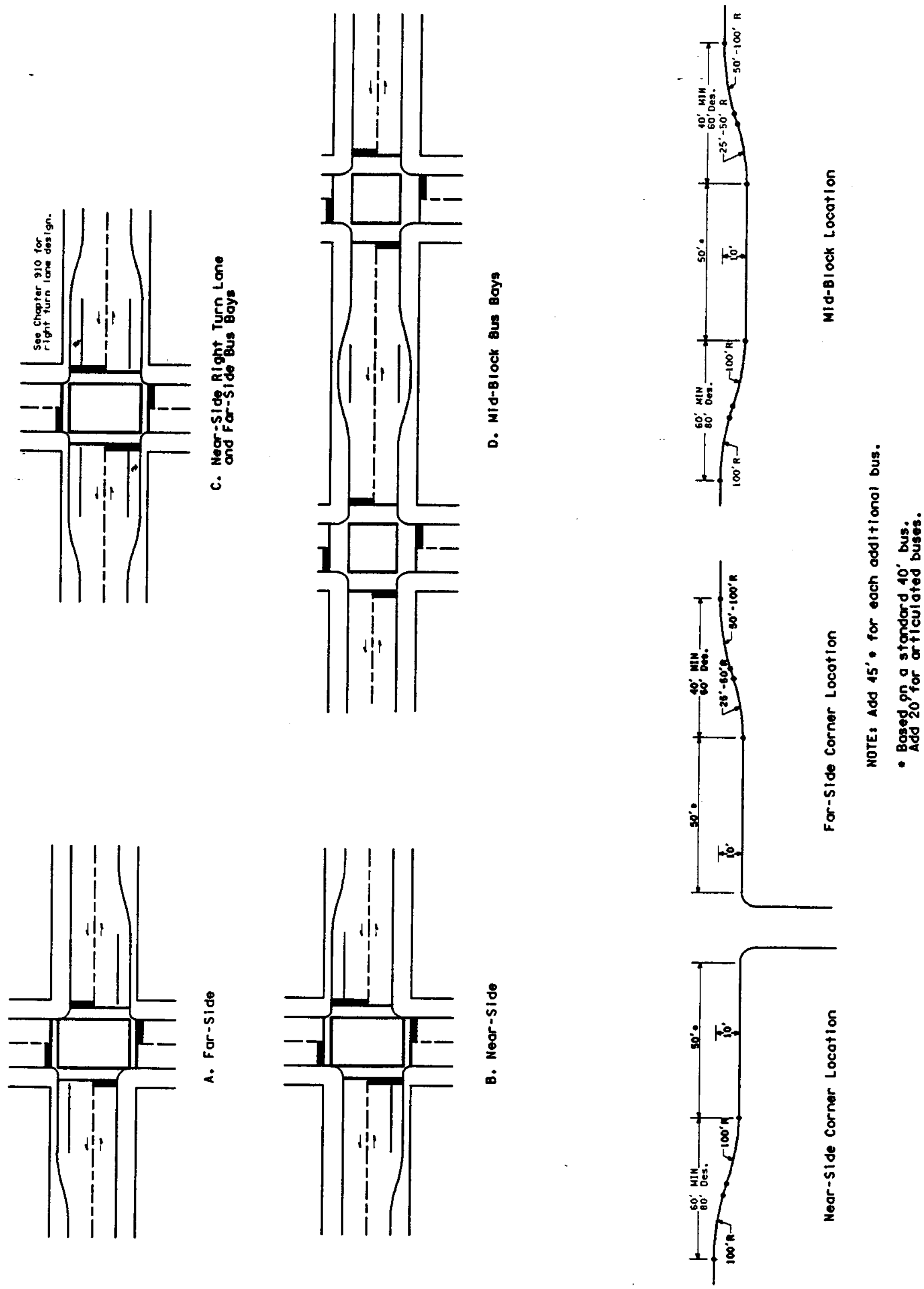
[1]Based on bus 1 foot from curb. When bus is 0.5 feet from curb, add 20 feet near side, 15 feet far side, and 20 feet midblock. Based on streets 40 feet wide, add 15 feet when 35 feet wide and 30 feet when 32 feet wide.

[2]Measured from extension of building line or established stop line. Add 15 feet where buses make a right turn.

[3]Add 30 feet where right turn volume is high for other vehicles.

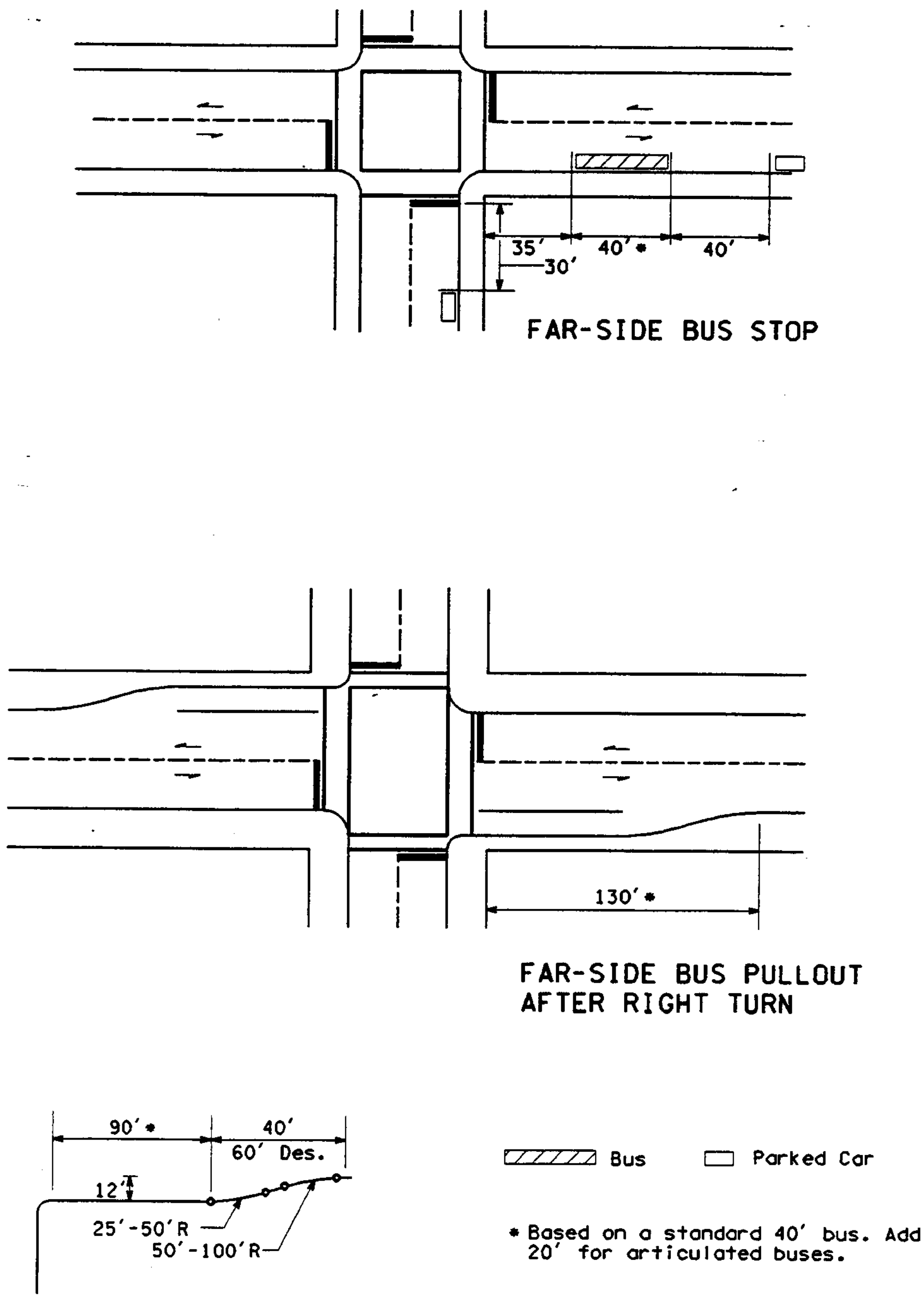
MINIMUM BUS ZONE DIMENSIONS

Figure 1060-5



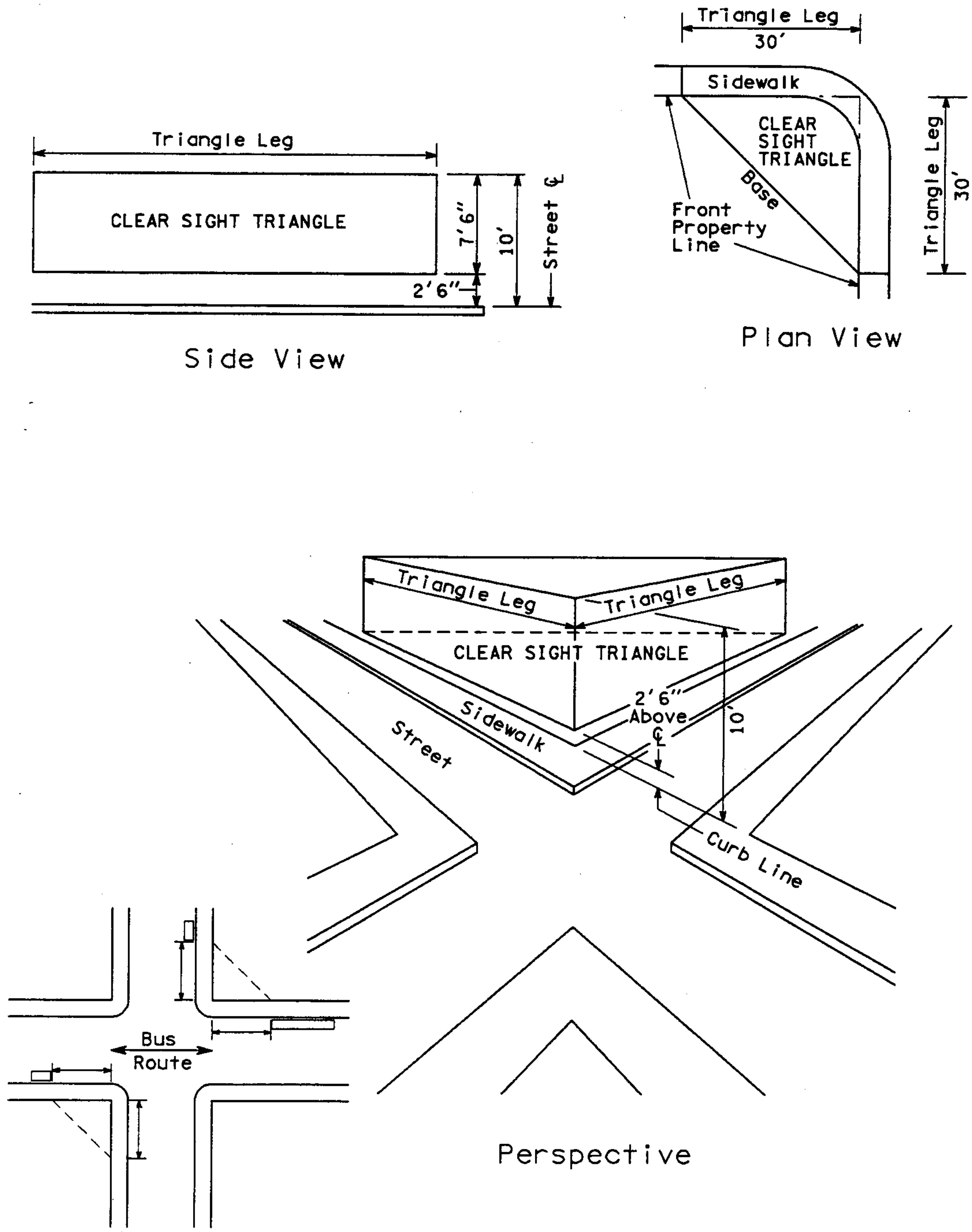
BUS STOP PULLOUTS, ARTERIAL STREETS

Figure 1060-6

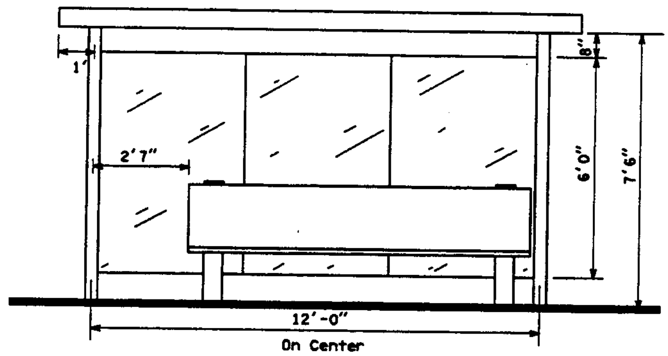


MINIMUM BUS ZONE AND PULLOUT AFTER RIGHT TURN DIMENSIONS

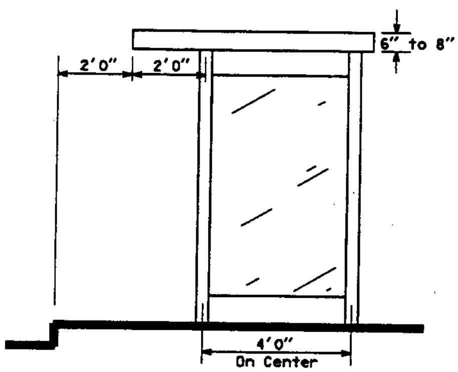
Figure 1060-7



SHELTER SITING
Figure 1060-8

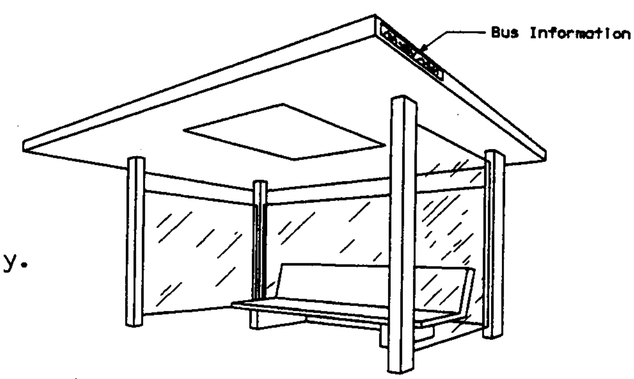


Front View



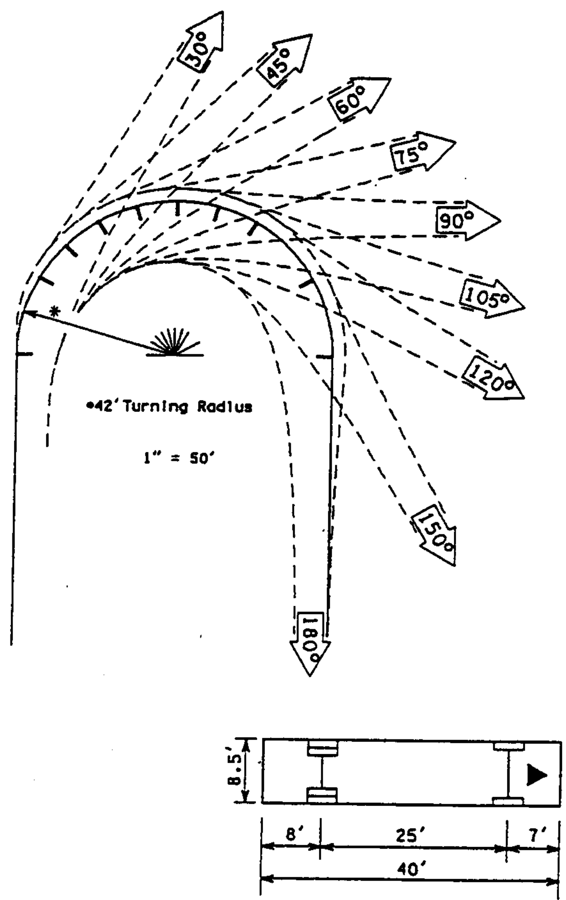
Side View

Note: Bench style can vary.

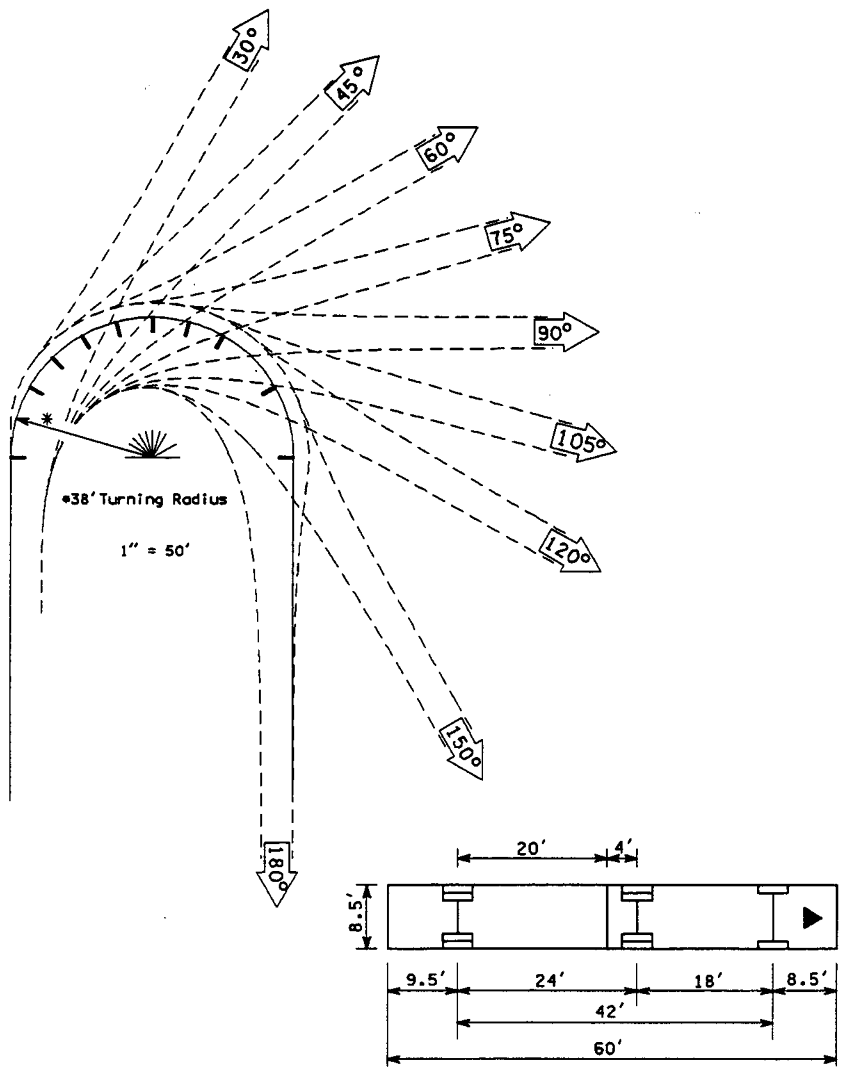


TYPICAL BUS SHELTER DESIGN

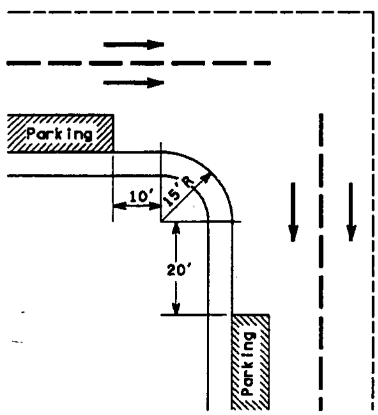
Figure 1060-9



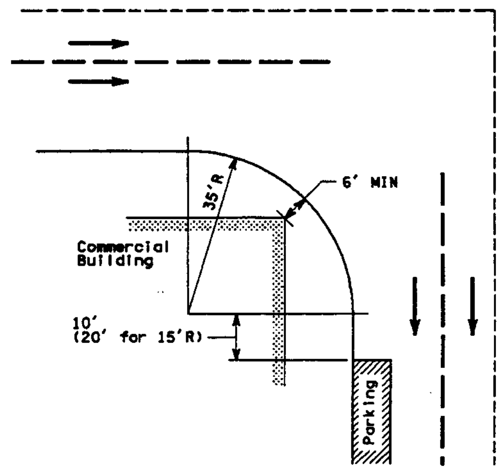
Design Vehicle Turning Movements
Figure 1060-10



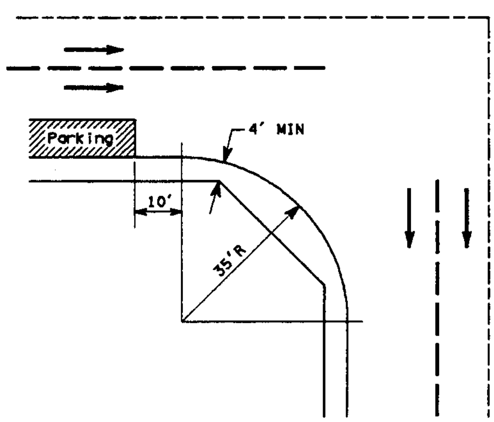
Turning Template for Articulated Bus
Figure 1060-11



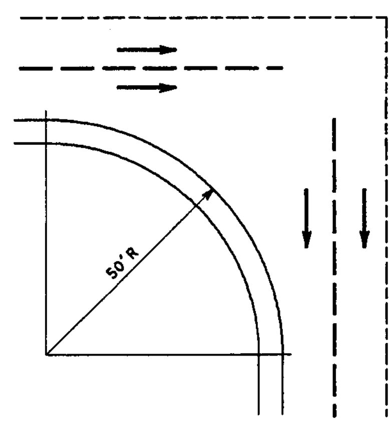
On Street Parking Before and After Turn



On Street Parking After Turn



On Street Parking Before Turn

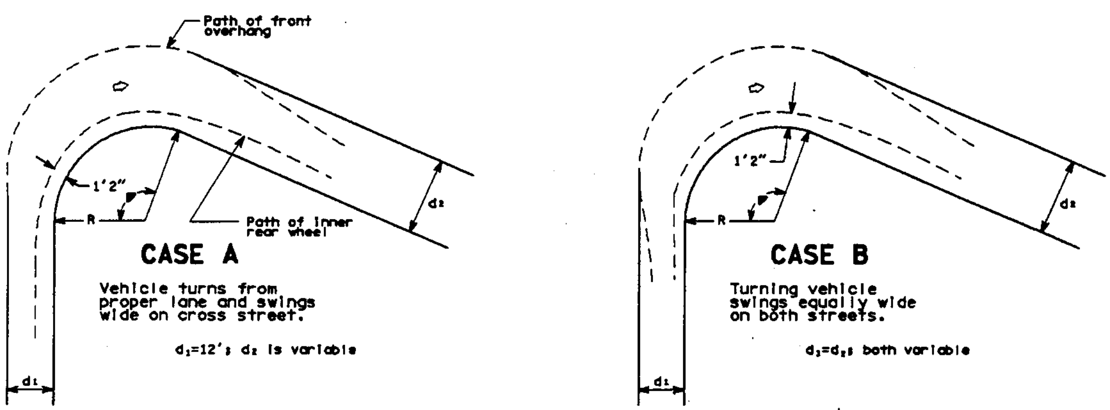


No On Street Parking

INTERSECTION DESIGN
Figure 1060-12

d_2 (ft) for Cases A and B Where:

Design Vehicle	R=15' A	R=15' B	R=20' A	R=20' B	R=25' A	R=25' B	R=30' A	R=30' B	R=40' A	R=40' B
30°	22	17	19	17	19	17	19	17	18	17
60°	28	21	26	20	24	20	23	19	22	18
90°	38	23	33	22	30	22	25	21	21	18
120°	46	28	40	25	32	23	26	19	19	18
150°	48	28	40	25	32	23	22	18	17	16



CROSS-STREET WIDTH OCCUPIED BY TURNING VEHICLE FOR VARIOUS ANGLES OF INTERSECTION AND CURB RADII

Figure 1060-13

1110.01 General

The Headquarters (HQ) Bridge and Structures Office provides structural design services to the regions. This chapter describes the information required by the HQ Bridge and Structures Office to perform this function.

1110.02 References

Bridge Design Manual, M 23-50, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

1110.03 Required Data for All Structures

Submit the bridge site data to the HQ Bridge and Structures Office. Provide a cover memo that gives general information on the project, describes the attachments, and transmits the forms and data included in the submittal. Submit site data as a CAD file, supplemental drawings, and a report. See Figure 1110-1 for items to include in a bridge site data submittal. Direct any questions relating to the preparation of bridge site data to the HQ Bridge and Structures Office. The *Bridge Design Manual* shows examples of required WSDOT forms.

(1) CAD Files and Supplemental Drawings

The HQ Bridge and Structures Office uses the microGDS Computer-Aided Drafting (CAD) system. CAD files prepared for use as bridge site data will be accepted in standard DGN, DXF, or DWG format.

Prepare plan, profile, and section drawings for all structures. Include copies of the CAD site data and supplemental drawings in the reduced plan sheet format with the submittal.

Use a complete and separate CAD file for each structure. See the *Plans Preparation Manual* for information regarding drawing levels and use the Bridge and Structures format. The *Bridge Design Manual* contains examples of completed Bridge Preliminary Plans. These plans show examples of the line styles and drawing format for site data in CAD.

Include the following information in the CAD files or in the supplemental drawings:

(a) **Plan**

- Drawing scales for the bridge site plan:

Length of Structure	**Scale**
20 ft to 100 ft	1″=10′
100 ft to 500 ft	1″=20′
500 ft to 800 ft	1″=30′
800 ft to 1,100 ft	1″=40′
more than 1,100 ft	1″=50′

  The bridge site data is used to prepare the bridge layout plan which is to be used in the contract plans. The drawing scales shown are for the full-sized contract plan format and are a guide only. Consider the width and general alignment of the structure when selecting the scale. For structures on curved alignments or where the bridge width is nearly equal to or greater than the bridge length, consult the HQ Bridge and Structures Office for an appropriate plan scale.

- Vertical and horizontal datum control. See Chapters 1440 and 1450.
- Contours of the existing ground surface. Use intervals of 1, 2, 5, or 10 ft depending on terrain and plan scale. The typical contour interval is 2 ft. Use 1 ft intervals for flat terrain. Use 5 ft or 10 ft intervals for steep terrain or small scales. Show contours beneath an existing or proposed structure and beneath the water surface of any waterway.
- Alignment of the proposed highway and traffic channelization in the vicinity.
- Location by section, township, and range.

- Type, size, and location of all existing or proposed sewers, telephone and power lines, water lines, gas lines, traffic barriers, culverts, bridges, buildings, and walls.
- Location of right of way lines and easement lines.
- Distance and direction to nearest towns or interchanges along the main alignment in each direction.
- Location of all roads, streets, and detours.
- Stage construction plan and alignment.
- Type, size, and location of all existing and proposed sign structures, light standards, and associated conduits and junction boxes. Provide proposed signing and lighting items when the information becomes available.
- Location of existing and proposed drainage.
- Horizontal curve data. Include coordinates for all control points.

(b) **Profile**

- Profile view showing the grade line of the proposed or existing alignment and the existing ground line along the alignment line.
- Vertical curve data.
- Superelevation transition diagram.

(c) **Section**

- Roadway sections on the bridge and at the bridge approaches. Indicate the lane and shoulder widths, cross slopes and side slopes, ditch dimensions, and traffic barrier requirements.
- Stage construction roadway geometrics with the minimum lane and roadway widths specified.

(2) Report

Submit DOT Form 235-002, "Bridge Site Data-General." Supplement the CAD drawings with the following items:

- Vicinity maps
- Class of highway
- Design speed
- Special requirements for replacing or relocating utility facilities
- ADT and DHV counts
- Truck traffic percentage
- Requirements for road or street maintenance during construction

(3) Video and Photographs

Submit a VHS video of the site. Show all the general features of the site and details of existing structures. Scan the area slowly, spending extra time showing existing bridge pier details and end slopes. A "voice over" narrative on the video is necessary for orientation.

Color photographs of the structure site are desirable. Include detailed photographs of existing abutments, piers, end slopes, and other pertinent details for widenings, bridge replacements, or sites with existing structures.

1110.04 Additional Data for Waterway Crossings

Coordinate with the Headquarters (HQ) Hydraulics Branch and supplement the bridge site data for all waterway crossings with the DOT Form 235-001, "Bridge Site Data for Stream Crossings" and the following:

- Show riprap or other slope protection requirements at the bridge site (type, plan limits, and cross section) as determined by the HQ Hydraulics Branch.
- Show a profile of the waterway. The extent will be determined by the HQ Hydraulics Branch.
- Show cross sections of the waterway. The extent will be determined by the HQ Hydraulics Branch.

The requirements for waterway profile and cross sections may be less stringent if the HQ Hydraulics Branch has sufficient documentation (FEMA reports, for example) to make a determination. Contact the HQ Hydraulics Branch to verify the extent of the information needed. Coordinate any rechannelization of the waterway with the HQ Hydraulics Branch.

Many waterway crossings require a permit from the U.S. Coast Guard. (See Chapter 240.) Generally, ocean tide influenced waterways and waterways used for commercial navigation require a Coast Guard permit. These structures require the following additional information:

- Names and addresses of the landowners adjacent to the bridge site.
- Quantity of new embankment material within the floodway. This quantity denotes, in cubic yards, the material below normal high water and the material above normal high water.

Some waterways may qualify for an exemption from Coast Guard permit requirements if certain conditions are met. See the *Bridge Design Manual*. If the waterway crossing appears to satisfy these conditions, then submit a statement explaining why this project is exempt from a Coast Guard permit. Attach this exemption statement to the Environmental Classification Summary prepared for the project and submit it to the HQ Design Office for processing to FHWA.

The region is responsible for coordination with the HQ Bridge and Structures Office, U. S. Army Corps of Engineers, and U. S. Coast Guard for waterways that may qualify for a permit exemption. The HQ Bridge and Structures Office is responsible for coordination with the U.S. Coast Guard for waterways that require a permit.

1110.05 Additional Data for Grade Separations

(1) Highway-Railroad Separation

Supplement bridge site data for structures involving railroads with the following:

(a) **Plan**

- Alignment of all existing and proposed railroad tracks.
- Center-to-center spacing of all tracks.
- Angle, station, and coordinates of all intersections between the highway alignment and each track.
- Location of railroad right of way lines.
- Horizontal curve data. Include coordinates for all circular and spiral curve control points.

(b) **Profile**

- For proposed railroad tracks; profile, vertical curve, and superelevation data for each track.
- For existing railroad tracks, elevations accurate to 0.1 ft taken at 10-ft intervals along the top of the highest rail of each track. Provide elevations to 50 ft beyond the extreme outside limits of the existing or proposed structure. Tabulate elevations in a format acceptable to the HQ Bridge and Structures Office.

(2) Highway-Highway Separation

Supplement bridge site data for structures involving other highways by the following:

(a) **Plan**

- Alignment of all existing and proposed highways, streets, and roads.
- Angle, station, and coordinates of all intersections between all crossing alignments.
- Horizontal curve data. Include coordinates for all curve control points.

(b) **Profile**

- For proposed highways; profile, vertical curve, and superelevation data for each.
- For existing highways; elevations accurate to 0.1 ft taken at intervals of 10 ft along the center line or crown line and each edge of shoulder, for each alignment, to define the existing roadway cross slopes. Provide elevations to 50 ft beyond the extreme outside limits of the existing or proposed structure. Tabulate elevations in a format acceptable to the HQ Bridge and Structures Office format.

(c) **Section**

- Roadway sections of each undercrossing roadway indicating the lane and shoulder widths, cross slopes and side slopes, ditch dimensions, and traffic barrier requirements.
- Falsework or construction opening requirements. Specify minimum vertical clearances, lane widths, and shy distances.

1110.06 Additional Data for Widenings

Bridge rehabilitations and modifications that require new substructure are defined as bridge widenings.

Supplement bridge site data for structures involving bridge widenings by the following:

- Submit DOT Form 235-002A, "Supplemental Bridge Site Data-Rehabilitation/Modification."

(a) **Plan**

- Stations for existing back of pavement seats, expansion joints, and pier center lines based on field measurement along the survey line and each curb line.
- Locations of existing bridge drains. Indicate whether these drains are to remain in use or be plugged.

(b) **Profile**

- Elevations accurate to 0.1 ft taken at intervals of 10 ft along the curb line of the side of the structure being widened. Pair these elevations with corresponding elevations (same station) taken along the crown line or an offset distance (minimum of 10 ft from the curb line). This information will be used to establish the cross slope of the existing bridge. Tabulate elevations in a format acceptable to the HQ Bridge and Structures Office.

  Take these elevations at the level of the concrete roadway deck. For bridges with latex modified or microsilica modified concrete overlay, elevations at the top of the overlay will be sufficient. For bridges with a nonstructural overlay, such as an asphalt concrete overlay, take elevations at the level of the concrete roadway deck. For skewed bridges, take elevations along the crown line or at an offset distance (10 ft minimum from the curb line) on the approach roadway for a sufficient distance to enable a cross slope to be established for the skewed corners of the bridge.

1110.07 Documentation

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

Review Chapter 1110 of the *Design Manual* for further information and description of the items listed below.

PLAN (In CAD file.)

- ______ Survey Lines and Station Ticks
- ______ Survey Line Intersection Angles
- ______ Survey Line Intersection Stations
- ______ Survey Line Bearings
- ______ Roadway and Median Widths
- ______ Lane and Shoulder Widths
- ______ Sidewalk Width
- ______ Connection/Widening for Traffic Barrier
- ______ Profile Grade and Pivot Point
- ______ Roadway Superelevation Rate (if constant)
- ______ Lane Taper and Channelization Data
- ______ Traffic Arrows
- ______ Mileage to Towns Along Main Line
- ______ Existing Drainage Structures
- ______ Existing Utilities — Type/Size/Location
- ______ New Utilities — Type/Size/Location
- ______ Light standards, Junction boxes, Conduits
- ______ Bridge Mounted Signs and Supports
- ______ Contours
- ______ Bottom of Ditches
- ______ Test Holes (if available)
- ______ Riprap Limits
- ______ Stream Flow Arrow
- ______ R/W Lines and/or Easement Lines
- ______ Exist. Bridge No. (to be removed, widened)
- ______ Section, Township, Range
- ______ City or Town
- ______ North Arrow
- ______ SR Number
- ______ Scale

TABLES (In tabular format in CAD file.)

- ______ Curb Line Elevations at Top of Existing Bridge Deck
- ______ Undercrossing Roadway Existing Elevations
- ______ Undercrossing Railroad Existing Elevations
- ______ Curve Data

OTHER SITE DATA (May be in CAD or may be on supplemental sheets or drawings.)

- ______ Superelevation Diagrams
- ______ End Slope Rate
- ______ Profile Grade Vertical Curves
- ______ Coast Guard Permit Status
- ______ Railroad Agreement Status
- ______ Highway Classification
- ______ Design Speed
- ______ ADT, DHV, and % Trucks

FORMS (Information noted on the form or attached on supplemental sheets or drawings.)

Bridge Site Data General

- ______ Slope Protection
- ______ Pedestrian Barrier/Pedestrian Rail Height Requirements
- ______ Construction/Falsework Openings
- ______ Stage Construction Channelization Plans
- ______ Bridge (before/with/after) Approach Fills
- ______ Datum
- ______ Video of Site
- ______ Photographs of Site
- ______ Control Section
- ______ Project Number
- ______ Region Number
- ______ Highway Section

Bridge Site Data for Stream Crossings

- ______ Water Surface Elevations and Flow Data
- ______ Riprap Cross Section Detail

Supplemental Bridge Site Data-Rehabilitation/Modification

BRIDGE, CROSSROAD, AND APPROACH ROADWAY CROSS SECTIONS
(May be in CAD or separate drawings.)

- ______ Bridge Roadway Width
- ______ Lane and Shoulder Widths
- ______ Profile Grade and Pivot Point
- ______ Superelevation Rate
- ______ Survey Line
- ______ PB/Pedestrian Rail Dimensions
- ______ Stage Construction Lane Orientations
- ______ Locations of Temporary Barrier
- ______ Conduits/Utilities in Bridge
- ______ Location and Depth of Ditches
- ______ Shoulder Widening for Barrier
- ______ Side Slope Rate

Bridge Site Data Check List
Figure 1110-1

Chapter 1120 Bridges

1120.01 General

A bridge is a structure having a clear span of 20 ft or more. Bridge design is the responsibility of the Bridge and Structures Office in Olympia. A project file is required for all bridge construction projects. The Bridge Office develops a preliminary bridge plan for a new or modified structure in collaboration with the region. This chapter provides basic design considerations for the development of this plan. Unique staging requirements, constructibility issues, and other considerations are addressed during the development of this plan. Contact the Bridge Office early in the planning stage on issues that might affect the planned project. See Chapter 141, Roles and Responsibilities for Projects with Structures, and Figures 141-1a and 1b, Determination of the Roles and Responsibilities for Projects with Structures (Project Development Phase).

1120.02 References

Bridge Design Manual, M 23-50, WSDOT

Local Agency Guidelines, M 36-63, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways USDOT, Washington DC, including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

LRFD Bridge Design Specifications, third edition, Washington D.C.: AASHTO 2004

A Policy on Geometric Design of Highways and Streets (Green Book), 2001, AASHTO

Traffic Manual, M 51-02, WSDOT

1120.03 Bridge Location

Bridges are located to conform to the alignment of the highway. Providing the following conditions can simplify design efforts, minimize construction activities, and reduce structure costs:

- A perpendicular crossing.
- The minimum required horizontal and vertical clearances.
- A constant bridge width (without tapered sections).
- A tangential approach alignment of sufficient length to not require superelevation on the bridge.
- A crest vertical curve profile that will facilitate drainage.
- An adequate construction staging area.

1120.04 Bridge Site Design Elements

(1) Structural Capacity

The structural capacity of a bridge is a measure of the structure's ability to carry vehicle loads. For new bridges, the bridge designer chooses the design load that determines the structural capacity. For existing bridges, the structural capacity is calculated to determine the "load rating" of the bridge. The load rating is used to determine whether or not a bridge is "posted" for legal weight vehicles or if the bridge is "restricted" for overweight permit vehicles.

(a) **New Structures.** All new structures that carry vehicular loads are designed to HL-93 notional live load in accordance with AASHTO LRFD Bridge Design Specifications or HS-25 live loading in accordance with the AASHTO Standard Specifications for Highway Bridges.

(b) **Existing Structures.** When the Structural Capacity column of a design matrix applies to the project, request a Structural Capacity Report from the Risk Reduction Engineer in the HQ Bridge and Structures Office. The report will state:

- The structural capacity status of the structures within the project limits.
- What action, if any, is appropriate.
- Whether a deficient bridge is included in the six-year or 20 year plans for replacement or rehabilitation under the P2 program and, if so, in which biennium the P2 project is likely to be funded.

Include the Structural Capacity Report in the design documentation file.

The considerations used to evaluate the structural capacity of a bridge are as follows:

1. On National Highway System (NHS) routes (including Interstate routes):

- Operating load rating is at least 36 tons (which is equal to HS-20).
- The bridge is not permanently posted for legal weight vehicles.
- The bridge is not permanently restricted for vehicles requiring overweight permits.

2. On non-NHS routes:

- The bridge is not permanently posted for legal weight vehicles.
- The bridge is not permanently restricted for vehicles requiring overweight permits.

(2) Bridge Widths for Structures

(a) **New Structures.** Full design level widths are provided on all new structures. See Chapter 440. All structures on city or county routes crossing over a state highway must conform to the *Local Agency Guidelines*. Use local city or county adopted and applied criteria when their minimums exceed state criteria.

(b) **Existing Structures.** See the design matrices in Chapter 325 for guidance.

(3) Horizontal Clearance

Horizontal clearance for structures is the distance from the edge of the traveled way to bridge piers and abutments, bridge rail ends, or bridge end embankment slopes. Minimum distances for this clearance vary depending on the type of structure. The *Bridge Design Manual* provides guidance on horizontal clearance.

(4) Medians

For multilane highways, the minimum median widths for new bridges are as shown in Chapters 430 and 440. An open area between two bridges is undesirable when the two roadways are separated by a median width of 26 ft or less. The preferred treatment is to provide a new, single structure that spans the area between the roadways. When this is impractical, consider widening the two bridges on the median sides to reduce the open area to 6 in. When neither option is practical, consider installing netting or other elements to enclose the area between the bridges. Consideration and analysis of all site factors are necessary if installation of netting or other elements is proposed. Document this evaluation in the design documentation file and obtain the approval of the State Design Engineer.

(5) Vertical Clearance

Vertical clearance is the critical height under a structure that will safely accommodate vehicular and rail traffic based on its design characteristics. This height is the least height available from the lower roadway surface (including usable shoulders), or the plane of the top of the rails, to the bottom of the bridge. Usable shoulders are the design shoulders for the roadway and do not include paved widened areas that may exist under the structure.

(a) **Minimum Clearance for New Structures.** For new structures, the minimum vertical clearances are as follows:

1. A bridge over a roadway. The minimum vertical clearance is 16.5 ft.

2. A bridge over a railroad track. The minimum vertical clearance is 23.5 ft. A lesser clearance may be considered for closed or dedicated rail corridors that do not intermix with general freight rail traffic. Any such reduced clearance established for a corridor requires an agreement between the department and the railroad company and approval of the Washington State Utilities and Transportation Commission (WUTC). Vertical clearance is provided for the width of the railroad freight car. (See Figure 1120-2a.) Coordinate railroad clearance issues with the WSDOT Railroad Liaison Engineer.

3. A pedestrian bridge over a roadway. The minimum vertical clearance is 17.5 ft.

(b) **Minimum Clearance for Existing Structures.** The criteria used to evaluate the vertical clearance of existing structures depends on the work that is being done on or under that structure. When evaluating an existing structure on the Interstate system, see 1120.04(5)(d) "Coordination." This guidance applies to bridge clearances over state highways and under state highways at interchanges. For state highways over local roads and streets, city or county vertical clearance requirements may be used as minimum design criteria. See Figure 1120-1 for a table of bridge vertical clearances.

1. For a project that will widen an existing structure over a highway or where the highway will be widened under an existing structure, the vertical clearance can be as little as 16.0 ft on the Interstate System or other freeways, or 15.5 ft on nonfreeway routes. An approved deviation is required for clearance less than 16.0 ft on Interstate routes or other freeways, and 15.5 ft on nonfreeway routes.

2. For a planned resurfacing of the highway under an existing bridge, if the clearance will be less than 16.0 ft on the Interstate System or other freeways and 15.5 ft on nonfreeway routes, evaluate the following options and include in a deviation request:

- Pavement removal and replacement.
- Roadway excavation and reconstruction to lower the profile of the roadway.
- Providing a new bridge with the required vertical clearance.

Reducing roadway paving and surfacing thickness under the bridge to achieve the minimum vertical clearance can cause accelerated deterioration of the highway and is not recommended. Elimination of the planned resurfacing in the immediate area of the bridge might be a short term solution if recommended by the region's Materials Engineer. Solutions that include milling the existing surface followed by overlay or inlay must be approved by the region's Materials Engineer to ensure that adequate pavement structure is provided.

3. For other projects that include an existing bridge where no widening is proposed on or under the bridge, and the project does not affect vertical clearance, the clearance can be as little as 14.5 ft. For these projects, document the clearance to the design documentation file. For an existing bridge with less than 14.5 ft vertical clearance in this situation, an approved deviation request is required.

4. For an existing structure over a railroad track, the vertical clearance can be as little as 22.5 ft. (See Figure 1120-2b.) A lesser clearance can be used with the agreement of the railroad company and approval of the Washington State Utilities and Transportation Commission. Coordinate railroad clearance issues with the WSDOT Railroad Liaison Engineer.

(c) **Signing.** Low clearance warning signs are necessary when the vertical clearance of an existing bridge is less than 15 ft 3 in. Other requirements for low clearance signing are contained in the *Manual on Uniform Traffic Control Devices* and the *Traffic Manual*.

(d) **Coordination.** The Interstate system is used by the Department of Defense (DOD) for the conveyance of military traffic. The Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) represents the DOD in public highway matters. The MTMCTEA has an inventory of vertical clearance deficiencies over the Interstate system in Washington State. Contact the MTMCTEA, through FHWA, if any of the following changes are proposed to these bridges:

- A project would create a new deficiency of less than 16.0 ft vertical clearance over an Interstate highway.
- The vertical clearance over the Interstate is already deficient (less than 16.0 ft) and a change (increase or decrease) to vertical clearance is proposed.

Coordination with MTMCTEA is required for these changes on all rural Interstate highways and for one Interstate route through each urban area.

Project Type	Vertical Clearance	Documentation Requirement (see notes)
Interstate and Other Freeways [1]		
New Bridge	> 16.5 ft	2
Widening Over or	> 16 ft	2
Under Existing Bridge	< 16 ft	4
Resurfacing Under	> 16 ft	2
Existing Bridge	< 16 ft	4
Other with No Change	>14.5	3
to Vertical Clearance	<14.5	4
Nonfreeway Routes		
New Bridge	>16.5 ft	2
Widening Over or	>15.5 ft	2
Under Existing Bridge	<15.5 ft	4
Resurfacing Under	>15.5 ft	2
Existing Bridge	<15.5 ft	4
Other with No Change	> 14.5 ft	3
to Vertical Clearance	< 14.5 ft	4
Bridge Over Railroad Tracks [7]		
New Bridge	> 23.5 ft ≤23.5 ft	2 4, 5
Existing Bridge	> 22.5 ft < 22.5 ft	2 4, 5
Pedestrian Bridge Over Roadway		
New Bridge	> 17.5 ft	2
Existing Bridge		6

Notes:
1. Applies to all bridge vertical clearances over highways and under highways at interchanges
2. No documentation required
3. Document to design documentation file
4. Approved deviation required
5. Requires written agreement between railroad company and the department and the approval via petition from the Washington State Utilities and Transportation Commission
6. Use the same criteria as other existing bridges previously listed in the figure
7. See Figure 1120-2a and 2b

Bridge Vertical Clearances
Figure 1120-1

(6) Pedestrian and Bicycle Facilities

When pedestrians or bicyclists are anticipated on bridges, provide facilities consistent with guidance in Chapters 1020 and 1025.

(7) Bridge Approach Slab

Bridge approach slabs are reinforced concrete pavement installed across the full width of the bridge ends. They provide a stable transition from normal roadway cross section to the bridge ends and compensate for differential expansion and contraction of the bridge and the roadway. Bridge approach slabs are provided on all new bridges. If an existing bridge is being widened and it has an approach slab, slabs are required on the widenings. The region, with the concurrence of the State Geotechnical Engineer and the State Bridge Engineer, may decide to omit bridge approach slabs.

(8) Bridge Rail End Treatment

Plans for new bridge construction and bridge rail modifications include provisions for the connection of traffic barriers to the bridge rail. Indicate the preferred traffic barrier type and connection during the review of the bridge preliminary plan.

(9) Bridge End Embankments

The design of the embankment slopes at bridge ends depends on several factors. The width of the embankment is determined not only by the width of the roadway but also by the presence of traffic barriers, curbs, and sidewalks, all of which create the need for additional widening. Examples of the additional widening required for these conditions are shown in the Standard Plans.

The end slope is determined by combining the recommendations of several technical experts within the department. Figure 1120-3 illustrates the factors taken into consideration and the experts who are involved in the process.

(10) Bridge Slope Protection

Slope protection provides a protective and aesthetic surface for exposed slopes under bridges. Slope protection is normally provided under:

- Structures over state highways.
- Structures within an interchange.
- Structures over other public roads unless requested otherwise by the public agency.
- Railroad overcrossings, if requested by the railroad.

Slope protection is usually not provided under pedestrian structures. The type of slope protection is selected at the bridge preliminary plan stage. Typical slope protection types are concrete slope protection, semi-open concrete masonry, and rubble stone.

(11) Slope Protection at Watercrossings

The WSDOT Headquarters (HQ) Hydraulics Branch determines the slope protection requirements for structures that cross waterways. The type, limits, and quantity of the slope protection are shown on the bridge preliminary plan.

(12) Protective Screening for Highway Structures

The Washington State Patrol classifies the throwing of an object from a highway structure as an assault, not an accident. Therefore, records of these assaults are not contained in the Patrol's accident databases. Contact the region's Maintenance Engineer's office and the Washington State Patrol for the history of reported incidents.

Protective screening might reduce the number of incidents but will not stop a determined individual. Enforcement provides the most effective deterrent.

Installation of protective screening is analyzed on a case-by-case basis at the following locations:

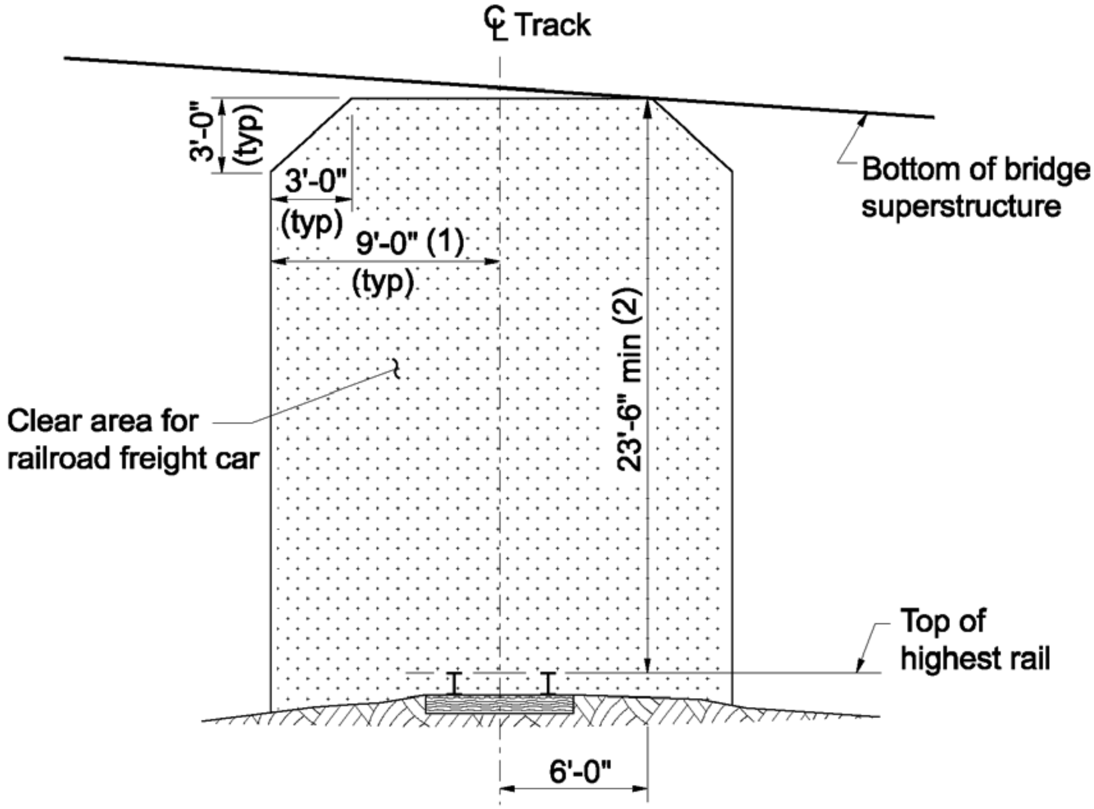
- On existing structures where there is a history of multiple incidents of objects being dropped or thrown and enforcement has not changed the situation.
- On a new structure near a school, a playground, or where frequently used by children not accompanied by adults.
- In urban areas, on a new structure used by pedestrians where surveillance by local law enforcement personnel is not likely.
- On new structures with walkways where experience on similar structures within a 1 mile radius indicates a need.
- On structures over private property that is subject to damage, such as buildings or power stations.

In most cases, the installation of a protective screen on a new structure can be postponed until there are indications of need.

Submit all proposals to install protective screening on structures to the State Design Engineer for approval. Contact the Bridge and Structures Office for approval to attach screening to structures and for specific design and mounting details.

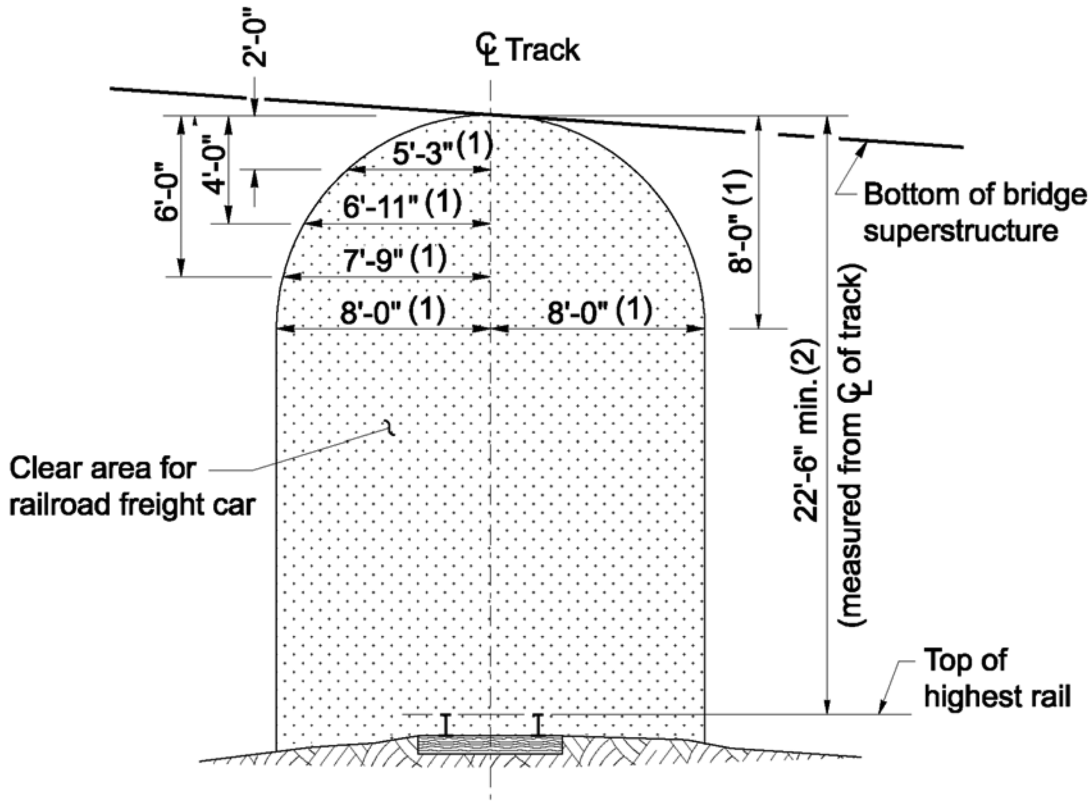
1120.05 Documentation

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wa.gov/eesc/design/projectdev/



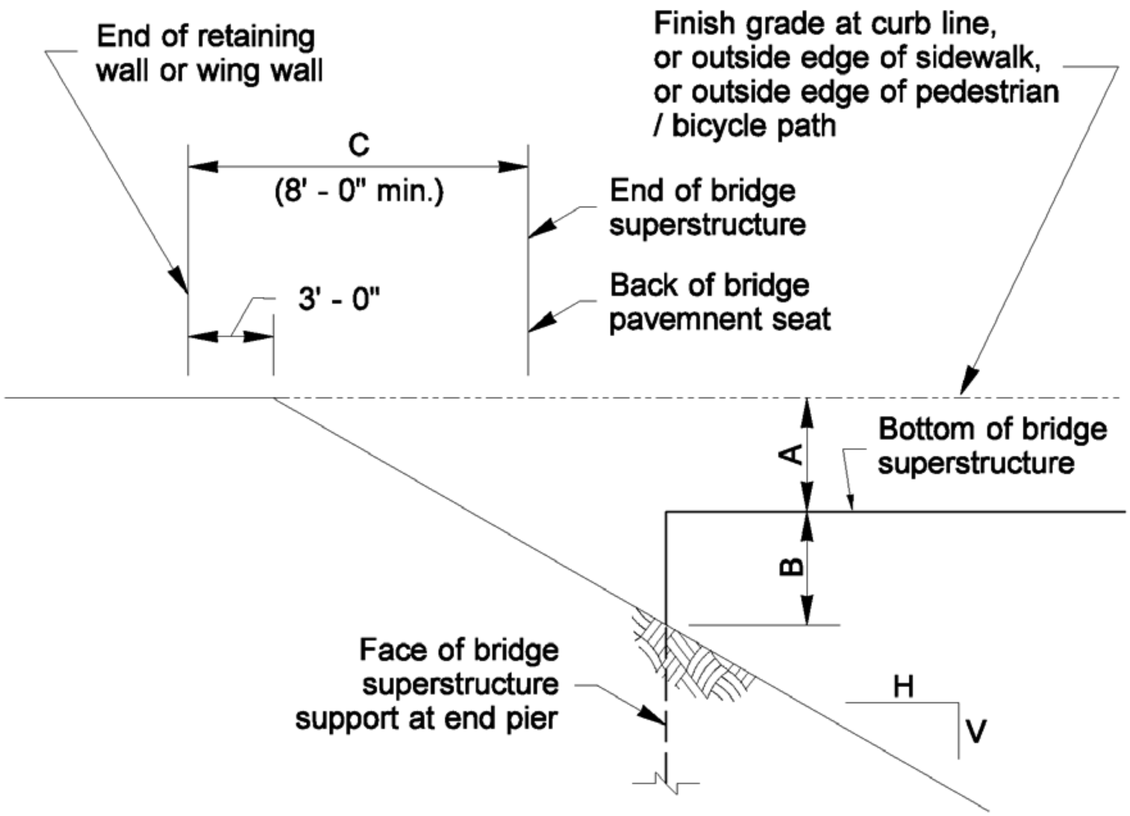
(1) Increase 1.5” for each degree of railroad alignment curve.
(2) Minimum clearances less than 23’-6” may be considered for closed or dedicated rail corridors, that do not intermix with general purpose freight rail traffic. Any such reduced clearance established for a corridor, must be approved by the railroad company and the WUTC.

Railroad Vertical Clearance for New Bridge Construction
Figure 1120-2a



(1) Increase 1.5” for each degree of railroad alignment curve.
(2) Minimum clearances less than 22’-6” may be considered for closed or dedicated rail corridors, that do not intermix with general purpose freight rail traffic. Any such reduced clearance established for a corridor, must be approved by the railroad company and the WUTC.

Railroad Vertical Clearance for Existing Bridge Modifications
Figure 1120-2b



BRIDGE END ELEVATION

Applies with retaining wall or wing wall
(or combination) extending beyond bridge
superstructure (barrier omitted for clarity)

LEGEND
A = Superstructure depth: Recommended by Bridge Design Office
B = Vertical clearance from bottom of superstructure to embankment:
Recommended by Bridge Preservation Engineer
C = Distance from the end of retaining wall or wing wall to back of pavement seat:
Recommended by Bridge Design Office
H & V = Embankment slope: Recommended by Geotechnical Engineer

Embankment Slope at Bridge Ends
Figure 1120-3

Chapter 1130 Retaining Walls and Steep Reinforced Slopes

1130.01 References

Bridge Design Manual, M 23-50, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

Roadside Manual, M 25-39, WSDOT

1130.02 General

The function of a retaining wall is to form a nearly vertical face through confinement and/or strengthening of a mass of earth or other bulk material. Likewise, the function of a reinforced slope is to strengthen the mass of earth or other bulk material such that a steep (up to 1H:2V) slope can be formed. In both cases, the purpose of constructing such structures is to make maximum use of limited right of way. The difference between the two is that a wall uses a structural facing whereas a steep reinforced slope does not require a structural facing. Reinforced slopes typically use a permanent erosion control matting with low vegetation as a slope cover to prevent erosion. See the *Roadside Manual* for more information.

To lay out and design a retaining wall or reinforced slope, consider the following items:

- Functional classification
- Highway geometry
- Design Clear Zone requirements (Chapter 700)
- The amount of excavation required
- Traffic characteristics
- Constructibility
- Impact to any adjacent environmentally sensitive areas
- Impact to adjacent structures
- Potential added lanes
- Length and height of wall
- Material to be retained
- Foundation support and potential for differential settlement
- Ground water
- Earthquake loads
- Right of way costs
- Need for construction easements
- Risk
- Overall cost
- Visual appearance

If the wall or toe of a reinforced slope is to be located adjacent to the right of way line, consider the space needed in front of the wall/slope to construct it.

(1) Retaining Wall Classifications

Retaining walls are generally classified as gravity, semigravity, nongravity cantilever, or anchored. Examples of the various types of walls are provided in Figures 1130-1a through 1c.

Gravity walls derive their capacity to resist lateral soil loads through a combination of dead weight and sliding resistance. Gravity walls can be further subdivided into rigid gravity walls, prefabricated modular gravity walls, and Mechanically Stabilized Earth (MSE) gravity walls.

Rigid gravity walls consist of a solid mass of concrete or mortared rubble and use the weight of the wall itself to resist lateral loads.

Prefabricated modular gravity walls consist of interlocking soil or rock filled concrete, steel, or wire modules or bins (gabions, for example). The combined weight resists the lateral loads from the soil.

MSE gravity walls use strips, bars, or mats of steel or polymeric reinforcement to reinforce the soil and create a reinforced soil block behind the face. The reinforced soil block then acts as a unit and resists the lateral soil loads through the dead weight of the reinforced mass. MSE walls may be constructed as fill walls, with fill and reinforcement placed in alternate layers to create a reinforced mass, or reinforcement may be drilled into an existing soil/rock mass using grouted anchor technology to create a reinforced soil mass (soil nail walls).

Semigravity walls rely more on structural resistance through cantilevering action of the wall stem. Generally, the backfill for a semigravity wall rests on part of the wall footing. The backfill, in combination with the weight of the wall and footing, provides the dead weight for resistance. An example of a semigravity wall is the reinforced concrete wall provided in the Standard Plans.

Nongravity cantilever walls rely strictly on the structural resistance of the wall in which vertical elements of the wall are partially embedded in the soil or rock to provide fixity. These vertical elements may consist of piles (soldier piles or sheet piles, for example), caissons, or drilled shafts. The vertical elements may form the entire wall face or they may be spanned structurally using timber lagging or other materials to form the wall face.

Anchored walls derive their lateral capacity through anchors embedded in stable soil or rock below or behind all potential soil/rock failure surfaces. Anchored walls are similar to nongravity cantilevered walls except that anchors embedded in the soil/rock are attached to the wall facing structure to provide lateral resistance. Anchors typically consist of deadmen or grouted soil/rock anchors.

Reinforced slopes are similar to MSE walls in that they also use fill and reinforcement placed in alternate layers to create a reinforced soil mass. However, the face is typically built at a 1.2H:1V to 1H:2V slope.

Rockeries (rock walls) behave to some extent like gravity walls. However, the primary function of a rockery is to prevent erosion of an oversteepened but technically stable slope. Rockeries consist of large well-fitted rocks stacked on top of one another to form a wall.

An example of a rockery and reinforced slope is provided in Figure 1130-1d.

The various wall types and their classifications are summarized in Table 1(a-f).

1130.03 Design Principles

The design of a retaining wall or reinforced slope consists of seven principal activities:

- Developing wall/slope geometry
- Adequate subsurface investigation
- Evaluation of loads and pressures that will act on the structure
- Design of the structure to safely withstand the loads and pressures
- Design of the structure to meet aesthetic requirements
- Wall/slope constructibility
- Coordination with other design elements

The structure and adjacent soil mass must also be stable as a system, and the anticipated wall settlement must be within acceptable limits.

1130.04 Design Requirements

(1) Wall/Slope Geometry

Wall/slope geometry is developed considering the following:

- Geometry of the transportation facility itself
- Design Clear Zone requirements (Chapter 700)
- Flare rate and approach slope when inside the Design Clear Zone (Chapter 710)

- Right of way constraints
- Existing ground contours
- Existing and future utility locations
- Impact to adjacent structures
- Impact to environmentally sensitive areas
- For wall/slope geometry, also consider the foundation embedment and type anticipated, which requires coordination among the various design groups involved.

Retaining walls must not have anything (such as bridge columns, light fixtures, or sign supports) protruding in such a way as to present a potential for snagging vehicles.

Provide a traffic barrier shape at the base of a new retaining wall constructed 12 ft or less from the edge of the nearest traffic lane. The traffic barrier shape is optional at the base of the new portion when an existing vertical-faced wall is being extended (or the existing wall may be retrofitted for continuity). Standard Concrete Barrier Type 4 is recommended for both new and existing walls except when the barrier face can be cast as an integral part of a new wall. Deviations may be considered but require approval as prescribed in Chapter 330. For deviations from the above, deviation approval is not required where sidewalk exists in front of the wall or in other situations where the wall face is otherwise inaccessible to traffic.

(2) Investigation of Soils

All retaining wall and reinforced slope structures require an investigation of the underlying soil/rock that supports the structure. Chapter 510 provides guidance on how to complete this investigation. A soil investigation is critical for the design of any retaining wall or reinforced slope. The stability of the underlying soils, their potential to settle under the imposed loads, the usability of any existing excavated soils for wall/reinforced slope backfill, and the location of the ground water table are determined through the geotechnical investigation.

(3) Geotechnical and Structural Design

The structural elements of the wall or slope and the soil below, behind, and/or within the structure must be designed together as a system. The wall/slope system is designed for overall external stability as well as internal stability. Overall external stability includes stability of the slope of which the wall/reinforced slope is a part and the local external stability (overturning, sliding, and bearing capacity). Internal stability includes resistance of the structural members to load and, in the case of MSE walls and reinforced slopes, pullout capacity of the structural members or soil reinforcement from the soil.

(4) Drainage Design

One of the principal causes of retaining wall/slope failure is the additional hydrostatic load imposed by an increase in the water content in the material behind the wall or slope. This condition results in a substantial increase in the lateral loads behind the wall/slope since the material undergoes a possible increase in unit weight, water pressure is exerted on the back of the wall, and the soil shear strength undergoes a possible reduction. To alleviate this, adequate drainage for the retaining wall/slope must be considered in the design stage and reviewed by the region's Materials Engineer during construction. The drainage features shown in the Standard Plans are the minimum basic requirements. Underdrains behind the wall/slope must daylight at some point in order to adequately perform their drainage function. Provide positive drainage at periodic intervals to prevent entrapment of water.

Native soil may be used for retaining wall and reinforced slopes backfill if it meets the requirements for the particular wall/slope system. In general, use backfill that is free-draining and granular in nature. Exceptions to this can be made depending on the site conditions as determined by the Geotechnical Services Branch of the Headquarters (HQ) Materials Laboratory.

A typical drainage detail for a gravity wall (in particular, an MSE wall) is shown in Figure 1130-2. Always include drainage details with a wall unless otherwise recommended to be deleted by the region's Materials Engineer or HQ Geotechnical Services Branch.

(5) Aesthetics

Retaining walls and slopes can have a pleasing appearance that is compatible with the surrounding terrain and other structures in the vicinity. To the extent possible within functional requirements and cost effectiveness criteria, this aesthetic goal is to be met for all visible retaining walls and reinforced slopes.

Aesthetic requirements include consideration of the wall face material, the top profile, the terminals, and the surface finish (texture, color, and pattern). Where appropriate, provide planting areas and irrigation conduits. These will visually soften walls and blend walls with adjacent areas. Avoid short sections of retaining wall or steep slope where possible.

In higher walls, variations in slope treatment are recommended for a pleasing appearance. High, continuous walls are generally not desirable from an aesthetic standpoint, as high, continuous walls can be quite imposing. Consider stepping high or long retaining walls in areas of high visibility. Plantings may be considered between wall steps.

Approval from the State Bridge and Structures Architect is required on all retaining wall aesthetics including finishes, materials, and configuration.

(6) Constructibility

Consider the potential effect that site constraints might have on the constructibility of the specific wall/slope. Constraints to be considered include, but are not limited to, site geometry, access, time required to construct the wall, environmental issues, and impact on traffic flow and other construction activities.

(7) Coordination with Other Design Elements

(a) **Other Design Elements.** Retaining wall and slope designs must be coordinated with other elements of the project that might interfere with or impact the design and/or construction of the wall/slope. Also consider drainage features, utilities, luminaire or sign structures, adjacent retaining walls or bridges, concrete traffic barriers, and beam guardrails. Locate these design elements in a manner that will minimize the impacts to the wall elements. In general, locate obstructions within the wall backfill (such as guardrail posts, drainage features, and minor structure foundations) a minimum of 3 ft from the back of the wall facing units. Greater offset distances may be required depending on the size and nature of the interfering design element. If possible, locate these elements to miss reinforcement layers or other portions of the wall system. Conceptual details for accommodating concrete traffic barriers and beam guardrails are provided in Figure 1130-3.

Where impact to the wall elements is unavoidable, the wall system must be designed to accommodate these impacts. For example, it may be necessary to place drainage structures or guardrail posts in the reinforced backfill zone of MSE walls. This may require that holes be cut in the upper soil reinforcement layers, or that discrete reinforcement strips be splayed around the obstruction. This causes additional load to be carried in the adjacent reinforcement layers due to the missing soil reinforcement or the distortion in the reinforcement layers.

The need for these other design elements and their impact on the proposed wall systems must be clearly indicated in the wall site data that is submitted so that the walls can be properly designed. Contact the Bridge and Structures Office (or the Geotechnical Services Branch, for geosynthetic walls/slopes and soil nail walls) for assistance regarding this issue.

(b) **Fall Protection.** Department of Labor and Industries regulations require that, when employees are exposed to the possibility of falling from a location 10 ft or more above the roadway (or other lower area), the employer is to ensure that fall restraint or fall arrest systems are provided, installed, and implemented.

Consider fall protection when a wall retains 10 ft or more of material. Any need for maintenance of the wall's surface or the area at the top can expose employees to a possible fall. If the area at the top will be open to the public, see Chapter 1025, "Pedestrian Design Considerations," and Chapter 1460, "Fencing."

For maintenance of a tall wall's surface, consider harness tie-offs if other protective means are not provided.

For maintenance of the area at the top of a tall wall, a fall restraint system is required when all of the following conditions will exist:

- The wall is on a cut slope.
- A possible fall will be of 10 ft or more.
- Periodic maintenance will be performed on the area at the top.
- The area at the top is not open to the public.

Recommended fall restraint systems are:

- Wire rope railing with top and intermediate rails of one-half inch diameter steel wire rope.
- Brown vinyl coated chain link fencing.
- Steel pipe railing with one and one-half inch nominal outside diameter pipe as posts and top and intermediate rails.
- Concrete as an extension of the height of the retaining wall.

A fall restraint system must be 36 in to 42 in high, measured from the top of the finished grade, and capable of withstanding a 200 lb force from any direction, at the top, with minimal deflection. Post spacing is no more than 8 ft on centers.

During rail system selection, the designer is to contact Maintenance regarding debris removal considerations.

Contact the Bridge and Structures Office for design details for any retrofit to an existing retaining wall and for any attachments to a new retaining wall.

1130.05 Guidelines for Wall/Slope Selection

Wall/slope selection is dependent on the following considerations:

- Whether the wall/slope will be located primarily in a cut or fill (how much excavation/shoring will be required to construct the wall or slope?)
- If located in a cut, the type of soil/rock present
- The need for space between the right of way line and the wall/slope or easement
- The amount of settlement expected
- The potential for deep failure surfaces to be present
- The structural capacity of the wall/slope in terms of maximum allowable height
- The nature of the wall/slope application
- Whether or not structures or utilities will be located on or above the wall
- Architectural requirements
- Overall economy

(1) Cut and Fill Considerations

Due to the construction technique and base width required, some wall types are best suited for cut situations whereas others are best suited for fill situations. For example, anchored walls and soil nail walls have soil reinforcements drilled into the in-situ soil/rock and, therefore, are generally used in cut situations. Nongravity cantilevered walls are drilled or cut into the in-situ soil/rock, have narrow base widths, and are also well suited to cut situations. Both types of walls are constructed from the top down. Such walls are also used as temporary shoring to allow other types of walls or other structures to be constructed where considerable excavation will otherwise be required.

MSE walls and reinforced slopes, however, are constructed by placing soil reinforcement between layers of fill from the bottom up and are therefore best suited to fill situations. Furthermore, the base width of MSE walls is typically on the order of 70 percent of the wall height, which requires considerable excavation in a cut situation. Therefore, in a cut situation, base width requirements usually make MSE structures uneconomical and possibly unconstructible.

Semigravity (cantilever) walls, rigid gravity walls, and prefabricated modular gravity walls are free-standing structural systems built from the bottom up but they do not rely on soil reinforcement techniques (placement of fill layers with soil reinforcement) to provide stability. These types of walls generally have a narrower base width than MSE structures, (on the order of 50 percent of the wall height). Both of these factors make these types of walls feasible in fill situations as well as many cut situations.

Reinforced slopes generally require more room overall to construct than a wall because of the sloping face, but are typically a feasible alternative to a combination wall and fill slope to add a new lane. Reinforced slopes can also be adapted to the existing ground contours to minimize excavation requirements where fill is placed on an existing slope. Reinforced slopes might also be feasible to repair slopes damaged by landslide activity or deep erosion.

Rockeries are best suited to cut situations, as they require only a narrow base width, on the order of 30 percent of the rockery height. Rockeries can be used in fill situations, but the fill heights that they support must be kept relatively low as it is difficult to get the cohesive strength needed in granular fill soils to provide minimal stability of the soil behind the rockery at the steep slope typically used for rockeries in a cut (such as 1H:6V or 1H:4V).

The key considerations in deciding which walls or slopes are feasible are the amount of excavation or shoring required and the overall height. The site geometric constraints must be well defined to determine these elements. Another consideration is whether or not an easement will be required. For example, a temporary easement might be required for a wall-in a fill situation to allow the contractor to work in front of the wall. For walls in cut situations, especially anchored walls and soil nail walls, a permanent easement may be required for the anchors or nails.

(2) Settlement and Deep Foundation Support Considerations

Settlement issues, especially differential settlement, are of primary concern for selection of walls. Some wall types are inherently flexible and can tolerate a great deal of settlement without suffering structurally. Other wall types are inherently rigid and cannot tolerate much settlement. In general, MSE walls have the greatest flexibility and tolerance to settlement, followed by prefabricated modular gravity walls. Reinforced slopes are also inherently very flexible. For MSE walls, the facing type used can affect the ability of the wall to tolerate settlement. Welded wire and geosynthetic wall facings are the most flexible and the most tolerant to settlement, whereas concrete facings are less tolerant to settlement. In some cases, concrete facing can be placed, after the wall settlement is complete, such that the concrete facing does not limit the wall's tolerance to settlement. Facing may also be added for aesthetic reasons.

Semigravity (cantilever) walls and rigid gravity walls have the least tolerance to settlement. In general, total settlement for these types of walls must be limited to approximately 1 in or less. Rockeries also cannot tolerate much settlement, as rocks can shift and fall out. Therefore, semigravity cantilever walls, rigid gravity walls, and rockeries are not used in settlement prone areas.

If very weak soils are present that will not support the wall and that are too deep to be overexcavated, or if a deep failure surface is present that results in inadequate slope stability, the wall type selected must be capable of using deep foundation support and/or anchors. In general, MSE walls, prefabricated modular gravity walls, and some rigid gravity walls are not appropriate for these situations. Walls that can be pile supported such as concrete semigravity cantilever walls, nongravity cantilever walls, and anchored walls are more appropriate for these situations.

(3) Feasible Wall and Slope Heights and Applications

Feasible wall heights are affected by issues such as the capacity of the wall structural elements, past experience with a particular wall, current practice, seismic risk, long-term durability, and aesthetics.

See Table 1 for height limitations.

(4) Supporting Structures or Utilities

Not all walls are acceptable to support other structures or utilities. Issues that must be considered include the potential for the wall to deform due to the structure foundation load, interference between the structure foundation and the wall components, and the potential long-term durability of the wall system. Using retaining walls to support other structures is considered to be a critical application, requiring a special design. In general, soil nail walls, semigravity cantilever walls, nongravity cantilever walls, and anchored walls are appropriate for use in supporting bridge and building structure foundations. In addition to these walls, MSE and prefabricated modular gravity walls may be used to support other retaining walls, noise walls, and minor structure foundations such as those for sign bridges and signals. On a project specific basis, MSE walls can be used to support bridge and building foundations, as approved by the Bridge and Structures Office.

Also consider the location of any utilities behind the wall or reinforced slope when making wall/slope selections. This is mainly an issue for walls that use some type of soil reinforcement and for reinforced slopes. It is best not to place utilities within a reinforced soil backfill zone because it will be impossible to access the utility from the ground surface without cutting through the soil reinforcement layers, thereby compromising the integrity of the wall.

Sometimes utilities, culverts, pipe arches, etc. must penetrate the face of a wall. Not all walls and facings are compatible with such penetrations. Consider how the facing can be formed around the penetration so that backfill soil cannot pipe or erode through the face. Contact the Bridge and Structures Office for assistance regarding this issue.

(5) Facing Options

Facing selection depends on the aesthetic and the structural needs of the wall system. Wall settlement may also affect the feasibility of the facing options. More than one wall facing may be available for a given system. The facing options available must be considered when selecting a particular wall.

For MSE walls, facing options typically include the following:

- Precast modular panels
- In some cases, full height precast concrete panels. (Full height panels are generally limited to walls with a maximum height of 20 ft placed in areas where minimal settlement is expected.)
- Welded wire facing
- Timber facing
- Shotcrete facing with various treatment options that vary from a simple broom finish to a textured and colored finish
- Segmental masonry concrete blocks
- Cast-in-place concrete facing with various texturing options.

Plantings on welded wire facings can be attempted in certain cases. The difficulty is in providing a soil at the wall face that is suitable for growing plants and meets engineering requirements in terms of soil compressibility, strength, and drainage. If plantings in the wall face are attempted, use only small plants, vines, and grasses. Small bushes may be considered for plantings between wall steps. Larger bushes or trees are not considered in these cases due to the loads on the wall face that they can create.

Geosynthetic facings are not acceptable for permanent facings due to potential facing degradation when exposed to sunlight. For permanent applications, geosynthetic walls must have some type of timber, welded wire, or concrete face. (Shotcrete, masonry concrete blocks, cast-in-place concrete, welded wire, or timber are typically used for geosynthetic wall facings.)

Soil nail walls can use either architecturally treated shotcrete or a cast-in-place facia wall textured as needed to produce the desired appearance.

For prefabricated modular gravity walls, the facing generally consists of the structural bin or crib elements used to construct the walls. For some walls, the elements can be rearranged to form areas for plantings. In some cases, textured structural elements might also be feasible. This is also true of rigid gravity walls, though planting areas on the face of rigid gravity walls are generally not feasible. The concrete facing for semigravity cantilever walls can be textured as needed to produce the desired appearance.

For nongravity cantilevered walls and anchored walls, a textured cast-in-place or precast facia wall is usually installed to produce the desired appearance.

(6) Cost Considerations

Usually, more than one wall type is feasible for a given situation. Consider cost throughout the selection process. Decisions in the selection process that may affect the overall cost might include the problem of whether to shut down a lane of traffic to install a low cost gravity wall system that requires more excavation room or to use a more expensive anchored wall system that will minimize excavation requirements and impacts to traffic. In this case, determine if the cost of traffic impacts and more excavation justifies the cost of the more expensive anchored wall system.

Decisions regarding aesthetics can also affect the overall cost of the wall system. In general, the least expensive aesthetic options use the structural members of the wall as facing (welded wire, concrete or steel cribbing or bins, for example), whereas the most expensive aesthetic options use textured cast-in-place concrete facias. In general, concrete facings increase in cost in the following order: shotcrete, segmental masonry concrete blocks, precast concrete facing panels, full height precast concrete facing panels, and cast-in-place concrete facing panels. Special architectural treatment usually increases the cost of any of these facing systems. Special wall terracing to provide locations for plants will also tend to increase costs. Therefore, the value of the desired aesthetics must be weighed against costs.

Other factors that affect costs of wall/slope systems include wall/slope size and length, access at the site and distance to the material supplier location, overall size of the project, and competition between wall suppliers. In general, costs tend to be higher for walls or slopes that are high, but short in length, due to lack of room for equipment to work. Sites that are remote or have difficult local access increase wall/slope costs. Small wall/slope quantities result in high unit costs. Lack of competition between materials or wall system suppliers can result in higher costs as well.

Some of the factors that increase costs are required parts of a project and are, therefore, unavoidable. Always consider such factors when estimating costs because a requirement may not affect all wall types in the same way. Current cost information can be obtained by consulting the *Bridge Design Manual* or by contacting the Bridge and Structures Office.

(7) Summary

For wall/slope selection, consider factors such as the intended application, the soil/rock conditions in terms of settlement, need for deep foundations, constructibility, impact to traffic, the overall geometry in terms of wall/slope height and length, location of adjacent structures and utilities, aesthetics, and cost. Table 1 provides a summary of many of the various wall/slope options available, including their advantages, disadvantages, and limitations. Note that specific wall types in the table may represent multiple wall systems, some or all of which will be proprietary.

1130.06 Design Responsibility and Process

(1) General

The retaining walls available for a given project include standard walls, nonstandard walls, and reinforced slopes.

Standard walls are those walls for which standard designs are provided in the WSDOT Standard Plans. Standard plans are provided for reinforced concrete cantilever walls up to 35 ft in height. The internal stability design, and the external stability design for overturning and sliding stability, have already been completed for these standard walls. However, overall slope stability and allowable soil bearing capacity (including settlement considerations) must be determined for each standard-design wall location.

Nonstandard walls may be either proprietary (patented or trademarked) or nonproprietary. Proprietary walls are designed by a wall manufacturer for internal and external stability, except bearing capacity, settlement, and overall slope stability which are determined by WSDOT. Nonstandard nonproprietary walls are fully designed by WSDOT.

The geosynthetic soil reinforcement used in non-standard nonproprietary geosynthetic walls is considered to be proprietary. It is likely that more than one manufacturer can supply proprietary materials for a nonstandard nonproprietary geosynthetic wall.

Reinforced slopes are similar to nonstandard non-proprietary walls in terms of their design process.

Some proprietary wall systems are preapproved. Preapproved proprietary wall systems have been extensively reviewed by the Bridge and Structures Office and the Geotechnical Services Branch. Design procedures and wall details for preapproved walls have already been agreed upon between WSDOT and the proprietary wall manufacturers, allowing the manufacturers to competitively bid a particular project without having a detailed wall design provided in the contract plans.

Note that proprietary wall manufacturers might produce several retaining wall options, and not all options from a given manufacturer have necessarily been preapproved. For example, proprietary wall manufacturers often offer more than one facing alternative. It is possible that some facing alternatives are preapproved, whereas other facing alternatives are not preapproved. WSDOT does not preapprove the manufacturer, but specific wall systems by a given manufacturer can be preapproved.

It is imperative with preapproved systems that the design requirements for all preapproved wall alternatives for a given project be clearly stated so that the wall manufacturer can adapt the preapproved system to specific project conditions. For a given project, coordination of the design of all wall alternatives with all project elements that impact the wall (such as drainage features, utilities, luminaires and sign structures, noise walls, traffic barriers, guardrails, or other walls or bridges) is critical to avoid costly change orders or delays during construction.

In general, standard walls are the easiest walls to incorporate into project plans, specifications, & estimate (PS&E), but they may not be the most cost effective option. Preapproved proprietary walls provide more options in terms of cost effectiveness and aesthetics and are also relatively easy to incorporate into a PS&E. Nonstandard state-designed walls and nonpreapproved proprietary walls generally take more time and effort to incorporate into a PS&E because a complete wall design must be developed. Some nonstandard walls (state-designed geosynthetic walls, for example) can be designed relatively quickly, require minimal plan preparation effort, and only involve the region and the Geotechnical Services Branch. Other nonstandard walls such as soil nail and anchored wall systems require complex designs, involve both the Bridge and Structures Office and the Geotechnical Services Branch, and require a significant number of plan sheets and considerable design effort.

The Bridge and Structures Office maintains a list of the proprietary retaining walls that are preapproved. The region consults the Bridge and Structures Office for the latest list. The region consults the Geotechnical Services Branch for the latest geosynthetic reinforcement list to determine which geosynthetic products are acceptable if a critical geosynthetic wall or reinforced slope application is anticipated.

Some proprietary retaining wall systems are classified as experimental by the FHWA. The Bridge and Structures Office maintains a list of walls that are classified as experimental. If the wall intended for use is classified as experimental, a work plan must be prepared by WSDOT and approved by the FHWA.

An approved public interest finding, signed by the State Design Engineer, is required for the use of a sole source proprietary wall.

Gabion walls are nonstandard walls that must be designed for overturning, sliding, overall slope stability, settlement, and bearing capacity. A full design for gabion walls is not provided in the Standard Plans. Gabion baskets are typically 3 ft high by 3 ft wide, and it is typically safe to build gabions two baskets high (6 ft) but only one basket deep, resulting in a wall base width of 50 percent of the wall height, provided soil conditions are reasonably good (medium dense to dense granular soils are present below and behind the wall).

(2) Responsibility and Process for Design

A flow chart illustrating the process and responsibility for retaining wall/reinforced slope design is provided in Figure 1130-4a. As shown in the figure, the region initiates the process, except for walls developed as part of a preliminary bridge plan. These are initiated by the Bridge and Structures Office. In general, it is the responsibility of the design office initiating the design process to coordinate with other groups in the department to identify all wall/slope systems that are appropriate for the project in question. Coordination between the region, Bridge and Structures Office, Geotechnical Services Branch, and the State Bridge and Structures Architect must occur as early in the process as possible.

HQ or region consultants, if used, are considered an extension of the HQ staff and must follow the process summarized in Figure 1130-4a. All consultant designs, from development of the scope of work to the final product, must be reviewed and approved by the appropriate HQ offices.

(a) **Standard Walls.** The regions are responsible for detailing retaining walls for which standard designs are available.

For standard walls greater than 10 ft in height, and for all standard walls where soft or unstable soil is present beneath or behind the wall, a geotechnical investigation must be conducted, or reviewed and approved, by the Geotechnical Services Branch. Through this investigation, provide the foundation design including bearing capacity requirements and settlement determin-ation, overall stability, and the selection of the wall types most feasible for the site.

For standard walls 10 ft in height or less where soft or unstable soils are not present, it is the responsibility of the region materials laboratory to perform the geotechnical investigation. If it has been verified that soil conditions are adequate for the proposed standard wall that is less than or equal to 10 ft in height, the region establishes the wall footing location based on the embedment criteria in the *Bridge Design Manual*, or places the bottom of the wall footing below any surficial loose soils. During this process, the region also evaluates other wall types that may be feasible for the site in question.

Figure 1130-5 provides design charts for standard reinforced concrete cantilever walls. These design charts, in combination with the Standard Plans, are used to size the walls and determine the applied bearing stresses to compare with the allowable soil bearing capacity determined from the geotechnical investigation. The charts provide two sets of bearing pressures: one for static loads, and one for earthquake loads. Allowable soil bearing capacity for both the static load case and the earthquake load case can be obtained from the Geotechnical Services Branch for standard walls over 10 ft in height and from the region materials laboratories for standard walls less than or equal to 10 ft in height. If the allowable soil bearing capacity exceeds the values provided in Figure 1130-5, the Standard Plans can be used for the wall design. If one or both of the allowable soil bearing capacities does not exceed the values provided in Figure 1130-5, the Standard Plans cannot be used for wall design and the Bridge and Structures Office must be contacted for a nonstandard wall design.

If the standard wall must support surcharge loads from bridge or building foundations, other retaining walls, noise walls, or other types of surcharge loads, a special wall design is required. The wall is considered to be supporting the surcharge load and is treated as a nonstandard wall if the surcharge load is located within a 1H:1V slope projected up from the bottom of the back of the wall. Contact the Bridge and Structures Office for assistance

The Standard Plans provide six types of reinforced concrete cantilever walls (which represent six loading cases). Reinforced concrete retaining wall Types 5 and 6 are not designed to withstand earthquake forces and are not used in Western Washington (west of the Cascade crest).

Once the geotechnical and architectural assessment have been completed, the region completes the PS&E for the standard wall option(s) selected including a generalized wall profile and plan, a typical cross-section as appropriate, details for desired wall appurtenances, drainage details, and other details as needed.

Metal bin walls, Types 1 and 2, have been deleted from the Standard Plans and are therefore no longer standard walls. Metal bin walls are seldom used due to cost and undesirable aesthetics. If this type of wall is proposed, contact the Bridge and Structures Office for plan details and toe bearing pressures. The applied toe bearing pressure will then have to be evaluated by the Geotechnical Services Branch to determine if the site soil conditions are appropriate for the applied load and anticipated settlement.

(b) **Preapproved Proprietary Walls.** Final approval of preapproved proprietary wall design, with the exception of geosynthetic walls, is the responsibility of the Bridge and Structures Office. Final approval of the design of preapproved proprietary geosynthetic walls is the responsibility of the Geotechnical Services Branch. It is the region's responsibility to coordinate the design effort for all preapproved wall systems.

The region materials laboratory performs the geotechnical investigation for preapproved proprietary walls 10 ft in height or less that are not bearing on soft or unstable soils. In all other cases, it is the responsibility of the Geotechnical Services Branch to conduct, or review and approve, the geotechnical investigation for the wall. The region also coordinates with the State Bridge and Structures Architect to ensure that the wall options selected meet the aesthetic requirements for the site.

Once the geotechnical and architectural assessments have been completed and the desired wall alternatives selected, it is the responsibility of the region to contact the suppliers of the selected preapproved systems to confirm in writing the adequacy and availability of the systems for the proposed use.

A minimum of three different wall systems must be included in the PS&E for any project with federal participation that includes a proprietary wall system unless specific justification is provided. Standard walls can be alternatives.

Once confirmation of adequacy and availability has been received, the region contacts the Bridge and Structures Office for special provisions for the selected wall systems and proceeds to finalize the contract PS&E in accordance with the *Plans Preparation Manual*. Provide the allowable bearing capacity and foundation embedment criteria for the wall, as well as backfill and foundation soil properties, in the special provisions. In general, assume that gravel borrow or better quality backfill material will be used for the walls when assessing soil parameters.

Complete wall plans and designs for the proprietary wall options will not be developed until after the contract is awarded, but will be developed by the proprietary wall supplier as shop drawings after the contract is awarded. Therefore, include a general wall plan, a profile showing neat line top and bottom of the wall, a final ground line in front of and in back of the wall, a typical cross-section, and the generic details for the desired appurtenances and drainage requirements in the contract PS&E for the proprietary walls. Estimate the ground line in back of the wall based on a nominal 1.5 ft facing thickness (and state this on the wall plan sheets). Include load or other design acceptance requirements for these appurtenances in the PS&E. Contact the Bridge and Structures Office for assistance regarding this.

It is best to locate catch basins, grate inlets, signal foundations, and the like outside the reinforced backfill zone of MSE walls to avoid interference with the soil reinforcement. In those cases where conflict with these reinforcement obstructions cannot be avoided, the location(s) and dimensions of the reinforcement obstruction(s) relative to the wall must be clearly indicated on the plans. Contact the Bridge and Structures Office for preapproved wall details and designs for size and location of obstructions, and to obtain the generic details that must be provided in the plans. If the obstruction is too large or too close to the wall face, a special design may be required to accommodate the obstruction, and the wall is treated as a nonpreapproved proprietary wall.

A special design is required if the wall must support structure foundations, other retaining walls, noise walls, signs or sign bridges, luminaires, or other types of surcharge loads. The wall is considered to be supporting the surcharge load if the surcharge is located within a 1H:1V slope projected from the bottom of the back of the wall. For MSE walls, the back of the wall is considered to be the back of the soil reinforcement layers. If this situation occurs, the wall is treated as a nonpreapproved proprietary wall.

For those alternative wall systems that have the same face embedment criteria, the wall face quantities depicted in the plans for each alternative must be identical. To provide an equal basis for competition, the region determines wall face quantities based on neat lines.

Once the detailed wall plans and designs are available as shop drawings after contract award, the Bridge and Structures Office will review and approve the wall shop drawings and calculations, with the exception of geosynthetic walls which are reviewed and approved by the Geotechnical Services Branch.

(c) **Nonpreapproved Proprietary Walls.** Final approval authority for nonpreapproved proprietary wall design is the same as for preapproved proprietary walls. The region initiates the design effort for all nonpreapproved wall systems by submitting wall plan, profile, cross-section, and other information for the proposed wall to the Bridge and Structures Office, with copies to the Geotechnical Services Branch and the State Bridge and Structures Architect. The Bridge and Structures Office coordinates the wall design effort.

Once the geotechnical and architectural assessments have been completed and the desired wall types selected, the Bridge and Structures Office contacts suppliers of the nonpreapproved wall systems selected to obtain and review detailed wall designs and plans to be included in the contract PS&E.

To ensure fair competition between all wall alternatives included in the PS&E, the wall face quantities for those wall systems subject to the same face embedment requirements must be identical.

The Bridge and Structures Office develops the special provisions and cost estimates for the nonpreapproved proprietary walls and sends the wall PS&E to the region for inclusion in the final PS&E in accordance with the *Plans Preparation Manual*.

(d) **Nonstandard Nonproprietary Walls.** With the exception of rockeries over 5 ft high, nonproprietary geosynthetic walls and reinforced slopes, and soil nail walls, the Bridge and Structures Office coordinates with the Geotechnical Services Branch and the State Bridge and Structures Architect to carry out the design of all nonstandard, nonproprietary walls. In this case, the Bridge and Structures Office develops the wall preliminary plan from site data provided by the region, completes the wall design, and develops the nonstandard nonproprietary wall PS&E package for inclusion in the contract.

For rockeries over 5 ft high, nonproprietary geosynthetic walls and reinforced slopes, and soil nail walls, the region develops wall/slope profiles, plans, and cross-sections and submits them to the Geotechnical Services Branch to complete a detailed wall/slope design.

For geosynthetic walls and slopes, and for rockeries, the region provides overall coordination of the wall/slope design effort, including coordination with the State Bridge and Structures Architect regarding aesthetics and finishes, and the region's or HQ Landscape Architect if the wall uses vegetation on the face. The Geotechnical Services Branch has overall approval authority for the wall design. Once the wall design has been completed, the Geotechnical Services Branch, and in some cases the Bridge and Structures Office, provides geotechnical and structural plan details to be included in the region plan sheets and special provisions for the PS&E. The region then completes the PS&E package.

For soil nail walls, once the Geotechnical Services Branch has performed the geotechnical design, the Bridge and Structures Office, in cooperation with the Geotechnical Services Branch, coordinates the design effort and completes the PS&E package.

(3) Guidelines for Wall/Slope Data Submission for Design

(a) Standard Walls, Proprietary Walls, Geosynthetic Walls/Slopes, and Soil Nail Walls. Where HQ involvement in retaining wall/slope design is required (as for standard walls and preapproved proprietary walls over 10 ft in height, gabions over 6 ft in height, rockeries over 5 ft in height, all nonpreapproved proprietary walls, geosynthetic walls/slopes, and all soil nail walls), the region submits the following information to the Geotechnical Services Branch or Bridge and Structures Office as appropriate:

- Wall/slope plans.
- Profiles showing the existing and final grades in front of and behind the wall.
- Wall/slope cross-sections (typically every 50 ft) or CAiCE files that define the existing and new ground-line above and below the wall/slope and show stations and offsets.
- Location of right of way lines as well as other constraints to wall/slope construction.
- Location of adjacent existing and/or proposed structures, utilities, and obstructions.
- Desired aesthetics.
- Date design must be completed.
- Key region contacts for the project.

Note that it is best to base existing ground measurements, for the purpose of defining the final wall geometry, on physical survey data rather than solely on photogrammetry. In addition, the region must complete a Retaining Wall/Reinforced Slope Site Data Check List, DOT Form 351-009 EF, for each wall or group of walls submitted.

(b) **Nonstandard Walls, Except Geosynthetic Walls/Slopes and Soil Nail Walls.** In this case, the region must submit site data in accordance with Chapter 1110. Additionally, a Retaining Wall Site Data Check List, DOT351-009EF, for each wall or group of walls must be completed by the region.

1130.07 Documentation

A list of the documents that are required to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

Specific Wall Type	Advantages	Disadvantages	Limitations
Steel soil reinforcement with full height precast concrete panels	Relatively low cost	Can tolerate little settlement; generally requires high quality backfill; wide base width required (70% of wall height)	Applicable primarily to fill situations; maximum feasible height is approximately 20 ft
Steel soil reinforcement with modular precast concrete panels	Relatively low cost; flexible enough to handle significant settlement	Generally requires high quality backfill; wide base width required (70% of wall height)	Applicable primarily to fill situations; maximum height of 33 ft; heights over 33 ft require a special design
Steel soil reinforcement with welded wire and cast in place concrete face	Can tolerate large short-term settlements	Relatively high cost; cannot tolerate long-term settlement; generally requires high quality wall backfill soil; wide base width required (70% of wall height); typically requires a settlement delay period during construction	Applicable primarily to fill situations; maximum height of 33 ft for routine designs; heights over 33 ft require a special design
Steel soil reinforcement with welded wire face only	Can tolerate large long-term settlements; low cost	Aesthetics, unless face plantings can be established; generally requires high quality backfill; wide base width required (70% of wall ht.)	Applicable primarily to fill situations; maximum height of 33 ft for routine designs; heights over 33 ft require a special design

Table 1(a)
Summary of mechanically stabilized earth (MSE) gravity wall/slope options available.

Specific Wall Type	Advantages	Disadvantages	Limitations
Segmental masonry concrete block faced walls, generally with geosynthetic soil reinforcement	Low cost; flexible enough to handle significant settlements	Internal wall deformations may be greater than for steel reinforced systems but are still acceptable for most applications; generally requires high quality backfill; wide base width required (70% of wall height)	Applicable primarily to fill situations; in general, limited to wall height of 20 ft or less; greater wall heights may be feasible by special design in areas of low seismic activity and when geosynthetic products are used in which long-term product durability is well defined. (See Qualified Products List.)
Geosynthetic walls with a shotcrete or cast in place concrete face	Very low cost, esp. with shotcrete face; can tolerate large short-term settlements	Internal wall deformations may be greater than for steel reinforced systems but are still acceptable for most applications; generally requires high quality backfill; wide base width required (70% of wall height)	Applicable primarily to fill situations; in general, limited to wall height of 20 ft or less unless using geosynthetic products in which long-term product durability is well defined. (See Qualified Products List.) For qualified products, heights of 33 ft or more are possible.
Geosynthetic walls with a welded wire face	Very low cost; can tolerate large long-term settlements	Internal wall deformations may be greater than for steel reinforced systems but are still acceptable for most applications; generally requires high quality wall backfill soil; wide base width required (70% of wall height)	Applicable primarily to fill situations; in general, limited to wall height of 20 ft or less unless using geosynthetic products in which long-term product durability is well defined. (See Qualified Products List.) For qualified products, heights of 33 ft or more are possible.

Table 1(a) continued

Specific Wall Type	Advantages	Disadvantages	Limitations
Geosynthetic walls with a geosynthetic face	Lowest cost of all wall options; can tolerate large long-term settlements	Internal wall deformations may be greater than for steel reinforced systems but are still acceptable for most applications; generally requires high quality backfill; wide base width required (70% of wall height); durability of wall facing	Applicable primarily to fill situations; use only for temporary applications due to durability of facing; can be designed for wall heights of 40 ft or more
Soil nail walls	Relatively low cost; can be used in areas of restricted overhead or lateral clearance	Soil/rock must have adequate standup time to stand in a vertical cut approximately 6 ft high for at least 1 to 2 days; not feasible for bouldery soils; may require an easement for the nails	Applicable to cut situations only; not recommended in clean or water bearing sands and gravels, in bouldery soils that can interfere with nail installation, or in landslide deposits, especially where deep potential failure surfaces are present; maximum wall heights of 35 ft are feasible, though greater wall heights are possible in excellent soil/rock conditions. A special design is always required.

Table 1(a) continued

Specific Wall Type	Advantages	Disadvantages	Limitations
Concrete crib walls	Relatively low cost; quantity of high quality backfill required relatively small; relatively narrow base width, on the order of 50% to 60% of the wall height; can tolerate moderate settlements	Aesthetics	Applicable to cut and fill situations; reinforced concrete can typically be designed for heights of up to 33 ft and unreinforced concrete up to 16 ft; not used to support bridge or building foundations
Metal crib walls	Quantity of high quality backfill required relatively small; relatively narrow base width, on the order of 50% to 60% of the wall height; can tolerate moderate settlements	Relatively high cost; aesthetics	Applicable to cut and fill situations; can be designed routinely for heights up to 35 ft; not used to support bridge or building foundations
Timber crib walls	Low cost; minimal high quality backfill required; relatively narrow base width, on the order of 50% to 60% of the wall height; can tolerate moderate settlements	Design life relatively short, aesthetics	Applicable to cut and fill situations; can be designed for heights up to 16 ft; not used to support structure foundations
Concrete bin walls	Relatively low cost; narrow base width, on the order of 50 to 60% of the wall height; can tolerate moderate settlements	Aesthetics	Applicable to cut and fill situations; can be designed routinely for heights up to 25 ft; not used to support bridge or building foundations
Gabion walls	Relatively narrow base width, on the order of 50 to 60% of the wall height; can tolerate moderate settlements	Relatively high cost, depending on proximity to source of high quality angular rock to fill baskets	Applicable to cut and fill situations; can be designed routinely for heights up to 15 ft, and by special design up to 21 ft; not used to support structure foundations

Table 1(b) Summary of prefabricated modular gravity wall options available

Specific Wall Type	Advantages	Disadvantages	Limitations
Mortar rubble masonry walls	Quantity of high quality backfill required is relatively small	High cost; relatively wide base width, on the order of 60% to 70% of the wall height; cannot tolerate settlement	Applicable mainly to fill situations where foundation conditions consist of very dense soil or rock; due to expense, only used in areas where other mortar rubble masonry walls are present and it is desired to match aesthetics; typically, can be designed for maximum heights of 25 ft
Unreinforced concrete gravity walls	Quantity of high quality backfill required is relatively small	High cost; relatively wide base width, on the order of 60% to 70% of the wall height; cannot tolerate settlement	Applicable mainly to fill situations where foundation conditions consist of very dense soil or rock; due to expense, only used in areas where other concrete gravity walls are present and it is desired to match aesthetics; typically, can be designed for maximum heights of 25 ft
Reinforced concrete cantilever walls	Relatively narrow base width on the order of 50% to 60% of the wall height; can be used to support structure foundations by special design	High cost; cannot tolerate much settlement; relatively deep embedment might be required on sloping ground due to toe in front of wall face	Applicable to cut and fill situations; can be routinely designed for heights up to 35 ft
Reinforced concrete counterfort walls	Relatively narrow base width on the order of 50% to 60% of the wall height; can be used to support structure foundations by special design	High cost; cannot tolerate much settlement; relatively deep embedment might be required on sloping ground due to toe in front of wall face	Applicable to cut and fill situations; can be routinely designed for heights up to 50 ft; proprietary versions typically 33 ft max

Table 1(c) Summary of rigid gravity and semigravity wall options available

Specific Wall Type	Advantages	Disadvantages	Limitations
Soldier pile wall	Very narrow base width; deep embedment to get below potential failure surfaces relatively easy to obtain	Relatively high cost	Applicable mainly to cut situations; maximum feasible exposed height is on the order of 10 ft; difficult to install in bouldery soil or soil with water bearing sands
Sheet pile wall	Low to moderate cost; very narrow base width	Difficult to get embedment in dense or bouldery soils; difficult to protect against corrosion	Applicable mainly to cut situations in soil; maximum feasible exposed height is on the order of 10 ft
Cylinder pile wall	Relatively narrow base width; can produce stable wall even if deep potential failure surfaces present	Very high cost	Applicable mainly to cut situations; max. feasible exposed height is on the order of 20 to 25 ft, depending on passive resistance available; can be installed in bouldery conditions, though cost will increase
Slurry wall	Relatively narrow base width; can produce stable wall even if deep potential failure surfaces present	Very high cost; difficult construction	Applicable mainly to cut situations; maximum feasible exposed height is on the order of 20 to 25 ft, depending on passive resistance available

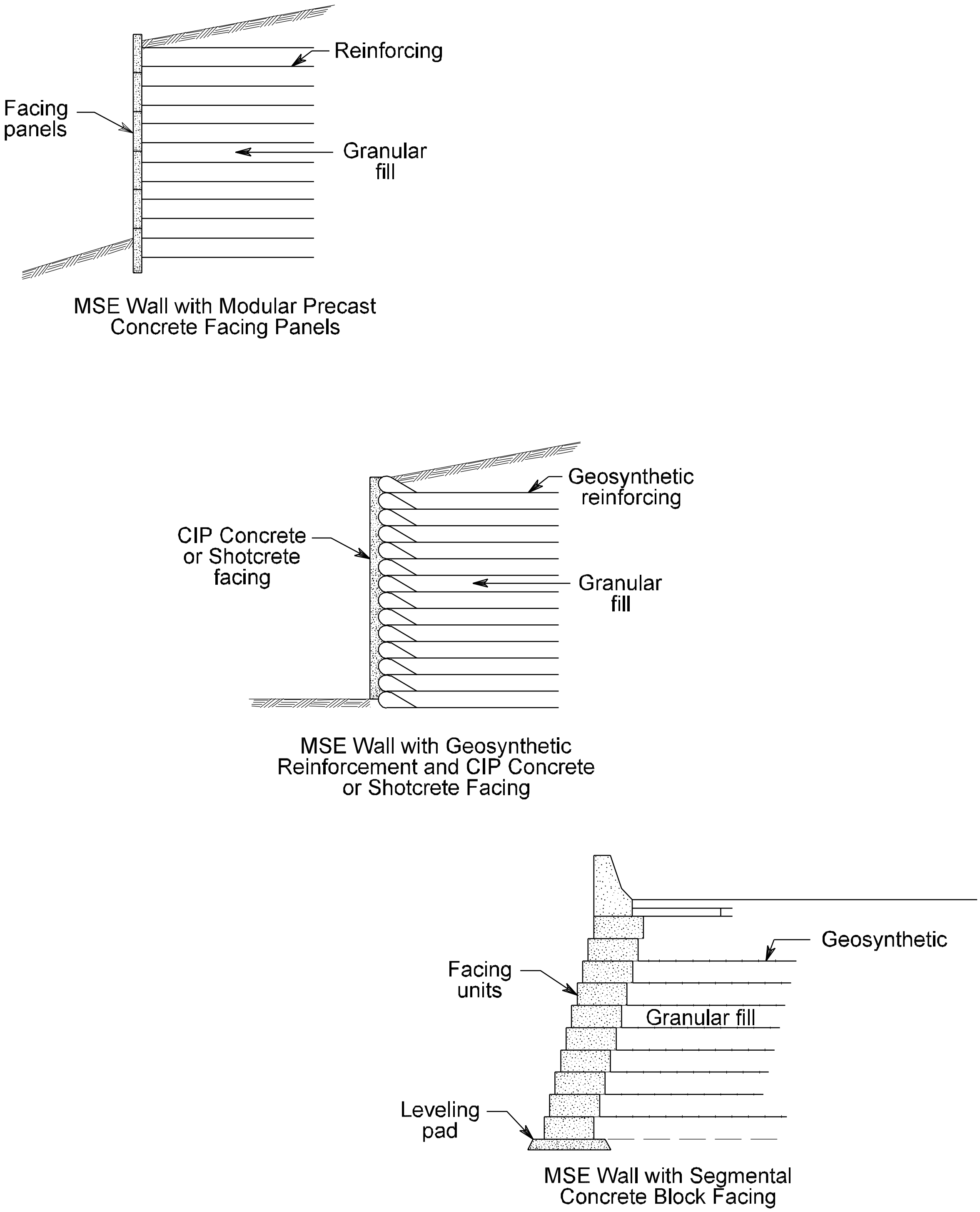
Table 1(d) Summary of nongravity wall options available

Specific Wall Type	Advantages	Disadvantages	Limitations
All nongravity cantilever walls with tiebacks	Relatively narrow base width; can produce stable wall even if deep potential failure surfaces present	Very high cost; difficult to install in areas where vertical or lateral clearance is limited; easements may be necessary; installation activities may impact adjacent traffic	Applicable only to cut situations; can be designed for heights of 50 ft or more depending on the specifics of the structure of the wall
All nongravity cantilever walls with deadman anchors	Relatively narrow base width; can produce stable wall even if deep potential failure surfaces present	Moderate to high cost; must have access behind wall to dig trench for deadman anchor; may impact traffic during deadman installation; easements may be necessary	Applicable to partial cut/fill situations; can be designed for wall heights of approximately 16 ft

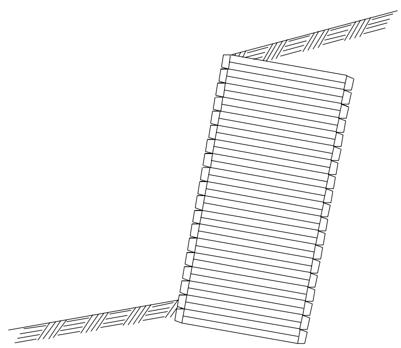
Table 1(e) Summary of anchored wall options available

Wall/Slope Classification	Specific Wall Type	Advantages	Disadvantages	Limitations
Rockeries	Only variations are in rock sizes used and overall wall dimensions	Low cost; narrow base width on the order of 30% of the wall height required	Slope must be at least marginally stable without rockery present; cannot tolerate much settlement	Applicable to both cut and fill situations; max. feasible height in a cut even for excellent soil conditions is approx. 16 ft and 8 ft in fill situations
Reinforced slopes	Only variations are in geosynthetic products used and in erosion control techniques used on slope face	Low cost; can tolerate large settlements; can adapt well to sloping ground conditions to minimize excavation required; high quality fill is not a requirement	Must have enough room between the right of way line and the edge of the shoulder to install a 1H:1V slope	Best suited to sloping fill situations; max. height limited to 30 ft unless geosynthetic products are used in which long-term product durability is well defined. Certain products can be used in critical applications and for greater slope heights on the order of 60 ft or more but consider need, landscaping maintenance, and the reach of available maintenance equipment.

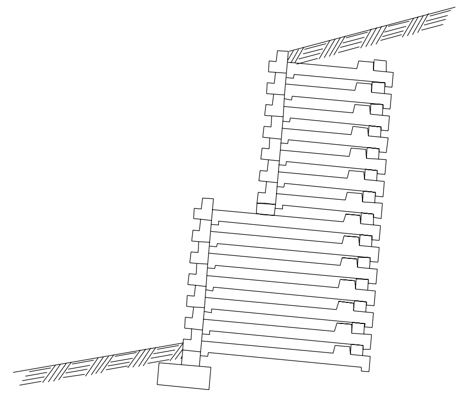
Table 1(f) Other wall/slope options available



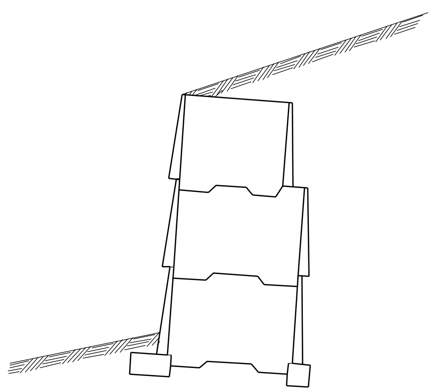
Typical Mechanically Stabilized Earth Gravity Walls
Figure 1130-1a



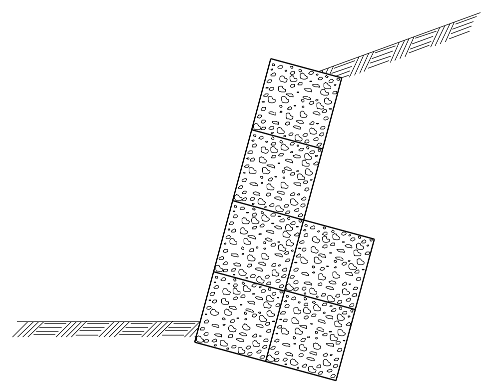
Metal Bin Wall



Precast Concrete Crib Wall

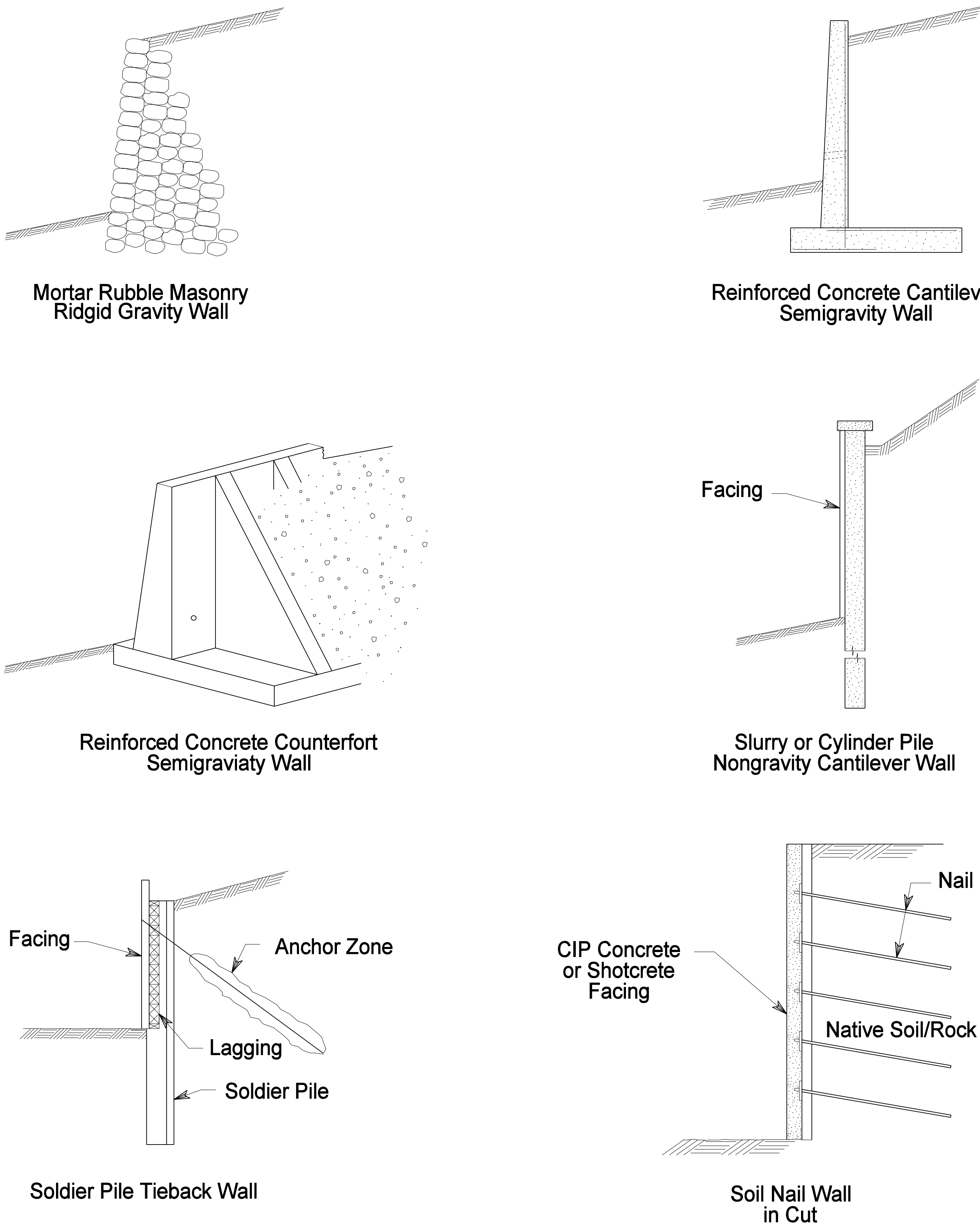


Precast Concrete Bin Wall

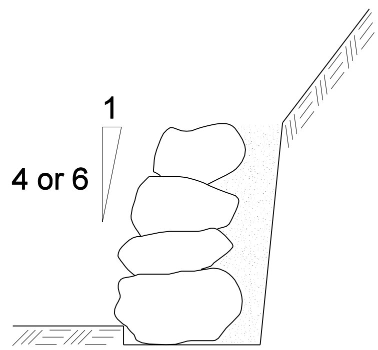


Gabion Wall

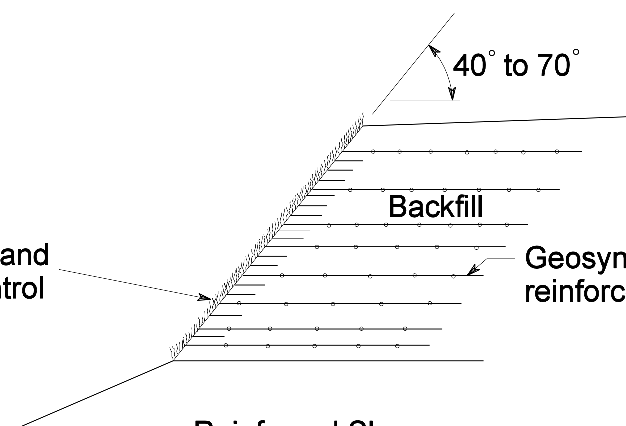
Typical Prefabricated Modular Gravity Walls
Figure 1130-1b



Typical Rigid Gravity, Semigravity Cantilever,
Nongravity Cantilever, and Anchored Walls
Figure 1130-1c

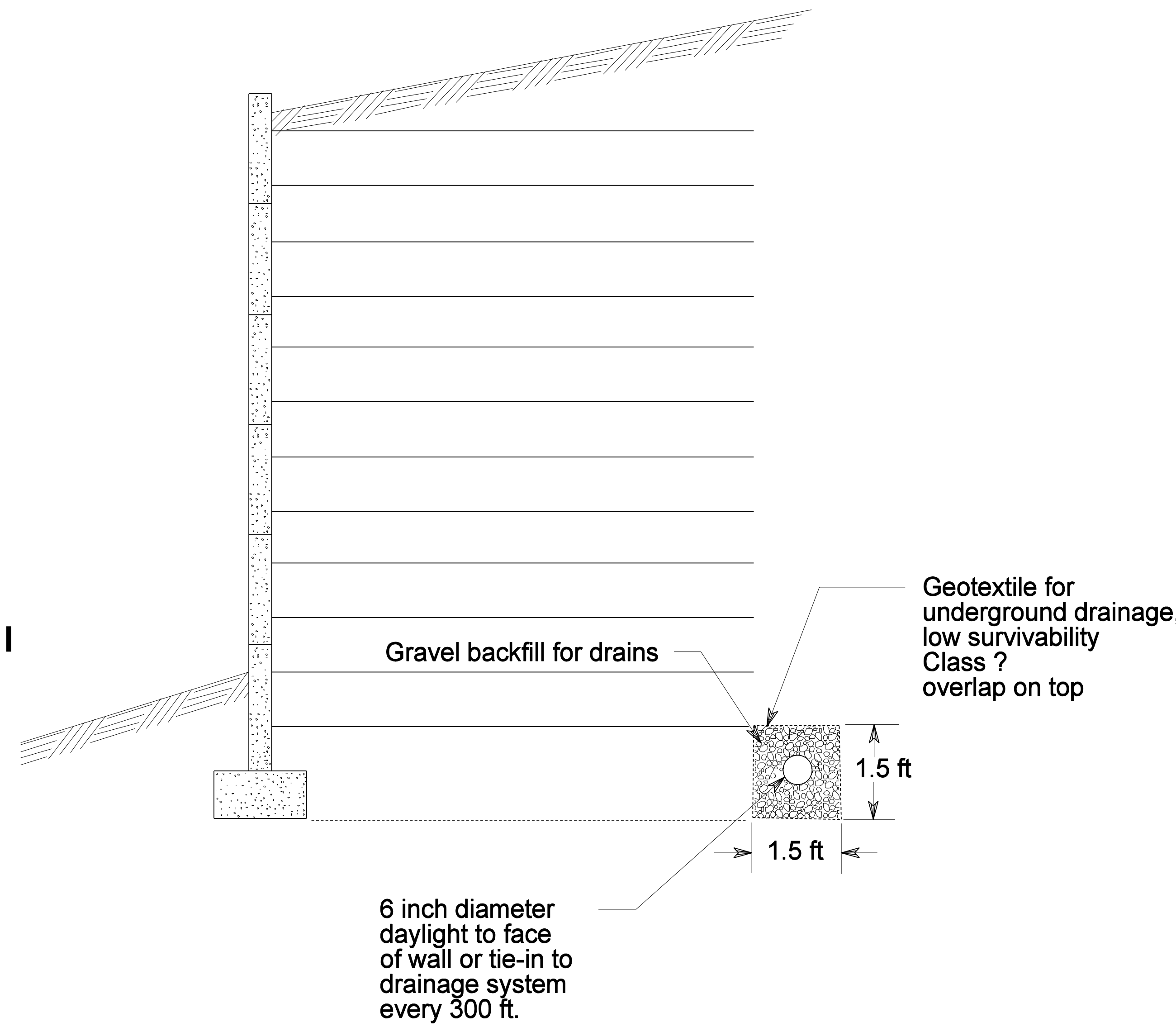


Rockery

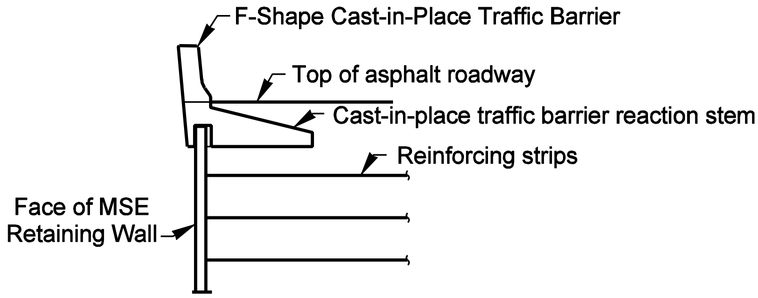


Reinforced Slope

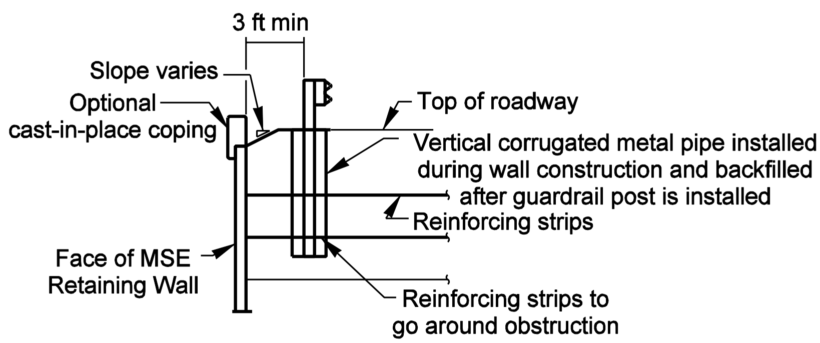
Typical Rockery and Reinforced Slope
Figure 1130-1d



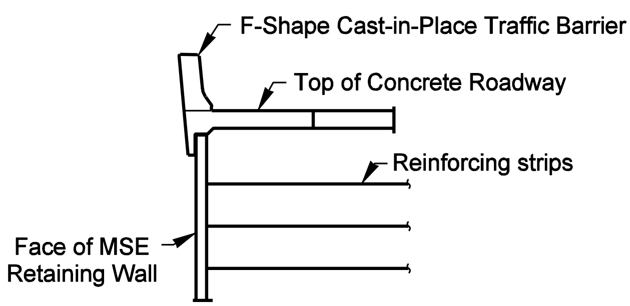
MSE Wall Drainage Detail
Figure 1130-2



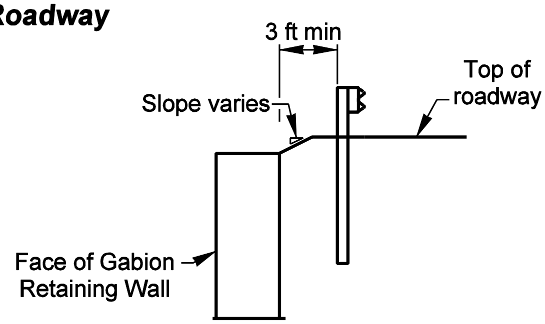
Concrete Traffic Barrier with Asphalt Roadway



Beam Guardrail on Top of MSE Retaining Wall

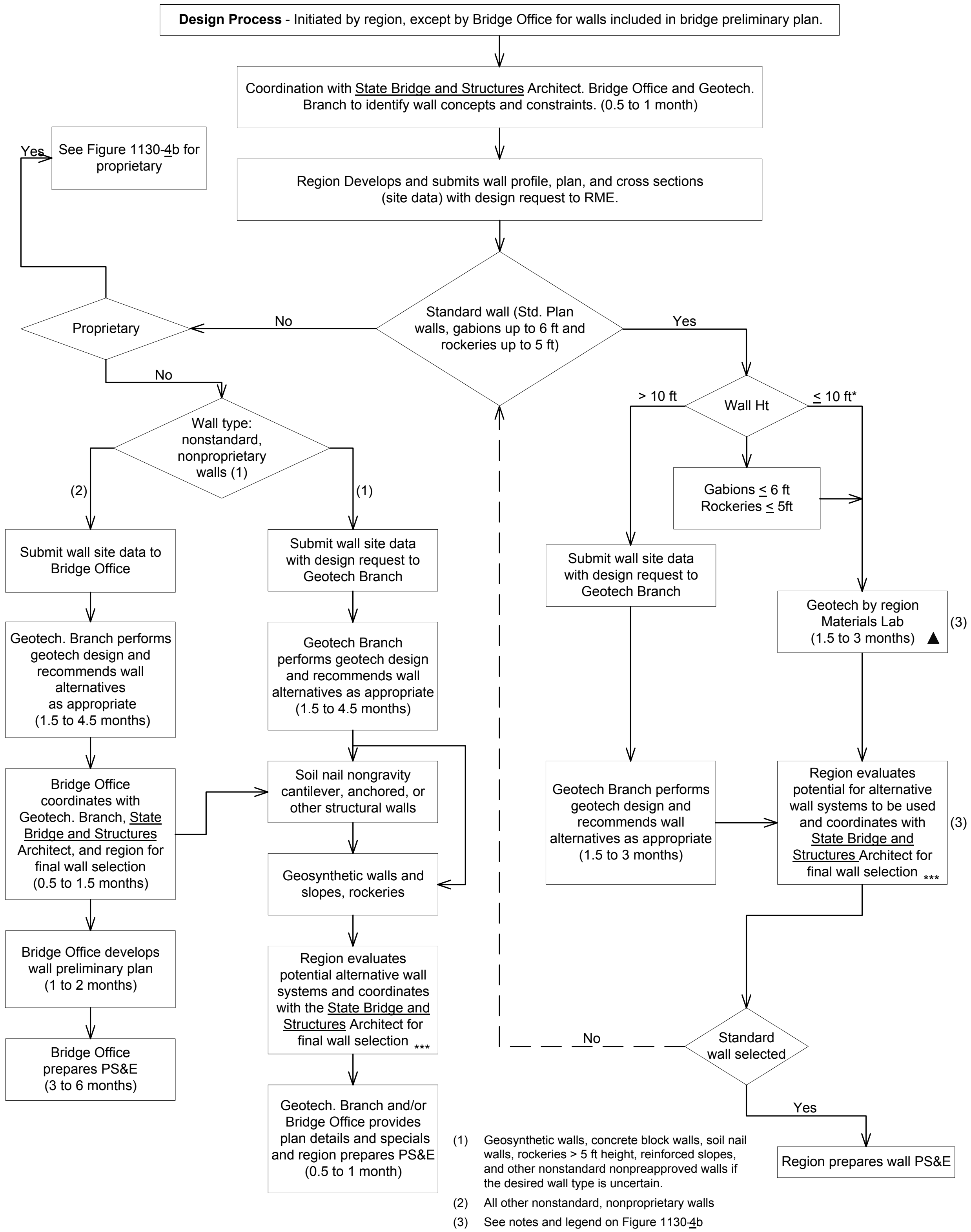


Concrete Traffic Barrier with Concrete Roadway



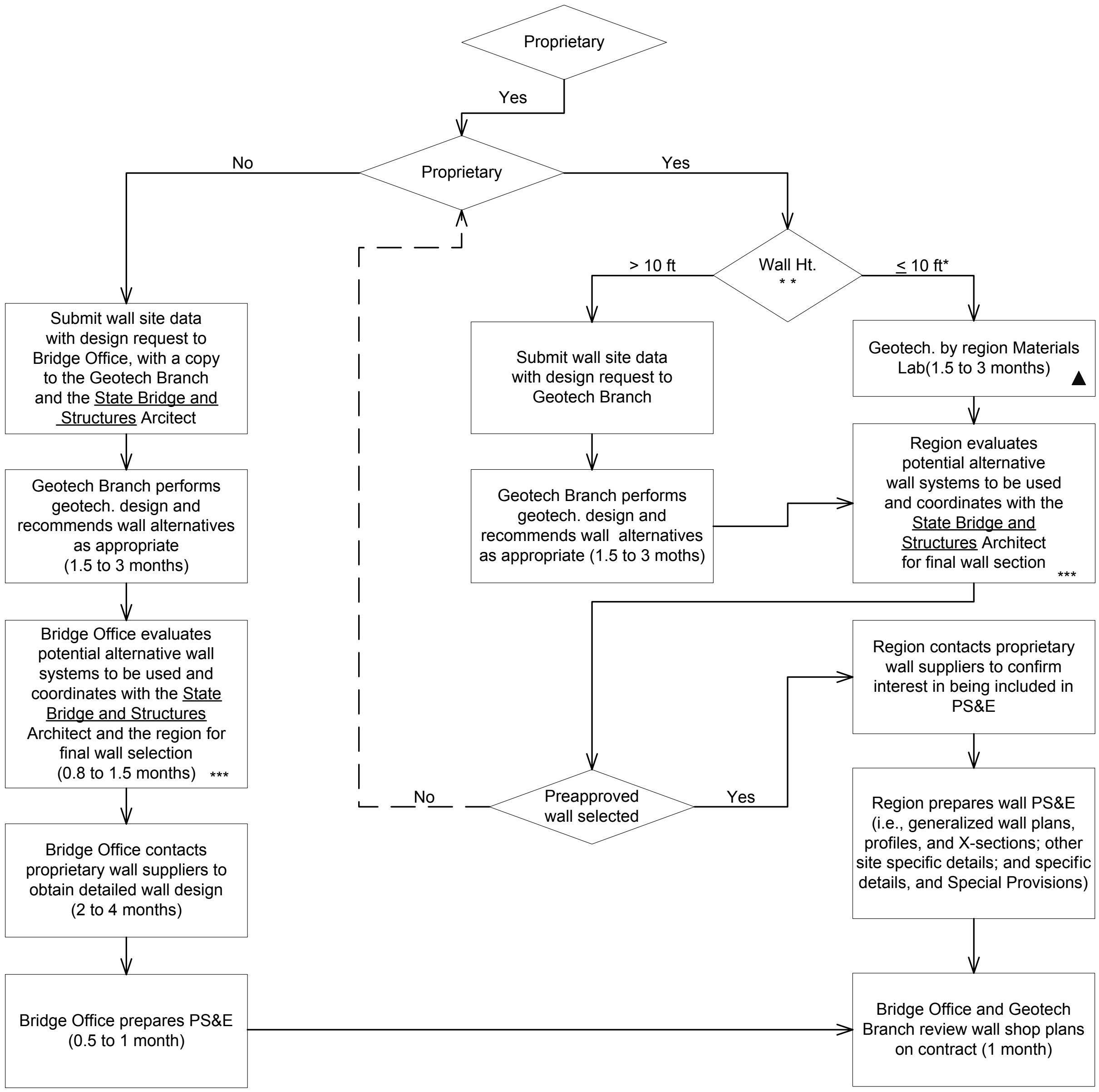
Beam Guardrail on Top of Gabion Wall

Retaining Walls With Traffic Barriers
Figure 1130-3



Retaining Wall Design Process

Figure 1130-4a



Notes:

The "Bridge Office" refers to the WSDOT Bridge and Structures Office in Headquarters.

The "Geotech Branch" refers to the WSDOT Geotechnical Services Branch in Headquarters.

The "State Bridge and Structures Architect" refers to the WSDOT Architecture Section of the Bridge and Structures Office in Headquarters.

Regarding time estimates:

- Assumes no major changes in the wall scope during design.
- Actual times may vary depending on complexity of project.
- Contact appropriate design offices for more accurate estimates of time.

Legend:

▲ Region provides courtesy coy of region's geotechnical report to Geotechnical Branch

* Assumes soft or unstable soil not present and wall does not support other structures.

** The preapproved maximum wall height is generally 33 ft. Some proprietary walls might be less. (Check with the Bridge and Structures Office.)

*** If the final wall selected is a different type than assumed, go back through the design process to ensure that all steps have been taken.

Retaining Wall Design Process - Proprietary

Figure 1130-4b

Ht (ft)	Maximum Soil Pressure (psf) for Reinforced Concrete Retaining Walls											
	Type 1 ①		Type 2 ②		Type 3 ③		Type 4 ④		Type 5 ③		Type 6 ④	
	Static	Earth-quake	Static	Earth-quake	Static	Earth-quake	Static	Earth-quake	Static	Earth-quake	Static	Earth-quake
5	1611	781	1607	770	630	1033	641	1115	702	971	611	798
6	1838	976	1842	974	705	1254	865	1661	908	1322	746	1141
7	1876	1137	1891	1150	797	1558	882	1904	1179	1782	882	1420
8	2178	1431	2213	1465	995	2047	1025	2323	1510	2419	1246	2091
9	2255	1646	2305	1703	1104	2402	1040	2473	1632	2666	1587	2692
10	2492	2078	2492	2063	1216	2786	1065	2651	1924	3224	1635	2918
11	2693	2474	2713	2482	1197	2787	1174	2907	2046	3475	1795	3233
12	2643	2666	2682	2702	1308	3172	1277	3351	2345	4063	1873	3282
13	2732	2999	2693	2923	1458	3560	1304	3158	2384	4041	1955	3377
14	2972	3508	3065	3624	1539	3790	1444	3643	2683	4611	2269	3941
15	3100	3886	3358	4281	1620	4019	1645	4205	2766	4664	2349	4036
16	3166	4128	3420	4552	1752	4305	1748	4466	2818	4715	2668	4603
17	3247	4372	3472	4795	1833	4534	1849	4723	3149	5293	2846	4927
18	3301	4577	3559	5067	2104	5223	2072	5246	3373	5625	2924	5021
19	3399	4825	3405	4877	2217	5457	2208	5534	3691	6417	3175	5551
20	3570	5205	3724	5585	2461	5983	2312	5822	3685	6422	3405	6103
21	3677	5453	3617	5423	2507	6197	2478	6111	3650	6403	3556	6406
22	3752	5659	3696	5664	2635	6473	2610	6547	3778	6672	3737	6741
23	3866	5910	3810	5939	2715	6693	2650	6729	4110	7280	3889	7046
24	4049	6294	3912	6180	2844	6972	2785	7071	4159	7293	4071	7383
25	4166	6544	4058	6457	2973	7252	2949	7462	4492	7894	4228	7689
26	4250	6752	4172	6698	3103	7532	3047	7711	4664	8241	4410	8031
27	4372	7004	4318	6976	3265	7986	3093	7928	4786	8507	4391	8040
28	4496	7258	4463	7254	3394	8264	3106	8115	4956	8832	4575	8385
29	4621	7512	4609	7533	3524	8544	3241	8402	4920	8819	4724	8693
30	4666	7480	4535	7371	3653	8824	3376	8690	4892	8824	4752	8760
31	4795	7734	4682	7648	3816	9280	3536	9130	5068	9158	4901	9068
32	4924	7988	4828	7926			3707	9422	5194	9433	5088	9415
33	5055	8244	4975	8204			3872	9901	5293	9513	5263	9723
34	5186	8500	5122	8483					5328	9603	5191	9536
35	5318	8757	5269	8763					5456	9877	5378	9880

Notes

① 2 ft surcharge or traffic barrier with vertical front face.

② 2 ft surcharge or traffic barrier with sloping front face.

③ 2H:V1 backslope with vertical front face.

④ 2H:1V backslope with sloping front face.

Retaining Wall Bearing Pressure
Figure 1130-5

1140.01 General

The function of a noise barrier is to reduce traffic noise levels at adjoining areas. The noise abatement decisions are made during the environmental stage of the project development process. This is a highly interactive process. Before a noise barrier is designed, the department must be confident that there is significant need, a cost effective and environmentally acceptable noise barrier, a source of funds, and acceptance by adjacent property owners, local governmental agencies, and the general public.

The designer will find the following preliminary design information in the noise report:

- Sources of noise
- Noise receiver locations
- Predicted level of noise reduction
- Locations of existing and future noise impacts along the project corridor
- Barrier location and height recommendations based on what is feasible and reasonable

Design of a noise barrier project is the result of a team effort coordinated by the project engineer.

This chapter addresses the factors that are considered when designing a noise barrier and the associated procedures and documentation requirements.

1140.02 References

Environmental Procedures Manual, M 31-11, WSDOT

Guide Specifications for Structural Design of Sound Barriers, AASHTO

Roadside Manual, M 25-30, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

1140.03 Design

The two basic types of noise barriers are the earth berm and the noise wall. An earth berm can be constructed to the full height required for noise abatement or to partial height in conjunction with a noise wall to reach the required height. A noise wall can be made of concrete, masonry, metal, wood, or other approved innovative products, and can be supported by spread, pile, shaft, or trench footings.

Consideration of the noise report and the visual characteristics of adjacent land forms, vegetation, and structural elements (such as buildings, bridges, and retaining walls) will determine whether a proposed noise barrier might be berm, wall, or both.

An earth berm is the primary alternative if the visual and environmental quality of the corridor will be preserved or enhanced and materials and right of way widths are available. See the *Roadside Manual* for criteria for determining if a vegetated earth berm is appropriate.

The region uses the noise report and other environmental documents (see the *Environmental Procedures Manual*) to help determine the location, exposure conditions, length, and heights of the proposed noise barrier.

To design and locate a noise barrier of any kind, consider the following:

- Desired noise abatement
- Future right of way needs
- Cost and constructibility
- Neighborhood character
- Visual character and quality of the corridor
- Future maintenance of the noise barrier and the whole right of way
- Wind

- Supporting soil
- Earthquakes
- Ground water
- Existing drainage systems and water courses
- Exposure to vehicular impacts
- Potential vandalism
- Existing vegetation and roadside restoration required
- Access for maintenance equipment and enforcement, traffic service, and emergency vehicles
- Access to fire hydrants from both sides
- Pedestrian and bicycle access
- Available and attainable width of right of way for berms
- Aesthetic and structural characteristics of available wall designs
- Visual compatibility of each wall design with other transportation structures within the corridor
- Construction limits for footings
- Locations of existing survey monuments
- Access to, and maintenance of, right of way behind a wall, including drainage structures
- Use of right of way and wall by adjacent property owners
- Drainage and highway runoff
- Drainage from adjacent land
- Existing utilities and objects to relocate or remove
- Water and electricity; needs, sources, and access points

A noise barrier must not have anything (such as bridge columns, light fixtures, or sign supports) protruding in such a way as to present a potential for snagging vehicles.

(1) Earth Berm

(a) Berm slopes are a function of the material used, the attainable right of way width, and the desired visual quality. Slopes steeper than 2H:1V (3H:1V for mowing) are not recommended. Design the end of the berm with a lead-in slope of 10H:1V and curve it toward the right of way line.

(b) See Chapter 710 and the Standard Plans for guidance on redirectional land forms if the berm is to function as a traffic barrier.

(c) See the *Roadside Manual* for guidance regarding vegetation on berms and redirectional land forms.

(2) Noise Wall

(a) When feasible, to encourage competitive bidding, include several alternate noise wall designs in the contract and permit the contractor to submit alternate designs under the value engineering specification.

(b) There are standard noise wall designs in the Standard Plans manual. Additional designs are in various stages of development to become standard plans. The draft-standard design sheets and other preapproved plans are available from the Bridge and Structures Office. The Bridge and Structures Office also works with the regions to facilitate the use of other designs as bidding options.

(c) When a noise wall has ground elevations that are independent of the roadway elevations, a survey of ground breaks (or cross sections at 25-ft intervals) along the entire length of the wall is needed for evaluation of constructibility and to assure accurate determination of panel heights.

(d) Size of openings (whether lapped, door, or gated) depends on the intended users. Agencies such as the local fire department can provide the necessary requirements. Unless an appropriate standard plan is available, such openings must be designed and detailed for the project.

(e) When a noise wall is inside the Design Clear Zone, design its horizontal and vertical (ground elevation) alignment as if it were a rigid concrete traffic barrier. See Chapter 710 for maximum flare rates.

(f) Provide a concrete traffic barrier shape at the base of a new noise wall constructed 12 ft or less from the edge of the nearest traffic lane. The traffic barrier shape is optional at the base of the new portion when an existing vertical-faced wall is being extended (or the existing wall may be retrofitted for continuity). Standard Concrete Barrier Type 4 is recommended for both new and existing walls except when the barrier face can be cast as an integral part of a new wall. Deviations may be considered but require approval as prescribed in Chapter 330. For deviations from the above, deviation approval is not required where sidewalk exists in front of the wall or in other situations where the wall face is otherwise inaccessible to traffic.

See Chapter 710, "Traffic Barriers," for flare rates and approach slopes for concrete barriers.

(g) To designate a standard noise wall, select the appropriate general special provisions and state the standard plan number, type, and foundation type. For example: Noise Barrier Standard Plan D-2a, Type 1A, Foundation D1.

Wall type is a function of exposure and wind speed. See Figure 1140-1.

A geotechnical report identifying the angle of internal friction f and the allowable bearing pressure is needed for selection of a standard foundation. The standard spread footing designs require an allowable bearing pressure of 1 Tsf. The standard trench and shaft footing designs require a f of at least 32° for D1 and 38° for D2.

A special design of the substructure is required for noise walls on substandard soil, where winds exceed 90 mph, and for exposures other than B1 and B2 as defined in Figure 1140-1.

(h) For maintenance of the surface of a tall wall (10 ft or more), consider harness tie-offs for the fall protection required by the Department of Labor and Industries.

	Exposure				
	B1		B2		C
Wind Speed	80 mph	90 mph	80 mph	90 mph	
Wall Type	A	B	C	D	Special Design*

Wind speed is according to Figure 1-2.1.2.A of the (AASHTO) *Guide Specifications for Structural Design of Sound Barriers*. Assume the wind to be perpendicular to the wall on both sides and design for the most exposed side.

Exposure is determined by the nature of the immediately adjacent ground surface and the extension of a plane at the adjacent ground surface elevation for 1,500 ft to either side of the noise wall:

Exposure B1 = Urban and suburban areas with numerous closely spaced obstructions having the size of single-family dwellings or larger that prevail in the upwind direction from the noise barrier for a distance of at least 1,500 ft.

Exposure B2 = Urban and suburban areas with more open terrain not meeting the requirements of Exposure B1.

Exposure C = Open terrain, with scattered obstructions, that includes flat, open country; grasslands; and elevated terrain.

*For a noise wall with Exposure C, on a bridge or overpass, or at the top of a slope, consult the Bridge and Structures Office, as a special design will probably be necessary.

Standard Noise Wall Types
Figure 1140-1

1140.04 Procedures

The noise unit notifies the Project Engineer's Office when a noise barrier is recommended in the noise report.

The Project Engineer's Office is responsible for interdisciplinary teams, consultation, and coordination with the public, noise specialists, maintenance, construction, region's Landscape Architecture Office (or the Roadside and Site Development Services Unit), right of way personnel, Materials Laboratory, State Bridge and Structures Architect (in the Bridge and Structures Office), Bridge and Structures Office, CAE Support Team, Access and Hearings Engineer, consultants, and many others.

The region evaluates the soils (see Chapters 510 and 1110) and, if a noise wall is contemplated, obtains a list of acceptable wall design options by sending information pertaining to soils and drainage conditions, the alignment, and heights of the proposed wall to the State Bridge and Structures Architect.

If a vegetated earth berm is considered, see the *Roadside Manual* for procedures.

The State Bridge and Structures Architect coordinates with the Bridge and Structures Office, Hydraulics Design Branch, Geotechnical Branch, and the region to provide a list of acceptable standard, draft-standard, and preapproved-proprietary noise wall designs, materials, and finishes that are compatible with existing visual elements of the corridor. Only wall designs from this list may be considered as alternatives. Design visualizations of the highway side of proposed walls (available from the CAE Support Team in Olympia) must be limited to options from this list. The visual elements of the private-property side of a wall are the responsibility of the region unless addressed in the environmental documents.

After the noise report, any changes to the dimensions or location of a noise barrier must be reviewed by the appropriate noise unit to determine the impacts of the changes on noise abatement.

On limited access highways, any opening in a wall or fence (for pedestrians or vehicles) must be coordinated with the Access and Hearings Engineer and approved by the State Design Engineer.

On nonlimited access highways, an access connection permit is required for any opening (approach) in a wall or fence.

The Bridge and Structures Office provides special substructure designs to the regions upon request; reviews contract design data related to standard, draft-standard, and preapproved designs; and reviews plans and calculations that have been prepared by others. (See Chapter 1110.)

Approval of the Bridge and Structures Office and the Architecture Office is required for any attachment or modification to a noise wall and for the design, appearance, and finish of door and gate type openings.

Approval of the State Bridge and Structures Architect is required for the final selection of noise wall appearance, finish, materials, and configuration.

1140.05 Documentation

A list of the documents that are required to be preserved in the Design Documentation Package (DDP) or the Project File (PF) is on the following web site:

http://www.wsdot.wa.gov/eesc/design/projectdev/

1210.01 General

Hydraulic design factors can significantly influence the corridor, horizontal alignment, grade, location of interchanges, and the necessary appurtenances required to convey water across, along, away from, or to a highway or highway facility. An effective hydraulic design conveys water in the most economical, efficient, and practical manner to ensure the public safety without incurring excessive maintenance costs or appreciably damaging the highway or highway facility, adjacent property, or the total environment.

This chapter is intended to serve as a guide to highway designers so they can identify and consider hydraulic related factors that impact the design. Detailed criteria and methods that govern highway hydraulic design are in WSDOT's *Hydraulics Manual* and *Highway Runoff Manual*.

Some drainage, flood, and water quality problems can be easily recognized and resolved; others might require extensive investigation before a solution can be developed. Specialists experienced in hydrology and hydraulics can contribute substantially to the planning and project definition phases of a highway project by recognizing potentially troublesome locations, making investigations and recommending practical solutions. Regions may request that the HQ Hydraulics Branch provide assistance regarding hydraulic problems.

Since hydraulic factors can affect the design of a proposed highway or highway facility from its inception, consider these factors at the earliest possible time during the planning phase.

In the project definition phase, begin coordination with all state and local governments and Indian tribes that issue or approve permits for the project.

1210.02 References

(1) Existing Criteria and References

Existing criteria and additional information for hydraulic design requirements, analyses, and procedures are contained in the following references:

Hydraulics Manual, M 23-03, WSDOT

Highway Runoff Manual, M 31-16, WSDOT

Standard Plans for Road, Bridge and Municipal Construction, (Standard Plans) M 21-01, WSDOT

Standard Specifications for Road, Bridge and Municipal Construction, (Standard Specifications) M 41-10, Amendments, and General Special Provisions, WSDOT

Utilities Manual, M 22-87, Section 1-19, "Storm Drainage," WSDOT

(2) Special Criteria

Special criteria for unique projects are available on request from the HQ Hydraulics Branch.

1210.03 Hydraulic Considerations

(1) The Flood Plain

Encroachment of a highway or highway facility into a flood plain might present significant problems. A thorough investigation considers the following:

(a) The effect of the design flood on the highway or highway facility and the required protective measures.

(b) The effect of the highway or highway facility on the upstream and downstream reaches of the stream and the adjacent property.

(c) Compliance with hydraulic related environmental concerns and hydraulic aspects of permits from other governmental agencies per Chapters 220 and 240.

Studies and reports published by the Federal Emergency Management Agency (FEMA) and the Corps of Engineers are very useful for flood plain analysis. The HQ Hydraulics Branch has access to all available reports and can provide any necessary information to the region.

(2) Stream Crossings

When rivers, streams, or surface waters (wetland) are crossed with bridges or culverts (including open bottom arches and three-sided box culverts), consider the following:

- Locating the crossing where the stream is most stable.
- Effectively conveying the design flow(s) at the crossing.
- Providing for passage of material transported by the stream.
- The effects of backwater on adjacent property.
- Avoiding large skews at the crossing.
- The effects on the channel and embankment stability upstream and downstream from the crossing.
- Location of confluences with other streams or rivers.
- Fish and wildlife migration.
- Minimizing disturbance to the original streambed.
- Minimizing wetland impact.

Also see the *Hydraulics Manual* Chapter 8 for further design details.

(3) Channel Changes

It is generally desirable to minimize the use of channel changes because ongoing liability and negative environmental impacts might result. Channel changes are permissible when the designer determines that a reasonable, practical alternative does not exist. When used, consider:

(a) Restoration of the original stream characteristics as nearly as practical. This includes:

- Meandering the channel change to retain its sinuosity.
- Maintaining existing stream slope and geometry (including meanders) so stream velocity and aesthetics do not change in undisturbed areas.
- Excavation, selection, and placement of bed material to promote formation of a natural pattern and prevent bed erosion.
- Retention of stream bank slopes.
- Retention or replacement of streamside vegetation.

(b) The ability to pass the design flood.

(c) The effects on adjacent property.

(d) The effects on the channel and embankment upstream and downstream from the channel change.

(e) Erosion protection for the channel change.

(f) Environmental requirements such as wetlands, fish migration, and vegetation re-establishment.

Do not redirect flow from one drainage basin to another. (Follow the historical drainage pattern.)

Consult the HQ Hydraulics Branch for the best guidance when channel changes are considered.

(4) Roadway Drainage

Effective collection and conveyance of storm water is critical. Incorporate the most efficient collection and conveyance system considering initial highway costs, maintenance costs, and legal and environmental considerations. Of particular concern are:

(a) Combinations of vertical grade and transverse roadway slopes that might inhibit drainage.

(b) Plugging of drains on bridges as the result of construction projects. This creates maintenance problems and might cause ponding on the structure. The use of drains on structures can be minimized by placing sag vertical curves and crossovers in superelevation outside the limits of the structure.

(c) See Chapter 630 for discussion of the relationship of roadway profiles to drainage profiles.

(5) Subsurface Drainage

Subsurface drainage installations control ground water encountered at highway locations. Ground water, as distinguished from capillary water, is free water occurring in a zone of saturation below the ground surface. The subsurface discharge depends on the effective hydraulic head and on the permeability, depth, slope, thickness, and extent of the aquifer.

The solution of subsurface drainage problems often calls for specialized knowledge of geology and the application of soil mechanics. The region Materials Engineer evaluates the subsurface conditions and includes findings and recommendations for design in the geotechnical report.

Typical subdrain installations control seepage in cuts or hillsides, control base and shallow subgrade drainage, or lower the ground water table (in swampy areas, for example).

Design a system that will keep the stormwater out of the subsurface system when stormwater and subsurface drainage systems are combined.

(6) Subsurface Discharge of Highway Drainage

Consider subsurface discharge of highway drainage when it is a requirement of the local government or when existing ground conditions are favorable for this type of discharge system. Criteria for the design of drywells or subsurface drainage pipe for this type of application are described in Chapter 6 of the *Hydraulics Manual*. The criteria for the design of infiltration ponds are described in the *Highway Runoff Manual.*

(7) Treatment of Runoff

On certain projects, effective quantity control of runoff rates and removal of pollutants from pavement are intended to address flooding and water quality impacts downstream. See the *Highway Runoff Manual* for specific criteria on quantity and quality control of runoff.

1210.04 Safety Considerations

Locate culvert ends outside the Design Clear Zone when practical. See Chapter 700 for culvert end treatments when this is impractical.

See Chapter 1460 regarding fencing for detention ponds and wetland mitigation sites.

1210.05 Design Responsibility

Chapter 1 of the *Hydraulics Manual* describes the responsibilities of the regions and the HQ Hydraulics Branch relative to hydraulic design issues.

1300.01 General

It is WSDOT policy to employ roadside treatments for the protection and restoration of community and roadside character as designated in the *Roadside Classification Plan* (RCP) and described in the *Roadside Manual*. WSDOT is committed to community-based context sensitive design, which is reflected in the Context Sensitive Solutions Executive Order (E 1028.00) and the 2003-2022 Washington Transportation Plan (WTP).

Whenever a project disturbs, or adds elements to, the roadside, the project is responsible for restoring roadside functions. This includes contour grading, visual elements (such as walls, lighting, signs, and bridges), pedestrian movement, vegetation, and stormwater treatment. The extent of restoration is dependent upon the source of funding. Figure 1300-1 and the following paragraph summarize the guidance found in the *Roadside Classification Plan*.

Funding	Restore Roadside Functions Beginning to End of Project R/W Line to R/W Line	Restore Only Roadside Functions That are Impacted by the Project
Mobility (I1) Economic Development (I3)	√	
Safety Improvement (I2) Environmental Retrofit (I4) Preservation (P)		√

Funding Source Determines Extent of Restoration
Figure 1300-1

For Mobility (I1) and Economic Development (I3) programs, the project is responsible for restoring the entire roadside from right of way line to right of way line and from beginning to end of project using the guidelines found in the RCP. For Preservation (P), Safety Improvement (I2), and Environmental Retrofit Program (I4) projects, the project is responsible for restoring roadside functions that are disturbed by the project, using the guidelines found in the RCP.

The *roadside* is the area outside the traveled way. This applies to all lands managed by WSDOT and may extend to elements outside the right of way boundaries. This includes unpaved median strips and auxiliary facilities such as rest areas, roadside parks, viewpoints, heritage markers, pedestrian and bicycle facilities, wetlands and their associated buffer areas, stormwater treatment facilities, park and ride lots, and quarries and pit sites.

The roadside is managed to fulfill operational, environmental, visual, and auxiliary functions. In reality, these functions are interrelated and inseparable. One element, such as vegetation, can provide multiple functions simultaneously. For example, vegetation provides erosion prevention and sediment control, stormwater quality and quantity control, may provide distraction screening, and may provide screening of the road from the view of adjacent residents. Roadside functions are described in detail in the *Roadside Manual,* (M 25-30).

The design of a roadside project incorporates site conditions, commitments, and the extent of need. Roadside development concepts covered elsewhere in the *Design Manual* are:

- Contour grading (Chapter 1310)
- Fencing (Chapter 1460)
- Irrigation (Chapter 1330)
- Jurisdiction (Chapters 325, 330, 700)
- Noise barriers (Chapter 1140)
- Retaining walls (Chapter 1130)

- Roadside safety (Chapter 700)
- Safety rest areas, roadside parks, view-points, and historical markers (Chapter 1030)
- Signs (Chapter 820)
- Traffic barriers (Chapter 710)
- Utilities (*Utilities Manual* and *Utilities Accommodation Policy*)
- Vegetation (Chapter 1320)

1300.02 References

Roadside Design Guide, AASHTO

Roadside Classification Plan, M 25-31, WSDOT

Roadside Manual, M 25-30, WSDOT

Utilities Accommodation Policy, M 22-86, WSDOT

Utilities Manual, M 22-87, WSDOT

Maintenance Manual, M 51-01, WSDOT

Understanding Flexibility in Transportation Design – Washington, WSDOT (Dec 2004)

1300.03 Legal Requirements

The following paragraphs represent a partial list of legal requirements relating to roadside work. Further laws, regulations, and policies can be found in the *Roadside Manual*, Section 200.

Washington Administrative Code (WAC) 173-270-040 requires the department to establish and maintain stable plant communities that resist encroachment by undesirable plants, noxious weeds, and other pests. It also requires a vegetation management plan that includes operational, aesthetic, and environmental standards. http://www.leg.wa.gov/wac/index.cfm?fuseaction=Section&Section=173-270-040

WAC 468-34-340 requires utilities to repair or replace unnecessarily removed or disfigured trees and shrubs, and specifies vegetation management practices when utilities use highway right of way. http://www.leg.wa.gov/wac/index.cfm?fuseaction=Section&Section=468-34-340

Revised Code of Washington (RCW) 47.40.010 states that planting and cultivating of any shrubs, trees, hedges or other domestic or native ornamental growth, the improvement of roadside facilities and view points, and the correction of unsightly conditions upon the right of way of any state highway is declared to be a proper state highway purpose.

RCW 47.40.020 authorizes the department to expend funds for this purpose. http://www.leg.wa.gov/RCW/index.cfm?fuseaction=chapterdigest&chapter=47.40

RCW 47.40.040 requires screening or removal of junkyards, located outside a zoned industrial area and within 1000 feet of the nearest edge of the right of way, so they are not visible from the traveled way. The department is authorized to acquire land for the purposes of screening these junkyards. http://www.leg.wa.gov/RCW/index.cfm?section=47.41.040&fuseaction=section

Code of Federal Regulation (CFR) 23 CFR 752 "Highway Beautification Act" furnishes guidelines and prescribes policies regarding landscaping and scenic enhancement programs, safety rest areas, scenic overlooks, and information centers. Policy statement (a) states "highway esthetics is a most important consideration in the Federal aid highway program. Highways must not only blend with our natural social, and cultural environment, but also provide pleasure and satisfaction in their use." http://frwebgate6.access.gpo.gov/cgi-bin/waisgate.cgi?WAISdocID=44327678878+12+0+0&WAISaction=retrieve

United States Code 23 USC 319, On Federal-aid highways, the costs of landscape and roadside development, including acquisition and development of rest areas and land necessary for the restoration, preservation, and enhancement of scenic beauty adjacent to such highways is authorized. http://uscode.house.gov/uscode-cgi/fastweb.exe?search

For any work in, or near wetlands, **Section 404 of the Clean Water Act** may apply. The act requires a permit to discharge dredged or fill materials into most waters of the United States, including wetlands. The Section 404 permitting process requires advanced planning and coordination with the permitting agency: the U.S. Army Corps of Engineers. Work with the regional environmental office for guidance on the 404 permit.

The *Roadside Classification Plan* and the *Roadside Manual* provide policy and guidance for the manner in which WSDOT implements these laws.

1300.04 *Roadside Classification Plan*

The *Roadside Classification Plan* (M25-31) coordinates and guides the management of Washington State highway roadsides within a framework of roadside character classifications. It provides policy and criteria for roadside restoration and advocates the use of native plants, integrated vegetation management (IVM), and a long-term management approach to achieve sustainable roadsides.

1300.05 *Roadside Manual*

The *Roadside Manual* establishes a common basis for consistent roadside management decisions statewide. It shows the links and coordination necessary between all WSDOT partners responsible for roadside activities.

It also establishes a convenient and accessible reference for new and previously unpublished material related to roadside management including planning, design, construction, and maintenance. In addition, the manual supplements statewide roadside criteria established in the *Roadside Classification Plan*.

A partial example of information to be found in the *Roadside Manual* includes:

- Federal, state, and departmental roadside law and policy.
- Americans with Disabilities Act.
- Safety Rest Areas and Scenic Byways.
- Roadside treatments such as erosion control, landform grading, soil bioengineering, wetland mitigation, and vegetation restoration.

See the *Roadside Manual* table of contents for more information on chapters in the manual.

1300.06 Project Development

The region's Landscape Architect designs, supervises, has approval authority of, and stamps roadside restoration and revegetation plans, and is responsible for coordinating the visual elements within highway corridors. The region's Landscape Architect also designs and supervises other roadside work, such as site design for park and ride lots or safety rest areas, to ensure roadside restoration is designed and constructed to WSDOT standards. The Landscape Architect is also responsible for visual discipline reports for environmental documentation. The Headquarters (HQ) Roadside & Site Development Unit will do roadside design, visual impact assessment, and construction inspection work for the project offices in regions without a Landscape Architect.

There are typically two types of roadside restoration projects pertaining to vegetation that are related to roadway construction projects. The first type is work related to regulatory requirements. This work typically must occur at the time of impact to an identified resource in order to meet permit requirements. These projects will typically be a part of the roadway construction contract. The second type of project is the restoration of construction impacts to meet WSDOT policy requirements as outlined in the RCP. It is often advisable to do this revegetation work as a separate contract because roadside restoration is done after the road construction is completed. At that time, all impacts can be identified that may be different than anticipated during the original project design, the prime contractor can be specialized in roadside work, and plant establishment periods can last between 3 and 10 years and extend the roadway contract period. The Landscape Architect typically administers this contract with funding from the project.

1300.07 Documentation

A list of the documents that are required to be preserved in the Design Documentation Package (DDP) or the Project File (PF) is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

Chapter 1310 Contour Grading

1310.01 General

Contour grading is an important element in achieving operational, environmental and visual functions.

Contour grading plans are required when profiles and cross sections do not provide a complete picture. Examples include stream channel changes, interchanges, noise abatement berms, wetland mitigation sites, and detention/retention ponds. Contour grading plans show the subtle changes in grading that occur between cross sections and can allow for finer grading so that the constructed earthform blends smoothly into the surrounding landscape. While engineered slopes define grades to meet engineering requirements, contours can be used to define a finished grade that will blend the facility into the surrounding landscape and meet the requirements of the *Roadside Classification Plan*.

A detention/retention pond can be designed and constructed to appear as if it were naturally formed. Contour grading plans facilitate this kind of earth sculpting. In addition, contour grading plans can be critical to wetland mitigation sites where inaccurate grading can leave a proposed mitigation site without access to a water source.

See the *Roadside Manual* for more detailed information on grading for roadsides.

1310.02 References

Roadside Manual, M 25-30, WSDOT

Roadside Classification Plan, M 25-31, WSDOT

Standard Plans for Road, Bridge and Municipal Construction (Standard Plans), M 21-01, WSDOT

1310.03 Procedures

See Chapter 330 for design approval levels.

When contour grading plans are needed, consult the regional, or Headquarters (HQ) Roadside & Site Development Unit.

Submit plans for contour grading on structures (such as lids) to the HQ Bridge and Structures Office for approval.

1310.04 Recommendations

Consider the following factors when developing a contour grading plan:

- Balancing of cut and fill within project limits.
- Preservation of existing desirable vegetation.
- Preservation of existing topsoil.
- Vehicle recovery areas.
- Sight distance.
- Pedestrian safety and security.
- Impacts to groundwater and surface water both on and off the right of way, including wetlands.
- Slope angle and potential soil erosion.
- Slope rounding.
- Drainage (including detention/retention functions).
- Surrounding landscape.
- Visual factors (a form that blends with the adjacent landforms).
- Grading construction cost.
- On slopes steeper than 2H to 1V it may be difficult to stabilize and establish vegetation.
- Soil properties and angle of repose.
- Maintenance access to drainage and traffic operational features.

- Maintenance requirements for slopes (slopes steeper than 3H:1V cannot be mowed).
- Access along fence line or noise walls, if necessary.
- Maximum allowable cut/fill next to a structure (minimum cover over a footing, maximum fill behind a wall or next to a pier).

Use a known stationing point or baseline as a starting point in drawing contours.

Recommended contour interval:

- 1 ft for highway plan drawings.
- 1 ft contour intervals for noise wall berms, and pedestrian related facilities.
- 0.5 ft contour intervals for wetland mitigation sites, stream mitigation sites, and wetland bank sites. Include two or more cross-sections done at a vertical exaggeration sufficient to communicate the design intent.

1310.05 Documentation

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

1320.01 General

Roadside vegetation provides operational, environmental, and visual benefits to WSDOT roadway users. Vegetation preservation and restoration is an integral part of roadside planning and design. When a project disturbs a roadside segment, that project is responsible for meeting the requirements of the roadside classification for that road segment. This may include working outside the actual disturbed area for buffering and blending into the surrounding landscape.

Consult early in the project process with the region Landscape Architect, or the Headquarters (HQ) Roadside & Site Development Unit for regions without a Landscape Architect, for all projects involving revegetation.

1320.02 References

Roadside Classification Plan, M 25-31, WSDOT

Roadside Manual, M 25-30, WSDOT

Integrated Vegetation Management for Roadsides, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

State Highway System Plan (HSP)

1320.03 Discussion

Operational, Environmental and Visual Functions of Roadside Vegetation

Roadside vegetation serves various functions. Vegetation is used to:

- Prevent soil erosion.
- Enhance water quality.
- Provide for water storage and slow runoff.
- Aid in de-watering soils.
- Stabilize slopes.
- Protect or restore wetlands and sensitive areas.
- Preserve and provide habitat.
- Prevent noxious weed infestation.
- Provide positive driver cues for guidance and navigation.
- Provide for corridor continuity.
- Screen glare and distractions, and buffer view of neighboring properties from the roadway.
- Buffer view of roadway by neighboring property owners.
- Preserve scenic views.
- Reduce driver monotony.
- Provide a transition between the transportation facility and adjacent land uses.
- Provide for a pleasing roadside experience.

1320.04 Design Guidelines

(1) General

The type and extent of vegetation will vary depending on the roadside character classification of the road segment, the approved treatment level of the project, the affected roadside management zone, and the planting environment. Select and maintain vegetation so that it does not present a hazard or restrict sight distances of drivers to other vehicles and to signs.

Apply the following guidelines when designing roadside revegetation projects:

- Meet the requirements of the *Roadside Classification Plan*.
- Review Corridor Master Plans and the *State Highway System Plan* for future projects and corridor goals.

- Design revegetation plans, including wetland mitigation sites and detention/retention ponds, to be sustainable over time and to require a low level of maintenance.
- Design roadside revegetation and restoration plans to reduce pesticide use.
- Select and maintain plants to achieve required clear zone, sight distance, clear sight to signing, and headlight screening.
- Evaluate the mature characteristics of plant species to meet safety requirements. Consider size and extent of vegetation at maturity for sight distance, clear zone, and shading problems.
- Preserve existing desirable vegetation and topsoil to the maximum extent reasonable.
- Select plants adaptable to the site conditions. Select native plants as the first choice, unless conditions warrant non-native species to be sustainable. (See the *Roadside Manual* for more information.)
- Consider stripping, stockpiling, and reapplying topsoil if construction will disturb topsoil. When this is not feasible, amend remaining soil to meet horticultural requirements, to reduce compaction, and to increase moisture retention.
- Consider design speeds in the selection and location of plants. For example, as traffic speed increases, include larger groupings of fewer species in the landscape since the motorist's perception of detail along the roadside diminishes.
- Accommodate existing and proposed utilities.
- When selecting vegetation, consider screening undesirable views, or consider allowing openings to reveal or maintain desirable views.
- Design roadsides, particularly areas under bridges, to reduce potential for homeless encampments. Keep clear lines of sight where this potential exists.

Roadway geometrics will also affect the type and extent of vegetation in specific locations. The maximum allowable diameter of trees within the Design Clear Zone is 4 in. measured at 6 in. above the ground when the tree has matured. Consider limiting vegetation diameters on the outside of curves beyond the Design Clear Zone to improve safety. See the *Roadside Manual* for more information.

(2) Existing Vegetation.

Avoid destruction of desirable existing vegetation, reduce impacts on desirable existing vegetation, and restore desirable damaged vegetation.

- Protect desirable existing vegetation wherever possible.
- Delineate trees that are to remain within the construction zone and provide adequate protection of the root zone (extending from the tree trunk to a minimum of 3 ft beyond the drip line).
- Encourage desirable vegetation by using revegetation techniques to prevent or preclude the establishment of undesirable vegetation. See *Integrated Vegetation Management for Roadsides.*
- Limit clearing and grubbing (especially grubbing) to the least area possible.

Selectively remove vegetation to:

- Remove dead and diseased trees when they are a hazard (including those outside the clear zone).
- Maintain clear zone and sight distance.
- Increase solar exposure and reduce accident rates, if analysis shows that removing vegetation will improve safety.
- Open up desirable views.
- Encourage understory development.
- Encourage individual tree growth.
- Prevent plant encroachment on adjacent properties.
- Ensure long-term plant viability.

Refer to Division 8 of the *Roadside Manual* for more information.

(3) Plant Material Selection.

Select noninvasive vegetation (not having the potential to spread onto roadways, ditches and adjacent lands).

Base plant material selection on:

- Functional needs of the roadside.
- Maintenance requirements.
- Site analysis and conditions expected after the facility is constructed.
- Horticultural requirements.
- Plant availability.
- Plant success rates in the field.
- Plant cost.
- Traffic speed.

The *Roadside Manual* provides more detailed guidelines on plant selection, sizing, and location.

(4) Establishment of Vegetation

Most WSDOT projects have 1 to 3-year plant establishment periods. Wetland mitigation projects often include additional years of monitoring and plant establishment to ensure that mitigation standards of success, defined in the permit conditions, are met. The goal of plant establishment is to promote a healthy, stable plant community and a project that has achieved a reasonable aerial coverage prior to WSDOT Maintenance taking over the responsibility and associated costs.

Soil treatments, for example incorporation of soil amendments such as compost into the soil layer, surface mulching, and the use of slow release fertilizer will improve the success rate of revegetation after highway construction activities have removed or disturbed the original topsoil. Woody native plants will grow faster and require less weed control through the combined use of compost and bark mulch. (Check with the local maintenance office or the local jurisdiction's comprehensive plan for any restrictions on fertilizer use, such as those in well-head protection areas or restricted watershed areas.)

- Use soil amendments based on the soil analysis done for the project. Soil testing is coordinated through the HQ Horticulturist or the Landscape Architect. Soil amendments will enhance the soil's moisture holding capacity.
- Use surface mulches to conserve soil moisture and moderate soil temperatures. Mulches also help keep weeds from competing with desirable plants for water and nutrients, and provide organic matter and nutrients to the soil.
- Permanent irrigation systems are only to be used in urban or semiurban areas where vegetation is surrounded by paved surfaces or it does not have available groundwater. Use temporary systems to establish vegetation when needed. If irrigation is required, see Chapter 1330 for design guidelines and the *Roadside Manual* for more detail.
- Weed control is necessary for plant establishment success. Include funding for weed control in the project budget to cover the full plant establishment period. The duration of this period is dependent upon plant and permit requirements.

1320.05 Documentation

A list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

1330.01 General

Irrigation provides additional moisture to plants during their establishment (the first 3-5 years), or in special cases, on a continuing basis. Irrigation is a high maintenance and high cost item; use only when absolutely necessary. Permanent irrigation is only used in semiurban and urban character classifications in Treatment Levels two and three. Refer to the *Roadside Classification Plan* for more information. Contact the regional Landscape Architect or the Headquarters (HQ) Roadside & Site Development Unit for assistance with irrigation plans.

1330.02 References

Roadside Classification Plan, M 25-31, WSDOT

Roadside Manual, M 25-30, WSDOT

1330.03 Design Considerations

During the project planning phase:

(a) Determine whether irrigation is necessary.

- Analyze soils
- Determine local climate conditions and microclimates
- Consult with the HQ Horticulturist, regional Landscape Architect, or HQ Roadside & Site Development Unit for regions without landscape architectural expertise for site, soil, and plant recommendations to reduce or eliminate need for irrigation
- Describe where irrigation is needed based on a functional design concept, such as "irrigation is needed to provide green lawn at a safety rest area"

(b) Determine the source of water, and its availability, rate of flow and pressure, and connection fees.

Sources of water for irrigation use include municipal water systems and water pumped from a well, pond, or stream. When selecting a source of water, consider what permits and agreements may be needed as well as the cost and feasibility of bringing water from the source to the site.

(c) Determine applicable laws and regulations regarding water, and backflow prevention.

During the design and implementation phases:

(a) Coordinate with the local water purveyor.

(b) Select durable, readily available, easy to operate, and vandal resistant irrigation components.

(c) Justify any proprietary device selections.

(d) Determine power source and connection fees.

(e) Consider the need for winterization of the irrigation system to avoid freeze damage to system components.

Use this information to document design decisions for the project file.

Show the location and type of water source on the irrigation plan.

For more detailed information on irrigation systems and irrigation documentation, see the *Roadside Manual*.

1330.04 Documentation

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

1350.01 General

Soil bioengineering is a land stabilization technology applied to disturbed sites and on slope and streambank projects. A multidisciplinary partnership is used to implement soil bioengineering techniques. Project managers initiate and design bioengineering features by employing the expertise of WSDOT hydraulic engineers, geotechnical engineers, engineering geologists, landscape architects, horticulturists, biologists, water quality specialists, environmental planners, and others. Soil bioengineering for slope stabilization provides additional environmental benefits such as habitat enhancement and water quality improvement.

Include consideration of slope geometry, climate, water regime, soil properties, and surrounding vegetation in soil bioengineering proposals. Applications of soil bioengineering are divided into three general categories: erosion control, streambank or shoreline stabilization, and upland slope stabilization. Refer to manuals according to the related discipline.

1350.02 References

For more detailed information, see:

Design Manual chapters, M 21-01, WSDOT:

1300 Roadside Development

510 Investigation of Soils, Rock, and Surfacing Materials

640 Geometric Cross Section

1130 Retaining Walls

1210 Hydraulics

Geotechnical Guidance — see geotechnical report for slope/soil stability. If further assistance is needed, contact Regional Materials Engineer.

Hydraulics Manual, M 23-03, WSDOT — for hydrology criteria.

Highway Runoff Manual, M 31-16, WSDOT — for Stormwater Site Plans, Temporary Erosion and Sediment Control Plans, and best management practices.

Roadside Manual, M 25-30, WSDOT — for vegetation and site preparation criteria, plant selection, design configurations, and other related topics.

Roadside Classification Plan, M 25-31, WSDOT — policy and guidelines for roadside treatment. Contact the region's Landscape Architect Office or the HQ Roadside and Site Development Services Unit.

Environmental Procedures Manual, M 31-11, WSDOT — permits.

Internet Bioengineering Drawings, WSDOT Homepage http://www.wsdot.wa.gov/eesc/cae/design/roadside/SBwebsite/mainpage/Design/Techniques/Specdetail.html

1350.03 Uses

(1) General

Soil bioengineering combines the use of live plants or cuttings, dead plant material, and inert structural members to produce living, functioning land stabilization systems. This technique uses living plants to control and prevent soil erosion, sedimentation, and shallow slope instability. The bioengineered solution benefits from engineering techniques that use live plant material.

Soil bioengineering methods can be cost effective and a useful mitigation solution for site specific problems. Soil bioengineering is effective in erosion prevention, streambank stabilization, and some upland instabilities. Soil bioengineering, like other engineering techniques, is not applicable in all situations. Soil bioengineering techniques may not effectively mitigate severe bridge scour, severe roadway erosion conditions, or deep seated slope instabilities. In such cases, soil bioengineering can be used in combination with other engineering techniques.

The use of native vegetation that is adapted to the conditions of the project site will increase the success of the application of soil bioengineering techniques. Over time, native vegetation will encourage the establishment of a diverse plant community and discourage undesirable and invasive plant species.

Other applications of soil bioengineering include:

- Wildlife and fisheries habitat enhancement
- Reinforcement and steepening of cut and fill slopes to limit impacts to adjacent properties and sensitive areas
- Vegetated buffer enhancement on steep slopes
- Enhancement of stormwater treatment areas and stabilization of drainage ways by providing erosion prevention and sediment control
- Site specific mitigations using standard geotechnical solutions in combination with vegetative control

(2) Erosion Prevention

Soil Bioengineering techniques can provide erosion prevention in the top soil layers. Erosion is the detachment and transport of surficial soil particles through the action of water, wind, and ice. Plant shoots and foliage diminish rainfall erosion and remove excess moisture through transpiration. Roots reinforce the soil mantle, allowing the system to grow more stable with age. Vegetative material slows down runoff and traps soil thereby reversing the effects of erosion. Refer to the *Roadside Manual* for more information.

(3) Streambank Stabilization

Soil bioengineering techniques can be used to stabilize streambanks, enhance wildlife habitat, improve water quality by controlling sediments, and protect structures. Bioengineering in the riparian zone (banks of streams, wetlands, lakes, or tidewater) requires an hydraulic study of stream characteristics and changes in stream alignment. Refer to the *Hydraulics Manual* for more information.

(4) Upland Slope Stabilization (generally less than 3 feet in depth)

Upland slope stabilization refers to the use of vegetation and plant materials to reduce or prevent soil erosion caused by wind or water on slopes not directly adjacent to riparian zones.

There are three classifications of unstable slopes:

- **Surface movement** refers to surface erosion caused by wind or water on slopes
- **Shallow-seated instability** is defined as a failure surface less than 3 ft in depth
- **Deep-seated instability** is defined as a failure surface greater than 3 ft in depth

Soil bioengineering is used for slopes that are at risk of shallow landslides, slumps, sloughing, and surface erosion.

Soil bioengineering alone is not appropriate for deep-seated landslides, but can be used in conjunction with other engineering methods to treat associated shallow instabilities.

Soil bioengineering techniques can be used to stabilize the slopes of construction sites or to repair disturbed or damaged slopes. Soil bioengineering is applied to both cut and fill slopes.

(5) Strategies

When planning for site specific soil bioengineering design, consider the factors, parameters, and design considerations/ specifications in Figure 1350-1.

Factors	Parameters	Design Considerations/ Specifications
Climate or Microclimate	Growing season Exposure/Aspect	Select suitable plants, methods and construction timing
Physical Properties of Soil	Density and compaction Permeability	Modify soil structures during construction Select suitable plants
Chemical Properties of Soil	pH Fertility Cation Exchange Capacity	Select suitable plants Add soil amendments
Water	Profile available water Water sources	Divert water during construction using drains, ditches, pipes, etc. Amend soil
Erosion Risk	Soil erodibility Rainfall erosivity Channel discharge Slope (height and angle) Wind, water, or ice	Temporary or Permanent covers Select suitable plants Reinforcement with geotextile
Geotechnical	Shear strength Slope Factor of Safety	Select suitable soil materials Structures Soil density and moisture Reinforcement with geosynthetics See (Chapter 530)

Soil Bioengineering Design
Figure 1350-1

1350.04 Design Responsibilities and Considerations

Consider the possible applications for soil bioengineering during the project definition process. Address soil bioengineering applications during the design process as part of the recommendations in the Hydraulic Report (for streambank/shoreline), Stormwater Site Plan (SSP), Geotechnical Report (for slope stabilization), and in the Environmental Documents. These reports provide design criteria and guidelines.

1350.05 Documentation

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

1410.01 General

Real Estate Services personnel participate in the project definition phase of a project to assist in minimizing right of way costs, defining route locations and acquisition areas, and determining potential problems and possible solutions.

Due to the variables in land acquisition, the following categories of right of way costs are considered in the project definition phase.

- Purchase costs (acquisition compensation).
- Relocation assistance benefits payments.
- Other Real Estate Services staff expenses (acquisition services, relocation services, interim property management services).

Right of way cost estimates are made by Real Estate Services specialists. When the parcels from which additional right of way will be acquired are known, title reports (including assessors' land areas) can be requested.

Real Estate Services personnel also "make project field inspections at appropriate times throughout the development of a project to ensure adequate consideration is given to significant right of way elements involved (including possible social, economic, and environmental effects)" in accordance with the *Right of Way Manual*.

During plan development:

- Title reports are examined for easements or other encumbrances that would reveal the existence and location of water lines, conduits, drainage or irrigation lines, etc., that must be provided for in construction.
- Easements that indicate other affected ownerships are added to the right of way/access plan.
- Arrangements are made to obtain utility, railroad, haul road, detour routes, or other essential agreements, as instructed in the *Utilities Manual* and the *Agreements Manual*.
- Right of way acquisition, disposal, and maintenance are planned.
- Easements and permits are planned (to accommodate activities outside of the right of way).

See Chapter 440 concerning design right of way widths. The widths may be modified based on Real Estate Services input but cannot be moved to coincide with property boundaries in anticipation of a total take. Jogs in the final widths of the right of way are held to a minimum. See *Right of Way Manual* Chapter 6 for discussion of remainders.

All acquisition documents are processed through the Headquarters (HQ) Real Estate Services Office except temporary permits that are not shown on the Right of Way Plans and are not needed for the project (such as driveway connections).

1410.02 References

(1) Law

Laws and codes (both federal and state) that may pertain to this chapter include the following:

Code of Federal Regulations 23 CFR Part 710

49 CFR Part 24 Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 as amended

Revised Code of Washington (RCW) RCW 8.26, Relocation Assistance - Real Property Acquisition Policy

Washington Administrative Code (WAC)
WAC 468-100, Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended

(2) Design Guidance

The following contain guidance that is included by reference within the text:

Agreements Manual, M 22-99, Washington State Department of Transportation (WSDOT)

Plans Preparation Manual, M 22-31, WSDOT

Right of Way Manual, M 26-01, WSDOT

Utilities Manual, M 22-87, WSDOT

1410.03 Special Features

(1) Road Approaches

On managed access highways, the department will reconstruct legally existing road approaches that are removed or destroyed as part of the highway construction. New approaches required by new highway construction are negotiated by the region with the approval of the Regional Administrator. The negotiator coordinates with the region's design section to ensure that new approaches conform to the requirements of Chapter 920 for road approaches. All new approaches will be by permit through the appropriate regional office.

On limited access highways, road approaches of any type must be approved by the State Design Engineer before there is legal basis for negotiation by the Real Estate Services Office. When approved, approaches will be specifically reserved in the right of way transaction and will contain the identical limitations set by the State Design Engineer and as shown on the approved Right of Way and Limited Access Plan.

(2) Cattle Passes

The desirability of, or need for a cattle pass will be considered during the appraisal or negotiation process. A cattle pass will be approved only after complete studies of location, utilization, cost, and safety elements have proved its necessity. Upon approval, such an improvement and appurtenant rights will be established. Future right of access for maintenance is negotiated during acquisition.

On limited access highways, approval of the State Design Engineer and the addition of a traffic movement note on the right of way / limited access plan (refer to *Plans Preparation Manual*) are required.

(3) Pit, Stockpile, and Waste Sites

These sites are investigated and planned as outlined in the *Plans Preparation Manual*. Detour and haul road agreements, approved by the Regional Administrator, are necessary when the state proposes to use city streets or county roads for the purpose of detouring traffic or hauling certain materials. See the *Utilities Manual* for detour and haul road agreement guidelines.

(4) International Boundaries

Construction proposed "within a 20-foot strip, 10 feet on each side of the international boundary," must be coordinated between the department and the British Columbia Ministry of Highways and Public Works.

Permission of the International Boundary Commission is required to work "within 10 feet of an international boundary." Their primary concern is monumentation of the boundary line and the line of sight between monuments. They require a written request stating what will be done, when, and why; sent to 1250 23rd Street NW, Washington DC 20037.

1410.04 Easements and Permits

(1) General

If others request rights within existing WSDOT ownership, they are to contact the region's Real Estate Services Office.

Easements and permits to accommodate WSDOT activities outside the right of way usually fall into one of the categories defined below.

Easements and permits are processed in accordance with the requirements of the *Right of Way Manual*. The region's Real Estate Services Office drafts the legal descriptions for all easements and permits for acquisition of property and property rights. The HQ Real Estate Office drafts the legal description for all easements and permits for disposition of property or property rights. The region's Real Estate Services Office either obtains or assists in obtaining easements and permits. The region is responsible for compliance with and appropriate retention of the final documents. Records of permanent property rights acquired are maintained by HQ Real Estate

Services. Easements and permits are to be shown on the contract plans in accordance with the *Plans Preparation Manual*.

The region's Real Estate Services Office either obtains or assists in obtaining easements and permits. The region is responsible for compliance with and appropriate retention of the final documents. Easements and permits are to be shown on the contract plans in accordance with the *Plans Preparation Manual*.

(2) Perpetual Easements

Perpetual easements are shown on the right of way plans in accordance with the *Plans Preparation Manual*.

(a) **State Maintenance Easement.** Used when the state is to construct a facility and provide all maintenance. Examples are slope and drainage easements.

(b) **Dual Maintenance Easement.** Used when the state is to construct and maintain a facility and the owner is to maintain the remainder. Examples are; the surface area above a tunnel and the area behind a retaining wall or noise wall.

(c) **Transfer Easement.** On occasion an easement must be acquired for transfer to another party. In this case contact the region Real Estate Services Office for early involvement. The right of way and limited access plan is modified to identify the party to whom the easement will be transferred. The department cannot obtain easements for transfer across lands under the jurisdiction of the Department of Natural Resources (DNR), and WSDOT cannot condemn for a transfer easement.

(3) Temporary Easements

Temporary easements are used when the state requires a property right of a temporary nature that involves either more than minor work or construction activities on privately-owned property. In the cases where the rights required or the work to be performed is not beneficial to the property owner, just compensation must be paid. When we are paying for the rights or when the encroachment is significant, temporary easements are shown on the right of way plans, in accordance with the *Plans Preparation Manual*. Consult the region's Plans and Real Estate Services personnel for exceptions. If the easement is not mapped, mark and submit plans as follows:

The region's Project Coordinator's Office provides a right of way plan with the required temporary easement(s) delineated in red to the region's Real Estate Services Office. These plan sheets provide the following information:

- Ownership boundaries. (Confirmation of ownership and parcel boundaries may be completed by a search of county records and mapping. A formal title report is required for temporary easements.)
- Parcel number assigned to each ownership.
- Sufficient engineering detail to write legal descriptions.
- Statement of the intended use of each temporary easement area.

In limited access areas, contact the HQ Access and Hearings Office.

(4) Construction Permits

Construction permits are used for temporary rights during construction. They are not used when WSDOT needs a perpetual right. A construction permit is only valid with the current owner and must be renegotiated if property ownership changes before construction begins. For private ownerships, a temporary construction easement is recommended. A construction permit is recommended for rights of entry to publicly owned property. Local agencies might require the use of specific forms when applying for these rights of entry. Regardless of the form or its name, the region is responsible for appropriate central storage of the original document.

A construction permit is only valid with the current owner and must be renegotiated if property ownership changes before construction begins. For private ownerships, a temporary construction easement is recommended.

When there is a benefit to the property owner (e.g. driveway or parking lot approach improvements) the construction permit is usually obtained without the payment of compensation (donation or mutual benefits, for example). Consult the region's Plans and Real Estate Services personnel for exceptions.

1410.05 Programming for Funds

In relation to plan development, the phases in Figure 1410-1, apply to the authorization of stage programming.

When federal funds are involved, special attention must be given to Federal Highway Administration (FHWA) requirements. When federal participation in right of way costs is anticipated, specific authorization must be obtained from the FHWA. The rules and procedures provided in RCW 8.26, WAC 468-100, and the *Right of Way Manual* must be followed to ensure federal and state participation. In many cases, for example, federal funds are contingent upon the department setting up a relocation advisory procedure for any owner or tenant who is displaced by an improvement and desires such assistance. Relocation advisory assistance is a function of the HQ Real Estate Services Office.

1410.06 Appraisal and Acquisition

(1) All Highways

In relation to plan development, the phases in Figure 1410-1, also apply to the authorization of right of way acquisition for all access highways.

(3) Exceptions

Exceptions can be made to the requirements in Figure 1410-1 if unusual hardships result for the individual or the state. The approval of right of way hardship action will be based on the individual parcel merit and is processed in accordance with hardship acquisition policy (*Right of Way Manual*).

1410.07 Transactions

(1) Private Ownerships

Right of way is ordinarily acquired from private property owners by region-level negotiation between the owner and the right of way agent.

(2) Utilities

The region ascertains ownership of all utilities and makes arrangements for necessary adjustment, including relocation of portions of the utility, if necessary. Provisions for relocation or adjustment are included in the PS&E plans when:

- The items are normal construction items and the department is obligated for the moving expense.
- The utility requests that relocation be performed by the department and the department has approved the request.

Readjustment may require the department to purchase substitute rights of way or easements for eventual transfer to the utility. Such rights of way or easements must be shown on the right of way plans with the same engineering detail as highway right of way. On limited access highways, if an approach is required for maintenance of a utility, the approach will be shown on the approach schedule. See the *Utilities Accommodation Policy* regarding location of and access to utilities.

The negotiations with the utilities are often done by HQ Real Estate Services. Because of the considerable time required to obtain approvals, processing of utility relocation agreements must begin as soon as possible.

(3) Railways

Right of way is generally not acquired in fee from a railroad company. Instead, the state acquires a perpetual easement for encroachment or crossing. A construction and maintenance agreement may also be required. The easement must be shown on the right of way plan and identified by both highway and railroad stationing.

The HQ Design Office coordinates with the railroad design staff to determine a mutually agreeable location before the proposed easement is sent to Real Estate Services. The negotiations with the railroads are generally done by HQ Real Estate Services. Because of the considerable time required to obtain approvals, processing of railroad agreements must begin as soon as possible.

The perpetual easement document is executed by the Director, Real Estate Services.

(4) Federal Agencies

Acquisition of right of way from most federal agencies must be negotiated and processed through several federal offices. Allow at least one year's time for efficient and economical right of way acquisition. Depending upon the particular federal agency involved, special exhibit maps and other documentation may be required, and the right of way may be acquired as an easement rather than in fee. The negotiations with the federal agencies are generally done by HQ Real Estate Services.

(5) Other State Agencies

Acquisition from other state agencies must be negotiated and processed through the individual agencies or designees. Negotiations with other state agencies are generally handled by HQ Real Estate Services. As in the case of federal agencies, substantial time must be allowed for compliance with applicable statutes and regulations peculiar to the agency before right of way will be granted.

(6) Condemnations

Condemnation can result from a disagreement between the department and the owner as to a fair settlement or from a faulty title. Since several months might elapse between the filing of a condemnation case and a court decision, the Region Real Estate Services Office can be requested to investigate the possibility of obtaining a negotiated possession and use agreement as in the case of an emergency project, or when a sundry site is required immediately.

1410.08 Documentation

A list of the documents that are required to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site:
http//www.wsdot.wa.gov/eesc/design/projectdev/

Plan Approval	Plan Approval	Programming of Funds for Appraisal and Acquisition
Limited Access Highways		
PHASE 1 Access Report Plan	State Design Engineer* approves Access Report Plan for prehearing discussion with county and/or city officials. The access report plan may be used for preparation of federal-aid program data for appraisals if federal funds are to be used for right of way acquisition. It may be used for requesting advance appraisal funds through the Planning and Capital Program Management for all projects with either state or federal funds.	Program appraisals of total takes. (No acquisition.)
PHASE 2 Access Hearing Plan	State Design Engineer* approves Access Hearing Plan for use at a public access hearing. R/W information is complete. The access hearing plan may be used for the preparation of federal-aid program data for negotiations on federally funded projects, and for the preparation of true cost estimates and fund requests.	Program all appraisals and acquisitions. Note: Do not appraise or purchase partial takes in areas subject to controversy. Appraise or purchase total takes only if federal design hearing requirements are met.
PHASE 3 Findings and Order Plan	No signature required. Results of Findings and Order Access Hearing are marked in red and green on Access Hearing plan and sent to HQ R/W Plans Branch.	Program appraisals of partial takes where data is available to appraisers. Acquisition of total takes.
PHASE 4 Final R/W and L/A Plan	State Design Engineer* Approves final R/W and L/A plans or approves revisions to established R/W and L/A plans	Program all remaining appraisals and all remaining acquisitions. Note: If appeal period is not complete, delay action in areas subject to controversy and possible appeal.
Managed Access Highways		
PHASE 5 Final R/W Plan	R/W plan submitted to HQ R/W Plans Branch for approval.	Program appraisals
	State Design Engineer* approves new R/W plans or approves revisions to established R/W plans.	Program all appraisals and acquisitions.

*Or a designee.

Appraisal and Acquisition
Figure 1410-1

Chapter 1420 Access Control

1420.01 General

The Washington State Department of Transportation (WSDOT) controls access to Washington State highways (with a few exceptions) in order to preserve the safety and efficiency of these highways as well as to preserve the public investment. All Washington State highways are distinguished as being either a *limited access* highway or a *managed access* highway. Control of access is accomplished by either acquiring rights of access from abutting property owners (limited access control) or by regulating access connections to the highway (managed access control). Until limited access rights have been acquired from abutting property owners, the route is a managed access highway. Managed access permits are issued either by a local authority (city or town) or by WSDOT.

Numerous studies have shown that controlling and limiting access to highways is a cost-effective way to help maintain the safety, capacity, and functional integrity of a highway. Adding more lanes to an existing highway is expensive and frequently not possible. Controlling access to our state highways, by promoting the use of frontage roads or other existing county or city roads, and advocating the internal shared circulation within adjacent developments, is a proactive and cost-effective way to accomplish this objective.

WSDOT has been purchasing and implementing limited access control since 1951 (RCW 47.52). While this has been effective, it is an expensive way to control access to the state highway system. Adequate funding to accomplish the purchasing of access rights has not kept up with the state's continuous population growth and land use development over the years. As a result, the lawmakers of this state debated a bill in the early 1990s titled "Highway Access Management," cognizant that controlling access to the state highway system by regulation was a cost-effective means to preserve the safety and capacity of our state highway system.

In 1991, the legislature passed and the governor approved RCW 47.50, titled *Highway Access Management*. This new law directed the Department of Transportation to develop new rules to be included in the Washington Administrative Code (WAC) for those state highways not already limited access highways. The result was a new class of access control called managed access.

Chapter 1430 describes limited access highways in greater detail. Chapter 1435 describes managed access highways in greater detail.

The following references and definitions apply to Washington's access control as presented in Chapters 1430 and 1435.

1420.02 References

Revised Code of Washington (RCW) 46.61, Rules of the Road

RCW 47.17, State Highway Routes

RCW 47.32, Obstructions on Right of Way

RCW 47.50, Highway Access Management

RCW 47.52, Limited Access Facilities

Washington Administrative Code (WAC) 468-51, Highway Access Management Access Permits-- Administrative Process

WAC 468-52, Highway Access Management -- Access Control Classification System and Standards

WAC 468-54, Limited Access Hearings

WAC 468-58, Limited Access Highways

Manual On Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, WSDOT (MUTCD) http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Agreements Manual, M 22-99, WSDOT

Highways Over National Forest Lands, MOU between WSDOT and USFS, 2001, M 22-50

Plans Preparation Manual, M 22-31, WSDOT

Right of Way Manual, M 26-01, WSDOT

Utilities Accommodation Policy, M 22-86, WSDOT

1420.03 Definitions

access A means of entering or leaving a public road, street, or highway with respect to abutting property or another public road, street, or highway.

access control The limiting and regulating of public and private access to Washington State's highways, as required by state law.

Access Control Tracking System A database list, related to highway route number and mile posts, that identifies either the level of limited access or the class of managed access at: http://www.wsdot.wa.gov/eesc/design/access under the RELATED SITES heading.

access connection See ***approach and access connection***

access connection permit A written authorization issued by the permitting authority for a specifically designed access connection to a managed access highway at a specific location, for a specific type and intensity of property use, and for a specific volume of traffic for the access connection, based on the final stage of the development of the applicant's property. The actual form used for this authorization is determined by the permitting authority.

access deviation A deviation (Chapter 330) that authorizes deferring or staging acquisition of limited access control, falling short of a 300 ft requirement, or allowing an existing access point to stay within 130 ft of an intersection on a limited access highway. Approval from the State Design Engineer is required. (Chapter 1430)

access hearing plan A limited access plan prepared for presentation at an access hearing.

access point Any point that allows private or public entrance to or exit from the traveled way of a state highway. (This includes "locked gate" access.)

access point spacing On a managed access highway, the distance between two adjacent access points on one side of the highway, measured along the edge of the traveled way from one center line or alignment line intersection to the next. See also *corner clearance*.

access report plan A limited access plan prepared for presentation to local governmental officials at preliminary meetings before preparation of the access hearing plan.

access rights Property rights that allow an abutting property owner to enter and leave the public roadway system.

allowed Authorized.

application for an access connection An application provided by the permitting authority to be completed by the applicant for access to a managed access highway.

approach and access connection These terms are listed under the specific access section they apply to. The first section below is for limited access highways and uses the term approach. The second section below is for managed access highways and uses the term access connection.

Approaches and access connections include any ability to leave or enter a highway other than at an intersection with another road or street.

limited access highways: approach An access point, other than a public road/street, that allows access to or from a limited access highway on the state highway system. There are five types of approaches to limited access highways that are allowed:

- ***Type A approach*** An off and on approach in legal manner, not to exceed 30 feet in width, for the sole purpose of serving a single family residence. It may be reserved by the abutting owner for specified use at a point satisfactory to the state at or between designated highway stations. This approach type is allowed on partial and modified control limited access highways.
- ***Type B approach*** An off and on approach in legal manner, not to exceed 50 feet in width, for use necessary to the normal operation of

a farm, but not for retail marketing. It may be reserved by the abutting owner for specified use at a point satisfactory to the state at or between designated highway stations. This approach type is allowed on partial and modified control limited access highways.

- ***Type C approach*** An off and on approach in legal manner, for special purpose and width to be agreed upon. It may be specified at a point satisfactory to the state at or between designated highway stations. This approach type is allowed on partial and modified control limited access highways.
- ***Type D approach*** An off and on approach in a legal manner not to exceed 50 feet in width for use necessary to the normal operation of a commercial establishment. It may be specified at a point satisfactory to the state at or between designated highway stations. This approach type is only allowed on modified control limited access highways.
- ***Type E approach*** This type is no longer allowed to be constructed because of the requirements that there be only one access point per parcel on a limited access state highway.
- ***Type F approach*** An off and on approach in a legal manner, not to exceed 30 feet in width, for the sole purpose of serving a wireless communication site. It may be specified at a point satisfactory to the state at or between designated highway stations. This approach type is only allowed on partial control limited access highways. See WAC 468-58-080(vi) for further restrictions.

managed access highways: access connection An access point, other than a public road/street, that permits access to or from a managed access highway on the state highway system. There are five types of access connection permits:

- ***conforming access connection*** A connection to a managed access highway that meets current WAC and WSDOT location, spacing, and design criteria.
- ***grand-fathered access connection*** Any connection to the state highway system that was in existence and in active use on July 1, 1990, and has not had a significant change in use.
- ***joint-use access connection*** A single connection to a managed access highway that serves two or more properties.
- ***nonconforming access connection*** A connection to a managed access highway that does not meet current WSDOT location, spacing, or design criteria pending availability of a future conforming access connection.
- ***variance access connection*** A connection to a managed access highway at a location not normally allowed by current WSDOT criteria.

managed access connection category There are four access connection permit categories for managed access connections to state highways: Category I, Category II, Category III, and Category IV. See Chapter 1435.

average annual daily traffic (AADT) The volume of traffic passing a point or segment of a highway, in both directions, during a period of time, divided by the number of days in the period and factored to represent an estimate of traffic volume for an average day of the year.

average weekday vehicle trip ends (AWDVTE) The estimated total of all trips entering plus all trips leaving the applicant's site based on the final stage of proposed development.

connection See ***approach and access connection***

contiguous parcels Two or more pieces of real property under the same ownership with one or more boundaries that touch and have similarity of use.

corner clearance On a managed access highway, the distance from an intersection of a public road or street to the nearest access connection along a managed access highway. The minimum corner clearance distance (Figure 1435-2) is measured from the closest edge of the intersecting road or street to the closest edge of the traveled way of the access connection, measured along one side of the traveled way (through lanes). See also *access point spacing*.

DHV Design hourly volume.

E&EP Environmental and Engineering Programs, a part of the Washington State Department of Transportation (WSDOT).

easement A documented right, as a right of way, to use the property of another for designated purposes.

findings and order (F&O) A legal package containing information based on the hearing record from a limited access hearing. See Chapters 210 and 1430.

findings and order (F&O) plan A limited access plan, prepared after a limited access hearing, that is based on the hearing record.

HQ The Headquarters organization of the Washington State Department of Transportation in Olympia.

intersection An at-grade access point connecting a state highway with a road or street duly established as a public road or public street by the local governmental entity.

limited access Full, partial, or modified access control is planned and established for each corridor and then acquired as the right to limit access to each individual parcel.

limited access highway All highways listed as "Established L/A" on the Master Plan for Limited Access Highways only where the rights of direct access to or from abutting lands have been acquired from the abutting landowners.

- ***full access control*** This most restrictive level of limited access provides access, using interchanges, for selected public roads/streets only, and prohibits highway intersections at grade.
- ***partial access control*** The second most restrictive level of limited access. At-grade intersections with selected public roads are allowed and there may be some crossings and some driveway approaches at grade. Direct commercial access is not allowed.
- ***modified access control*** The least restrictive level of limited access. Characteristics are the same as for partial access control except that direct commercial access is allowed.

managed access highway Any highway not listed as "Established L/A" on the Master Plan for Limited Access Highways and any highway or portion of a highway designated on the Master Plan as "Established L/A" until such time as the limited access rights are acquired. Under managed access legislation, the property owner's access rights are regulated through an access connection permitting process.

Master Plan for Limited Access Highways A map of Washington State that shows established and planned limited access highways. More detail is given in the database list: Access Control Tracking System. (Location given above in the list's definition.)

median The portion of a divided highway separating vehicular traffic in opposite directions; not including speed change lanes, storage lanes for left- or U-turning vehicles, or two-way left-turn lanes.

median opening An opening in a continuous median for the specific purpose of allowing vehicle movement.

MOU Memorandum of Understanding. There is one MOU between the United States Forest Service and the Washington State Department of Transportation (*Highways Over National Forest Lands)* that requires the USFS to obtain a road approach permit for new access to a state highway that is crossing Forest Service land.

permit holder The abutting property owner or other legally authorized person to whom an access connection permit is issued by the permitting authority.

permitted access connection A connection for which an access connection permit has been issued by a permitting authority.

permitting authority The agency having legal authority to issue managed access connection permits: for access connections in unincorporated areas, WSDOT; for access connections within corporate limits, a city or town.

right of way (R/W) A general term denoting land or interest therein, acquired for or designated for transportation purposes. More specifically, lands that have been dedicated for public transportation purposes or land in which WSDOT, a county, or a municipality owns the fee simple title, has an easement devoted to or required for use as a public road/street and appurtenant facilities, or has established ownership by prescriptive right.

right of way and limited access plan (R/W and L/A plan) A right of way plan that also shows limited access control details.

road approach A road or driveway built to provide private access to or from the state highway system.

shoulder The portion of the highway contiguous with the traveled lanes for the accommodation of stopped vehicles for emergency use and, where allowed, for bicycles. (Chapter 1430)

state highway system All roads, streets, and highways designated as state routes in compliance with RCW 47.17.

1420.04 Vocabulary

These entries demonstrate the difference in terminology between limited access and managed access in the applicable WACs. For instance, there is nothing about *permit*, *connection*, *category*, or *class* in the limited access vocabulary and, likewise, nothing about *approach* or *type* in the managed access vocabulary.

Chapter 920's vocabulary uses *road approach* in a generic way, unrelated to WAC legalese, and makes no distinction related to access control.

The entries shown on Figure 1420-1 are examples of suitable wording for the distinctly different types of access control in Chapters 1430 and 1435.

Access Vocabulary	
functional classification of highways intersections at grade, geometrics roundabout geometrics road approach geometrics interchange geometrics freeway access point	Chapter 440 Chapter 910 Chapter 915 Chapter 920 Chapter 940 Chapter 1425
limited access highway (Chapter 1430)	**managed access highway (Chapter 1435)**
access point (ramp) approach (street, road, driveway) road approach (street, road, driveway) driveway approach (not street or road)	access point (public or not) public access point access connection (not public)
(level of) limited access (highway) [full, partial, modified] control limited access highway	managed access highway class Class [1-5] managed access highway
Type [A, B, C, D, F] approach Type A approach = Type A road approach	Category [I-IV] access connection
allowed (policy)	permitted (a document) or allowed (policy)
	conforming access connection permit (etc.)

These words are not used in the respective chapters:

Not:	Not:
class	classification (except functional)
category	type
connection	approach
permit or permitted	

Access Vocabulary
Figure 1420-1

Chapter 1425 Interchange Justification Report

1425.01 General

This chapter provides guidance on Interchange Justification Reports (IJR), developing the required documentation for an IJR, and the sequence of an IJR presentation. The guidance is applicable to both Interstate and non-Interstate limited access routes. Engineers in the Washington State Department of Transportation (WSDOT) Headquarters (HQ) Access and Hearings Unit specialize in providing support for meeting the guidance provided in this chapter. They should be consulted early and frequently during the development of projects that require the types of documentation described herein.

Federal law requires Federal Highway Administration (FHWA) approval of all revisions to the Interstate system, including changes to limited access. Both FHWA and WSDOT policy require the formal submission of a request to either break or revise the existing limited access on Interstate and state routes, respectively. An IJR is the document used to request a new access point or access point revision on limited access freeways in Washington State. The IJR is used to document the planning process, the evaluation of the alternatives considered, the design of the preferred alternative, and the coordination that supports and justifies the request for an access revision. The IJR is scalable to the complexity of the proposal (see Figures 1425-1, 2, and 3).

A transportation proposal that requires a break in or revision to the existing limited access control, such as a new interchange, should begin with a study of the corridor to determine existing and future access needs. These needs then become part of the statewide plan, called the *State Highway System Plan*. The *State Highway System Plan defines Service Objectives, Action Strategie*s, and costs to plan for, maintain, operate, preserve, and improve the state highway system for the next 20 years. Work that does not fit any of the action strategies will not be authorized or considered in the development of the Statewide Transportation Improvement Program (STIP) or any other budget proposal. (See Chapter 120.) Alternatives should be developed and evaluated. A final preferred alternative is then analyzed, selected, approved, designed, constructed, maintained, and monitored.

The corridor study must evaluate existing local infrastructure and existing access points to determine whether an access point revision is necessary. The evaluation of the proposal begins by studying the corridor throughout the area of influence.

For all complex projects (new or significantly reconfigured interchanges), WSDOT strongly advises that a support team be established to help integrate the planning, programming, environmental, traffic, safety, and design efforts that lead to development of a proposal. When a third party, such as a local agency, is proposing an access point revision, FHWA requires that a study team be formed.

An IJR is a stand-alone document that includes the necessary supporting information needed for a request to break or revise the existing limited access. The IJR includes information about the proposed project, the new access or access point revision, and information about all other local and state improvements that are needed for the access to operate. The complexity of the report varies considerably with the scope of the proposed access point revision. For example, for minor ramp revisions, added on- and off-ramp lanes, and locked gates to sites normally accessed by another route, the approval request may be condensed to a letter format that includes adequate justification. An operational/safety analysis may be required to assure no adverse impacts to the Interstate or crossroad(s). Contact the HQ Access and Hearings Unit to determine the appropriate level of report documentation needed for all access changes.

An IJR cannot be approved prior to the approval of the project environmental document. For example, a project environmental document might be an Environmental Impact Statement (EIS) or an Environmental Assessment (EA). Approval of these documents is signified by a Record of Decision for an EIS, or a Finding of No Significant Impact might be issued for an EA document indicating an EIS is not required. (Chapter 220 provides further discussion on project environmental documentation.)

If the new or revised access proposal is found to be acceptable prior to the environmental approval, a finding of engineering and operational acceptability is granted by FHWA. Final approval of the IJR is granted concurrently with the appropriate environmental documentation. If the proposal is found to be acceptable after the project environmental document is approved, the IJR can be approved. On Interstate projects, a submittal letter shall be sent by the region through the WSDOT Access and Hearings Unit requesting final FHWA approval of the IJR. On non-Interstate projects, a similar process is followed, except that the WSDOT Assistant State Design Engineer grants the final approval, not the FHWA.

Recognizing that the time period between the approval of the IJR, the environmental documentation, and the construction contract commonly spans several years, the approved IJR will be reviewed and updated if significant changes have occurred during this process. A summary assessment will be submitted to the HQ Design Office and FHWA for evaluation to determine whether the IJR needs to be updated. Contact the HQ Access and Hearings Unit to coordinate this summary assessment.

1425.02 References

(1) Law

Laws and codes (both federal and state) that may pertain to this chapter include the following:

Code of Federal Regulations (CFR) 23 CFR Part 450 (implementing 23 USC Section 111)

40 CFR Parts 51 and 93 (regarding federal conformity with state and federal air quality implementation plans)

United States Code 23 USC Section 111 (requires the U.S. Secretary of Transportation to approve access revisions to the Interstate System), 134 (Metropolitan Planning), and 135 (Statewide Planning)

(2) Design Guidance

The following contain guidance that is included by reference within the text:

Highway Capacity Manual, Special Report No 209 (HCM), Transportation Research Council

Local Agency Guidelines (LAG), M 36-63, WSDOT

(3) Supporting Information

The following were used in the development of this chapter or contain additional information:

Forecasting and Methods Matrix (when available), WSDOT

Notice of policy statement: "Additional Interchanges to the Interstate System," Federal Highway Administration notice published in the Federal Register, October 22, 1990 (Vol. 55, No. 204)

Notice of policy statement: "Additional Interchanges to the Interstate System," Federal Highway Administration notice published in the Federal Register on February 11, 1998. (Vol. 63, No. 28) (accessible in http://www.access.gpo.gov/su_docs/fedreg/a980211c.html, under FHWA notices, "Interstate system, additional interchanges, policy statement, 7045-7047")

1425.03 Definitions

access A means of entering or leaving a public road, street, or highway with respect to abutting property or another public road, street, or highway.

access break Any point from inside or outside the state limited access right of way limited access hachures that crosses over, under, or physically through the plane of the limited access, is an access break or "break in access" (including, but not limited, to locked gates and temporary construction access breaks).

access point Any point from inside or outside the limited access hachures that allows entrance to or exit from the traveled way of a limited access freeway, including "locked gate" access and temporary construction access.

access point revision A new access point or a revision of an existing interchange/intersection configuration. Locked gates and temporary construction breaks are also access point revisions.

accident rate Accidents per one million vehicle miles traveled.

alternatives Possible solutions to accomplish a defined purpose and need. These include local and state transportation system design options, locations, and travel demand management and transportation system management type-improvements, such as ramp metering, mass transit, and high occupancy vehicle (HOV) facilities.

area of influence The area that will be directly impacted by the proposed action: freeway main line, ramps, crossroads, immediate off-system intersections, and local roadway system.

assumptions document A document developed at the beginning of the study phase to capture access study assumptions and criteria such as traffic volumes, design year, opening year, travel demand assumptions, baseline conditions, and design year conditions. The document also serves as a historical record of the processes, dates, and decisions made by the team.

baseline The existing transportation system configuration and traffic volumes for a specific year against which to compare possible alternative solutions.

break See "*access break*" above.

design year 20 years from the beginning of construction.

ECS Environmental Classification Summary (Documented Categorical Exclusion).

FONSI Finding of No Significant Impact (Environmental Assessment).

freeway A divided highway that has a minimum of two lanes in each direction, for the exclusive use of traffic, and with full access control.

limited access Full, Partial, or Modified access control is planned and established for a corridor and then acquired as the right to limit access to each individual parcel.

need A statement which identifies the transportation problem(s) that the proposal is designed to address and explains how the problem will be resolved. An existing or anticipated travel demand that has been documented through the study process to require a change in access to the state's limited access freeway system.

no-build condition The baseline, plus state transportation plan and comprehensive plan improvements expected to exist, as applied to the year of opening, or the design year.

proposal The combination of projects/actions selected through the project study process to meet a specific transportation system need.

purpose General project goals such as: (1) improve safety, (2) enhance mobility, or (3) enhance economic development.

Record of Decision Under the National Environmental Policy Act, the Record of Decision (ROD) accompanies the Final Environmental Impact Statement; explains the reasons for the project decision; discusses alternatives and values considered in selection of the preferred alternative; and summarizes mitigation measures and commitments that will be incorporated in the project.

study area The transportation system area to study in both step one of the study process and for an IJR. The study area is a minimum of one interchange upstream and downstream from the proposal.

support team An integral part of the IJR process consisting of an assemblage of people organized to develop and analyze solutions to meet the need of a proposal.

Transportation Management Area (TMA) Urbanized areas with populations of 200,000 or greater are federally designated as Transportation Management Areas.

travel demand Local travel demand constitutes short trips that should be made on the local transportation system, such as intracity roads and streets. Regional travel demand constitutes long trips that are made on the regional transportation system, such as Interstate, regional, and/or intercity/ interregional roads, streets, or highways.

traveled way The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

trips Short trips are normally intracity. Long trips are normally interstate, regional, or interregional.

1425.04 Procedures

Figures 1425-1 and 2 list the project types most likely to affect freeway safety and operations, requiring the submission of an Interchange Justification Report. Figure 1425-3 lists project types least likely to require the submission of an IJR. Consult the HQ Access and Hearings Unit early in the process for specific direction.

Gaining concurrence and approval for an access point revision is a multistep process. The first step consists of a study. If the study shows that the purpose and need of the proposal cannot be achieved with improvements to the local infrastructure only, the next step would normally be an IJR. (See the IJR Flow Chart, Figure 1425-4.)

(1) The First Step

Study the transportation systems in the area. This study will identify the segments of both the local and regional network that are currently experiencing congestion or safety deficiencies, or where planned land use changes will prompt the need to evaluate the demands on and the capacity of the transportation system. The study area includes the affected existing and proposed adjacent interchanges/intersections upstream and downstream from the proposed access point revision. If it is documented that the proposal creates no impacts to the adjacent interchanges/ intersections, then analyze only through the area of influence. When the area of influence extends beyond the one interchange upstream and downstream, extend the analysis far enough to include the extent of the traffic impacts.

Segments of the local and regional network within the study area will be evaluated for system improvements. Part of the study process is to identify local infrastructure needs and develop a proposal. The study must consider investments in local infrastructure improvements to meet the needs of the proposal, because those improvements may provide the desired solution.

During the study process and while developing a proposal, it is important to use the data and analysis methods required for an IJR. If the study indicates that an IJR is warranted, the study data can be utilized in the IJR. Establish a support team for the study. This same support team would also be involved with the IJR process if the study shows that either a revision or a new access point is needed to meet the proposal purpose and need. The support team normally consists of the following:

- FHWA Area Engineer for Interstate Projects
- Region's Design or Project Development Engineer or Designee
- HQ Assistant State Design Engineer
- HQ Access and Hearings Unit Engineer
- HQ Traffic Office Representative
- Representative From Local Agencies (city, county, port, or tribal government)
- Recorder

The support team is encouraged to call upon specialists as needed; for example:

- Metropolitan Planning Organization (MPO)
- Regional Transportation Planning Organization (RTPO)
- WSDOT Region
    - Planning
    - Design
    - Environmental
    - Maintenance
    - IJR writer

- WSDOT Headquarters
  - Design
  - Bridge
  - Traffic
  - Geotechnical
- Project Proponent Specialists
- Transit Agencies

The support team's role is to:

- Develop a charter that includes the processes for reaching agreement, resolving disputes, and assigning responsibility for final decisions when consensus is not reached.
- Develop purpose, need, and vision statements for the study. This should be consistent with the project environmental document.
- Expedite the study step (and, if needed, the IJR development and review process) through early communication and agreement.
- Agree on area of influence and travel assumptions for the study and, if an IJR is needed, for each of the alternatives being considered.
- Develop the access assumptions document.
- Provide guidance and support.
- Evaluate data and identify possible alternatives for the proposal during the study and, if needed, for an IJR.
- Contribute material for the report that documents the discussions and decisions.
- Review results and determine whether an IJR is warranted.
- Ensure the compatibility of data used in various studies.
- Ensure integration of the Project Definition process, Value Engineering studies, public involvement efforts, environmental analyses, operational analyses, safety analyses, other analyses for the study (and, if needed, to prepare an IJR). This encourages the use of consistent data.
- Address design elements. Status of known deviations must be noted in Policy Point 4. Deviations are discouraged on new accesses.

(2) The Second Step

Prepare a detailed IJR using the guidance in 1425.05, "Interchange Justification Report and Supporting Analyses," and Figure 1425-4.

The IJR addresses eight specific policy topics. (See Figures 1425-1 and 2 for exceptions.) In order of presentation, the topics are:

1. Need for the Access Point Revision
2. Reasonable Alternatives
3. Operational and Accident Analyses
4. Access Connections and Design
5. Land Use and Transportation Plans
6. Future Interchanges
7. Coordination
8. Environmental Processes

The IJR is initiated early in the environmental process. Traffic analyses help define the area of impact and the range of alternatives. Since the traffic data required for the National Environmental Policy Act (NEPA) or the State Environmental Policy Act (SEPA) and the operational/safety analyses of the decision report are similar, these documents are usually developed together using the same data sources and procedures.

(3) The Third Step

Concurrence and approval of a new or revised access point is based on the IJR. The IJR contains sufficient information about and evaluation/analysis of the proposal to provide assurance that the safety and operations of the freeway system are not adversely impacted.

The region, with the help of the support team, prepares the IJR and submits four draft copies, including backup traffic data, for review. For a final IJR submittal, contact the HQ Access and Hearing Unit for the necessary number of copies. All IJRs are submitted to the HQ Access and Hearings Unit for review. Interstate IJRs are submitted by Headquarters to FHWA for concurrence and approval.

Interstate access point revisions are reviewed by both Headquarters and FHWA. If they are found to be acceptable to FHWA, they are given a finding of engineering and operational acceptability. Some Interstate IJRs are reviewed and approved by the local FHWA Division Office. Other Interstate IJRs are reviewed and approved by the Federal Highway Administration in Washington, DC. Additional review time is necessary for reports that have to be submitted to Washington DC. (See Figure 1425-1.)

If the IJR is finalized prior to the completion of the environmental process, it can be submitted for concurrence. Concurrence with the proposed Interstate access point revision can be made by FHWA in the form of a finding of engineering and operational acceptability. Final IJR approval by FHWA is provided concurrently with the appropriate final environmental decision: ECS, FONSI, or ROD (see definitions). For non-Interstate routes, the Assistant State Design Engineer's approval is given concurrently with environmental approval. (See Figure 1425-4.)

1425.05 Interchange Justification Report and Supporting Analyses

Begin the IJR with an executive summary. Briefly state what access point revision is being submitted for a decision and why the revision is needed. Include a brief summary of the proposal. Formatting for the IJR includes (1) providing numbered tabs in the decision report for the policy points and appendices, and (2) numbering all pages including references and appendices. A suggestion for page numbering is to number each individual section, such as "Policy Point 3, PP3–4" and "Appendix 2, A2–25." This allows for changes without renumbering the entire report. The IJR must be assembled in the policy point order noted in this chapter.

On the bottom left of each page, place the revision date for each version of the IJR. As an individual page is updated, this revision date will help track the most current version of that page. Also, include the title of the report on the bottom left of each page. The use of comb binding is not allowed.

The eight policy points, which apply to both urban and rural areas, are presented below. Guidance is provided for the most extreme condition—a new interchange in an urbanized area. The scope of the analyses and documentation need not be as extensive for more modest access point revisions. Factors that affect the scope include location (rural or urban), access points (new or revised), ramps (new or existing), and ramp terminals (freeway or local road).

(1) **Policy Point 1:** Need for the Access Point Revision

What are the current and projected needs? Why are the existing access points and the existing or improved local system unable to meet the proposal needs? Is the anticipated demand short or long trip?

Describe the need for the access point revision and why the existing access points and the existing or improved local system do not address the need. How does the proposal meet the anticipated travel demand? Provide the analysis and data to support the need for the access request.

(a) ***Project Description.*** Describe the needs being addressed and the proposal.

Demonstrate that improvements to the local transportation system and the existing interchanges cannot be improved to satisfactorily accommodate the design year travel demands. Describe traffic mitigation measures considered at locations where the level of service is (or will be) below service standards in the design year.

The access point revision is primarily to meet regional, not local, travel demands. Describe the local and regional traffic (trip link and/or route choice) benefiting from the proposal.

(b) ***Analysis and Data.*** The proposal analysis, data, and study area must be agreed upon by the support team. The assumptions document captures the specific items.

Show that a preliminary (planning level) analysis, comparing build to no-build (baseline) data, was conducted for the current year, year of opening, and design year, comparing baseline, no-build condition, and build alternatives. Include the following steps:

- Define the study areas. The study area normally includes one interchange upstream and downstream from the proposed system revision. If the proposal's area of influence extends beyond those interchanges, the study area will be expanded accordingly.
- Collect and analyze current traffic volumes to develop current year, year of opening, and design year peak hour traffic estimates for the regional and local systems in the area of the proposal. Use regional transportation planning organization-based forecasts, refined by accepted travel demand estimating procedures. Forecasts for specific ramp traffic can require other methods of estimation procedures and must be consistent with the projections of the travel demand models. Modeling must include increased demand caused by anticipated development.
- Using existing information, identify the origins and destinations of trips on the local systems, the existing interchange/ intersections, and the proposed access.
- Assign the appropriate travel demand to improvements that might be made to:
- The local system (widen, add new surface routes, coordinate the signal system, control access, improve local circulation, or improve parallel roads or streets).
- The existing interchanges (lengthen or widen ramps, add park and ride lots, or add frontage roads).
- The freeway lanes (add collector-distributor roads or auxiliary lanes).
- Transportation system management and travel demand management measures.
- Describe the current, year of opening, and design year level of service at all affected locations within the study area, including local systems, existing ramps, and freeway lanes.

(2) Policy Point 2: Reasonable Alternatives

Describe the reasonable alternatives that have been evaluated.

Describe all reasonable alternatives that have been considered: the design options, locations, and transportation system management-type improvements such as ramp metering, mass transit, and HOV facilities that have been assessed and that meet the proposal design year needs.

After describing each of the alternatives that were proposed, explain why reasonable alternatives were omitted or dismissed from further consideration.

Future projects must be coordinated as described in Policy Point 7.

(3) Policy Point 3: Operational and Accident Analyses

How will the proposal affect safety and traffic operations at year of opening and design year?

Policy Point 3 documents the procedures used to conduct the operational and accident analyses and the results that support the proposal.

The preferred operational alternative is selected, in part, by showing that it will not have a significant adverse impact on the operation and safety of the freeway and the affected local network, or that the proposal impacts will be mitigated.

Document the results of the following analyses in the report:

- "No-Build" Analysis – An operational analysis of the current year, year of opening, and design year for the existing limited access freeway and the affected local roadway system. This is the baseline "no-build" condition, including state transportation plan and comprehensive plan improvements expected to exist. All of the alternatives will be compared to the no-build condition.
- "Build" Analysis – An operational analysis of the year of opening and design year for the proposed future freeway and the affected local roadway system.

- An accident analysis for the most current data year, year of opening, and design year of the existing limited access freeway and the affected local roadway system for the "no-build." An accident analysis should also be performed for the "build" as well.

The data used must be consistent with the data used in the environmental documentation. If not, provide justification for the discrepancies.

(a) ***Operational Analyses.*** Demonstrate that the proposal does not have a significant adverse impact on the operation of the freeway or the adjacent affected local roadway system. If there are proposal impacts, explain how the impacts will be mitigated.

Document the selected operational analysis procedures. For complex urban projects, a refined model might be necessary. As a minimum, an analysis using the current version of the latest accepted *Highway Capacity Manual* (HCM) is necessary. Any procedure used must provide a measure of effectiveness compatible with the HCM. WSDOT currently supports the following traffic analysis and traffic simulation software:

- HCS
- Synchro
- Vissim
- Corsim

Refer to *Design Manual* Chapter 610, "Highway Capacity," for more detail.

FHWA must conduct its independent analysis using HCS. In those instances where HCS is not the appropriate tool to use and a simulation-type software is chosen, early coordination with FHWA is necessary.

All operational analyses shall be of sufficient detail, and include sufficient data and procedure documentation to allow independent analysis during FHWA and HQ evaluation of the proposal. For Interstates, HQ must provide concurrence before it transmits the proposal to FHWA with its recommendation.

Prepare a layout displaying adjacent interchanges/intersections and the data noted below. The data should show:

- Distances between intersections or ramps of a proposed interchange, and that of adjacent existing and known proposed interchanges.
- Design speeds.
- Grades.
- Truck volume percentages on the freeway, ramps, and affected roadways.
- Adjustment factors (such as peak hour factors).
- Affected freeway, ramp, and local roadway system traffic volumes for the "no-build" and each "build" option. This will include: A.M. and P.M. peaks (noon peaks, if applicable); turning volumes; average daily traffic (ADT) for the current year; and forecast ADT for year of opening and design year.
- Affected main line, ramp, and local roadway system lane configurations.

The study area of the capacity analysis on the local roadway system includes documenting that the local network is able to safely and adequately collect and distribute any new traffic loads resulting from the access point revision. Expand the limits of the study area, if necessary, to analyze the coordination required with an in-place or proposed traffic signal system. Record the limits of the analysis as well as how the limits were established in the project assumptions document.

Document the results of analyzing the existing access and the proposed access point revision at all affected locations within the limits of the study area, such as weave, merge, diverge, ramp terminals, accident sites, and HOV lanes; along the affected section of freeway main line and ramps; and on the affected local roadway system. In the report, highlight the following:

- Any location for which there is a significant adverse impact on the operation or safety of the freeway facility, such as causing a reduction of the operational efficiency of a merge condition at an existing ramp; introducing a weave; or significantly reducing the level of service on the main line due to additional travel demand. Note what will be done to mitigate this adverse impact.

- Any location where a congestion point will be improved or eliminated by the proposal, such as proposed auxiliary lanes or collector-distributor roads for weave sections.
- Any local roadway network conditions that will affect traffic entering or exiting the freeway. If entering traffic is to be metered, explain the effect on the connecting local system (for example, vehicle storage).
- When the existing local and freeway network does not meet the desired level of service, show how the proposal will improve the level of service or keep it from becoming worse than the no-build condition in the year of opening and the design year.

(b) ***Accident Analysis.*** The Accident Analysis identifies areas where there may be a safety concern. The study limits are the same as for operational analyses.

Identify and document all safety program (I2) locations. Identify and document accident histories, rates, and types for the freeway section and the adjacent affected local surface system. Project the rates that will result from traffic flow and geometric conditions imposed by the proposed access point revision. Document the basis for all assumptions.

Demonstrate (1) that the proposal does not have a significant adverse impact on the safety of the freeway or the adjacent affected local surface system, or (2) that the impacts will be mitigated. The safety analysis for both existing and proposed conditions should include the following:

1. Type of Accidents
    - What types of accidents are occurring (overturns, rear-ends, enter-at-angle, hitting fixed object)?
    - What types of accidents are most prevalent?
    - Are there any patterns of accident type or cause?
2. Severity of Accidents (fatalities, disabling, evident injuries, property damage)
3. Accident Rates and Numbers
    - Document the number and rate of accidents within the study limits for existing and proposed conditions.
    - What are the existing and anticipated crash/serious injury/fatality rates and numbers by proximity to the interchange exit and entrance ramps?
    - How do these rates compare to similar corridors or interchanges?
    - How do these rates compare to the future rates and numbers?
    - What are the existing and anticipated crash/serious injury/fatality rates and numbers for the impacted adjacent and parallel road system (with and without the access revision)?
4. Contributing Factors and Conclusions
    - Document contributing causes of accidents and conclusions. What are the most prevalent causes?
    - Evaluate and document the existing and proposed roadway conditions for geometric design standards, stopping sight distance and other possible contributing factors. Would the proposal reduce the frequency and severity of accidents?

(4) Policy Point 4: Access Connections and Design

Will the proposal provide fully directional interchanges connected to public streets or roads, spaced appropriately, and designed to full design level geometric control criteria?

Wherever possible, provide for all directions of traffic movement. The intent is to provide full movement at all interchanges, whenever possible. Partial interchanges are discouraged. Less than fully directional interchanges for special-purpose access for transit vehicles, for HOVs, or to or from park-and-ride lots, will be considered on a case-by-case basis.

A proposed new or revised interchange access must connect to a public freeway, road, or street and be endorsed by the local governmental agency or tribal government having jurisdiction over said public freeway, road, or street.

Explain how the proposed access point relates to present and future proposed interchange configurations and the *Design Manual* spacing criteria. Note that urban and rural interchange spacing for crossroads also includes additional spacing requirements between the noses of adjacent ramps, as noted in Chapter 940.

Develop the proposal in sufficient detail to conduct a design and operational analysis. Include the number of lanes, horizontal and vertical curvature, lateral clearance, lane width, shoulder width, weaving distance, ramp taper, interchange spacing, and all traffic movements. This information is presented as a sketch or a more complex layout, depending on the complexity of the proposal.

The status of all known or anticipated project deviations must be noted in this policy point, as described in Chapter 330.

(5) Policy Point 5: Land Use and Transportation Plans

Is the proposed access point revision compatible with all land use and transportation plans for the area?

Show that the proposal is consistent with local and regional land use and transportation plans. Before final approval, all requests for access point revisions must be consistent with the metropolitan and/or statewide transportation plan, as appropriate. (See Chapter 120.) The proposed access point revision will affect adjacent land use and, conversely, land use will affect the travel demand generated. Therefore, reference and show compatibility with the land use plans, zoning controls, and transportation ordinances in the affected area.

Explain the consistency of the proposed access point revision with the plans and studies, the applicable provisions of 23 CFR Part 450, and the applicable transportation conformity requirements of 40 CFR Parts 51 and 93.

If the proposed access is not specifically referenced in the transportation plans, define its consistency with the plans and indicate the process for the responsible planning agency to incorporate the project. In urbanized areas, the plan refinement must be adopted by the metropolitan planning organization (MPO) before the project is designed. The action must also be consistent with the *State Transportation Plan*.

(6) Policy Point 6: Future Interchanges

Is the proposed access point revision compatible with a comprehensive network plan? Is the proposal compatible with other known new access points and known revisions to existing points?

The report must demonstrate that the proposed access point revision is compatible with other known new access points and known revisions to existing points.

Reference and summarize any comprehensive freeway network study, plan refinement study, or traffic circulation study.

Explain the consistency of the proposed access point revision with those studies.

(7) Policy Point 7: Coordination

Are all coordinating projects and actions programmed and funded?

When the request for an access point revision is generated by new or expanded development, demonstrate appropriate coordination between the development and the changes to the transportation system.

Show that the proposal includes a commitment to complete the other noninterchange/nonintersection improvements that are necessary for the interchange/intersection to function as proposed. For example, if the local circulation system is necessary for the proposal to operate, it must be in place before new ramps are opened to traffic. If future reconstruction is part of the mitigation for design year level of service, the reconstruction projects must be in the *State Highway System Plan*.

All elements for improvements are encouraged to include a fiscal commitment and an anticipated time for completion. If the project is to be constructed in phases, it must be demonstrated in Policy Point 3 that each phase can function independently and does not affect the safety and operational efficiency of the freeway. Note the known funding sources, the projected funding sources, and the estimated time of completion for each project phase.

(8) Policy Point 8: Environmental Processes

What is the status of the proposal's environmental processes? This section should be something more than just a status report of the environmental process; it should be a brief summary of the environmental process.

All requests for access point revisions on freeways must contain information on the status of the environmental approval and permitting processes.

The following are just a few examples of environmental status information that may apply:

- Have the environmental documents been approved? If not, when is the anticipated approval date?
- What applicable permits and approvals have been obtained and/or are pending?
- Are there hearings still to be held?
- Is the environmental process waiting for an engineering and operational acceptability decision?

1425.06 Documentation

A list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/EESC/Design/projectdev/

Project Type	Support Team	Policy Point								Concurrence	Approval
		1	2	3	4	5	6	7	8		
Interstate Routes											
New freeway-to-crossroad interchange in a Transportation Management Area(1)	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA DC
New partial interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA DC
New HOV direct access	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA DC
New freeway-to-freeway interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA DC
Revision to freeway-to-freeway interchange in a Transportation Management Area(1)(2)	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA DC
New freeway-to-crossroad interchange not in a Transportation Management Area(1)	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Revision to freeway-to-freeway interchange not in a Transportation Management Area(1)(2)	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Revision to interchange(2)(3)	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Revision to existing interchange—no adverse impacts to main line	No	(6)	(6)	✓	✓	(6)	(6)	(6)	(6)	HQ	FHWA
Transit flyer stop on main line	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Transit flyer stop on an on-ramp	No			✓	✓					HQ	FHWA
Addition of entrance or exit ramps that complete basic movements at an existing interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Abandonment of a ramp(4)	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Locked gate(7)	No	✓			(5)					HQ	FHWA
Access breaks that do not allow any type of access to main line or ramps	No	✓	✓		(5)					HQ	FHWA
Pedestrian structure	No	✓			(5)					HQ	FHWA
Construction/emergency access break	No	✓	✓	✓	✓					Region	FHWA

Notes:

(1) In Washington, designated Transportation Management Areas include Clark, King, Kitsap, Pierce, Snohomish, and Spokane Counties.

(2) “Revision” includes changes in interchange configuration, even though the number of access points does not change. Changing from a cloverleaf to a directional interchange is an example of a “revision.” If the revision does not add new lanes and can be shown to have no adverse impacts, and the spacing and geometric control criteria requirements will be met, a modified IJR will be the acceptable document, meaning fewer than the eight policy points will be required. Consult the HQ Access and Hearings Unit for direction.

(3) Revisions that might adversely affect the level of service of the through lanes. Examples include: doubling lanes for an on-ramp with double entry to the freeway; adding a loop ramp to an existing diamond interchange, replacing a diamond ramp with a loop ramp. If the revision does not have adverse impacts to the Interstate main line, and the spacing and geometric control criteria requirements will be met, a modified IJR will be the acceptable document.

(4) Unless it is a condition of the original approval.

(5) Update the right-of-way/limited access plan as necessary.

(6) If the results of the operational analysis show an adverse impact to the main line, the remaining policy points must be fully, not briefly, addressed.

(7) As part of Policy Point 1, include a narrative stating that all other alternatives are not feasible.

Interstate Routes – Interchange Justification Report Content and Review Levels

Figure 1425-1

Project Type	Support Team	Policy Point								Concurrence	Approval
		1	2	3	4	5	6	7	8		
Non-Interstate Routes											
New freeway-to-crossroad interchange on a predominately grade-separated corridor	Yes	✓	✓	✓	✓	✓	✓	✓	✓	Region	HQ
New freeway-to-freeway interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	Region	HQ
Revision to freeway-to-freeway interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	Region	HQ
New freeway-to-crossroad interchange on a predominately at-grade corridor	No			✓	✓					Region	HQ
Revision to interchange(1)	No			✓	✓					Region	HQ
Addition of entrance or exit ramps that complete basic movements at an existing interchange	No			✓	✓					Region	HQ
Abandonment of a ramp(2)	No			✓						Region	HQ
Locked gate(4)	No	✓			(3)					Region	HQ
Pedestrian structure	No	✓			(3)					Region	HQ
Construction/emergency access break	No	✓	✓	✓						Region	HQ

Notes:

(1) Revisions that might adversely affect the level of service of the through lanes. Examples include: doubling lanes for an on-ramp with double entry to the freeway, adding a loop ramp to an existing diamond interchange, and replacing a diamond ramp with a loop ramp. If the revision does not have adverse impacts to the main line, and the spacing and geometric control criteria requirements will be met, a modified IJR will be the acceptable document.

(2) Unless it is a condition of the original approval.

(3) Update the right-of-way/limited access plan as necessary.

(4) As part of Policy Point 1, include a narrative stating that all other alternatives are not feasible.

Non-Interstate – Interchange Justification Report Content and Review Levels

Figure 1425-2

Interstate actions that *may not* require an IJR or FHWA action.

Project Type	Examples/Comments
Minor revision to existing freeway-to- freeway interchange	To bring to standard
Increasing the length of an exit ramp deceleration lane or entrance ramp acceleration lane	To meet current geometric control criteria
Relocating entrance or exit ramp gore points along the main line	
Adding an auxiliary lane between two adjacent interchange ramps	
Ramp terminal revision at the terminal connection with the crossroad, with no effect to the main line lanes of the interstate.	New turn pocket(s), through lane(s), signalization, roundabout(s)
Converting a one-lane ramp to two lanes with no effect on the through lanes of the Interstate	If there are impacts to the main line, an IJR is required. Contact the HQ Access and Hearings Unit for direction.
Transit flyer stops near the ramp terminals of on-ramps	

Complete Policy Point 3 first for all proposals. If Policy Point 3 shows impacts to the main line, complete the remaining Policy Points.

Notes:

The table above shows some, but not all, of the types of access revisions that normally do not require an Interchange Justification Report.

All changes to limited access routes must receive the approval of the Assistant State Design Engineer.

All access changes on Interstate routes must be approved by FHWA.

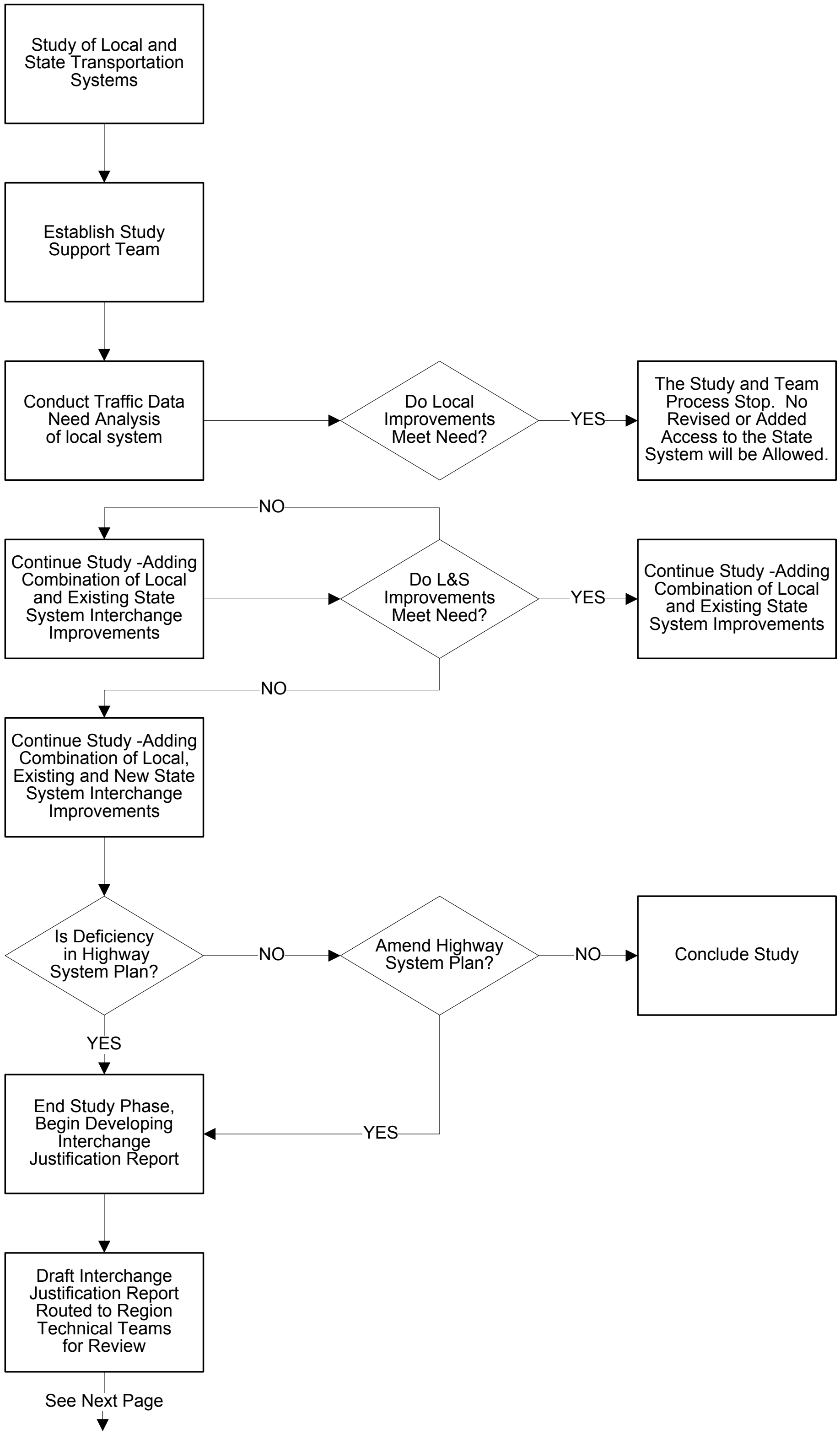
If the following conditions are met, the proposal may be considered under lesser documentation:

- A traffic analysis documents that there will be no adverse impact to the freeway main line.
- The data used is consistent with the data used in the environmental analyses.
- The access is designed to the design level required by the appropriate Design Matrix.
- Access spacing meets requirements in Chapter 940.
- The project is approved per Chapter 330 as part of the Project Summary approval process.

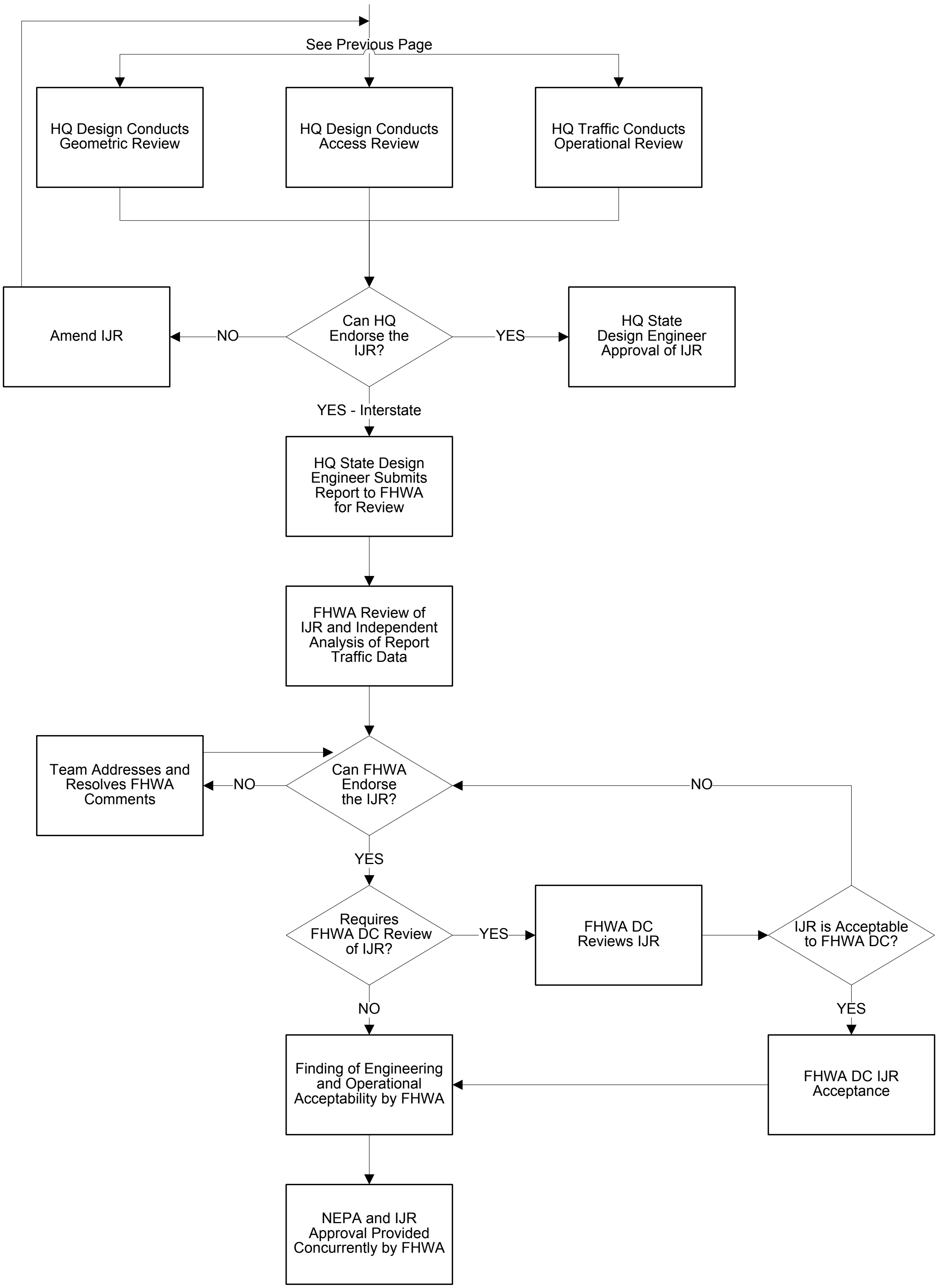
The omission of the IJR is justified in the Design Documentation Package, with a copy sent to the state Access and Hearings Engineer after the Assistant State Design Engineer has concurred in writing. If Interstate, FHWA must concur.

Interchange Justification Report Possibly Not Required

Figure 1425-3



Interchange Justification Report Process Flow Chart
Figure 1425-4



Interchange Justification Report Process Flow Chart
Figure 1425-4 Continued

Chapter 1430 Limited Access

1430.01 General

Chapter 1420, "Access Control," has an overview of access control and the references list and definitions of terminology for this chapter.

Requirements for the establishment of limited access highways are set forth in Revised Code of Washington (RCW) 47.52. The level of limited access is determined during the early stages of design in conformance with this chapter.

Limited access is established to preserve the safety and efficiency of specific highways and to preserve the public investment. Limited access is achieved by acquiring access rights from abutting property owners, and by selectively limiting approaches to the highway.

Highways controlled by acquiring abutting property owners' access rights are termed limited access highways and are further distinguished as having full, partial, or modified control. The number of access points per mile, spacing of interchanges or intersections, and the location of frontage roads or local road/street approaches are determined by:

- The functional classification and importance of the highway.
- The character of the traffic.
- The present and future land use.
- The environment and aesthetics.
- The highway design and operation.
- The economic considerations involved.

The Washington State Department of Transportation (WSDOT) has full jurisdiction on limited access highways, whether they are inside or outside incorporated city limits except that the Federal Highway Administration (FHWA) has jurisdiction on the Interstate System.

WSDOT keeps a record of the status of limited access control, by state route number and mile post, in the database: Access Control Tracking System at http://www.wsdot.wa.gov/eesc/design/access, under the RELATED SITES heading.

The acquisition of full, partial, or modified control is to be evaluated when right of way is being acquired on an existing highway if the route is shown on the Access Control Tracking System list as either established or planned for limited access. The matrices in Chapter 325 list several project types for which acquisition is indicated as a design element.

The cost of acquiring limited access must be evaluated considering future accident costs, future development, and the improved level of service of limited access highways. This cost will be evaluated against the cost to realign the highway in the future if limited access is not acquired at current prices.

Nothing in this chapter is to be construed to prevent acquisition of short sections of full, partial, or modified control of access.

1430.02 Achieving Limited Access

(1) Process

All Washington highways are managed access highways (Chapter 1435) except where limited access rights have been acquired. The right of way and limited access plans show the acquired limited access boundaries along the highways shown on the Access Control Tracking System as "Established Limited Access." The Tracking System list also shows the highways that are "Planned for Limited Access."

To achieve limited access:

(a) The Transportation Commission first identifies a highway as "Planned for Limited Access."

(b) To establish or revise limited access on new or existing highways, access hearings are held. See Chapter 210, "Public Involvement" regarding hearings, and Chapter 1410 for the phases of appraisal and acquisition.

- Phase 1. The region develops an access report and an access report plan for department approval and presentation to local officials. The plan notes the level of limited access proposed to be established.
- Phase 2. The region develops an access hearing plan for the State Design Engineer or designee approval and for presentation at the hearings.
- Phase 3. After the hearing, the region develops the findings and order and revises the hearing plan to become the findings and order plan. The findings and order is processed to Headquarters (HQ) Access and Hearings Unit for review and approval.

(c) The Transportation Commission or a designee adopts the findings and order and thus establishes the limits and level of limited access control to be acquired.

(d) The findings and order plan is now revised by the Right of Way Plans Office for approval by the State Design Engineer or designee as a Phase 4 final right of way and limited access plan.

(e) Real Estate Services acquires limited access rights from individual property owners based on final design decisions (diamond interchange or single point, for instance) and updates the right of way and limited access plans.

(f) These highways or portions thereof are now limited access highways and no longer fall under the managed access program.

Highways are shown in the Access Control Tracking System as "L/A" in the CURRENT ACCESS column and further listed under ESTABLISHED L/A, PLANNED L/A, or L/A ACQUIRED, based on the current right of way and limited access plans. If not listed under L/A ACQUIRED, the highway section is a managed access highway section until the acquisition is final.

(2) Access Report

The access report is developed by the region to inform local governmental officials of the proposed limited access highway, the principal access features involved, and to secure their approval. This report is not furnished to abutting property owners. Three copies of the report are submitted to the HQ Access and Hearings Unit for review and approval prior to submission to local authorities.

The access report consists of:

(a) A description of the existing and proposed highways. Data on the history of the existing highway (may include references to High Accident Locations (HAL), High Accident Corridors (HAC), Pedestrian Accident Locations (PAL), and Risk locations) and development of the proposed highway(s).

(b) Traffic analyses pertaining to the proposed highway, including available information concerning present and potential future traffic volumes of county roads and city streets crossing or severed by the proposed highway, and sources of information (origin-destination surveys, and so forth).

Traffic data developed for the design decision summary, together with counts of existing traffic directly available from state or local records, is normally adequate. Special counts of existing traffic are obtained only if circumstances indicate that the available data is inadequate or outdated.

(c) A discussion of factors affecting the design of the subject highway, including:

- Design level.
- Level of limited access, with definition.
- Roadway section.
- Interchange, grade separation, and intersection spacing.
- Pedestrian and bicycle trails or paths.

- Operational controls with emphasis on proposed fencing, the general concept of illumination, signing, and other traffic control devices.
- Locations of utilities and how affected.
- Proposed plan for landscaping and beautification, including an artist's graphic rendition or design visualization.

(d) Governmental responsibility, comprehensive planning, land use, and community service relative to the new highway.

(e) The disposition of frontage roads, city street and county road intersections, and excess right of way.

(f) An appendix containing the following:

- A glossary of engineering terms.
- A traffic volume diagram(s).
- Pages showing diagrammatically or graphically the roadway section(s), operational controls, and rest areas (if rest areas are included in the project covered by the report).
- A vicinity map.
- An access report plan and profiles for the project.

  The access report plan shows the effects of the proposed highway on the street and road system by delineating the points of public access. See the *Plans Preparation Manual* for a list of the minimum details to be shown on the plan and for a sample plan.

(h) Conferences and Reviews. Upon receipt of the Environmental and Engineering Programs (E&EP) Director's approval of Phase 1 (Figure 1410-1), the region publishes the necessary copies, submits the access report to the county and/or city officials for review and approval, and meets with all local governmental agencies involved to discuss the report. The region reviews any request for modification and submits recommendations, with copies of any correspondence or minutes relating thereto, to the HQ Access and Hearings Unit.

(3) Access Hearing Plan

The region prepares an access hearing plan to be used as an exhibit at the public hearing (Chapter 210) and forwards it to the HQ Right of Way Plans Office for review. See the *Plans Preparation Manual* for a list of data to be shown on the access hearing plan in addition to the access report plan data.

When the plan review is completed by Headquarters, the access hearing plan is placed on the E&EP Director's calendar for approval of Phase 2 authority (Figure 1410-1).

(4) Documentation

Documentation for the establishment of limited access control is in Chapter 210.

1430.03 Full Control (Most Restrictive)

(1) Introduction

Full control limited access highways provide almost complete freedom from disruption by allowing access only through interchanges at selected public roads/streets, rest areas, viewpoints, or weigh stations, and by prohibiting at-grade crossings and approaches. Gated approaches are occasionally allowed but only with approval of a request that includes an Access Point Decision Report (Chapter 1425).

At times, on state highways where full access control has been established, except Interstate, staged access acquisition may be used (subject to the approval of an access deviation) with initial acquisition as partial or modified control and with ultimate acquisition of full control planned on the highway. Where there is no practical alternative within reasonable cost, the decision to defer acquisition of limited control of access must be documented and is subject to the approval of an access deviation.

(2) Application

Terminate full control limited access sections at apparent logical points of design change. The following guidelines are to be used for the application of full control on limited access highways:

(a) **Interstate.** Full control is required on Interstate highways.

(b) **Principal Arterial.** Documentation assessing the evaluation of full control is required for principal arterial highways requiring four or more through traffic lanes within a 20-year design period unless approved for partial or modified control on existing highways by the Transportation Commission.

(c) **Minor Arterial and Collector.** Minor arterial and collector highways will not normally be considered for development to full control.

(3) Crossroads at Interchange Ramps

The extension of limited access control beyond an intersection is measured from the center line of ramps, crossroads, or parallel roads as shown in Figures 1430-1a, b, and c, from the terminus of transition tapers, Figure 1430-2, and single point urban intersections, Figure 1430-3.

(a) **Ramps.** At-grade intersections and approaches are prohibited within the full length of any off or on interchange ramp. The ramp is considered to terminate at its intersection with the local road or street.

(b) **Frontage Roads.** See Figures 1430-1a, b and c. Direct access from the highway to a local service or frontage road is allowed only via the interchange crossroad.

(c) **Interchange Crossroads.** In both urban and rural areas, full control limited access must be established and then acquired along the crossroad at an interchange for a minimum distance of 300 ft beyond the center line of the ramp or the end of the transition taper.

If a frontage road or local road is located at or within 350 ft of a ramp, limited access will be established and then acquired along the crossroad and for an additional minimum distance of 130 ft in all directions from the center line of the intersection of the crossroad and the frontage or local road (Figures 1430-1a and b) or 130 ft from the ends of the raised splitter islands of a roundabout (Figure 1430-1c).

For interchanges incorporating partial cloverleaf and/or buttonhook ramps (Figure 1430-1b), limited access is required for all portions of the crossroad and frontage roads between the ramp terminals, and for a distance of 300 ft beyond the ramp terminals. If an at-grade intersection for a local road or street is to be served directly opposite the ramp terminals, limited access will be extended additionally for a minimum of 300 ft, along that leg of the intersection.

When the intersection in question is a roundabout, see Figure 1430-1c. This shows extension of full control to be 300 ft measured from the end of the raised splitter island for an intersection with a ramp terminal and 130 ft for three legs of an at-grade intersection at or within 350 ft of a ramp terminal intersection.

Figure 1430-2 shows the terminus of transition taper.

For a single point urban interchange (SPUI) with a right or left turn “ramp branch” (separated by islands), Figure 1430-3, access control is measured (300 ft) from the intersection of the center line of the ramp branch with the center line of the nearest directional roadway.

(d) **Levels of Limited Access, Location of Approaches.** See Figures 1430-1a, b, and c and Figures 1430-2 and 3. Provide full control for 300 ft from the center line of the ramp or terminus of a transition taper.

If the economic considerations to implement full control for the full 300 ft are excessive, then provide full control for the first 130 ft and partial or modified control may be provided for the remaining 170 ft, for a total minimum distance of 300 ft of limited access. Contact the HQ Access and Hearings Unit when considering this option.

An approved access deviation is required if the limited access control falls short of 300 ft and for any access that has been allowed to remain within the first 130 ft.

Ensure that approaches are far enough away from a frontage road intersection to provide efficient intersection operation.

(4) Location of Utilities, Bus Stops, Mailboxes, and Pedestrian Crossings

(a) **Utilities.** See the *Utilities Accommodation Policy* regarding location of and access to utilities. Connecting utility lines are allowed along the outer right of way line between intermittent frontage roads.

(b) **Bus Stops.** Common carrier or school bus stops are not allowed except at:

- Railroad crossings (Chapter 930).
- Locations provided by the state on the interchanges (such as flyer stops).
- In exceptional cases, along the main roadway where pedestrian separation is available.

(c) **Mailboxes.** Mailboxes are not allowed on full control limited access highways. Mail delivery will be from frontage roads or other adjacent local roads.

(d) **Pedestrian Crossings.** At-grade pedestrian crossings are not allowed except at ramp terminal at-grade intersections.

(5) Nonmotorized Traffic

All nonmotorized traffic is prohibited on full control limited access highways. This prohibition does not apply to:

- Pedestrian separations or other facilities provided specifically for pedestrian use.
- Bicyclists using facilities provided specifically for bicycle use (separated paths).
- Bicyclists using the right-hand shoulders, except where such use has been specifically prohibited. Information pertaining to such prohibition is available from the Traffic Branch of the Operations and Maintenance Office.

(6) Trails

Pedestrian and bicycle trails are allowed, consistent with “Rules of the Road” (RCW 46.61), within the limits of full control limited access highways. When trails are allowed (with headquarters approval), they must be documented on the right of way and limited access plan. The plan shows the location of the trail and where the trail crosses limited access, and provides movement notes. See 1430.10(1).

1430.04 Partial Control

(1) Introduction

Partial control may be established, when justified, on any highway except Interstate. Partial control provides a considerable level of protection from traffic interference and protects the highway from future strip-type development.

Upon acquisition of partial control limited access rights, the number, type, and use of the access approaches of abutting property are frozen. The abutting property access rights and type of use are recorded upon the property deed. The rights and use may not be altered by the abutting property owner, the local jurisdiction, or the region. This authority resides with the State Design Engineer. See 1430.10.

(2) Application

Partial control will not normally be used in urban areas, or inside corporate limits on existing principal arterial highways where traffic volumes are less than 700 design hourly volume (DHV). Terminate limited access sections at apparent logical points of design change.

(a) **Principal Arterial.** The minimum route length is all sections not requiring full control. See 1430.03(2)(b).

Partial control is required when the estimated traffic volumes exceed 3,000 average daily traffic (ADT) within a 20-year design period on principal arterial highways requiring two through traffic lanes. For multilane principal arterial highways, see 1430.03(2)(b).

(b) **Minor Arterial.** The minimum route length is: urban, 2 miles; rural, 5 miles; and combination urban and rural, 3 miles.

Partial control is required on rural minor arterial highways on both new and existing locations, and urban minor arterial highways on new locations, requiring four or more through traffic lanes within a 20-year design period, or requiring only two through traffic lanes where the estimated traffic volumes exceed 3,000 ADT within a 20-year design period.

Other rural minor arterial highways with only two lanes may be considered for partial control if any of the following conditions apply:

- The partial control can be acquired at a reasonable cost.
- The route connects two highways of a higher functional classification.
- The potential land development can result in numerous individual approaches, such as encountered in recreational or rapidly developing areas.
- The highway traverses publicly owned lands where partial control is desirable.

(c) **Collector (New Alignment).** Partial control is required on collector highways on new locations requiring four or more through traffic lanes in a 20-year design period.

(d) **Collector (Existing).** Existing collector highways will normally be considered for partial control limited access only when all of the following conditions apply:

- The highway serves an area that is not directly served by a higher functional classification of highway.
- Existing or planned development will result in traffic volumes significantly higher than what is required for partial control on minor arterials.
- Partial control can be established without a major impact on development of abutting properties within the constraints of established zoning at the time when the partial control is proposed.

(3) Interchanges and Intersections

(a) **Interchanges.** When an interchange occurs on a partial control limited access highway, full control applies at the interchange and interchange ramps. Refer to 1430.03(3) and see Figures 1430-1a, b, and c for required minimum lengths of access control.

(b) **Intersections.** At an at-grade intersection on a partial control limited access highway, control will be established and acquired along the crossroad for a minimum distance of 300 ft from the center line of the highway. (Figure 1430-4) If another frontage or local road is located at or within 350 ft of the at-grade intersection, limited access will be established and then acquired along the crossroad for the required minimum 300 ft and for an additional minimum distance of 130 ft in all directions from the center line of the intersection of the frontage or local road or the ends of the raised splitter islands of a roundabout (Figure 1430-5) and the crossroad. On multilane highways, measurements will be made from the center line of the nearest directional roadway.

An approved access deviation is required if the limited access control falls short of 300 ft and for any access that has been allowed to remain within the first 130 ft.

At-grade intersections with public roads are limited to the number allowed for the functional classification of highway involved as follows:

Principal Arterial - If the ADT is less than 2,000, one mile spacing (minimum), center line to center line. If over 2,000 ADT within 20 years, plan for grade separation.

Minor Arterial - If the ADT is less than 2,000, one-half mile spacing (minimum), center line to center line. If over 2,000 ADT within 20 years, plan for grade separation.

Collector - Road (or street) plus property approaches not more than six per side per mile.

However, with approval from the State Design Engineer, shorter intervals may be used where topography or other conditions restrict the design. When intersecting roads are spaced farther apart than one per mile, median crossings may be considered for U-turns in accordance with Chapter 910. Keep U-turns to a minimum, consistent with requirements for operation and maintenance of the highway.

To discourage movement in the wrong direction on multilane highways, locate private approaches 300 ft or more from an at-grade intersection. At a tee intersection, a private approach may be located directly opposite the intersection or a minimum of 300 ft away from the intersection. Ensure that a private approach directly opposite a tee intersection cannot be mistaken for a continuation or part of the public traveled way.

(4) Access Approach

Partial control is exercised to the level that, in addition to intersections with selected public roads, some crossings and private driveways may be allowed.

(a) **Approach Types.** Partial control limited access highways allow at-grade intersections with selected public roads and private approaches using Type A, B, C, and F approaches. See Chapter 1420 for definitions of the approach types.

Type D, commercial approaches, are not allowed direct access to partial control limited access highways. Commercial access is allowed only by way of public roads.

The type of approach provided for each parcel takes into consideration present and potential land use and is based on an economic evaluation. See 1430.05(4) for a list of considerations.

(b) **Design Considerations.** The following considerations are used to determine the number and location of access approaches on partial control limited access highways.

1. Access approaches must be held to a minimum. The number is limited as follows:
    - Principal arterial - 2 per side per mile.
    - Minor arterial - 4 per side per mile.
    - Collector - 6 per side per mile including at-grade intersections
2. Approaches in excess of the number listed in 1., above, may be allowed as stage construction if approved by the State Design Engineer.
3. Approaches are not allowed for parcels that have reasonable access to other public roads unless the parcel has extensive highway frontage.
4. Relocate or close approaches located in areas where sight limitations create undue hazard.
5. Allow only one approach for each parcel except for very large ownerships, or where terrain features do not allow the property to be served by a single approach. This includes contiguous parcels under a single ownership.
6. Where possible, locate a single approach to serve two or more parcels.
7. The approved design is to provide for future development of frontage roads that will eliminate an excessive number of approaches.

(5) Location of Utilities, Bus Stops, Mailboxes, and Pedestrian Crossings

(a) **Utilities.** See the *Utilities Accommodation Policy* regarding location of and access to utilities. Connecting utility lines are allowed along the outer right of way line between intermittent frontage roads.

(b) **Bus Stops.** Bus stops for both common carriers and school buses are not allowed on either two or four-lane highways, except as follows:

- At railroad crossings per Chapter 930.
- At locations of intersections with necessary pullouts to be constructed by the state.
- Where shoulder widening has been provided for mail delivery service.
- For a designated school bus loading zone on the traveled lane or adjacent thereto which has been approved by the Department of Transportation.

Buses are not allowed to stop in the traveled lanes blocking at-grade intersections or private approaches to load or unload passengers.

School bus loading zones on partial control limited access highways must be posted with school bus loading zone signs, in accordance with the latest edition of the *Manual on Uniform Traffic Control Devices*.

(c) **Mailboxes.** Locate mailboxes on frontage roads or at intersections with the following exceptions for properties that are served by Type A or B approaches:

- Locate mailboxes on a four-lane highway only on the side of the highway on which the deeded approach is provided.
- Locate mailboxes on a two-lane highway on the side of the highway that is on the right in the direction of the mail delivery.

Whenever mailboxes are allowed on a partial control limited access highway, provide mailbox turnouts to allow mail delivery vehicles to stop clear of the through traffic lanes. See Chapter 700 for additional information concerning mailbox locations and turnouts.

(d) **Pedestrian Crossings.** Pedestrian crossings are allowed when grade-separated.

At-grade pedestrian crossings are allowed:

- At intersections only where an at-grade crossing is provided in accordance with Chapter 1025.
- On two-lane highways at mailbox locations.
- On two-lane highways not less than 100 ft from a school bus loading zone (pull out) adjacent to the traveled lane, if school district and WSDOT personnel determine that stopping in the traveled lane is hazardous.
- On two-lane highways where the school bus is stopped on the traveled lane to load or unload passengers and the required sign and signal lights are displayed.

(6) Nonmotorized Traffic

On partial control limited access highways, pedestrian and bicycle traffic is allowed, consistent with "Rules of the Road" (RCW 46.61), except when unusual safety conditions support prohibition. Information pertaining to such prohibitions is available from the Traffic Engineering Branch of the Operations and Maintenance Office.

(7) Trails

Pedestrian and bicycle trails are allowed, consistent with "Rules of the Road," on partial control limited access highways. When trails are allowed (with headquarters approval), they must be documented on the right of way and limited access plan. The plan shows the location of the trail and where the trail crosses limited access, and provides movement notes. See 1430.10(1).

1430.05 Modified Control (Least Restrictive)

(1) Introduction

Modified control is intended to prevent further deterioration in the safety and operational characteristics of existing highways by limiting the number and location of access points.

Upon acquisition of modified control limited access, the number, type, and use of access approaches of abutting property are frozen. The abutting property access rights and type of use are recorded upon the property deed. The rights and use may not be altered by the abutting property owner, the local jurisdiction, or the region. This authority resides with the State Design Engineer. See 1430.10.

(2) Application

In general, modified control is applied where some level of control is desired, but existing and potential commercial development precludes the implementation of full or partial control.

(a) **Existing Highways.** Modified control may be established and acquired on existing highways other than Interstate. Priority is given to highway segments where one or both of the following conditions apply:

- Commercial development potential is high, but most of the adjoining property remains undeveloped.
- There is a reasonable expectation that the adjoining property will be redeveloped to a more intensive land use resulting in greater traffic congestion.

(b) **Design Analysis**. Selection of highways on which modified control may be applied is based on a design analysis including the following factors:

- Traffic volumes.
- Level of service.
- Safety.
- Level of Development Plan.
- Route continuity.
- Population density.
- Local land use planning.
- Present and potential land use.
- Predicted growth rate.
- Economic analysis.

(c) **Exceptions.** Where modified control is to be established, developed commercial areas may be excepted from control when all or most of the abutting property has been developed to the extent that few, if any, additional commercial approaches will be required with full development of the area. Contact the HQ Access and Hearings Unit when considering this option. If this exception is within the limits of access control requirements, an approved access deviation is required.

(3) Intersections

At an intersection on a modified control limited access highway, access control will be established and acquired along the crossroad for a minimum distance of 130 ft from the center line of a two-lane highway, from the center line of the nearest directional roadway of a four-lane highway, or from the ends of the raised splitter islands of a roundabout (Figures 1430-5 and 6). Approaches are allowed within this area only when there is no reasonable alternative. An approved access deviation is required for any access that has been allowed to remain within the first 130 ft.

(4) Access Approach

The number and location of approaches on a highway, with modified control, must be carefully planned to provide a safe and efficient highway compatible with present and potential land use.

(a) **Approach Types.** Modified control limited access highways allow at-grade intersections with selected public roads and with private approaches using Type A, B, C, D, and F approaches. See Chapter 1420 for definitions of the approach types.

The type of approach provided for each parcel takes into consideration present and potential land use and is based on an economic evaluation that considers the following:

- Local comprehensive plans, zoning, and land use ordinances.
- Property covenants and/or agreements.
- City or county ordinances.
- The highest and best use of the property.
- Highest and best use of adjoining lands.
- Change in use by merger of adjoining ownerships.
- All other factors bearing upon proper land use of the parcel.

(b) **Design Considerations.** The following considerations are used to determine the number and location of approaches:

1. Parcels that have access to another public road or street are not normally allowed direct access to the highway.
2. Relocate or close approaches located in areas where sight limitations create undue hazard.
3. Hold the number of access approaches to a minimum. Access approaches are limited to one approach for each parcel of land, or when adjoining parcels are under one contiguous ownership.
4. Encourage joint use of access approaches where similar use of land allows.
5. Additional approaches may be allowed for future development consistent with local zoning. Once limited access has been acquired, this will require a value determination process. See 1430.10.
6. Close existing access approaches not meeting the above.

(5) Location of Utilities, Bus Stops, Mailboxes, and Pedestrian Crossings

(a) **Utilities**. See the *Utilities Accommodation Policy* regarding location of and access to utilities. Connecting utility lines are allowed along the outer right of way line between intermittent frontage roads.

(b) **Bus Stops and Pedestrian Crossings.** Bus stops and pedestrian crossings are allowed as follows:

- In rural areas, bus stops and pedestrian crossings are subject to the same restrictions as in 1430.04(5).
- In urban areas, bus stops for both commercial carriers and school buses are allowed. See Chapter 1060 for requirements.

(c) **Mailboxes.** Locate mailboxes adjacent to or opposite all authorized approaches as follows:

- Locate mailboxes on a four-lane highway only on the side of the highway on which the deeded approach is provided.
- Locate mailboxes on a two-lane highway on the side of the highway that is on the right in the direction of the mail delivery. Where mailboxes are allowed, a mailbox turnout is recommended to allow mail delivery vehicles to stop clear of the through traffic lanes. See Chapter 700 for additional information concerning mailbox locations and turnouts.

(6) Nonmotorized Traffic

Pedestrian and bicycle traffic is allowed, consistent with "Rules of the Road" (RCW 46.61), on modified control limited access highways, except where unusual safety considerations support prohibition. Information pertaining to such prohibitions is available from the Traffic Engineering Branch of the Operations and Maintenance Office.

(7) Trails

Pedestrian and bicycle trails are allowed, consistent with "Rules of the Road," on modified control limited access highways. When trails are allowed, they must be documented on the right of way and limited access plan. The plan shows the location of the trail and where the trail crosses limited access, and provides movement notes. See 1430.10(1)

1430.06 Access Approaches

(1) General

Access approaches may be allowed on limited access highways consistent with the requirements outlined in 1430.03, 1430.04, and 1430.05.

For additional information pertaining to approaches, refer to Chapters 915 (roundabouts), 920 (approach design templates), and 1410 (right of way), and the *Plans Preparation Manual*.

(2) Definitions

See Chapter 1420 for specific definitions of the approach types. The widths for the approach types are negotiated, and only the negotiated width is shown on the right of way and limited access plan.

1430.07 Frontage Roads

Local agency approval is required for any planned frontage roads, county roads, city streets, or cul-de-sacs. The local agency must also agree in writing to accept and maintain the new section as a county road or city street.

(1) General

Frontage roads are provided in conjunction with limited access highways to:

- Limit access to the main line.
- Provide access to abutting land ownerships.
- Restore continuity of the local street or roadway system.

Refer to Chapter 620 for frontage road general policy, and to Chapter 330 for required documentation.

By agreement under which the state is reimbursed for all costs involved, frontage roads that are not the responsibility of the state may be built by the state upon request of a local political subdivision, a private agency, or an individual.

(2) County Road and City Street

To connect roads or streets that have been closed off by the highway, short sections of county roads or city streets that are not adjacent to the highway may be constructed if they will serve the same purpose as, and cost less than, a frontage road.

(3) Cul-de-Sacs

For a frontage road or local street bearing substantial traffic that is terminated or closed at one end, provide a cul-de-sac (or other street or roadway consistent with the local policy or practice) that is sufficient to allow vehicles to turn around without encroachment on private property.

1430.08 Turnbacks

When WSDOT transfers jurisdiction of operating right of way to a city, town, or county a turnback agreement is required. See the *Agreements Manual* for turnback procedures.

Locate the turnback limits at points of logical termination. This will allow WSDOT to retain an adequate amount of right of way for maintenance of the highway and for other operational functions.

In areas where limited access rights have been acquired from the abutting property owners, the limited access rights will continue to be required for highway purposes, thus the limited access rights will not be included as part of a turnback agreement.

When a signalized intersection is in the area of a turnback, locate the turnback limit outside of the detector loops if WSDOT is continuing the ownership, operation, and maintenance of the signal system. For a roundabout, locate the turnback limit at the back of the raised approach splitter island if WSDOT is continuing the ownership, operation, and maintenance of the roundabout.

1430.09 Adjacent Railroads

(1) General

A limited access highway and a railroad are considered adjacent when they have a common right of way border with no other property separating them. The allowed approaches only apply to adjacent railroad property that is directly used for current railroad operation.

(2) Requirements

It is in the public interest to provide access to the railroad right of way, from limited access highways, for maintenance of the railroad and the utilities located on the railroad right of way when other access is not feasible. This applies both to new highways and to existing highways where limited access has been acquired.

Direct access is allowed when local roads are infrequent or there are few highway-railroad crossings from which trail-type access for maintenance purposes is feasible, and when unique topography or other unusual conditions justify its use.

Direct access from the highway is considered unnecessary and is not allowed when:

- There are local roads adjacent to or crossing the railroad.
- A trail-type road can be provided by the railroad between crossroads.
- The limited access highway is paralleled by a frontage road adjacent to the railroad.
- No highway previously existed adjacent to the railroad.

(3) Restrictions

To justify direct approaches to provide access to railroad right of way, all of the following conditions must be met:

- A maximum of one approach is allowed for every 2 miles of highway.
- The approach must not adversely affect the design, construction, stability, traffic safety, or operation of the highway.
- Except when the railroad is located in the median area, the approach is to be accomplished in a legal manner by right turns only to and from the roadway nearest the railroad. Median crossing is not allowed.

- The approach is secured by a locked gate under arrangements satisfactory to the department. (See approach Type C in Chapter 1420, and Chapter 1425.)
- Parking of any vehicles or railroad equipment is prohibited within limited access highway right of way.
- A special emergency maintenance permit must be obtained for periods of intensive railroad maintenance.
- The approach must be closed if the railroad operation ceases.
- Approaches are limited to use by the railroad company unless specific provisions for other use are shown on the right of way and limited access plan and included in the right of way negotiations.

1430.10 Modifications to Limited Access Highways

(1) General

Modifications to limited access highways can only be made by application of current design requirements and with the approval of the E&EP Director or designee and, when appropriate, the Federal Highway Administration.

Any change is a modification to limited access: new fence openings, closing existing fence openings, adding trails that cross into and out of the right of way, and widening existing approaches, for instance. The right of way and limited access plan must be revised and, if private approaches are involved, deeds must be redone.

Consider the following factors when evaluating a request for modification of a limited access highway:

- Existing level of control on the highway.
- Functional classification and importance of the highway.
- Percentage of truck traffic.
- Highway operations.
- Present or future land use.
- Environment or aesthetics.
- Economic considerations.
- Safety considerations.

Evaluate all revisions to limited access highways to determine if access hearings are required.

Also see Chapter 1425, "Access Point Decision Report," for requirements to be met for selected modifications to full control limited access highways such as the Interstate System and multilane state highway.

(2) Modifications for Private Access Approaches

(a) **Requirements.** Examples of access modification requested by abutting property owners include additional road approaches, changes in the allowed use, or additional users of existing road approaches.

Plan revisions that provide for additional access to abutting properties after the department has purchased the access rights are discouraged. However, these revisions may be considered if all of the following can be established:

- There are no other reasonable alternatives.
- The efficiency and safety of the highway will not be adversely impacted.
- The existing situation causes extreme hardship on the owner(s).
- The revision is consistent with the limited access highway requirements.

(b) **Procedures**. The region initiates a preliminary engineering review of the requested modification to or break in limited access. This preliminary review will be conducted with the HQ Access and Hearings Unit to determine if conceptual approval can be granted for the request. If conceptual approval can be granted then:

- The region initiates an engineering review of the requested modification.
- The region prepares and submits to HQ Plans Branch a preliminary right of way and limited access plan revision together with a recommendation for approval by the E&EP Director. When federal aid funds are

involved in any phase of the project, the proposed modification will be sent to FHWA for their review and approval.

- The recommendation will include an item-by-item analysis of the factors listed in 1430.10(1) and 1430.10(2)(a) above.

(c) **Valuation Determination.** Upon preliminary approval, region Real Estate Services prepares an appraisal for the value of the access change using a before and after appraisal.

- The appraisal follows the requirements set forth in the *Right of Way Manual*.
- The appraisal is reviewed by the HQ Real Estate Services Office. If the appraisal data does not support a value of $1,500 or more, a minimum value of $1,500 is used.
- For well documented special cases where it does not appear appropriate to base the charges on the reviewed appraisal, region Real Estate Services documents the circumstances that support granting the requested change at less than the determination of value in an administrative settlement letter.
- The appraisal package is sent to HQ Real Estate Services Office for review and approval.
- If federal aid funds were involved in purchasing access control, HQ Real Estate Services will send a copy of the appraisal package to FHWA for their review and approval.

(d) **Final Processing**.

- Region Real Estate Services informs the requestor of the approved appraised value for the change.
- If requestor is still interested, region prepares a "Surplus Disposal Package" for HQ Real Estate Services Office review and approval.
- At the same time, the preliminary right of way and limited access plan revision previously transmitted is processed for approval.
- After the department collects the payment from the requestor, the region issues a permit for the construction, if required.
- If an existing approach is being surrendered, region Real Estate Services obtains a conveyance from the property owner.
- HQ Real Estate Services Office prepares and processes a deed granting the change to the access rights.

(3) Modifications for Public At-Grade Intersections

(a) **Requirements**.

- Public at-grade intersections on partial control limited access highways serve local arterials that form part of the local transportation network.
- Requests for new intersections on limited access highways must be made by or through the local governmental agency to WSDOT. The region will forward this request, including the data referenced in 1430.10(1) and 1430.10(2)(a) to the HQ Access and Hearings Unit.
- New intersections require full application of current limited access acquisition and conveyance to the WSDOT. The access acquisition and conveyance must be completed prior to beginning construction of the new intersection. The new intersection will meet WSDOT design and spacing requirements.

(b) **Procedures**.

- The region evaluates the request and contacts the HQ Access and Hearings Unit for conceptual approval.
- The region submits an intersection plan for approval (Chapter 910) and right of way and limited access plan revision request *(Plans Preparation Manual*). This plan includes the limited access design requirements along the proposed public at-grade intersection.

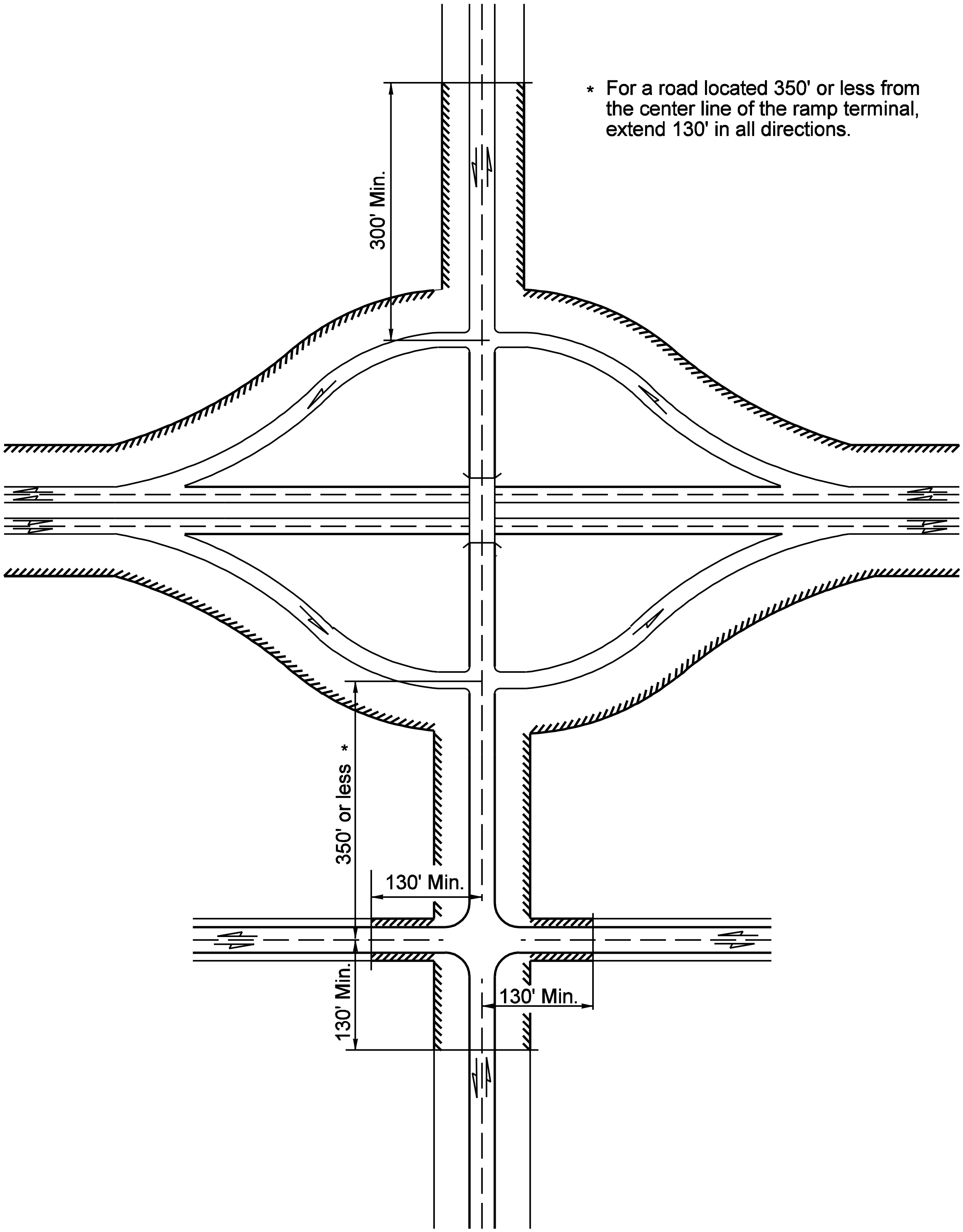
- The State Design Engineer approves the intersection plan.
- The E&EP Director approves the access revision.
- The region submits the construction agreement to the State Design Engineer. *(*See the *Agreements Manual.*)
- The E&EP Director approves construction agreement.

(c) **Valuation Determination**.

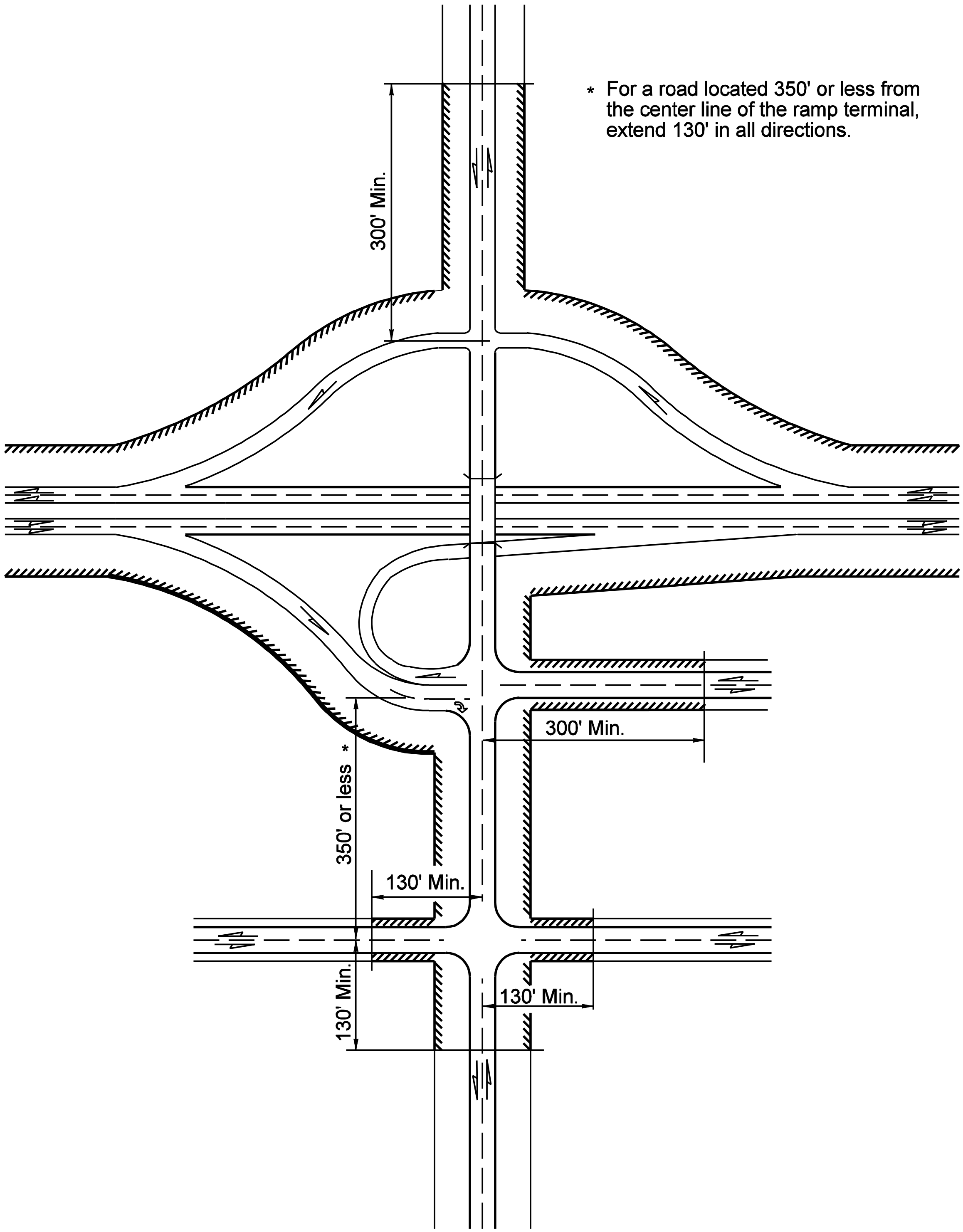
- When a requested public at-grade intersection will serve a local arterial that immediately connects to the local transportation network, compensation will not be required.
- When a requested public at-grade intersection will serve only a limited area, does not immediately connect to the local transportation network, or is primarily for the benefit of a limited number of developers, compensation for the access change will be addressed in the plan revision request. In these situations, compensation is appropriate and a value will be determined as outlined in 1430.10(2)(c) above.

1430.11 Documentation

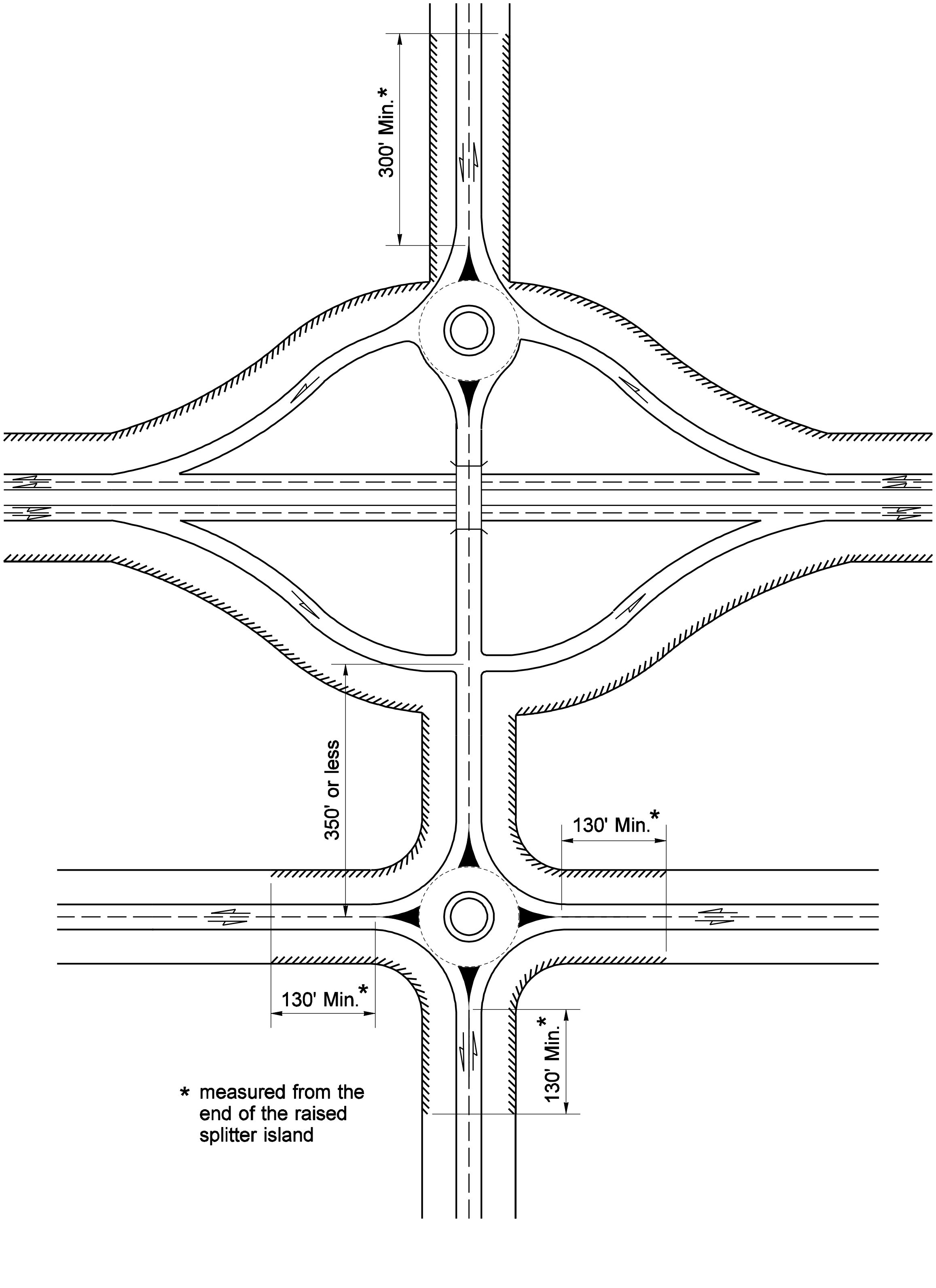
A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/



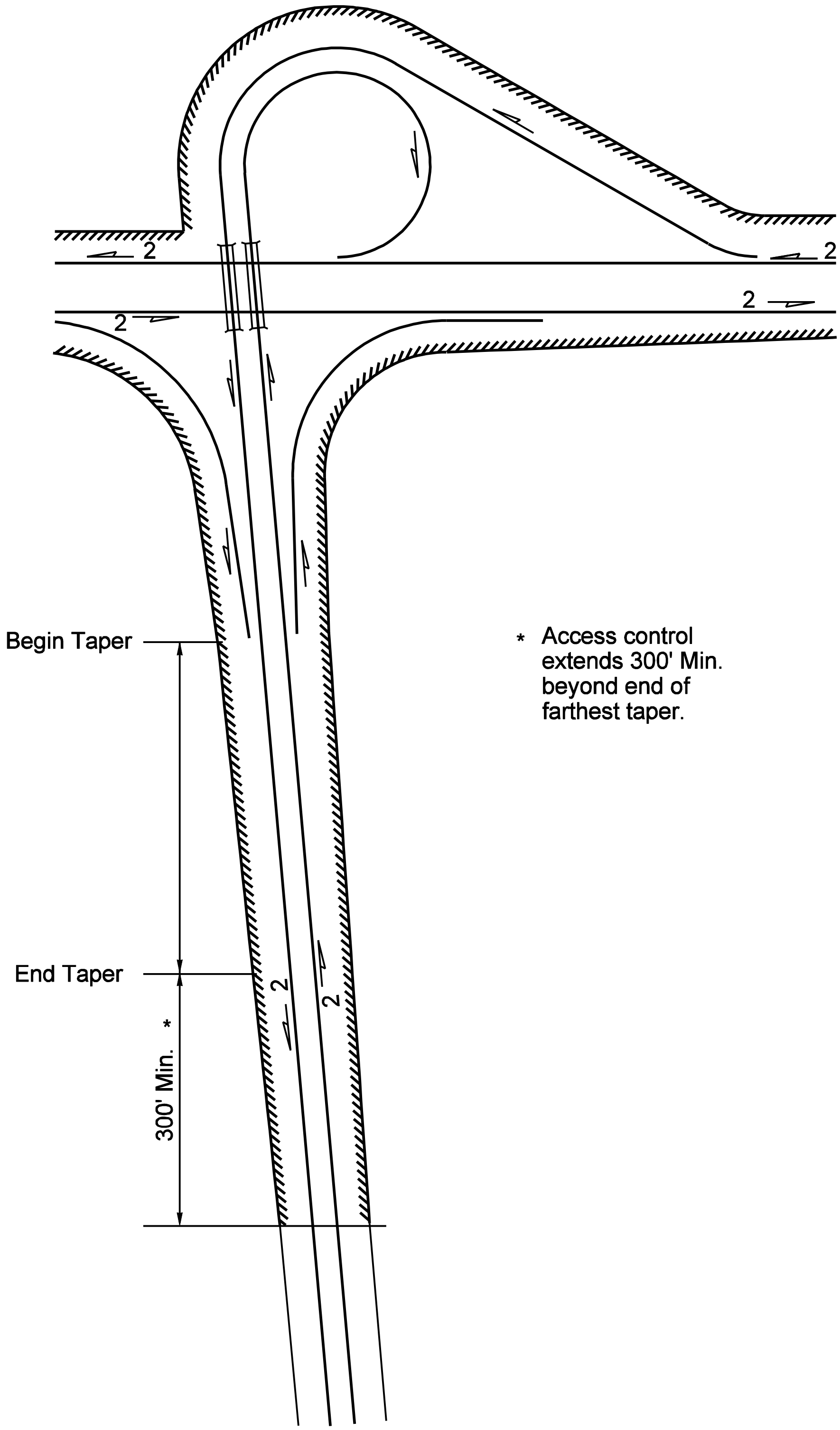
Full Access Control Limits - Interchange
Figure 1430-1a



Full Access Control Limits - Interchange
Figure 1430-1b

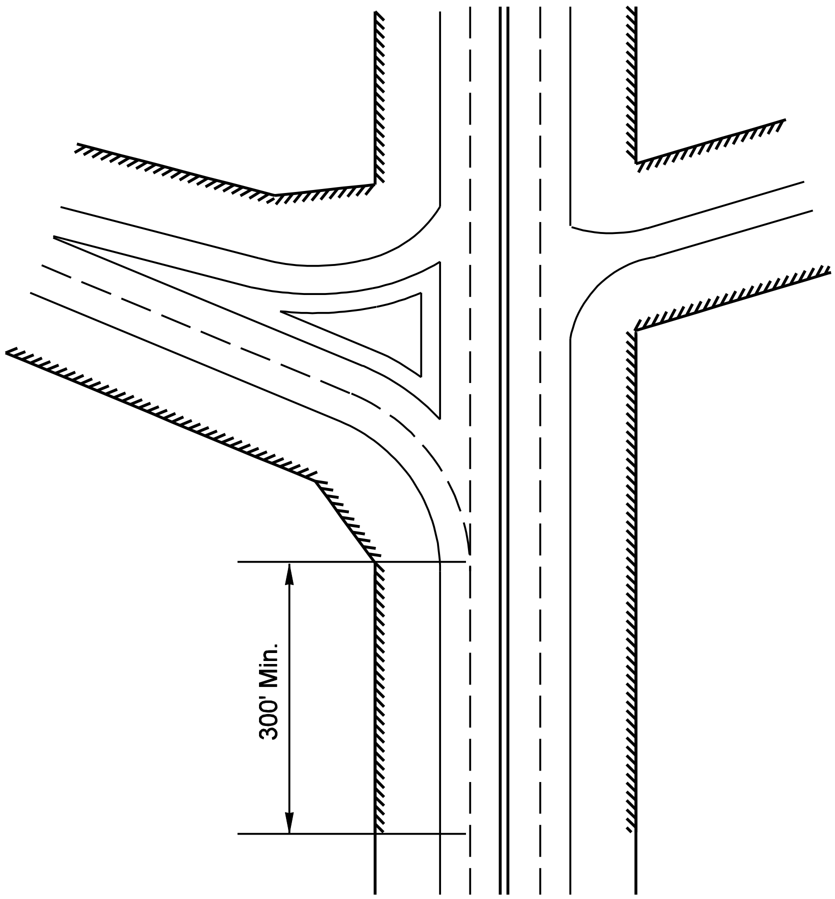


Full Access Control Limits - Interchange
Figure 1430-1c

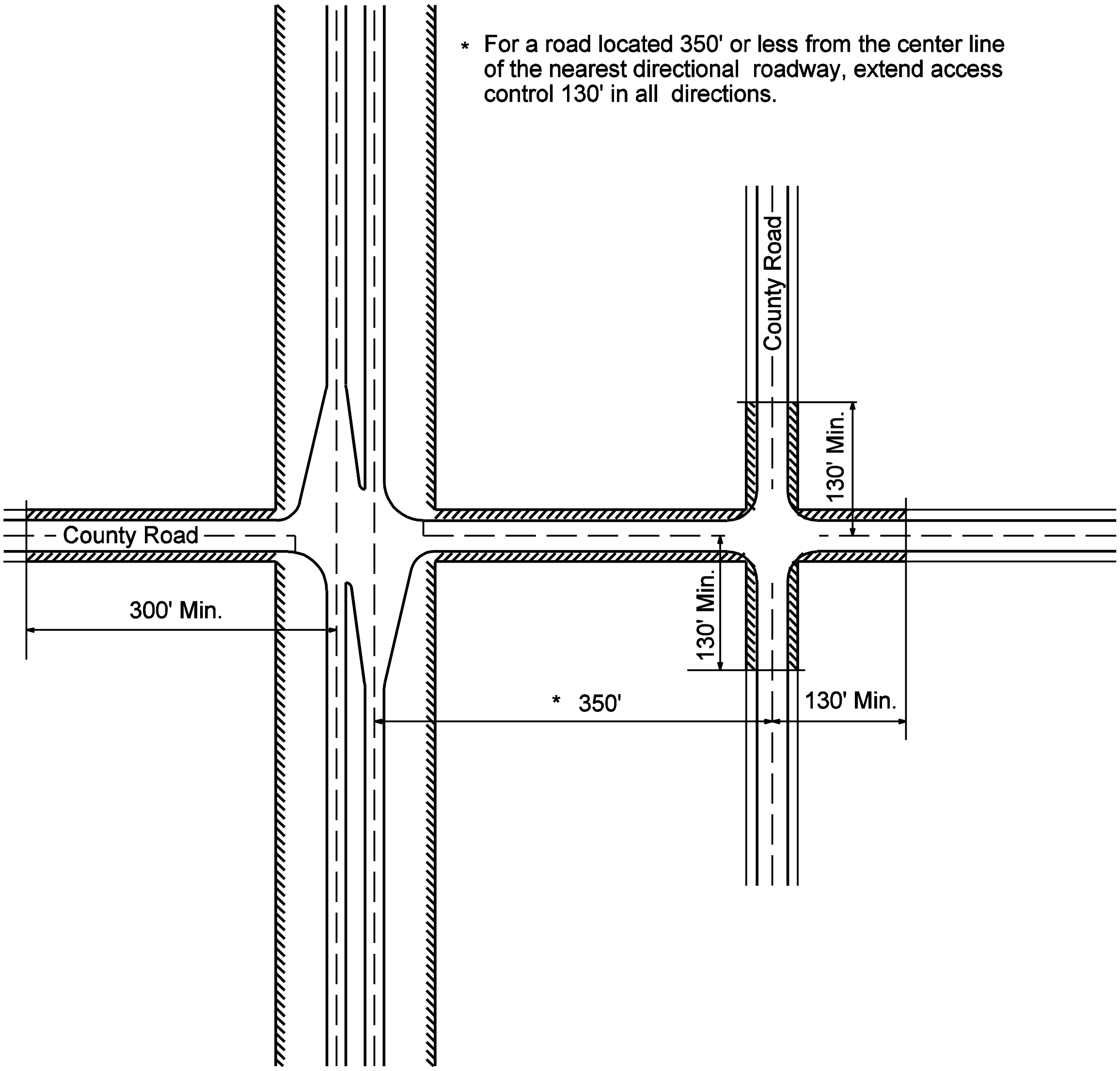


Full Access Control Limits - Ramp Terminal With Transition Taper

Figure 1430-2

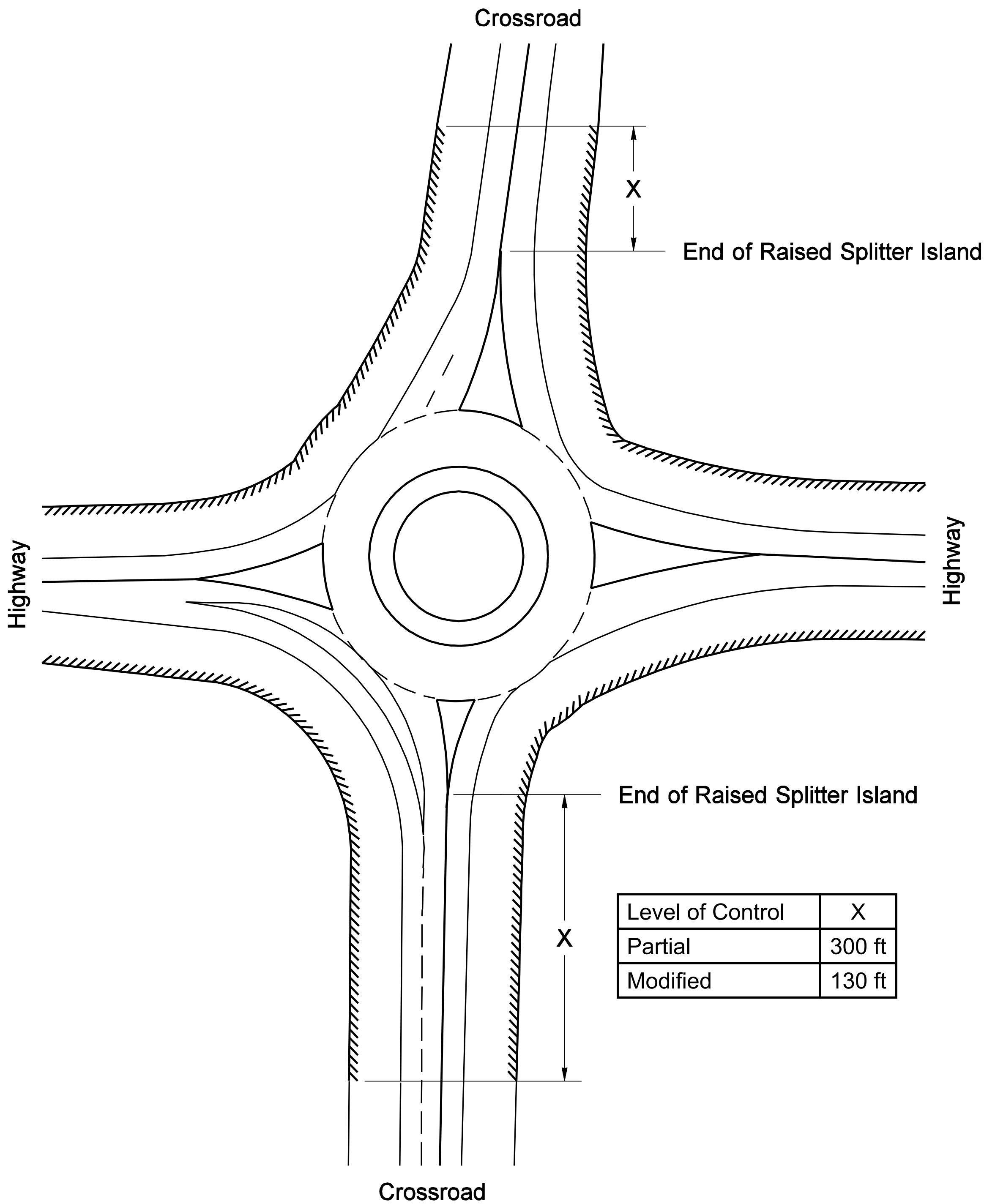


Full Access Control Limits - Single Point Urban Interchange
Figure 1430-3



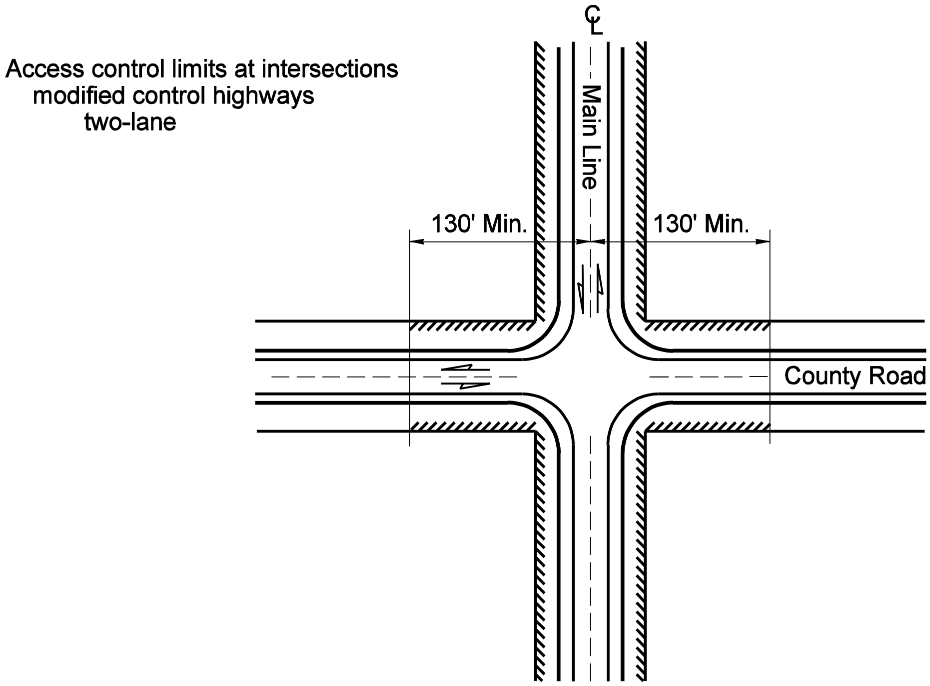
Partial Access Control Limits - At-Grade Intersections

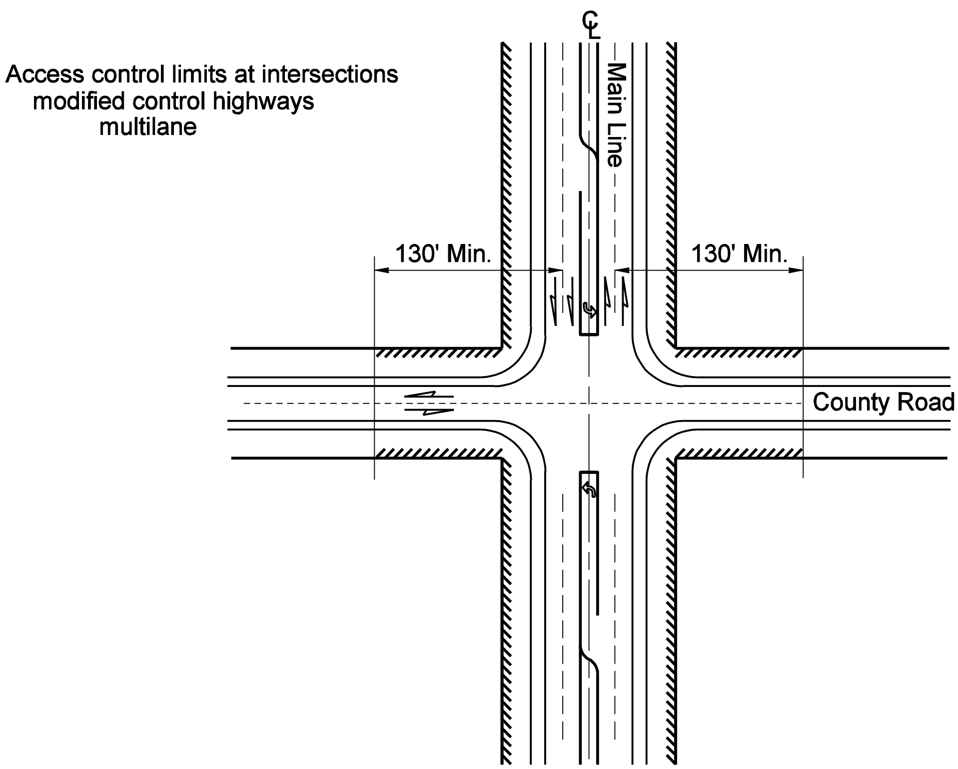
Figure 1430-4



Level of Control	X
Partial	300 ft
Modified	130 ft

Partial and Modified Access Control Limits - Roundabout Intersections
Figure 1430-5





Modified Access Control Limits - Intersections

Figure 1430-6

1435.01 General

This chapter describes the permitting process for granting permission to connect to managed access highways within unincorporated areas. Chapter 1420, "Access Control," has an overview of access control, and the references list and the definitions of terminology for this chapter.

In Washington, managed access highways include all state highways that are not limited access highways. The managed access highways do not include limited access highways where the access rights have been acquired in compliance with Revised Code of Washington (RCW) Chapter 47.52. State highways that are planned for or established as limited access, as listed in the Access Control Tracking System (at http://www.wsdot.wa.gov/eesc/design/access/, under the RELATED SITES heading), are treated as managed access highways until such time when the limited access rights are acquired.

Access to managed access highways is regulated by the governmental entity having jurisdiction over the highway's roadsides. Access connection permits are issued on managed access highways. The Washington State Department of Transportation (WSDOT) has access connection permitting authority over all state highways outside incorporated towns and cities. Incorporated towns and cities have access connection permitting authority for the managed access state highways within their boundaries.

Managed access highways are classified from Class 1, the most restrictive, to Class 5, the least restrictive. Access connections to managed access highways are further designated by category, from Category I to Category IV, by vehicular usage.

After a new law, RCW 47.50, went into effect (in 1991) by establishing access management, the first set of new rules, Washington Administrative Code (WAC) 468-51, titled Highway Access Management Access Permits-- Administrative Process, was prepared and then adopted by the department in July 1992. This first WAC established a permit fee schedule and application process for only those state highways under the access connection permitting authority of WSDOT.

The second set of new rules, WAC 468-52, titled Highway Access Management -- Access Control Classification System and Standards, was prepared and then adopted by the department in February 1993. This second WAC created a classification system and established design criteria for all managed access highways, including those managed access state highways within the incorporated limits of a town or city.

As with any set of rules, time determines what works and what needs to be changed. Beginning in 1998, the department began reviewing the two existing Highway Access Management WACs (468-51 and 468-52) for possible modifications and improvements. After numerous meetings with representatives from the private sector, government, lawmakers, and the public, the department adopted a newly revised pair of WACs in March 1999.

1435.02 Managed Access Classes

Managed access state highways consist of a classification system of five classes. The classes are arranged from the most restrictive Class 1 to the least restrictive Class 5. In general, most state highways outside the incorporated limits of a city or town have been designated as a Class 1 or 2 highway, with only the most urban, lower speed state highways within an incorporated town or city having the Class 5 designation. Figure 1435-3 lists the five classes of highways with a brief description of each class.

WSDOT keeps a record of the assigned managed access classifications, by mile post, in the database: Access Control Tracking System at http://www.wsdot.wa.gov/eesc/design/access/ under the RELATED SITES heading.

The principal objective of the managed access classification system is to establish access management criteria to be adhered to in the planning for and (regional) approval of access connections to the state highway system.

On Class 1 highways, mobility is the primary function, while on Class 5 highways, access needs may have priority over through mobility needs. Class 2 highways also favor mobility while Class 3 and Class 4 highways generally try to strike a balance between mobility and access. However, remember that restricting or keeping access connections to a minimum is a goal of WSDOT to help preserve the safety, operations, and functional integrity of the state highway.

The most notable distinction between the five classes is the minimum spacing requirements of access connections. Minimum access point spacings, on the same side of the highway, are shown in Figure 1435-3.

On all highway classes one through five, access connections are to be located and designed to minimize interference with transit facilities and high occupancy vehicle (HOV) facilities on state highways where such facilities exist or where such facilities are proposed in a state, regional, metropolitan, or local transportation plan. In such cases, if reasonable access is available from the public road/street system, access is to be provided from the public road/street system rather than from the state highway.

The functional characteristics and the legal requirements for each class are as follows:

(1) Class 1

(a) **Functional Characteristics:**

Class 1 highways provide for high speed and/or high volume traffic movements for interstate, interregional, and intercity travel needs, and some intracity travel needs. Service to abutting land is subordinate to providing service to major traffic movements.

Highways in Class 1 are typically distinguished by a highly controlled, limited number of (public and private) access points, restrictive medians with limited median openings on multilane facilities, and infrequent traffic signals.

(b) **Legal Requirements:**

1. It is the intent that Class 1 highways be designed to have a posted speed limit of 50 to 65 mph. Spacing of intersecting streets, roads, and highways are planned with a minimum spacing of one mile (1 mi). One-half mile (1/2 mi) spacing may be allowed, but only when no reasonable alternative access exists.
2. Private access connections to the state highway are not allowed except when the property has no other reasonable access to the public road/street system. When a private access connection must be provided, the following conditions apply:
   - The access connection continues until such time when other reasonable access to a highway with a less restrictive access control class or access to the public road/street system becomes available and is allowed.
   - The minimum distance to another access point is one thousand three hundred twenty feet (1320’) along the same side of the highway. Nonconforming access connection permits may be issued to provide access connections to parcels whose highway frontage, topography, or location otherwise precludes issuance of a conforming access connection permit, however, variance permits are not allowed.
   - No more than one access connection may be provided to an individual parcel or to contiguous parcels under the same ownership.
   - All private access connections are for right turns only on multilane facilities, unless special conditions justify the exception and are documented by a traffic analysis, in the access connection permit application, that is signed and

sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

- Additional access connections to the state highway are not allowed for newly created parcels resulting from property divisions. All access for these parcels must be provided by an internal road/street network. Access to the state highway will be at existing permitted locations or at revised locations.

3. Restrictive medians are provided on multilane facilities to separate opposing traffic movements and to prevent unauthorized turning movements.

(2) Class 2

(a) **Functional Characteristics**

Class 2 highways provide for medium to high speeds and medium to high volume traffic movements over medium and long distances for interregional, intercity, and intracity travel needs. Direct access service to abutting land is subordinate to providing service to traffic movement.

Highways in Class 2 are typically distinguished by existing or planned restrictive medians on multilane facilities, and by large minimum distances between (public and private) access points.

(b) **Legal Requirements**

1. It is the intent that Class 2 highways be designed to have a posted speed limit of 35 to 50 mph in urbanized areas and 45 to 55 mph in rural areas. Spacing of intersecting streets, roads, and highways is planned with a minimum spacing of one-half mile (1/2 mi). Less than one-half mile (1/2 mi) intersection spacing may be allowed, but only when no reasonable alternative access exists.

   In urban areas and developing areas where higher volumes are present or growth that will require signalization is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate signal progression. Addition of all new access points, public or private, that might require signalization will require an engineering analysis that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

2. Private access connections to the state highway system are allowed only when the property has no other reasonable access to the public road/street system or if access to the public road/street system will cause unacceptable traffic operational conditions or safety concerns on that system. When a private access connection must be provided, the following conditions apply:

   - The access connection continues until such time when other reasonable access to a highway with a less restrictive access control class or acceptable access to the public road/street system becomes available and is allowed.
   - The minimum distance to another (public or private) access point is six hundred sixty feet (660’) on the same side of the highway. Nonconforming access connection permits may be issued to provide access to parcels whose highway frontage, topography, or location precludes issuance of a conforming access connection permit.
   - Only one access connection is allowed for an individual parcel or to contiguous parcels under the same ownership unless the highway frontage exceeds one thousand three hundred twenty feet (1320’) and it can be shown that the additional access connection will not adversely affect the desired function of the state highway in accordance with the assigned managed access Class 2, and will not adversely affect the safety or operation of the state highway.
   - Variance permits may be allowed if there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the access connection permit application

that is signed and sealed by a qualified professional engineer who is registered in accordance with Chapter 18.43 RCW.

- All private access connections are for right turns only on multilane facilities unless there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the access connection permit application that is signed and sealed by a qualified professional engineer who is registered in accordance with Chapter 18.43 RCW, and only if left turn channelization is provided.
- Additional access connections to the state highway are not allowed for newly created parcels resulting from property divisions. All access for these parcels must be provided by an internal road/street network. Access to the state highway will be at existing permitted locations or at revised locations.

3. On multilane facilities, restrictive medians are provided to separate opposing traffic movements and to prevent unauthorized turning movements; however, a nonrestrictive median or a two way left turn lane may be used when special conditions exist and main line volumes are below 20,000 ADT.

(3) Class 3

(a) **Functional Characteristics**

Class 3 highways provide for moderate travel speeds and moderate traffic volumes for medium and short travel distances for intercity, intracity and intercommunity travel needs. There is a reasonable balance between access and mobility needs for highways in this class. This class is to be used primarily where the existing level of development of the adjoining land is less intensive than maximum build out and where the probability of significant land use change and increased traffic demand is high.

Highways in Class 3 are typically distinguished by planned restrictive medians on multilane facilities, and medium minimum distances between (public and private) access points. Two-way left-turn lanes may be used where special conditions justify them and main line traffic volumes are below 25,000 ADT. Development of properties with internal road/street networks and joint access connections are encouraged.

(b) **Legal Requirements**

1. It is the intent that Class 3 highways be designed to have a posted speed limit of 30 to 40 mph in urbanized areas and 45 to 55 mph in rural areas. In rural areas, spacing of intersecting streets, roads, and highways is planned with a minimum spacing of one-half mile (1/2 mi). Less than one-half mile (1/2 mi) intersection spacing may be allowed, but only when no reasonable alternative access exists.

   In urban areas and developing areas where higher volumes are present or growth that will require signalization is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate signal progression. Where feasible, major intersecting roadways that might ultimately require signalization are planned with a minimum of one-half mile (1/2 mi) spacing. Addition of all new access points, public or private, that may require signalization will require an engineering analysis that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

2. Private Access Connections:

   - No more than one access connection may be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that additional access connections will not adversely affect the desired function of the state highway in accordance with the assigned managed access Class 3, and will not adversely affect the safety or operation of the state highway.

- The minimum distance to another (public or private) access point is three hundred thirty feet (330’) on the same side of the highway. Nonconforming access connection permits may be issued to provide access to parcels whose highway frontage, topography, or location precludes issuance of a conforming access connection permit.
- Variance permits may be allowed if there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the access connection permit application that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

(4) Class 4

(a) **Functional Characteristics**

Class 4 highways provide for moderate travel speeds and moderate traffic volumes for medium and short travel distances for intercity, intracity and intercommunity travel needs. There is a reasonable balance between direct access and mobility needs for highways in this class. This class is to be used primarily where the existing level of development of the adjoining land is more intensive and where the probability of major land use changes is less probable than on Class 3 highways segments.

Highways in Class 4 are typically distinguished by existing or planned nonrestrictive medians. Restrictive medians may be used to mitigate unfavorable operational conditions such as turning, weaving, and crossing conflicts. Minimum access connection spacing requirements apply if adjoining properties are redeveloped.

(b) **Legal Requirements**

1. It is the intent that Class 4 highways be designed to have a posted speed limit of 30 to 35 mph in urbanized areas and 35 to 45 mph in rural areas. In rural areas, spacing of intersecting streets, roads, and highways is planned with a minimum spacing of one-half mile (1/2 mi). Less than one-half mile (1/2 mi) intersection spacing may be allowed, but only when no reasonable alternative access exists.

   In urban areas and developing areas where higher volumes are present or growth that will require signalization is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate signal progression. Where feasible, major intersecting roadways that might ultimately require signalization are planned with a minimum of one-half mile (1/2 mi) spacing. Addition of all new access points, public or private, that may require signalization will require an engineering analysis that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

2. Private Access Connections:
   - No more than one access connection may be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that additional access connections will not adversely affect the desired function of the state highway in accordance with the assigned managed access Class 4, and will not adversely affect the safety or operation of the state highway.
   - The minimum distance to another (public or private) access point is two hundred fifty feet (250’) on the same side of the highway. Nonconforming access connection permits may be issued to provide access connections to parcels whose highway frontage, topography, or location precludes issuance of a conforming access connection permit.
   - Variance permits may be allowed if there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the connection permit application that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

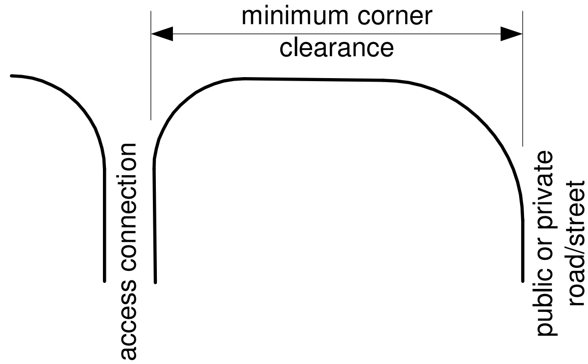
(5) Class 5

(a) **Functional Characteristics**

Class 5 highways provide for moderate travel speeds and moderate traffic volumes for primarily short travel distances for intracity and intracommunity trips and for access to state highways of a higher class. Access needs may generally be higher than the need for through traffic mobility without compromising the public health, welfare, or safety. These highways will generally have nonrestrictive medians.

(b) **Legal Requirements**

1. It is the intent that Class 5 highways be designed to have a posted speed limit of 25 to 35 mph. In rural areas, spacing of intersecting streets, roads, and highways is planned with a minimum spacing of one-quarter mile (1/4 mi). Less than one-quarter mile (1/4 mi) spacing may be allowed where no reasonable alternative exists. In urban areas and developing areas where higher volumes are present or growth that will require signalization is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate signal progression. Where feasible, major intersecting roadways that might ultimately require signalization are planned with a minimum of one-quarter mile (1/4 mi) spacing. Addition of all new access points, public or private, that might require signalization will require an engineering analysis that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.
2. Private Access Connection:
    - No more than one access connection may be provided to an individual parcel or to contiguous parcels under the same ownership unless it can be shown that additional access connections will not adversely affect the desired function of the state highway in accordance with the assigned managed access Class 5, and will not adversely affect the safety or operation of the state highway.
    - The minimum distance to another (public or private) access point is one hundred twenty five feet (125’) on the same side of the highway. Nonconforming access connection permits may be issued to provide access to parcels whose highway frontage, topography, or location precludes issuance of a conforming access connection permit.
    - Variance permits may be allowed if there are special conditions and the exception can be justified to the satisfaction of the department by a traffic analysis in the access connection permit application that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.



Minimum Corner Clearance
Figure 1435-1

1435.03 Corner Clearance Criteria

In addition to the five access control classes, there are also corner clearance criteria that may be used for access connections near intersections. See Figure 1435-1.

Corner clearance spacing must meet or exceed the minimum access point spacing requirements of the applicable managed access highway class. A single access connection may be placed closer to the intersection, in compliance with the permit application process specified in WAC 468-51, and in accordance with the following criteria:

With Restrictive Median		
Position	**Access Allowed**	**Minimum (feet)**
Approaching Intersection	Right In/Right Out	115
Approaching Intersection	Right In Only	75
Departing Intersection	Right In/Right Out	230*
Departing Intersection	Right Out Only	100
Without Restrictive Median		
Position	**Access Allowed**	**Minimum (feet)**
Approaching Intersection	Full Access	230*
Approaching Intersection	Right In Only	100
Departing Intersection	Full Access	230*
Departing Intersection	Right Out Only	100

* For speeds less than 35 mph, and for access Class 5, 125 feet may be used.

Minimum Corner Clearance: Distance From Access Connection to Intersections
Figure 1435-2

(a) The minimum corner clearance criteria in Figure 1435-2 may be used where access point spacing cannot be obtained due to property size and a joint use access connection cannot be secured, or where it is determined by WSDOT to be not feasible because of conflicting land use or conflicting traffic volumes or operational characteristics.

(b) Some local agencies have adopted corner clearance as a design element in their adopted design standards. Coordinate with the local agency regarding corner clearance of an access connection near an intersecting local road or street.

(c) In cases where access connections are allowed under the above criteria, the conforming permit issued in compliance with WAC 468-51 must contain the following additional conditions:

1. Variance and nonconforming permits are not allowed.
2. There must be no more than one access connection per property frontage on the state highway.
3. When a joint-use access connection or an alternate road/street system access (meeting or exceeding the minimum corner clearance requirement) becomes available, the permit holder must close the permitted access connection, unless the permit holder shows to the WSDOT's satisfaction that such closure is not feasible.

1435.04 Access Connection Categories

Whenever an access connection permit is issued on a managed access state highway, the permit must also specify an access connection category. There are four categories, defined as Category I to Category IV. The first three categories, I through III, are based on the maximum vehicular usage of the access connection. Category IV specifies a temporary use, usually for less than a year. Access connection permits must specify the category and the maximum vehicular usage of the access connection in the permit

All access connections are determined by the WSDOT to be in one of the following categories (WAC 468-51-040):

(1) Category I

“Category I - minimum connection” provides connection to the state highway system for up to ten single family residences, a duplex, or a small multifamily complex of up to ten dwelling units that use a common access connection. The category also applies to permanent access connections to agricultural and forest lands, including field entrances; access connections for the operation, maintenance, and repair of utilities; and access connections serving other low volume traffic generators expected to have an average weekday vehicle trip ends (AWDVTE) of one hundred (100) or less.

(2) Category II

"Category II - minor connection" provides connection to the state highway system for medium volume traffic generators expected to have an AWDVTE of one thousand five hundred (1500) or less, but not included in Category I.

(3) Category III

"Category III - major connection" provides connection to the state highway system for high volume traffic generators expected to have an AWDVTE exceeding one thousand five hundred (1500).

(4) Category IV

"Category IV - temporary connection" provides a temporary, time limited, connection to the state highway system for a specific property for a specific use with a specific traffic volume. Such uses include, but are not limited to, logging, forest land clearing, temporary agricultural uses, temporary construction, and temporary emergency access. The department reserves the right to remove any temporary access connection at its sole discretion and at the expense of the property owner after the expiration of the permit. Further, a temporary access connection permit does not bind the department, in any way, to the future issuance of a permanent access connection permit at the temporary access connection location.

1435.05 Access Connection Permit

RCW 47.50 requires all access connections to be permitted. This can be accomplished by the permitting process or by the connection being "grand-fathered." Grand-fathered means it was in place prior to July 1, 1990. The grand-fathered status remains in effect until WSDOT requires removal (1435.07) or there is a change from the 1990 AWDVTE or established use of the property.

All new access connections and alterations and improvements to existing access connections to state highways require an access connection permit. Every owner of property that abuts a state highway has the right to reasonable access. This right may be restricted with respect to the highway if reasonable access can be provided by way of another public road/street.

When a new road or street is to be constructed, WSDOT approval is required for intersection design, spacing, and construction work on the right of way. This is usually in the form of a Developer Agreement. If, however, an access connection permit is issued, it will be rendered null and void if and when the road or street is duly established as a public road or public street by the local governmental entity.

Access connection permits authorize construction improvements, relating to the access connection only, to be built by the permit holder on department right of way. It is the responsibility of the applicant or permit holder to obtain all other local permits or other agency approvals that are required, including satisfaction of all environmental regulations. Except where the access connection replaces an existing access connection as a result of department relocation activity, it is the responsibility of the applicant to acquire any property rights necessary to provide continuity from the applicant's property to the state highway right of way if the applicant's property does not abut the state's right of way.

The alteration or closure of any existing access connection caused by changes to the character, intensity of development, or use of the property served by the access connection or the construction of any new access connection must not begin before an access connection permit is obtained.

If a property owner or permit holder who has a valid access connection permit wishes to change the character, use, or intensity of the property or development served by the access connection, the permitting authority must be contacted to determine whether an upgraded access connection permit will be required.

Regardless of where the permitting authority lies, it is the responsibility of the applicant to gain approval of plans (showing the construction details) from the Department of Transportation if there is to be any effect on state highway geometrics, channelization, or drainage. The design must conform to guidance that is elsewhere in this manual; Chapters 910, 920, and 940, for example; and other WSDOT manuals as applicable. Scheduling the work is discussed in 1435.08(3). The preconstruction conference is discussed in 1435.09.

1435.06 Permit Process

An access connection permit is obtained from the department by submitting the appropriate application form, including the fee, plans, traffic data, and access connection information to the department for review. All access connection and roadway design documents for Category II and III permits must bear the seal and signature of a professional engineer registered in Washington State.

The permitting process begins with the application. Upon submittal of the application with all the attached requirements it is reviewed and either denied or accepted. If denied, the department must notify the applicant in writing stating the reasons and the applicant will have thirty (30) days to submit a revised application. Once the application is approved and the permit is issued, the applicant may begin construction. No construction is allowed on the department's right of way until all necessary department and local government permits are issued.

The Access Manager in each region keeps a record of all access points distinguishing between those that are permitted and those that are grand-fathered. A permit for a grand-fathered access point is not required but may be issued for record-keeping reasons.

(1) Conforming Access Connection Permit

Conforming access connection permits may be issued for access connections that conform to the functional characteristics and all legal requirements for the designated class of the highway.

Conforming access connection permits may not be issued for access connections to Class I or II highways because of the legal restriction of private access connections. See Figure 1435-3.

(2) Nonconforming Access Connection Permit

Nonconforming access connection permits may be issued for short-term access connections pending availability of a future joint-use access connection or public road/street system access:

- For location and spacing not meeting requirements.
- For Category I through IV permits.
- After an analysis and determination by the department that a conforming access connection cannot be made at the time of permit application submittal.
- After a finding that the denial of an access connection will leave the property without a reasonable means of access to the public road/street system.

In such instances, the permit is to be noted as being a nonconforming access connection permit and contains specific restrictions and provisions, including:

- Limits on the maximum vehicular use of the access connection.
- The future availability of alternate means of reasonable access for which a conforming access connection permit can be obtained.
- The removal of the nonconforming access connection at the time the conforming access is available.
- The properties to be served by the access connection.
- Other conditions as necessary to carry out the provisions of RCW 47.50.

(3) Variance Access Connection Permit

Variance access connection is a special nonconforming or additional access connection permit issued for long-term use where future public road/street system access is not foreseeable:

- For location and spacing not meeting requirements or for an access connection that exceeds the number allowed for the class.
- For Category II and III permits only.
- After an engineering study demonstrates, to the satisfaction of the department, that the access connection will not adversely affect the safety, maintenance, or operation of the highway in accordance with its assigned managed access class.

In such instances, the permit is to be noted as being a variance access connection permit and specifies conditions or limits including, but not limited to:

- Limits on the maximum vehicular use of the access connection.
- The properties to be served by the access connection.
- Other conditions as necessary to carry out the provisions of RCW 47.50.

This permit will remain valid until modified or revoked by the permitting authority unless an upgraded permit is required due to changes in property site use. (See 1435.08(1).)

A variance access connection permit must not be issued for an access connection that does not conform to minimum corner clearance requirements. (See 1435.03.)

(4) Median Opening

Median opening includes openings requested for both new access connections and for existing access connections. See Chapter 910 for median crossover spacing and other design guidance.

- New median openings proposed as part of a new access connection are reviewed as part of the permit application review process.
- Requests for the construction of new median openings to serve existing permitted access connections require a reevaluation of the location, quantity, design of existing access connections, and traffic at the existing access connections.
- The property owner must file a new access connection permit application, for the proper access connection category, showing the new proposed median opening location and design and its relationship to the existing or modified access connections.
- Nothing contained herein is to be construed to prohibit the department from closing an existing median opening where operational or safety reasons require the action.
- The department must notify affected property owners, permit holders and tenants, in writing, thirty (30) days in advance of the closure of a median opening unless immediate closure is needed for safety or operational reasons.

1435.07 Design Considerations

See Chapter 920, "Road Approaches," for design considerations (design templates) and Chapter 700 regarding mailbox locations.

1435.08 Other Considerations

(1) Changes in Property Site Use With Permitted Access Connection

The access connection permit is issued to the permit holder for a particular type of land use generating specific projected traffic volumes at the final stage of proposed development. Any changes made in the use, intensity of development, type of traffic, or traffic flow require the permit holder, an assignee, or the property owner to contact the department to determine if further analysis is needed because the change is significant and will require a new permit and modifications to the access connection. (WAC 468-51-110)

A significant change is one that will cause a change in the category of the access connection permit or one that causes an operational, safety, or maintenance problem on the state highway system based on objective engineering criteria or available accident data. Such data will be provided to the property owner and/or permit holder and tenant upon written request. (WAC 468-51-110)

(2) Existing Access Connections

(a) **Closure of Grand-Fathered Access Connections** Any access connections that were in existence and in active use on July 1, 1990 may be grand-fathered.

The grand-fathered access connection may continue unless:

- There are changes from the 1990 AWDVTE.
- There are changes from the 1990 established use.
- The department determines that the access connection does not provide minimum acceptable levels of highway safety and mobility based on accident and/or traffic data or accepted traffic engineering criteria. (A copy of which must be provided to the property owner, permit holder, and/or tenant upon written request.) (WAC 468-51-130)

(b) **Department Construction Projects**

1. Notification

   The department must notify affected property owners, permit holders, business owners, and emergency services in writing, where appropriate, whenever the department's work program requires the modification, relocation, or replacement of their access connections. In addition to written notification, the department will facilitate, where appropriate, a public process that may include, but is not limited to, public notices, meetings or hearings, and individual meetings.

2. Modifications -- Considerations

   When the number, location, or design of existing access connections to the state highway is being modified by a department construction project, the resulting modified access connections must provide the same general *functionality* for the existing property use as they did before the modification, taking into consideration the existing site design, normal vehicle types, and traffic circulation requirements. These are evaluated on an individual basis. It is important to remember that the intent is not to *damage* the property owner by removing nonconforming access connections, but to eliminate access connections that are both nonconforming and not needed.

   The permitting authority evaluates each property individually to make a determination of which category of access connection and which design template (Chapter 920) will be reasonable. If it is a commercial parcel, determine if the business can function with one access connection. Each parcel, or contiguous parcels under the same ownership being used for the same purpose, is only allowed one access connection. If the business cannot function properly with only one access connection, a variance permit may be issued for additional access connections. If the property is residential, only one access connection is allowed, however, certain circumstances might require an additional access connection.

3. Costs

   - **Replacement of existing access connections** - When access connections are made as part of a department construction project replacing existing access connection points without material differences, no additional permit is required. Costs are borne by the department.
   - **Modifications** - If the modification of the access connection point is based on the owner's request and is more extensive than the routine replacement of an existing access connection, the owner must also participate in the differential cost.

(3) Work by Permit Holder's Contractor

The department requires that work done by the owner's contractor be accomplished at the completion of the department's contract or be scheduled so as not to interfere with the department's contractor. The department may require a surety bond prior to construction of the access connection in accordance with WAC 468-51-070.

1435.09 Preconstruction Conference

All new access connections including alterations and improvements to existing access connections to the highway require an access connection permit. The department may require a preconstruction conference prior to any work being performed on the department's right of way. The preconstruction conference must be attended by those necessary to assure compliance with the terms and provisions of the permit. Details for the individual access connections will be included in the construction permit. This may include access connection widths, drainage requirements, surfacing requirements, mailbox locations, and other information. (WAC 468-51-090)

1435.10 Adjudicative Proceedings

Any person who has standing to challenge any of the following department actions may request an adjudicative proceeding (an appeal to an Administrative Law Judge) within thirty (30) days of the department's written decision: (WAC 468-51-150)

- Denial of an access connection permit application pursuant to WAC 468-51-080
- Permit conditions pursuant to WAC 468-51-150
- Permit modifications pursuant to WAC 468-51-120
- Permit revocation pursuant to WAC 468-51-120
- Closure of permitted access connection pursuant to WAC 468-51-120
- Closure of grand-fathered access connection pursuant to WAC 468-51-130

An appeal of a decision by the department can only be requested if the administrative fee has been paid. If the fee has not been paid, the permit application is considered incomplete and an adjudicative proceeding cannot be requested.

Below is a brief summary of the adjudicative proceeding process. For the purpose of this summary, the responsibilities of the department are separated into those actions required of the region and those actions required of Headquarters. The following summary is also written as if the appealable condition was a denial of an access connection request.

1. The region receives an access connection permit application, with fee.
2. The region processes the application and makes a determination that the access connection request will be denied.
3. The region sends to the applicant a written letter denying the access connection. Included in this letter is notification that the applicant has thirty (30) days to request an adjudicative proceeding if the applicant disagrees with the region's denial decision. The region must notify affected property owners, permit holders, business owners, tenants, lessees, and emergency services, as appropriate.
4. The applicant, within thirty (30) days, requests an adjudicative proceeding.
5. The region reviews its initial denial decision and determines if there is any additional information presented that justifies reversing the original decision.
6. If the region determines that the original denial decision will stand, the region then forwards copies of all applicable permit documentation to the Access and Hearings Manager (AHM) at Headquarters for review and processing.
7. The AHM reviews the permit application and, if need be, consults the Attorney General's (AG) office for advice and direction.

8. If the initial findings of the AHM agree with the region's denial decision, Headquarters sends to the applicant a written letter, with the signature of the State Design Engineer, informing the applicant that a hearing will be set up for the applicant to attend and appeal in person the department's decision to deny access.
9. The region reserves a location and obtains a court reporter, while Headquarters obtains an Administrative Law Judge (ALJ) to conduct the proceeding. Headquarters, by written letter with the State Design Engineer's signature, notifies the applicant of the time and place for the hearing. The department has ninety (90) days from receipt of the applicant's appeal to approve or deny the appeal application, schedule a hearing, or decide not to conduct a hearing. The actual hearing date can be set beyond this ninety (90) day review period.
10. The region's AG leads the department's presentation and works with both the region and the AHM regarding who will testify and what displays and other information will be presented to the ALJ (note: the AHM will typically not attend these proceedings).
11. After hearing all the facts, the ALJ issues a decision, usually within a couple of weeks after the proceedings. However, the ALJ has ninety (90) days in which to serve a written Initial Order, stating the decision.
12. The ALJ's decision is final unless the applicant, or the department through the AHM, decides to appeal the ALJ's decision to the State Design Engineer. This second appeal must occur within twenty (20) days of the ALJ's written decision.
13. If appealed to the State Design Engineer, the State Design Engineer has ninety (90) days to review the Initial Order, and all the facts and supporting documentation, and issue a Final Order. The review by the State Design Engineer does not require the applicable parties to be present and may involve only a review of the material submitted at the adjudicative proceeding.
14. The State Design Engineer's decision is final unless appealed within thirty (30) days to the Washington State Superior Court.

The above represents a general timeline if all appeals are pursued. Based on the above timelines it can take nearly a year before a Final Order is issued. If appealed to Superior Court, up to an additional 18 months can be added to the process. In any case, contact the region's Development Services Engineer for further guidance and direction if an appeal might be coming.

1435.11 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

Class	Noncon-forming	Variance	Conforming	Access Point Spacing **	Limitations
Class 1 Mobility is the primary function	Yes*	No	No	1320’	1 access connection only to contiguous parcels under same ownership Private access connection is not allowed unless no other reasonable access exists. (Must use public road/street system if possible.)
Class 2 Mobility favored over access	Yes*	Yes*	No	660’	1 access connection only to contiguous parcels under same ownership unless frontage >1320’ Private access connection is not allowed unless no other reasonable access exists. (Must use public road/street system if possible.)
Class 3 Balance between mobility and access in areas with less than maximum build out	Yes	Yes	Yes	330’	1 access connection only to contiguous parcels under same ownership. Joint access connection for subdivisions preferred, but private access connection allowed with acceptable justification.
Class 4 Balance between mobility and access in areas with less than maximum build out	Yes	Yes	Yes	250’	1 access connection only to contiguous parcels under same ownership except with acceptable justification.
Class 5 Access needs may have priority over through mobility needs	Yes	Yes	Yes	125’	More than 1 access connection per ownership allowed with acceptable justification.

* The access connection continues only until such time when other reasonable access to a highway with a less restrictive class or acceptable access to the public road/street system becomes available and is allowed.
** Minimum, on the same side of the highway.

Managed Access Highway Class Description
Figure 1435-3

Chapter 1440 Surveying and Mapping

1440.01 General

The Washington State Department of Transportation (WSDOT) is permitted, by an agreement with the Board of Registration for Professional Engineers and Land Surveyors, to practice land surveying "under the direct supervision of a licensed professional land surveyor OR a licensed professional engineer." (See Figures 1440-1a and b, Interagency Agreement.)

1440.02 References

Revised Code of Washington (RCW) 58.09, "Surveys – Recording"

RCW 58.20.120, "System designation – Permitted uses"

RCW 58.24.040(8), " . . . temporary removal of boundary marks or monuments"

Washington Administrative Code (WAC) 332-120, "Survey Monuments – Removal or Destruction"

WAC 332-130, "Minimum Standards for Land Boundary Surveys and Geodetic Control Surveys and Guidelines for the Preparation of Land Descriptions"

Interagency Agreement Between the Washington State Department of Transportation and the Board of Registration for Professional Engineers and Land Surveyors (1990)

Construction Manual, M 41-01, WSDOT

Highway Surveying Manual, M 22-97, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

WSDOT Monument Database:
http://www.wsdot.wa.gov/monument/

1440.03 Procedures

For WSDOT projects, it is recommended that surveying activities include (if appropriate) but not be limited to the following items.

(1) During the Project Definition Phase

(a) Record any pertinent surveying information as detailed in the Design Documentation Check List at:
http://www.wsdot.wa.gov/eesc/design/projectdev/

(b) Research for recorded survey monuments existing within the project area.

(c) Determine and prioritize project survey needs and tasks to be completed. Needs and tasks may include:

- Cadastral issues
- Right of way issues
- Geodetic control issues
- Photogrammetry issues
- Other issues as needed

(2) During Design and Development of the Plans, Specifications, and Estimates

(a) The project manager and project surveyor hold a preliminary survey meeting, covering:

- Project schedule
- Anticipated survey requests

For preliminary survey meeting specifics and roles and responsibilities of the project manager and project surveyor, see the *Highway Surveying Manual.*

(b) Perform field reconnaissance, mark existing recorded survey monuments, and determine the location of possible new survey monuments. Also, mark found unrecorded monuments for preservation if practical.

(c) Determine the impact to geodetic monuments and notify the Headquarters (HQ) Geographic Services Office.

(d) Refer to the *Highway Surveying Manual* to:

- Convert Washington State plane coordinates to project datum.
- Document the procedure and combined factor used for converting between datums.
- Determine survey collection methods.
- Collect primary, secondary, and tertiary survey data.
- Process and import secondary, tertiary, or other survey data into design software for use by designers.

(e) Apply to the Department of Natural Resources (DNR) for permits for monuments that will be disturbed or removed (Chapter 1450).

(f) Archive new primary and secondary survey control data in the WSDOT Monument Database and GIS, as appropriate, for future retrieval.

(g) Ensure that all survey monuments within the project right of way are shown on the contract plans in order to avoid accidental damage.

(h) Develop a Record of Survey (RCW 58.09) or a Monumentation Map as required (Chapter 1450).

(3) After Construction is Completed

(a) Complete a "Post Construction" survey as described in the *Highway Surveying Manual* and the *Construction Manual*.

(b) Have the DNR Completion Report signed and stamped by the appropriate professional in direct charge of the surveying work, then file with DNR as described in Chapter 1450.

1440.04 Datums

A datum is a geometrical quantity (or set of quantities) that serves as a reference, forming the basis for computation of horizontal and vertical control surveys in which the curvature of the earth is considered. Adjusted positions of the datum, described in terms of latitude and longitude, may be transformed into state plane coordinates.

All engineering work (mapping, planning, design, right of way, and construction) for WSDOT projects is based on a common datum.

(1) Horizontal

WAC 332-130-060 states, "The datum for the horizontal control network in Washington shall be NAD83 (1991) [the North American Datum of 1983] as officially adjusted and published by the National Geodetic Survey of the United States Department of Commerce and as established in accordance with chapter 58.20 RCW. The datum adjustment shall be identified on all documents prepared; i.e., NAD83 (1991)." For further information, see the *Highway Surveying Manual*.

(2) Vertical

The North American Vertical Datum of 1988 (NAVD88) as defined by the National Geodetic Survey (NGS) is the official civilian datum for surveying and mapping activities in the United States. WSDOT has adopted this datum. For further information, see the *Highway Surveying Manual*.

1440.05 Global Positioning System

A Global Positioning System (GPS) uses a constellation of satellites and earth stationed receivers to determine geodetic positions (latitude and longitude) on the surface of the earth. WSDOT personnel use this survey technology. (See the *Highway Surveying Manual* for more detailed discussions.)

GPS technology is changing rapidly. The key point is for the designer and surveyor to select the best tool (GPS or conventional applications) for doing the survey fieldwork. Oftentimes a combination of GPS and conventional (Total Station) surveying is appropriate.

1440.06 WSDOT Monument Database

The WSDOT Monument Database provides storage and retrieval capabilities for data associated with survey control monuments set by WSDOT. This database supports and tracks the Report of Survey Mark and aids in fulfilling WSDOT's obligation to contribute to the body of public record, thereby minimizing the duplication of survey work. The Report of Survey Mark provides data on specific GPS stations. (See Figure 1440-2 for an example of a Report of Survey Mark.)

To access the WSDOT Monument Database, see the following web site:
http://www.wsdot.wa.gov/monument/

1440.07 Geographic Information System

The Geographic Information System (GIS) is a collection of information from many sources. Its purpose is to assemble data into a central database for the common good. The data is stored on many levels so that the desired information can be selected and combined to achieve the desired product. Surveying and photogrammetric data are vital elements of this system.

1440.08 Photogrammetric Surveys

Photogrammetric surveys are performed to furnish topographic or planimetric maps and cross sections for use in the reconnaissance, location, and preliminary design phases of highway work. To use photogrammetric surveys for final design and construction requires that the ground be nearly bare to obtain the necessary accuracy. By using well-planned aerial photography in stereoscopic plotters, contours and other physical features are delineated on map sheets to a scale consistent with the accuracies or detail required.

The usefulness of aerial photography is not limited to mapping. Taking the form of enlargements, mosaics, and digital images, it can be used as a visual communication tool (displays and exhibits) for planning, design, property acquisition, engineering, construction, litigation, and public relations.

To obtain information on preparation, procedure, and programming of aerial photography and photogrammetric mapping and applications, contact the HQ Geographic Services Office. When requesting a photogrammetric survey, specify the desired units and check the units of the product. Allow for the time required to communicate the complex and detailed work request, develop the service, and accomplish the product.

1440.09 Documentation

For documentation related to monuments, see Chapter 1450.

Primary and secondary survey control data are archived in the WSDOT Monument Database and GIS when available.

The documents required to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

**INTERAGENCY AGREEMENT BETWEEN
THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
AND THE BOARD OF REGISTRATION FOR PROFESSIONAL
ENGINEERS AND LAND SURVEYORS**

THE FOLLOWING Interagency Agreement is hereby entered into between the Washington State Department of Transportation (hereafter referred to as "WSDOT") and the Washington State Board of Registration for Professional Engineers and Land Surveyors (hereafter referred to as "BOARD").

I

DECLARATIONS OF THE PARTIES

A. WHEREAS the BOARD has the exclusive authority to regulate the practice of engineering and land surveying in Washington; and

B. WHEREAS WSDOT employees are required to practice land surveying as defined by RCW 18.43.020 in carrying out the program of said agency; and

C. WHEREAS WSDOT is exempted from necessarily using a licensed land surveyor to perform said surveys in accordance with the provisions of the Survey Recording Act, RCW 58.09.090; and

D. WHEREAS both the BOARD'S and WSDOT'S goals include the performance of land surveys in conformance with recognized standards of practice and relevant laws and administrative codes in order to safeguard life, health, and property; and

E. WHEREAS the parties to the Agreement agree to the following Principles of Agreement.

II

PRINCIPLES OF AGREEMENT

A. The practice of land surveying performed by WSDOT employees shall be under the direct supervision of a licensed professional land surveyor OR licensed professional engineer. Said licensee shall hold a valid Washington license issued in conformance with RCW 18.43.

B. All surveys performed by WSDOT employees shall be performed in accordance with the Survey Standards promulgated under Chapter 332-130 WAC.

C. When a survey has been performed by WSDOT employees a survey map shall be prepared and filed with the county engineer in compliance with RCW 58.09.090(1)(a). Said map's contents shall be in conformance with the requirements of RCW 58.09.060 and WAC 332-130. Furthermore, said map shall contain the stamp and signature of the licensee who was in direct responsible charge of the work.

Interagency Agreement
Figure 1440-1a

D. A record of corner information shall be filed in accordance with RCW 58.09.040(2) and 58.09.090(2) where WSDOT employees replace or restore an existing or obliterated general land office corner. Said record of corner information shall be signed and stamped by the professional land surveyor or professional engineer responsible for said work.

E. The temporary removal or destruction of any section corner or any other land boundary mark or monument shall be permitted if performed in compliance with RCW 58.24.040(8).

F. Whether performed by a licensed professional engineer or a licensed professional land surveyor, any surveys performed by WSDOT shall be in accordance with the standards generally expected of those practicing professional land surveying.

IN WITNESS WHEREOF: The Washington State Department of Transportation and the Board of Registration have signed this Agreement.

/s/ Ed W. Ferguson

Ed W. Ferguson, PE DEPUTY SECRETARY Department of Transportation	January 5, 1990 Date

This Agreement approved by motion of the Board dated January 19, 1990.

/s/ Wesley E. Taft

Wesley E. Taft, PE CHAIRMAN, Board of Registration	January 19, 1990 Date

Interagency Agreement
Figure 1440-1b

Washington State Department of Transportation

Geographic Services

SURVEY INFORMATION SYSTEM

Report of Survey Mark

GENERAL MONUMENT INFORMATION

Designation:	GP29530-21	**T.R.S:**	31N, 5E , 2	
Monument ID:	8	**Corner Code:**		
State:	WASHINGTON	**State Route:**	530	
County:	SNOHOMISH	**Mile Post:**	20.590	
Region:	NW	**Station:**		
Nearest Town:	ARLINGTON	**Offset:**		
Usgs Quad:	ARLINGTON WEST	**Owner:**	GS	
		Bearing:	M	

ACCOUNTS INFORMATION

BOOK	PROJECT	INVOICE
49	0L2030	23-94042

Description

TO REACH THE STATION FROM THE INTERSECTION OF SR 530 AND SR 009 AT ARLINGTON, GO WEST 0.2 MILES ALONG SR 530 TO THE STATION ON THE RIGHT. IT IS LOCATED 1.1 METERS SOUTH OF A WITNESS POST, 33.5 METERS WEST OF THE APPROXIMATE CENTERLINE OF DIKE ROAD AND 1.2 METERS NORTH OF A GUARD RAIL. THE STATION IS A STANDARD WSDOT BRASS DISK SET IN A ROUND CONCRETE MONUMENT PROJECTING 0.2 FEET ABOVE THE GROUND. NOTE: 'POSITION UP-DATE BY OCCUPYING WITH G.P.S.' NOTE: TIED TO HPN 4/94. THIS IS A NAVD88 UPDATE.

CURRENT SURVEY CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	48 11 54.567381	N	122 08 03.530464	W	PRIMARY	GPS	2 CM

Report of Survey Mark

Figure 1440-2

1450.01 General

Proper monumentation is important in referencing a highway's alignment, which is used to define its right of way. The department can contribute to the body of public records and minimize duplication of survey work by establishing and recording monuments that are tied to a state plane coordinate system and to a standard vertical datum. The department is required by law to perpetuate existing recorded monuments. (See RCW 58.09.) The department provides monuments for realignments and new highway alignments and perpetuates existing monuments impacted by a project.

The Department of Natural Resources (DNR) is designated as the official agency for surveys and maps. New monuments set to establish property corners, highway alignment, etc., shall be recorded on a Record of Survey or Monumentation Map and filed with the DNR Public Land Survey Office and the appropriate county auditor or county engineer. All Records of Survey and Monumentation Maps are retained at DNR. Geodetic monuments are established and the Headquarters Geographic Services Office retains their placement records. Geodetic monuments are recorded on a Report of Survey Mark. These records are made available to the public on the internet by viewing: http://www.wsdot.wa.gov/monument

Existing monuments are not to be disturbed without first obtaining the DNR permits required by state law. DNR allows the temporary covering of a string of monuments under a single permit. State law requires replacement of land boundary monuments after temporary removal according to permit procedures. Washington State Department of Transportation (WSDOT) control and alignment monuments may not be removed without replacement, unless the location of the original position is perpetuated by reference and the appropriate document(s) prepared and filed with the county and the WSDOT Right of Way Plans Branch. Other requirements pertaining to specific monuments are discussed below.

Figure 1450-1 summarizes the documentation requirements for new and existing monuments.

The region is responsible for identifying and locating all existing monuments; obtaining all required permits before any existing monument is disturbed; and the research to locate existing monuments as required by WAC 332-120-030, as follows:

(2) *Any person, corporation, association, department, or subdivision of the state, county or municipality responsible for an activity that may cause a survey monument to be removed or destroyed shall be responsible for ensuring that the original survey point is perpetuated. It shall be the responsibility of the governmental agency or others performing construction work or other activity (including road or street resurfacing projects) to adequately search the records and the physical area of the proposed construction work or other activity for the purpose of locating and referencing any known or existing survey monuments.*

1450.02 References

Revised Code of Washington (RCW) 18.43 "Engineers and Land Surveyors,"

RCW 58.09 "Surveys – Recording,"

RCW 58.24 "State Agency for Surveys and Maps – Fees,"

Washington Administrative Code (WAC) 332-120 "Survey Monuments – Removal or Destruction," WAC 332-130 "Minimum Standards for Land Boundary Surveys and Geodetic Control Surveys and Guidelines for the Preparation of Land Descriptions,"

Highway Surveying Manual, M 22-97, WSDOT

"Manual of Instructions for the Survey of the Public Lands of the United States 1973 BLM, U.S. Department of Interior"

1450.03 Definitions

monument As defined for this chapter, a monument is any physical object or structure which marks or references a survey point. This includes but is not limited to a point of curvature (P.C.), a point of tangency (P.T.), a property corner, a section corner, a General Land Office (GLO) survey point, a Bureau of Land Management (BLM) survey point, and any other permanent reference set by a governmental agency or private surveyor.

removal or destruction The physical disturbance or covering of a monument such that the survey point is no longer visible or readily accessible.

1450.04 Control Monuments

Horizontal and vertical control monuments are permanent references required for the establishment of project coordinates tied to the Washington State plane system and elevations tied to a standard vertical datum. By establishing and recording permanent control monuments, the department eliminates duplication of survey work and contributes to the body of public records.

Horizontal and vertical control monuments are required for highway projects requiring the location of existing or proposed alignment or right of way limits. Monuments set by other agencies may be used if within 1 mile of the project, and the required datum and accuracy were used.

When control monuments are required for a given project, show the existing and proposed control monuments on the contract plans.

For horizontal control:

- Use North American Datum 1983, revised 1991 (NAD83/91).
- Use a minimum of second order, Class II procedures as defined in the *Highway Survey Manual* (M 22-97).
- Provide two monuments near the beginning of the project. Where possible, when setting horizontal control, set points to act as azimuth points. Place points so that line of sight is preserved between them and in an area that will not be disturbed by construction.
- Provide two monuments near the end of the project.
- Provide a pair of monuments at about 3-mile intervals throughout the length of the project.

For vertical control:

- Use North American Vertical Datum 1988 (NAVD88). (See the *Highway Surveying Manual* for orders of accuracy required.)
- Use at least second order procedures for primary vertical control within project limits as defined in the *Highway Surveying Manual*. Use third order for secondary control throughout the project.
- Provide vertical control throughout the length of the project. Desirable spacing is at or near each milepost. Maximum spacing is 3 miles apart.

All control monuments that are established, reestablished, or reset must be filed with the county engineer and the Department of Natural Resources (DNR). Submit a Record of Survey or a Monumentation Map that has been signed by the supervising, licensed, professional engineer or licensed, professional land survey or; if the monument is not used to reference right of way or land corners, submit a Report of Survey Mark. (See the *Highway Surveying Manual* for more detailed guidance on Control Monuments.)

1450.05 Alignment Monuments

Alignment monuments are permanent references required for the establishment or reestablishment of the highway and its right of way. Placing monuments at random points, in safe locations and tied to the Washington State plane coordinate system is recommended. (See the *Highway Surveying Manual*.)

Establishment, reestablishment, or resetting of alignment monuments is required on the following highway projects:

- New highway alignment projects
- Highway realignment projects involving new right of way (monuments are only required for the realigned highway section)
- Highway projects where alignment monuments already exist

Before an existing alignment monument is reestablished or reset, a DNR permit is required.

All alignment monuments that are established, reestablished, or reset must be filed with the appropriate county auditor or county engineer. The Record of Survey is filed with the county auditor in the county in which the monument is located and a recorded copy is sent to the Headquarters (HQ) Right of Way Plans Branch. The original Monumentation Map is filed with the county engineer of the county in which the monument is located and a recorded copy, with the filing signatures, is sent to the HQ Right of Way Plans Branch. The HQ Right of Way Plans Branch will forward a copy to DNR.

1450.06 Property Corners

A new property corner monument will be provided where an existing recorded monument has been invalidated as a direct result of a right of way purchase by the department. The new property corner monument shall be set by or under the direct supervision of a licensed professional engineer or licensed professional land surveyor.

The licensed land surveyor files the Record of Survey with the county auditor. A recorded copy of the Record of Survey is sent to the HQ Right of Way Plans Branch, and the HQ Real Estate Services Office. The licensed professional engineer files a Monumentation Map with the county engineer of the county in which the monument is located and a recorded copy is sent to the HQ Right of Way Plans Branch and the HQ Real Estate Services Office.

1450.07 Other Monuments

A DNR permit is required before any monument may be removed or destroyed.

Existing section corners and BLM or GLO monuments impacted by a project shall be reset to perpetuate their existence. After completing the work, a DNR Land Corner Record is required.

Other permanent monuments established by any other governmental agency must not be disturbed until the agency has been contacted to determine specific requirements for the monument. If assistance is needed to identify a monument, contact the HQ Geographic Services Office.

Resetting monuments must be done by or under the direct supervision of a licensed professional engineer or a licensed professional land surveyor. If a Record of Survey is prepared, it will be filed with the county auditor in the county in which the monument is located. If a Monumentation Map is prepared, it is filed with the county engineer of the county in which the monument is located and a recorded copy is sent to the HQ Right of Way Plans Section. The HQ Right of Way Plans Branch will forward a copy to DNR for their records.

1450.08 Documentation

The documents required to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

1450.09 Filing Requirements

(1) DNR Permit

When a DNR permit is required, use the application form shown in Figure 1450-2a. The completed application must be signed by a licensed professional engineer or a licensed professional land surveyor and submitted to DNR. The DNR permit applications can be down loaded in TIFF, PDF, or Word format at the following web site: http://www.dnr.wa.gov/htdocs/plso/download.htm.

Monumentation work cannot be done until DNR has approved the permit. In extraordinary circumstances, verbal authorization may be granted by DNR pending the issuance of a written permit.

After resetting the monument, the survey method used must be filed with DNR using the completion report form shown in Figure 1450-2b. The form must be signed by a licensed professional engineer or a licensed professional land surveyor.

(2) Documentation Map

When a Monumentation Map is required, a plan sheet is prepared. Generally, the plan sheet is based on a right of way plan obtained from the HQ Right of Way Plans Branch.A Monumentation Map contains a description of all new and existing monuments indicating their kind, size, and location. In addition, it must contain the seal and signature of a licensed professional engineer or a licensed professional land surveyor. (See the *Plans Preparation Manual*.)

A copy of a Monumentation Map is filed with the county engineer of the county in which the monument is located and a recorded copy is sent to the HQ Right of Way Plans Branch. The HQ Right of Way Plans Branch will forward a copy to DNR for their records.

(3) Land Corner Record

When a Land Corner Record is required, use the forms shown in Figures 1450-3a and 3b. The completed forms must be signed and stamped by a licensed professional engineer or a licensed professional land surveyor and submitted to the county auditor for the county in which the monument is located.

SET NEW

WSDOT Control Monument

Before: No permit required.

After: File a copy of the Monumentation Map with the county engineer. Send the original to the HQ Right of Way Plans Branch.

Alignment Monument

Before: No permit required

After: File a Record of Survey with the county auditor or a Monumentation Map with the county engineer. Send a copy to the HQ Right of Way Plans Branch.

Property Corner Monument*

Before: Engage a licensed professional land surveyor

After: Licensed professional land surveyor files Record of Survey with county auditor or a licensed professional engineer files a Monumentation Map with the county engineer and sends a copy to the HQ Right of Way Plans Branch.

DISTURB EXISTING*

Control Monument

Before: Obtain DNR permit.

After: File a copy of the Monumentation Map with the county engineer. Send the original to the HQ Right of Way Plans Branch.

Alignment Monument

Before: Obtain DNR permit.

After: File a copy of a Monumentation Map with the county engineer. Send the original to the HQ Right of Way Plans Branch.

Section Corner, BLM, or GLO Monument

Before: Obtain DNR permit.

After: File Land Corner Record with the county engineer. Send a copy to the HQ Right of Way Plans Branch.

All Other Monuments

Before:

- Obtain DNR permit.
- Contact governmental agency

After: File a copy of a Monumentation Map with the county engineer. Send the original to the HQ Right of Way Plans Branch.

*Property corner monuments must be filed within 90 days of establishment, re-establishment, or restoration.

Monument Documentation Summary

Figure 1450-1

APPLICATION FOR PERMIT TO REMOVE OR DESTROY A SURVEY MONUMENT

PERMIT NO.
You are hereby authorized to remove or destroy the described survey monument(s):

AUTHORIZING SIGNATURE/DATE
(DNR or Other Authorizing Agency)

APPLICANT INFORMATION:

NAME: TELEPHONE NO: DATE:

COMPANY OR AGENCY NAME AND ADDRESS:

I estimate that this work will be finished by (date)__________.

_________I request a variance from the requirement to reference to the Washington Coordinate System. (Please provide your justification in the space below.)

The variance request is approved; not approved. (FOR DNR USE ONLY) Reason for not approving:

MULTIPLE MONUMENTS:
______Check here if this form is being used for more than one monument. You must attach separate sheets showing the information required below for each monument affected. You must seal, sign and date each sheet.

INDEXING INFORMATION FOR AN INDIVIDUAL MONUMENT:
1) THE MONUMENT IS LOCATED IN: SEC TWP RGE 1/4-1/4
2) ADDITIONAL IDENTIFIER: (e.g., BLM designation for the corner, street intersection, plat name, block, lot, etc.)

MONUMENT INFORMATION: Describe: 3) the monument/accessories found marking the position, 4) the temporary references set to remonument the position (include coordinates when applicable), and 5) the permanent monument(s) to be placed on completion (if a permanent witness monument(s) is set include the references to the original position).

SEAL/SIGNATURE/DATE SIGNED

(Form prescribed 2/94 by the Public Land Survey Office, Dept. of Natural Resources, pursuant to RCW 58.24.040 (8).)

DNR Permit Application
Figure 1450-2a

COMPLETION REPORT FOR MONUMENT
REMOVAL OR DESTRUCTION

(TO BE COMPLETED AND SENT TO THE DNR AFTER THE WORK IS DONE.)

_____I have perpetuated the position(s) as per the detail shown on the application form.

SEAL/SIGNATURE/DATE SIGNED

OR

______I was unable to fulfill the plan as shown on the application form. Below is the detail of what I did do to perpetuate the original position(s). (If the application covered multiple monuments attach sheets providing the required information. Seal, sign and date each sheet.)

SEAL/SIGNATURE/DATE SIGNED

DNR Completion Record Form

Figure 1450-2b

LAND CORNER RECORD

GRANTOR/SURVEYOR/PUBLIC OFFICER: This corner record correctly represents work performed by me or under my direction in conformance with the Survey Recording Act.

COMPANY OR AGENCY:

ADDRESS:

GRANTEE: PUBLIC SEAL/SIGNATURE/DATE

LEGAL: TWP: RGE: CORNER CODE:

ADDITIONAL IDENTIFIER:(BLM designation, street or plat names, block, lot, etc.)

COUNTY:

WASHINGTON PLANE COORDINATES: N: E:

ORDER: ZONE: DATUM (Date of adjustment):

CORNER INFORMATION: Discuss the history, evidence found, and perpetuation of the corner. Diagram the references; provide the date of work; and, if applicable, a reference to a map of record and/or the field book/page no. Use the back, if needed.

This form is in compliance with the intent of RCW 65.04.045 and prescribed by the Public Land Survey Office, Department of Natural Resources - 1/97.

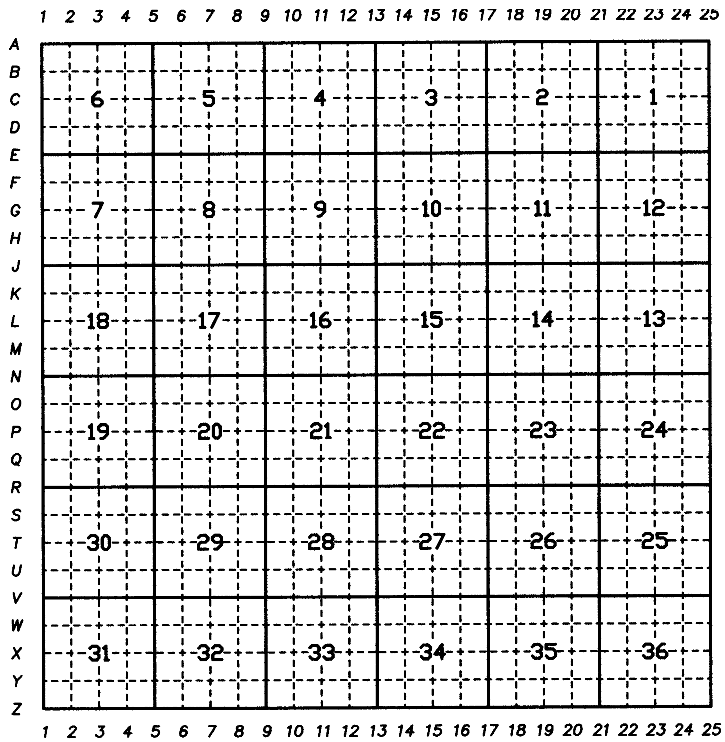
Land Corner Record

Figure 1450-3a

MARK THE CORNER LOCATION BELOW AND FILL IN THE CORNER CODE BLANK ON THE OTHER SIDE:
For corners at the intersection of two lines, the corner code is the alphanumeric coordinate that corresponds to the appropriate intersection of lines.

For corners that are only on one line, the corner code is the line designation and the related line segment; i.e., a corner on line 5 between "B" and "C" is designated BC-5.

For corners that are between lines, the corner code is both line segments; i.e., a corner in the SE1/4 of the SE1/4 of section 18 is designated MN 4-5.



RCW 58.09.060 (2) requires the following information on this form: an accurate description and location, in reference to the corner position, of all monuments and accessories (a) found at the corner and (b) placed or replaced at the corner; (c) basis of bearings used to describe or locate such monuments or accessories; and (d) corollary information that may be helpful to relocate or identify the corner position.

SPACE FOR ADDITIONAL COMMENT:

Land Corner Record

Figure 1450-3b

Chapter 1460 Fencing

1460.01 General

Fencing is provided primarily to discourage encroachment onto the Washington State Department of Transportation's (WSDOT's) highway right of way from adjacent property and to delineate the right of way. It is also used to replace fencing that has been disrupted by construction and to discourage encroachment onto adjacent property from the highway right of way.

Encroachment onto the right of way is discouraged to limit the presence of people and animals that might disrupt the efficient flow of traffic on the facility. Although not the primary intent, fencing does provide some form of separation between people, animals, the traffic flow, or other special features and, therefore, a small measure of protection for each.

1460.02 References

Plans Preparation Manual, M 22-31, WSDOT

Roadside Manual, M 25-30, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

1460.03 Design Criteria

(1) General

Fencing on a continuous alignment usually has a pleasing appearance and is the most economical to construct and maintain. The recommended practice is to locate fencing on or, depending on the terrain, 12 inches inside the right of way line.

Where the anticipated or existing right of way line has abrupt irregularities over short distances, coordinate with Maintenance and Real Estate Services personnel to dispose of the irregularities as excess property (where possible), and fence the final property line in a manner acceptable to Maintenance.

Whenever possible, preserve the natural assets of the surrounding area and minimize the number of fence types on any particular project.

(2) Limited Access Highways

On highways with full and partial limited access control, fencing is mandatory unless it has been established that such fencing may be deferred. Fencing is not required for modified limited access control areas, but may be installed where appropriate. Fencing is required between frontage roads and adjacent parking or pedestrian areas (such as at rest areas and flyer stops) and highway lanes or ramps unless other barriers are used to discourage access violations.

On new alignment, fencing is not provided between the frontage road and abutting property unless the abutting property was enclosed prior to highway construction. Such fencing is normally part of the right of way negotiation.

Unless there is a possibility of access control violation, fencing installation may be deferred until needed at the following locations (when in doubt, consult the Headquarters (HQ) Access and Hearings Engineer):

- Areas where rough topography or dense vegetation provides a natural barrier
- Along rivers or other natural bodies of water
- In sagebrush country that is sparsely settled
- In areas with high snowfall levels and sparse population
- On long sections of undeveloped public or private lands not previously fenced

(3) Managed Access Highways

Fencing is not required for managed access highways. When highway construction will destroy the fence of an abutting property owner, originally constructed on private property, the cost of such replacement fencing may be included in the right of way payment. When the fences of several property owners will be impacted, it may be cost effective to replace the fences as part of the project.

If fencing is essential to the safe operation of the highway, it will be constructed and maintained by the state. Examples are the separation of traveled highway lanes, and adjacent facilities with parking or pedestrian areas (such as rest areas and flyer stops).

(4) Special Sites

Fencing may be needed at special sites such as pit sites, stockpiles, borrow areas, and stormwater detention facilities.

Fencing is not normally installed around stormwater detention ponds. Evaluate the need to provide fencing around stormwater detention facilities when pedestrians or bicyclists are frequently present. Document your decision in the Design Documentation Package. The following conditions suggest a need to evaluate fencing:

- Children or persons with mobility impairments are frequently present in significant numbers adjacent to the facility, such as a route identified in a school walk route plan, nearby residential areas, or near a park
- Water depth reaches or exceeds 12 inches for several days' duration
- Side slopes into the facility are steeper than 3H:1V

Fencing proposed at sites that will be outside WSDOT right of way requires that local ordinances be followed if they are more stringent than WSDOT's.

Wetland mitigation sites are not normally fenced. When evaluating fencing for wetland mitigation sites, balance the need to restrict human access for safety considerations (such as the presence of children), with the need to provide animal habitat.

Other special sites where fencing may be required are addressed in the following chapters:

- Chapter 1020, "Bicycle Facilities"
- Chapter 1025, "Pedestrian Design Considerations"
- Chapter 1120, "Bridges" (refers to protective screening)

The type and configuration of the fence is determined by the requirements of each situation.

1460.04 Fencing Types

(1) Chain Link

Installation of chain link fence is appropriate for maximum protection against right of way encroachment on sections of high-volume highways under the following conditions:

- Along an existing business district adjacent to a freeway
- Between a freeway and an adjacent parallel city street
- At locations where existing streets have been cut off by freeway construction
- At industrial areas
- At large residential developments
- At military reservations
- At schools and colleges
- At recreational and athletic areas
- At developed areas at the intersection of two limited access highways
- At any other location where a barrier is needed to protect against pedestrian, bicyclist, or livestock encroachment in limited access areas

For roadway sections in rock cuts, see Chapter 640.

The Standard Plans contains details for the approved types of chain link fence. The recommended uses for each type of fence are as follows:

(a) Type 3. A high fence for areas of intensified use, such as industrial areas, or school playgrounds. Use this fence for new installations of high fencing. It may be used within the Design Clear Zone.

(b) Type 4. A lower fence for special use, such as between the traveled highway lanes and a rest area or flyer stop, or as a rest area boundary fence if required by the development of the surrounding area. This fence may be used along a bike path or hiking trail to separate it from an adjacent roadway.

Justify why corrective action is not taken when existing fencing with a rigid top rail will be left in place within the limits of a proposed project. For those cases where a more rigid fence is required, contact the HQ Design Office.

Coated galvanized chain link fence is available in various colors and may be considered in areas where aesthetic considerations are important. Coated ungalvanized chain link fence is not recommended.

(2) Wire Fencing

The Standard Plans and the Standard Specifications contain details for the two approved types of wire fence. The recommended uses for each type of fence are as follows:

(a) **Type 1.** This fence is used in urban and suburban areas where improvements along the right of way are infrequent and future development is not anticipated. It may also be used adjacent to livestock grazing areas. The lower portion of this fence is wire mesh and provides a barrier to children and small animals.

(b) **Type 2.** This fence is used in farming areas to limit highway crossings by farm vehicles to designated approaches. These areas include irrigation districts to prevent ditch riders, maintenance personnel, and farmers from making unauthorized highway crossings, and where new alignment crosses parcels previously enclosed by barbed wire.

(3) Other Considerations

Extremely tall fences (7 to 10 feet high) may be used in areas where there are exceptional hazards such as large concentrations of deer or elk. (See the region's Environmental Services Office and the *Roadside Manual* concerning wildlife management.)

Metal fencing can interfere with airport traffic control radar. When locating fencing in the vicinity of an airport, contact the Federal Aviation Administration to determine if metal fence will create radar interference at the airport. If so, use nonmetallic fencing.

Do not straddle or obstruct surveying monuments.

1460.05 Gates

Keep the number of fence gates along limited access highways to a minimum. On limited access highways, all new gates must be approved as described in Chapter 1425.

Usually such gates are necessary only to allow highway maintenance personnel and operating equipment to reach the state right of way without using the highway or freeway main line. Gates may be needed to provide access to utility supports, manholes, and the like, located within the right of way.

Use gates of the same type as the particular fence, and provide locks to deter unauthorized use.

In highly developed and landscaped areas where maintenance equipment is parked outside the fence, provide the double gate indicated in the Standard Plans.

Where continuous fencing is not provided on limited access highways, Type C approaches (see Chapter 920) are normally gated and locked, with a short section of fence on both sides of the gate.

1460.06 Procedure

Fencing is addressed in the access report, in accordance with Chapter 1430, and the Plans, Specifications and Estimates (PS&E), in accordance with the *Plans Preparation Manual*.

1460.07 Documentation

A list of documents that are to be preserved in the Design Documentation Package (DDP) or the Project File (PF) can be found on the following web site:
http://www.wsdot.wa.gov/eesc/design/projectdev/

Index

A

B

C

D

E

F

G

H

M

N

O

P

S

T

U

V

W