Washington State Department of Transportation

Publications Transmittal

Publication Distribution	Date
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Design Manual – September 2020	M 22-01.19
Originating Organization	
WSDOT Development Division, Design Office – Design Policy, Standards, and Safety Research Section	

Remarks and Instructions

What's changed in the Design Manual for September 2020?

How do you stay connected to current design policy?

It's the designer's responsibility to apply current design policy when developing transportation projects at WSDOT. The best way to know what's current is to reference the manual online.
Access the current electronic WSDOT *Design Manual,* the latest revision package, and individual chapters at: www.wsdot.wa.gov/publications/manuals/m22-01.htm

We're ready to help. If you have comments or questions about the Design Manual, please don't hesitate to contact us.

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HQ Design Office Signature	Email
John Tevis Digitally signed by John Tevis Date: 2020.11.30 13:34:23 -08'00'	John.Tevis@wsdot.wa.gov

Remove/Insert instructions for those who maintain a printed manual

CHAPTER/SECTION	REMOVE PAGES	INSERT PAGES
Title Page	All	All
Contents/Exhibits	All	All
300 Design Documentation Approval and Process Review	All	All
305 Project Management	All	All
310 Value Engineering	All	All
320 Traffic Analysis	All	All
540 Managed Access Control	All	All
710 Site Data for Structures	All	All
720 Bridges	All	All
730 Retaining Walls and Steep Reinforced Slopes	All	All
950 Public Art	All	All
1010 Work Zone Safety and Mobility	All	All
1020 Signing	All	All
1040 Illumination	All	All
1231 Geometric Cross Section – Highways	All	All
1239 Geometric Cross Section – Shoulders, Side Slopes, Curbs, and Medians	All	All
1250 Cross-Slope and Superelevation	All	All
1270 Auxiliary Lanes	All	All
1310 Intersections	All	All
1320 Roundabouts	All	All
1330 Traffic Control Signals	All	All
1340 Driveways	All	All
1360 Interchanges	All	All
1510 Pedestrian Facilities	All	All
1515 Share-Use Paths	All	All
1600 Roadside Safety	All	All
1610 Traffic Barriers	All	All
Glossary	All	All

Chapter	**List of Changes**
Glossary	
300	New Exhibit 300-1 lays out the content of the Design Documentation Package.
	A more robust section was added for Design-Build Projects (300.04(2))
	FHWA involvement updated to reflect new FHWA policies (300.05).
305	Updated information about the Deliverables Expectations Matrix
	New Exhibit 305-2 Project Risk Management Requirements
	New Section 305.04(1) Risk Assessment Timing
310	Added timing for Design Build VE studies, from the DB manual.
	Benefits of conducting VE studies earlier in project development.
	List of activities that should occur prior to the actual VE study.

320 Updated traffic analysis tools

540 8 small changes about high, intermediate, & low speed.

710 Preparing a preliminary plan in the design process.

Clarifying the measurement of the bridge interior horizontal opening.

New Section 710.07 Responsibilities for Design-Bid-Build structures.

720 New Section 720.03(5)(b)(4) Water Crossing Structures.

730 Contact Bridge about fall protection Systems.

950 New Section 950.04(1)(a) City Entrance Markers on Structures over the Interstate.

1010 Concrete barrier offset protecting drop-offs during construction.

1020 2 small changes about high, intermediate, & low speed.

1040 Reminder that Type II sign sheeting is reaching the end of service life.

Ensuring existing overhead sign structures can handle the size of the proposed sign.

Stop practice of installing unbalanced signs on overhead sign structures.

Replaced “laminated Wood Box Posts” with “Square Steel Posts”.

1231 1 small change about high, intermediate, & low speed.

1239 Fixed shoulder widening graphics to match standard plans.

Cleaned up Section 1239.03(1) Drainage Ditches and Exhibit 1239-4 Drainage Ditch Details.

Described mountable and non-mountable curbs better.

Moved Chain-up areas from axillary lane chapter to shoulders chapter.

1250 2 small changes about high, intermediate, & low speed.

1270 Moved Chain-up and Chain-off areas from this chapter to shoulders in Chapter 1239 as they are shoulders not Auxiliary Lanes.

1310 How low “Do Not Enter” & “Wong Way” signs can be lowered.

Added desirable Deceleration lane length to left-turn lane.

1320 Peer reviews for existing and proposed roundabouts.

1330 1 small change about high, intermediate, & low speed.

1340 Describing what accommodating a design vehicle means for driveways.

1360 Removing required justification for parallel on-ramps.

1510 3 small changes about high, intermediate, & low speed.

1515 Accounting for things that reduce vertical clearance.

1600 Section 1600.03(2)(g) updates mitigation guidance concerning utility objects found within the Design Clear Zone.

1610 Section 1610.01 incorporates Project Delivery Memo 16-03 concerning MASH implementation of WSDOT roadside safety systems.

Section 1610.03(1)(b) introduces guidance for allowable barrier types in median locations and provides guidance concerning the use of barrier between highways and collector-distributor roads.

Section 1610.03(5) expands guidance concerning allowable gaps between barrier runs and provides design alternatives when gaps are required.

Exhibit 1610-9 updated to more accurately show grading requirements (per Ch. 1239).

Section 1610.04(5)(b) adds guidance concerning placement of terminals on horizontal curves and behind curbs.

About revision marks and footer dates:

- A new date appears in the footer of all the chapters listed above.
- Changes include inserted or deleted content and existing content that shifts to a new page.
- The Substantially rewritten chapter 300 has no revision marks.

Chapter 300 Design Documentation, Approval, and Process Review

300.01 General

This chapter provides the WSDOT design procedures, documentation and approvals necessary to deliver projects on the transportation network in Washington, including projects involving the Federal Highways Administration (FHWA).

This chapter presents critical information for design teams, including:

- WSDOT's Project Development process.
- Design documentation tools, procedures, and records retention policy.
- Major Project approvals including Design Approval, Project Development Approval, Basis of Design, Design Analysis, and other specific project documents for design-bid-build and for design-build delivery methods.
- FHWA oversight and approvals.
- Information about conducting project process reviews.
- Additional references and resources.

For local agency and developer projects on state highways, design documentation is also needed. It is retained by the region office responsible for the project oversight, in accordance with the WSDOT records retention policy. All participants in the design process are to provide the appropriate documentation for their decisions. See 300.04(3) for information about the approval process and authority. For more information about these types of projects, see the *Local Agency Guidelines* and *Development Services Manual*.

For operational changes identified by the Traffic Operations Low Cost Enhancement or Field Assessment Program that are included in a project, design documentation is also needed. The project documentation will be provided by Traffic Operations in the form of a QBOD (Q program Basis of Design). The QBOD is included in the project documentation along with the project's BOD and retained in accordance with the WSDOT records retention policy.

For emergency projects, also refer to the *Emergency Funding Manual*. It provides the legal and procedural guidelines for WSDOT employees to prepare all necessary documentation to respond to, and recover from, emergencies and disasters that affect the operations of the department.

300.02 WSDOT Project Delivery

A project is developed in accordance with all applicable procedures, Executive Orders, Directives, Instructional Letters, Supplements, manuals, and the FHWA/WSDOT Stewardship and Oversight Agreement. A project can be influenced by separate plans or studies such as the Washington State Highway System Plan, corridor sketches, planning studies, Field Assessments, and scoping phase documentation.

300.02(1) Project Delivery Method

The project delivery method may vary depending on project type and cost. Preservation projects with an overall project cost of $10 million and over, and all other projects with an overall project cost of $2 million and over, are required to go through the Project Delivery Method Selection process. The overall project cost is the total of the Preliminary Engineering, Right of Way, and Construction costs.

WSDOT primarily uses two delivery methods: Design-bid-build (DBB) and design-build (DB). DBB is considered the traditional project delivery method where a project office puts together a complete set of plans, specifications, and estimate (PS&E), that is advertised for contractors to bid on. The project is constructed by a contractor in accordance with the PS&E and WSDOT provides construction oversight. For DB projects, the WSDOT develops a request for proposal (RFP) that includes a basic configuration for the project and a Conceptual Design Approval. The RFP is advertised and a contractor is selected. The contractor is responsible for the design, project construction, and final Design Documentation Package.

Design-build's typical application is for improvement projects in the mobility, economic initiatives, or environmental subprograms where there are opportunities for innovation, greater efficiencies, or significant savings in project delivery time.

For all projects, the delivery method is determined using WSDOT Project Delivery Method Selection Guidance (PDMSG) with the following exceptions:

- Projects under $2 million are programmatically exempt from PDMSG, do not require a Project Delivery Method Selection Checklist, and will be DBB.
- Preservation Paving projects under $10 million are programmatically exempt from PDMSG, do not require a Project Delivery Method Selection Checklist, and will be DBB.

300.02(2) Environmental Requirements

WSDOT uses the Environmental Review Summary (ERS) portion of the Project Summary to scope environmental impacts associated with the proposed project and document the anticipated environmental class of action (Environmental Impact Statement/Environmental Assessment/Categorical Exclusion). Projects that have only state funds must have State Environmental Policy Act (SEPA) documentation. Projects involving a federal action in any phase of the project require National Environmental Policy Act (NEPA) documentation. On National Highway System (NHS) routes, a Design Analysis involving one of the controlling criteria (see 300.05(3)) is a federal action.

Upon receipt of the ERS approval for projects requiring an Environmental Assessment or Environmental Impact Statement under NEPA, the region proceeds with environmental documentation, including public involvement, appropriate for the magnitude and type of the project.

The environmental approval levels are shown in Exhibit 300-3. Refer to your Region Environmental Office and Chapter 225 for more information.

300.02(3) Real Estate Acquisition

Design Approval and approval of right of way plans are required prior to acquiring property. A temporary construction easement may be acquired prior to Design Approval for State funded projects and with completion of NEPA for Federally funded projects. For early acquisition of right of way, consult the Real Estate Services Office, the April 2, 2013 memorandum on early acquisition policy, and *Right of Way Manual* Chapter 6-3.

300.03 Design Documentation

300.03(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.

All original technical documents must bear the certification of the responsible licensee as listed in Executive Order E 1010

300.03(2) Design Decisions

Throughout the Design Manual, the terms consider, document, justify, and Design Analysis are used. These terms indicate a scaled level of documenting a design decision.

The lowest level of documentation is consider. “Consider” means to think carefully about a decision and the level of documentation is at the discretion of the engineer. “Document” means to place a short note in the Design Documentation Package (see 300.03(3)) that explains the decision. The actual form of this note is at the discretion of the engineer. “Justify” means to prepare a design decision memo to the DDP that identifies the reason for the decision with a comparison of the advantages and disadvantages. The format used to justify a decision is the same as a Design Analysis except it is only approved by the engineer of record. The highest level of documenting a decision is the Design Analysis. When a Design Analysis is required, how it is documented, and who approves it, is explained in the next section.

300.03(2)(a) Design Analysis

A Design Analysis is a process and tool used to document important design decisions, summarizing information needed for an approving authority to understand and support the decision. The approving authority is shown in Exhibit 300-2 or 300-5.

A Design Analysis is required where a dimension chosen for a design element that will be changed by the project is outside the range of values provided for that element in the Design Manual. A Design Analysis is also required where the need for one is specifically referenced in the Design Manual.

A region approved Design Analysis is required if a dimension or design element meets current AASHTO guidance adopted by FHWA, but is outside the corresponding Design Manual criteria. Email a PDF copy of all region approved Design Analyses to the ASDE supporting your region.

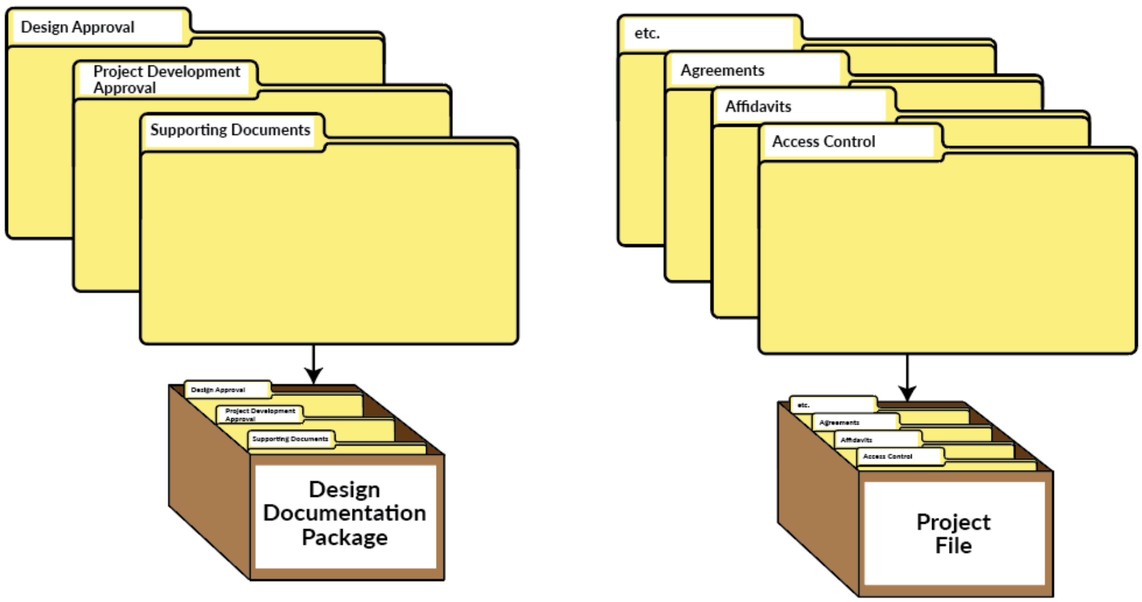
A Design Analysis may be classified as a federal action and require FHWA involvement as discussed in 300.05(3).

In the case of a shoulder width reduction at an existing bridge pier, bridge abutment, sign structure, or luminaire base in a run of median barrier, the Design Parameter Sheet may be used instead of a Design Analysis to document the dimensioning decision for the shoulder at that location.

A template is available for the development of the Design Analysis document here: www.wsdot.wa.gov/design/support.htm.

300.03(3) Design Documentation Package and Project File

The Design Documentation Package and Project File include documentation of project work. They are effectively two separate documentation products that have two separate retention processes.



The **Design Documentation Package (DDP)** consists of the Design Approval, Project Development Approval, and supporting documents that preserves the decision documents generated during the design process. The DDP documents and explains design decisions, design criteria, and the design process that was followed.

The contents of the DDP are listed in the DDP checklist in seven sections as follows:

1. Introductory Documents
2. Project Summary Documents
3. Core Documents
4. Environmental Documents
5. Supporting Documents
6. Other Approvals and Justifications
7. Other Items

Sections one through five of the checklist remain the same for all projects. Items in section 6 and 7 may vary depending on the project at the discretion of the engineer of record. Reference the instructions for the DDP checklist of further information.

Any time after completion of the design efforts, the design team submits the DDP to the person in the region responsible for records retention (e.g., Region Plans Engineer). These people work with the WSDOT Records Department to place the DDP into the State Records Center. The DDP is retained in a State Records Center for a period of 75 years and then transferred to State Archives for permanent storage.

The **Project File (PF)** contains the documentation that is important to the project design, but not included in the DDP. This includes items for planning, scoping, programming, design, contract assembly, utility relocation, needed right of way, advertisement, award, constructability, traffic management, 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.

See the Project File checklist for documents that are contained in the Project File. The Project File checklist should be included at the beginning of the Project File as a table of contents. If an item on the checklist is not applicable to the project, you may simply state such in the comment column.

The Project File may be purged 3 years after the Construction Office has issued the Final Contract Voucher Certification.

300.04 Project Approvals

This section describes WSDOT's project design milestones for design-bid-build (DBB) and design-build (DB) projects. Work with the ASDE for project approvals that will be required for other delivery methods.

Exhibit 300-1 shows all the deliverables that are required for DB and DBB projects. Use information in this section, Exhibit 300-1, and the DDP checklist to understand what is necessary for each project approval and how they are assembled.

Information pertaining to FHWA approvals and oversight is provided in 300.05. Documents for projects requiring FHWA review or approval are submitted through the ASDE.

300.04(1) Design-Bid-Build Projects

The region develops and maintains documentation for DBB projects using this chapter and the checklist for the Project File and Design Documentation Package (see 300.03(3)). For an idea of when design documentation should be completed in the design process, consult the Deliverables Expectation Matrix in 305.03(2).

For the purpose of documentation, DBB projects have two approval milestones: Design Approval and Project Development Approval (PDA). Design Approval can be achieved when a basic configuration of the project is known, which is around 30% design. Project Development Approval is achieved near the end of the design process prior to advertising the project for construction.

Design Approval locks the version of the Design Manual that will be utilized for up to three years of the design process. When PDA is acquired, the design must conform to the version of the Design Manual as stated in the Design Approval. In essence, having a Design Approval allows the design team to continue through the remainder of the design process without having to reanalyze their project for updates to the Design Manual.

The contents of the Design Approval and PDA are discussed in detail in 300.04(1)(a) and (b). Projects that have a short duration may combine the Design Approval and PDA into one document. This is called a Combined Design Approval/PDA and is discussed further in 300.04(1)(c).

DBB projects that are designed by one project office and then turned over to another office for construction must transfer the Project File (along with a copy of the DDP) to the construction office for their use. Exhibit 300-6 is an example checklist of recommended items to be turned over to the construction office at the time of project transition. If the construction office changes an item documented in the DDP, it is responsible for documenting the change in a supplement to the DDP.

300.04(1)(a) Design Approval

Design Approval may occur prior to NEPA/SEPA approval and is required prior to acquiring property. Approval levels for design and PS&E documents are presented in Exhibits 300-2 through 300-5.

The Design Approval contains the introductory documents, project summary documents, and core documents as shown in Exhibit 300-1 and detailed in the DDP Checklist. Include other items from the DDP Checklist that are complete prior to Design Approval.

Once complete, the Design Approval becomes part of the DDP. The portion of the DDP Checklist applicable to Design Approval is used as the table of contents.

Design Approval is entered into the DDP and remains valid for three years or as approved by the ASDE. An extension must be documented and filed in the DDP.

300.04(1)(b) Project Development Approval

When all project development documents are completed and approved, Project Development Approval (PDA) is granted by the approval authority designated in Exhibit 300-2. The PDA becomes part of the DDP.

Refer to this chapter and the DDP checklist for design documents necessary for PDA. Exhibits 300-2 through 300-5 provide approval levels for project design and PS&E documents.

The PDA contains the same introductory documents and project summary documents as the Design Approval (see Exhibit 300-1). Any of the documents that are unchanged from the Design Approval may simply be referenced in the PDA. If they have changed, update the document and insert it in the PDA. If the plans for approval are conceptual in the Design Approval, they must be finalized for the PDA.

The NEPA/SEPA process must be complete for PDA.

Project Development Approval remains valid for three years.

300.04(1)(c) Combined Design Approval / Project Development Approval

All projects require Design Approval and PDA, however many projects have a short timeline for design and the design offices do not find it beneficial to create two separate documents. If this is the case, both approvals may be combined into one approval. To do this, complete all the products as listed in Exhibit 300-1 and title the approval "Combined Design Approval / Project Development Approval". Even though the products listed in Exhibit 300-1 are not required until design is complete, most of these products should be completed early as they set direction for the project. For an idea of when products should be delivered in the design process, consult the Deliverables Expectation Matrix in 305.03(2).

A Combined Design Approval / Project Development Approval remains valid for three years.

300.04(2) Design-Build Projects

For design-build (DB) projects, WSDOT provides a preliminary design referred to as the conceptual design and the design-builder becomes the engineer of record responsible for completing the final design. For this reason, WSDOT obtains Conceptual Design Approval (CDA) for DB projects and does not apply a PE stamp. See the WSDOT Design-Build Manual for additional information regarding the level of completeness required for the conceptual design and development of the request for proposal (RFP).

Once a contract is executed, the design-builder is responsible for maintaining and completing all design documentation, including the PDA, DDP supporting documents, and Project File. Refer to the design-build DDP checklist for design documents necessary for CDA, PDA, and DDP supporting documents.

Conceptual Design Approval is entered into the DDP and remains valid for three years or as approved by the ASDE. An extension to the CDA must be filed in the DDP. Once the RFP is issued, the version of the Design Manual is locked throughout the duration of the contract.

300.04(2)(a) Conceptual Design Approval

Assemble the CDA similar to the DBB Design Approval (see 300.04(1)(a) and Exhibit 300-1) with the most significant difference being that environmental documentation completion is required. There are rare cases where the environmental documentation cannot be complete prior to RFP. In these cases, the approving authority (Exhibit 300-2) must provide their approval and the environmental documentation must be complete prior to executing the DB contract.

300.04(2)(b) Project Development Approval

For DB projects, the design-builder undertakes full responsibility for delivery of the project, including developing the final design. The CDA package is transferred to the design-builder upon contract execution, and the design-builder updates the files to reflect their design. The updated documents, and all other items shown in Exhibit 300-1, make up the PDA package. Refer to the project RFP for final and intermediate deliverables, the approval process, and final records for the project. PDA <u>and the applicable DDP Supporting Documents are</u> required prior to project completion.

It is a prudent practice to start the compilation of design documentation early in a project and to acquire PDA before the completion of the project. At the start of a project, it is critical that WSDOT project administration staff recognize the importance of all required documentation and how it will be used in the DB project delivery process.

300.04(3) Local Agency and Development Services Approvals

Other entities (e.g. local agencies, tribes, or developers) proposing projects within WSDOT jurisdiction are required to follow WSDOT design documentation policy as noted in this chapter. Documentation is submitted to WSDOT for review and approval according to Exhibit 300-5. Where FHWA approval is indicated, the ASDE will forward project documentation to FHWA for approval and transmit FHWA’s approval, comments, and/or questions back to the submitter.

A <u>Summary of Design (</u>SOD<u>)</u> may replace the <u>Basis of Design (</u>BOD<u>)</u> in Exhibit 300-1if agreed to by the region signing authority and the ASDE. All other documentation required by this chapter must be provided, however a non-WSDOT funded project may not have a Project Profile or an Environmental Review Summary.

In cases where design decisions are imposed by WSDOT or FHWA as mitigation, the decision will be documented by WSDOT and included in the design documentation package.

The requirement to submit a BOD/SOD for approval may be waived by the approving authority designated in Exhibit 300-5, based on the criterion in 1100.10(1)(a). When a region is the approval authority for the BOD/SOD and is considering an exemption, the region approving authority can assume the role of the ASDE to determine if an exemption is appropriate.

For information on jurisdiction, consult 1230.04.

300.05 FHWA Oversight and Approvals

The March 2015 Stewardship & Oversight (S&O) Agreement between WSDOT and FHWA Washington Division created new procedures and terminology associated with FHWA oversight and approvals. One such term, and new relevant procedure, is “Projects of Division Interest” (PoDI) described below.

For all projects on the National Highway System (NHS), the level of FHWA oversight and approvals can vary for numerous reasons such as type of project, the agency doing the work, PoDI/non-PoDI designation, and funding sources. Oversight and funding do not affect the level of design documentation required for a project, but it may instigate FHWA approval as detailed in the following sections.

Documents requiring FHWA review and approval are submitted through the HQ Design Office.

300.05(1) FHWA Projects of Division Interest (PoDI)

Projects of Division Interest (PoDI) are projects for which FHWA determines the need to exercise oversight and approval authority. These projects have an elevated risk, contain elements of higher risk, or present a meaningful opportunity for FHWA involvement to enhance meeting program or project objectives. Collaborative identification of these projects allows FHWA Washington Division to concentrate resources on project stages or areas of interest. It also allows WSDOT to identify which projects are PoDIs and plan for the expected level of engagement with FHWA.

The Stewardship & Oversight Agreement generally defines Projects of Division Interest as:

- Major Projects (A federal aid project with total cost >$500M)
- Federal Discretionary Grant Projects
- NHS Projects that may require FHWA Project or Program Approvals
- Projects Selected by FHWA based on Risk or Opportunity

The S&O Agreement also states: Regardless of retained project approval actions, any Federal-aid Highway Project either on or off the NHS that the Division identifies as having an elevated level of risk can be selected for risk-based stewardship and oversight and would then be identified as a PoDI.

For each project designated as a PoDI, FHWA and WSDOT prepare a Project-Specific PoDI Stewardship & Oversight Agreement that identifies project approvals and related responsibilities specific to the project.

300.05(2) FHWA Approvals on Non-PoDI Projects

On projects that are not identified as PoDI, FHWA design approvals are required for the following:

- Any new or revised access point (including interchanges, temporary access breaks, and locked gate access points) on the Interstate System, regardless of funding source or PoDI designation (see Chapters 530 and 550).

300.05(3) FHWA-Approved Design Analysis

FHWA approves Design Analysis on all Interstate projects (mainline and ramps) associated with the following ten controlling criteria:

- Design Speed
- Lane Width
- Shoulder Width
- Horizontal Curve Radius
- Superelevation Rate
- Stopping Sight Distance: horizontal alignments and vertical alignments except for sag vertical curves
- Maximum Grade
- Cross Slope
- Vertical Clearance
- Design Loading Structural Capacity

Interstate Design Analysis not associated with the above ten controlling criteria have been delegated to HQ Design.

Approval of Design Analyses on non-Interstate NHS routes has been delegated to HQ Design. However, a Design Analysis on a NHS route is a federal action and NEPA documentation is required in the following cases:

- NHS route with a speed greater than or equal to 50 mph: Any Design Analysis associated with the above ten controlling criteria.
- NHS routes with a speed less than 50 mph: Only Design Analysis associated with the following two controlling criteria:
  - Design Loading Structural Capacity
  - Design Speed

No FHWA involvement is required for non-NHS routes.

300.06 Process Review

The ASDEs conduct process reviews. The process review is done to provide reasonable assurance that projects are prepared in compliance with established policies and procedures and adequate records exist to show compliance. Projects are normally selected for a review after contract award, which allows the design team appropriate time to assemble the final project documentation. The process review will focus on the Design Documentation Package and the Project File, but may include other documents as requested.

A process review usually involves the region's project development leadership, project engineer, and the design team leader. The ASDE may invite others to participate such as FHWA, Traffic, Hydraulics, Public Transit, or Active Transportation.

At the conclusion of a process review, findings may be issued that ask for corrections or additions to the DDP. The original DDP will remain intact and additions or corrections will be added via memorandum and/or supplements and filed with the original DDP.

300.07 References

300.07(1) Federal/State Laws and Codes

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

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,"
www.wsdot.wa.gov/publications/fulltext/design/ASDE/2015_Stewardship.pdf

300.07(2) Design Guidance

WSDOT Directional Documents Index, including the one listed below:

http://wwwi.wsdot.wa.gov/publications/policies

Executive Order E 1010, "Certification of Documents by Licensed Professionals," WSDOT

WSDOT technical manuals, including those listed below:

www.wsdot.wa.gov/publications/manuals/index.htm

- *Advertisement and Award Manual*, M 27-02, WSDOT
- *Cost Estimating Manual for WSDOT Projects*, M 3034, WSDOT
- *Design Manual*, M 22-01, WSDOT
- *Emergency Relief Procedures Manual*, M 3014, WSDOT
- *Environmental Manual*, M 31-11, WSDOT
- *Hydraulics Manual*, M 23-03, WSDOT
- *Highway Runoff Manual*, M 31-16, WSDOT
- Local Agency Guidelines (LAG), M 36-63, WSDOT
- *Plans Preparation Manual*, M 22-31, WSDOT
- *Roadside Manual*, M 25-30, WSDOT
- *Roadside Policy Manual*, M 3110, WSDOT
- *Temporary Erosion and Sediment Control Manual*, M 3109, WSDOT
- *Traffic Manual*, M 51-02, WSDOT

Limited Access and Managed Access Master Plan, WSDOT

www.wsdot.wa.gov/design/accessandhearings/

Program Management Manual, M 3005, WSDOT http://wwwi.wsdot.wa.gov/publications/manuals/fulltext/M3005/PMM.pdf

Washington State Multimodal Planning, WSDOT

www.wsdot.wa.gov/planning/

300.07(3) Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2018

Mitigation Strategies for Design Exceptions, FHWA, July 2007. This publication provides detailed information on design exceptions and mitigating the potential adverse impacts to highway safety and traffic operations.

Exhibit 300-1 Design Documentation Package

DDP Section	Document	Design-bid-build DA	Design-bid-build PDA	Design-bid-build Combined DA/PDA	Design-Build CDA	Design-Build PDA
1	Introductory Documents					
1.1	Table of Contents	R	U	R	R	R
1.2	Memorandum	R	U	R	R	R
1.3	Vicinity Map	R	U	R	R	R
2	Project Summary Documents **					
	2.1 Project Definition or Project Profile 2.2 Basis of Design (BOD) 2.3 Environmental Review Summary	R	U	R	R	U
3	Core Documents					
3.1	Design Parameters Sheets	R	U	R	R	U
3.2	Safety Analysis	R	U	R	R	U
3.3	Design Analysis	R*	R	R	R*	R
3.4	Maximum Extent Feasible	R*	R	R	R*	R
3.5	Plans for Approval · Intersection/Channelization Plans · Interchange Plans	C	R	R	C	R
3.6	Alignment Plans and Profiles	C	N/A	R	C	R
3.7	Cost Estimate	R	U	R	R	N/A
4	Environmental Documentation	N/A	R	R	R	N/A
5	Supporting Documents	As Needed See DDP Checklist				
6	Other Approvals and Justifications					
7	Other Items as Deemed Necessary					

* If known at this stage in the design process

** See 300.04(3) for non-WSDOT funded projects

C = Conceptual
R = Required
U = Required if Updated after Design Approval
N/A = Not Applicable

Exhibit 300-2 Approval Authorities

Project Type	Basis of Design (BOD) Approval	Design Analysis Approval [1]	Design Approval and Project Development Approval
Project of Division Interest (PoDI)	[2]	[2]	[2]
Interstate			
All Projects [3]	HQ Design	FHWA[4] HQ Design	FHWA[5] HQ Design
National Highway System (NHS)			
Projects on all limited access highways, or on managed access highways outside of incorporated cities and towns	Region ‡	HQ Design	Region
Projects on managed access highways within incorporated cities and towns Inside curb or EPS [6] Outside curb or EPS	Region ‡ City/Town	HQ Design HQ LP	Region City/Town
Non-National Highway System (Non-NHS)			
Improvement projects on all limited access highways, or on managed access highways outside of incorporated cities and towns	Region ‡	HQ Design	Region
Improvement projects on managed access highways within incorporated cities and towns [7] Inside curb or EPS [6] Outside curb or EPS	Region ‡ City/Town	HQ Design HQ LP	Region City/Town
Preservation projects on limited access highway, or on managed access highways outside of incorporated cities and towns, or within unincorporated cities and towns [8]	Region	Region	Region
Preservation projects on managed access highways within incorporated cities and towns [8] Inside curb or EPS [6] Outside curb or EPS	Region City/Town	Region HQ LP	Region City/Town

‡ HQ concurrence required
FHWA = Federal Highway Administration
HQ = WSDOT Headquarters
HQ LP = WSDOT Headquarters Local Programs Office
EPS = Edge of paved shoulder where curbs do not exist
NHS = National Highway System
www.wsdot.wa.gov/mapsdata/travel/hpms/NHSRoutes.htm

Exhibit 300-2 Approval Authorities (continued)

Notes:

[1] See 300.03(2)(a)

[2] Projects of Division Interest (PoDI) must receive FHWA approvals per the PoDI Agreement regardless of funding source or project type.

[3] For projects types needing FHWA approval, see 300.05(2).

[4] See 300.05(3) for FHWA involvement with Design Analysis.

[5] FHWA will provide Design Approval prior to NEPA Approval, but will not provide Project Development Approval until NEPA is complete.

[6] Includes raised medians (see Chapter 1600).

[7] Refer to RCW 47.24.020 for more specific information about jurisdiction and responsibilities that can affect approvals.

[8] For Bridge Replacement projects in the Preservation program, follow the approval level specified for Improvement projects.

Exhibit 300-3 Approvals

Item	Approval Authority		
	Region	HQ	FHWA
Program Management			
Project Profile		X [10]	
Work Order Authorization		X	X [1]
Public Hearings			
Corridor Hearing Summary		X [2]	
Design Hearing Summary		X [3]	X [8]
Limited Access Hearing		X [4]	
Access Control			
Limited Access Break: Interstate		[7]	X
Limited Access Break: non-Interstate		X	
Environmental Document			
Environmental Review Summary	X		
NEPA – Environmental Impact Statement (EIS)		[7]	X
NEPA – Categorical Exclusion (CE)	X		
NEPA – Environmental Assessment (EA)		[7]	X
SEPA – Categorical Exemption (CE)	X		
SEPA – Environmental Checklist & Determination of Non-Significance (DNS)	X		
SEPA – Environmental Impact Statement (EIS)		X	
Design			
Access Revision Report		[7]	X
Basis of Design (BOD)	[9]	[9]	[9]
Design Analysis	[9]	[9]	[9]
Design Approval	[9]	[9]	[9]
Experimental Features		X	X
Geotechnical Report		X [12]	
Grading Plans	X		
Hydraulic Report	X [15]	[15]	
Materials Source Report		X [12]	
Maximum Extent Feasible	X	X[19]	
Monumentation Map	X		
Pavement Determination Report		X [12]	
Planting Plans	X [16]	X [17]	
Proprietary Items	X		
Project Development Approval	[9]	[9]	[9]
Public Art Plan – Interstate	X [16]	X [17][21]	X
Public Art Plan – Non-Interstate	X [16]	X [17][21]	
Roadside Restoration Plans	X [16]	X [17]	
Rest Area Plans		X	
Resurfacing Report		X [12]	
Right of Way Plans	[11]	X	
Tied Bids	X [14]		

Exhibit 300-3 Approvals (cont.)

Item	Approval Authority		
	Region	HQ	FHWA
Structures			
Bridge Design Plans (Bridge Layout)	X	X	
Preliminary Bridge Plans for Unusual/Complex Bridges on the Interstate		[7]	X
Structures Requiring Type Size and Location		X	
Traffic			
Continuous Illumination – Mainline	X [20]	X [18]	
Crash Analysis Report	X [20]	X	
High Mast Illumination		X [18]	
Illumination Plans	X [20]		
Intelligent Transportation System (ITS) Plans	X [20]		
Interchange Plan for Approval	X		
Intersection Control Evaluation	X [20]	X [18]	
Intersection or Channelization Plans	X		
ITS Systems Engineering Analysis Worksheet	X [20]		
Preliminary Signalization Plans		X [6][18]	
Safety Analysis	X		
Signal Permits	X [13]		
Signalization Plans	X [20]		
Traffic Analysis	X		
Tunnel Illumination		X [18]	
Work Zone Transportation Management Plan/Traffic Control Plan	X [20]		

Notes:

[1] Federal-aid projects
[2] Assistant Secretary Regions and Mega Programs
[3] State Design Engineer
[4] Right of Way Plans Manager
[5] Vacant
[6] Vacant
[7] Final review & concurrence required at HQ prior to submittal to approving authority.
[8] On Interstate projects, the State Design Engineer submits the approved design hearing summary to the FHWA for federal approval.
[9] See Exhibit 300-2
[10] HQ Capital Program Development and Management (CPDM)
[11] Certified by a professional licensee
[12] HQ Materials Lab
[13] Regional Administrator
[14] Per 23 CFR 635.111
[15] See the *Hydraulics Manual* for approvals levels.
[16] Applies to regions with a Landscape Architect.
[17] Applies to regions without a Landscape Architect.
[18] State Traffic Engineer
[19] ASDE with OEO Deputy Director concurrence
[20] Region Traffic Engineer
[21] ASDE and Bridge and Structures Office

Exhibit 300-4 PS&E Process Approvals

Item	Approval Authority
DBE/training goals */**	Office of Equal Opportunity
Right of way certification for federal-aid projects***	Region; HQ Real Estate Services Office or HQ Local Programs Right of Way Manager [7]
Right of way certification for state or local funded projects***	Region; HQ Real Estate Services Office or HQ Local Programs Right of Way Manager
Railroad agreements	HQ Design Office
Work performed for public or private entities *	Region [1][2]
State force work *	Region [3][4]
Use of state-furnished materials *	Region [3][4]
Ultimate reclamation plan approval through DNR	Region
Mandatory material sources and/or waste sites *	Region [4]
Nonstandard bid item use *	Region
Incentive provisions	HQ Construction Office
Nonstandard time for completion liquidated damages *	HQ Construction Office
Special Provisions	HQ Construction Office
Lump Sum Traffic Control	Region
Interim liquidated damages *	Transportation Data, GIS & Modeling Office

Notes:

FHWA PS&E Approval has been delegated to WSDOT unless otherwise stated differently in a Project Specific PoDI S&O Agreement.

[1] This work requires a written agreement.
[2] Region approval subject to $250,000 limitation.
[3] The Region justifies use of state force work and/or state-furnished materials HQ CPDM reviews to ensure process has been followed. For more details on state force work or state-furnished materials, see Division 700.09 of the Plans Preparation Manual.
[4] Applies only to federal-aid projects; however, document for all projects.
[5] Vacant
[6] The Region is required to certify that the proprietary product is either: (a) necessary for synchronization with existing facilities, or (b) a unique product for which there is no equally suitable alternative.
[7] For any federal aid project FHWA only approves Right of Way Certification 3s (All R/W Not Acquired), WSDOT approves Right of Way Certification 1s and 2s for all other federal aid projects.

References:

* *Plans Preparation Manual*
** *Advertisement and Award Manual*
*** *Right of Way Manual*

Exhibit 300-5 Local Agency and Development Services Approving Authority

Project Type	Basis of Design (BOD/SOD) Approval	Design Analysis Approval [1]	Design Approval and Project Development Approval
Interstate			
All projects [2]	FHWA HQ Design	FHWA [3] HQ Design	FHWA [4] HQ Design
Highways (NHS) & (Non-NHS)			
Projects on limited access highways	HQ Design	HQ Design	Region*
Projects on managed access highways	Region*	HQ Design	Region*

* The Approving Authority may be the Local Programs Engineer or Project Development Engineer as determined by the Region.

[1] See 300.03(2)(a).

[2] For projects types needing FHWA approval, see 300.05(2).

[3] See 300.05(3) for FHWA involvement with Design Analysis.

[4] FHWA will provide Design Approval prior to NEPA Approval, but will not provide Project Development Approval until NEPA is complete.

Exhibit 300-6 Design to Construction Transition Project Turnover Checklist Example

This checklist is recommended for use when coordinating project transition from design to construction.

1. Survey

- ❑ End areas (cut & fill)
- ❑ Staking data
- ❑ Horizontal/Vertical control
- ❑ Monumentation/Control information

2. Design Backup

- ❑ Index for all backup material
- ❑ Backup calculations for quantities
- ❑ Geotech shrink/swell assumptions
- ❑ Basis of Design, Design decisions and constraints
- ❑ Approved Design Analyses
- ❑ Hydraulics/Drainage information
- ❑ Clarify work zone traffic control/workforce estimates
- ❑ Geotechnical information (report)
- ❑ Package of as-builts used (which were verified) and right of way files
- ❑ Detailed assumptions for construction CPM schedule (working days)
- ❑ Graphics and design visualization information (aerials)
- ❑ Specific work item information for inspectors (details not covered in plans)
- ❑ Traffic counts
- ❑ Management of utility relocation

3. Concise Electronic Information with Indices

- ❑ Detailed survey information (see Survey above)
- ❑ Archived InRoads data
- ❑ Only one set of electronic information
- ❑ “Storybook” on electronic files (what’s what)
- ❑ CADD files

4. Agreements, Commitments, and Issues

- ❑ Agreements and commitments by WSDOT
- ❑ RES commitments
- ❑ Summary of environmental permit conditions/commitments
- ❑ Other permit conditions/commitments
- ❑ Internal contact list
- ❑ Construction permits
- ❑ Utility status/contact
- ❑ Identification of the work elements included in the Turnback Agreement (recommend highlighted plan sheets)

5. Construction Support

- ❑ Assign a Design Technical Advisor (Design Lead) for construction support

An expanded version of this checklist is available at: www.wsdot.wa.gov/design/projectdev

Chapter 305 Project Management

305.01 Introduction

The Washington State Department of Transportation (WSDOT) embraces project management best practices to deliver quality projects within the project scope, on schedule, and within budget. WSDOT's project management process provides an organized approach to building collaborative teams. Resources including methods, processes, tools, templates, and examples.

This chapter serves as a reference and gives a brief overview of project management resources. It outlines the project management steps. Project management includes strategies to manage:

- Teams – identify roles and responsibilities; align the teams' project goals.
- Collaboration – engage internal and external stakeholders and participants.
- Deliverables – identify what will be produced. See the WSDOT Master Deliverables List and the Deliverables Expectations Matrix.
- Tasks – plan and organize the sequence, levels of effort, and persons responsible for producing deliverables.
- Schedules – determine durations, critical dates, task linkages, and critical path(s).
- Costs – plan and control the project budget at each project stage.
- Risks – determine the threats to and opportunities for the project and plan accordingly.
- Integration and coordination of processes – for efficiency and eliminating waste.
- Change – describe the reason for, make decisions during, approving, and reporting change.
- Quality – determine the metric and target; monitor to assure, control, and verify quality.
- Communication – Constant communication amongst and between the project team, stakeholders, and external parties based on roles, responsibilities, and agreed to project goals. Inform sponsors and decision-makers.

Effective project delivery includes a strong commitment to project management best practices and principles. Another major factor in successful project delivery is building trust through communication about the project within, and external to, the design team.

Executive Orders 1032, 1038, 1053, and Policy Statement 2047 ensure a consistent process for practical design, project management, and risk management statewide.

305.02 Project Management

The project management process provides the framework for project managers and team members to deliver quality projects on time and within the scope and budget. Project management resources are consistent with a practical design approach and offer structure for organizing and aligning collaborative teams to engage stakeholders and the community.

Exhibit 305-1 shows the project management process used to deliver projects. Each of the five parts shown is briefly described in the following sections.

Exhibit 305-1 WSDOT Project Management Process

305.02(1) *Initiate (and Align)*

Teams deliver projects, hence one of the first orders of business in project management is to initiate and align the team. Our projects are successful because of the effectiveness of the team delivering them. To that end, initiating and aligning the team is an important early accomplishment. Aligning the team establishes communications and responsibilities of the project manager and team. The Initiate and Align worksheet is a tool that can be helpful in this phase.

305.02(2) *Plan the Work*

Plan the work is the portion of the project management process that produces the Project Management Plan (PMP).

The PMP defines the project performance baseline—including deliverables, schedule and budget, and management methods. As the project manager and project team plan the work, they integrate and coordinate processes in a manner that optimizes resources and reduces waste. For example, if a project requires an Access Revision Report (ARR), National Environmental Policy Act (NEPA) documentation, or a Value Engineering study (VE), the project manager and team coordinate and align these efforts. This way they make use of common information and subject matter experts.

The performance baseline documents the team goals for project performance. The performance baseline includes:

- Scope – the deliverables to be produced by the project team.
- Schedule – the logical sequence of work and related milestones.
- Budget – the amount of money programmed for the project.
- Risk – uncertainty that affects project objectives.

The PMP includes management plans for Risk, Change, Communication, Quality, Transition, and Closure. These plans align the team toward uniform goals. A complete PMP considers how the project will start, be executed, monitored, controlled, and close.

305.02(3) Executing (Working the Plan)

During execution, the team, subject matter experts, and others are coordinated with as necessary to produce deliverables. The project manager and project team ensure the integration of various project development and design processes that are optimal for completing the required work and meeting the performance objectives.

305.02(4) Monitoring and Controlling

As the project team executes the work, progress is tracked and reported to the project manager. If changes or course corrections are required, the project manager takes appropriate action in a timely manner. As the team monitors progress, they may need to take action that includes: developing and implementing recovery strategies, updating the PMP, implementing risk response strategies and updating the risk assessment. Obtain change request approvals as necessary and ensure the quality plan is being implemented. Report on the performance of the team and communicate with management, staff and team.

305.02(5) Closing (the Project)

At the end of the project, it is helpful to review lessons learned and reward and recognize the team for successes. Capturing lessons learned and recognize people occurs throughout the project; however, the closure phase provides an opportunity to finalize this and bring it to conclusion. As a project comes to an end it will either close or transition to a new phase. The project manager performs the closure or transition in an orderly and appropriate manner. This involves demobilizing and reassigning staff and transferring resources or facilities.

Address the closure and transition phase of the project management process during creation of the PMP and the work plan.

Project team planning and transitions can be aided by using the Deliverable Expectation Matrix which provides a range of project development deliverables and the general order in which they will occur (see Section 305.03(2).

A project is complete after transition and closure is accomplished, and the project manager is released from responsibility for the project.

305.03 Project Management Tools

For an overview of project management, with links to the WSDOT project management process and tools for delivering the WSDOT Capital Construction Program, see the following website: www.wsdot.wa.gov/projects/projectmgmt

305.03(1) WSDOT's Master Deliverables List (MDL)

The Master Deliverables List (MDL) is a comprehensive list of project elements down to the deliverable level. This list serves as a starting point for creating the project's Work Breakdown Structure (WBS) by adding or removing elements to match the specific project. This ensures:

- Appropriate project deliverables are included in the PMP and schedule; and
- A common vocabulary and a map of the agreed to strategy that spans project teams and specialty/support groups in the region and Headquarters (HQ).

For additional information, see the MDL:
www.wsdot.wa.gov/projects/projectmgmt/masterdeliverables.htm

305.03(2) Deliverables Expectations Matrix

The Deliverables Expectation Matrix (DEM) communicates typical expectations for project deliverables and helps establish mutual understanding of these expectations. The DEM offers "at-a-glance" information about an extensive list of deliverables developed during the entire project development process from planning to design phase closure. Coordinate with appropriate support groups and other subject matter experts for deliverable details specific to the project.

The DEM is intended to help scope, schedule, budget, and execute the work needed for each needed project deliverable along with the benefits of Quality Control, Quality Assurance, and Quality Verification. It also shows where the deliverable fit in the following project development milestones:

- Planning (corridor sketch strategies)
- Scoping Pre 30%
- Geometric design review / design approval (~ 30% design level)
- Constructability review (~60 design level)
- Pre-contract review (~90% design level)
- Contract ready final review (~100% design level)
- Contract ad and award (bid letting)
- Design Phase Close Out (transition to construction)
- Construction

For additional information, see the DEM:

www.wsdot.wa.gov/publications/fulltext/design/demintro.pdf

305.03(3) Project Management and Reporting System

The Project Management and Reporting System (PMRS) is a tool for effective and efficient management of design project schedules, resources, and costs. The following website provides tools for project planning, WBS development, scheduling, and resource and cost management:
http://wwwi.wsdot.wa.gov/planning/cpdmo/pmrs.htm

305.04 Project Risk Management

Project risk management is required for every WSDOT project. WSDOT has developed a world-renowned program for project risk management that is scalable and effective. Executive Order 1053 "Project Risk Management and Risk-Based Estimating" offers direction and general information about project risk management at WSDOT. Exhibit 305-2 summarizes project risk management requirements. Project managers may choose to use a higher level process than the required process.

Exhibit 305-2 Minimum Project Risk Management Process based on project size

Project Size ($M)	Required Process*
Less than $10M	Qualitative spreadsheet[1].
$10M to $25M	Informal workshop using the self-modeling spreadsheet[1][3]
$25M to $100M	Cost Risk Assessment (CRA) workshop[1][2]
Greater than $100M	Cost Estimate Validation Process® (CEVP®) workshop[2]

[1] In some cases, it is acceptable to combine a Value Engineering Study with a Risk-Based Estimating Workshop.

[2] Projects $25 million and over should use the self-modeling spreadsheet in the scoping phase of the risk-based estimating process, followed up by the more formal CRA or CEVP® process during the design phase.

[3] An informal workshop is composed of the project team (or key project team members); other participants may be included as the Project Manager/project team deem necessary.

* Project Managers can use a higher-level process if desired.

Proactive risk management is an integral part of project management that monitors projects to determine, document, and, account for risks and uncertainty. Knowing the risk triggers, the risk probabilities and impacts allows a project team to develop risk strategies that benefit the efficiency of a project through the design and construction stages.

For more information on risk planning and risk management, see:

www.wsdot.wa.gov/publications/fulltext/cevp/projectriskmanagement.pdf

For more information on risk assessment, see:
www.wsdot.wa.gov/projects/projectmgmt/riskassessment/

Sound project risk management begins with a defined project scope, estimated cost, and schedule commensurate with the current level of development. To that end, there are several WSDOT sources for cost estimating guidance, including:

- Strategic Analysis and Estimating: http://www.wsdot.wa.gov/Design/SAEO/
- Estimating Information
  www.wsdot.wa.gov/Projects/ProjectMgmt/RiskAssessment/Information.htm
- Cost Estimating Manual www.wsdot.wa.gov/publications/manuals/m3034.htm

Document each estimate review in the Project File, and clearly show any changes made to the estimate as a result of the review.

305.04(1) Risk Assessment Timing

Timing matters. Risk analyses must be coordinated with other project development activities, especially Value Engineering.

Optimizing the timing of the initial risk analysis maximizes the opportunity to identify and implement effective risk response actions. Subsequent updates to the risk assessment can be scheduled appropriately based on the specific needs of the project.

1. Planning / pre-scoping

An early risk assessment helps refine expectations and evaluate alternatives. It also shows the importance of risk management through the life of the project.

2. Scoping Phase

Early in preliminary engineering is a good time to consider project risks. At the conclusion of the risk assessment there are clearer expectations with regard to project cost and schedule and time to find innovative ways to respond to the risks.

3. Start of Design

A risk assessment informs the project delivery method selection. It is conducted prior to final decision on delivery method (see the Project Delivery Method Selection Guide, PDMSG). At the start of design, the project scope and preliminary costs have been established and major design decisions have been made. Some Plans, Specifications, and Estimates (PS&E) activities may have begun, and coordination with support groups and subject matter experts is underway. At this stage, the project scope, costs, and schedule should be updated. This is a time to update the risk assessment as well. There is opportunity to focus on the technical issues of the design elements.

4. Design Approval

After Design Approval, most of the important project decisions have been made and the opportunity to affect the design is limited. The risk analysis update can assess the risk profile of the project as it has evolved. The g may focus on constructability, construction sequencing, staging, traffic control, and significant design issues.

305.04(2) Risk Response and Value Engineering

An effective tool to generate risk response actions is Value Engineering (VE). See Design Manual Chapter 310 and the Project Risk Management Guide. Exhibit 305-3 illustrates the natural complementary features of Project Management and VE.

Exhibit 305-3 Project Management and Value Engineering

Alignment of Value Engineering (VE) to PMBOK®

The tools and techniques of VE align with, and can enhance, Project Management as defined in the PMBOK® Guide. Consider the following ways VE and Project Management work together:

Initiate and Plan the work	Execute and Monitor	Close
Clarify vision and refine scope *Identify/verify quality measures* *Promote innovation* *Enhance project function*	*Validate business case* *Implement value recommendations* *Coordinate with stakeholders* *Measure Quality*	*Validate benefits* *Lessons learned for quality*

305.05 References

305.05(1) Federal/State Laws and Codes

23 United States Code (USC) 106, Project approval and oversight

305.05(2) WSDOT Policies

WSDOT Design Manual

https://www.wsdot.wa.gov/Publications/Manuals/M22-01.htm

Directives, Executive Orders, Instructional Letters, Manuals, and Policy Statements

http://wwwi.wsdot.wa.gov/publications/policies/default.htm

Executive Order E 1032, Project Management

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1032.pdf

Executive Order E 1038, Enterprise Risk Management

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1038.pdf

Executive Order E 1053, Project Risk Management and Risk Based Estimating

www.wsdot.wa.gov/publications/fulltext/cevp/1053policy.pdf

Executive Order E 1090, Moving Washington Forward: Practical Solutions

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1090.pdf

Executive Order E 1096, WSDOT 2015–17: Agency Emphasis and Expectations

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1096.pdf

Executive Order E 1082, Business Practices for Moving Washington

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1082.pdf

Policy Statement P 2047.00 "Estimating Project Budget and Uncertainty"

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/2047.pdf

Project Delivery Memos

www.wsdot.wa.gov/design/projectdev/memos.htm

305.05(3) WSDOT Project Management References

Project Management Guide:
http://www.wsdot.wa.gov/Projects/ProjectMgmt/OnlineGuide/ProjectManagementOnlineGuide.htm

Project Risk Management Guide:
www.wsdot.wa.gov/projects/projectmgmt/riskassessment/default.htm

Cost Estimating Manual for Projects:

http://www.wsdot.wa.gov/publications/manuals/fulltext/M3034/EstimatingGuidelines.pdf

Project Management Glossary:

www.wsdot.wa.gov/publications/fulltext/projectmgmt/pmog/pm_glossary.pdf

Glossary for Cost Risk Estimating Management:

http://www.wsdot.wa.gov/publications/fulltext/CEVP/Glossary.pdf

A NOTE ABOUT THE FUTURE

WSDOT Project Management is consistent with Project Management Institute, PMI best practices per 6th edition of the Project Management Body Of Knowledge, PMBOK.

PMI Plans to release the 7th Edition of PMBOK in the 4th Quarter of 2020. A number of changes are anticipated in the new release. WSDOT will and review and ensure that our project management approach continues to represent best practices.

Chapter 310 Value Engineering

310.01 General

Value Engineering is one of the most effective techniques known to identify and eliminate unnecessary costs in design, testing, manufacturing, construction, operations, maintenance, data, procedures and practices.

Value engineering (VE) is a systematic review of a project by a multidisciplinary team not directly involved in the planning and development phases of the project. The VE process includes consideration of design; construction; maintenance; contractor; state, local, and federal partner agencies; other stakeholders; and the public.

Properly timing a Value Engineering analysis influences its benefits. Value analyses are typically conducted fairly early in project development to improve project value by identifying ideas that improve function, offer efficiencies, reduce cost and; refine scope. Section 310.02(3) VE Analysis Timing, of this chapter offers additional information about timing.

A VE analysis [1] may be applied as a quick-response study to address a problem or as an integral part of an overall organizational effort to stimulate innovation and improve performance characteristics.

Value Engineering is a critical part of good project management practices. Project managers are accountable for ensuring that, at a minimum, those projects near the threshold include Value Engineering activities in the project schedule. Project managers should carefully plan the timing of the VE analysis for optimum benefit. Project managers should evaluate each project individually and consider the benefits a VE analysis could provide regardless of delivery method or whether the project is above or below the threshold. In addition, local programs projects are accountable for ensuring they comply with Local Agency Guidelines requirements. In all cases, when a VE study is completed, the project manager is accountable for completing, signing, and submitting the VE Recommendations Approval Form.

310.02 Statewide VE Program

310.02(1) Annual VE Plan

The State VE Manager, located in the X division coordinates annually with the Capital Program Development & Management division and region VE Coordinators to prepare an annual VE Plan, with specific projects scheduled quarterly. The VE Plan is the basis for determining the projected VE program needs, including team members, team leaders, consultants, and training. The Statewide VE Plan is a working document that reflects coordination between Headquarters and the regions to keep it updated and projects on schedule.

[1] The terms "value management", "value engineering", and "value analysis" are used interchangeably.

310.02(2) Selecting Projects for VE Analysis

310.02(2)(a) Requirements

WSDOT projects for VE studies may be selected from any of the categories identified in the Highway Construction Program, including Preservation and Improvement projects, depending on the size and/or complexity of the project. Projects that do not require a VE study can still benefit for one. In addition to cost, other considerations include: project complexity in design or construction, engagement with stakeholders, public interest, technical challenges or limited budgets.

WSDOT may conduct VE analyses on any project the project manager deems will benefit from the exercise. In addition, WSDOT conducts VE analyses for all projects as required by the criteria set forth in Federal Highway Administration (FHWA) Value Engineering Policy Order.

1. The following projects require a value engineering analysis
    - A total estimated cost (includes project development, design, right of way, and construction costs) of $25 million or more, regardless of funding.
    - A bridge project located on or off of the federal-aid system with an estimated total project cost of $20 million or more. WSDOT policy is to conduct a VE analysis regardless of funding source.
    - A Major Project with Federal-Aid Highway Program (FAHP) funding. In some cases, regardless of the amount of FAHP funding, a project team may be required to perform more than one VE analysis for a major project.
    - Any other project the Secretary or FHWA determines to be appropriate.
2. WSDOT encourages a VE analysis on other projects where there is a potential for significant cost savings or improved project performance or quality. Projects involving complex technical issues, challenging project constraints, unique requirements, and competing community and stakeholder objectives offer opportunities for improved value by conducting VE analyses.
3. After completing the required VE analysis, if the project is split into smaller projects in final design or is programmed to be completed by the advertisement of multiple construction contracts, an additional VE analysis is not required. However, splitting a project into smaller projects or multiple construction contracts is not an accepted method to avoid the requirements to conduct a VE analysis.
4. WSDOT may require a VE analysis if a region or public authority encounters instances when the design of a project has been completed but the project does not immediately proceed to construction.
    a. If a project meeting the above criteria encounters a three-year or longer delay prior to advertisement for construction, and a substantial change to the project's scope or design is identified, WSDOT may require a new VE analysis or an update to the previous VE analysis; or
    b. If a project advances to contract procurement and scope or design changes are made that results in a required re-evaluation of the environmental document, WSDOT requires that a VE analysis be conducted.

Other projects that should be considered for value engineering have a total estimated cost exceeding $5 million and include one or more of the following:

- Significant risks
- Alternative solutions that vary the scope and cost
- New alignment or bypass sections
- Capacity improvements that widen the existing highway
- Major structures
- Interchanges
- Social justice concerns and inclusion of underserved communities
- Possible or likely presence of cultural/archaeologic resources
- Geotechnical or geographical challenges
- Extensive or expensive environmental or geotechnical requirements
- Materials that are difficult to acquire or that require special efforts to acquire, transport, or store
- Inferior materials sources
- New/Reconstruction projects
- Major traffic control requirements or multiple construction stages
- Existing or expected high pedestrian and/or bicyclist use
- Existing or expected use by other modes (trucks, rail, etc.)
- No transportation demand management elements

310.02(3) VE Analysis Timing

310.02(3)(a) When to Conduct the VE Analysis

Timing is a key to the success of the VE analysis. A VE analysis must be coordinated with other project development activities. For example, a project requiring an Access Revision Report (ARR), NEPA and a VE must consider how to best integrate the processes with development of project need statements. Conducting VE analysis’s in conjunction with these efforts ensures any revisions to the scope of the project due to the VE outcomes are considered during your environmental documentation and avoids the necessity to re-evaluate NEPA.

- When conducting VE analysis’s for design-build projects, timing of the analysis is critical. As with the design-bid-build delivery method, the VE analysis for design build projects need to occur in scoping. VE workshops conducted for design build projects enable WSDOT to be a better informed owner in the selection of the design builder by focusing the VE analysis effort on response actions to identified risks
- specific areas of interest or concern to the project manager and team
- the procurement process and in particular the request for proposal (RFP)
- maximizing value by delivering the required project function(s) most efficiently

Optimizing the timing of a VE analysis minimizes impacts of approved recommendations on previous commitments (agency, community, or environmental) and project's scope. VE analyses can also be coordinated with project risk assessments.

See www.wsdot.wa.gov/design/saeo/Benefits can be realized by performing a VE analysis at any time during project development; however, the WSDOT VE program identifies the following three windows of opportunity for performing a VE analysis.

1. Planning / pre-scoping

An early Value Engineering study can be conducted to assess early concepts and alternatives and help refine the assortment of alternatives. VE analysis in planning and pre-scoping also promotes the identification of performance attributes that can be carried forward to future more focused and in-depth VE analysis during design.

In fact this early effort could be a Value Engineering / Practical Design peer review and used as a forum for community engagement with major stakeholders. Value Engineering in Planning can also inform the project with respect possible risks that need to be examined more fully at a future Cost Risk Assessment or Cost Estimate Validation Process workshop.

Coordination timing with NEPA and Access Revision Report activities. Optimize the VE process so that it integrates naturally with these complementary processes and can utilize or inform project need statements.

2. Scoping Phase

Scoping is a good time for value analysis consideration. Along with deciding which recommendations to use from a planning study, this is a time to consider other alternatives or design solutions. At the conclusion of the VE study, the project scope, preliminary costs, and major design decisions are informed by the recommendations.

When conducting value engineering during the scoping phase of a project, the VE analysis focuses on project drivers. This stage often provides an opportunity for community engagement and building consent with stakeholders.

3. Start of Design

At the start of design, the project scope and preliminary costs have been established and major design decisions have been made. S Some Plans, Specifications, and Estimates (PS&E) activities may have begun, and coordination with support groups and subject matter experts is underway. At this stage, the project scope, costs, and schedule define the limits of the VE analysis. There is opportunity to focus on the technical issues of the design elements.

4. Design Approval

After Design Approval, most of the important project decisions have been made and the opportunity to affect the design is limited. Provided there is time to incorporate VE recommendations, the VE analysis may likely focus on constructability, construction sequencing, staging, traffic control, and significant design issues.

An additional VE analysis may be beneficial late in the development stage when the estimated cost of the project exceeds the project budget. The value engineering process can be applied to the project to lower the cost while maintaining the value and quality of the design.

310.02(4) VE Program Roles and Responsibilities

310.02(4)(a) Region VE Coordinator

- Identifies region projects for VE analyses (for the next 12 to 36 months).
- Work with HQ and the project team to optimize timing of the VE analysis.
- Present a list of identified projects to region and HQ management to prioritize into a region and HQ annual VE Plan.
- Identifies potential team facilitators and members for participation statewide.
- Provides assistance in planning and conducting the VE study.

310.02(4)(b) State VE Manager

- Reviews regional VE Plans regarding content and schedule.

310.02(4)(c) State VE Coordinator

- Incorporates the regional annual VE Plans and the Headquarters Plan to create the Statewide VE Plan.
- Prepares annual VE Report.
- Maintains policy documents for the department.
- Coordinates studies.
- Arranges training for future VE team leaders and members.
- Maintains a statewide list of qualified VE team leaders.

310.02(4)(d) VE Team Leader

The quality of the VE analysis largely depends on the skills of the VE team leader. This individual guides the team's efforts and is responsible for its actions during the analysis. The VE team leader should be knowledgeable and proficient in transportation design and construction and in the VE analysis process for transportation projects.

The VE team leader's responsibilities include the following:

- Plans, leads, and facilitates the VE study.
- Ensures proper application of a value methodology.
- Follows the Job Plan.
- Guides the team through the activities needed to complete the pre-study, the VE study, and the post-study stages of a VE study.
- Schedules a pre-workshop meeting with the project team and prepares the agenda for the VE study.
- Team leaders from within WSDOT are encouraged, but not required, to be certified by SAVE International as a Value Methodology Associate or Certified Value Specialist (CVS). Team leadership can be supplied from within the region, from another region, or from Headquarters. A statewide pool of qualified team leaders is maintained by the State VE Coordinator, who works with the Region VE Coordinator to select the team leader.

Consultants who lead VE teams are required to be a current SAVE International Certified Value Specialist.

310.02(4)(e) VE Team Members

The VE teams are usually composed of six to ten people with diverse expertise relevant to the project under study. The team members may come from regions; Headquarters; other local, state, or federal agencies; or the private sector.

Ideally VE team members should not be directly involved in the planning and development phases of the project. They are selected based on the expertise needed to address major functional areas and critical high-cost issues of the study. All team members must be committed to the time required for the study. It is desirable for team members to have attended Value Methodology Fundamentals 1 training before participating in a VE study.

310.03 VE Procedure

The WSDOT VE analysis uses the Seven-Phase Job Plan shown in Exhibit 310-1. A detailed discussion of how each phase is supposed to be conducted can be found in the document, Value Methodology Standard and Body of Knowledge, developed by SAVE International. This document can be downloaded at the SAVE website: https://cdn.ymaws.com/www.value-eng.org/resource/resmgr/standards_documents/vmstd.pdf

310.03(1) Pre-Analysis Preparation

To initiate a VE study, the project manager submits a Request for Value Engineering Study form to the Region VE Coordinator at 10 to 12 weeks before the proposed study date. The form is located on the WSDOT value engineering website:
www.wsdot.wa.gov/design/valueengineering/tools/

The Region VE Coordinator then works with the State VE Coordinator to determine the team leader and team members for the VE study. Contacts are listed on the WSDOT value engineering website: www.wsdot.wa.gov/design/valueengineering

The design team prepares a study package of project information for each of the team members. (A list of potential items is shown in Exhibit 310-2). Work with the State VE Coordinator for the best/most concise list of materials to send to the team members. If the package is provided via a network drive or FTP site, make sure the materials are well titled and sorted in a well-titled file structure. The VE team members should receive this information or a link to this information at least one week prior to the study so they have time to review the material.

The region coordinator provides assistance in locating a facility and equipment for the study (see Exhibit 310-2).

310.03(2) VE Analysis Requirements

The time required to conduct a VE analysis varies with the complexity and size of the project, but typically ranges from three to five days. The VE team leader working with the project manager will determine the best length of time for the study.

The VE analysis Final Report includes:

- executive summary;
- a short description of the VE process;
- a narrative description of project information;

- the background, history, constraints, and controlling decisions;
- a list of VE team members;
- the VE team's focus areas;
- a discussion of the team's creative and evaluation processes;
- and the team's final recommendations.

All of the team's evaluation documentation, including sketches, calculations, analyses, and rationale for recommendations, is included in the Final Report. A copy of the Final Report is to be included in the Project File. A copy of the report is also provided to FHWA for projects on the National Highway System or federal-aid system.

Post-VE analysis activities include:

- The Project Manager and Project team are responsible for:
  - Implementation of approved recommendations.
  - Documentation of reasons recommendations were not implemented.

310.03(3) Implementation Phase

As soon as possible, preferably no more than two weeks following the VE analysis, the project manager reviews and evaluates the VE team's recommendation(s). The project manager completes the VE Recommendation Approval form included in the Final Report and returns it to the Statewide VE Manager.

Recommendations not approved or modified by the project manager require a brief justification in the VE Recommendation Approval form.

The project manager sends the completed VE Recommendation Approval form to the State VE Manager following receipt of the Final Report and not later than September 1 of each year, whichever comes first, so the results can be included in WSDOT's annual VE Report to FHWA.

Exhibit 310-1 Job Plan for VE Studies

VE Study Phase	Job Plan
Pre-study	Identify projects and needs; schedule prep meeting(s); identify and invite VE workshop team members; obtain and distribute project information to VE team members; project manager reserves meeting venues; develop plan for site visit (virtual or actual)
1. Information	Gather project information, including commitments and constraints. • *Investigate technical reports and field data* • *Review project management plane and risk management plan* • *Develop team focus and objectives* • *Identify and define performance requirements*
2. Function Analysis	Analyze the project to understand the required functions. • *Define project functions using active verb/measurable nouns* • *Review and analyze functions to determine which need improvement, elimination, or creation to meet project goals*
3. Creative	Generate ideas on how to accomplish the required functions that improve project performance, enhance quality, and lower costs. • *Be creative* • *Brainstorm alternative proposals and solutions to lower project costs, improve performance, and enhance quality*
4. Evaluation	Evaluate and select feasible ideas for development. • *Analyze design alternatives, technical processes, and life cycle costs*
5. Development	Develop selected alternative ideas into recommendations. • *Develop technical and economic supporting data to prove the benefits and feasibility of the desirable concepts* • *Develop team recommendations (long-term and interim)*
6. Presentation	Present the VE recommendation to the project stakeholders. • *Present the VE recommendation to the project team and region management in an oral presentation* • *Provide a written report*
7. Implementation	The decision to implement or not implement recommendations is documented in the signed VE Recommendation Approval form. The Project Manager implements approved recommendations.

Note: Phases 1–6 are performed during the study; see *Value Standard and Body of Knowledge* for procedures during these steps.

Exhibit 310-2 VE Analysis Team Tools

Project-Related Input* and Design Resources (Study Package)
Project Management Plan
Vicinity map
Aerial photos
Large-scale aerial photographs
Pertinent maps - Land use, contours, quadrant, etc.
Speed study data
Vehicle volumes
Bicyclist volumes
Pedestrian volumes
Crash data with collision analysis
Transit data
Existing as-built plans
Design file
Cross sections and profiles
Environmental documents Environmental constraints, and commitments
Utility Locations
Cultural resources / Archeological surveys
Basis Of Estimate
Estimates
Risk Assessments
Geotechnical reports
Hydraulic Report
Plan sheets
Quantities
Right of way plans
Bridge List/Bridge condition report
Design Manual
Field Formulas and *Field Tables*
Standard Plans
Standard Specifications
State Highway Log / Roadway data
Other manuals as needed

Study-Related Facilities and Equipment
AASHTO *Green Book*
Calculators
Computer (with network if available) / projector
Easel(s) and easel paper pads
Marking pens
Pencils and erasers
Masking and clear tape
Power strip(s) and extension cords
Room with a large table and adequate space for the team
Scales, straight edges, and curves
Vehicle or vehicles with adequate seating to transport the VE team for a site visit**

*Not all information may be available. Work with your Region VE Coordinator or the State VE Coordinator to verify that all needed information is available.

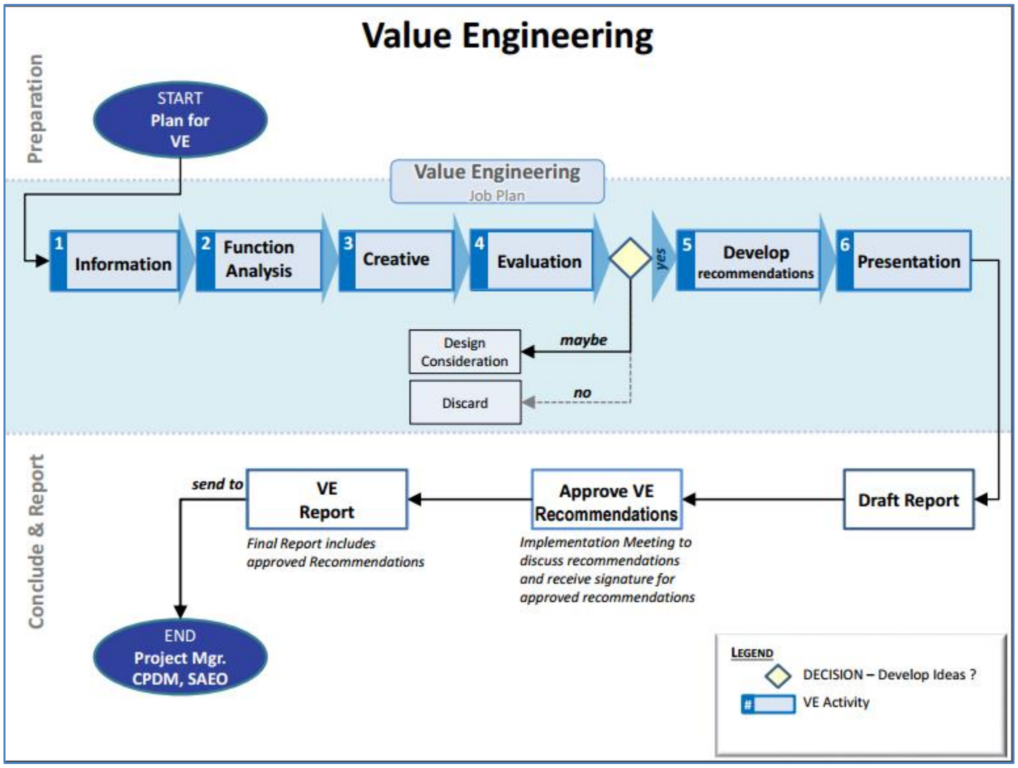
**If a site visit is not possible, perform a "virtual" tour of the project.

310.04 Value Engineering Job Plan

The VE process is comprised of a 6-step Job Plan. FHWA adds a "7th" step known as implementation. Exhibit 310-3 depicts the process for Value Engineering. An interactive version of this exhibit is available at:

http://www.wsdot.wa.gov/publications/fulltext/CEVP/VE_JobPlan.pdf

Exhibit 310-3 Value Engineering Job Plan



310.05 Project Management Accountability

Project Managers are required to make a determination for each VE recommendation. To that end, project managers, in consultation with their project teams, support staff, other management support, and subject matter experts, decide the action to be taken for each recommendation.

310.06 Documentation

Refer to Chapter 300 for design documentation requirements.

The following value engineering documentation is required to be included in:

- **Project File** – Value Engineering Final Report with the signed VE Recommendation Approval Form
- **Design Approval** – Design Documentation Package for Approval – the Value Engineering Recommendation Approval Form

310.07 References

310.07(1) Federal Laws and Codes

Title 23 U.S.C. Section 106(e) – Value Engineering Analysis

Title 23 CFR Part 627 – Value Engineering

Circular A-131, Office of Management and Budget (OMB)

FHWA Value Engineering Policy
https://www.fhwa.dot.gov/legsregs/directives/orders/13111b.cfm

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

310.07(2) Guidance and Resources

WSDOT Value Engineering website:

www.wsdot.wa.gov/design/valueengineering/

SAVE International

https://www.value-eng.org/default.aspx

Miles Value Foundation

https://www.valuefoundation.org/

Value Standard and Body of Knowledge, SAVE International:

http://www.value-eng.org/

Chapter 320 Traffic Analysis

320.01 General

This chapter is intended to address policy-related issues associated with WSDOT multimodal traffic analysis. It is not intended to address the specifics of demand forecasting; mesoscopic, analytical/deterministic, stochastic microsimulation; or safety performance analyses. For those items, see the latest versions of the *Highway Capacity Manual*, *Traffic Analysis Procedures Manual* (TAPM), and *Highway Safety Manual* (HSM).

Traffic analysis is intended to produce information for decision makers; it is not intended as a stand-alone tool for making decisions. Consideration of empirical data, similar traffic situations, studies, local knowledge, and seasoned traffic engineering and planning experience can also add to a pool of traffic information that is provided to decision makers.

Traffic analysis is either "operational" or "planning" in nature. Operational analysis is associated with engineering concepts focusing on near-term or existing/opening year, while planning analyses are generally focused on a horizon year or interim phase years. Planning-level analyses are also used to determine impacts for environmental documentation phases of Environmental Assessment (EA) or Environmental Impact Statement (EIS) work. Much caution should be used when operational tools are used with planning-level future year projection data.

Be aware that operational models were not primarily intended for use with planning-level future year projected volumes, but there is a need to understand the difference between proposed future scenarios. Therefore, operational models need to use data from forecasting models, but analysts need to do so with an understanding of the imperfections.

Forecasting demand volumes 20 years into the future can be difficult to do well, so there should be little expectation that intersection turning movement projection-related traffic analyses by themselves will be sufficient to produce actionable designs. Consequently, some future year Measures of Effectiveness (MOEs) such as turn lane queue length should not be considered accurate, but they may be useful when comparing various scenarios if the reported differences are substantial.

With the aforementioned limitations, project-specific traffic volumes, forecasts, and system capacities are used to establish the extent of improvements needed for facilities to operate acceptably from year of opening or through interim phases and, eventually, through to the horizon year; for example:

- Number of general purpose/HOV/HOT lanes
- Length and number of ramp or auxiliary lanes
- Intersection or interchange spacing
- Channelization
- Signal timing
- Right of way needs
- Roundabout design parameters
- Width of sidewalks
- Extent of bike lanes
- Ferry holding lanes

Traffic analysis should examine multimodal access, mobility, and safety objectives; project benefits and costs; development impacts; and mitigation needs.

Not all projects will require the same level of effort. The specific depth and complexity of a traffic analysis will depend on a variety of factors, including:

- Project proponents (federal, tribal, state, local, and private sector)
- Legal requirements (laws, regulations, procedures, and contractual obligations)
- Lead agency
- Purpose or scope of the traffic analysis
- Data availability
- Time of day (am/pm peak hour or other)
- Funding
- ROW availability

For projects that fall under FHWA approval, coordinate with the Headquarters (HQ) Traffic Office for concurrence on traffic analysis details. Other projects can be coordinated through region Traffic offices. (See Chapter 300 for FHWA oversight and approval policy.)

320.02 Design Year and Forecasting Considerations

Project evaluation requirements can be (1) focused on near-term functionality, (2) contain interim phases, and/or (3) require a long-term focus. The project proponent can be the state (WSDOT or other state agencies) or developers (other public agencies or private concerns).

For Access Revision Reports (AARs), the design year and multimodal travel demand forecasting methodologies are to be documented by the project stakeholders in the Methods and Assumptions (M&A) Documents.

Guidance on the horizon year and interim design year(s) for projects is given in Chapter 1103, Design Controls. When selecting horizon year and interim design year phases, stakeholders need to consider the regional significance of a proposed project, how it functions within the existing system, and the expected lifespan. The traffic analysis for developer-related projects will typically focus on existing conditions and the build-out year of the proposed project. Some larger developer projects will need to be evaluated in multiple phases, as they have the potential to significantly impact the transportation system and will thus require a longer-term focus. Mitigation measures may also be phased with these projects.

Project teams are encouraged to consider the strategic importance, economic potential, network constraints, and investment scale when determining the analysis methodologies for project phasing, design year, and forecasts. With acceptance/concurrence by the Traffic Office of purview,[1] the following are possible approaches to be used individually or in concert to develop future year demand volumes:

- Travel demand models
- Trend line projections
- Cumulative impacts
- Limitations of the surrounding network

320.03 Traffic Analysis Software

Select the least complex and data-intensive traffic analysis software available to address the questions raised by the project. The Region Traffic Engineer, in consultation with HQ Traffic Office, approves the software selection and version based on performance criteria provided in the WSDOT Traffic Manual. Document the software selection in the Methods and Assumptions document, or similar project document.

For deterministic analysis, consider Sidra, Rodel, Synchro, and HCS as the primary analytical tools. For system wide multimodal forecasting, EMME3, TransCad, and Visum are the primary tools. For choosing between project-level scenarios involving multimodal traffic, and/or where various transportation system elements interact, Vissim or Dynameq are the primary tools. These tools may have version limitations due to WSDOT purchased rights and contract limitations. For details about these and other traffic analysis software used by WSDOT, see the Traffic Analysis Procedures Manual or contact the region or HQ Traffic Offices.

320.04 Travel Demand Forecasting

Designers, planners, and analysts need to be aware of the practical limitations of the selected method of multimodal traffic demand forecasting and should consider the impact of demand uncertainty when conducting analyses and drawing conclusions from those analyses. Special attention should be given to any post-processing efforts. For guidance in the selection of analysis methodology, refer to the *Traffic Analysis Procedures Manual*. Following are brief descriptions of the four main methods for demand forecasting.

320.04(1) Travel Demand Models

For the vast majority of projects, this will be the proper approach for developing future year demand volumes. However, caution should be taken when using this approach to draw conclusions from operational model Measures of Effectiveness (MOEs) that are based on such forecasts, because specific and accurate turning movement volumes are needed to produce credible MOEs. Forecast models are most commonly used to produce general volumes that

[1] See Chapter 300 and the Federal-Aid Highway Program Stewardship and Oversight Agreement: Generally, region for non-Highways of Statewide Significance (HSS) or non-National Highway System (NHS), and Headquarters for HSS and NHS.

can help traffic planners evaluate and compare the relative merits of potential solutions against each other.

320.04(2) Trend Line Projections

Where travel demand models are not established or are otherwise considered inadequate, trend data can be used but must be constrained by system flow limitations. Trend line growth cannot account for peak spreading when traffic demand exceeds system supply. Use with caution and consult the HQ Transportation Data & GIS Office (TDGO) for further details about this method and any inherent limitations.

320.04(3) Cumulative Impacts

This method is typically used to forecast volumes in areas that demonstrate uniform growth and exhibit only minor changes and marginal impacts to the region. It is also useful for analyzing growth in suburban areas that are experiencing rapid development, as other methods may not be as reliable. The basic concept is to add volumes for developments to the trending background traffic growth. The comprehensive plan for such areas should be consistent with the expected growth predicted by a project (and include other anticipated projects) in order to result in a reasonable estimate of cumulative impacts. Use with caution due to an inability to fully account for secondary impacts like future environmental issues, local network connectivity, public services, and multimodal demands.

320.04(4) Limitations of the Surrounding Network

For projects that contain infrastructure of particular importance, extraordinary expense, life span expectancy beyond 20 years, or where travel demand will likely always exceed transportation system capacity constraints, give consideration to the concept of facility capacity balancing within the context of the larger transportation system.

This approach needs to demonstrate that the maximum amount of upstream traffic flowing into a project, as well as all project-area traffic flowing into downstream sections, can be handled acceptably. This does not require traditional travel demand forecasting, which has a limitation of about 20 years. Instead, it requires a sensitivity approach where maximum up- and downstream flows are used to right-size the project area's proposed improvements. The simplest example is the SR 520 Floating Bridge: constraints on either end of the bridge limit the usefulness of adding more lanes on the bridge.

TIAs and ARRs (see Chapter 550) shall clearly describe the methodology and process used to develop forecasts in support of a proposed project's analysis. For example, include only those projects that:

- Are on the six-year Transportation Improvement Plan.
- Are fully funded.
- Have entered the environmental review process.

320.05 Traffic Impact Analysis (TIA)

TIA is a term used for all analyses that are not structured ARRs (see Chapter 550) or planning-level efforts like corridor studies. The quality and level of service[2] for state-owned and state-

[2] WSDOT sets level of service (LOS) standards for state highways and ferry routes of statewide significance (HSS) based on RCW 47.06.140(2). Regional transportation planning organizations (RTPOs) and WSDOT jointly develop

interest facilities shall be based upon MOEs that support the project purpose and need. They shall also be developed and presented in accordance with the latest versions of the *Highway Capacity Manual* (HCM), FHWA Traffic Analysis Toolbox, *Traffic Analysis Procedures Manual*, and WSDOT Vissim Protocol.

For some example MOEs, see the FHWA MOE List, which describes measures typically used for analyzing state and local agency facilities such as freeway segments, signalized intersections, ramp terminals/junctions, sidewalks, and transit services.

Depending on the facility and when HCM Level of Service MOE is used, WSDOT thresholds are "C" for rural and "D" for urban non-NHS facilities, unless a WSDOT region specifies otherwise for specific route segments. (See each WSDOT region for details.) Refer to the WSDOT State Highway Log for a determination of existing route segment definitions for urban or rural status.

Depending on the project type and purpose, multimodal MOEs may be employed.

320.05(1) Updating an Existing TIA

TIAs require either updating or a sensitivity analysis if they become more than 3 years old; however, a TIA will require updating sooner in rapidly developing areas. TIAs can avoid such update efforts in slowly developing areas. To determine if an update is required, an assessment of critical infrastructure functionality must be documented.

If the amount or character of traffic in the study area is significantly different from an earlier analysis, an update will be required. The definition of significant is 10% (volume, flow rate, travel time, delay, density, or other key MOEs) where existing operations are currently acceptable. If they are not currently acceptable, the threshold is reduced to 5%. In cases where greater than 10% change or failed MOEs have been found, consultation and concurrence with WSDOT Traffic Office of purview is required to avoid a full ARRs or TIA update.

Developer-initiated TIAs are typically valid for 5 or 6 years, as that is the window provided under the Growth Management Act for concurrency. The Development Services Office should be consulted regarding the need for updates to TIAs for developer, tribal, and local agency projects.

320.06 TIA Scope

To establish the appropriate scope, consultation between the lead agency, WSDOT, and those preparing the TIA is encouraged before beginning work. TIA-required elements can be found in the *Traffic Analysis Procedures Manual* (an abbreviated list is provided below). ***Note:*** For developer-initiated TIAs, the local agency may prescribe the scope of the TIA per the local agency's adopted standards.

320.06(1) TIA Boundaries

The traffic impacts of local streets and roads can impact intersections on state highway facilities. In these cases, include in the TIA an analysis of adjacent local facilities (driveways, intersections, main lines, and interchanges) upstream and downstream of the intersection with the state highway. A "lesser analysis" may include obtaining traffic counts, preparing signal warrants, or a focused TIA. For developer projects, the boundaries of the analysis (such as the city limits) may

and RTPOs establish LOS standards for regionally significant state highways and ferry routes (non-HSS) based on RCW 47.80.030(1)(c).

be determined in consultation with local agencies and WSDOT. For further guidance, consult the *Traffic Analysis Procedures Manual* and *Development Services Manual*.

320.06(2) Traffic Analysis Scenarios

WSDOT must understand the effects of plan updates and amendments, as well as the effects of specific project elements (including site plans, conditional use permits, subdivisions, and rezoning) that have the potential to impact state facilities. Consultation between the lead agency, WSDOT, and those preparing the TIA is essential early in the process to help determine appropriate scenario analyses and goals. For further guidance, consult the *Traffic Analysis Procedures Manual* and *Development Services Manual*.

Depending on the type of work being analyzed, required TIA scenarios can range from simple “existing conditions with and without project,” to more complex analyses where TIA scenarios could include: existing; opening year with and without project; interim years with and without project; and design year with and without project. If developed with WSDOT, and if following ARR guidance, pre-ARR work such as Area Study TIAs can be used in future ARRs.

The appropriate and necessary scenarios shall be agreed upon by the TIA study team and documented in the TIA Methods and Assumptions (M&A) Document.

For existing networks, calibrate models to existing conditions.

If a near-term baseline network is required, only funding-secured projects should be added to the existing network. This is typical of opening year models that are a few years beyond existing year.

For interim scenario networks, include only projects or developments within the forecasting process that have the highest probability within the 10-year horizon. For example, include projects that are fully funded or have a construction phase in the six-year Transportation Improvement Plan.

For scenarios with phases beyond 10 years, TIA or ARR teams should discuss and document the merits of including other potential projects. For example:

- Projects on current long-range regional transportation plans (or the locally-adopted transportation plan, if the TIA is not on a regionally-significant facility)
- Projects on the HSP or MTP

All other potential influences with lower probability should not be allowed to affect travel or trip demand forecast results—with one exception: TIAs and ARRs may include multiple scenarios for the design year. For example, if a major assumption for unfunded additional lanes “feeding traffic into” or “allowing traffic from” the project is desired for the design year to allow for a better understanding of expensive infrastructure sizing (such as ultimate bridge widths), ensure a constrained design year scenario is included so that proper funding-based phasing solutions are communicated.

320.07 TIA Methods and Assumptions Document

The TIA M&A is similar to an ARR M&A in that it documents the “who, what, where, when, how, and why” items associated with the traffic analysis portion of a project.

Prior to any substantial fieldwork or traffic/facility data collection, consultation between the lead agency, WSDOT, and those preparing the TIA is encouraged to help reach and document consensus on study data needs and assumptions. These and other items should be documented and the M&A signed by all lead staff that conduct work in association with the TIA M&A document. For further guidance, consult the *Traffic Analysis Procedures Manual* and *Development Services Manual*.

320.08 TIA Methodologies

The FHWA Traffic Analysis Toolbox, Volume 2, provides a methodology for selecting traffic analysis tools. However, in general, traffic analysis methodologies for those facility types indicated below are used by WSDOT and will be accepted if agreed upon by those who sign TIA or ARR M&A Documents.

- **Freeway Segments:** *Highway Capacity Manual*/Software (HCM/S); operational and design analysis; macroscopic, mesoscopic, and microsimulation
- **Weaving Areas:** *Design Manual* (DM); HCM/S; operational and design analysis; microsimulation
- **Ramps and Ramp Terminals:** HCM/S; operational and design analysis; DM; microsimulation
- **Multilane Highways:** HCM/S; operational and design analysis; macroscopic, mesoscopic, and microsimulation
- **Two-Lane Highways:** HCM/S; operational and design analysis
- **Intersection, Signalized:** Sidra; Synchro; SimTraffic; HCM/S; Vissim,
- **Intersection, Roundabout:** Sidra; Rodel; HCM; Vissim
- **Corridors:** Sidra; Synchro; SimTraffic; HCM; Vissim
- **Stop-Controlled Intersections:** HCM/S for capacity; DM Chapter 1330 and the MUTCD for signal warrants (if a signal is being considered)
- **Transit:** HCM/S; operational and design analysis; *Traffic Manual*
- **Pedestrians:** HCM/S
- **Bicycles:** HCM/S
- **WSDOT Criteria/Warrants:** MUTCD (signals, stop signs); *Traffic Manual* (school crossings); DM Chapter 1040 (freeway lighting, conventional highway lighting)
- **Channelization:** DM

The procedures in the *Highway Capacity Manual* do not explicitly address operations of closely spaced signalized intersections, nor does WSDOT currently endorse microsimulation or roundabout guidance as noted in the HCM/S. 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 results of analyses that follow the procedures in the HCM.

Other analysis methods may be accepted; however, consultation between the lead agency, region or HQ Traffic, and those preparing the TIA is encouraged to reach consensus on the data necessary for the analysis if meso- or microsimulation is employed. When a state highway has saturated flows, the use of a meso- or microsimulation models can provide additional understanding. Note, however, that the simulation model must be calibrated and validated for reliable results and is intended for near-term operational analyses (see the *Traffic Analysis Procedures Manual* for guidance on calibration and validation).

Operational MOEs for simulation models based on long-term forecasts should be used primarily to determine which scenarios are better than others. The models can only do so if the resultant MOEs demonstrate significant differentiation between scenarios. TIA or ARR teams will determine what is considered significant and will document those findings in the study. However, at a minimum, significant must be greater than the expected error band of the models used. For example, if Vissim is considered to be calibrated to a given MOE within 15% of existing conditions (a very wide band), the scenarios need to show greater than 15% differentiation between each other to be significant.

320.09 TIA Mitigation Measures

Consultation between the lead agency, WSDOT, and the responsible parties preparing the TIA is recommended in order to reach consensus on the project mitigation measures. Mitigation measures, if applicable, need to be included in the TIA to determine whether 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 the State Environmental Policy Act (SEPA) and National Environmental Policy Act (NEPA). The lead agency is responsible for administering the SEPA and/or NEPA review process. WSDOT is responsible for reviewing the TIA for impacts that pertain to state highway facilities. However, the authority vested in the lead agency under SEPA/NEPA does not take precedence over other authorities in law.

Development work in the state highway right of way requires a WSDOT permit or agreement. Normally, this work is coordinated by the region Development Services Office.

Mitigation measures may take the following forms:

- Channelization such as turn lanes or raised islands
- Installation of a roundabout or, if necessary, a traffic signal (signal warrant analysis per MUTCD is required)
- Frontage improvements
- Donation of right of way
- Addressing any design or operational deficiencies created by the proposal
- Possible restrictions of turning movements
- Sight distance enhancements
- Traffic mitigation payment (pro rata share contribution) to a programmed WSDOT project (see Chapter 4 of the *Development Services Manual*)
- Satisfaction of local agency guidelines and interlocal agreements

320.10 TIA Report

320.10(1) TIA Minimum Contents

The minimum contents of a TIA report are listed in the *Traffic Analysis Procedures Manual* and *Development Services Manual*. Listed below is a summary; however, the depth and detail of content under each element varies in relation to the scale and complexity of the project.

(a) Executive Summary

(b) Table of Contents

1. List of Exhibits (Maps)
2. List of Tables

(c) Introduction

1. Description of the proposed project with purpose and need.
2. Traffic Impact Analysis Methods and Assumptions summary.
3. Map of project location.
4. Site plan, including all access to state highways (site plan, map).
5. Circulation network, including all access to state highways (vicinity map).
6. Land use and zoning.
7. Phasing plan, including proposed dates of project (phase) completion.
8. Project sponsor and contact person(s).
9. References to other traffic impact studies.
10. Other mitigation measures considered

(d) Traffic Analysis

1. TIA M&A (see the *Traffic Analysis Procedures Manual* for a template or the *Development Services Manual*).
2. Existing and projected conditions of the site: posted speed; traffic counts (to include turning movements); sight distance; channelization; design analyses; pedestrian and bicycle facilities; design vehicle; and traffic controls, including signal phasing and multi-signal progression where appropriate (exhibit(s)).
3. DHV and ADT; project trip generation and distribution map, including references and a detailed description of the process involved in forecasting the projected trips, including tables.
4. Project-related transportation mode split, with a detailed description of the process involved in determining transportation mode split.
5. Project-generated trip distribution and assignment with a detailed description of the process involved in distributing and assigning the generated traffic, including exhibit(s).
6. If intersection control additions are employed and traffic signals are assumed, include functionality and warrant analyses. With roundabouts or signals, include existing

conditions, cumulative conditions, and full-build of plan conditions with and without project.

7. Safety performance analysis (see Chapter 321 and the *Traffic Analysis Procedures Manual*).

(e) Conclusions and Recommendations

1. Quantified or qualified LOS, QOS, and other appropriate MOEs of impacted facilities with and without mitigation measures.
2. Predicted safety performance with and without mitigation measures.
3. Mitigation phasing plan with dates of proposed mitigation measures.
4. Defined responsibilities for implementing mitigation measures.
5. Cost estimates for mitigation measures and financing plan.

(f) Appendices

1. Description of traffic data and how data was collected and manipulated.
2. Description of methodologies and assumptions used in analyses.
3. Worksheets used in analyses; for example, signal warrants, LOS, QOS, and traffic count information.
4. If microsimulation is used, provide a copy of the Confidence and Calibration Report.

320.11 References

320.11(1) Federal/State Laws and Codes

42 United States Code 4321, National Environmental Policy Act (NEPA) of 1969

Revised Code of Washington (RCW) 43.21C, State environmental policy (Chapter 197-11 WAC and Chapter 468-12 WAC)

RCW 36.70a, Growth Management Act

RCW 36.70A.070, Comprehensive plans – Mandatory elements

RCW 47.06.140, Transportation facilities and services of statewide significance – Level of service standards

Washington Administrative Code (WAC) 365-196-430, Transportation elements of comprehensive plans

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC “Manual on uniform traffic control devices for streets and highways” (MUTCD)

320.11(2) Design Guidance

Design Manual, Chapter 321, for sustainable safety

Design Manual, Chapter 550, for Access Revision Report guidelines

Design Manual, Chapter 1300, for selecting intersection control type

Design Manual, Chapter 1310, for intersection guidelines

Design Manual, Chapter 1320, for roundabout guidelines

Federal-Aid Highway Program Stewardship and Oversight Agreement:
https://www.fhwa.dot.gov/federalaid/stewardship/agreements/wa.pdf

Highway Capacity Manual (HCM), latest edition, Transportation Research Board, National Research Council

Level of Service Standards for Washington State Highways

Roadside Design Guide and *A Policy on Geometric Design of Highways and Streets,* latest editions, American Association of State Highway and Transportation Officials (AASHTO)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Traffic Analysis Procedures Manual (TAPM)

WSDOT Traffic Analysis web page:
http://www.wsdot.wa.gov/design/traffic/analysis/

320.11(3) Supporting Information

Development Services Manual, M 3007.00, WSDOT

FHWA Traffic Analysis Toolbox:
http://www.ops.fhwa.dot.gov/trafficanalysistools/index.htm

Traffic Manual, M 51-02, WSDOT

“Trip Generation,” Institute of Transportation Engineers (ITE)

WSDOT’s Highway Segment Analysis Program

WSDOT’s Planning Level Cost Estimation (PLCE) Tool

Chapter 540 Managed Access Control

540.01 General

Access management is the systematic regulation of the location, spacing, design, and operation of driveway, city street, and county road connections to state highways. This chapter describes the access management process for granting permission to connect to managed access highways within cities and unincorporated areas. For an overview of access control, references to related state laws and codes, and definitions of terminology for this chapter, see Chapter 520, Access Control.

In Washington State, managed access highways include all state highways that are not limited access highways. State highways that are planned for or established as limited access, are treated as managed access highways until the limited access rights are acquired.

The Access Control Tracking System Limited Access and Managed Access Master Plan (Access Master Plan) identifies not only the limits of limited access control, but also managed access control segments. The current managed access classification is based on access connection densities, distance between access connections, spacing of intersections, and context (see Washington Administrative Code (WAC) 468-52-040). The existing access classification is periodically updated by Headquarters (HQ) with region input to reflect changes on a corridor segment. Conditions may have changed since the Access Master Plan was envisioned or the last managed access classification update. On non-freeways it is important to consider the current classification and any classifications previously planned, and determine the access design control most appropriate for the agreed context (see Chapters 1102 and 1103 for context and design control guidance, respectively). The Access Master Plan database is available at:
www.wsdot.wa.gov/design/accessandhearings

Access to managed access highways is regulated by the governmental entity with jurisdiction over a 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 city streets that are part of state highways, as specified in Revised Code of Washington (RCW) 47.24.020. When any project is developed on a state highway outside an incorporated city or town, state law requires that existing access connections be evaluated to determine whether they are consistent with all current department spacing, location, and design standards (see 540.03).

540.02 Design Considerations

Evaluate access connections by using the Access Master Plan database to identify the route classification and determine access connection requirements in conformance with this chapter or Chapter 530 as appropriate. See also Chapter 1100, Practical Design, and chapters in that series for guidance on how access control is used as a design control.

Review all connections and verify whether they are in the Roadway Access Management Permit System (RAMPS) database. Contact the region Development Services Office or the HQ Access and Hearings Section for permission to log on to the link through this page:
www.wsdot.wa.gov/design/accessandhearings

If a nonconforming connection is identified, consider relocating, modifying, or eliminating the connection. It is not the intent of the managed access program that modifications to the connection will change the general functionality of the property.

Where current department standards cannot be met while providing the same general functionality, classify the connection as nonconforming and process the appropriate documentation as discussed below. This documentation is part of the permit process.

540.03 Managed Access Highway Classes

The principal objective of the managed access classification system is to maintain the safety and capacity of existing highways. This is accomplished by establishing access management criteria, which are to be adhered to in the planning and regional approval of access connections to the state highway system.

The classification system for state managed access highways consists 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 Class 1 or Class 2, with only the most urban and lowest-speed state highways within an incorporated town or city designated as Class 5. Exhibit 540-1 shows the five classes of highways, with a brief description of each class. WSDOT keeps a record of the assigned managed access classifications, by state route and milepost, in the Access Control Tracking System database:
www.wsdot.wa.gov/design/accessandhearings

One of the goals of state law is to restrict or keep access connections to a minimum in order to help preserve the safety, operation, and functional integrity of the state highway. On Class 1 highways, mobility is the primary function, while on Class 5 highways, access needs have priority over mobility needs. Class 2 highways also favor mobility, while Class 3 and Class 4 highways generally achieve a balance between mobility and access.

The most notable distinction between the five highway classes is the minimum spacing requirements of access connections. Exhibit 540-1 shows the minimum distances between access points on the same side of the highway. Exhibit 540-2 applies to the minimum clearance from a public road or street.

In all five highway classes, 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 are proposed in state, regional, metropolitan, or local transportation plans. In these cases, if reasonable access is available to the local road/street system, access is to be provided to the local road/street system rather than directly to the state highway. Following are the functional characteristics and the legal requirements for each class.

540.03(1) Class 1

540.03(1)(a) Functional Characteristics

Class 1 highways provide for high-speed and/or high-volume traffic movements for interstate, interregional, and intercity (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 intersections.

540.03(1)(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. Intersecting streets, roads, and highways are planned with a minimum spacing of 1 mile. Spacing of ½ mile may be allowed, but only when no reasonable alternative access exists.
2. Private access connections to the state highway are not allowed except where the property has no other reasonable access to the local road/street system. When a private access connection must be provided, the following conditions apply:
    - The access connection continues until such time other reasonable access to a highway with a less restrictive access control class or access to the local road/street system becomes available and is allowed.
    - The minimum distance to another (public or private) access point is 1,320 feet 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. Where special conditions apply, justify the exception in 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 revised locations.
3. Restrictive medians are provided on multilane facilities to separate opposing traffic movements and to prevent unauthorized turning movements.

540.03(2) Class 2

540.03(2)(a) Functional Characteristics

Class 2 highways provide for low-to-high travel speeds depending on context, 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 movements.

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.

540.03(2)(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. Intersecting streets, roads, and highways are planned with a minimum spacing of ½ mile. Intersection spacing of less than ½-mile 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 a change to intersection control is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate traffic progression. The addition of all new public or private access points that might require signalization or other form of intersection control 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 where the property has no other reasonable access to the local road/street system or where access to the local 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 other reasonable access to a highway with a less restrictive access control class or acceptable access to the local road/street system becomes available and is allowed.
   - The minimum distance to another (public or private) access point is 660 feet 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. This applies unless the highway frontage exceeds 1,320 feet 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 or 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 RCW 18.43.

- All private access connections are for right turns only on multilane facilities. This applies 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 RCW 18.43 and only if left-turn channelization is provided.

- Additional access connections to the state highway are not allowed for newly created parcels that result 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 where special conditions exist and main line volumes are below 20,000 average daily traffic (ADT).

540.03(3) Class 3

540.03(3)(a) Functional Characteristics

Class 3 highways provide for moderate travel speeds depending on context, 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 buildout 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 by meeting minimum distances between (public and private) access points. Two way left-turn lanes may be used where justified and main line traffic volumes are below 25,000 ADT. Development of properties with internal road/street networks and joint access connections is encouraged.

540.03(3)(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, intersecting streets, roads, and highways are planned with a minimum spacing of ½ mile. Intersection spacing of less than ½-mile 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 a change to intersection control is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate traffic progression. Where feasible, major intersecting roadways that might ultimately require signalization or other intersection control type are planned with a minimum of ½-mile spacing. The addition of all new public or private access points that may require signalization or other intersection control type, 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. This applies 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 330 feet 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.

540.03(4) Class 4

540.03(4)(a) Functional Characteristics

Class 4 highways provide for low to intermediate travel speeds depending on context, 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 than on Class 3 highway 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.

540.03(4)(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, intersecting streets, roads, and highways are planned with a minimum spacing of ½ mile. Intersection spacing of less than ½ mile 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 a change in intersection control is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate traffic progression. Where feasible, major intersecting roadways that might ultimately require intersection control changes are planned with a minimum of ½-mile spacing. The addition of all new public or private access points that may require signalization, or other intersection control type, 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. This applies 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 250 feet 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 access connection permit application that is signed and sealed by a qualified professional engineer who is registered in accordance with RCW 18.43.

540.03(5) Class 5

540.03(5)(a) Functional Characteristics

Class 5 highways provide for low 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 generally may be higher than the need for through-traffic mobility without compromising the public's health, welfare, or safety. These highways will normally have nonrestrictive medians.

540.03(5)(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, intersecting streets, roads, and highways are planned with a minimum spacing of ¼ mile. Spacing of less than ¼ mile may be allowed where no reasonable alternative exists. In urban areas and developing areas where higher volumes are present or growth that will require changes to intersection control is expected in the foreseeable future, it is imperative that the location of any public access point be planned carefully to ensure adequate traffic progression. Where feasible, major intersecting roadways that might ultimately require changes to intersection control are planned with a minimum of ¼ mile spacing. The addition of all new public or private access points that might require signalization, or other control type, 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. This applies 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 125 feet 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.

Exhibit 540-1 Managed Access Highway Class Description

Class	Non-Conforming[1]	Variance[2]	Conforming[3]	Access Point Spacing**	Limitations[4]
Class 1 Mobility is the primary function	Yes*	No	No	1,320 ft	• One access only to contiguous parcels under same ownership • Private access connection is not allowed unless no other reasonable access exists (must use local road/ street system if possible)
Class 2 Mobility is favored over access	Yes*	Yes*	No	660 ft	• One access connection only to contiguous parcels under same ownership unless frontage > 1,320 ft • Private access connection not allowed unless no other reasonable access exists; must use local road/street system if possible
Class 3 Balance between mobility and access in areas with less than maximum buildout	Yes	Yes	Yes	330 ft	• One access connection only to contiguous parcels under same ownership • Joint access connection for subdivisions preferred; private connection allowed, with justification
Class 4 Balance between mobility and access in areas with less than maximum buildout	Yes	Yes	Yes	250 ft	One access connection only to contiguous parcels under same ownership, except with justification
Class 5 Access needs may have priority over mobility	Yes	Yes	Yes	125 ft	More than one access connection per ownership, with justification

*The access connection continues only until such time other reasonable access to a highway with a less restrictive class or acceptable access to the local road/street system becomes available and is allowed.

**Minimum, on the same side of the highway.

[1] See 540.07(2).

[2] See 540.07(3).

[3] See 540.07(1).

[4] Unless grandfathered (see 540.06).

540.03(6) Changes in Managed Access Classification

WSDOT, RTPOs, MPOs, or other entities such as cities, towns, or counties may initiate a review of managed access classifications per the process identified by WAC 468-52. In all cases, WSDOT consults with the RTPOs, MPOs, and local agencies and takes into consideration comments received during the review process. For city streets that are designated as state highways, the department will obtain concurrence in the final classification assignment from the city or town.

The modified highway classification list shall be submitted to Headquarters for approval by the Director & State Design Engineer, Development Division, or a designee. WSDOT regions shall notify the RTPOs, MPOs, and local governmental entities in writing of the final determination of the reclassification.

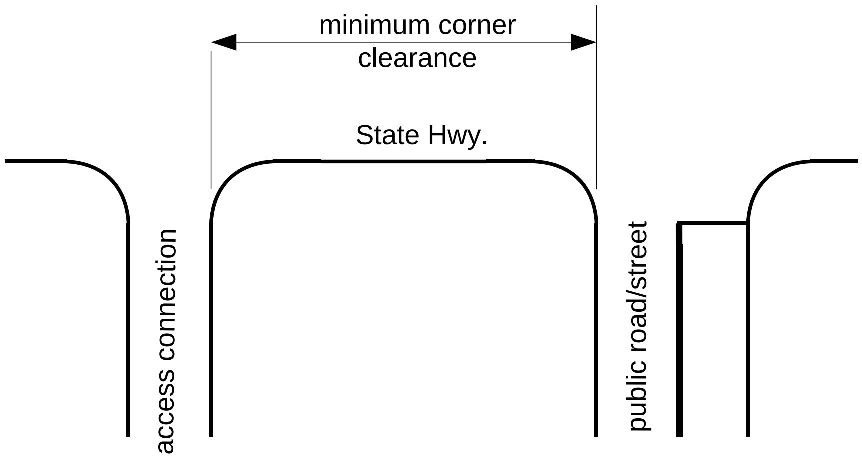
540.04 Corner Clearance Criteria

In addition to the five access control classes, there are also corner clearance criteria that must be used for access connections near intersections (see Exhibit 540-2).

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:

- The minimum corner clearance criteria in Exhibit 540-2 may be used where access point spacing cannot be obtained due to property size and where a joint-use access connection cannot be secured or where it is determined by WSDOT not to be feasible because of conflicting land use or conflicting traffic volumes or operational characteristics.
- Some local agencies have adopted corner clearance as a design element in their design standards; these standards are to meet or exceed WSDOT standards. Coordinate with the local agency regarding corner clearance of an access connection on or near an intersecting local road or street.
- When a joint-use access connection or an alternate road/street system access—meeting or exceeding the minimum corner clearance requirements—becomes available, the permit holder must close the permitted access connection unless the permit holder shows to WSDOT's satisfaction that such closure is not feasible.

Exhibit 540-2 Minimum Corner Clearance: Distance From Access Connection to Public Road or Street



With Restrictive Median		
Position	**Access Allowed**	**Minimum (ft)**
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 (ft)**
Approaching Intersection	Full Access**	230*
Approaching Intersection	Right In Only	100
Departing Intersection	Full Access**	230*
Departing Intersection	Right Out Only	100

*125 ft may be used for Class 5 facilities with a posted speed of 35 mph or less.
**Full Access = All four movements (Right in/Right out; Left in/Left out)

540.05 Access Connection Categories

Whenever an access connection permit is issued on a managed access state highway, the permit must also specify one of four access connection categories: Category I to Category IV. Categories I through III are based on the maximum vehicular usage of the access connection. Category IV specifies 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 WSDOT to be in one of the following categories (WAC 468-51-040):

540.05(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. This category also applies to permanent access connections to agricultural and forestlands, 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 average weekday vehicle trip ends (AWDVTE) of 100 or less.

540.05(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 1,500 or less, but not included in Category I.

540.05(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 1,500.

540.05(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, forestland 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.

540.06 Access Connection Permit

RCW 47.50 requires all access connections to be permitted. This can be accomplished by the permitting process (see 540.07) or by the connection being "grandfathered" (in place prior to July 1, 1990).

All new access connections to state highways, as well as alterations and improvements to existing access connections, require an access connection permit. Every owner of property that abuts a managed access state highway has the right to reasonable access, but not a particular means of access. This right may be restricted with respect to the highway if reasonable access can be provided by way of another local road/street.

When a new private road or street is to be constructed, approval by the permitting authority is required for intersection design, spacing, and construction work on the right of way. However, if 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 local road or street by the local governmental entity.

It is the responsibility of the applicant or permit holder to obtain all necessary local, state, and federal approvals and permits (which includes all environmental permits and documentation).

The access connection permit only allows the applicant permission to connect to the state highway. It is also the responsibility of the applicant to acquire any and all property rights necessary to provide continuity from the applicant's property to the state highway.

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 approved access connection permit is obtained.

If a property owner or permit holder with 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.

540.07 Permitting and Design Documentation

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.

The Access Manager in each region keeps a record of all access points, including those that are permitted and those that are grandfathered (see 540.08). A permit for a grandfathered access point is not required but may be issued for recordkeeping reasons.

540.07(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.

540.07(2) Nonconforming Access Connection Permit

Nonconforming access connection permits may be issued:

- For short-term access connections pending the availability of a future joint-use access connection or local 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 local road/street system.

In such instances, the permit is to be noted as being a nonconforming access connection permit and may contain the following specific restrictions and provisions:

- 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.

540.07(3) Variance Access Connection Permit

Variance access connection is a special nonconforming or additional access connection permit issued for long-term use where future local 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.
- 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 may contain the following specific restrictions and provisions:

- 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 540.08(1)).

A variance access connection permit must not be issued for an access connection that does not conform to minimum corner clearance requirements (see 540.04).

540.07(4) Corner Clearance Design Analysis

540.07(4)(a) Outside Incorporated City Limits

A design analysis request will be required for nonconforming access connections if corner clearance criteria are not met. The ASDE should be involved early in the process. Such an access will be outside the corner radius and as close as feasible to the property line farthest away from the intersection.

An exception to the above may be allowed for a single-family residence, serving a single residence, not meeting the minimum corner clearance criteria and having no feasible connection to the local cross street. One single family home generates a very low volume of traffic and will pose a low conflict potential for traffic on the State Highway System. A single-family access connection exception is to comply with the following criteria:

- Serves a single residence
- Access is to be outside the corner radius
- Access is to be located as close as feasible to the property line farthest away from the intersection
- The denial of an access connection would leave the property without a reasonable means of access.
- The connection is to be relocated to a local road/street system, if one becomes available.

Document the above criteria in the access connection permit.

540.07(4)(b) Within Incorporated Cities

In accordance with RCW 35.78.030 and RCW 47.50, incorporated cities and towns have jurisdiction over access permitting on streets designated as state highways and, therefore, no design analysis by WSDOT will be required. On WSDOT projects, document decisions made on these accesses in the DDP.

540.08 Other Considerations

540.08(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 whether 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 collision data. Such data will be provided to the property owner and/or permit holder and tenant upon written request (WAC 468-51-110).

540.08(2) Existing Access Connections

540.08(2)(a) Closure of Grandfathered Access Connections

Any access connections that were in existence and in active use on July 1, 1990, are grandfathered.

The grandfathered 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 collision 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).

540.08(2)(b) Department Construction Projects

540.08(2)(b)(1) Notification

The department must notify affected property owners, permit holders, business owners, and emergency services in writing, when appropriate, whenever the department's work program requires the modification, relocation, or replacement of its access connections. In addition to written notification, the department will facilitate, when appropriate, a process that may include, but is not limited to, public notices, meetings, or hearings, as well as individual meetings.

540.08(2)(b)(2) Modification 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 about which category of access connection (see 540.05) and which design template (see Chapter 1340) will be reasonable. If it is a commercial parcel, determine whether the business can function with one access connection. Each parcel, or contiguous parcels under the same ownership being used for the same purpose, is allowed only 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 (see 540.07(4)(a)).

540.08(2)(b)(3) Costs: Replacement of/Modifications to Existing Access Connections

The costs of modifying or replacing the access points are borne by the department if the department construction project caused the replacement or modification. Modification of the connection may require a change to the existing permit.

540.08(3) Work by Permit Holder's Contractor

The department requires that work 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.

540.09 Preconstruction Conference

All new access connections, including alterations and improvements to existing access connections to the highway, require an access connection permit. The permitting authority may require a preconstruction conference prior to any work being performed on the access. The preconstruction conference must be attended by those necessary to ensure compliance with the terms and provisions of the permit. Details regarding 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).

540.10 Adjudicative Proceedings

Any person who can challenge any of the following departmental 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 grandfathered access connection pursuant to WAC 468-51-130

An appeal of a decision by the department can be requested only 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.

540.10(1) Adjudicative Proceedings Process

Following 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 summary is 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 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 requests, within thirty (30) days, an adjudicative proceeding.
5. The region reviews its initial denial decision and determines whether 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 HQ Development Services & Access Manager for review and processing.
7. The HQ Development Services & Access Manager reviews the permit application and sends the permit documentation and appeal request to the Office of the Attorney General (AG).
8. If the initial findings of the AG agree with the region's denial decision, the AG's Office sends the applicant a written letter, with the AG's signature, informing the applicant that a hearing will be scheduled for the applicant to appeal in person the department's decision to deny access.
9. The region reserves a location and obtains a court reporter, and Headquarters obtains an Administrative Law Judge (ALJ) to conduct the proceeding. The AG, by written letter, notifies the applicant of the time and place for the hearing. The AG's Office 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-day (90-day) review period.
10. The AG's Office leads the department's presentation and works with the region regarding who will testify and what displays and other information will be presented to the ALJ. The HQ Development Services & Access Manager will typically not attend these proceedings.
11. After hearing all the facts, the ALJ issues a decision, usually within a few 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 HQ Development Services & Access Manager, decides to appeal the ALJ's decision to the Director & State Design Engineer, Development Division. This second appeal must occur within twenty (20) days of the ALJ's written decision.
13. If appealed to the Director & State Design Engineer, Development Division, the Director & 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 Director & 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 Director & 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 noted 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

Development Services Engineer for further guidance and direction if an appeal might be forthcoming.

540.11 Documentation

Refer to Chapter 300 for design documentation requirements.

540.12 References

540.12(1) State Laws and Codes

Chapter 520, Access Control, provides reference to laws and codes

540.12(2) Design Guidance

Chapter 520, Access Control

Chapters in the 1100 series for guidance on practical design, context, and design controls

Chapter 1230, Geometric Cross Section

Chapters 1300 and 1310, for intersection design policy and guidance

Chapter 1340, Driveways

Chapter 1600, Roadside Safety

Chapter 710 Site Data for Structures

710.01 General

The Washington State Department of Transportation (WSDOT) Headquarters (HQ) Bridge and Structures Office provides preliminary site data reviews to determine the applicability of, and requirements surrounding, proprietary structural solutions, or the need for specific structural design strategies, as well as structural design services to the regions. This chapter describes the information required by the HQ Bridge and Structures Office to perform these functions.

710.02 Required Data for All Structures

Structure site data provides information about the type of crossing, topography, type of structure, and potential future construction. Submit structure site data to the HQ Bridge and Structures Office for all structures meeting the Chapter 720 definition of a bridge with a structural clear span equal to 30 feet or greater measured along the overcrossing alignment. This includes all buried structures such as concrete three-sided structures, concrete box culverts and split box culverts, and steel and aluminum structural plate, pipes, arches, and boxes.

Structures conforming to the National Bridge Inspection Standards (NBIS) definition of a bridge, as cited in Chapter 720, having structural clear spans less than 30-feet as a general rule do not require preparation of a preliminary plan at the onset of design, and hence do not require structure site data to be submitted to HQ Bridge and Structures Office. See 720.03(14) when the delivery method involves a contractor supplied design. However, unique site specific conditions known at the completion of the Preliminary Hydraulics Report may indicate the need for preparation of a preliminary plan in the design process, and thus require development of structural site data. Contact HQ Bridge and Structures Office after the completion of the Preliminary Hydraulics Report for collaboration.

Site data shall also provide information on nonstandard retaining walls needing project-specific design by the HQ Bridge and Structures Office.

Submit the structure site data to the HQ Bridge and Structures Office, Project Support unit, by email. In the email message, provide a general description of the project and provide a bullet list itemization of the structure site data forms, files, and data attached or linked in the email. Submit the structure site data as a CAD file with associated supplemental drawings and a report. (See Exhibit 710-1 for items to include in a structure site data submittal). Direct any questions relating to the preparation of structure site data to the HQ Bridge and Structures Office, Project Support unit. The *Bridge Design Manual* shows examples of required WSDOT forms.

710.02(1) Scour

At any location where a structure can be in contact with water (such as culvert outfall, lake, river, or floodplain), there is a risk of scour. This risk is to be analyzed as part of the Hydraulic Report. Contact the HQ Geotechnical Office and the HQ Hydraulics Office to determine whether a scour analysis is required.

710.02(2) CAD Files and Supplemental Drawings

710.02(2)(a) Plan

- Vertical and horizontal datum control (see Chapters 400 and 410).
- Contours of the existing ground surface (index and intermediate). Use intervals of 2 feet. Show contours beneath an existing or proposed structure and beneath the water surface of any waterway. Do not partially delete contour lines that cover index contour text.
- Alignment of the proposed highway and multimodal 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 state highway intersections 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. Provide the Inroads report for each alignment. Include coordinates for all control points.

710.02(2)(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. Provide the Inroads report for each alignment along with the CAD detail.
- Superelevation transition diagram for each alignment as applicable.

710.02(2)(c) Section

- Channelization roadway sections on the structure and at structure 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.

710.02(3) 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

710.02(4) Video and Photographs

Submit a 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.

710.03 Additional Data for Waterway Crossings (Bridges and Buried Structures)

Coordinate with the HQ Hydraulics Section and supplement the structure 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 structure site (type, plan limits, and cross section) as determined by the HQ Hydraulics Section.
- Show a profile of the waterway. The extent will be determined by the HQ Hydraulics Section.
- Show cross sections of the waterway including new streambed design, defining the bankfull width and the bank shelf widths and slopes. The extent will be determined by the HQ Hydraulics Section. The requirements for waterway profile and cross sections may be less stringent if the HQ Hydraulics Section has sufficient documentation (FEMA reports, for example) to make a determination. Contact the HQ Hydraulics Section to verify the extent of the information needed. Coordinate any rechannelization of the waterway with the HQ Hydraulics Section.
- Many waterway crossings require a permit from the U.S. Coast Guard (see *Bridge Design Manual* Chapter 2.2.4 and the *Environmental Manual*). 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 and the material above normal high water.

For all waterway crossings, where the structural clear span parallel to the centerline of roadway width is less than 30 feet, the Region's designer shall contact the US Coast Guard for determination of waterway jurisdiction and any associated permit requirements. For all waterway crossings, where the structural clear span parallel to the centerline of roadway width is 30 feet or greater, the Bridge and Structures Office US Coast Guard Liaison will contact the US Coast Guard for determination of waterway jurisdiction and any associated permit requirements.

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 an exemption to navigation permit requirements. The HQ Bridge and Structures Office is responsible for coordination with the U.S. Coast Guard for waterways that require a navigation permit.

710.04 Additional Data for Grade Separations

710.04(1) Highway-Railroad Separation

Supplement structure site data for structures involving railroads with the following:

710.04(1)(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 curve control points.

710.04(1)(b) Profile

- For proposed railroad tracks: profile, vertical curve, and superelevation data for each track.
- For existing railroad tracks: elevations accurate to 0.1 foot taken at 10-foot intervals along the top of the highest rail of each track. Provide elevations to 50 feet beyond the extreme outside limits of the existing or proposed structure. Tabulate elevations in a format acceptable to the HQ Bridge and Structures Office.

710.04(2) Highway-Highway Separation

Supplement structure site data for structures involving other highways by the following:

710.04(2)(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.

710.04(2)(b) Profile

- For proposed highways: profile, vertical curve, and superelevation data for each.
- For existing highways: elevations accurate to 0.1 foot taken at 10-foot intervals along the centerline or crown line and each edge of shoulder, for each alignment, to define the existing roadway cross slopes. Provide elevations to 50 feet beyond the extreme

outside limits of the existing or proposed structure. Tabulate elevations in a format acceptable to the HQ Bridge and Structures Office.

710.04(2)(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 lateral clearances.

710.05 Additional Data for Widenings

Bridge rehabilitations and modifications that require new substructure are defined as bridge widenings.

710.05(1) Bridge Widenings

Submit DOT Form 235-002A, Supplemental Bridge Site Data-Rehabilitation/ Modification. Supplement structure site data for structures involving bridge widenings by the following:

710.05(1)(a) Plan

- Stations for existing back of pavement seats, expansion joints, and pier centerlines based on field measurements 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.
- Description of existing barriers, railings, expansion joints, and bridge attachments, in accordance with Form 235-002A.

710.05(1)(b) Profile

- Elevations accurate to 0.1 foot taken at 10-foot intervals 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 (10-foot minimum 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 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-foot 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.

710.06 Site Data for Design-Build Conceptual Drawings

Structure site data content and submittal requirements for development of structure conceptual drawings associated with Design-Build projects are similar but simplified to those associated with Design-Bid-Build projects. The simplified content requirements are outlined in Exhibit 710-2. The submittal of elements identified in Exhibit 710-2 as conceptual plan structure site data components shall conform to and be as described in Sections 710.02 through 710.05

710.07 Structure Preliminary Plan and Structure Conceptual Drawing Process Responsibilities

The sequential process and responsibilities for development of a structure preliminary plan in a project under the design-bid-build delivery method is described in Section 2.2 of the WSDOT Bridge Design Manual LRFD M 23-50. The assignment of plan preparation, review, and approval is summarized below:

Lead Unit Developing Structure Preliminary Plan	**Responsibility for Approval**
HQ Bridge and Structures Office or Consultant under agreement with the Bridge and Structures Office	HQ Bridge and Structures Office and Region Approval
Consultant under agreement with Region	HQ Bridge and Structures Office Review Only Region Approval

The sequential process and responsibilities for development of a structure conceptual drawing in a project under the design-build delivery method is described in Section 15.2.1.A (as supported by Chapter 2) of the WSDOT Bridge Design Manual LRFD M 23-50. The assignment of drawing preparation and approval is summarized below:

Lead Unit Developing Structure Conceptual Drawing in conjunction with developing RFP Chapter 2.13	**Responsibility for Approval**
HQ Bridge and Structures Office or Consultant under agreement with the Bridge and Structures Office	HQ Bridge and Structures Office Review Only Region Approval
Consultant under agreement with Region	HQ Bridge and Structures Office Review Only Region Approval

710.08 Documentation

Refer to Chapter 300 for design documentation requirements.

710.09 References

Bridge Design Manual, M 23-50, WSDOT

Electronic Engineering Data Standards, M 3028

Environmental Manual, M31-11

Hydraulics Manual, M 23-03

Exhibit 710-1 Structure Site Data Checklist

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
_____ Bicycle and Pedestrian Facility and widths
_____ 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 file or 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
_____ InRoads reports

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
_____ Bankfull width
_____ Bank shelf width

Supplemental Bridge Site Data: Rehabilitation/ Modification

BRIDGE, CROSSROAD, AND APPROACH ROADWAY CROSS SECTIONS (may be in CAD file or on separate drawings)

_____ Bridge Roadway Width
_____ Lane and Shoulder Widths
_____ Profile Grade and Pivot Point
_____ Superelevation Rate
_____ Survey Line
_____ Pedestrian facility width
_____ Bicycle facility width
_____ 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

Exhibit 710-2 Conceptual Plan Structure Site Data Checklist

PLAN (in CAD file)

_____ Survey Lines and Station Ticks
_____ Survey Line Bearings
_____ Roadway and Median Widths
_____ Lane and Shoulder Widths
_____Bicycle and Pedestrian Facility and widths
_____ Bridge Deck Sidewalk Width
_____ Profile Grade and Pivot Point
_____ Roadway Superelevation Rate (if constant)
_____ Traffic Arrows
_____ Existing utilities Type, Size, and Location
_____ Contours
_____ Stream Flow Arrow
_____ R/W Lines and/or Easement Lines
_____ Exist. Bridge No. (to be removed, widened)
_____ Section, Township, Range
_____ County, City or Town
_____ North Arrow
_____ SR Number
_____ Scale

TABLES (in tabular format in CAD file)

_____ Curb Line Elevations at Top of Existing Br. Deck
_____ Undercrossing Roadway Existing Elevations
_____ Undercrossing Railroad Existing Elevations
_____ Curve Data

OTHER SITE DATA (may be in CAD file or on supplemental sheets or drawings)

_____ Superelevation Diagrams
_____ Profile Grade Vertical Curves
_____ Railroad Agreement Status
_____ Highway Classification
_____ Design Speed
_____ADT, DHV, and % Trucks
_____ In Roads reports

FORMS (information noted on the form or attached on supplemental sheets or drawings)

Bridge Site Data General

_____ Pedestrian Barrier/Pedestrian Rail Height
_____ Datum
_____ Control Section
_____ Project Number
_____ Region Name
_____ Project Name

Bridge Site Data for Stream Crossings

_____ Water Surface Elevations and Flow Data
_____ Bankfull Width
_____ Bank shelf width

BRIDGE, CROSSROAD, & APPROACH ROADWAY CROSS SECTIONS (may be in CAD file or on Separate drawings)

_____ Bridge Roadway Width
_____ Lane and Shoulder Widths
_____Bicycle facility width
_____Pedestrian facility width
_____ Profile Grade and Pivot Point
_____ Superelevation Rate
_____ Survey Line
_____ PB/Pedestrian Rail Dimensions

Chapter 720 Bridges

720.01 General

The National Bridge Inspection Standards (NBIS), published in the Code of Federal Regulations (23 CFR 650, Subpart C), defines a bridge as:

> *A structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening.*

The term "bridge" as used in this chapter applies to all structures conforming to the above definition. This includes all buried structures with a structural clear span greater than 20 feet measured along the overcrossing alignment, such as concrete three-sided structures, concrete box culverts and split box culverts, and steel and aluminum structural plate, pipes, arches, and boxes.

Bridge design is the responsibility of the Washington State Department of Transportation (WSDOT) Headquarters (HQ) Bridge and Structures Office, which 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, constructability issues, and other considerations are addressed during plan development. Contact the HQ Bridge and Structures Office early in the planning stage regarding issues that might affect the planned project (see Chapter 700).

720.02 Bridge Locations

Bridge locations are chosen to conform to the alignment of the highway. Conditions that can simplify design efforts, minimize construction activities, and reduce structure costs are:

- A perpendicular crossing.
- The minimum required horizontal and vertical clearances.
- A constant bridge width (without tapered sections).
- A tangential approach alignment of sufficient length not to require superelevation on the bridge.
- A crest vertical curve profile that will facilitate drainage.
- An adequate construction staging area.

720.03 Bridge Site Design Elements

720.03(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 "restricted" for overweight permit vehicles.

720.03(1)(a) New Structures

All new structures that carry vehicular loads are designed to HL-93 notional live load in accordance with AASHTO's LRFD Bridge Design Specifications.

720.03(1)(b) Existing Structures

When the structural capacity of a bridge will be affected by the project, the Region requests a Structural Capacity Report from the Risk Reduction Engineer in the HQ Bridge and Structures Office. Permanent redistribution of traffic, introduction of median barrier, and widening or deck rehabilitation are among the triggers for evaluation of a bridge's structural capacity. The report will state:

- The structural capacity status of the structures within the project limits.
- What action, if any, is appropriate.

The Region requests the Bridge and Structures Asset Manager to provide status about whether a bridge is included in the 6-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.

The criteria used by the Bridge and Structures office to evaluate the structural capacity of a bridge are as follows:

1. On National Highway System (NHS) routes (including Interstate routes):
    - The 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.

Include the Structural Capacity Report in the Project File (see Chapter 300).

720.03(2) Bridge Widths

The Design Manual contains multiple chapters that provide geometric cross section criteria and procedures relevant to determining design element widths. See Chapter 1230 for a guide to chapters that provide geometric cross section element widths.

While it is preferred not to alter the continuity of a roadway, there may be situations where providing a structure width more or less than the roadway approaching the structure is appropriate.

All structures on city or county routes crossing over a state highway must conform to the Local Agency Guidelines.

For structures involving railroads, contact the HQ Design Office Railroad Liaison.

720.03(3) Horizontal Clearance

Horizontal clearance for structures is the distance from the edge of the traveled way to bridge piers and abutments, traffic barrier ends, or bridge end embankment slopes. Minimum distances for this clearance vary depending on the type of structure. (See Chapters 1239, 1600, and 1610 and the *Bridge Design Manual* for guidance on horizontal clearance.)

For structures involving railroads, contact the HQ Design Office Railroad Liaison.

720.03(4) Bridge Medians

Designs for bridges on divided multilane highways often include the decision to join parallel bridges as one or build them as independent structures. There are several factors in this decision, such as in new corridor construction, phased construction of corridors, and the general median width of the divided highway. This section covers some common design considerations related to bridge medians.

Advances in crash barriers and their applications have resulted in an expanded set of choices for bridge medians on divided highways.

Modern barrier designs and applications have allowed for longer runs of traffic barrier, different barrier types, and bullnose guardrail designs for shielding the gap between parallel structures. These tools have reduced collisions with abrupt bridge ends as well as shielded the opening between bridges.

Some highway corridors are initially planned as multilane divided highways but may be developed in logical, affordable phases and individual projects. This could result in an initial phase where a corridor may open as a two-lane rural highway used by both travel directions. A later phase could convert the facility to a divided highway, bringing with it the need for median separation. Consider the long-range plans when determining median widths for bridges. The photos in Exhibit 720-1 show a completed multilane highway where two separate bridges were ultimately constructed years apart and a new corridor underway where one bridge is now built.

Joining two structures may not be the most cost-effective or sustainable solution for all projects. Coordinate with the Bridge and Structures Office and the local Maintenance Office when discussing options and concerns. For bridges on parallel horizontal and vertical alignments, practical considerations for joining two structures as one include, but are not limited to:

- Phased development where one structure exists and another is planned.
- Old and new structure types and compatibility (with phased corridor construction).
- Median width.
- Median barrier treatment options.
- Environmental contexts and regulations.
- Seismic conditions and load ratings.
- Bridge maintenance and inspection techniques: accessibility options and equipment for terrain in specific contexts. An open area between structures may be needed for bridge inspection.
- Skew angles and/or curvature of waterways or roadways beneath the structures.
- Economics.
- Historical/aesthetic value of existing bridges to remain in place.

If structures will not be joined, evaluate the median as described here:

When there is a median gap between bridges of 6 inches or more, the Region PEO will evaluate whether or not the median gap needs to be screened. Address the potential for pedestrians on the bridge and if closing the median gap to less than 6 inches, or installing fencing, netting, or other elements to enclose the area between the bridges would be beneficial. Document this evaluation in the Basis of Design and Alternatives Comparison Table.

Exhibit 720-1 Phased Development of Multilane Divided Highways

720.03(5) Vertical Clearance

Vertical clearance is the critical height under a structure that will 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.

In addition to the following vertical clearance guidance, consider whether the corridor experiences overheight loads. Consider a vertical clearance such that it will not create a new "low point" in the corridor.

720.03(5)(a) Vertical Falsework Clearance for Bridges Over Highways

Construction of new bridges and the reconstruction or widening of existing structures often requires the erection of falsework across the traveled way of a highway. The erection of this falsework can reduce the vertical clearance for vehicles to pass under the work area. The potential for collisions to occur by hitting this lower construction stage falsework is increased.

1. On all routes that require a 16.5-foot vertical clearance, maintain this same clearance for falsework vertical clearance.
   - On structures that currently have less than a 16.5-foot vertical clearance for the falsework envelope, maintain existing clearance.
   - On new structures, maintain the falsework vertical clearance at least to those of the minimum vertical clearances referenced below.
2. Any variance from the above must be approved by the Regional Administrator or designee in writing and made a part of the Project File.

720.03(5)(b) Minimum Clearance for New Structures

For new structures, the minimum vertical clearances are as follows:

720.03(5)(b)(1) Bridge Over a Roadway

The minimum vertical clearance for a bridge over a roadway is 16.5 feet.

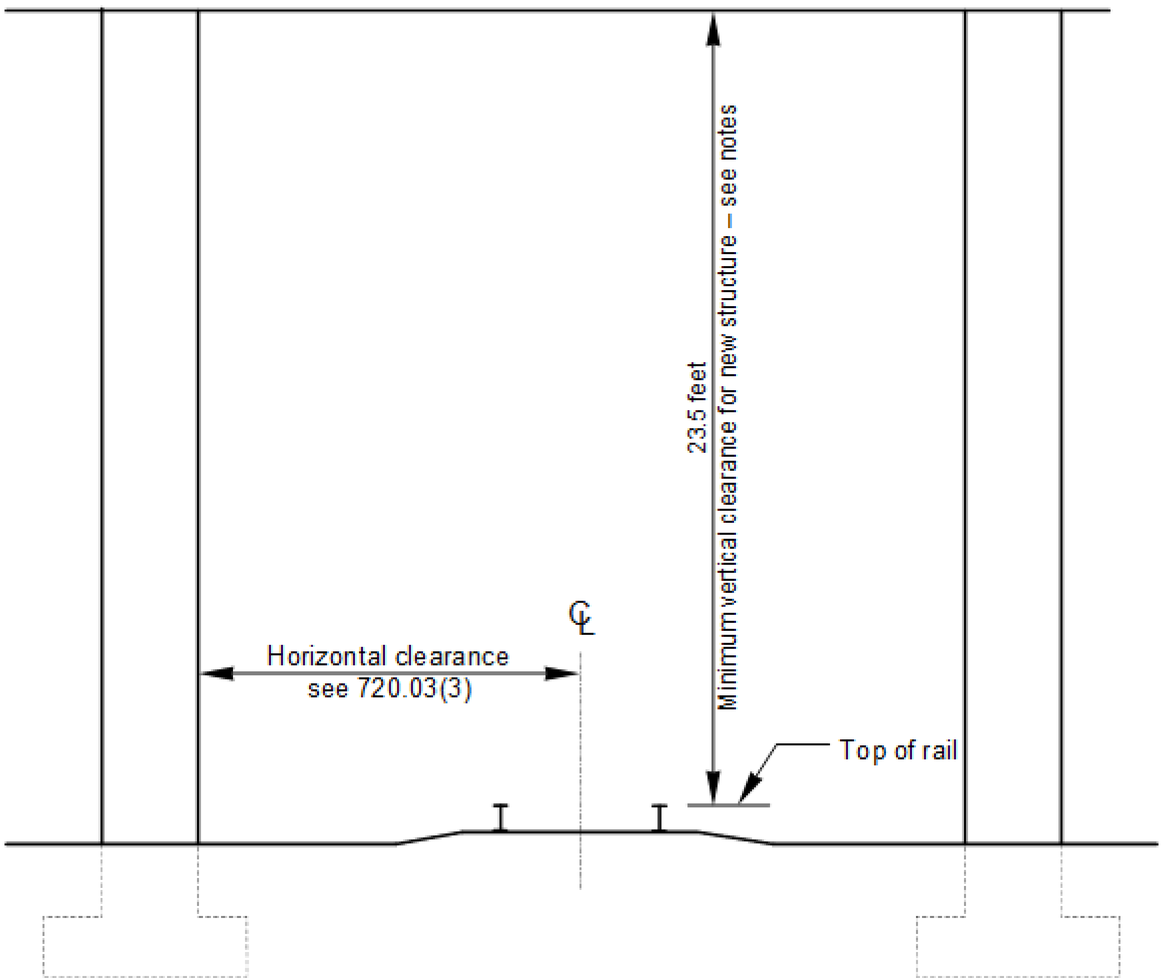
720.03(5)(b)(2) Bridge Over a Railroad Track

The minimum vertical clearance for a bridge over a railroad track is 23.5 feet (see Exhibit 720-2). A lesser clearance may be negotiated with the railroad company based on certain operational characteristics of the rail line; however, any clearance less than 22.5 feet requires the approval of the Washington State Utilities and Transportation Commission (WUTC) per WAC 480-60. Vertical clearance is provided for the width of the railroad clearance envelope. Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

720.03(5)(b)(3) Pedestrian Bridge Over a Roadway

The minimum vertical clearance for a pedestrian bridge over a roadway is 17.5 feet.

Exhibit 720-2 Highway Structure Over Railroad



Notes:

- Use 22.5-foot vertical clearance for existing structures.
- Lesser vertical clearance may be negotiated (see 720.03(5)).
- Increase horizontal clearance when the track is curved.
- Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

720.03(5)(b)(4) Water Crossing Structures

When determining the vertical clearance beneath a bridge or inside a buried structure, there are two elements that must be considered. The first is 100 Year Design Freeboard (Freeboard), and the second is Maintenance Clearance.

Freeboard is related to the hydraulic capacity of the structure, and is required by state and federal guidance. Typically, all bridges and buried structures are required to have a minimum of 1-3 feet of Freeboard above the 100 year water surface elevation (see WSDOT Hydraulics Manual). The State Hydraulics Engineer determines the Freeboard, and it is documented in the Preliminary/Final Hydraulic Design Report (P/FHD). Approval from the State Hydraulics Engineer is required for any vertical clearance that is less than Freeboard.

Maintenance Clearance is the distance from the Thalweg (or line of the lowest streambed elevation within the watercourse) to the bottom spanning member. Providing Maintenance Clearance beyond the minimum Freeboard is beneficial for required monitoring and inspections, as well as any maintenance activities that may be required during the life of the structure. Generally, these activities include staff walking through the culvert, taking measurements and photographs, but could also involve the use of machinery within the structure limits.

For each water crossing location, evaluate and document the type of activities that will be conducted in collaboration with Region Maintenance, Bridge Preservation, ESO/Stream Restoration Biologists, and other key stakeholders. Additionally, site specific considerations must be evaluated in order to determine the appropriate Maintenance Clearance. See Design Instructions - Vertical Clearance Considerations for additional information and considerations when determining the preferred vertical clearance.

In general, when no large objects are placed beneath the structure, use 6 feet from the Thalweg to the bottom spanning member as the initial Maintenance Clearance target. However, it is desirable to provide as much vertical clearance as feasible.

Large objects, including boulders and large woody debris, under or inside water crossing structures are not allowed unless approved by the State Hydraulics Engineer. When large objects are approved to be placed beneath the structure, use 10 feet as the minimum Maintenance Clearance. However, it is desirable to provide as much vertical clearance as feasible.

The ARA for Development approves vertical clearance where greater than or equal to the Freeboard.

720.03(5)(c) Minimum Clearance for Existing Structures

The criteria used to evaluate the vertical clearance for existing structures depend on the work being done on or under that structure. When evaluating an existing structure on the Interstate System, see 720.03(5)(e), 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 Exhibit 720-3 for bridge vertical clearances.)

720.03(5)(c)(1) Bridge Over a Roadway

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 feet on the Interstate System or other freeways or 15.5 feet on nonfreeway routes. An approved design analysis is required for clearance less than 16.0 feet on Interstate routes or other freeways and 15.5 feet on nonfreeway routes.

For a planned resurfacing of the highway under an existing bridge, if the clearance will be less than 16.0 feet on the Interstate System or other freeways and 15.5 feet on nonfreeway routes, evaluate the following options and include in a design analysis request:

- Pavement removal and replacement
- Roadway excavation and reconstruction to lower the roadway profile
- 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 Materials Engineer (RME). Solutions that include milling the existing surface followed by overlay or inlay must be approved by the RME to ensure adequate pavement structure is provided.

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 feet. For these projects, document the clearance in the Design Documentation Package. For an existing bridge with less than a 14.5-foot vertical clearance, an approved design analysis request is required.

720.03(5)(c)(2) Bridge Over a Railroad Track

For an existing structure over a railroad track (see Exhibit 720-2), the vertical clearance can be as little as 22.5 feet. A lesser clearance can be used with the agreement of the railroad company and the approval of the Washington State Utilities and Transportation Commission. Coordinate railroad clearance issues with the HQ Design Office Railroad Liaison.

Exhibit 720-3 Bridge Vertical Clearances

Project Type	Vertical Clearance [8]	Documentation Requirement (see notes)
Interstate and Other Freeways [1]		
New Bridge	> 16.5 ft	[2]
Widening Over or Under Existing Bridge	> 16 ft	[2]
	< 16 ft	[4]
Resurfacing Under Existing Bridge (See Section 1120.03(5) Vertical clearance)	> 16 ft	[2]
	< 16 ft	[4]
Other With No Change to Vertical Clearance	> 14.5 ft	[3]
	< 14.5 ft	[4]
Nonfreeway Routes		
New Bridge	> 16.5 ft	[2]
Widening Over or Under Existing Bridge	> 15.5 ft	[2]
	< 15.5 ft	[4]
Resurfacing Under Existing Bridge (See Section 1120.03(5) Vertical clearance)	> 15.5 ft	[2]
	< 15.5 ft	[4]
Other With No Change to Vertical Clearance	> 14.5 ft	[3]
	< 14.5 ft	[4]
Bridge Over Railroad Tracks [7]		
New Bridge (as measured from top of rail)	> 23.5 ft < 23.5 ft	[2] [4][5]
Existing Bridge (as measured from top of rail)	> 22.5 ft < 22.5 ft	[2] [4][5]
Pedestrian Bridge Over Roadway		
New Bridge	> 17.5 ft	[2]
Existing Bridge	17.5 ft	[6]

Project Type	Vertical Clearance [8]	Documentation Requirement (see notes)
Water Crossing Structures		
Water Crossings without boulders and LWD	≥ 6 ft [10]	[3][9]
Water Crossings with boulders and LWD	≥ 10 ft [10]	[3][9]

Notes:

[1] Applies to all bridge vertical clearances over highways and under highways at interchanges.

[2] No documentation required.

[3] Document to Design Documentation Package.

[4] Approved design analysis required.

[5] Requires written agreement between railroad company and WSDOT and approval via petition from the WUTC.

[6] Maintain 17.5-ft clearance.

[7] Coordinate railroad clearance with the HQ Design Office Railroad Liaison.

[8] See 720.03(5).

[9] Approved by the ARA for Development.

[10] See Section 720.03(5)(b)(4) for information on how determine the vertical clearance.

720.03(5)(d) Signing

Low-clearance warning signs are necessary when the vertical clearance of an existing bridge is less than 15 feet 3 inches. Refer to the *Manual on Uniform Traffic Control Devices* and the *Traffic Manual* for other requirements for low-clearance signing.

720.03(5)(e) 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 the Federal Highway Administration (FHWA), if either of the following changes is proposed to these bridges:

- A project would create a new deficiency of less than a 16.0-foot vertical clearance over an Interstate highway.
- The vertical clearance over the Interstate is already deficient (less than 16.0 feet) 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.

720.03(6) Liquefaction Impact Considerations

To determine the amount of settlement and the potential for the soil to flow laterally during the design level earthquake due to liquefaction, an analysis performed by the HQ Geotechnical Office is needed for each bridge project site location. The information collected is used by bridge engineers to determine the bridge's capability to withstand the movement and loading in a seismic event and to explore other foundation mitigation options not necessitating total bridge replacement.

The HQ Bridge and Structures Office, in collaboration with the HQ Geotechnical Office, evaluates bridge-widening projects involving liquefiable soils and recommends appropriate liquefaction mitigation.

See the *Bridge Design Manual LRFD* for further information.

720.03(7) Pedestrian and Bicycle Facilities

When pedestrians or bicyclists are anticipated on bridges, provide facilities consistent with guidance in Chapters 1510, 1515, and 1520.

Evolving programs and technologies such as incident response, personal cell phones, and ITS cameras have further reduced the probability of motorists becoming pedestrians. Investigate other methods of treatment such as pedestrian scale signing or other low-cost safety improvement measures. Document decisions in the Basis of Design.

720.03(8) 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 they 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 Design Engineer, may decide to omit bridge approach slabs. Document decisions in the DDP.

720.03(9) Traffic Barrier End Treatment

Plans for new bridge construction and bridge traffic barrier modifications include provisions for the connection of bridge traffic barriers to the longitudinal barrier approaching and departing the bridge. Indicate the preferred longitudinal barrier type and connection during the review of the bridge preliminary plan.

720.03(10) Bridge End Embankments

The design of 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 WSDOT. Exhibit 720-4 illustrates the factors taken into consideration and the experts involved in the process.

720.03(11) 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.

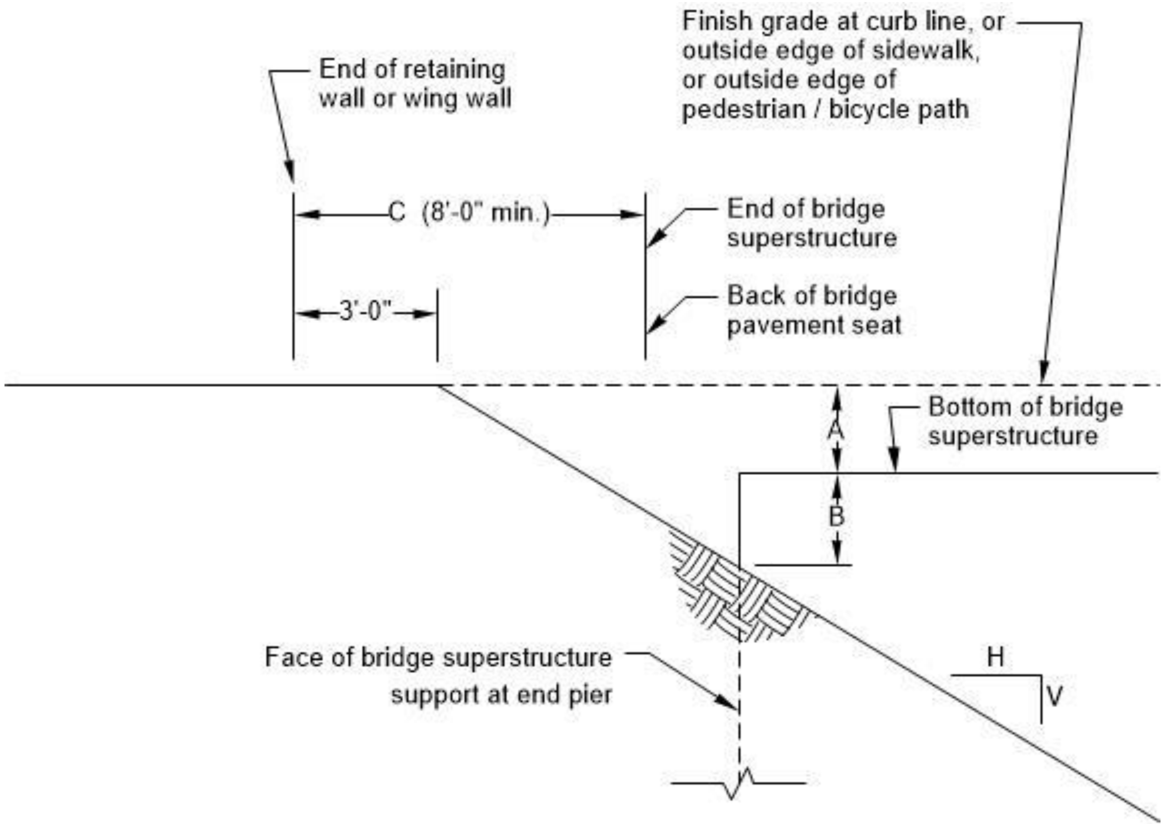
Slope protection is usually not provided under pedestrian structures.

The type of slope protection is selected at the bridge preliminary plan stage. Typical slope protection types are concrete slope protection, and rubble stone.

720.03(12) Slope Protection at Water Crossings

The HQ Hydraulics Section determines the slope protection requirements for structures that cross waterways. The type, limits, and quantity of slope protection are shown on the bridge preliminary plan.

Exhibit 720-4 Embankment Slope at Bridge Ends



Bridge End Elevation

Applies to retaining wall or wing wall (or combination) extending beyond bridge superstructure (barrier omitted for clarity)

Legend

A = Superstructure depth: recommended by HQ Bridge and Structures Office

B = Vertical clearance from bottom of superstructure to embankment: recommended by Bridge Preservation Engineer

C = Distance from end of retaining wall or wing wall to back of pavement seat: recommended by HQ Bridge and Structures Office

H & V = Embankment slope: recommended by Geotechnical Engineer

720.03(13) Screening for Highway Structures

The Washington State Patrol (WSP) classifies the throwing of an object from a highway structure as an assault, not an accident or collision. Therefore, records of these assaults are not contained in WSDOT’s crash databases. Contact the Region Traffic Engineer, RME’s office and the WSP for the history of reported incidents.

Screening might reduce the number of incidents, but will not stop a determined individual at that location, or deter them from moving to other locations in the area. Enforcement provides the most effective deterrent and is typically the first approach used.

Installation of 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 where enforcement has not changed the situation.
- On new structures near schools, playgrounds, or areas frequently used by children not accompanied by adults.
- In urban areas on new structures 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 private property structures, such as buildings or power stations, subject to damage.

In most cases, the installation of a screen on a new structure can be postponed until there are indications of need.

Submit all proposals to install screening on structures to the Director & State Design Engineer, Development Division, for approval. Contact the HQ Bridge and Structures Office for approval to attach screening to structures and for specific design and mounting details.

720.03(14) Contractor Supplied Designs for Buried Structures

When utilizing a contractor supplied design for a buried structure in a design-bid-build Contract (see WSDOT Bridge Design Manual 8.3.3.A), provide for sufficient time from award to any construction windows to allow for design, review, and fabrication of the Buried Structure (typically up to 6 months). Determine any restrictions to be placed on the contractor in their selection of buried structure, headwall, wingwall, vehicle barrier, and fall protection types. Include sufficient information in the contract documents so that the contractor can properly execute the design (see Plans Preparation Manual 700.06(2)).

720.04 Coordination with US Coast Guard for Existing Bridges

Existing bridges crossing navigable waters occasionally require construction or maintenance activities that impact navigation channels governed by USCG permits. For fixed span bridges, this may include construction or maintenance activities that infringe upon the horizontal and vertical navigation opening defined in the USCG permit. For movable bridges, in addition to the above, this may also include adjustments to existing bridge opening operating notice and process as defined in current regulations.

Because these impacts are temporary and are limited to the duration of the construction or maintenance activity, they do not affect or change the actual USCG bridge permit. However, such temporary adjustments still require coordination with the US Coast Guard early in the project design schedule.

The primary responsibility for this contact and coordination lies with the Region Design Project Office. The scope of such coordination varies depending on the extent of the infringement into the defined horizontal or vertical navigation clearance opening, the extent of the change to the bridge operation notice or process as defined in current regulation, and the duration of the construction or maintenance activity.

This coordination activity may require the Design Project Office to conduct a survey of waterway users or to perform other background information tasks requested by the US Coast Guard. Projects with more extensive impacts may lie outside the approval authority of the local USCG Commander and may require review and action by US Coast Guard HQ in Washington, DC. In all cases, the earlier in the design process that the Region Design Project Office initiates these coordination efforts, the more likely the USCG can complete their regulatory process without impacting the project schedule.

720.05 Documentation

Refer to Chapter 300 for design documentation requirements.

720.06 References

720.06(1) Federal/State Laws and Codes

23 CFR Part 650, Subpart C – National Bridge Inspection Standards

Washington Administrative Code (WAC) 480-60*, Railroad companies – Clearances

*Note: railroads may have stricter clearances than what is required in law and each railroad should be consulted as early as possible as to allowable clearances.

720.06(2) Design Guidance

Bridge Design Manual LRFD, M 23-50, WSDOT

Geotechnical Design Manual, M 46-03, WSDOT

Local Agency Guidelines (LAG), M 36-63, WSDOT

LRFD Bridge Design Specifications, AASHTO, Current Edition

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC “Manual on uniform traffic control devices for streets and highways” (MUTCD)

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

720.06(3) Supporting Information

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

Manual for Railway Engineering, American Railway Engineering and Maintenance-of-Way Association (AREMA)

Chapter 730 Retaining Walls and Steep Reinforced Slopes

730.01 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 (see Chapter 1600)
- Amount of excavation required
- Traffic characteristics
- Constructability
- Impact to 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
- Groundwater
- 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.

730.01(1) Retaining Wall Classifications

Retaining walls are generally classified as gravity, semigravity, nongravity cantilever, or anchored. The various wall types and their classifications are summarized in Exhibits 730-1 through 730-6.

a) **Gravity Walls**
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 they 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 (such as gabions). 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).

b) **Semigravity 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*.

c) **Nongravity Cantilever Walls**
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 (such as soldier piles or sheet piles), 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.

d) **Anchored Walls**
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 deadman 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 Exhibit 730-10.

730.02 References

730.02(1) Federal/State Laws and Codes

Washington Administrative Code (WAC) 296-155, Safety standards for construction work

730.02(2) Design Guidance

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 25-30, WSDOT

730.03 Design Principles

The design of a retaining wall or reinforced slope consists of the following principal activities:

- Develop wall/slope geometry
- Provide adequate subsurface investigation
- Evaluate loads and pressures that will act on the structure
- Design the structure to withstand the loads and pressures
- Design the structure to meet aesthetic requirements
- Ensure wall/slope constructibility
- Coordinate with other design elements

The structure and adjacent soil mass also needs to be stable as a system, and the anticipated wall settlement needs to be within acceptable limits.

730.04 Design Requirements

730.04(1) Wall/Slope Geometry

Wall/slope geometry is developed considering the following:

- Geometry of the transportation facility itself
- Design Clear Zone requirements (see Chapter 1600)
- Flare rate and approach slope when inside the Design Clear Zone (see Chapter 1610)
- Right of way constraints
- Existing ground contours
- Existing and future utility locations
- Impact to adjacent structures

Impact to environmentally sensitive areasFor wall/slope geometry, also consider the foundation embedment and type anticipated, which requires coordination between the various design groups involved.

Retaining walls are designed to limit the potential for snagging vehicles by removing protruding objects (such as bridge columns, light fixtures, or sign supports).

Provide a traffic barrier shape at the base of a new retaining wall constructed 12 feet 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). Depending on the application, precast or cast-in-place Single Slope Concrete Barrier with vertical back or Type 4 Concrete Barrier may be used for both new and existing walls except when the barrier face can be cast as an integral part of a new wall. Design analyses may be considered, but they require approval as prescribed in Chapter 300. A design analysis is not required where sidewalk exists in front of the wall or in other situations where the wall face is otherwise inaccessible to traffic.

730.04(2) Investigation of Soils

All retaining wall and reinforced slope structures require an investigation of the underlying soil/rock that supports the structure. Chapter 610 provides guidance on how to complete this investigation. A soil investigation is an integral part of 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 groundwater table are determined through the geotechnical investigation.

730.04(3) Geotechnical and Structural Design

The structural elements of the wall or slope and the soil below, behind, and/or within the structure are 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 the wall/reinforced slope is a part of 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.

730.04(3)(a) Scour

At any location where a retaining wall or reinforced slope can be in contact with water (such as a culvert outfall, ditch, wetland, lake, river, or floodplain), there is a risk of scour at the toe. This risk must be analyzed. Contact the HQ Geotechnical Office and HQ Hydraulics Office to determine whether a scour analysis is required.

730.04(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 needs to be considered in the design stage and reviewed by the region Materials Engineer during construction. The drainage features shown in the *Standard Plans* are the minimum basic requirements. Underdrains behind the wall/slope need to 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 slope 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 Office of the Headquarters (HQ) Materials Laboratory.

A typical drainage detail for a gravity wall (in particular, an MSE wall) is shown in Exhibit 730-11. Include drainage details with a wall unless otherwise recommended to be deleted by the Region Materials Engineer or HQ Geotechnical Office.

730.04(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, top profile, terminals, and surface finish (texture, color, and pattern). Where appropriate, provide planting areas and irrigation conduits. These will visually soften walls and blend them 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, because they can be quite imposing. Consider stepping high or long retaining walls in areas of high visibility. Plantings may be considered between wall steps.

Approval by the State Bridge and Structures Architect is required on all retaining wall aesthetics, including finishes, materials, and configuration (see Chapter 950).

730.04(6) Constructability

Consider the potential effect that site constraints might have on the constructability 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.

730.04(7) Coordination With Other Design Elements

730.04(7)(a) Other Design Elements

Retaining wall and slope designs are to be coordinated with other elements of the project that might interfere with or impact the design 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 feet 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 Exhibit 730-12.

Where impact to the wall elements is unavoidable, the wall system needs to 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 impacts on the proposed wall systems are to be clearly indicated in the submitted wall site data so the walls can be properly designed. Contact the HQ Bridge and Structures Office (or the Geotechnical Office for geosynthetic walls/slopes and soil nail walls) for assistance regarding this issue.

730.04(7)(b) Worker Fall Protection

Department of Labor and Industries regulations require that, when employees are exposed to the possibility of falling from a location 4 feet or more above the roadway (or other lower area), the employer is to ensure fall restraint or fall arrest systems are provided, installed, and implemented.

Design fall protection in accordance with WAC 296-155-24609 for walls that create a potential for a fall of 4 feet or more. During construction or other temporary or emergency condition, fall protection will follow WAC 296-155. 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 1510, Pedestrian Facilities.

For maintenance of a tall wall's surface (10 feet or more), 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:

- A possible fall will be of 4 feet 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.
- Steel pipe railing with top and intermediate rails.
- Concrete as an extension of the height of the retaining wall.
- <u>Other systems may be available. Contact HQ Bridge for more information.</u>

A fall restraint system is to be 42 inches high, plus or minus 3 inches, 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. An intermediate cable or rail shall be halfway between the top rail and the platform. A toe board with a minimum height of 4 inches will be provided. Post spacing is no more than 8 feet on centers. (See the *Construction Manual* and WAC 296-155 for fall arrest and protection information.) For wire rope railing, the top railing shall be flagged at not more than 6-foot intervals with high-visibility material.

The designer is to contact maintenance personnel regarding fall protection and debris removal considerations.

Contact the HQ Bridge and Structures Office for design details for any retrofit to an existing retaining wall and for any attachments to a new retaining wall.

730.05 Guidelines for Wall/Slope Selection

Wall/slope selection is dependent on:

- 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.

730.05(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 are therefore 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% 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% 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 they typically are 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 a feasible choice 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% of the rockery height. Rockeries can be used in fill situations, but the fill heights they support need to be kept relatively low. 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 are 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.

730.05(2) Settlement and Deep Foundation Support Considerations

Settlement issues, especially differential settlement, are of primary concern in the 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, after the wall settlement is complete, concrete facing can be placed 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 needs to be limited to approximately 1 inch 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 are too deep to be overexcavated, or if a deep failure surface is present that results in inadequate slope stability, select a wall type 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.

730.05(3) Feasible Wall Heights and Limitations

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.

For height limitations, see Exhibits 730-1 through 730-6.

730.05(4) Supporting Structures or Utilities

Not all walls are acceptable to support other structures or utilities. Issues that are to 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 HQ Bridge and Structures Office.

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, and so on 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 HQ Bridge and Structures Office for assistance regarding this issue.

730.05(5) Facing Options

Facing selection depends on the aesthetic and 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. Consider the available facing options when selecting a particular wall.

730.05(5)(a) MSE Walls

For MSE walls, facing options typically include:

- 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 feet placed in areas where minimal settlement is expected.
- Welded wire facing.
- Timber facing.
- Shotcrete facing with 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 they can create on the wall face.

Geosynthetic facings are not acceptable for permanent facings due to potential facing degradation when exposed to sunlight. For permanent applications, use some type of timber, welded wire, or concrete face for geosynthetic walls. Shotcrete, masonry concrete blocks, cast-in-place concrete, welded wire, or timber are typically used for geosynthetic wall facings.

730.05(5)(b) Soil Nail Walls

Soil nail walls can use either architecturally treated shotcrete or a cast-in-place facia wall textured as needed to produce the desired appearance.

730.05(5)(c) Prefabricated Modular Gravity Walls

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.

730.05(5)(d) Nongravity Cantilevered Walls

For nongravity cantilevered walls and anchored walls, a textured cast-in-place or precast facia wall is usually installed to produce the desired appearance.

730.05(6) Cost Considerations

Usually, more than one wall type is feasible for a given situation. Consider initial and future maintenance costs throughout the selection process, as the decisions made may affect the overall cost. For example, you may have to decide whether to shut down a lane of traffic to install a low-cost gravity wall system that requires more excavation room or use a more expensive anchored wall system that will minimize excavation requirements and impacts to traffic. In this case, determine whether the cost of traffic impacts and more excavation justifies the cost of the more expensive anchored wall system. Consider long-term maintenance costs when determining wall type.

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 or concrete or steel cribbing or bins), 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 treatments usually increase the cost of any of these facing systems. Special wall terracing to provide locations for plants will also tend to increase costs. Therefore, weigh the costs against the value of the desired aesthetics.

Other factors that affect the 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 HQ Bridge and Structures Office.

730.05(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, and impacts to traffic; and the overall geometry in terms of wall/slope height and length, location of adjacent structures and utilities, aesthetics, and cost. Exhibits 730-1 through 730-6 provide a summary of many of the various wall/slope options available, including their advantages, disadvantages, and limitations. Note that specific wall types in the exhibits may represent multiple wall systems, some or all of which will be proprietary.

730.06 Design Responsibility and Process

730.06(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 Washington State Department of Transportation (WSDOT) *Standard Plans*. These designs are provided for reinforced concrete cantilever walls up to 35 feet in height. The internal stability design and the external stability design for overturning and sliding stability have already been completed for these standard walls. Determine overall slope stability and allowable soil bearing capacity (including settlement considerations) 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 nonstandard 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 nonproprietary walls in terms of their design process.

730.06(1)(a) Preapproved Proprietary Walls

Some proprietary wall systems are preapproved. Preapproved proprietary wall systems have been extensively reviewed by the HQ Bridge and Structures Office and the Geotechnical Office. 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 others 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 is critical to avoid costly change orders or delays during construction. These elements include drainage features, utilities, luminaires and sign structures, noise walls, traffic barriers, guardrails, or other walls or bridges.

In general, standard walls are the easiest walls to incorporate into project Plans, Specifications, and Estimates (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 needs to be developed. Some nonstandard walls (such as state-designed geosynthetic walls) can be designed relatively quickly, require minimal plan preparation effort, and only involve the region and the Geotechnical Office. Other nonstandard walls such as soil nail and anchored wall systems require complex designs, involve both the HQ Bridge and Structures Office and Geotechnical Office, and require a significant number of plan sheets and considerable design effort.

The HQ Bridge and Structures Office maintains a list of the proprietary retaining walls that are preapproved. The region consults the HQ Bridge and Structures Office for the latest list. The region consults the HQ Geotechnical Office for the latest geosynthetic reinforcement list to determine which geosynthetic products are acceptable if a critical geosynthetic wall or reinforced slope application is anticipated.

730.06(1)(b) Experimental Wall Systems

Some proprietary retaining wall systems are classified as experimental by the Federal Highway Administration (FHWA). The HQ 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 is to be prepared by WSDOT and approved by the FHWA.

An approved public interest finding, signed by the Director & State Design Engineer, Development Division, is required for the use of a sole source proprietary wall.

730.06(1)(c) Gabion Walls

Gabion walls are nonstandard walls that are to 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 feet high by 3 feet wide, and it is typically safe to build gabions two baskets high (6 feet) but only one basket deep. This results in a wall base width of 50% of the wall height, provided soil conditions are reasonably good (medium-dense to dense granular soils are present below and behind the wall).

730.06(2) Responsibility and Process for Design

A flow chart illustrating the process and responsibility for retaining wall/reinforced slope design is provided in Exhibit 730-13a. As shown in the exhibit, the region initiates the process except for walls developed as part of a preliminary bridge plan. These are initiated by the HQ 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. Coordinate with the region and the HQ Bridge and Structures Office, Geotechnical Office, and State Bridge and Structures Architect as early in the process as feasible.

Headquarters or region consultants, if used, are considered an extension of the Headquarters staff and must follow the process summarized in Exhibit 730-13a.
All consultant designs, from development of the scope of work to the final product, are to be reviewed and approved by the appropriate Headquarters offices.

730.06(2)(a) Standard Walls

The regions are responsible for detailing retaining walls for which standard designs are available.

For standard walls greater than 10 feet in height, and for all standard walls where soft or unstable soil is present beneath or behind the wall, a geotechnical investigation will be conducted, or reviewed and approved, by the HQ Geotechnical Office. Through this investigation, provide the foundation design, including bearing capacity requirements and settlement determination, overall stability, and the selection of the wall types most feasible for the site.

For standard walls 10 feet 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 feet 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.

The *Standard Plans* provides design charts and details for standard reinforced concrete cantilever walls. The *Standard Plans* are used to size the walls and determine the factored bearing pressure to compare with the factored bearing resistance determined from the geotechnical investigation. The charts provide maximum soil pressure for the LRFD service, strength, and extreme event limit states. Factored bearing resistance for the LRFD service, strength, and extreme event limit states can be obtained from the HQ Geotechnical Office for standard walls over 10 feet in height and from the region Materials Laboratory for standard walls less than or equal to 10 feet in height. The *Standard Plans* can be used for the wall design if the factored bearing resistance exceeds the maximum soil pressure shown in the *Standard Plans* for the respective LRFD limit states.

Contact the HQ Bridge and Structures Office if the factored bearing resistance provided by the geotechnical investigation does not exceed the maximum soil pressure shown in the *Standard Plans* for one or all of the LRFD limit states. The wall is considered a nonstandard wall design and the *Standard Plans* cannot be used.

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 HQ Bridge and Structures Office for assistance

The *Standard Plans* provides eight types of reinforced concrete cantilever walls (which represent eight loading cases). Reinforced concrete retaining walls Types 5 through 8 are not designed to withstand western Washington earthquake forces and are not to be used in western Washington (west of the Cascade crest).

Once the geotechnical and architectural assessments 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, and 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 HQ Bridge and Structures Office for plan details and toe bearing pressures. The applied toe bearing pressure will then have to be evaluated by the HQ Geotechnical Office to determine whether the site soil conditions are appropriate for the applied load and anticipated settlement.

730.06(2)(b) Preapproved Proprietary Walls

Final approval of preapproved proprietary wall design, with the exception of geosynthetic walls, is the responsibility of the HQ Bridge and Structures Office. Final approval of the design of preapproved proprietary geosynthetic walls is the responsibility of the HQ Geotechnical Office. 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 feet in height or less that are not bearing on soft or unstable soils. In all other cases, it is the responsibility of the HQ Geotechnical Office 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.

Include a minimum of three different wall systems 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 HQ 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-foot 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 HQ Bridge and Structures Office for assistance.

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, indicate the location(s) and dimensions of the reinforcement obstruction(s) relative to the wall on the plans. Contact the HQ Bridge and Structures Office for preapproved wall details and designs for size and location of obstructions and to obtain the generic details that are to 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 will 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 are to 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 HQ Bridge and Structures Office will review and approve the wall shop drawings and calculations, with the exception of geosynthetic walls. They are reviewed and approved by the HQ Geotechnical Office.

730.06(2)(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 HQ Bridge and Structures Office, with copies to the HQ Geotechnical Office and the State Bridge and Structures Architect. The HQ 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 HQ Bridge and Structures Office contacts suppliers of the selected nonpreapproved wall systems 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, make the wall face quantities identical for those wall systems subject to the same face embedment requirements.

The HQ 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*.

730.06(2)(d) Nonstandard Nonproprietary Walls

With the exception of rockeries over 5 feet high, nonproprietary geosynthetic walls and reinforced slopes, and soil nail walls, the HQ Bridge and Structures Office coordinates with the HQ Geotechnical Office and the State Bridge and Structures Architect to carry out the design of all nonstandard, nonproprietary walls. The HQ 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 feet 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 HQ Geotechnical Office 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 or HQ Landscape Architect if the wall uses vegetation on the face.

The HQ Geotechnical Office has overall approval authority for the wall design. Once the wall design has been completed, the HQ Geotechnical Office, and in some cases the HQ 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 HQ Geotechnical Office has performed the geotechnical design, the HQ Bridge and Structures Office, in cooperation with the HQ Geotechnical Office, coordinates the design effort and completes the PS&E package.

730.06(3) Guidelines for Wall/Slope Data Submission for Design

730.06(3)(a) Standard Walls, Proprietary Walls, Geosynthetic Walls/Slopes, and Soil Nail Walls

Where Headquarters involvement in retaining wall/slope design is required (as it is for standard walls and preapproved proprietary walls over 10 feet in height, gabions over 6 feet in height, rockeries over 5 feet in height, all nonpreapproved proprietary walls, geosynthetic walls/slopes, and all soil nail walls), the region submits the following information to the HQ Geotechnical Office or HQ 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 feet) or InRoads 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 and 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 for the purpose of defining the final wall geometry, it is best to base existing ground measurements on physical survey data rather than solely on photogrammetry. In addition, the region is to complete a Retaining Wall/ Reinforced Slope Site Data Check List, DOT Form 351-009 EF, for each wall or group of walls submitted.

730.06(3)(b) Nonstandard Walls, Except Geosynthetic Walls/Slopes and Soil Nail Walls

In this case, the region is to submit site data in accordance with Chapter 710. Additionally, the region is to complete a Retaining Wall/Reinforced Slope Site Data Check List, DOT Form 351-009 EF, for each wall or group of walls.

730.07 Documentation

Refer to Chapter 300 for design documentation requirements.

Exhibit 730-1 Summary of Mechanically Stabilized Earth (MSE) Gravity Wall/Slope Options Available

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 feet.
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 feet; heights over 33 feet 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 during construction.	Applicable primarily to fill situations; maximum height of 33 feet for routine designs; heights over 33 feet require a special design.
Steel soil reinforcement with welded wire face only	Can tolerate large short-term settlements; low cost.	Aesthetics, unless face plantings can be established; generally requires high-quality backfill; wide base width required (70% of wall height).	Applicable primarily to fill situations; maximum height of 33 feet for routine designs; heights over 33 feet require a special design.
Segmental masonry concrete block-faced walls, generally with geosynthetic soil reinforcement	Low cost; flexible enough to handle significant settlement.	Internal wall deformations may be greater for steel reinforced systems, but are acceptable for most applications; generally requires high-quality backfill; wide base required (70% of wall height).	Applicable primarily to fill situations; in general, limited to a wall height of 20 feet 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*.)

Specific Wall Type	Advantages	Disadvantages	Limitations
Geosynthetic walls with a shotcrete or cast-in-place concrete face	Very low cost, especially 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 feet 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 feet 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 feet 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 feet or more are possible.
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 feet or more.

Specific Wall Type	Advantages	Disadvantages	Limitations
Soil nail walls	Relatively low cost; can be used in areas with restricted overhead or lateral clearance.	Allow adequate standup time for soil/rock to stand in a vertical cut approximately 6 feet 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 feet are feasible, though greater wall heights are possible in excellent soil/rock conditions. A special design is always required.

Exhibit 730-2 Summary of Prefabricated Modular Gravity Wall Options Available

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 typically can be designed for heights of up to 33 feet and unreinforced concrete up to 16 feet; 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 feet; not used to support bridge or building foundations.

Specific Wall Type	Advantages	Disadvantages	Limitations
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 feet; 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 feet; 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 feet, and by special design up to 21 feet; not used to support structure foundations.

Exhibit 730-3 Summary of Rigid Gravity and Semigravity 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 feet.

Specific Wall Type	Advantages	Disadvantages	Limitations
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 gravity walls are present and it is desired to match aesthetics; typically can be designed for maximum heights of 25 feet.
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 face wall.	Applicable to cut and fill situations; can be routinely designed for heights up to 35 feet.
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 feet; proprietary versions are typically 33 feet maximum.

Exhibit 730-4 Summary of Nongravity 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 feet; difficult to install in bouldery soil or soil with water-bearing sands.

Specific Wall Type	Advantages	Disadvantages	Limitations
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 feet.
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; maximum feasible exposed height is on the order of 20 to 25 feet depending on the 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 feet, depending on passive resistance available.

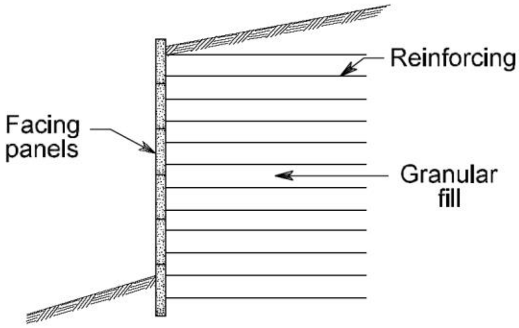
Exhibit 730-5 Summary of Anchored Wall Options Available

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 feet 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; access required 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 feet.

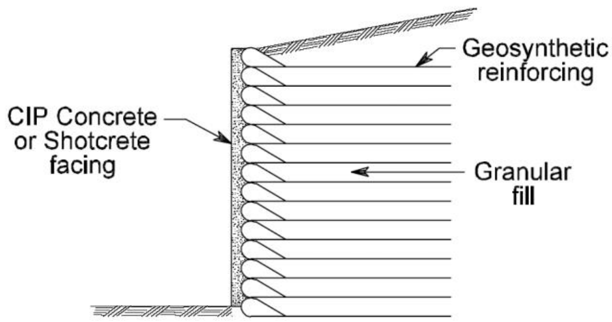
Exhibit 730-6 Other Wall/Slope Options Available

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 needs to be at least marginally stable without rockery present; cannot tolerate much settlement.	Applicable to both cut and fill situations; maximum feasible height in a cut, even for excellent soil conditions, is approx. 16 feet and 8 feet 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.	Room required between the right of way line and the edge of the shoulder to install a 1H:1V slope.	Best suited to sloping fill situations; maximum height limited to 30 feet 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 feet or more, but consider need, landscaping maintenance, and the reach of available maintenance equipment.

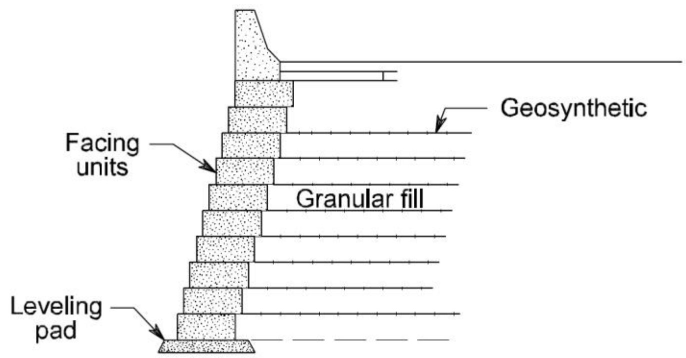
Exhibit 730-7 Typical Mechanically Stabilized Earth Gravity Walls



MSE Wall with Modular Precast Concrete Facing Panels

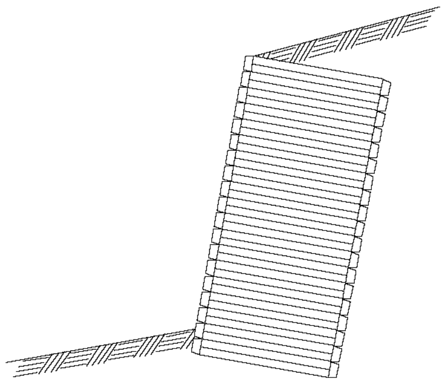


MSE Wall with Geosynthetic Reinforcement and CIP Concrete or Shotcrete Facing

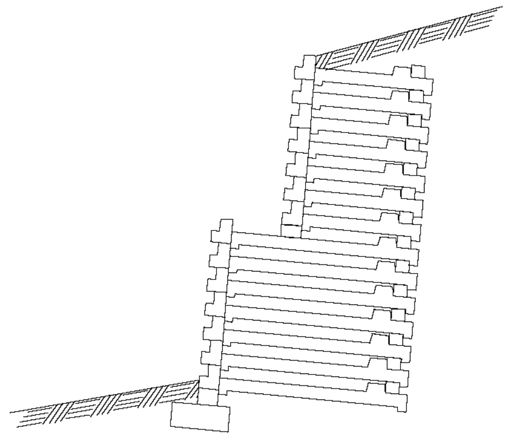


MSE Wall with Segmental Concrete Block Facing

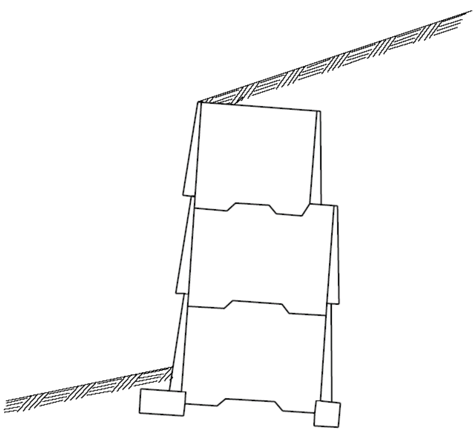
Exhibit 730-8 Typical Prefabricated Modular Gravity Walls



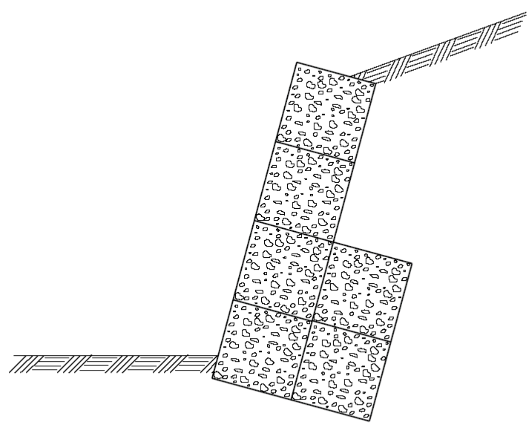
Metal Bin Wall



Precast Concrete Crib Wall

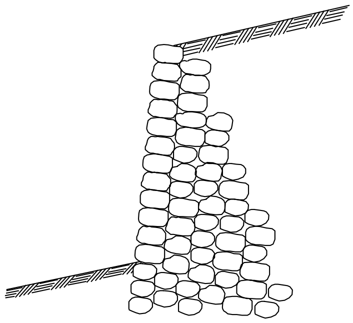


Precast Concrete Bin Wall

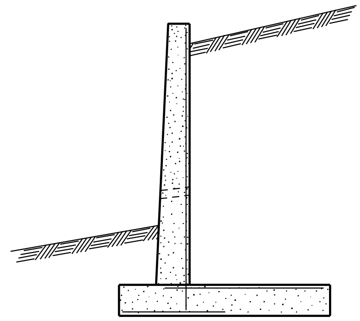


Gabion Wall

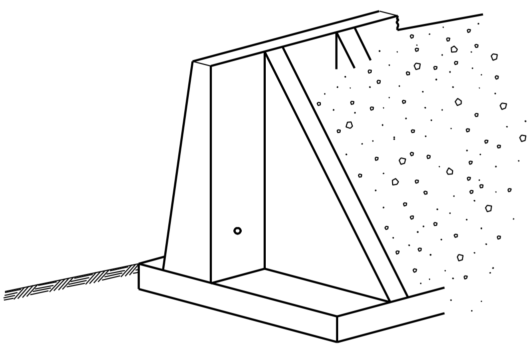
Exhibit 730-9 Typical Rigid Gravity, Semigravity Cantilever, Nongravity Cantilever, and Anchored Walls



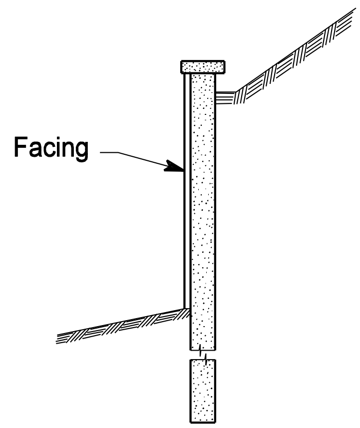
Mortar Rubble Masonry
Ridgid Gravity Wall



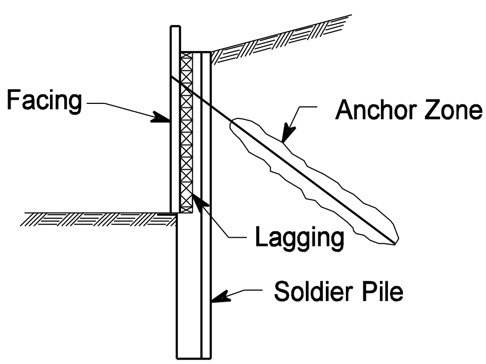
Reinforced Concrete Cantilever
Semigravity Wall



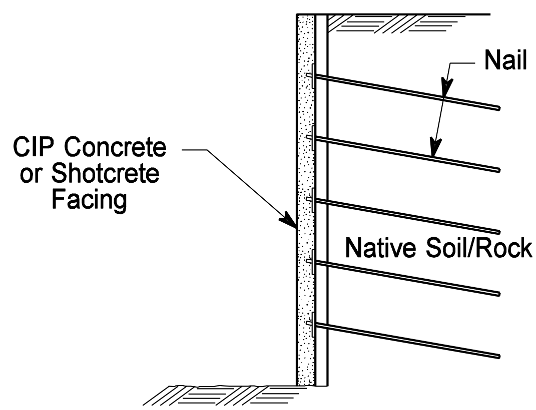
Reinforced Concrete Counterfort
Semigravity Wall



Slurry or Cylinder Pile
Nongravity Cantilever Wall

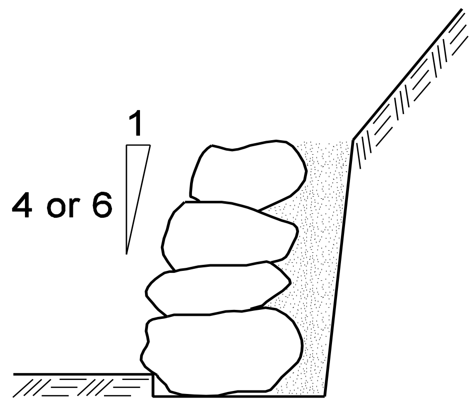


Soldier Pile Tieback Wall

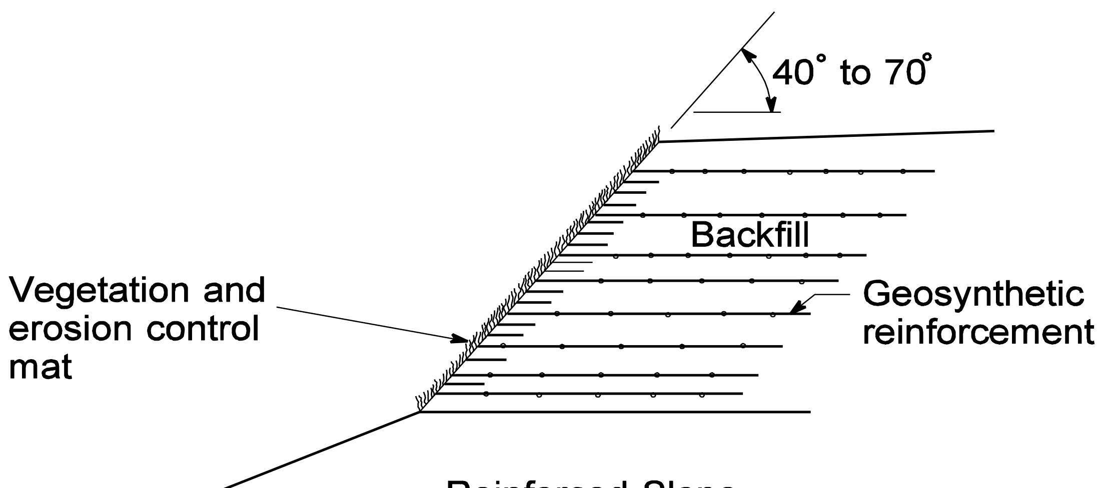


Soil Nail Wall
in Cut

Exhibit 730-10 Typical Rockery and Reinforced Slopes



Rockery



Reinforced Slope

Exhibit 730-11 MSE Wall Drainage Detail

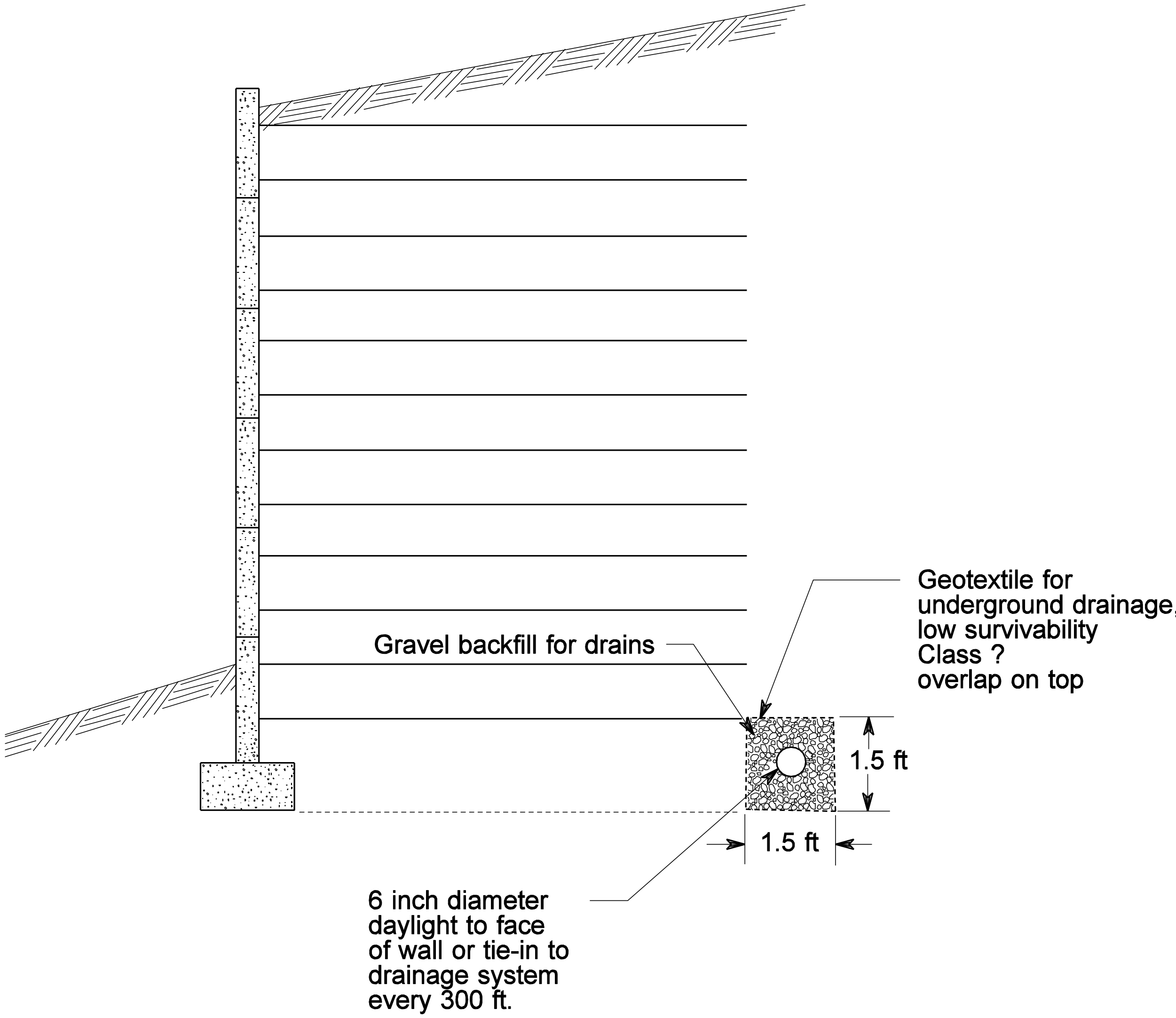
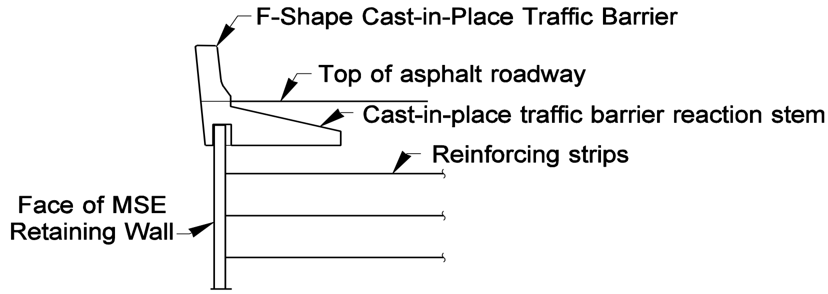
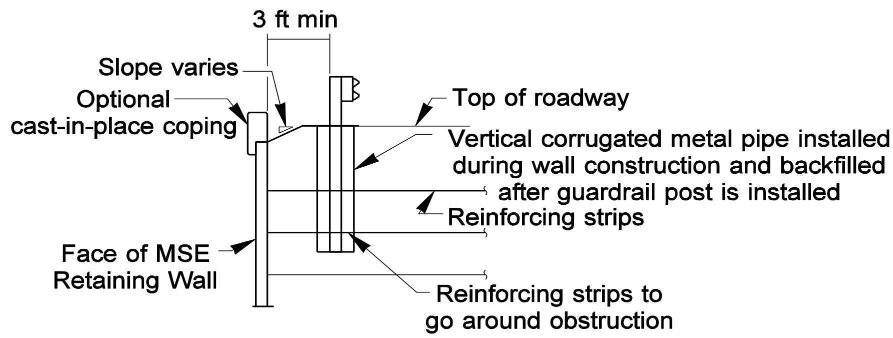


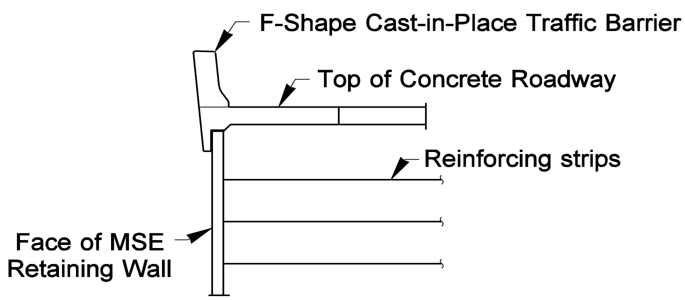
Exhibit 730-12 Retaining Walls with Traffic Barriers



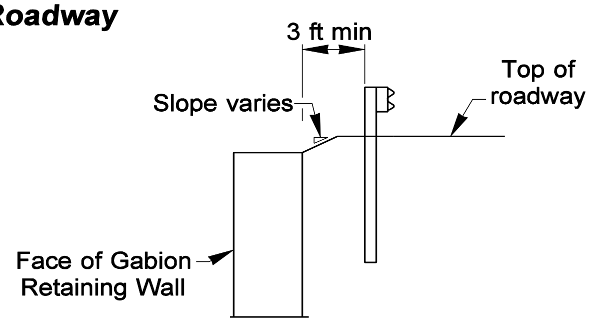
Concrete Traffic Barrier with Asphalt Roadway



Beam Guardrail on Top of MSE Retaining Wall

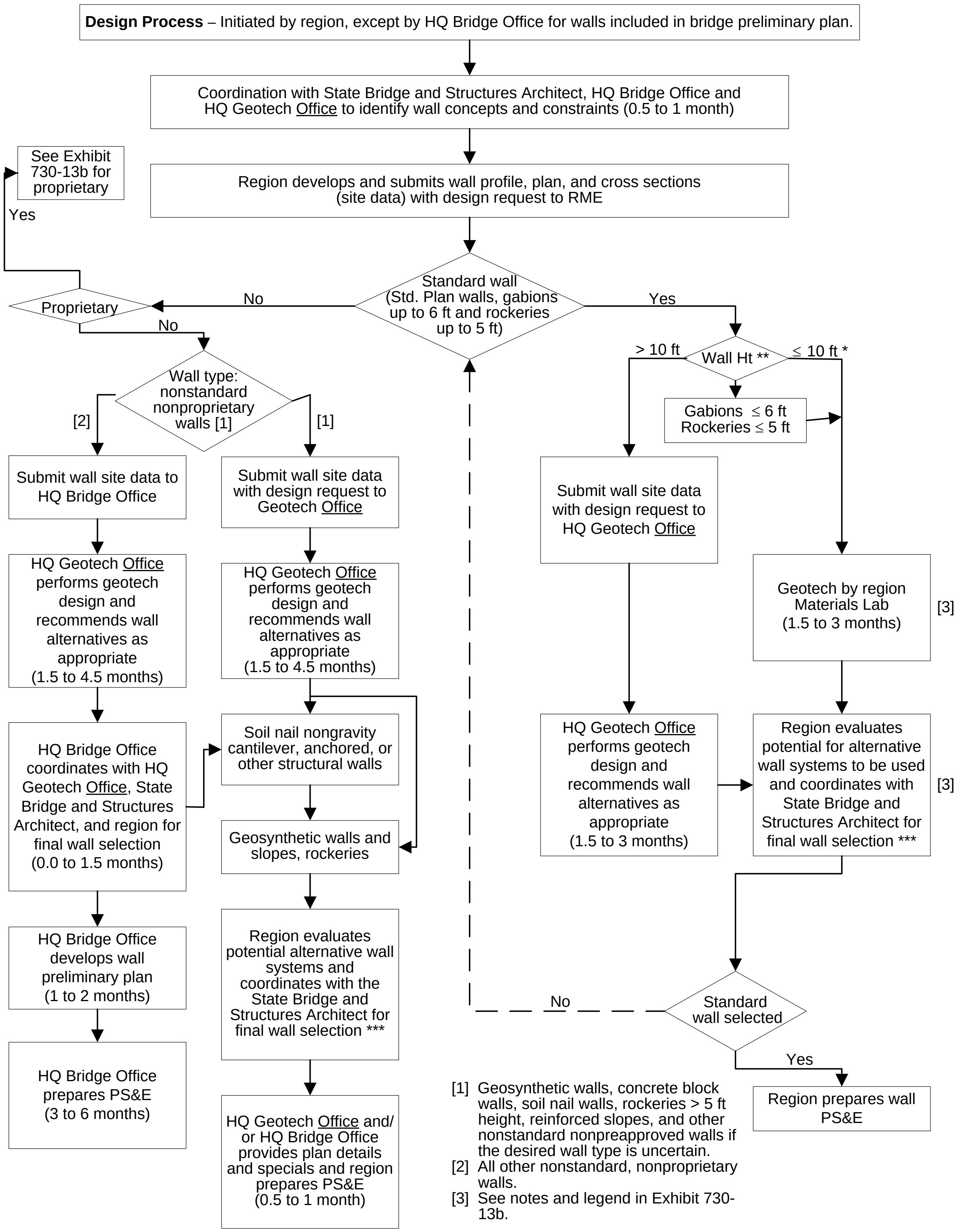


Concrete Traffic Barrier with Concrete Roadway



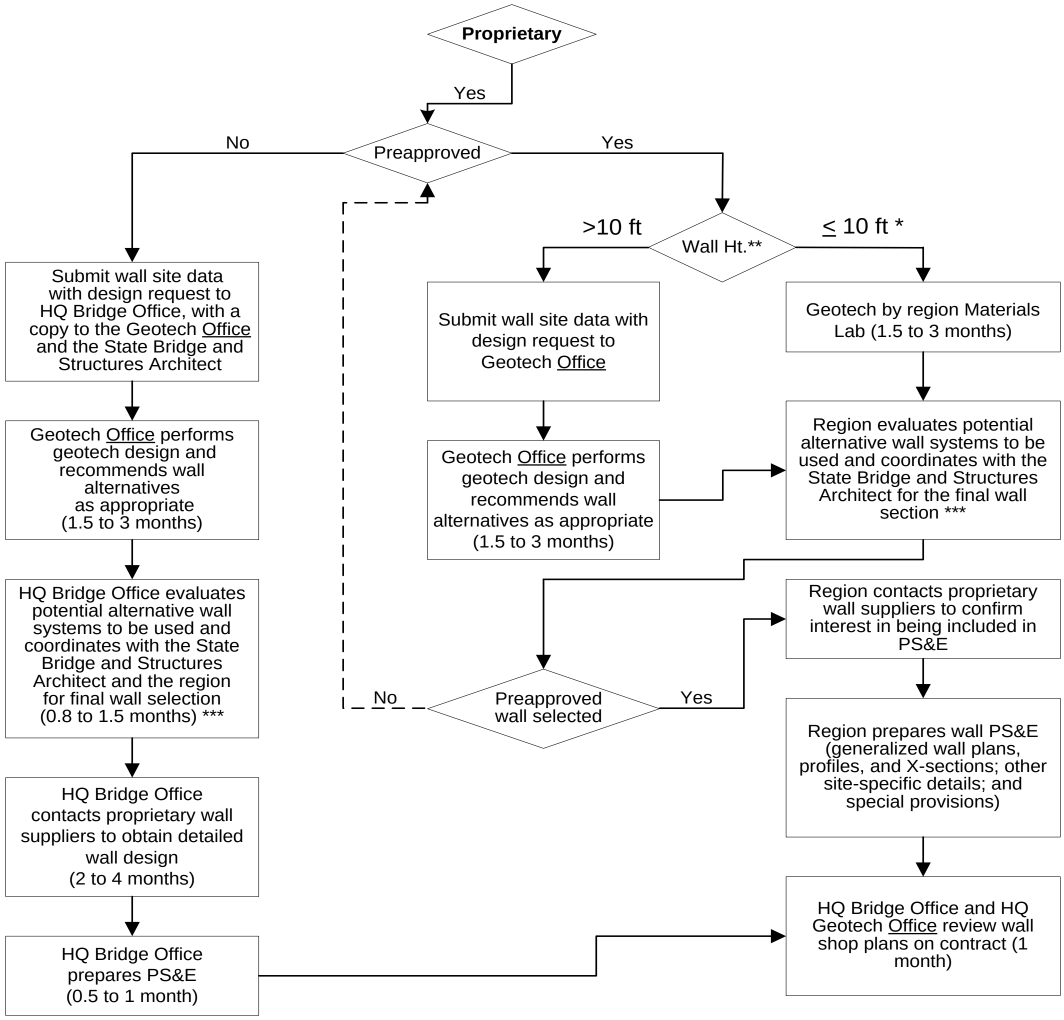
Beam Guardrail on Top of Gabion Wall

Exhibit 730-13a Retaining Wall Design Process



Retaining Wall Design Process
Exhibit 730-4a

Exhibit 730-13b Retaining Wall Design Process: Proprietary



Notes:

"HQ Bridge Office" refers to the WSDOT HQ Bridge and Structures Office.

"Geotech Office" refers to the WSDOT HQ Geotechnical Office.

"State Bridge and Structures Architect" refers to the Architecture Section, HQ Bridge and Structures Office.

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 copy of geotechnical report to HQ Geotechnical Office.

*Assumes soft or unstable soil not present and wall does not support other structures.

**The preapproved maximum wall height is generally 33 feet. Some proprietary walls might be less. (Check with the HQ 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 the steps have been taken.

Chapter 950 Public Art

950.01 General

There has been a growing interest on the part of communities to use art within the transportation facilities of the Washington State Department of Transportation (WSDOT). It can be used to provide visual interest along roadsides, make unique statements about community character, and create a positive public response that will last over time.

Proponents for public art might be local agencies or engaged citizens' groups with interest in the outcome of a WSDOT project. The environmental and public involvement processes offer opportunities for community partnership on the visual and aesthetic qualities of a corridor.

The public art policy in this chapter is intended to: provide guidance for managing public art on WSDOT facilities and within its rights of way; reinforce the existing policy in the *Roadside Policy Manual*; designate appropriate locations for the incorporation of public art features; and provide for the consistent use of statewide development, review, and approval processes on new and existing features.

What is public art?

For the purposes of WSDOT policy, public art is an enhancement to a functional element, feature, or place within a transportation corridor to provide visual interest. The enhancement could be an addition to a functional element, integrated into a design, or for purely aesthetic purposes.

An element is considered "public art" if it is beyond WSDOT standard practice for architectural treatment.

The appropriateness of public art is frequently dependent upon its location and composition. For example, an art piece or feature chosen for the back side of a noise wall, at a safety rest area, or along a bike path may not be suitable at the end of a freeway ramp or along the main line of a highway. In addition to appropriate placement, WSDOT must balance the requests for proposed public art projects with the need to provide corridor continuity, improve the unity of highway elements, and provide roadsides that do not divert motorists' attention from driving.

While some local jurisdictions dedicate a percentage of their project budgets for art, WSDOT has no such dedicated funding. Section 40 of the State Constitution specifies that gas tax money must be used for a "highway purpose." Therefore, public art beyond WSDOT standard design is typically funded by communities or other entities outside of WSDOT.

When city or community entrance markers are proposed, this policy should be used in conjunction with the guidance contained in Chapter 1600, Roadside Safety, the *Traffic Manual,* and the *Roadside Policy Manual*.

950.02 References

950.02(1) Federal/State Laws and Codes

Chapter 47.42 Revised Code of Washington (RCW), Highway advertising control act – Scenic vistas act

950.02(2) Design Guidance

Bridge Design Manual, M 23-50, WSDOT

Roadside Policy Manual, M 25-31, WSDOT

950.02(3) Supporting Information

A Guide for Achieving Flexibility in Highway Design, AASHTO, 2004

Flexibility in Highway Design, FHWA, 1997

Roadside Manual, M 25-30, WSDOT

Traffic Manual, M 51-02, WSDOT

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005
www.wsdot.wa.gov/research/reports/600/638.1.htm

950.03 Standard Architectural Design

WSDOT's public art policy does not apply to the standard design of transportation architectural elements such as simple geometric patterns; combinations of WSDOT standard concrete formliners; contrasting pavement patterns or colors in crosswalks or roundabouts; or earth-tone colors on structures or barriers.

To discuss the details of proposed public art projects, contact the State Bridge and Structures Architect, and the region or Headquarters (HQ) Landscape Architect for regions without a Landscape Architect. They are key members of the Public Art Specialty Services Team (described in 950.05) and can answer questions and assist in determining an appropriate course of action.

950.04 Criteria for Public Art

950.04(1) Acceptable Public Art Features

Public art must be in compliance with WSDOT corridor guidelines, such as the Mountains to Sound Greenway Implementation Plan or the I-90 Architectural Design Standards, and existing policies such as the Roadside Policy Manual and the Bridge Design Manual.
The following are examples of types and locations of acceptable public art features:

- Concrete surface treatments (beyond WSDOT standard)
- Colored paving/colored pavers/scoring patterns (beyond WSDOT standard)
- Specially designed benches, trash cans, planters, or other street furnishings
- Soft lighting and lighting fixtures
- Small-scale sculptures or art pieces (when not viewed from the main line)
- Attachments to decorative railings, light poles, or fences
- Decorative bus shelters

950.04(1)(a) City Entrance Markers on Structures over the Interstate

In order for a city to mount an entrance marker on a structure over the Interstate, the applicant must met the following criteria in addition to other requirements set forth in this Chapter.

- Limited to existing structures. No new overhead structures will be added to allow city entrance markers.
- Cannot be placed on structures with existing traffic control devices such as signals, guide signs, warning signs, regulatory signs, or variable message signs.
- The requesting agency enters into an airspace lease for use of WSDOT right-of-way. The airspace lease must include the removal of the item after its useful life and indicate the requesting agency is responsible for all cost for plan review, design, construction, maintenance, repair (including vandalism or damage), and damage to WSDOT property as the result of construction, maintenance, or repair.
- The proposed design meets Bridge & Structure Office design criteria on loading and clearance and is consistent with current WSDOT structural design details. The Bridge and Structures Office is responsible for review and approved of the design prior to installation.
- Display the name of a city only. Must be near or inside city limits.
- No phone numbers or web links can be displayed on the entrance marker.
- The entrance marker cannot be made of a material that has a short lifespan (such as a fabric or canvas banner) or requires routine maintenance. Maintenance of lighting is allowed during the lifespan.
- Should be centered on the direction of travel side of the structure.
- Distance from other existing traffic control signs both upstream and downstream must be at least 500 feet.
- Sight distance is not restricted.
- WSDOT will inspect the entrance marker as part of the bridge inspection program. The requesting agency is also responsible for all cost associated with addressing items found during the inspection. Once the need for maintenance is determined, the items must be addressed within 90 days of notification. Otherwise, the entrance marker will be repaired or removed by the WSDOT at the cost of the requesting agency.
- Must be relocated or removed by WSDOT at the cost of the requesting agency if the WSDOT structure is removed, rebuilt, needed for traffic control signing, or relocated, as directed by WSDOT.
- Requesting agency is also responsible for damages to the structure due to placement or maintenance of the city marker.
- No additional items may be attached to or hung from the display after approval. Any such items must be removed by the requesting agency.
- Does not obstruct pedestrian or cyclist’s clearance, visibility, and/or stopping sight distance.
- The city entrance marker has no moving parts, lights, design, or materials that may create glare or distraction. Decorative accents may be allowed but cannot be distracting to drivers per Chapter 950.04(2).
- Muted, non-MUTCD sign related colors may be used.
- Approval of the entrance marker is granted through the Public Art Plan process.

950.04(2) Unacceptable Public Art Features

The following are examples of unacceptable public art features:

- Kinetic sculptures
- Brightly lit or flashing art
- Art that poses a safety risk or liability
- Large sculptures (the size is relative to its context and location in the landscape)
- Art with highly reflective qualities or adverse colors
- Art that is a distraction to drivers or out of context with the surroundings
- Art with a topic/theme that could cause negative public reaction
- Art that resembles a traffic control device
- Art that contains advertising

950.05 Process and Project Delivery Timing

Begin the development and review of public art early in the design process, and conduct subsequent reviews during the course of its development. Do not include public art as a change order or addendum to a project without first having gone through the process described in this policy. Project Ad and Award dates will not be delayed due to an incomplete public art process.

A public art plan is developed to incorporate public art into projects on state highways. Include the review of the public art plan by the Public Art Specialty Services Team in project reviews.

950.05(1) Public Art Plan

The public art plan is developed by the Project Engineer's Office or by the local artist or community sponsoring the proposal. The plan provides enough detail and description to convey the intent of the proposed art project. The plan documents how the proposed art meets the criteria listed in 950.04 and includes the following elements:

- Cover sheet with appropriate approval signatures (see 950.06).
- Project overview.
- Location of the proposed art.
- Scale drawings of the proposed art, including proposed materials, attachments, and finishes. Any attachments to fencing or structures, or proposed new structures, will require structural engineering calculations.
- All criteria from 950.04, Criteria for Public Art, addressed and documented.
- Justification and recommendations for public art.
- Documentation showing support by the local community.

Without an approved public art plan, a Maintenance Agreement (as appropriate), and funding, the "art" will not be constructed or installed.

950.05(2) Public Art Specialty Services Team

Include the Public Art Specialty Services Team in the development of public art and the public art plan. The Team includes the following:

- Project Engineer or a designee (if the art is included in a project)
- State Bridge and Structures Architect
- Region or HQ Landscape Architect

- Region Traffic Engineer
- Region Local Programs Engineer (if the proponent is a local community)

For public art proposed within Interstate Limited Access, the following team members are also required:

- Assistant State Design Engineer
- Federal Highway Administration (FHWA) Safety/Geometric Engineer or a designee

Consider team membership from the following functional areas when their expertise is applicable:

- Maintenance
- Planning
- Environmental
- Real Estate Services

950.06 Approvals

950.06(1) Intermediate Approvals

The Public Art Specialty Services Team is responsible for approving the public art; therefore, be sure to involve them in the development of art during the earliest possible phase of project development. This will ensure approvals happen smoothly and WSDOT and FHWA are aware of the public art as soon as possible.

Project development phases include the following:

- Initial Art Concept review: input and approval.
- Selected Art Concept review: input and approval.
- Final Proposed Art review: input and approval.

950.06(2) Final Approval

Approval of the public art plan is considered approval for the public art. The public art plan cover letter needs to include the following approval signatures as appropriate.

950.06(2)(a) Within Limited Access

Public art within Limited Access on the Interstate is approved by:

- Project Engineer or a designee (if the art is included in a project)
- State Bridge and Structures Architect
- Region or HQ Landscape Architect
- Region Traffic Engineer
- Region Local Programs Engineer (if the proponent is a local community)
- Assistant State Design Engineer
- Region Administrator or designee
- FHWA Safety/Geometric Design Engineer or designee

950.06(2)(b) All Other Projects

Public art for all other projects is approved by:

- Project Engineer or a designee (if the art is included in a project)
- Region or HQ Landscape Architect
- State Bridge and Structures Architect
- Region Traffic Engineer
- Region Local Programs Engineer (if the proponent is a local community)
- Region Administrator or designee

950.07 Documentation

The public art plan, complete with approval signatures, is retained in the Design Documentation Package (DDP).

Refer to Chapter 300 for design documentation requirements.

Chapter 1010 Work Zone Safety and Mobility

1010.01 General

Addressing work zone impacts to all road users is an important component in the design of a project and needs to be given adequate consideration early in the design process. Most work zones create some level of traffic impacts and require additional safety features; therefore, all work areas and operations needed for construction must be identified and addressed during the project design. Planners, designers, construction engineers, maintenance personnel, and others all play a role in developing a comprehensive work zone design. Consider including Rail, Freight, and Ports, Commercial Vehicle Services, and Public Transportation Divisions for help coordinating with freight and transit industries. See the WSDOT Project Management website for information on project teams.

This chapter provides the designer with guidance to develop comprehensive work zone strategies and plans to address a project's safety and mobility benefits/improvements for all modes, as well as constructability. A systematic process for addressing work zone impacts is required by federal regulations and state policy.

1010.02 Definitions

The following terms are defined in the Design Manual Glossary:

- Transportation Management Area (TMA)
- Transportation Management Plan (TMP)
- work zone
- work zone impact
- work zone traffic control
- traveling public

1010.03 Work Zone Safety and Mobility

Washington State Department of Transportation (WSDOT) policy per Executive Order E 1001, Work Zone Safety and Mobility, is intended to support systematic consideration and management of work zone impacts across all stages of project development.

The policy states:

> *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.*

Designers should be familiar with this document. The policy defines how WSDOT programs address work zone safety and mobility issues during project planning, design, and construction.

1010.04 Transportation Management Plans and Significant Projects

1010.04(1) Transportation Management Plan

A transportation management plan is a set of strategies for managing the corridor-wide work zone impacts of a project. A TMP is required for all projects and is the key element in addressing all work zone safety and mobility impacts. The TMP development begins in the scoping phase of a project by assessing impacts known at the time and then selecting mitigating strategies and design solutions to manage those impacts. It is very important to continue the development of the TMP throughout the project development process.

Not all work zone impacts have to be addressed with traffic control plans only. Many work zone impacts can be reduced or eliminated through project design elements like alignment choice, materials selection, structure types, overbuilding, and phased construction. Work zone impacts related to work duration may be resolved or reduced through innovative bidding and contract administration.

The three major components of a TMP are described below.

1010.04(1)(a) Temporary Traffic Control

Temporary Traffic Control (TTC) components are those strategies for directing traffic through the work zone and minimizing the duration of the impacts. These components are to be included in the Plans, Specifications, and Estimates (PS&E) as Traffic Control Plans (TCPs) and contract provisions. The TTC components may include but are not limited to the following strategies:

- TTC strategies such as lane closures or shifts, one-lane two-way operations (flagging and or pilot car), staged construction, or full road closures and detours.
- Traffic Control Devices such as temporary signing, channelizing devices (cones, drums), changeable message signs, arrow boards, temporary signals, and temporary pavement markings.
- Corridor Project Coordination, Contracting Strategies, and Innovative Construction Strategies such as A+B bidding, incentives/disincentives, and precast members or rapid cure materials.

1010.04(1)(b) Transportation Operations (TO)

The TO components are those strategies for improving traffic flow and safety through the work zone. Some of these strategies may be included in the PS&E, but could also be WSDOT-managed elements outside the contract. The TO components may include but are not limited to the following strategies:

- Demand Management Strategies such as Transit service improvements, transit incentives, and park & ride promotion.
- Corridor/Network Management (traffic operations) Strategies such as Signal timing/coordination improvements, temporary signals, bus pullouts, reversible lanes, and truck/heavy-vehicle restrictions.
- Work Zone Safety Management Strategies such as using positive protective devices, speed limit reductions, automated flagger assistance devices, radar speed display signs, and smart work zone systems.
- Traffic/Incident Management and Enforcement Strategies such as Work Zone Intelligent Transportation Systems (ITS), Washington State Patrol, tow service, WSDOT Incident Response Team vehicle(s), traffic screens, and emergency pullouts in long work zones with narrowed shoulders.

1010.04(1)(c) Public Information (PI)

The PI components are those strategies for raising awareness of the upcoming project impacts or current restrictions. Public awareness strategies may be developed and implemented by WSDOT through the region or Headquarters (HQ) Communications offices and implemented before and during construction. Motorist information strategies may be WSDOT-managed elements with state equipment outside the contract or identified on plans in the PS&E. The PI components may include, but are not limited to, the following strategies:

- Public Awareness Strategies such as Brochures or mailers, press releases, paid advertisements, and project website (consider providing information in other languages if appropriate).
- Motorist Information Strategies such as Highway advisory radio (HAR), changeable message signs, and transportation management center (TMC).

It is very important to continue the development of the TMP throughout the project development process. Not all work zone impacts have to be addressed with traffic control plans only. Many work zone impacts can be reduced or eliminated through project design elements like alignment choice, materials selection, structure types, overbuilding, and phased construction. Work zone impacts related to work duration may be resolved or reduced through innovative bidding and contract administration.

The TMP Checklist in Exhibit 1010-3 will help identify and organize TMP components. Include the completed checklist in the Project File. For significant projects, develop this checklist and the supporting plans, data, impacts assessment, strategies, capacity/delay analysis and endorsements into a formal TMP document to be included in the Project File. For TMP examples, see:
http://www.ops.fhwa.dot.gov/wz/resources/final_rule/tmp_examples/sample_tmps.htm

http://www.ops.fhwa.dot.gov/wz/resources/publications/trans_mgmt_plans/trans_mgmt_plans.pdf

1010.04(2) Significant Projects

The FHWA definition of a "significant project" is as follows:

> *A significant project is 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 state policy and/or engineering judgment.*
>
> *All Interstate system projects within the boundaries of a designated Transportation Management Area (TMA) that occupy a location for more than three days with either intermittent or continuous lane closures shall be considered as significant projects.*

Note: Significant projects require a TMP document addressing safety and mobility impacts with strategies or elements from all three TMP components.

The size and scale of the TMP document will depend on the project's complexity and impacts. For examples of WSDOT TMP's see:
http://www.wsdot.wa.gov/Safety/WorkZones/resources.htm

For projects not identified as significant, the Temporary Traffic Control components included in the PS&E will be considered the TMP. Transportation Operations and Public Information components may also be required to properly address the impacts as many projects can have significant work zone safety and mobility impacts, but are not necessarily a significant project as defined under the federal requirements stated above. Consider developing a TMP document for these types of projects as well.

The Project Summary must include a Work Zone Strategy Statement and indicate whether the project is significant in regard to work zone impacts.

Significant projects may require a Value Engineering (VE) study (see Chapter 310) and a Cost Risk Assessment (CRA) or Cost Estimate Validation Process (CEVP) that could help define strategies or identify risks: www.wsdot.wa.gov/projects/projectmgmt/riskassessment/

1010.05 Developing TMP Strategies

1010.05(1) Key Considerations

The following list is intended to alert the designer to actions and issues that need to be addressed as part of a TMP. Addressing these items is required per WSDOT's work zone policy and federal regulations, and they are key to the successful development of a project's TMP.

- Determine work zone impacts through an impact assessment process.
- Minimize, mitigate, and manage work zone impacts.
- Integrate work zone impacts strategies early, during planning, programming, and design.
- Develop an accurate scoping estimate based on the work zone strategies.
- Hold a Work Zone Design Strategy Conference early in the design process. (Include bridge, construction, traffic, maintenance, freight, transit, local agency, and law enforcement personnel.)
- Utilize the Work Zone TMP Checklist/TMP document (required for significant projects).
- Emphasize flagger safety.
- Assess work zone mobility through a capacity analysis.
- Integrate project constructability, work efficiency and cost containment into the work zone strategy.
- Attend work zone training.
- Address Washington State traffic and safety regulations as provided for by state law.
- Use the legally adopted *Manual on Uniform Traffic Control Devices* (MUTCD), with Washington State modifications as the minimum standard.
- Provide an appropriate level of traffic control plans (TCPs).
- Consider work zone ITS elements.
- Use established design criteria in work zone roadway and roadside design.
- Accommodate pedestrian access (including ADA requirements) and maintenance of existing transit stops and bicycle traffic.
- Consider maintenance issues and needs through the duration of the project.
- Consider school, hospital, emergency services, and postal delivery, impacts.
- Consider economic impacts (business access) due to traffic delay or restricted access.
- Consider freight mobility; total roadway widths to less than 16 feet should be avoided if possible. Truck routes can be found here:
  http://www.wsdot.wa.gov/Freight/EconCorridors.htm
- Address traffic impacts extending beyond the project limits and impacting other roads.
- Identify seasonal or special event impacts that affect recreation or business due to work zone impacts.

- Consider risk management and tort liability exposure.
- Approach the work zone design from the road user's perspective.
- Incorporate worker safety needs (positive protection) in your work zone designs.
- Account for all needed work areas, operations and possible staging areas.
- Address work vehicle ingress and egress to each work area.
- Use of law enforcement

1010.05(2) Impacts Assessment

One of the most important tasks in developing a TMP is assessing all of the project impacts to mobility and safety. Impacts that are not identified and addressed in the TMP will undoubtedly become issues during the construction phase of the project. A designer needs to possess a clear understanding of how project features will be constructed, including work methods, equipment, materials, and duration, to complete the work. Involve the construction PE when making decisions on assessing and addressing impacts.

A complete and accurate impacts assessment will allow for the development of an effective TMP that should only need minor modifications to address construction issues. The *Traffic Manual* provides information on how to determine expected work zone congestion along with mobility management strategies.

An early and ongoing impacts assessment allows time to:

- Develop TTC, TO, and PI (see Section 1010.04(1)) strategies to address identified impacts as needed to effectively manage the project.
- Resolve potential work zone impacts within the design features of the project. Decisions that consider work zone impacts during bridge type selection, materials selection, advertisement dates, and others have the potential to resolve or minimize work zone impacts.
- Consider innovative mitigation strategies that may involve many stakeholders.

Some impacts may be difficult to completely solve and may ultimately need a management decision to determine the level of mitigation or impact that is acceptable. These types of impacts need to be clearly addressed in the TMP with documentation supporting and explaining the decision.

The following are some examples of impacts that need to be managed during the design of a project:

1. Bridge construction sequence or falsework opening plans need to match the TTC staging or channelization plans. Coordination with the HQ Bridge and Structures Office is essential as the bridge design schedule may differ than the project schedule. 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, possible additional signing needs, and temporary bypass routes. Impacts to shoulder widths due to barrier or bridge staging may impact bicycle or pedestrian access and must be addressed in TTC plans. Refer to Chapter 720 for additional requirements and approvals. Coordination with the Permits Office may be needed.

2. If existing signal and illumination systems are not able to be maintained during the construction phases, plans for temporary systems or connections need to be included in the project.
3. Temporary relocation of existing signing (including overhead signing) may be required and should be detailed in the plans.
4. Permanent traffic loop installation (such as advance loops, turn pockets, and stop bars, and ITS loops) and pavement marking installations (crosswalks, arrows, and so on) may require specific TTC plans.
5. What type of temporary marking is most appropriate for the installation, work duration, and the pavement surface? Will the final pavement surface have a “ghost stripe” potential?
6. Lane shifts onto existing shoulders:
   - Is the depth of the existing shoulder adequate to carry the extra traffic and are there rumble stripe that need to be removed?
   - Are there any existing catch basins or junction boxes located in the shoulder that cannot accept traffic loads over them?
   - 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.
   - Signal head alignment: When the lane is shifted approaching the intersection, is the signal head alignment within appropriate limits?
7. Roundabout construction at an existing intersection requires site-specific staging plans. Roundabouts create many unique construction challenges and each roundabout has very site-specific design features.

1010.05(3) Work Duration

The duration of work is a major factor in determining a strategy and the amount and types of devices to use in traffic control work zones. A project may have work operations with durations that meet several or all of the following conditions:

1010.05(3)(a) Long-Term Stationary Work Zone

This is work that occupies a location continuously for more than three days. Construction signs should be post-mounted and larger; more stable channelizing devices should be used for increased visibility. Temporary barriers, pavement markings, illumination, and other considerations may be required for long-term stationary work. Staged construction or temporary alignment/channelization plans are required with this type of work.

1010.05(3)(b) Intermediate-Term Stationary Work Zone

This is work that occupies a location for up to three days. Signs may still be post-mounted if in place continuously. Temporary pavement markings, in addition to channelization devices, may be required for lane shifts. Barrier and temporary illumination would normally not be used in this work zone duration.

1010.05(3)(c) Short-Term Stationary Work Zone

This is work that occupies a location for more than one hour within a single day. At these locations, all devices are placed and removed during the single period.

1010.05(3)(d) Short-Duration Work Zone

This is work that occupies a location for up to one hour. Because the work time is short, the impact to motorists is usually not significant. Simplified traffic control set-ups are allowed, to reduce worker exposure to traffic. 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 usually apply to maintenance work and are not used on construction projects. (See Work Zone Traffic Control Guidelines for more information.)

1010.05(3)(e) Mobile Work Zone

This is work that moves intermittently or continuously. These operations often involve frequent stops for activities such as sweeping, paint striping, litter cleanup, pothole patching, or utility operations, and they are similar to short-duration work zones. Truck-mounted attenuators, warning signs, flashing vehicle lights, flags, and channelizing devices are used, and they 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.

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.

1010.05(4) Transportation Management Plan (TMP) Strategies

With a completed impacts assessment, strategy development can begin. There are often several strategies to address a work zone impact, and engineering judgment will be needed in selecting the best option. Constructability, along with addressing safety and mobility, is the goal. Selecting a strategy is often a compromise and involves many engineering and non-engineering factors. Work closely with bridge, construction, maintenance and traffic office personnel when selecting and developing strategies for the TMP and PS&E.

Do not assume that strategies chosen for past projects will adequately address the impacts for similar current projects. There may be similarities with the type of work, but each project is unique and is to be approached in that manner. Always look for other options or innovative approaches; 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 *Traffic Manual* contains comprehensive information regarding work zone traffic analysis to determine expected delay and queuing.

For a list of work zone analysis tools, see:
http://ops.fhwa.dot.gov/wz/traffic_analysis/index.htm#tools

1010.05(5) Temporary Traffic Control (TTC) Strategies

1010.05(5)(a) Lane Closure

When one or more traffic lanes are closed, a capacity analysis is necessary to determine the extent of congestion that may result. Night work or peak hour work restrictions may be required if the analysis shows adverse traffic impacts. On highways with speeds over 40 MPH, traffic safety drums and truck-mounted attenuators should be used in lane closures and the drums should not encroach on the open lanes. Additional lanes should be closed if encroachment is necessary. Consider closing additional lanes to increase the lateral buffer space for worker safety.

1010.05(5)(b) Shoulder Closure

A shoulder closure is used for work areas off the traveled way. On high-volume freeways or expressways, they should not be allowed during peak traffic hours. Channelization devices should not encroach on the open lanes of roadways with speeds of 45 mph and above.

1010.05(5)(c) Alternating One-Lane Two-Way Traffic

This strategy involves using one lane for both directions of traffic. Flaggers are used to alternate the traffic movements.

If flaggers are used at an intersection, a flagger is required for each leg of the intersection. Only law enforcement personnel are allowed to flag from the center of an intersection. Close lanes and turn pockets so only one lane of traffic approaches a flagger station. When a signal is present, it shall be turned off or set to red flash mode when flagging.

Law enforcement personnel may be considered for some flagging operations and can be very effective where additional driver compliance is desired. The *Traffic Manual* contains information on the use of law enforcement personnel at work zones.

Flagger safety is a high emphasis area. Do not include alternating traffic with flaggers as a traffic control strategy until all other reasonable means of traffic control have been considered. Flagging stations need to be illuminated at night. Flaggers need escape routes in case of errant vehicles. Provide a method of alerting them to vehicles approaching from behind. Two-way radios or cellular phones are required to allow flaggers to communicate with one another. The flagger’s location, escape route, protection, signing, and any other safety-related issues all need to be incorporated into the traffic control plan for the flagging operation. Flaggers are not to be used on freeways or expressways. Using flaggers solely to instruct motorists to proceed slowly is an unacceptable practice.

Removing flaggers from the roadway during alternating traffic operations can be done with portable temporary traffic control signals or automated flagging assistance devices (AFAD). Portable signals work best when the length between signals will be 1,500 feet maximum and no accesses lie between the temporary signals. Each AFAD unit will need a flagger operating the device from a safe location off the roadway. A traffic control plan should show the advance signing and the AFAD or signal locations. Temporary stop bars, and lighting at the stop bars is required for signal use. For assistance on using these devices, contact the region Traffic Office.

Refer to WAC 296-155-305 for flagging requirements.

1010.05(5)(d) Temporary Alignment and Channelization

Temporary alignments and/or channelization may be an option for long-term work zones or staged traffic control. The following are guiding principles for the design of temporary alignment and channelization plans:

- Use site-specific base data to develop site-specific traffic control plans.
- Use permanent geometric design criteria.
- Provide beginning and ending station ties and curve data.
- Include lane and shoulder widths.
- Provide temporary roadway sections.
- To avoid confusion, do not show existing conflicting or unnecessary details on the plan.
- Do not use straight line tapers through curves; use circular alignment.
- Be aware of existing crown points, lane/shoulder cross slope breaks, and super-elevation transitions that may affect a driver's ability to maintain control of a vehicle.
- If the project has multiple stages, from one stage to the next, show newly constructed features as existing elements. 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 needed for removal of existing markings and placement of the new markings and possibly placement of barriers and attenuators. In urban areas where work hours for lane closures are limited, special consideration may be necessary to allow time to implement the plan, or an interim stage may be necessary.
- Use shoulder closure signing and channelizing devices to close a shoulder prior to a temporary impact attenuator and run of temporary concrete barrier.
- Existing signing may need to be covered or revised, and additional construction warning signs may be needed for the new alignment.

- Temporary pavement marking types and colors should be specified. Long-duration temporary markings should be installed per the Standard Plans for permanent markings.
- For better guidance through shifting or taper areas, consider solid lane lines. Return to broken lane lines between shift areas.
- Provide a list of the approved temporary impact attenuators that may be used for the plan if applicable.
- The plans must provide all the layout information for all the temporary features just as a permanent pavement marking plan would.

1010.05(5)(d)(1) Staged Construction

Staged construction entails combining multiple work areas into a logical order to provide large protected work areas for long durations, which maximizes work operations and minimizes daily impacts to traffic. Temporary alignment and channelization plans must be designed to place traffic in these semi-permanent locations. Minimum geometric design criteria are to be used when developing these plans. Design strategies such as overbuilding for future stages or the use of temporary structures are often part of staged construction on significant impact projects or mega projects. Develop detailed capacity analysis and traffic modeling for each stage.

1010.05(5)(d)(2) Lane Shift/Reduced Lane Width

Traffic lanes may be shifted and/or width-reduced in order to accommodate a long-duration work area when it is not practicable, for capacity reasons, to reduce the number of available lanes. Shifting more than one lane of traffic requires the removal of conflicting pavement markings and the installation of temporary markings; the use of channelization devices to delineate multiple lanes of traffic is not allowed. Use advanced warning signs to show the changed alignment when the lateral shifting distance is greater than one-half of a lane width, and consider the use of solid lane lines through the shift areas.

Utilizing the existing shoulder may be necessary to accommodate the shifting movement. First, determine the structural capacity of the shoulder to ensure its ability to carry the proposed traffic. Remove and inlay existing shoulder rumble strips prior to routing traffic onto the shoulder.

1010.05(5)(d)(3) Traffic Split or Island Work Zone

This strategy separates lanes of traffic traveling in one direction around a work area. On higher-speed roadways, temporary barriers are provided to prevent errant vehicles from entering the work area. Some drivers have difficulty understanding "lane split" configurations, which sometimes results in poor driving decisions such as unnecessary or late lane changes. Braking and erratic lane changes decrease the traffic capacity through the work zone, which results in an unstable traffic flow approaching the lane split.

Evaluate other strategies, such as overbuilding, to keep traffic on one side of the work area to avoid a traffic split if possible.

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 and disincentives to encourage 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 Portable Changeable Message Signs (PCMS), portable Highway Advisory Radio (HAR), and other dynamic devices. Overhead signing and in-lane pavement markings also may be necessary to give additional driver notice of the traffic split.
- 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, it eliminates much of the potential for truck/car conflicts and sorts out undesirable truck lane changes through the work zone. For questions concerning truck operations, contact the HQ Freight Systems Division.
- To discourage lane changing, consider the use of solid lane line markings to delineate traffic approaching the split or island. Refer to the MUTCD for additional details.
- 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 Washington State Patrol (WSP).
- Supplement the existing roadway lighting with additional temporary lighting to improve the visibility of the island work area (see exhibit in Chapter 1040).
- Coordinate with the region Traffic Office for signing and pavement marking details when designing island work zones.

1010.05(5)(d)(4) Temporary Bypass

This strategy 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 right of way. An example of this is the replacement of an existing bridge by building an adjacent temporary structure and shifting traffic onto the temporary structure. A temporary channelization plan will show pavement markings, barrier and attenuators, sign and device placement.

1010.05(5)(d)(5) Median Crossover

This strategy involves placing all multilane highway traffic on one side of the median. Lanes are usually reduced in both directions and one direction is routed across the median. The design for elements of temporary crossovers needs to follow the same guidance as permanent design for alignment, barriers, delineation, and illumination.

- Design crossovers for operating speeds not less than 10 mph below the posted speed limit unless unusual site conditions require a lower design speed.
- Median paving may be required to create crossover locations (consider drainage for the added pavement).
- Use temporary barrier to separate the two directions of traffic normally separated by a median barrier,
- Temporary illumination at the crossover locations (see exhibit in Chapter 1040)
- Straight line crossover tapers work best for highways with narrow paved medians.
- Temporary pavement markings, removal of conflicting existing markings, and construction signs are also required.
- A good array of channelizing devices and properly placed pavement markings is essential in providing clear, positive guidance to drivers.
- Provide a clear roadside recovery area adjacent to the crossover. Consider how the roadway safety hardware (guardrail, crash cushions, and so on) 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. Avoid placing crossover detours near structures.

1010.05(5)(e) Total Closures and Detours

Total closures may be for the project duration or for a critical work operation that has major constructability or safety issues. The main requirement for total closures is the availability of a detour route and if the route can accommodate the increased traffic volumes and trucks turning movements. Local roads may have lower geometric criteria than state facilities. Placing additional and new types of traffic on a local road may create new safety concerns, especially when drivers are accustomed to the geometrics associated with state highways. Pavement integrity and rehabilitation may need to be addressed when traffic is detoured to specific local roadways.

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 47.48). Advance notification of the closure is required, and a signed detour route may be required.

Consider the following road closure issues:

- Communication with all stakeholders, including road users, adjoining property owners, local agencies, transit agencies, the freight industry, emergency services, schools, and others, is required when considering a total closure strategy. This helps determine the level of support for a closure and development of an acceptable closure. Include Rail, Freight, and Ports; Commercial Vehicle Services; and Public Transportation Divisions to help coordinate.
- Analyze a closure strategy and compare it to other strategies, such as staged work zones, to determine which is overall more beneficial. This information helps stakeholders understand the impacts if a closure is not selected.
- A closure decision (other than short-term, minor-impact closures) will require stakeholder acceptance and management approval once impacts and benefits have been analyzed.
- Closures that reopen to a new, completed roadway or other noticeable improvements are generally more accepted by the public.
- Route-to-route connections and other strategic access points may have to be maintained or a reasonable alternative provided.
- Material selection, production rates, and work operation efficiencies have a direct tie to the feasibility of the closure strategy. A strong emphasis has been placed on this area and several successful strategies have been implemented, such as weekend-long closures or extended-duration single-shift closures. These strategies use specific materials such as quick-curing concrete, accelerated work schedules, prefabricated structure components, on-site mix plants, and so on, and are based on actual production rates. The WSDOT Materials Laboratory and the HQ Construction Office are good resources for more information on constructability as a component of an effective work zone strategy.
- Interstate or interstate ramp closures (including interstate closures with interchange ramps as detours) lasting more than 7 days require FHWA 60-day advance notice. (See the Stewardship and Oversight Agreement for closure notification requirements.)
- Short-duration closures of ramps or intersecting streets during off-peak hours do not require extensive approval if advance notice is provided and reasonable alternate routes are available.
- Detailed, project-specific traffic control plans, traffic operation plans, and public information plans are required.
- Depending on the duration of the closure/detour and the anticipated amount and type of traffic that will use the route, consider upgrades to the route such as signal timing, intersection turning radius for large vehicle, structural pavement enhancements, or shoulder widening.

- An approved detour agreement with the appropriate local agency is required for detour routes using local roadways and must be completed prior to project advertisement.
- Document road closure decisions and agreements in the Project File.

1010.05(5)(f) Intermittent Closure

This involves stopping all traffic for a short time to allow the work to proceed. Traffic volumes will determine the allowed duration of the closures. Typically, the closure would be limited to a ten-minute maximum and would occur in the lowest traffic volume hours. Equipment crossing and material delivery are where this type of closure may work well. Traffic is reduced to a single lane on a multilane highway, and a flagger or law enforcement is used to stop traffic.

1010.05(5)(g) Rolling Slowdown

Rolling slowdowns are commonly practiced by the Washington State Patrol (WSP) for emergency closures. They are a legitimate form of traffic control for contractors or utility and highway maintenance crews for very specific short-duration closures (to move large equipment across the highway, to pull power lines across the roadway, to switch traffic onto a new alignment, and so on). They are not to be used for routine work that can be addressed by lane closures or other formal traffic control strategies. Traffic control vehicles, during off-peak hours, 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.

Consider other forms of traffic control as the primary choice before the rolling slowdown. A project-specific traffic control plan (TCP) must be developed for this operation. The TCP or contact provisions should list the work operations in which a rolling slowdown is allowed. The gap required for the work and the location where the rolling slowdown begins needs to be addressed on the TCP. Use of the WSP is encouraged whenever possible. Refer to the Standard Specifications and Work Zone Traffic Control Guidelines for additional information on rolling slowdown operations.

1010.05(5)(h) Pedestrian and Bike Detour Route

When existing pedestrian access routes and bike routes are disrupted due to construction activities, address detour routes 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 reasonably safe and adequate to meet the needs of the user. Also, consider the impacts to transit stops for pedestrians: Will the bus stops be able to remain in use during construction or will adjustments be necessary? (See Chapter 1510 for pedestrian work zone design requirements.)

1010.05(5)(i) Alternative Project Delivery

To reduce construction times and minimize impacts to the traveling public, consider alternative delivery techniques to accomplish this. For more information, see: http://www.wsdot.wa.gov/projects/delivery/alternative/

1010.05(5)(j) Innovative Design/Construction Methods

- Overbuild beyond normal project needs to maintain additional traffic or facilitate staged construction.
- Replace bridges using new alignments so they can be built with minimal impacts.
- Bring adjacent lifts of hot mix asphalt (HMA) to match the latest lifts (lag up), and require a tapered wedge joint to eliminate drop-off and abrupt lane edges to improve motorist safety.
- Require permanent pavement markings at intervals during multi-season projects to limit the duration temporary markings are needed and to avoid temporary marking issues during winter shut-down.

1010.05(6) Transportation Operations (TO) Strategies

The following are operational strategies to consider based on project specific needs:

1010.05(6)(a) Demand Management

- Provide transit service improvements and possible incentives to help reduce demand.
- For long-term freeway projects, consider ramp metering.
- Provide a shuttle service for pedestrians and bicyclists.
- Provide local road improvements (signals modifications, widening, and so on) to improve capacity for use as alternate routes.
- Provide traffic screens to reduce driver distraction.

1010.05(6)(b) Corridor/Network Management

- Provide a temporary express lane with no access through the project.
- Consider signal timing or coordination modifications.
- Provide emergency pullouts for disabled vehicles on projects with long stretches of narrow shoulders and no other access points.
- Use heavy-vehicle restrictions and provide alternate routes or lane use restrictions.

1010.05(6)(c) Work Zone Safety Management

- Provide temporary access road approaches for work zone access.
- Use positive protective devices (barrier) for long-term work zones to improve the environment for workers and motorists.
- Install intrusion alarms or vehicle arresting devices.

- Use speed limit reductions when temporary conditions create a need for motorist slow-downs. Refer to the *Traffic Manual* for additional information, guidance and approval requirements for speed limit reductions in work zones.
- Use advanced queue warning systems depending on the extent of expected work zone congestion on high-speed roadways. Refer to the *Traffic Manual* for additional information and guidance for Smart Work Zone Systems and other simpler truck-mounted PCMS versions.

1010.05(6)(d) Traffic/Incident Management and Enforcement

- Provide law enforcement patrols to reduce speeding and aggressive drivers.
- Provide incident response patrols during construction to reduce delays due to collisions in the work zone.
- Include work zone ITS elements in the project or coordinate with TMC to use existing equipment.
- Provide a dedicated tow service to clear incidents.

1010.05(7) Public Information (PI) Strategies

The following are strategies to consider based on project specific needs:

1010.05(7)(a) Public Awareness

One PI strategy is a public awareness campaign using the media, project websites, public meetings, e-mail updates, and mailed brochures. This gives regular road users advance notice of impacts they can expect and time to plan for alternate routes or other options to avoid project impacts. Involve the region or HQ Communications Office in developing and implementing these strategies. Coordinate transit travel information and restrictions with the Public Transportation Division. 🖰 http://wwwi.wsdot.wa.gov/PubTran/

Coordinate freight travel information and restrictions with the Rail, Freight, and Ports Division.

🖰 http://www.wsdot.wa.gov/freight/

🖰 http://www.wsdot.wa.gov/Freight/Trucking/default

1010.05(7)(b) Driver Information

In addition to work zone signs, provide driver information using highway advisory radio (HAR) and changeable message signs (existing or portable). Include a Smart Work Zone System to provide drivers with real time information on queuing and delays. Involve the region TMC in the development and implementation of these strategies. Additional information on smart work zone systems can be found on the Work Zone Safety web page:
🖰 www.wsdot.wa.gov/safety/workzones/

The Freight Alert system should be used to communicate information with freight industry on work zones. Each region has the capability to send alerts with this system.

http://www.wsdot.wa.gov/freight/

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.

1010.05(7)(c) Pedestrian and Bicycle Information

Include pedestrian and bicycle access information and alternate routes in the public awareness plans. Pedestrian and bicyclist information signing, including alternate route maps specifically for these road users, could be considered.

1010.06 Work Zone Capacity Analysis

Work zone congestion and delay is a significant issue for many highway projects. At high-volume locations with existing capacity problems, even shoulder closures will increase congestion.

All work zone traffic restrictions need to be analyzed to determine the level of impacts. Short-term lane closures may only require work hour restrictions to address delays; long-term temporary channelization, realignments, lane shifts, and more will require a detailed capacity analysis to determine the level of impact. Demand management and public information strategies may be required to address delays. Traffic capacity mitigation measures are important since many projects cannot effectively design out all the work zone impacts. Include a Work Zone & Traffic Analysis in the TMP.

Work zone mobility impacts can have the following effects:

- **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 inappropriate driving actions.
- **Constructability:** Constructing a project efficiently relies on the ability to pursue work operations while maintaining traffic flow. Delays in material delivery, work hour restrictions, and constant installation and removal of traffic control devices all detract from constructability.
- **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.
- **Public Credibility:** Work zone congestion and delay can create poor credibility for WSDOT 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, and so on.
- **User Cost Impacts:** Traffic delays have an economic impact on road users and the surrounding community. Calculated user costs are part of a work zone capacity analysis and may be used to determine liquidated damages specifications.

WSDOT has a responsibility to maintain traffic mobility through and around its projects. The goal is to keep a project's work zone traffic capacity compatible with existing traffic demands. 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.

Maintaining mobility does not rule out innovative strategies such as roadway closures. Planned closures can accelerate work operations, reducing the duration of impacts to road users. These types of traffic control strategies must include demand management and public information plans to notify road users and mitigate and manage the impacts as much as possible.

A work zone capacity analysis helps determine whether a work zone strategy is feasible. Mitigation measures that provide the right combination of good public information, 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 reducing mobility impacts.

Some of the impact issues and mitigating measures commonly addressed by traffic analyses include:

- Work hour time restrictions
- Hourly liquidated damage assessment
- Use of staged 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 (internal and local agency)

Many projects will have several potential work zone strategies, while other projects may only have one obvious work zone strategy. It is possible that a significant mobility impact strategy may be the only option. TMP strategies still need to be considered. An analysis will help show the results of these mitigating measures.

There is no absolute answer for how much congestion and delay are acceptable on a project; it may ultimately become a management decision.

Reductions in traffic capacity are to be mitigated and managed as part of the TMP. The traffic analysis process helps shape the TMP as the work zone strategies are evaluated and refined into traffic control plans and specifications. Maintain analysis documents in the Project File.

1010.06(1) Collecting Traffic Volume Data

Current volume data in the project vicinity is required for accurate traffic analysis results. Seasonal adjustment factors may be needed depending on when the data was collected and when the proposed traffic restrictions may be in place. Assess existing data as early as possible to determine whether additional data collection may be required. The region Traffic Office and the HQ Transportation Data & GIS Office can assist with collecting traffic volume data. Coordination with local agencies may be needed to obtain data on affected local roads.

Refer to the *Traffic Manual* for additional information and guidance.

1010.06(2) Short-Term Work Zone Traffic Analysis

Refer to the *Traffic Manual* for comprehensive work zone capacity information in addition to work zone queue and delay estimation calculations.

For short-term lane closures on multilane highways or alternating one-way traffic on two-lane highways, see Exhibit 1010-1. It provides information for a quick analysis when compared to current hourly volumes on the highway. The basic traffic analysis programs QUEWZ 98, along with hourly volume input, the number of lanes to be closed, the hours of closure, and other default information, will output queue length, delay time, user costs, and running speed.

Exhibit 1010-1 General Lane Closure Work Zone Capacity

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*.

1010.06(3) Long-Term Work Zone Traffic Analysis

For complex strategies that change traffic patterns, a more detailed analysis is required using advanced traffic modeling software. These strategies could include reducing lane and shoulder widths for extended lengths, reducing the number of lanes for extended durations, moving all lanes of traffic onto a temporary alignment, changing access locations to and from the highway, or closures with detours (including public information and traffic operation plans with anticipated reduction in demand). Work with the region Traffic Office for assistance with this level of analysis.

Refer to the *Traffic Manual* for additional information and guidance.

The following resources are also available to assist with the actual analysis and mitigation strategy development upon request:

HQ Transportation Data & GIS Office
HQ Traffic Offices
Region Work Zone Specialist
Region Public Information Office

Training is also available to obtain further knowledge and expertise in traffic analysis (see 1010.12).

1010.07 Work Zone Design

Part 6 of the MUTCD mostly addresses short-duration temporary traffic control standards. Some long-duration work zones may require temporary alignments and channelization, including barrier and attenuator use, temporary illumination and signals, and temporary pedestrian and bicycle routes. Refer to the *Design Manual*'s chapters for permanent features for design guidance.

1010.07(1) Lane Widths

Maintain existing lane widths during work zone operations whenever practicable.

For projects that require lane shifts or narrowed lanes due to work area limits and staging, consider the following before determining the work zone lane configurations to be implemented:

- Overall roadway width available
- Posted speed limit
- Traffic volumes through the project limits
- Number of lanes
- Existing lane and shoulder widths
- Crown points and shoulder slope breaks
- Treat lane lines and construction joints to provide a smooth flow
- Length and duration of lane width reduction (if in place)
- Roadway geometry (cross slope, vertical and horizontal curves)
- Vertical clearances
- Transit and freight vehicles, including over-sized vehicles

Work zone geometric transitions should be minimized or avoided if possible. When necessary, such transitions should be made as smoothly as the space available allows. 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.

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. In order to maintain the minimum lane widths, temporary widening may be needed.

1010.07(2) Buffer Space

Buffer spaces separate road users from the work space or other areas off limits to travel. Buffer spaces also might provide some recovery space for an errant vehicle.

- A lateral buffer provides space between the vehicles and adjacent work space, traffic control device, or a condition such as an abrupt lane edge or drop-off. As a minimum, a 2-foot lateral buffer space is used. Positive Protective Devices may be required if workers are within one lane width of traffic. When temporary barriers are used, place a temporary edge line 2-foot laterally from the barrier.
- When feasible, a longitudinal buffer space is used immediately downstream of a closed or shifted traffic lane or shoulder. This space provides a recovery area for errant vehicles as they approach the work space.

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.

In order to achieve the minimum lateral buffer, there may be instances where 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 buffer needs to be identified on the plan to ensure additional width is available; use temporary roadway cross sections to show the space in relation to the traffic and work area.

1010.07(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 and employee's private vehicles and storage or stockpiling of project materials. The WZCZ applies during working and nonworking hours and applies only to roadside objects introduced by the contractor's operations. It 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 Exhibit 1010-2. 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 a 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 exhibit in Chapter 1600 may be used as a tool to assess increases in WZCZ values.)

Exhibit 1010-2 Minimum Work Zone Clear Zone Distance

Posted Speed	Distance From Traveled Way (ft)
35 mph or less	10
40 mph	15
45 to 55 mph	20
60 mph or greater	30

1010.07(4) Abrupt Lane Edges and Drop-offs

Minimize, mitigate, or eliminate abrupt lane edges and drop-offs whenever practicable. When unavoidable, traffic control plans should provide a protection method. Consider temporary barriers for long duration drop off protection and contract provisions limiting the duration of edges from daily paving operations consistent with Standard Specification section 1-07.23(1).

When a temporary concrete barrier is used to protect a drop-off, provide a lateral offset from the drop-off to the back side of the barrier with an offset distance equal-to or greater than the distance listed in DM Exhibit 1610-3. Provide an edge line on the traffic side of the temporary barrier at least 2-feet from the face of the barrier. Provide a barrier end treatment; such as a buried end, impact attenuator, or end terminal, when the barrier end is located inside the Design Clear Zone.

Open trenches within the traveled way or auxiliary lane shall have a steel-plate cover placed and anchored over them. A wedge of suitable material, if required, shall be placed for a smooth transition between the pavement and the steel plate. Warning signs shall be used to alert motorists of the presence of the steel plates.

Abrupt lane edges, and drop-offs and steel plates require additional warning and considerations for motorcyclists, bicyclists, and pedestrians, including pedestrians with disabilities. Adequate signing to warn the motorcycle rider, bicyclists and pedestrians, including pedestrians with disabilities of these conditions is required. (See RCW 47.36.200 and WAC 468-95-305.) See *Design Manual* Chapter 1510 for work zone pedestrian accommodation guidance.

See Standard Specifications section 1-07.23(1) for the contract requirements for drop off protection and address project specific protection if necessary.

1010.07(5) Vertical Clearance

In accordance with Chapter 720, the minimum vertical clearance over new highways is 16.5 feet. Anything less than the minimum must follow the reduced clearance criteria discussed in Chapter 720 and be included in the temporary traffic control plans. Maintain legal height on temporary falsework for bridge construction projects. Anything less than this must consider over-height vehicle impacts and possible additional signing needs and coordination with permit offices. Widening of existing structures can prove challenging when the existing height is at or less than legal height, so extra care is required in the consideration of over-height vehicles when temporary falsework is necessary. Coordination with the HQ Bridge and Structures Office is essential to ensure traffic needs have been accommodated. Vertical clearance requirements associated with local road networks may be different than what is shown in Chapter 720. Coordinate with the local agency.

1010.07(6) Reduced Speeds in Work Zones

Drivers tend to reduce their speed only if they perceive a need to do so. Reduced speed limits should only be used to address an altered geometry when not able to meet design standards for the existing speed, when the roadway will be narrowed with minimal shy distance to barriers, when roadway conditions warrant a reduction like BST operations, and when there will be workers on foot within a lane width of high-volume traffic traveling at 45 mph and faster without positive protection devices in place. Speed reductions are not applied as a means for selecting lower work zone design criteria (tapers, temporary alignment, device spacing, and so on).

Speed limit reductions are categorized as follows:

Continuous Regulatory Speed Limit Reduction: A speed reduction in place 24 hours a day for the duration of the project, stage, or roadway condition.

Variable Regulatory Speed Limit Reduction: A speed reduction in place only during active work hours (Class B construction signs may be used). This is a good option when positive protection devices are not used.

Advisory Speed Reduction: In combination with a warning sign, an advisory speed plaque may be used to indicate a recommended safe speed through a work zone or work zone condition. Refer to the MUTCD for additional guidance.

Refer to the *Traffic Manual* for additional information, guidance and approval requirements for speed limit reductions in work zones. Include approval documents in the Project File.

1010.07(7) Accommodation for Pedestrians and Bicyclists

Many public highways and streets accommodate pedestrians and bicyclists, predominately in urban areas. During construction, access must be maintained through or around the work zones. When existing pedestrian routes that are accessible to pedestrians with disabilities are closed, the alternate routes must be designed and constructed to meet or exceed the existing level of accessibility. Temporary pedestrian facilities within the work zone must meet accessibility criteria to the maximum extent feasible. (See Chapter 1510 for pedestrian circulation path and pedestrian access route accessibility criteria.) Covered walkways are to be provided where there is a potential for falling objects.

In work areas where the speeds are low (25 mph), or the ADT is 2,000 or less, bicyclists can use the same route as motorized vehicles. For work zones on higher-speed facilities, bicyclists will need a minimum 4-foot shoulder or detour route to provide passage through or around a work zone. Bicyclists may be required to dismount and walk their bikes through a work zone on the route provided for pedestrians.

It may be possible to make other provisions to transport pedestrians and bicyclists through a work zone or with a walking escort around the active work area. Roadway surfaces are an important consideration for pedestrian and bicycle use. Unacceptable conditions such as loose gravel, uneven surfaces, milled pavement, and asphalt tack coats endanger the bicyclist and restrict access to pedestrians with disabilities.

Information can be gathered on bike issues by contacting local bike clubs. Coordination with local bike clubs goes a long way to ensuring their members are notified of work zone impacts, and it helps maintain good public relations. (See Chapter 1520 for more bicycle design requirements and Chapter 1510 and MUTCD Chapter 6D for pedestrian work zone design requirements.)

1010.07(8) Warning Signs for Motorcyclists

The roadway surface condition requires additional warning signs to alert the motorcyclist of work zone conditions. Per RCW 47.36.200 paragraph 2, “(2) If the construction, repair, or maintenance work includes or uses grooved pavement, abrupt lane edges, steel plates, or gravel or earth surfaces, the construction, repair, or maintenance zone must be posted with signs stating the condition, as required by current law, and in addition, must warn motorcyclists of the potential hazard only if the hazard or condition exists on a paved public highway, county road, street, bridge, or other thoroughfare commonly traveled. For the purposes of this subsection, the department shall adopt by rule a uniform sign or signs for this purpose, including at least the following language, "MOTORCYCLES USE EXTREME CAUTION."

1010.07(9) Oversized Vehicles

The region Maintenance offices and the HQ Commercial Vehicle Services Office issue permits to allow vehicles that exceed the legal width, height, or weight limits to use certain routes. If a proposed work zone will reduce roadway width or vertical clearance, or have weight restrictions, adequate warning signs and notification to the HQ Commercial Vehicle Services Office and the appropriate region Maintenance Office is required as a minimum. When the total width of a roadway is to be reduced to less than 16 feet for more than three days, communication with these offices and any other stakeholders is required; include documentation in the Project File. The contract documents shall include provisions requiring the contractor to provide a 30-calendar-day notice prior to placing the restriction.

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 only on warning or prohibition signs. 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, staging, and falsework openings may need to be reconsidered to safely accommodate oversized loads.

1010.08 Temporary Traffic Control Devices

FHWA regulations require that temporary traffic control devices be compliant with the 2016 edition of the Manual for Assessing Safety Hardware (MASH) crash test requirements. In some cases, either the 2009 MASH or the National Cooperative Highway Research Program (NCHRP) Report 350 compliant devices may be used. See Standard Specification 1-10.2(3) for more information.

1010.08(1) Channelizing Devices

Channelizing devices are used to alert and guide road users through the work zone. They are used to channelize traffic away from the work space, pavement drop-offs, or opposing directions of traffic. Traffic Safety Drums are the preferred devices on freeways and expressways as they are highly visible and are less likely to be displaced by traffic wind. 28-inch cones are also used on WSDOT projects. They are a good choice for flagging operations. Tall channelization devices are 42-inch cone-type devices and should be used in place of tubular markers to separate opposing traffic. Tubular markers are not a recommended device unless they are being used to separate traffic on low-volume low-speed roadways. Longitudinal channelizing devices are interconnected devices that provide channelization with no gaps. These devices look like a temporary barrier, but are not approved as a positive protective device. Barricades are a channelization device mostly used to supplement other channelization devices in traffic control operations involving road, ramp, or sidewalk closures.

1010.08(2) Construction Signs

Portable and temporary signs (Class B Construction Signs) are generally used in short-term work zones. They are set up and removed daily or frequently repositioned as the work moves along the highway. These signs are mounted on crashworthy, collapsible sign supports. The minimum mount height is 1 foot above the roadway, but there are temporary sign supports that will provide 5- to 7-foot mounting heights. This may be useful when temporary signs are mounted behind channelizing device or in urban areas with roadside parking that may obstruct sign visibility and multilane facilities. Temporary signs need to be placed such that they do not obstruct pedestrian facilities. Warning signs in place longer than three days at one location must be post-mounted.

Fixed signing (Class A Construction Signs) are the signs mounted on conventional sign supports along or over the roadway. This signing is used for long-term stationary work zones. Details for their design are in Chapter 1020 and the *Standard Plans*. Sign messages, color, configuration, and usage are shown in the MUTCD and the *Sign Fabrication Manual*. Existing signs may need to be covered, removed, or modified during construction.

1010.08(3) Warning Lights

Warning lights are either flashing or steady burn and can be mounted on channelizing devices, barriers, and signs. Secure crashworthy mounting of warning lights is required.

- **Type A:** Low-intensity flashing warning light used on a sign or barricade to warn road users during nighttime hours that they are approaching a work zone.
- **Type B:** High-intensity flashing warning light used on a sign or barricade to warn road users during both daytime and nighttime hours.
- **Type C and Type D 360 degree:** Steady-burn warning lights designed to operate 24 hours a day to delineate the edge of the roadway.

1010.08(4) Arrow Board

The arrow board (Sequential Arrow Sign) displays either an arrow or a chevron pointing in the direction of the intended route of travel. Arrow board displays are required for lane closures on multilane roadways. When closing more than one lane, use an arrow board display for each lane reduction. Place the arrow board 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 boards are not used on two-lane two-way roadways.

1010.08(5) Portable Changeable Message Signs (PCMS)

PCMS have electronic displays that can be modified and programmed with specific messages and may be used to supplement other warning signs. These signs are usually trailer mounted with solar power and batteries to energize the electronic displays. A two-second display of two messages is the recommended method to ensure motorists have time to read the sign's message twice. These devices are not crashworthy and should be removed when not in use, or placed behind barrier or guardrail. PCMS are best used to provide notice of unexpected situations like the potential for traffic delays or queuing and to provide a notice of future closures or restrictions. They should not be used in place of required signs or to provide redundant information.

1010.08(6) Portable Temporary Traffic Control Signals

These versatile trailer-mounted portable signals are battery powered, with the ability to be connected to AC power. They can operate on fixed timing or be traffic actuated. They are typically used on two-lane two-way highways to alternate traffic in a single lane for extended durations.

1010.08(7) Portable Highway Advisory Radio (HAR)

HAR can be used to broadcast AM radio messages about work zone traffic and travel-related information. 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 Traffic Office for specific guidance and advice on the use of these systems.

1010.08(8) Automated Flagger Assistance Device (AFAD)

An AFAD is a flagging machine that is operated remotely by a flagger located off the roadway and away from traffic. This device could be used to enhance safety for flaggers on highways with reduced sight distance or limited escape routes. A traffic control plan is required for use of the AFAD. A flagger is required to operate each device.

Refer to the MUTCD for additional guidance on temporary traffic control zone devices.

1010.08(9) Radar Speed Display Sign (RSDS)

RSDS are a work zone speed management device that display motorist's speed in real time along with a regulatory speed limit sign or advisory speed sign mounted above the speed display.

RSDS work best when a single lane of traffic remains open but may be used when multiple lanes are open. When multiple lanes are open in heavy traffic volume conditions, it may be unclear which vehicle's speed is actually displayed.

RSDS are not an automated speed enforcement speed, but a passive feedback system to drivers. Modest speed reductions of 3 to 6 mph have been recorded when used within an active work zone.

1010.09 Positive Protection Devices

Channelizing devices will not provide adequate worker and road user protection in some work zones. Positive protective devices are required for the following conditions unless an engineering study determines otherwise:

- To separate opposing traffic traveling 45 mph and faster normally separated by a median or existing median barrier.
- Where existing traffic barriers or bridge railings are to be removed.
- For drop-off protection during widening or excavations (see Standard Specification 1-07.23(1)).
- When temporary slopes change clear zone requirements.
- For bridge falsework protection.
- When equipment or materials must remain in the work zone clear zone.
- When newly constructed features in the clear zone will not have permanent protection until later in the project.
- Where temporary signs or light standards are not crashworthy.
- To separate workers from motorized traffic when work zone offers no means of escape for the worker, such as tunnels, bridges, and retaining walls, or for long-duration worker exposure within one lane-width of high-volume traffic with speeds of 45 mph and faster.

1010.09(1) Temporary Barriers

Providing temporary barrier protection may become the key component of the work zone strategy. Barrier use usually requires long-term stationary work zones with pavement marking revisions, and will increase the traffic control costs of a project. The safety benefit versus the cost of using barrier requires careful consideration, and cost should not be the only or primary factor determining the use of barrier. (See Chapter 1610 for guidance on barriers.)

1010.09(1)(a) Concrete Barriers

These are the safety-shape barriers (Type F, Type 2) shown in the Standard Plans. Safety-shape barriers can be unanchored or anchored. See Chapter 1610 for more detailed information on these barriers and their deflection characteristics.

1010.09(1)(b) Movable Barrier Systems

Movable barriers are specially designed segmental barriers that can be moved laterally one lane width or more as a unit with specialized equipment. This allows strategies with frequent or daily relocation of a barrier. The ends of the barrier must be located out of the clear zone or fitted with an impact attenuator. Storage sites at both ends of the barrier will be needed for the barrier-moving machine. WSDOT owns this type of barrier and equipment and it may be available for project use. Pay items are included in the PS&E to deliver the barrier and equipment from and back to the WSDOT storage location and for operation and maintenance during the project.

1010.09(1)(c) Portable Steel Barriers

Portable steel barriers have a lightweight stackable design. They have options for gate-type openings and relocation without heavy equipment. Steel barriers can be unanchored or anchored per the manufacturer’s specifications. The lateral displacement of unanchored steel barriers from vehicle impacts typically ranges from 5 to 8 feet depending on manufacturer. The lateral displacement of anchored steel barriers from vehicle impacts typically ranges from 1 to 3 feet depending on manufacturer and anchor pinning arrangement. Steel barriers are proprietary items. See manufacturer website for more information.

1010.09(2) Impact Attenuators

Within the Design Clear Zone, the approach ends of temporary barriers shall be fitted with impact attenuators. The information in Chapter 1620 provides all the necessary impact attenuator performance and selection information. In addition to the guidance in Chapter 1620, consider the characteristics of the work zone when selecting an attenuator. Selection should consider site specific conditions and the dynamic nature of work zones throughout the project.

Contract plans showing temporary impact attenuator placement need to include a list of the approved attenuators that a contractor may use for that installation. See the Attenuator Selection Template at:

http://www.wsdot.wa.gov/publications/fulltext/design/ProductFolder/Impact_attenuator_selection_template.xlsx

1010.09(3) Transportable Attenuators

A transportable attenuator (TA) is a positive protection device that will provide protection for the work area only a short distance in front of the device. An impact attenuator device is attached to the rear of a large truck the weighs 15,000 lbs. total weight or more to minimize the roll-ahead distance when impacted by an errant vehicle. A TA should be used on all roadway operations with speeds of 45 mph and faster.

1010.10 Other Traffic Control Devices or Features

1010.10(1) Delineation

Temporary pavement markings will be required when permanent pavement markings are obliterated due to construction operations or temporary reconfigurations needed for long-term work zone strategies. Temporary pavement markings can be made using paint, preformed tape, or raised pavement markers. Complex projects will most likely require both long- and short-duration temporary markings. All temporary pavement markings must be retroreflective and match permanent pavement marking colors. All conflicting pavement markings must be completely removed. Temporary pavement markings are installed in accordance with the Standard Plans and Standard Specifications.

Short-duration temporary pavement markings are made with materials intended to last only until permanent markings can be installed on paving and BST projects, or for short durations between construction stages. Short-duration broken line patterns typically consist of a 4-foot line with a 36-foot gap for paint and tape markings but may be increased to a 10-foot line with a 30-foot gap when specified in the Contract. Short-duration broken line patterns consist of a grouping of three raised pavement markings at 3-foot spacing with a 34-foot gap. Flexible raised pavement markers are required for bituminous surface treatments but typically are not allowed on other pavement types. Temporary edge lines are installed only when specified in the plans. When specified, temporary edge lines are either solid lines or raised pavement markers at 5-foot spacing.

Long-duration temporary pavement markings layouts will match permanent pavement marking standards and should be used on projects spanning multiple seasons and/or wintering over. To enhance wet-weather visibility, long-duration temporary pavement markings should be supplemented with reflective Type 2 Raised Pavement Markers. Long-duration markings need to be detailed in the contract plans for installation and material type. Pre-formed tapes should be used on the final pavement surface to avoid leaving scars when removed.

Lateral clearance markers are used at the angle points of barriers where they encroach on or otherwise restrict the adjacent shoulder. Barrier delineation is necessary where the barrier is less than 4 feet from the edge of traveled way.

Guideposts may be considered to aid nighttime driving through temporary alignments or diversions. (See Chapter 1030 for delineation requirements.)

1010.10(2) Screening

Screening devices can be used to reduce motorists' distraction due to construction activities adjacent to the traveled way. Consider screening when a highway operates near capacity during most of the day. Screening should be positioned behind traffic barriers to prevent impacts by errant vehicles and should be 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 criteria if exposed to traffic and is approved by the Engineer prior to installation.

Glare screening may be required 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 construction equipment and the headlights of other vehicles on adjacent roadways. Make sure that motorists' sight distance 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.

1010.10(3) 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 or diversions.
- Median crossovers on freeways.
- Complex or temporary alignment or channelization.
- Haul road crossings (if operational at night).
- Temporary traffic signals.
- Temporary ramp connections.
- Projects with lane shifts and restricted geometrics.
- Projects with existing illumination that needs to be removed as part of the construction process.

Illumination is required when:

- Traffic flow is split around or near an obstruction.
- Flaggers are necessary for nighttime construction activities (supplemental lighting of the flagger stations by use of portable light plants or other approved methods). Refer to *Standard Specification* 1-10.3(1)A.

For information on light levels and other electrical design requirements, see Chapter 1040.

1010.10(4) Signals

A permanent signal system can be modified for a temporary configuration such as temporary pole locations during intersection construction, span wire systems, and adjustment of signal heads and alternative detection systems to accommodate a construction stage (see Chapter 1330).

1010.10(5) Smart Work Zone Systems (SWZS)

A Smart Work Zone System uses real time information to optimize the safety and efficiency of traffic through the work zone.

SWZS can provide information such as queue detection for "slowed or stopped traffic ahead" messaging before motorists see brake lights, merging instructions (zipper merging where motorists use all open lanes up to the merge point where they take turns merging) to reduce the queue lengths, or travel time information so drivers can choose alternate routes.

Portable equipment used in SWZS may include portable changeable message signs, portable roadside traffic sensors and cameras that communicate wirelessly through a web-based central management platform. Pre-determined messages will be displayed on the changeable message signs approaching a work area based on traffic data from the portable sensors also placed approaching the work area. A SWZS technician will install, program and monitor the system.

Existing permanent freeway cameras and message boards could also be part of a SWZS; coordination with the region Traffic Management Center (TMC) will be required to determine how these devices may be included and the information sharing with the SWZS and the TMC.

1010.11 Traffic Control Plan Development and PS&E

WSDOT projects need to include plans and payment items for controlling traffic based on a strategy that is consistent with the project construction elements, even though there may be more than one workable strategy. A constructible and biddable method of temporary traffic control is the goal. The contractor has the option of adopting the contract plans or proposing an alternative method.

1010.11(1) Traffic Control Plans (TCPs)

"Typical" traffic control plans are generic in nature and are not intended to address all site conditions. They are intended for use at multiple work locations and roadways with little or no field modifications necessary. Typical plans may be all that are needed for basic paving projects. Some typical plans are located at:
www.wsdot.wa.gov/design/standards/plansheet.htm

"Project-specific" traffic control plans are typical-type plans that have been modified to fit a specific project or roadway condition. Dimension lines for signs and device placement have the distances based on the project highway speed limit, and spacing charts have been removed; the lane and roadway configuration may also be modified to match the project conditions.

"Site-specific" traffic control plans are drawn for a specific location. Scaled base data drawn plans will be the most accurate as device placement and layout issues can be resolved by the designer. These types of plans should be used for temporary alignment and channelization for long-duration traffic control. Making a "project-specific" plan applicable for a site-specific location is another option, but the designer must ensure the device layout will match the site-specific location since the plan is usually not to scale.

The following plans, in addition to the TCP types above addressing the TTC strategies, may be included in the PS&E.

1010.11(1)(a) Construction Sign Plan

Show Class A Construction Signs that will remain in place for the duration of the project located by either station or milepost. Verify the locations to avoid conflicts with existing signing or other roadway features. These locations may still be subject to movement in the field to fit specific conditions. For simple projects these sign are often shown on the vicinity map sheet.

1010.11(1)(b) Construction Sign Specification Sheet

Provide a Class A Construction Sign Specifications sheet on complex or staged projects. Include location, post information, and notes for Standard Plans or other specific sign information and sign details.

1010.11(1)(c) Quantity Tabulation Sheets

Quantity Tabulation sheets are a good idea for barrier and attenuator items and temporary pavement markings on projects with large quantities of these items or for staged construction projects.

1010.11(1)(d) 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 provides the contractor a quick referencing tool indicating the applicable traffic control plan for the specific work operation.

1010.11(1)(e) Construction Sequence Plans

Sequence plans are placed early in the plan set and are intended to show the proposed construction stages and the work required for each stage. They should refer to the corresponding TCPs for the traffic control details of each stage.

1010.11(1)(f) Temporary Signal Plan

The temporary signal plan will follow conventions used to develop permanent signals (as described in Chapter 1330), but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations. Ensure opposing left-turn clearances are maintained as described in Chapter 1310 if channelization has been temporarily revised, or adjust signal timing to accommodate. Some existing systems can be maintained using temporary span wires for signal heads and video, microwave actuation, or timed control.

1010.11(1)(g) 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 1040), but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations.

1010.11(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.

1010.11(3) Cost Estimating

Temporary traffic control devices and traffic control labor can be difficult to estimate. There is no way of knowing how many operations a contractor may implement at the same time. The best method is to follow the working day estimate schedule and the TCPs that will be used for each operation. Temporary signs and devices will be used on many plans, but the estimated quantity reflects the most used at any one time. To use the lump sum item to pay for all temporary traffic control, be certain how the contractor’s work operations will progress and that the traffic control plans fully define the work zone expectations.

1010.12 Training and Resources

Temporary traffic control-related training is an important component in an effective work zone safety and mobility program. Federal regulations require that those involved in the development, design, implementation, operation, inspection, and enforcement be trained at a level consistent with their responsibilities.

1010.12(1) Training Courses

The following work zone related courses are available through the Talent Development office and the State Work Zone Training Specialist can assist with the availability and scheduling of classes:

- **Work Zone Traffic Control Design:** This 2-day course, taught by the HQ Traffic Office, focuses on work zone safety and mobility through transportation management plan and temporary traffic control PS&E development.

- **Traffic Control Supervisor (TCS) Certification:** This course is a 1-day add-on to the Work Zone Traffic Control Design course for WSDOT employees that want to become certified as a TCS. For those with a current TCS card, attending this 1-day class only will provide re-certification.
- **Flagger Certification:** This course is for employees who may have flagging duties or want to become a certified Traffic Control Supervisor. The safety offices can assist with class scheduling.
- Traffic analysis, traffic engineering, pedestrian facilities design and other courses may also be available and apply to work zone safety and mobility.

The American Traffic Safety Services Association (ATSSA) offers free or low-cost training through an FHWA work zone safety grant.

1010.12(2) Resources

The responsibility of the designer to fully address all work zone traffic control impacts is very important because the level of traffic safety and mobility will be directly affected by the effectiveness of the transportation management plan (TMP). The following resources are available to assist the designer with various aspects of the work zone design effort.

1010.12(2)(a) 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. They include:

- Region Traffic Office
- Region Construction and Design Offices

1010.12(2)(b) 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. They include:

- State Assistant Traffic Design Engineer
- State Work Zone Engineer
- WSDOT Work Zone Web Page

1010.12(2)(c) FHWA Work Zone Resources

The FHWA Washington Division Office and Headquarters (HQ) Office may be able to provide some additional information through the WSDOT HQ Traffic Office. The FHWA also has a work zone web page: www.ops.fhwa.dot.gov/wz/

1010.13 Documentation

Refer to Chapter 300 for design documentation requirements.

1010.14 References

1010.14(1) Federal/State Laws and Codes

23 Code of Federal Regulations (CFR) Part 630 Subpart J and Subpart K – Work Zone Safety and Mobility and Temporary Traffic Control Devices

See Chapter 1510 for Americans with Disabilities Act policy and references.

"Final Rule on Work Zone Safety and Mobility," Federal Highway Administration (FHWA), Published on September 9, 2004

www.ops.fhwa.dot.gov/wz/resources/final_rule.htm

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

1010.14(2) Design Guidance

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

Executive Order E 1001, Work Zone Safety and Mobility

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1001.pdf

Executive Order E 1060, Speed Limit Reductions in Work Zones

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1060.pdf

Executive Order E 1033, WSDOT Employee Safety

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1033.pdf

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

1010.14(3) Supporting Information

Construction Manual, M 41-01, WSDOT

"Crashworthy Work Zone Traffic Control Devices," Report 553, NCHRP, 2006

Environmental Manual, M 31-11, WSDOT

Highway Capacity Manual, 2010, TRB

ITE Temporary Traffic Control Device Handbook, 2001

ITS in Work Zones 🖰 www.ops.fhwa.dot.gov/wz/its/

"Recommended Procedures for the Safety Evaluation of Highway Features," Report 350, NCHRP, 1993

Roadside Design Guide, AASHTO, 2011

Manual for Assessing Safety Hardware, AASHTO, 2009

Manual for Assessing Safety Hardware, AASHTO, 2016

Work Zone & Traffic Analysis, FHWA 🖰 www.ops.fhwa.dot.gov/wz/traffic_analysis.htm

Work Zone Operations Best Practices Guidebook, FHWA, 2007
🖰 www.ops.fhwa.dot.gov/wz/practices/practices.htm

Work Zone Safety and Mobility, FHWA 🖰 www.ops.fhwa.dot.gov/wz/index.asp

Work Zone Safety Web Page, WSDOT 🖰 www.wsdot.wa.gov/safety/workzones/

WSDOT Project Management website: 🖰 http://www.wsdot.wa.gov/Projects/ProjectMgmt/

Exhibit 1010-3 Transportation Management Plan Components Checklist

Use the following checklist to develop a formal TMP document on significant projects.

TMP Component	✓
1. Introductory Material	
Cover page	
Licensed Engineer stamp page (if necessary)	
Table of contents	
List of figures	
List of tables	
List of abbreviations and symbols	
Terminology	
2. Executive Summary	
3. TMP Roles and Responsibilities	
TMP manager	
Stakeholders/review committee	
Approval contact(s)	
TMP implementation task leaders (public information liaison, incident management coordinator)	
TMP monitors	
Emergency contacts	
4. Project Description	
Project background	
Project type	
Project area/corridor	
Project goals and constraints	
Proposed construction phasing/staging	
General schedule and timeline	
Adjacent projects	
5. Existing and Future Conditions	
Data collection and modeling approach	
Existing roadway characteristics (history, roadway classification, number of lanes, geometrics, urban/suburban/rural)	
Existing and historical traffic data (volumes, speed, capacity, volume-to-capacity ratio, percent trucks, queue length, peak traffic hours)	
Existing traffic operations (signal timing, traffic controls)	
Incident and crash data	
Local community and business concerns/issues	
Traffic growth rates (for future construction dates)	
Traffic predictions during construction (volume, delay, queue)	
6. Work Zone Impacts Assessment Report	
Qualitative summary of anticipated work zone impacts	
Impacts assessment of alternative project design and management strategies (in conjunction with each other)	
• Construction approach/phasing/staging strategies	
• Work zone impacts management strategies	

Exhibit 1010-3 Transportation Management Plan Components Checklist (continued)

TMP Component	✓
Traffic analysis results (if applicable)	
• Traffic analysis strategies	
• Measures of effectiveness	
• Analysis tool selection methodology and justification	
• Analysis results	
Traffic (volume, capacity, delay, queue, noise)	
Safety	
Adequacy of detour routes	
Business/community impact	
Seasonal impacts	
Cost-effectiveness/evaluation of alternatives	
Selected alternative	
• Construction approach/phasing/staging strategy	
• Work zone impacts management strategies	
7. Selected Work Zone Impacts Management Strategies	
Temporary Traffic Control (TTC) strategies	
• Control strategies	
• Traffic control devices	
• Corridor Project coordination, contracting, and innovative construction strategies	
Public Information (PI)	
• Public awareness strategies	
• Motorist information strategies	
Transportation Operations (TO)	
• Demand management strategies	
• Corridor/network management strategies	
• Work zone safety management strategies	
• Traffic/incident management and enforcement strategies	
8. TMP Monitoring	
Monitoring requirements	
Evaluation report of successes and failures of TMP	
9. Contingency Plans	
Trigger points	
Decision tree	
Contractor's contingency plan	
Standby equipment or personnel	
10. TMP Implementation Costs	
Itemized costs	
Cost responsibilities/sharing opportunities	
Funding source(s)	
11. Special Considerations (as needed)	
12. Attachments (as needed)	

Chapter 1020 Signing

1020.01 General

The Washington State Department of Transportation (WSDOT) uses signing as the 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 directional information 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 Traffic Engineer. The use of nonstandard signs is strongly discouraged and their use requires the approval of the State Traffic Engineer.

Apply the following criteria when determining whether to replace or modify existing signs:

- Current sign's service life is reached
- Lack of nighttime retroreflectivity
- Substantial damage, vandalism, or deterioration
- Replace existing signs with either Type I or Type II sheeting
- 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 in accordance with Chapter 1600.

1020.02 Design Components

1020.02(1) Location

The MUTCD contains the guidelines for positioning signs. Check sign locations to ensure the motorist's view of the sign is not obscured by other roadside appurtenances. Also, determine whether 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.

1020.02(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 provide for visibility and adequate response time. In most cases, signs can be shifted longitudinally to enhance safety without compromising their intended purpose.

1020.02(3) Lateral Clearance

The *Standard Plans* and the MUTCD contain minimum requirements for the lateral placement of signs. Where possible, position the signs at the maximum feasible lateral clearance for safety and reduced maintenance costs. Locate large guide signs and motorist information signs beyond the Design Clear Zone (see Chapter 1600) where limited right of way or other physical constraints are not a factor. 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 feet down the slope. When signs are placed on fill slopes steeper than 6H:1V, locate the support at least 12 feet 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 signposts located behind traffic barriers. Install longitudinal barriers 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 (see Chapter 1610).

Do not locate signposts 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 (see the *Standard Plans*). 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.

1020.02(4) Sign Heights

For ground-mounted signs installed at the side of the road, provide a mounting height of at least 7 feet, 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 feet.

Do not attach supplemental guide signs to the posts below the hinge mechanism or the 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-foot 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 feet, measured from the bottom of the sign to the edge of traveled way. A lower mounting height of 5 feet may be used when replacing a sign panel on an existing sign assembly located behind the longitudinal barrier. The *Standard Plans* shows typical sign installations.

For ground-mounted signs installed on multiple posts that are a minimum of

12 feet from the edge of traveled way in cut sections, the minimum height clearance between the sign and the ground for the post farther from the edge of traveled way is as follows:

- For slopes 2H:1V and steeper, the minimum height clearance is 2 feet.
- For slopes 3H:1V or flatter, the minimum height clearance is 7 feet.

Signs used to reserve parking for people with disabilities are installed at each designated parking stall and are mounted 7 feet above the surface at the sign location.

1020.02(5) Foundations

Foundation details for timber and steel ground-mounted sign supports are shown in the *Standard Plans*, which 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. Use the data obtained from the geotechnical report to select the foundation type.

- 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 design has a large rectangular footing design and is an alternative to the Type 1 foundation when the concrete shaft is not suitable.
- The **Type 3** foundation design is used in poorer soil conditions where the lateral bearing pressure of the soil is between 1,500 psf and 2,500 psf.

If a nonstandard foundation or monotube structure design is planned, forward the report to the Headquarters (HQ) Bridge and Structures Office for use in developing a suitable foundation design (see Chapter 610).

1020.02(6) Signposts

Ground-mounted signs are installed on either timber 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 Exhibits 1020-2, 1020-3, and 1020-4 and the *Standard Plans* to determine the posts required for each installation. Coordinate with the region Maintenance Office concerning signpost installation.

Use steel posts with breakaway supports that are multidirectional if the support is likely to be hit from more than one direction. For any wide flange multiple-steel post installations located within the Design Clear Zone, the total weight of all the posts in a 7-foot-wide path is not to exceed a combined post weight of 34 lbs/foot. Use the Wide Flange Beam Weights table in Exhibit 1020-3 to determine wide flange steel post weights. If the proposed sign configuration does not meet the weight criterion, relocate, resize, or provide barrier protection for the proposed installation.

All signposts are to be designed to 90 mph wind loads. Design features of breakaway supports are shown in the *Standard Plans*. Steel signposts commonly used are: Perforated Square Steel Tube (PSST); Square Steel Tube (SST); Round Pipe (RP); and Wide Flange "H-Beam." Steel posts with Type TP-A, TP-B, PL, PL-T, PL-U, AS, AP, SB-1, and SB-2 bases have multidirectional breakaway features.

1020.03 Overhead Installation

Guidance on the use of overhead sign installations is provided 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 HQ Bridge and Structures Office designs structure-mounted sign mountings, monotube sign bridges, and monotube cantilever sign supports. For overhead sign installation designs, provide sign dimensions, horizontal location in relation to the roadway, and location of the lighting fixtures to facilitate design of the mounting components by the HQ Bridge and Structures Office. Provide existing and proposed sign dimensions to the Bridge Preservation Office for review when replacing or modifying any overhead sign.

1020.03(1) Illumination

The retroreflectivity of currently approved sign sheeting removes the need to provide illumination for most sign installations.

The sign lights for existing illuminated overhead and ground-mounted signs can only be de-energized and removed if the retroreflective sheeting is adequate for nighttime legibility, or replace the existing sign with a new sign (see Exhibit 1020-1 for sheeting requirements). A nighttime assessment of all nonilluminated overhead signs within the project limits is required. Replace all signs that have inadequate retroreflectivity (contact the region Traffic Office). In situations where a nonhighway light source interferes with a sign’s legibility, consider relocating the sign or providing sign lights.

Flashing beacon signs are used to alert motorists of unusual or unexpected driving conditions ahead. Sign lights are unnecessary on flashing beacon signs when appropriate sign sheeting, full circle or tunnel signal head visors, and automatic dimmer devices are used.

Exhibit 1020-1 Reflective Sheeting Requirements for Overhead Signs

Overhead Sign Type	Sheeting Type (Background)	Sheeting Type (Legend & Border)
EXIT ONLY guide sign	IV*	XI
Guide signs for left side exits	IV	XI
Other guide signs	IV	XI
Overhead street name signs	IV	XI
Regulatory signs	IV	n/a
Warning signs	IX or XI	n/a
*For Yellow Background Sheeting, use Type IX or XI Fluorescent Sheeting.		

All other overhead signs are illuminated only when one of the following conditions is present:

- Sign visibility is less than 800 feet due to intervening sight obstructions such as highway structures or roadside features.
- Signs directly adjacent to other overhead signs have sign lights.

1020.03(2) Vertical Clearance

The minimum vertical clearance from the roadway surface to the lowest point of an overhead sign assembly is 17 feet 6 inches. The minimum vertical clearance from the roadway surface to the lowest point of an overhead sign assembly without sign light(s) is 19 feet 6 inches. The maximum clearance is 21 feet. Vertically unbalanced mountings should be avoided on all overhead sign structures. Provide existing and proposed sign dimensions to the Bridge Preservation Office for review when replacing or modifying existing overhead signs. Contact the HQ Traffic Office regarding signs under bridges and in tunnels.

1020.03(3) Horizontal Placement

Consider roadway geometrics and anticipated traffic characteristics when locating signs above the lane(s) to which they apply. Install advance guide signs/exit direction signs that require an EXIT ONLY and “down arrow” panel directly above the drop lanes. To reduce driver confusion about which lane is being dropped, avoid locating a sign with an EXIT ONLY panel on a horizontal curve.

1020.03(4) Service Walkways

Walkways are provided on structure-mounted signs, truss-type sign bridges, and truss-type cantilever sign supports where roadway and traffic conditions prohibit normal sign maintenance activities. Monotube sign bridges/cantilever sign supports normally 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 and vandalize the signs. Maintenance costs for cleaning or replacing the vandalized signs at these locations can exceed the benefit of providing the service walkway.

1020.04 State Highway Route Numbers

For state routes, RCW 47.36.095 authorizes WSDOT to sign state highways using a system of state route numbers assigned to eliminate duplication of numbers. This numbering system follows the system employed by the federal government in the assignment of Interstate and U.S. routes: odd numbers indicate general north-south routes and even numbers indicate general east-west routes.

1020.05 Mileposts

Milepost markers are a part of a statewide system for all state highways and are installed in accordance with Executive Order E 1064, “State Route Mileposts,” and Chapter 2 of the *Traffic Manual*.

1020.06 Guide Sign Plan

A preliminary guide sign plan is developed to identify existing and proposed guide signing on state highways and is reviewed by the region Traffic Engineer. Preliminary guide signs for Interstate routes are to be furnished to the HQ Traffic Office for review and concurrence. The plan provides an easily understood graphic representation of the signing and its continuity to motorist destinations, activities, and services. It is also used to identify deficiencies or poorly defined routes of travel. A guide sign plan for safety and mobility Improvement projects 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 Traffic Engineer.

1020.07 Documentation

Refer to Chapter 300 for design documentation requirements.

1020.08 References

1020.08(1) Federal/State Laws and Codes

23 Code of Federal Regulations (CFR) 655, Traffic Operations

WSDOT Executive Order E 1064, “State Route Mileposts,” WSDOT

Revised Code of Washington (RCW) 47.36, Traffic control devices

1020.08(2) Design Guidance

Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), 2009 Edition, FHWA, 2003, including the Washington State Modifications to the MUTCD, WAC 468-95*Plans Preparation Manual*, M 22-31, WSDOT

Sign Fabrication Manual, M 55-05, WSDOT

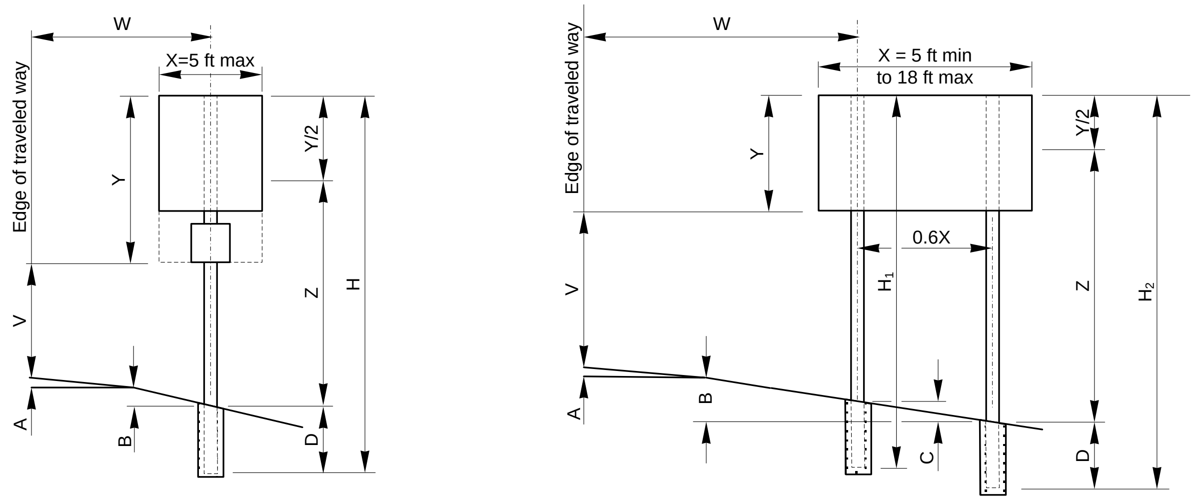
Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, Edition, Washington DC, AASHTO, 2001

Traffic Manual, M 51-02, WSDOT

Exhibit 1020-2 Timber Posts



Notes:
The following designs are *not permitted* when a sign is to be located in or outside the Design Clear Zone in an area where it is likely to be struck by an errant vehicle:

1. A sign with any post larger than 6x8 inches.
2. A 2-post, 3-post, or 4-post sign that uses 6x6-inch or larger posts and has two posts spaced less than 7 ft apart on center.

Table 1 Timber Post Selection

	Number of Posts				
	1	2	3	4	
4 x 4	60	115	175	235	3
4 x 6	125	335	500	675	4
6 x 6	200	415	620	815	4
6 x 8	330	695	1150	1515	5
6 x 10	670	1355	2030	2700	6
8 x 10	835	1685	2515	3360	6
6 x 12	985	2005	2965	3945	7

Values shown are the maximum permitted.
For timber grade requirements, see the *Standard Specifications*.
Foundation depths are based on allowable lateral bearing pressure in excess of 2500 psf.
If the value (X)(Y)(Z) amount exceeds the limit for 6x12 post(s), use steel post(s) for sign installation.

A = Vertical distance from edge of traveled way to edge of shoulder
B = Vertical distance from slope catch point to centerline of longest post
C = Vertical distance between adjacent posts
X & Y = Single sign or back-to-back signs: Overall dimensions of the sign
Multiple signs: Dimensions of the area within the perimeter of a rectangle enclosing the extremities of the sign
Z = Height from ground line to midheight of sign at the centerline of the longest post
D = Embedment depth
H = Total post height
V = Vertical clearance from edge of traveled way
W = Distance from edge of traveled way to the centerline of the post nearest the roadway

Design Example – Single Post
Given:
Sign 3 ft wide, 3.5 ft high; a secondary sign 1.5 ft wide, 2 ft high, mounted 3 inches (0.25 ft) below;
8-ft shoulder with 2% slope; 6H:1V embankment;
W = 15 ft; V = 5 ft
Solution:
X = 3 ft
Y = 3.5 + 2 + 0.25 = 5.75 ft
A = (0.02)(8) = 0.16
B = (W-8)/6 = (15-8)/6 = 1.17
Z = Y/2 + V + A + B
= (5.75/2) + 5 + 0.16 + 1.17 = 9.2 ft
(X)(Y)(Z) = (3)(5.75)(9.2) = 158.7 ft^3
Since 159 ft^3< 200 ft^3, from Table 1, select 6x6 post
H = 9.2 + (5.75/2) + 4 = 16.1 ft

Design Example – Double Post
Given:
Sign 12 ft wide, 4 ft high; 10-ft shoulder with 2% slope; 6H:1V embankment; W = 25 ft; V = 7 ft
Solution:
X = 12 ft; Y = 4 ft
A = (0.02)(10) = 0.2
B = [(W-10) + (0.6X)]/6 = [(25-10) + (0.6)(12)]/6 = 3.7
C = (0.6)(12)/6 = 1.2
Z = Y/2 + V + A + B = 4/2+7 + 0.2 + 3.7 = 12.9 ft
(X)(Y)(Z) = (12)(4)(12.9) = 619 ft^3
Since 619 ft^3 < 695 ft^3, select two 6x8 posts.
H_2 = Y/2 + Z + D = 4/2 + 12.9 + 5 = 19.9 ft
H_1 = H_2-C = 19.9-1.2 = 18.7 ft

Note: 6x6 and larger posts require 7-ft spacing. Sign may be installed within the Design Clear Zone.

Exhibit 1020-3 Wide Flange Steel Posts

X & Y = Single sign or back-to-back signs: Overall dimensions of the sign

Multiple signs: Dimensions of the area within the perimeter of a rectangle enclosing the extremities of the signs

Z = Height from the base connection (2½ inches above the post foundation for wide flange beams) to the midheight of the sign at the centerline of the longest post

H = Post length

V = Vertical clearance from the edge of traveled way

W = Distance from the edge of traveled way to the centerline of the longest post nearest the roadway

Design Example – Steel Post Selection

Given:

Sign 22 ft wide, 12 ft high; 10 ft shoulder with 2% slope; 3H:1V embankment; W = 32 ft; V = 7ft.

Solution:

X = 22

Y = 12

A = (0.02)(10) = 0.2

B = [(W-10) + (0.7)(X/3)] = [(32-10) + (0.7x22)]/3 = 12.5

C = (0.35)(22)/3 = 2.6

Z = Y/2 + V + A + B-0.21 = 12/2 + 7 + 0.2 + 12.5-0.21 = 25.5 ft

(X)(Y)(Z) = (22)(12)(25.5) = 6729 ft^3

Since 6729 ft^3 < 9480 ft^3, select three W10x26 (ASTM A36) or W10x22 (ASTM A992) (see the *Standard Plans*)

$H3 = 12/2 + 25.5 = 31.5$ ft

$H2 = H3-C = 31.5-2.6 = 28.9$ ft

$H1 = H2-C = 28.9-2.6 = 26.3$ ft

Table 1 Wide Flange Steel Post Selection

Wide Flange Beam			
Post Size		(X)(Y)(Z) (ft^3)	
		Number of Posts	
ASTM A992	ASTM A36	2	3
W6x9	W6x12	1570	2355
W6x12	W6x16	2340	3510
W8x18	W8x21	4120	6180
W10x22	W10x26	6320	9480
W12x26	W12x30	8700	- - -

Table 2 Wide Flange Beam Weights

Beam Size	Weight lbs/ft	Beam Size	Weight lbs/ft
W6x9	9	W8x21	21
W6x12	12	W10x22	22
W6x16	16	W10x26	26
W8x18	18	W12x26	26
		W10x30	30

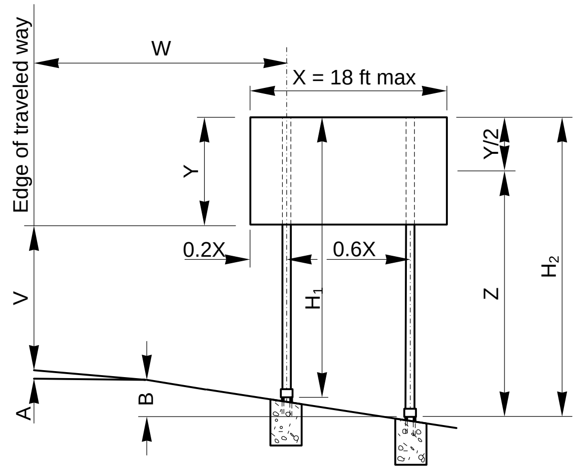
Notes:

Values shown in Table 1 are the maximum permitted.

A single-wide flange post installation is not allowed. Consider using one of the following: perforated square steel tube posts, solid steel tube posts, or round steel posts.

For post selection for other than wide flange beam supports and a single-post assembly, see the *Standard Plans*.

(See the *Standard Plans* for additional information.)



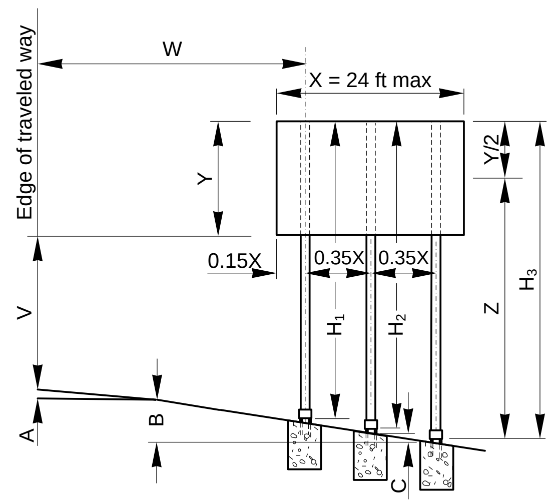


Exhibit 1020-4 Square Steel Posts

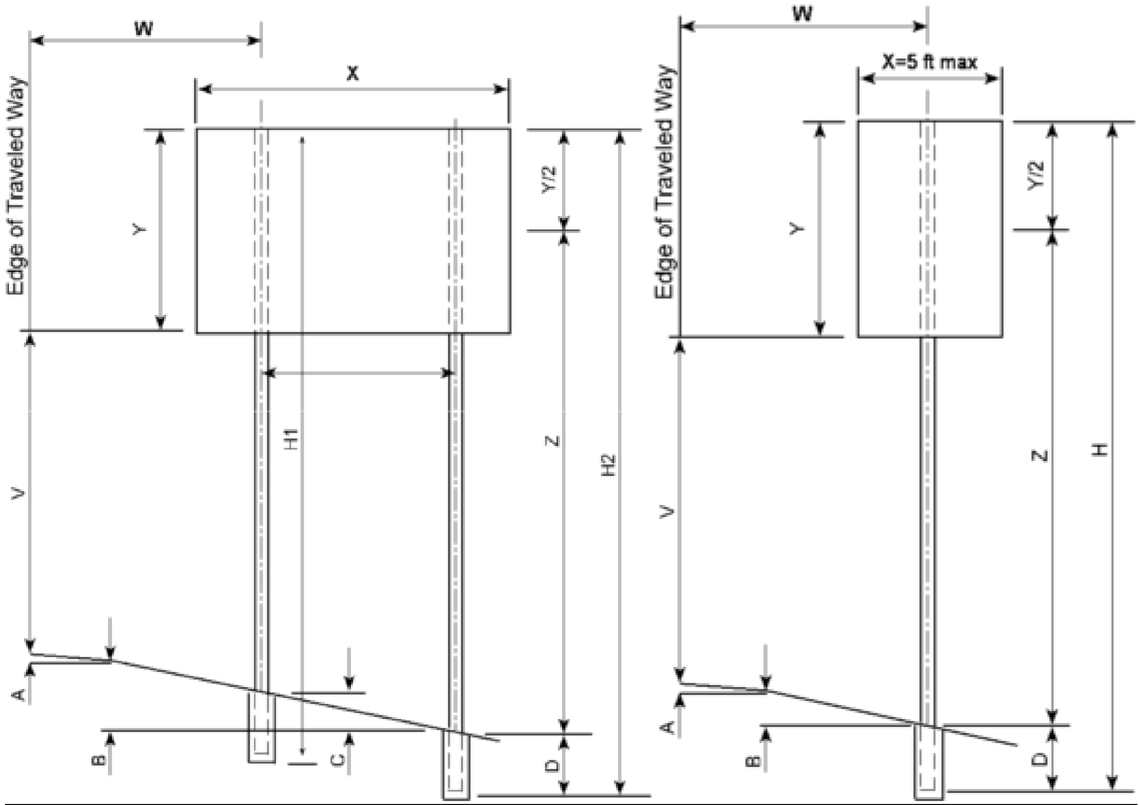


Table 1 – 2 1/2" & 3" Square Steel Posts

Posts		Maximum XYZ		
		1 Post	*2 Post	*3 Post
2 ½" PSST	12 Gage	**172**	**344**	**516**
*2 ½" PSST with 2 ¼" PSST (7') insert	12 Gage	**309**	**618**	**927**
*3" Solid	7 Gage	**471**	**942**	**1413**

***** Slip base required (maximum 3 slip bases allowed in 7' span)

Foundation depths are based on allowable lateral bearing pressure in excess of 2500 psf.
If the value (X)(Y)(Z) amount exceeds the limit for 3 – 3-inch post(s), use wide flange steel post(s) for sign installation.

A = Vertical distance from edge of traveled way to edge of shoulder
B = Vertical distance from slope catch point to centerline of longest post
C = Vertical distance between adjacent posts
X & Y = Single sign or back-to-back signs: Overall dimensions of the sign
Multiple signs: Dimensions of the area within the perimeter of a rectangle enclosing the extremities of the sign

Design Example – Single Post

Given:

Sign 4 ft wide, 5 ft high; 8-ft shoulder with 2% slope; 6H:1V embankment;

W = 15 ft; V = 5 ft

Solution:

X = 4 ft

Y = 5 + 2 + 0.25 = 7.75 ft

A = (0.02)(8) = 0.16

B = (W-8)/6 = (15-8)/6 = 1.17

Z = Y/2 + V + A + B

= (5/2) + 5 + 0.16 + 1.17 = 8.8 ft

(X)(Y)(Z) = (4)(5)(8.8) = 176 ft^3

Since 176 ft^3< 309 ft^3, from Table 1, select 2 ½" post with 2 ¼" post insert

H = 8.8 + (5/2) + 3 = 16.1 ft

Chapter 1040 Illumination

1040.01 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 (WAC 468-18-040 and WAC 468-18-050) with partial limited access control, modified limited access control, or full limited access control, regardless of the location. WSDOT is responsible (WAC 468-18-050) for illumination on state highways and crossroads with managed access control located outside the corporate limits of cities. Cities are responsible for illumination on managed access state highways within their corporate limits.

For the definitions of limited access control and managed access control, see Chapter 520. For a listing (by milepost) of the limited access or managed access status of all state highways, refer to the Access Control Tracking System Limited Access and Managed Access Master Plan, under the "More Information" heading: www.wsdot.wa.gov/design/accessandhearings. For further information, refer to the WSDOT/Association of Washington Cities agreement "City Streets as Part of State Highways": www.wsdot.wa.gov/localprograms/lag/construction.htm

1040.02 Definitions

The following terms are defined in the Glossary: *adaptive lighting system, average light level, complex ramp alignment and grade, continuous load, footcandle (fc), lamp lumens, light emitting diode(LED), long tunnel, lumen, luminaire, luminance, luminous flux, maximum uniformity ratio, maximum veiling luminance ratio, minimum average light level, minimum light level, mounting height – luminaire, multimodal connection, negative illumination, nighttime, pedestrian crossing, pole height (H1), positive illumination, roadway luminance, security lighting, short tunnel, SIgnal Maintenance Management System (SIMMS), slip base, spacing, transit flyer stop, transit stop, uniformity ratio,* and *veiling luminance*.

1040.03 Design Considerations

An illumination system is built from many separate components. The simplest illumination system contains the following:

- 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 light standard 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 is acceptable for use under the design requirements and National Electric Code (NEC) rules that were in effect at the time of installation. When modifying an existing electrical service or transformer, the designer is responsible for bringing the whole system up to current NEC design standards. Retrofitting an existing fixed base light standard with a slip base feature requires the installation of quick disconnect fittings and fuses in the circuit, at the luminaire only. 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 is to be designed to current standards. This may mean replacing the whole circuit back to the nearest overcurrent protection device (circuit breaker). Address the following 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).
- Whether the existing bonding and grounding system is adequate: cabinets, poles, junction boxes, including lids, and other appurtenances are bonded and grounded per NEC requirements.
- 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 the existing foundation to meet current design standards.
- The design life remaining for the existing light standard (deficient electrical component).

- The condition of the existing light standard (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 process. Ensure potential system deficiencies are reflected in the estimate of work.

Maintain required illumination during all construction activities, except when shutdown is permitted to allow for alterations or final removal of the system per the Engineer. Site preparation, widening, drainage, guardrail installation, or other work can easily impact existing conduit runs or luminaire locations. Also, changed conditions such as merging, weaving, or unusual alignment due to traffic control often require additional temporary illumination.

Note: The same lighting requirements apply whether a condition is temporary or permanent.

Illumination is not required for minor operational enhancement projects, unless that is the specific reasoning for the project.

1040.04 Required Illumination

The following items are to be considered for each project:

- Replace standard duty junction boxes that are located in paved areas with heavy-duty junction boxes, and bring electrical components to current standards. Relocate/remove junction boxes that are located in the travel way when practical.
- Review the age of the equipment as listed in SIMMS and consider replacing components that have reached the end of their design life. Replace poles, foundations, heads, and other equipment, that have reached their design life.
- Locate components so that they can be safely accessed from the right of way.
- Ensure existing slip base features are in accordance with current design standards.
- Consider additional illumination in accordance with 1040.05, if warranted, or design additional illumination if it is called for in the Project Definition.
- When it is necessary to relocate existing light standard foundations, evaluate the entire conduit run serving those light standards and replace deficient components to current (NEC) standards.

Exhibits 1040-1a through 1040-21 show examples of illumination for roadway, transit flyer stops, parking lots, truck weigh stations, tunnels, bridges, work zones, and detour applications.

A minimum of two light standards of standard pole height are required at all design areas, with the exception of some ramp terminals, entrance/exit points at minor parking lots, and basic transit stop lighting.

1040.04(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 1040.06(2) and Exhibits 1040-1a, 1b, and 1c).

1040.04(2) Freeway Ramp Terminals

Provide the necessary illumination for the design area (see Exhibit 1040-2). Ramp terminals may use a single light standard where all of the following are true:

- The ramp terminal is stop controlled (no traffic signal).
- The on and off-ramps are a single lane, regardless of width.
- The cross street is two lanes with no channelization.
- There are no sidewalks or marked crosswalks.

Verify with the HQ Traffic Office that the location is acceptable for a single light standard.

1040.04(3) Freeway On-Ramps With Ramp Meter Signals

Provide the necessary number of light standards to illuminate freeway on-ramps with ramp meters, from 150’ before the ramp meter stop bar to 50’ past the ramp meter stop bar. When there is an HOV bypass lane or a two-lane merge beyond the ramp meter, then also provide illumination from the point where the merging lane width is 10’ to 200’ downstream of that point (see Exhibit 1040-3). Illumination for the ramp merge with mainline is to be done per Exhibit 1040-1b.

1040.04(4) HOT (High-Occupancy Toll) Lane Enter/Exit Zones and Access Weave Lanes

Provide the necessary number of luminaires to illuminate the design area of the enter/exit zones and access weave lanes of the HOT lane (see Exhibits 1040-4a and 4b).

1040.04(5) 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 Exhibit 1040-5). This requirement does not apply to:

- The end of slow-moving vehicle turnouts.
- The end of the area where driving on shoulders is allowed.

1040.04(6) Intersections With Left-Turn Lane Channelization

Illumination of the intersection 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 on the State Route from 25’ before the raised channelization begins (see Exhibits 1040-6a, 6b, and 6c).

1040.04(7) Intersections With Traffic Signals

Illuminate intersections with traffic signals on state highways (see Exhibit 1040-7). In cities with a population under 27,500, the state may assume responsibility for illumination installed on signal standards.

1040.04(8) Roundabouts

Provide the necessary number of light standards to illuminate the design areas of roundabouts (see Chapter 1320 and Exhibit 1040-9).

1040.04(9) 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, to backlight the train (see Exhibit 1040-10).

1040.04(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 the raised channelization (see Exhibit 1040-11).

1040.04(11) Transit Flyer Stops

Illuminate the pedestrian-loading areas of transit flyer stops, as described in Chapter 1420 (see Exhibit 1040-12). For all other types of transit stops, see 1040.05(8).

1040.04(12) 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 Exhibit 1040-22. (See Exhibit 1040-13 for the parking design area and bus loading zone design area.) During periods of low usage at night, security lighting is required only in the parking area and bus loading zone. Provide an electrical circuitry design that allows the illumination system to be reduced to approximately 25% of the required light level.

1040.04(13) 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 Exhibit 1040-14).

1040.04(14) Truck Weigh Sites

Provide illumination of the roadway diverge and merge sections, scale platforms, parking areas, and inspection areas of weigh sites (see Exhibit 1040-15).

1040.04(15) Safety Rest Areas

Provide illumination within rest areas at the roadway diverge and merge sections, the walkways between parking areas and rest room buildings, and the parking areas the same as for a major parking lot (see Exhibit 1040-16).

1040.04(16) Chain-Up/Chain-Off Parking Areas

Provide the necessary number of luminaires to illuminate the design area of the chain-up/chain-off parking areas (see Exhibit 1040-17) on State Routes 2, 12, and 90 where a power distribution point is within a half mile and power is readily accessible. Illumination is to be installed in the median and on the right shoulder to provide lighting on both sides of the stopped vehicles.

Luminaires should only be energized during periods when traction tires are required and vehicles over 10,000 pounds are required to use chains.

1040.04(17) Tunnels, Lids, and Underpasses

For the purposes of this chapter, a tunnel is a structure over a roadway, which restricts the normal daytime illumination of a roadway section such that the driver's visibility is substantially diminished. Tunnels cover roadways and produce a shadow that limits the ability of the driver to see objects or obstructions within the tunnel. In most locations, no supplemental daytime lighting is required for underpasses or structures less than 80 feet in length. Provide both nighttime and daytime lighting for long tunnels. (See ANSI/IES publication RP-22-11 for tunnel lighting design criteria.) Provide vandal-resistant daytime and nighttime security lighting in pedestrian tunnels. 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.

1040.04(18) Bridge Inspection Lighting

Provide the necessary number of light fixtures and electrical outlets to illuminate the interior inspection areas of floating bridges, steel box girder bridges and concrete box girder bridges where access is provided (see Exhibit 1040-18). Separate circuits are to be used for lighting and electrical outlets. Each electrical outlet is to be powered by 2 Duplex receptacles on two separate circuits. All electrical outlets are to be labeled with circuit identifications. Coordinate bridge illumination requirements with the HQ Bridge and Structures Office.

1040.04(19) 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, illuminate the obstruction for the duration of the traffic split (see Exhibit 1040-19).

1040.04(20) Diverging Diamond Interchange

Provide the necessary number of light standards to illuminate the design area shown in Exhibit 1040-21. The design area starts 25' before the raised channelization as you approach the interchange and continues through the interchange until 25' past the raised channelization as you exit the interchange.

1040.05 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 could be reviewed as a crash countermeasure under certain circumstances, which are listed in this section.

1040.05(1) Conditions for Additional Illumination

Following are some conditions used in making the decision to provide additional illumination:

1040.05(1)(a) Crash Analysis

The following conditions have to be met when making the decision to provide additional illumination:

- During the last full five calendar years, the site has experienced nighttime crashes that are correctable with illumination, AND
- The benefit-cost analysis for the proposed illumination exceeds 1, AND
- Alternative lower-cost countermeasures have been evaluated and did not address the particular nighttime crash history.

Nighttime crashes are defined as crashes occurring between half an hour after sunset and half an hour before sunrise. Correctable nighttime crashes are crashes that (a) meet the nighttime definition in this chapter, (b) have contributing factors related to a lack of lighting, and (c) where lighting, if installed, would directly address the contributing factor(s) to the crashes.

Collision reporting forms and the crash data are not adequate means to distinguish between day and nighttime conditions: the crash location, the reported crash times, and seasonal variations should be used to determine which crashes qualify as nighttime crashes. Also:

- For sites where the number of nighttime crashes equals or exceeds the number of daytime crashes, the above-mentioned crash and benefit-cost analysis should be performed.
- For sites where these nighttime crashes involve pedestrians, refer to 1040.05(11).

1040.05(1)(b) Locations With Nighttime Pedestrian Crashes

The mitigation of nighttime vehicle/pedestrian crashes may require different lighting strategies than vehicular crash locations. Provide light levels to emphasize crosswalks and adjacent sidewalks by using positive lighting of the pedestrians.

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 and intermediate 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 See Section 1040.05.

1040.05(2) Highways

Proposals to provide full (continuous) illumination require the approval of the Region and State Traffic Engineers. Regions may choose to develop (regional or corridor-specific) system plans for providing full (continuous) illumination. The State Traffic Engineer's approval of a system plan will eliminate the need for a project-specific approval from the State Traffic Engineer. Continuous illumination can be provided inside city limits at the city's request provided the city takes on the maintenance and operational costs and responsibilities of maintaining and operating the system.

The decision whether to provide full (continuous) illumination is to be made during the scoping stage and communicated to the designers as soon as possible.

Continuous illumination should be considered when the crash analysis requirements in 1040.05(1) are met and a benefit/cost analysis between the required and full (continuous) illumination exceeds 1.

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 the crash analysis requirements in 1040.05(1) are met, has raised channelization, has medium or high pedestrian activity during night time hours, and an engineering study indicates that nighttime driving conditions will be improved.

1040.05(3) Ramps

Consider additional illumination at ramps where the alignment or grade is complex.

1040.05(4) Crossroads

Consider additional illumination if the crossroad is in a short tunnel, an underpass, or a lid.

1040.05(5) Intersections Without Turn-Lane Channelization

Refer to Exhibit 1040-8.

1040.05(6) Short Tunnels, Underpasses, or Lids

Consider illumination of the sidewalk, walkway, or shared-use path if it is included as part of the short tunnels, underpasses, or lids.

1040.05(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. Exhibit 1040-20 illustrates considerations for temporary illumination, such as reduced roadway widths, work zone lane shifts, and median cross overs.

For further information on illumination in work zones, see Chapter 1010.

1040.05(8) Transit Stops

The responsibility for lighting at transit stops is shared with the transit agency. Consider illuminating transit stops with shelters as they usually indicate greater 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, consider a single light standard positioned to illuminate both the transit pullout area and the loading area.

1040.05(9) Bridges

Justification for illuminating the roadway/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 1040.05(11).

1040.05(10) Railroad Crossing Without Gates or Signals

Consider the illumination of railroad crossings without gates or signals when:

- The crash 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.

1040.05(11) Sidewalks, Walkways, and Shared-Use Paths

Consider illumination of a pedestrian walkway if the walkway is a connection between two highway facilities. This could be between parking areas and rest room buildings at rest areas; between drop-off/pick-up points and bus loading areas at flyer stops; or between parking areas and bus loading areas or ferry loading zones. Consider illuminating existing sidewalks, walkways, and shared-use paths if security problems have been reported or are anticipated. Under these conditions, these facilities are illuminated to the level shown in Exhibit 1040-22.

1040.06 Design Criteria

1040.06(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 Exhibit 1040-22. 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 still apply when the complete walkway or path is to be illuminated for public safety.

The access areas used for interior inspection of floating bridges or steel box/concrete box girder bridges are exempt from lighting level and lighting ratio design requirements.

For functional classifications of highways, see:
www.wsdot.wa.gov/mapsdata/travel/hpms/functionalclass.htm

1040.06(1)(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:

1040.06(1)(a)(1) High Activity

Areas with over 100 pedestrian crossings during 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.

1040.06(1)(a)(2) Medium Activity

Areas with pedestrian crossings that number between 11 and 100 during 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.

1040.06(1)(a)(3) 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.

1040.06(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 and is located in a medium or high pedestrian activity area, the design area includes these features; however, sidewalks adjacent to the traveled way are exempt from maximum veiling luminance ratio requirements.

1040.06(2)(a) Design Area Requirements

Design area requirements for various applications are shown in Exhibits 1040-1a through 1040-21 and are described in the following:

1040.06(2)(a)(1) Single-Lane Off-Ramp

Two main line through lanes and the ramp lane, including gore area, from the gore point (beginning of wide line) to a point 200 feet (minimum) downstream of the gore point. A 100 foot longitudinal tolerance either way from the gore point is allowed.

1040.06(2)(a)(2) 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 (beginning of wide line) to a point 200 feet downstream of the gore point. A 100-foot longitudinal tolerance either way from the gore point is allowed.

1040.06(2)(a)(3) 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.

1040.06(2)(a)(4) 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.

1040.06(2)(a)(5) Intersections Channelized With Pavement Markings

When the leg of an intersection is two lanes wide or less, the design area starts at the stop bar and encompasses the intersection area. When the leg of an intersection is three or more lanes wide, the design area starts 25’ before the stop bar and encompasses the intersection area.

1040.06(2)(a)(6) Intersections With Raised Channelization

The design area has two components: the intersection area and the approach areas. When the leg of an intersection is two lanes wide or less, the intersection design area starts at the stop bar and encompasses the intersection area. When the leg of an intersection is three or more lanes wide, the intersection design area starts 25 feet before the stop bar and encompasses the intersection area 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 intersection design area and where the left-turn taper begins.

1040.06(2)(a)(7) Unchannelized Intersection

The area between the stopping points on both the main road and the minor road, including marked or unmarked crosswalks.

1040.06(2)(a)(8) Railroad Crossing

The roadway width from a point 50 feet on either side of the track (the approach side only for one-way roadways).

1040.06(2)(a)(9) Transit Loading Area

The lane width and length designated for loading.

1040.06(2)(a)(10) Major Parking Lot

The entire area designated for parking, including internal access lanes.

1040.06(2)(a)(11) Scale Platform at Weigh Site

The approach width from the beginning of the scale platform to the end of the platform.

1040.06(2)(a)(12) Inspection Area at Weigh Site

The area dedicated to inspection as agreed upon with the Washington State Patrol.

1040.06(2)(a)(13) Bridge Inspection Lighting System

Fixtures are to be ceiling mounted. For steel box girders bridges, the spacing shall not be greater than the smaller of 4 times the web depth or 25 ft. For concrete box girder bridges, the spacing shall not be greater than the smaller of 8 times the web depth or 50 ft. Illumination is to consists of a 100 watt incandescent (or fluorescent equivalent) fixture. The bulb should have a minimum of 1600 lumens. 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.

1040.06(3) Daytime Light Levels for Tunnels, Lids, and Underpasses

It is important to provide sufficient illumination inside a tunnel. When driving into and through a tunnel during the day, 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 their eyes 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 and may experience a "black hole" or "blackout" effect. This "black hole" effect may cause a motorist to slow down, reducing the efficiency of the roadway. When leaving 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 1040.08(2) in the Design Guidance section.

- All designs for illuminating 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. The zones are Threshold Zone, Transition Zone(s), and Interior Zone. Each zone length is calculated using the method described in ANSI/IES RP-22-11.
- The designer of a long tunnel shall perform a Lseq (Equivalent Veiling Luminance) calculation. Lseq values obtained from this calculation shall be used to reduce (or increase) the Suggested Daytime Maintained Average Pavement Luminance Levels where indicated.
- Tunnel wall illumination is required.
- The approach and exit roadways shall have a nighttime luminance level of no less than one third of the tunnel interior level for one safe stopping sight distance (SSSD).
- Provide illumination of fire protection equipment, alarm pull boxes, phones, and emergency exits in long tunnels. (See NFPA 502 for additional information.)
- 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 are treated the same as an entrance zone on a long tunnel to establish daytime light levels.
- 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.

1040.06(4) Light Standards

1040.06(4)(a) Light Standards on State Highway Facilities

Light standards are the most common supports used to provide illumination for highway facilities. The 40-foot light standard with a slip bases and Type 1 mast arm is predominantly used on state highways. In areas with continuous illumination, 50-foot light standards may be used. Use Type 1 mast arms on all new systems and when modifying existing systems. Cities and counties may elect to use different mounting heights to address factors unique to their environments. On state highways, alternative colored 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, and higher maintenance costs since the work will most likely be done during night time hours due to decreased traffic volumes. Region Signal Maintenance approval is required for all median mounted luminaires except chain on/off areas. 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 (WAC 296-24-960). Consult the 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 for impacts from errant vehicles. The typical luminaire position is mounted directly over the edge line plus or minus 4 feet. However, some flexibility is acceptable with the luminaire position to allow for placement of the light standard provided light levels, uniformity, and maintenance considerations are addressed, and with the Region Traffic Engineer’s approval. 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 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 standard. The maximum allowable mast arm length for a double luminaire light standard is 12 feet.

Light standards should always use slip bases, unless a fixed base is justified as described in Chapter 1610.

- In curb and sidewalk sections, locate the light standard behind the sidewalk. In locations where the light standard cannot be placed behind the sidewalk and still have the luminaire mounted within 4’ of the edge line, the luminaire should be located in the sidewalk. When installed in the sidewalk, ensure that the minimum sidewalk width is available to at least one side of the light standard for the pedestrian access route (see Chapter 1510).

1040.06(4)(b) Light Standard Heights

Standard pole heights (20-foot, 30-foot, or 40-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, or 37-foot) will not only require a longer delivery time, they will also be more expensive.

In almost all cases, use a standard pole heights of 40 feet for roadway illumination. Structure-mounted light standards may need to be shorter than the standard 40-foot grade-mounted pole. It is acceptable to use 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. Luminaires with a mounting height over 40 feet should only be used in continuously illuminated areas that are not in residential areas. 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. Luminaires with a mounting height over 50 feet require lowering devices.

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.

1040.06(4)(c) Standard Luminaire

The standard luminaire in use now for roadway lighting is a cobra head style type III LED fixture. The list of LED fixtures approved for use on WSDOT projects can be found at:
http://www.wsdot.wa.gov/Design/Traffic/ledluminaires.htm

For continuously illuminated area a type V distribution pattern can be used for the interior areas with type III distribution on the perimeters.

1040.06(4)(d) Electrical Design

For an example of circuit layout, conductor sizing, conduit sizing, overcurrent protection device sizing, and other electrical design calculations, see the Power Supply Design material located at:
http://www.wsdot.wa.gov/design/traffic/electrical/training.htm

An example of illumination design grid layouts and calculations is located in the Illumination Design for Transportation Applications material located in the link above.

The illumination circuitry is to be laid out so that if four or more luminaires are installed, it should have a minimum of two circuits. The intent is to make sure that if a circuit fails, there will still be partial lighting from the other circuits.

The maximum allowable junction box spacing is as follows:

1. 360 feet allowed between in grade junction boxes with a straight pull.
2. 180 feet when conduit run is along a curve or when the conduit makes a 30 degree or greater change in direction.
3. 180 feet between NEMA junction boxes in traffic barrier, retaining wall, or structure.
4. A junction box is required within 5 feet minimum (preferred) & 10 feet maximum of the luminaire base, regardless of the luminaire spacing.
5. 360 feet between NEMA junction boxes when fiber optic cable is run through conduit in traffic barrier, retaining wall, or structure.
6. Pull Box interconnect to Traffic Signal – spacing is 500 feet maximum. Disclaimer: This would only apply to a single fiber optic cable.
7. 1,000 feet between cable vaults or pull boxes – main line fiber optic cable.

1040.06(5) Adaptive Lighting

Adaptive Lighting Systems may be used at select locations where changing traffic conditions allow for lowering of light levels or the changing of a required design area. Some examples would be: the Pedestrian/Area Classification changes requiring different levels; traffic volumes drop sharply; or chain up/chain off areas. Region and State Traffic Engineers’ approval is required for adaptive lighting systems.

1040.07 Documentation

Justify and document any additional illumination in the Design Documentation Package (DDP).

The approval from maintenance to install median mounted luminaires can be an email or memo from the area maintenance superintendent and is kept in the design file.

Any areas in this section that says to “consider” a design element should have the logic of the consideration and decision documented in the design file for future reference.

Refer to Chapter 300 for design documentation requirements.

1040.08 References

1040.08(1) Federal/State Laws and Codes

National Electrical Code (NEC), 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

1040.08(2) Design Guidance

American National Standard Practice for Roadway Lighting, IES RP-8-00, New York, NY 2000

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

NFPA 502: Standard for Road Tunnels, Bridges, and Other Limited Access Highways, NFPA, Quincy, MA 2011

Recommended Practice for Tunnel Lighting, IESNA RP-22-05, New York, NY 2011

Roadway Lighting Design Guide, AASHTO, October 2005

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

Roadway Lighting Handbook, Federal Highway Administration, Implementation Package 78-15, Washington, DC 1978 (Reprinted April 1984)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

1040.08(3) Supporting Information

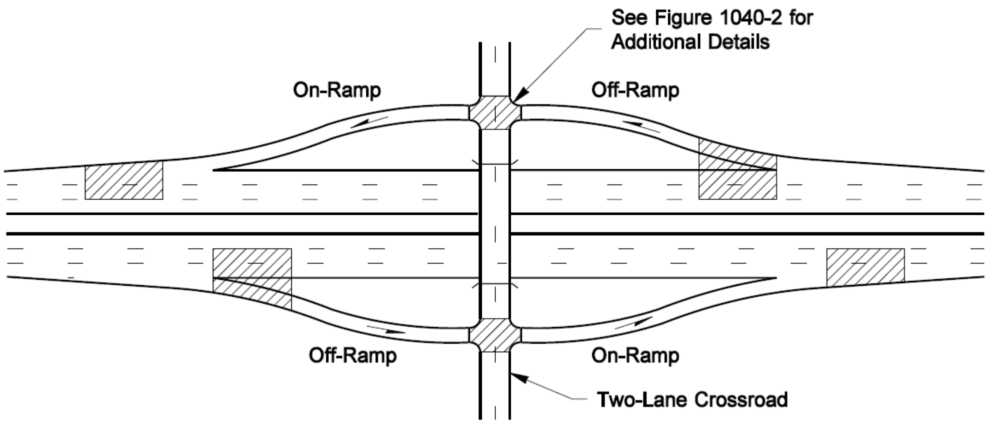
A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, Current Edition

An Informational Guide for Roadway Lighting, AASHTO, Washington, DC 1984

City Streets as Part of State Highways Guidelines Reached by the Washington State Department of Transportation and the Association of Washington Cities on Interpretation of Selected Topics of RCW 47.24 and Figures of WAC 468-18-050 for the Construction, Operations and Maintenance Responsibilities of WSDOT and Cities for such Streets, 4-30-1997 amended 4-2-2013

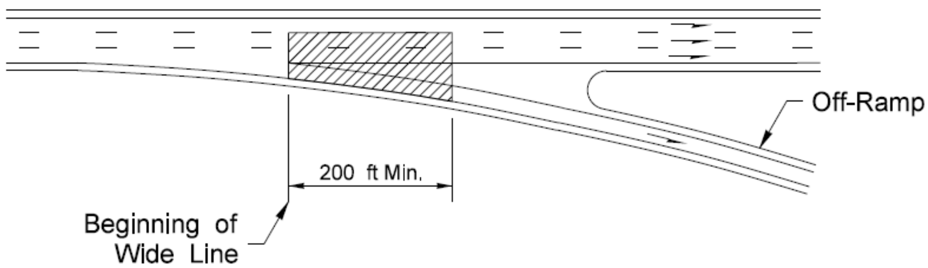
Light Trespass: Research Results and Recommendations, IES TM-11-00, New York, NY 2000

Exhibit 1040-1a Freeway Lighting Applications



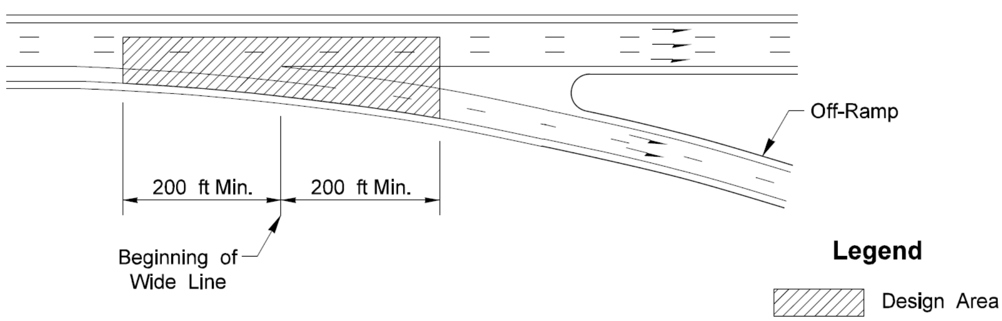
Required Illumination for a Typical Diamond Interchange

Shown for single-lane ramp connection and a two-lane crossroad without channelization.



Single-Lane Off-Connection

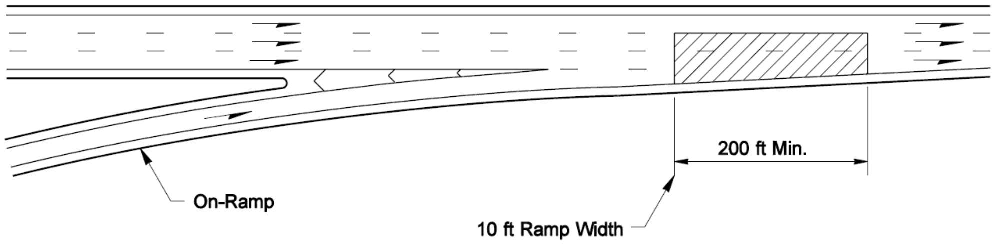
The design area may be shifted up to 100 ft from the beginning of the wide line; a minimum of two light standards of standard pole height required for design area.



Two-Lane Off-Connection: One Exit Only Lane; One Optional Lane

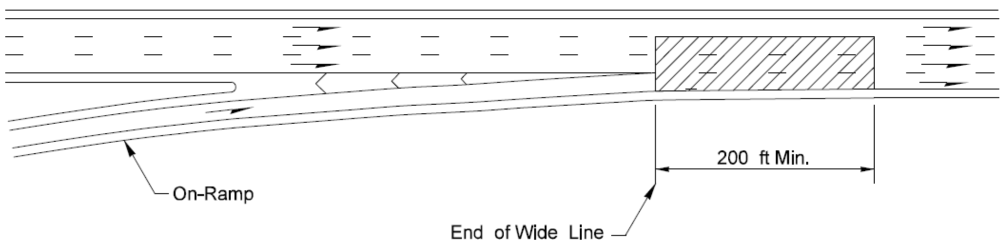
The design area may be shifted up to 100 ft from the beginning of the wide line; a minimum of three light standards of standard pole height required for design area.

Exhibit 1040-1b Freeway Lighting Applications



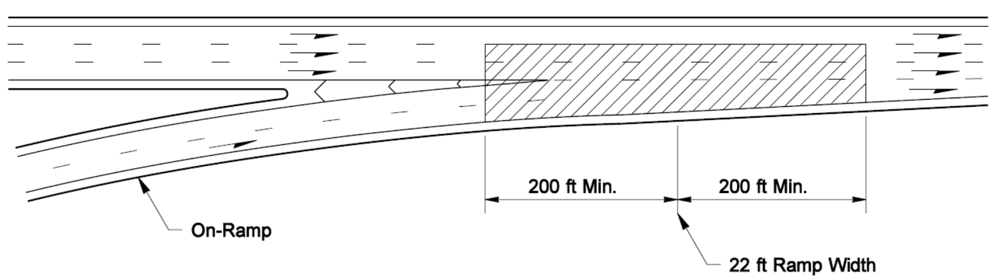
Single-Lane On-Connection

The design area may be shifted up to 100 ft from the 10-ft-wide ramp point; a minimum of two light standards of standard pole height required for design area.



Auxiliary Lane at On-Connection

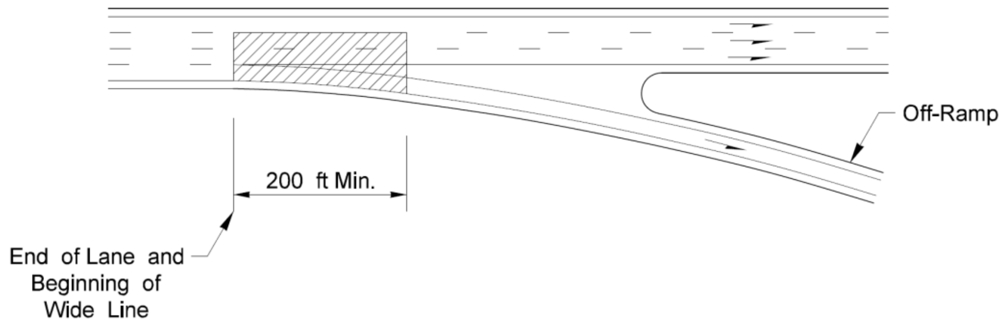
The design area may be shifted up to 100 ft from the end of wide line; a minimum of two light standards of standard pole height required for design area.



Two-Lane On-Connection: One Auxiliary Lane; One Merge Lane

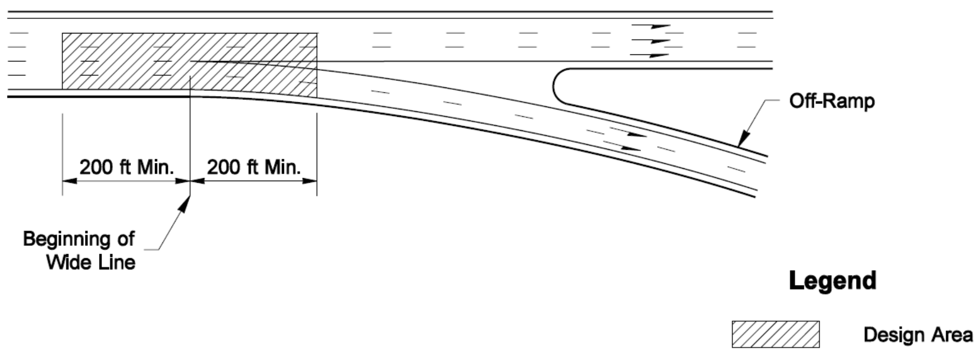
The design area may be shifted up to 100 ft from the 22-ft-wide ramp point; a minimum of three light standards of standard pole height required for design area.

Exhibit 1040-1c Freeway Lighting Applications



Single Exit-Only Lane

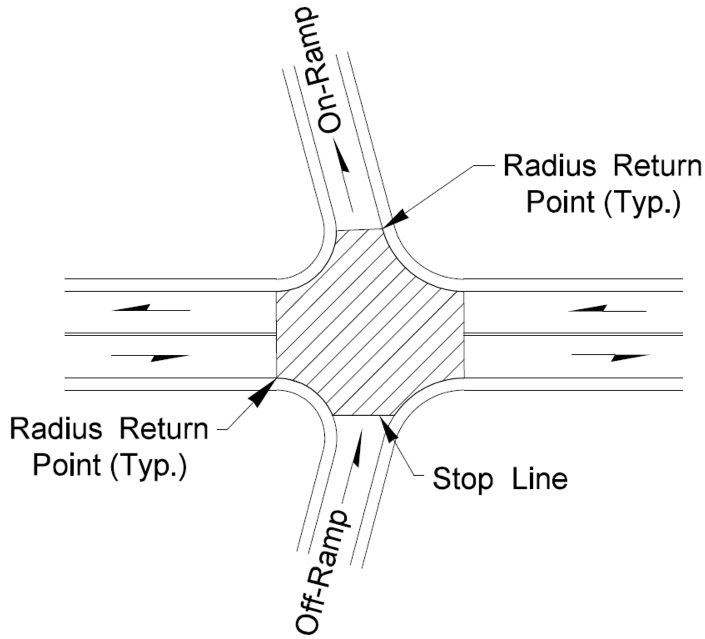
The design area may be shifted up to 100 ft from the end of lane and the beginning of wide line; a minimum of two light standards of standard pole height required for design area.



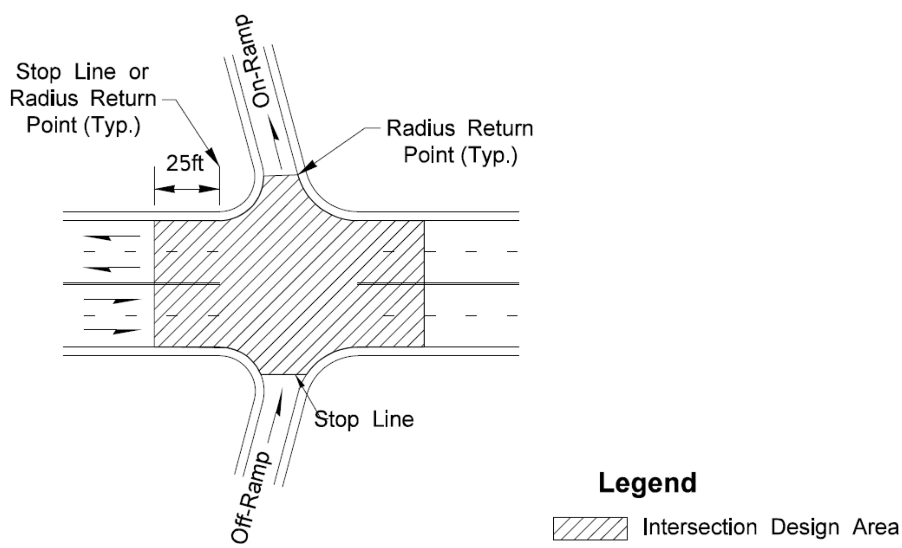
Two Exit-Only Lanes

The design area may be shifted up to 100 ft from the end of lane and the beginning of wide line; a minimum of three light standards of standard pole height required for design area.

Exhibit 1040-2 Freeway Ramp Terminals

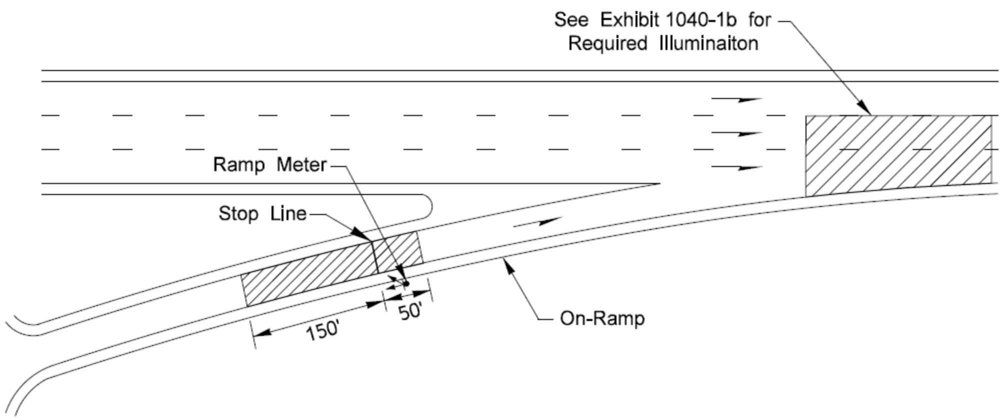


Off Ramp with Single-Lane Crossroad

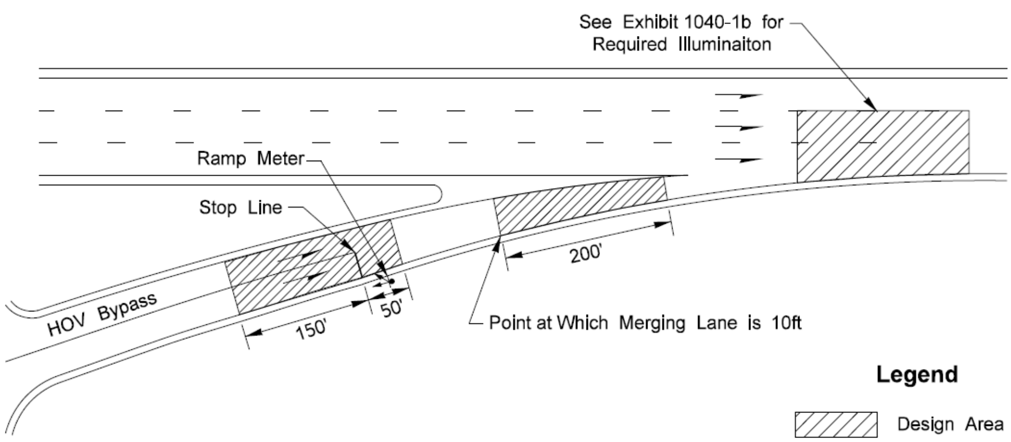


Off-Ramp with Multilane Crossroad

Exhibit 1040-3 Ramp with Meter

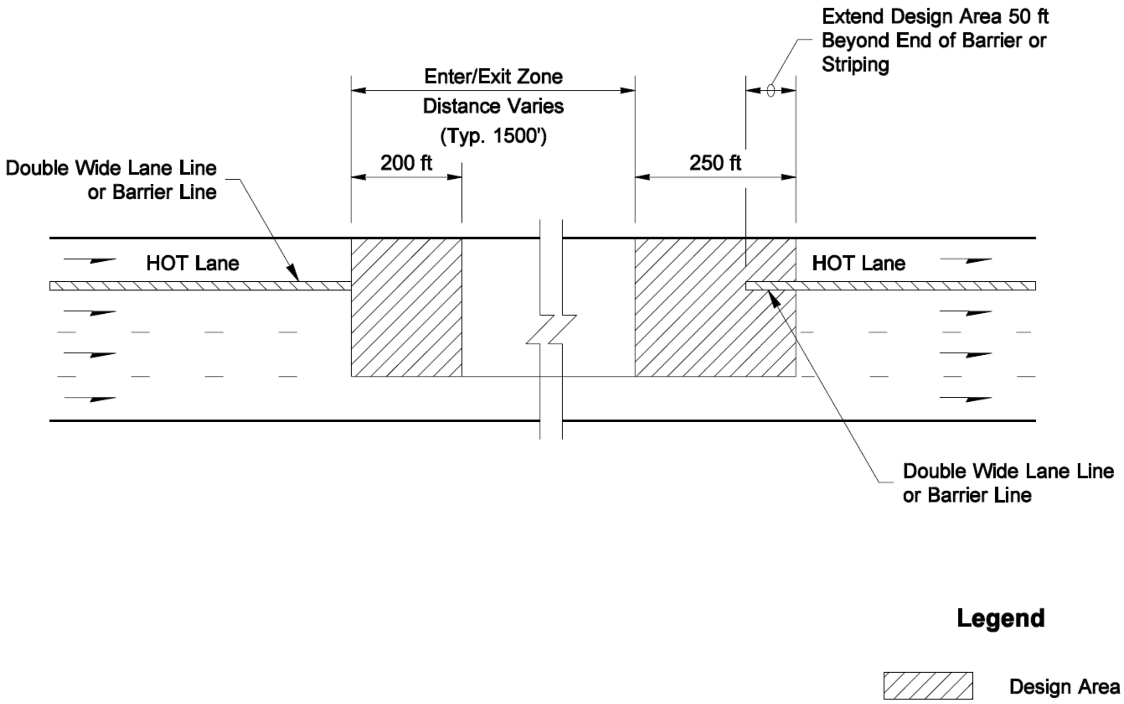


Single-Lane On-Ramp



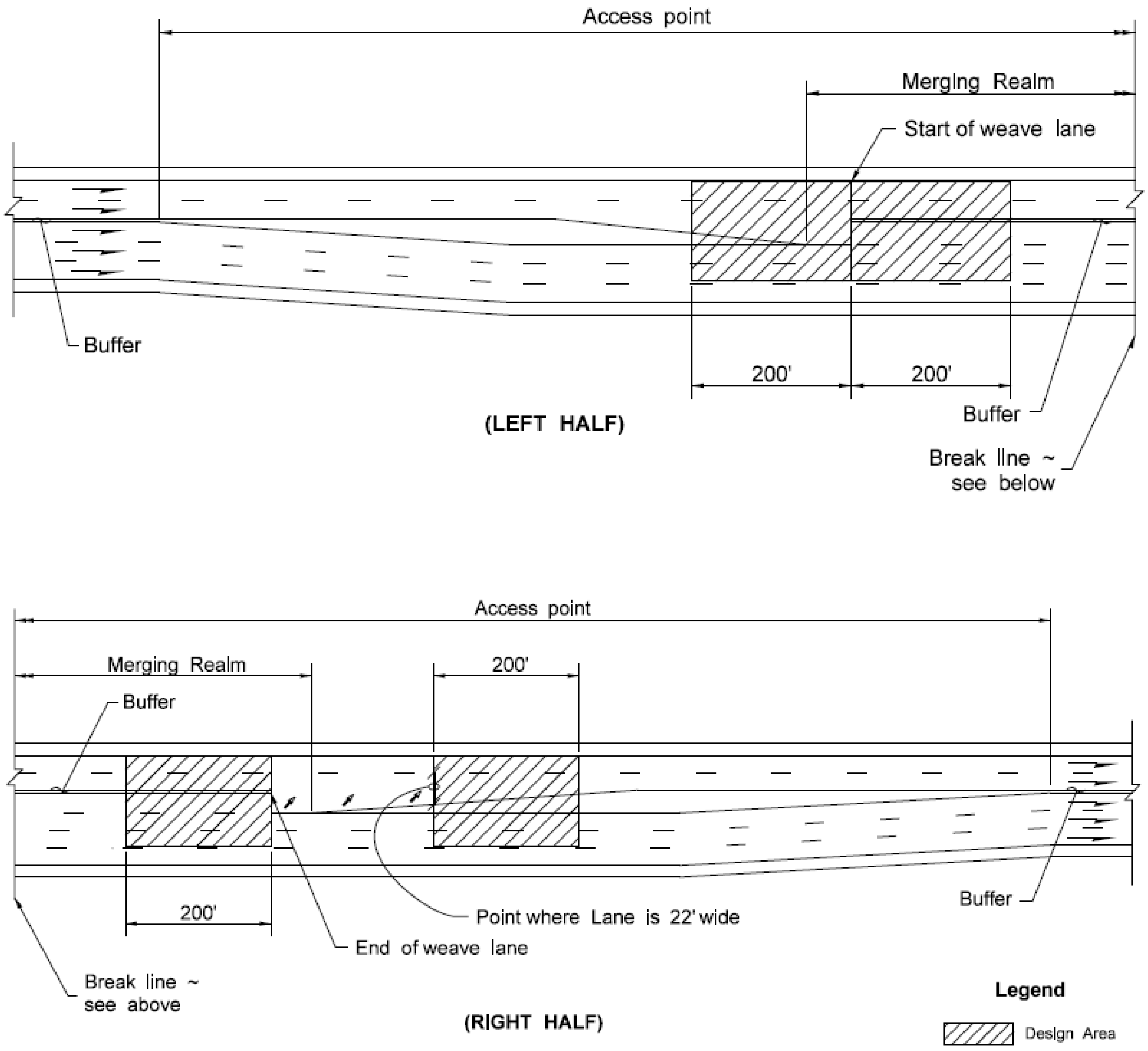
Multilane On-Ramp with HOV Bypass Lane

Exhibit 1040-4a HOT (High-Occupancy Toll) Lane Enter/Exit Zone



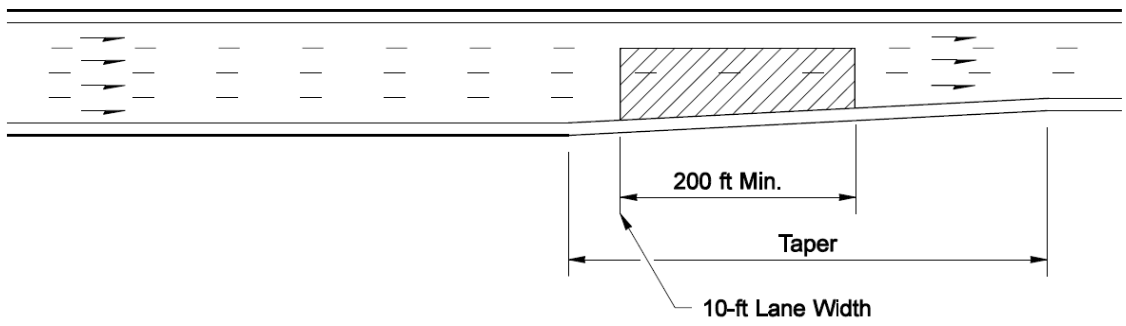
A minimum of two light standards of standard pole height required for each design area.

Exhibit 1040-4b HOT (High-Occupancy Toll) Lane ACCESS WEAVE LANE



TOLL LANE ACCESS WEAVE LANE

Exhibit 1040-5 Lane Reduction



A minimum of two light standards of standard pole height required for design area; design area may be shifted 100 ft.

Exhibit 1040-6a Intersection with Left-Turn Channelization: Divided Highway

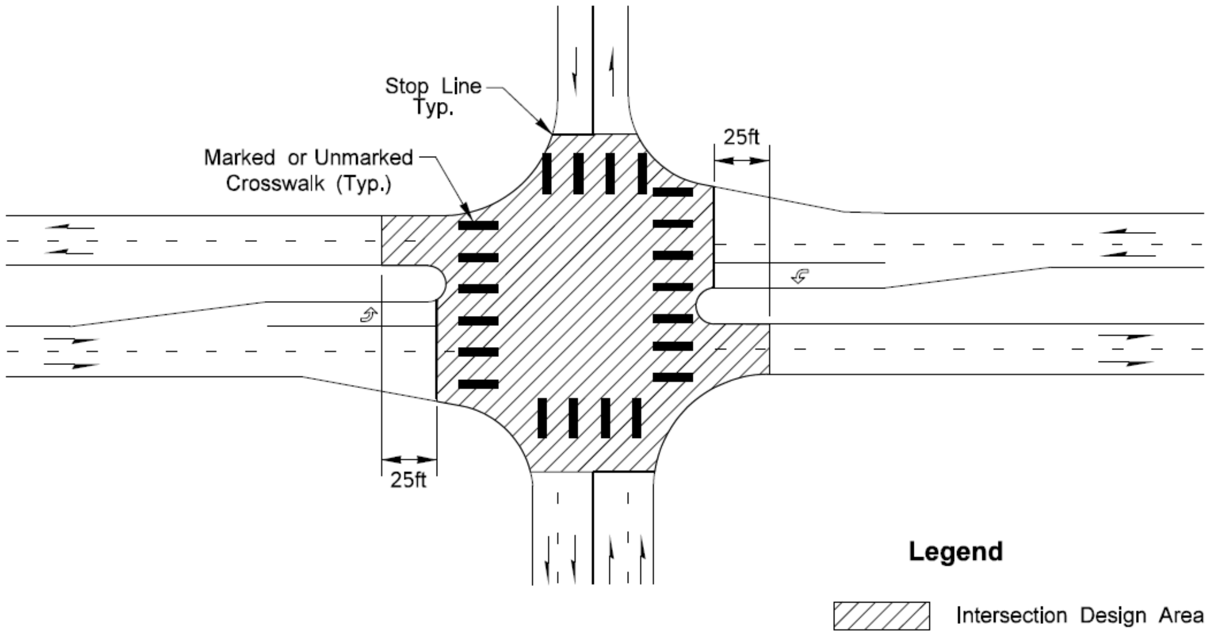
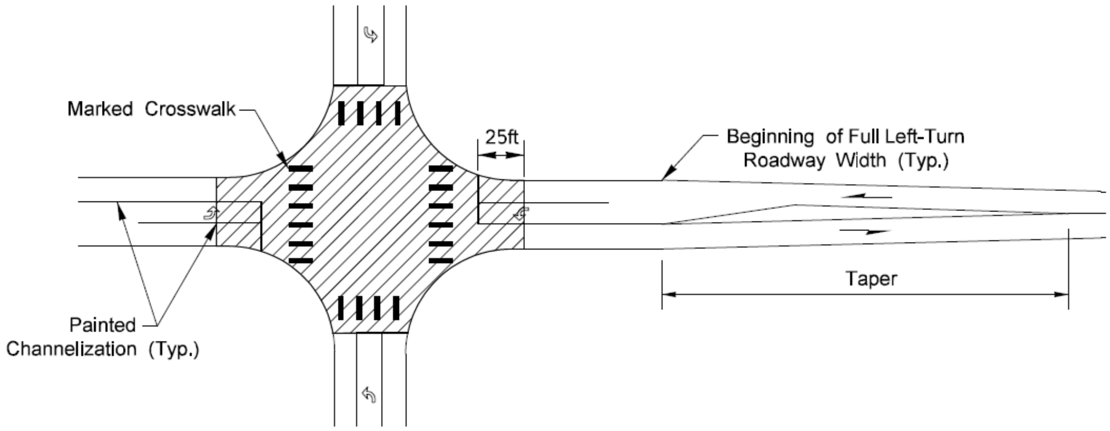
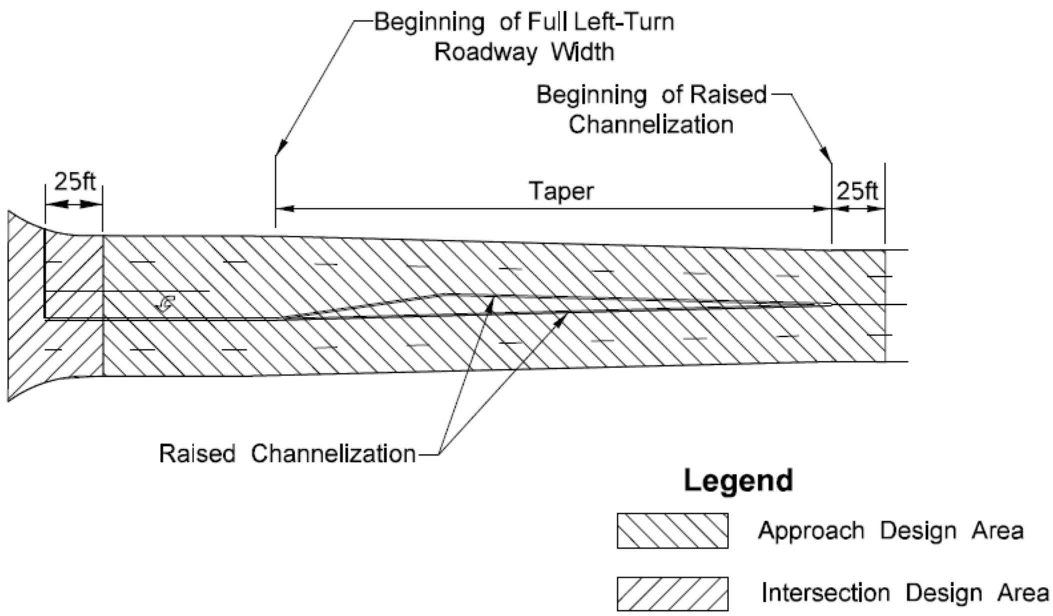


Exhibit 1040-6b Intersections with Left-Turn Channelization



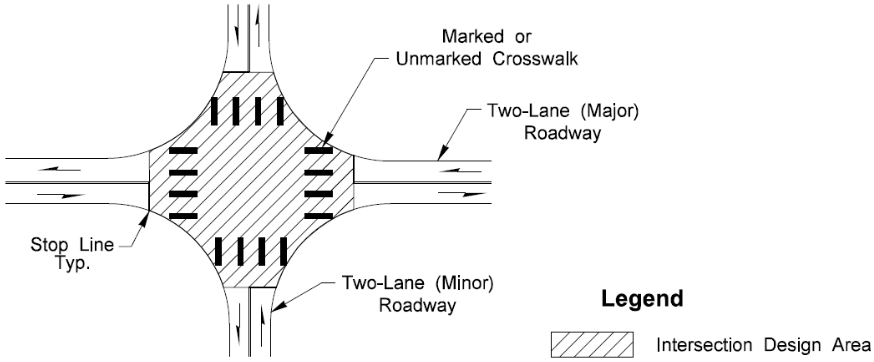
Intersection with Low-Profile Left-Turn Channelization Pavement Markings

Exhibit 1040-6c Intersections with Raised Left-Turn Channelization

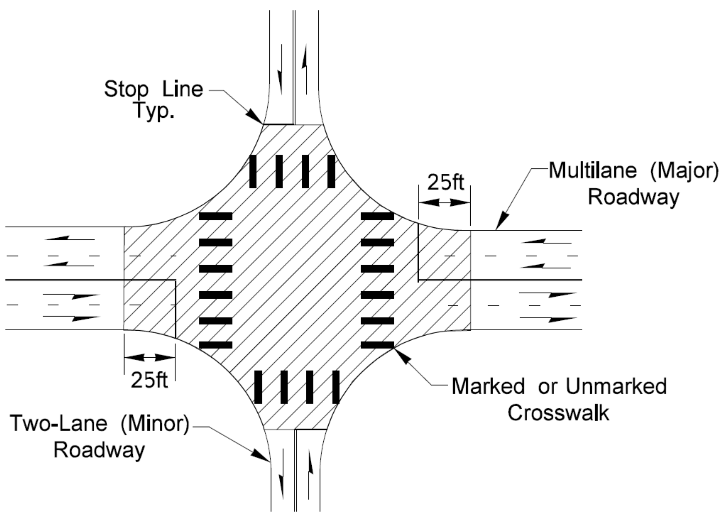


Intersection with Raised Left-Turn Channelization

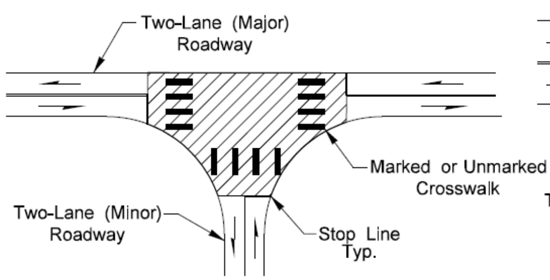
Exhibit 1040-7 Intersections with Traffic Signals



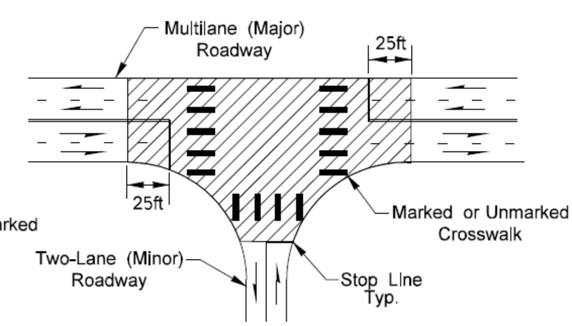
Four-Way Intersection with Single-Lane Approaches



Four-Way Intersection with Multilane Major Approaches
A minimum of two light standards required for design area.

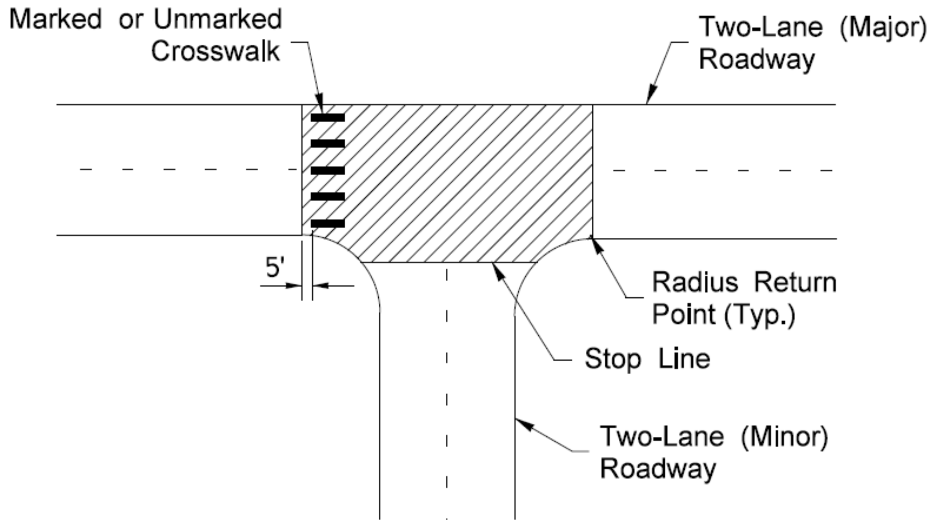


Minor Tee Intersection



Major Tee Intersection
A minimum of two light standards is required for design area.

Exhibit 1040-8 Intersection without Channelization



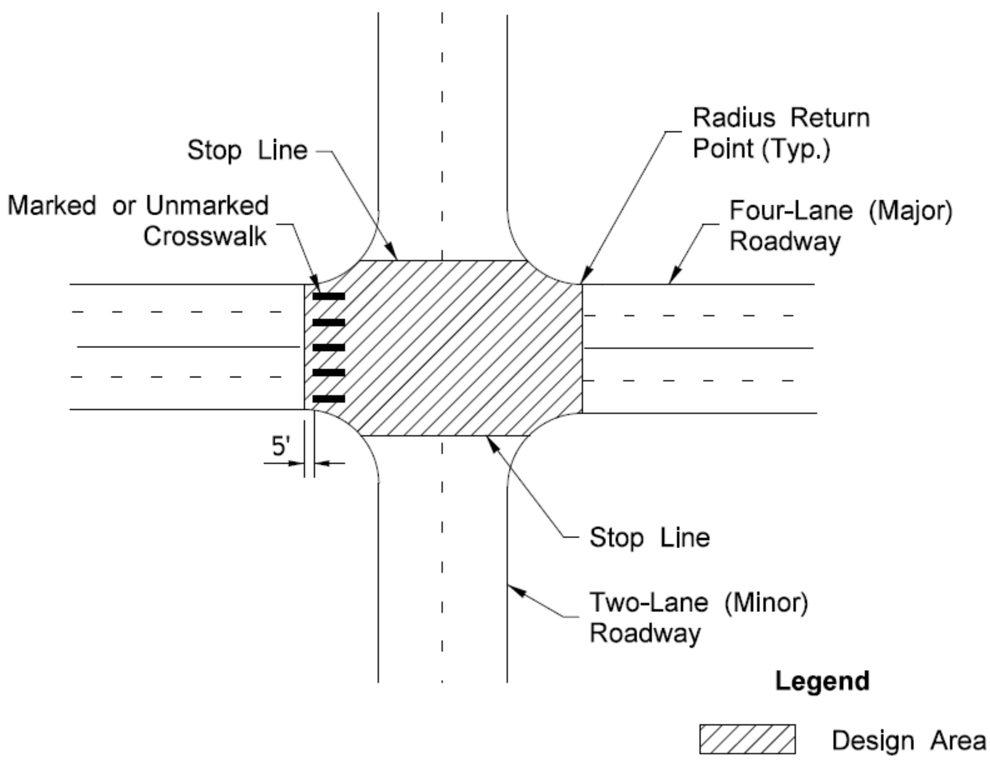
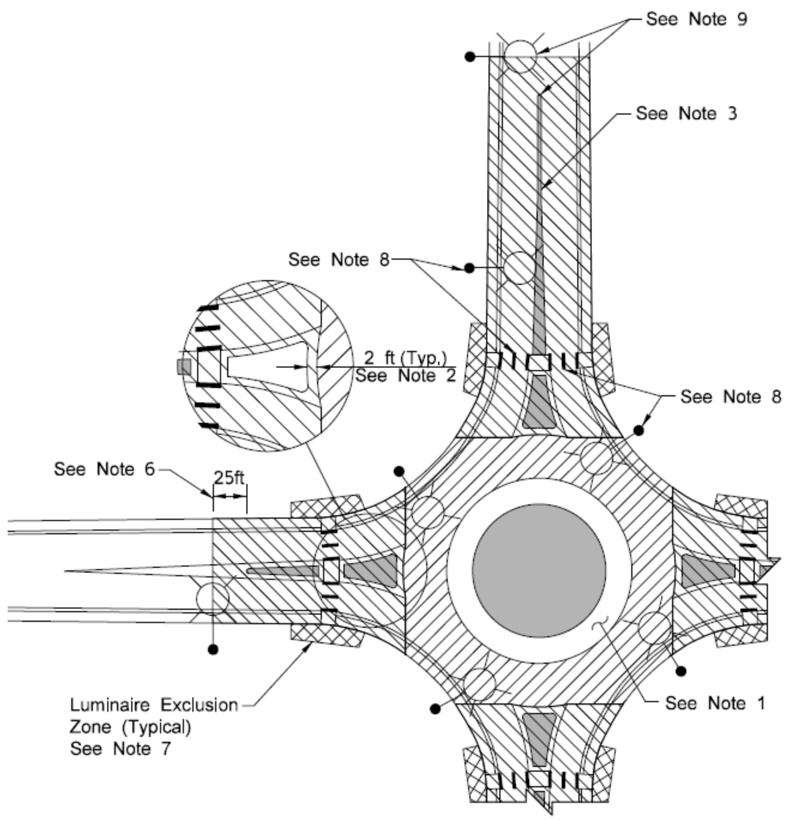
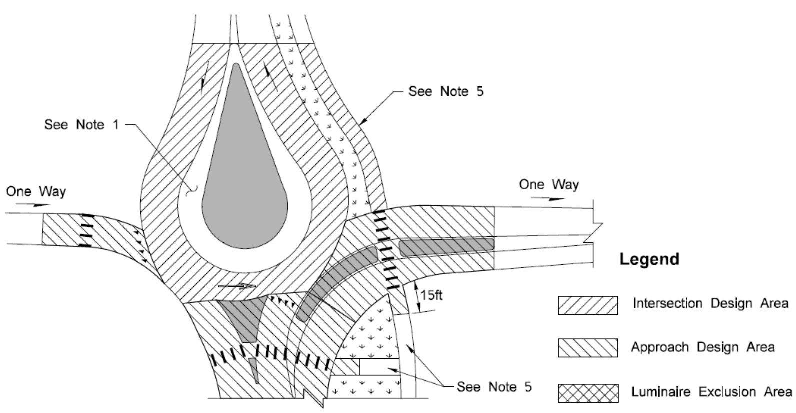


Exhibit 1040-9 Roundabout





Notes

1. Exclude Truck Apron from lighting calculations.
2. Exclude the portion inside the 2ft offset areas of the raised channelization islands from calculation.
3. All channelization 2ft wide or less is included in the Approach Design Area calculation.
4. When a leg of the roundabout is a one-way roadway, the Approach Design Area starts at the beginning of the raised channelization, or 50ft from the outside edge of the circulating roadway, or 50ft beyond a sidewalk, whichever is further.
5. A sidewalk is included in the Intersection Design Area calculation when a planting strip is less than 15ft wide.
6. Install luminaire to provide positive illumination of raised channelization. The preferred luminaire location would be from 20’ to one mounting height’s distance in front of the raised channelization.
7. Do not install luminaire in the area from 20’ in front of the crosswalk to 20’ past the crosswalk.
8. Install luminaire to provide positive illumination of the crosswalk for approaching vehicles. The preferred luminaire location would be one mounting height’s distance in front of the crosswalk.
9. If approach intersection area requires more than one luminaire, the last luminaire on that approach chain can be replaced with a ground-mounted, internally illuminated bollard with sign in place of 2nd luminaire.

Exhibit 1040-10 Railroad Crossing with Gates or Signals

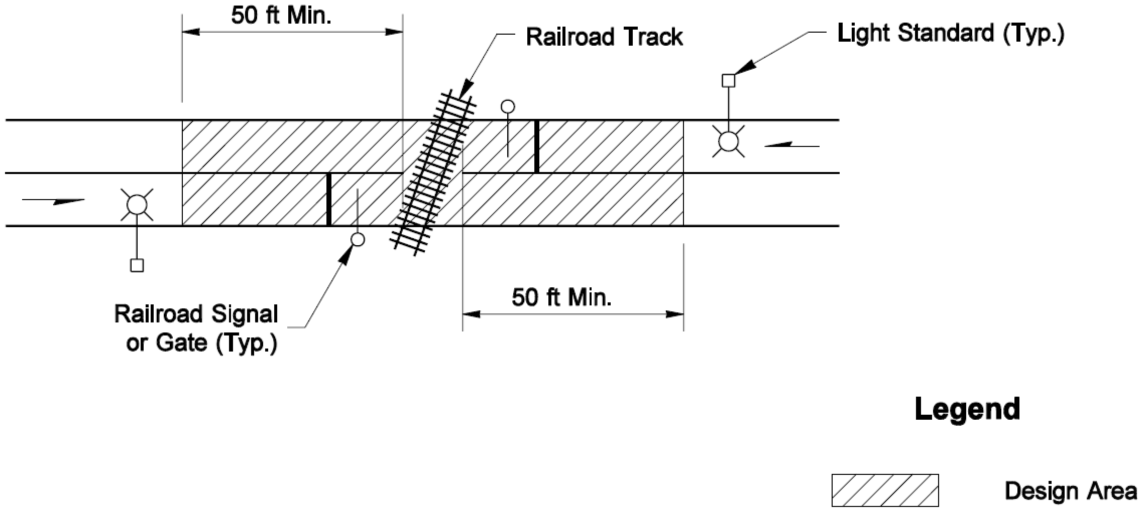
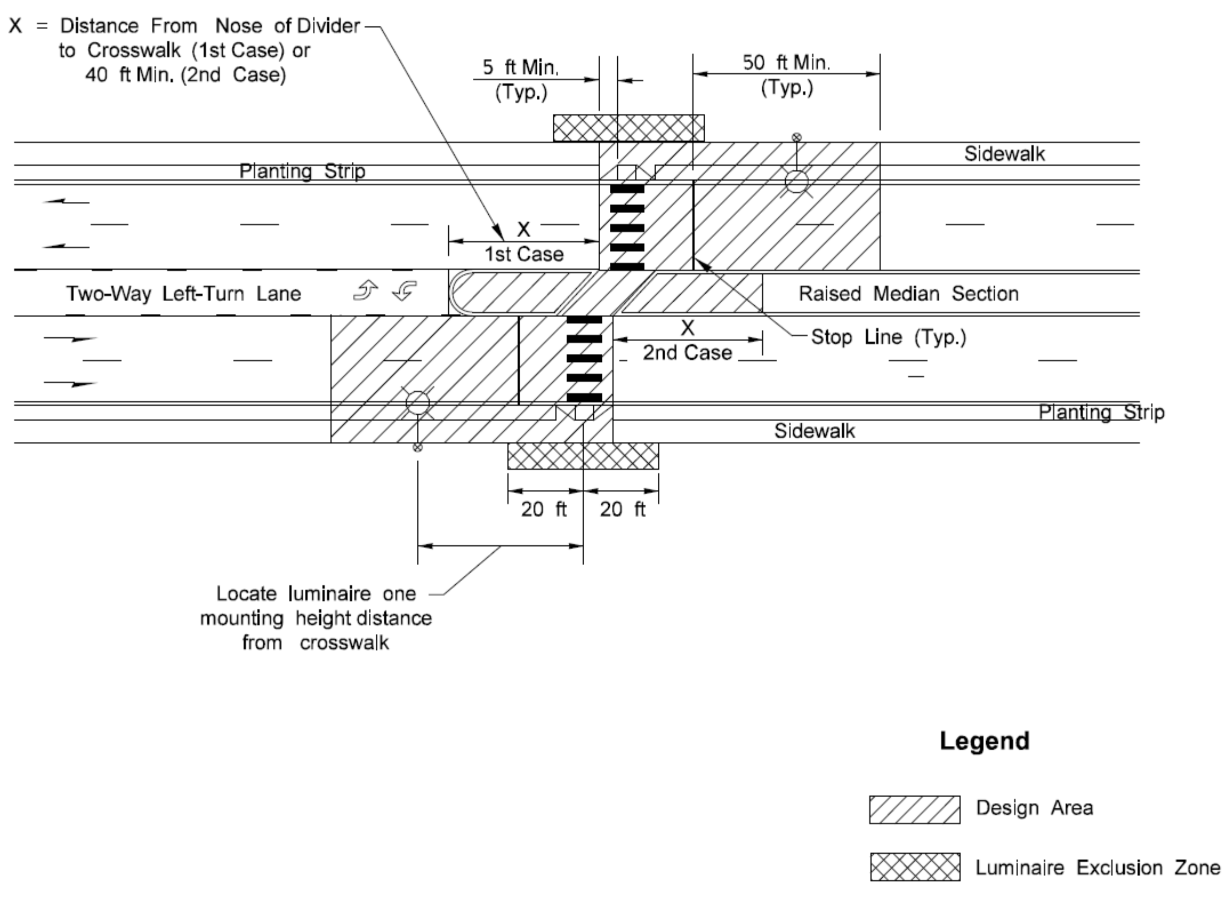


Exhibit 1040-11 Midblock Pedestrian Crossing



A minimum of two light standards of standard height is required for the design area.

Exhibit 1040-12 Transit Flyer Stop

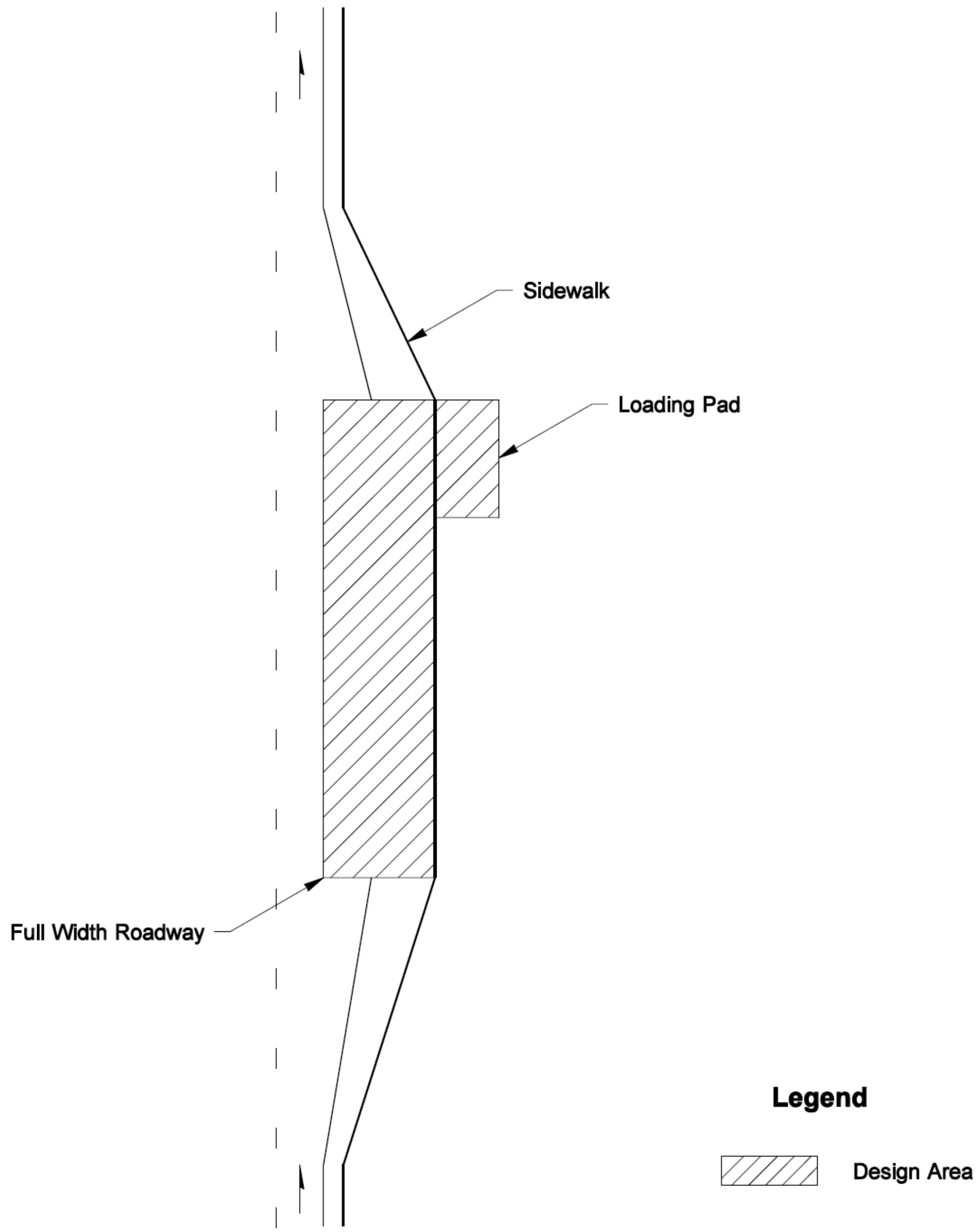


Exhibit 1040-13 Major Parking Lot

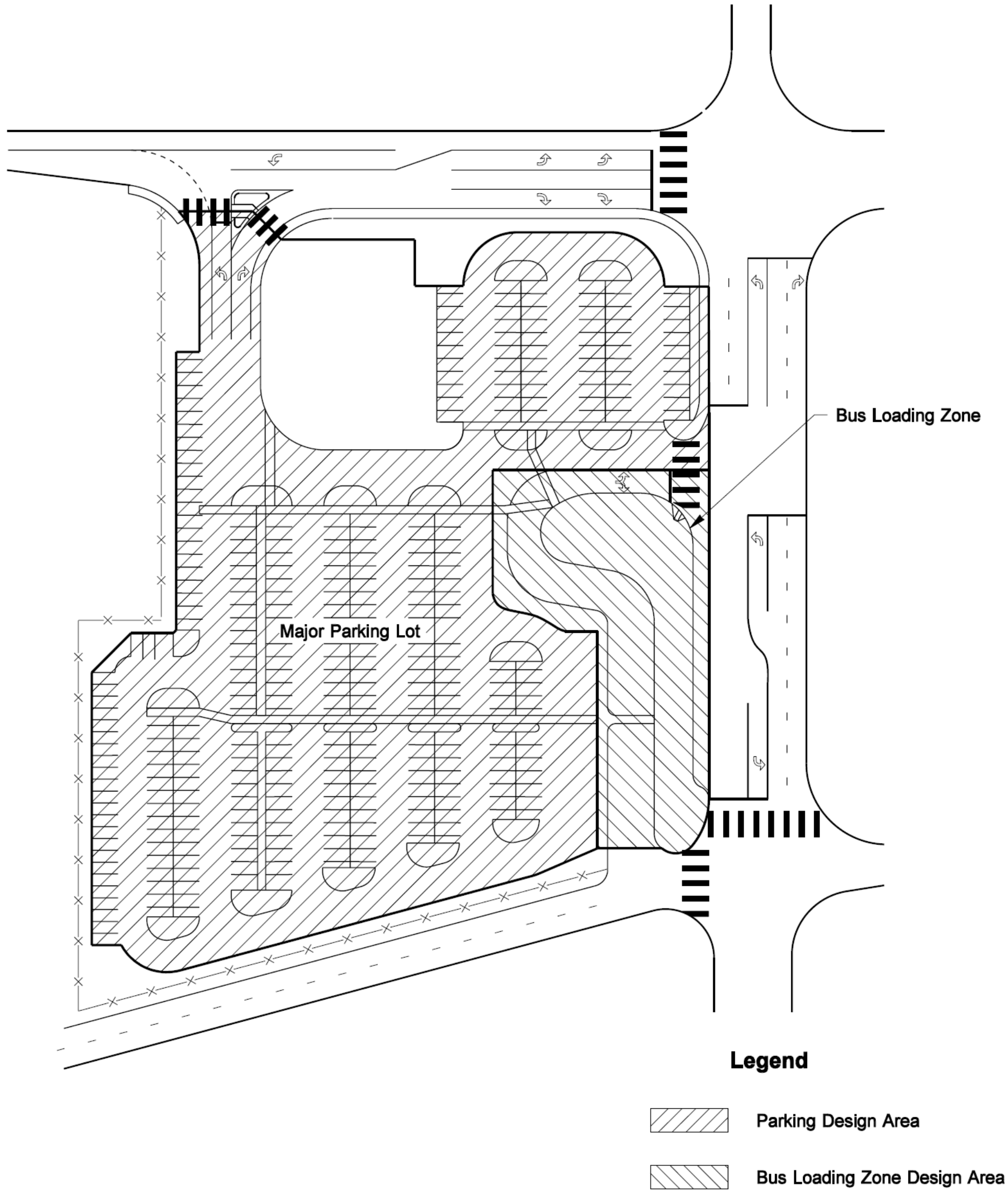


Exhibit 1040-14 Minor Parking Lot

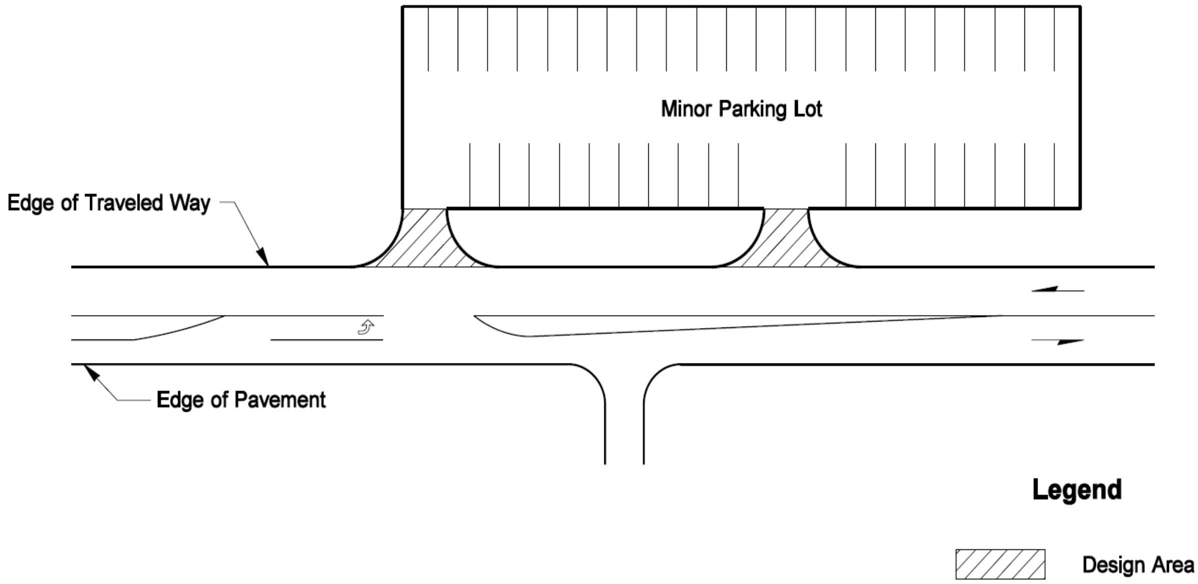


Exhibit 1040-15 Truck Weigh Site

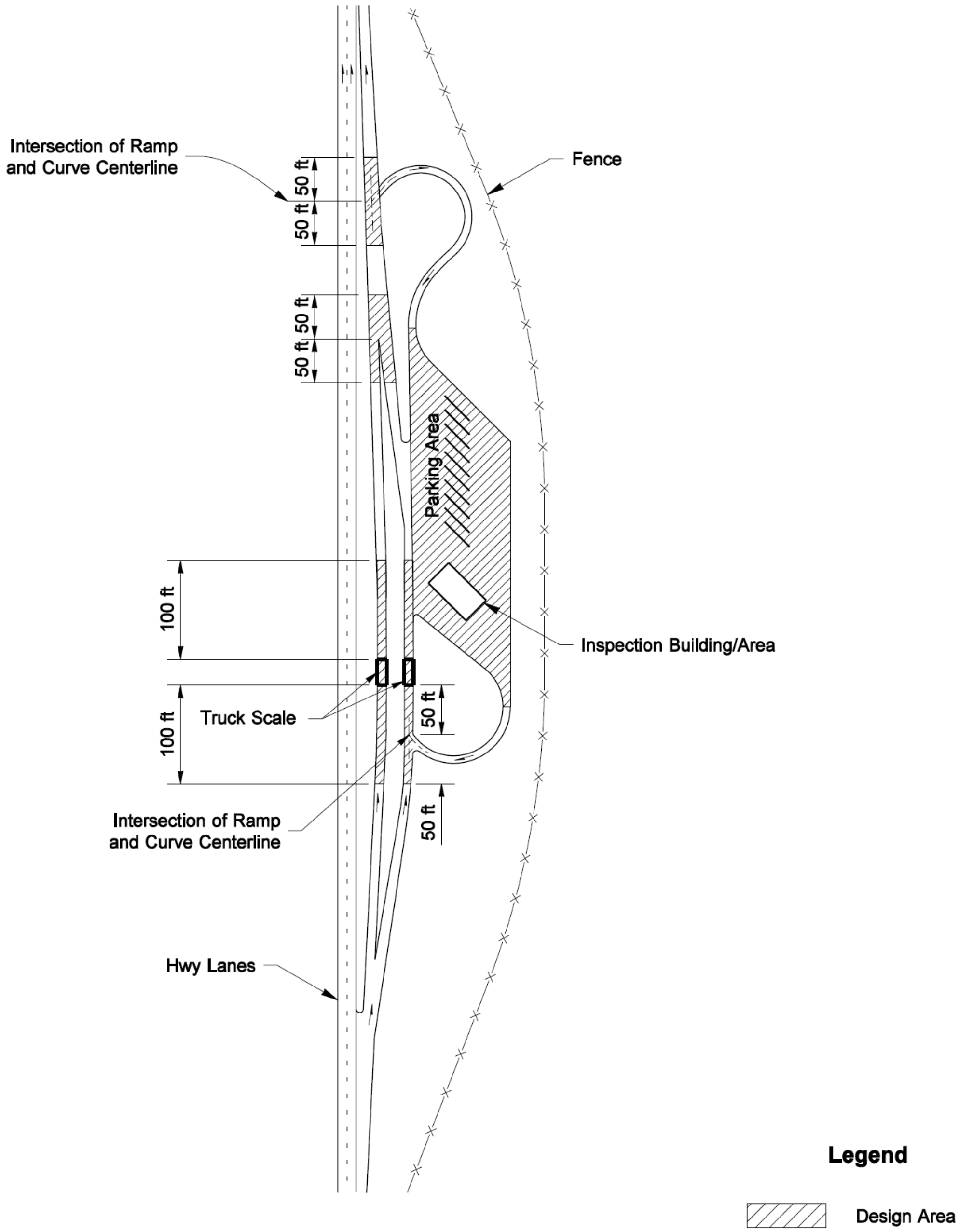


Exhibit 1040-16 Safety Rest Area

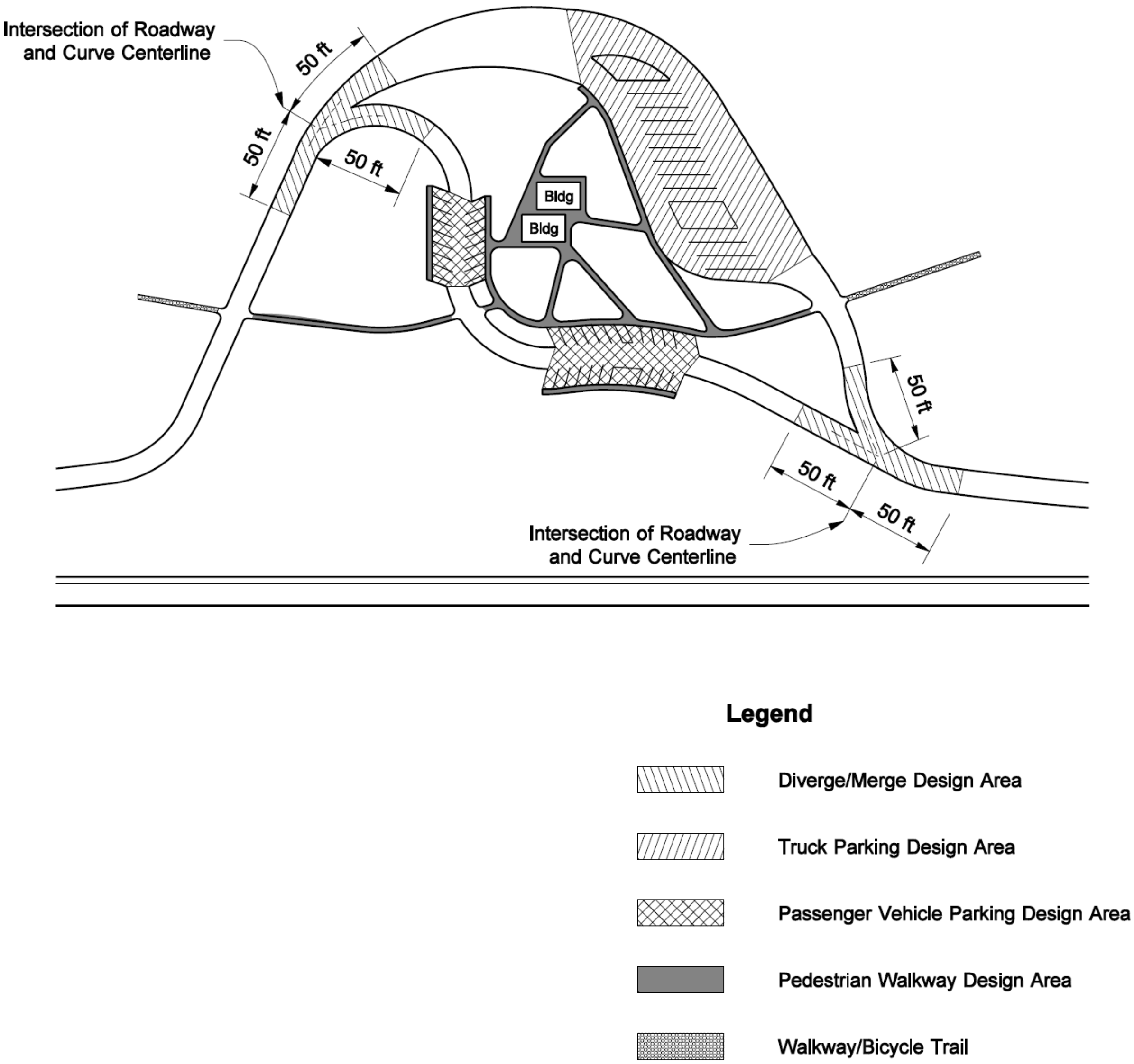


Exhibit 1040-17 Chain-Up/Chain-Off Parking Area

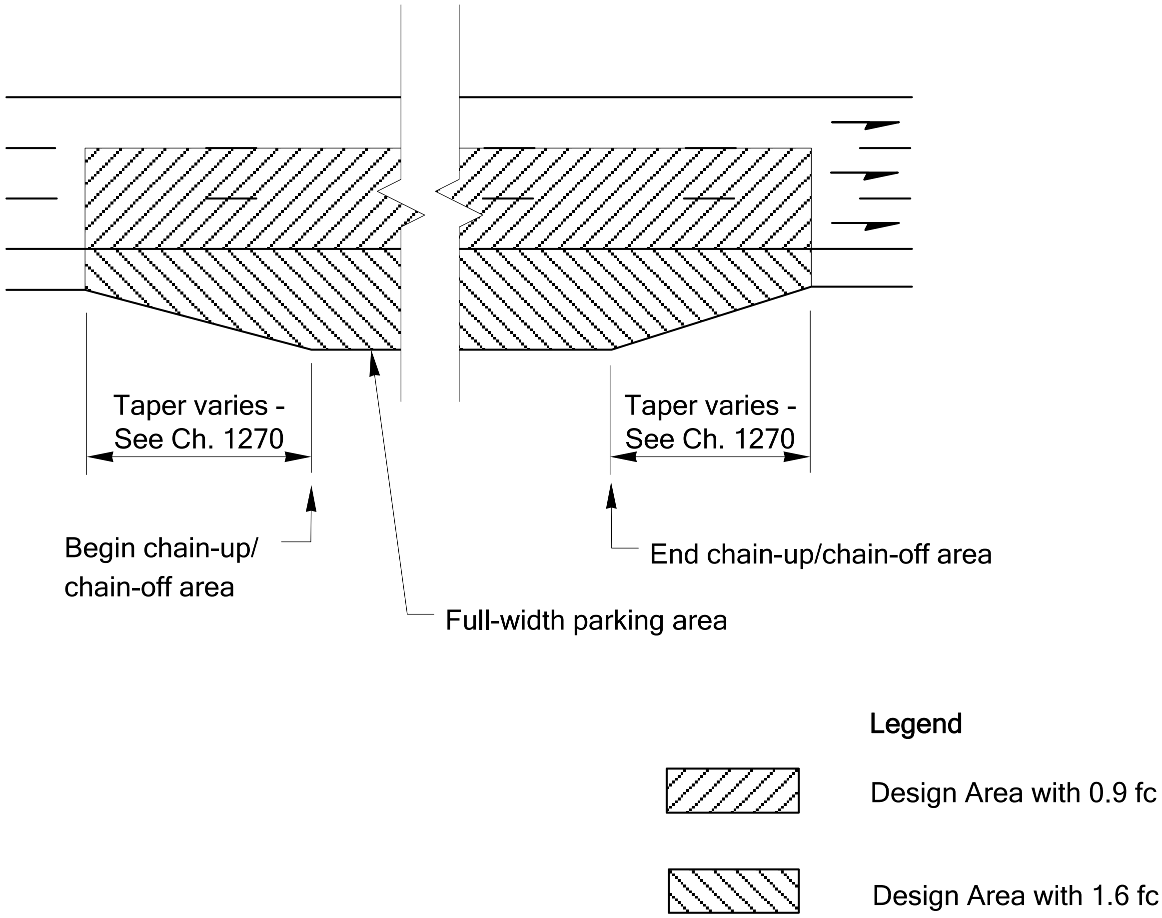
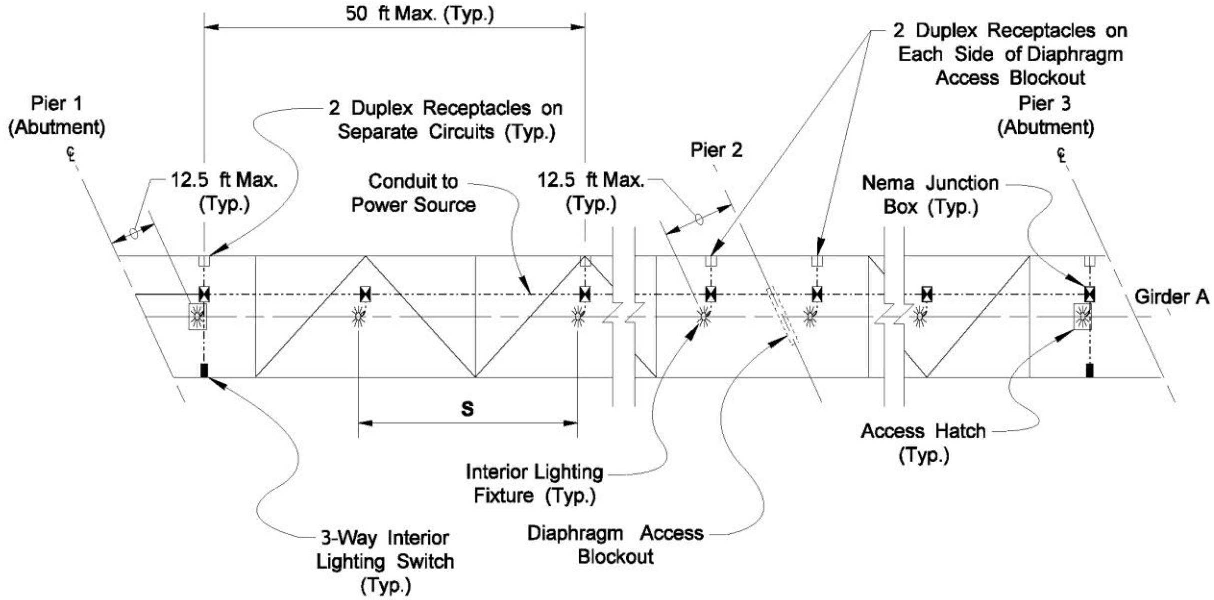


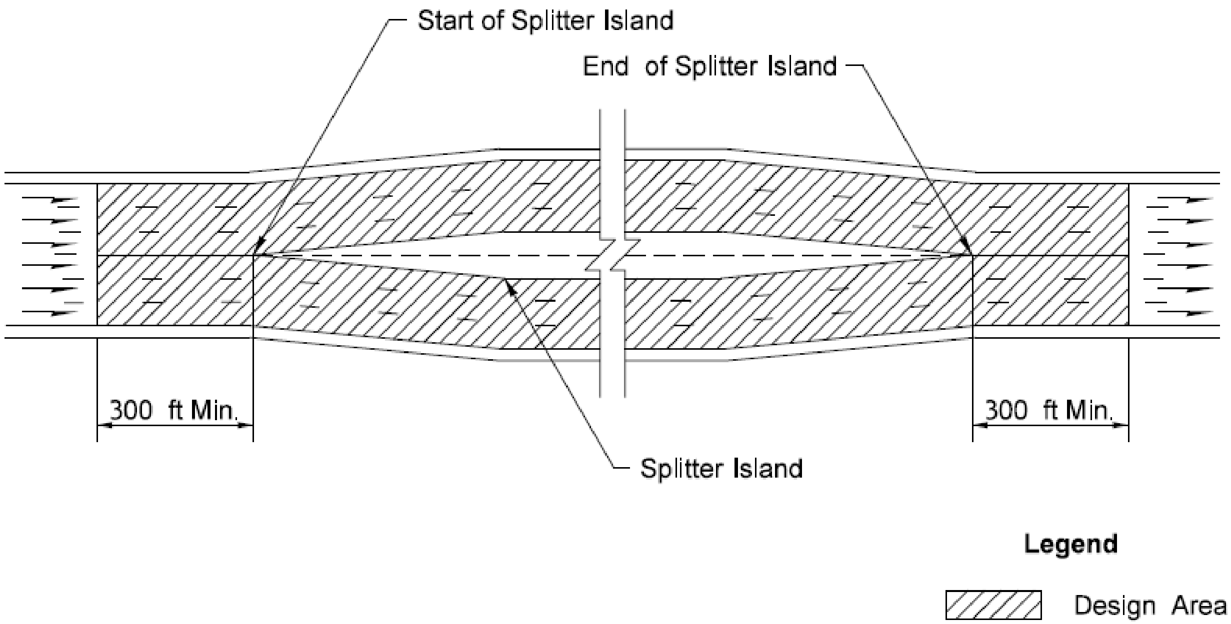
Exhibit 1040-18 Bridge Inspection Lighting System



Maximum Lighting Fixture Spacing (S):

Steel Box Girder Bridge S= 4 x (WEB DEPTH) ≤ 25 FT
Conrecte Box Girder Bridge S = 8 x (WEB DEPTH) ≤ 50 FT

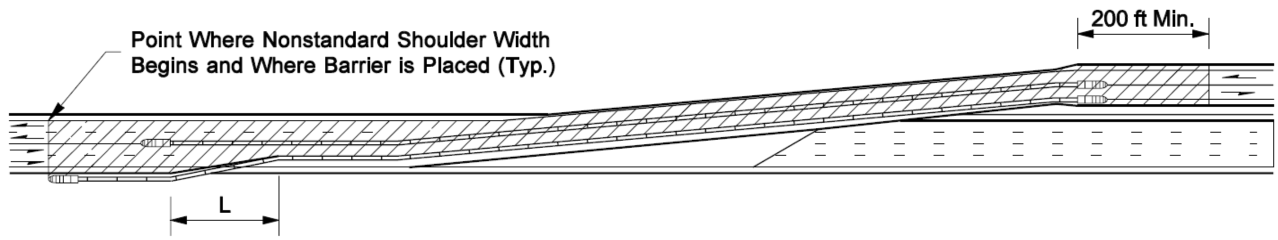
Exhibit 1040-19 Traffic Split Around an Obstruction



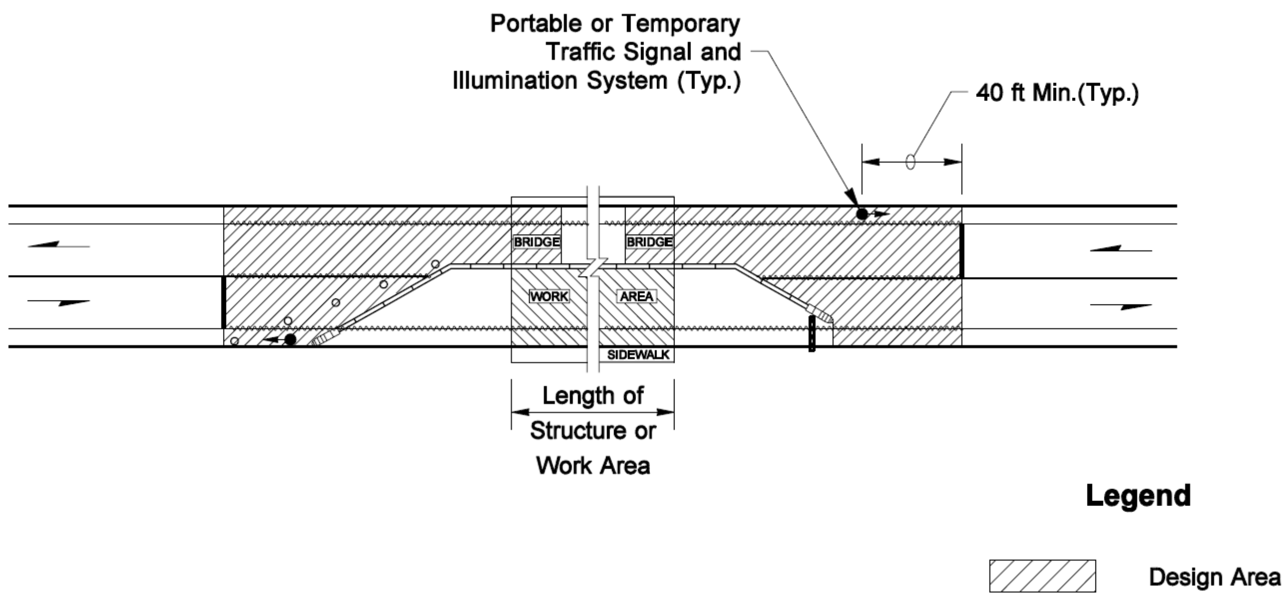
Note:

For temporary work zone plan applications, a site-specific traffic control plan is required. Refer to Chapters 1610 and 1620 for traffic barrier and attenuator information, Chapter 1010 for work zone information, and Chapter 1020 for signing information.

Exhibit 1040-20 Construction Work Zone and Detour



Detour Traffic



Lane Closure with Barrier and Signals without Flaggers or Spotters
One-direction closure shown/other direction closure typical.

Note:
For temporary work zone plan applications, a site-specific traffic control plan is required. Refer to Chapters 1610 and 1620 for traffic barrier and attenuator information, Chapter 1010 for work zone information, and Chapter 1020 for signing information. Refer to the MUTCD Typical Application 12 for additional details.

Exhibit 1040-21 Diverging Diamond Interchange

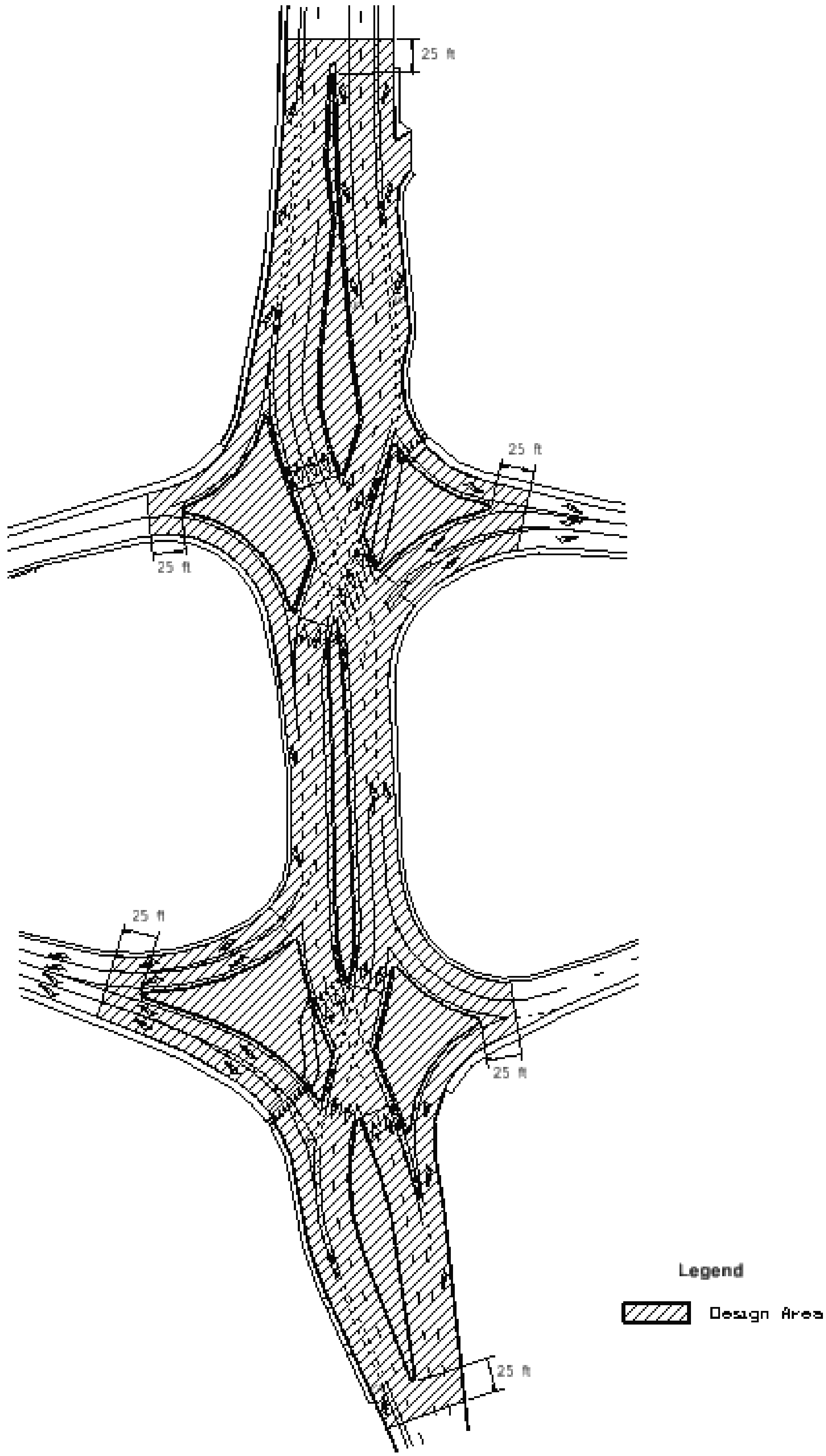


Exhibit 1040-22 Light Levels and Uniformity Ratios

Light Level and Uniformity Ratio Chart					
Highway Design Class	Minimum Average Maintained Horizontal Light Level — Pedestrian/Area Classification			Maximum Uniformity Ratio [5]	Maximum Veiling Luminance Ratio [6]
	High (footcandles)	Medium (footcandles)	Low (footcandles)		
Highways With Full Access Control [1][8]					
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	4:1	0.3:1
Ramp Intersections	0.9 [2]	0.9 [2]	0.9 [2]	4:1 [2]	0.3:1
Highways Without Full Access Control [3][8]					
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
Other Illuminated Features					
Construction Lanes and Detours	1.0	1.0	1.0	4:1	0.3:1
Major Parking Lots/Rest Areas	0.8	0.8	0.8	4:1	0.3:1
Vehicle Inspection Areas	2.0	2.0	2.0	4:1	0.3:1
Sidewalks, Walkways & Shared Use Paths	0.8	0.8	0.8	4:1	0.3:1
Weigh Scales	0.8	0.8	0.8	4:1	0.3:1
Transit Stops [4]	2.0	2.0	2.0	NA [7]	0.3:1
Midblock Ped X-ing	2.0	2.0	2.0	4:1	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] The minimum average maintained light level may be reduced to 0.6 fc and the uniformity ratio may be ignored when only one light standard is used. Also applies to minor parking lot entrances and exits, and basic transit stop lighting.

[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 Exhibit 1040-12).

[5] Minimum Average Maintained Light Level/Minimum Light Level = Maximum Uniformity Ratio.

[6] Maximum Veiling Luminance/Average Luminance = Maximum Veiling Luminance Ratio.

[7] The Maximum Uniformity Ratio is 4:1 when more than one light standard is justified.

Roundabout illumination shall meet intersection lighting requirements for the associated roadway classification.

Chapter 1231 Geometric Cross Section – Highways

1231.01 General

Geometric cross sections for state highways are governed by the need to balance performance metrics, the context, and selected design controls. The objective is to optimize the use of available public space while avoiding an unreasonable investment in right of way acquisition.

The term "highways" refers to all WSDOT roadways, including freeways. However, note that freeways have their own geometric cross section guidance. This chapter is not intended for freeway design. See Chapter 1232 for freeways.

1231.02 Design Up

Unless otherwise specified, use the "design up" method described in Chapter 1106 to choose a design element width when a range of widths is given in this chapter.

1231.03 Common Elements

The geometric cross sections shown in this chapter have many elements that are also common to facilities addressed in other chapters. The following chapters contain guidance related to these common geometric cross section elements:

- Lanes — Chapter 1231
- Shoulders, side slopes & ditches, medians & curbs — Chapter 1239
- Lateral clearance to curb or barrier — Chapter 1239
- Parking & streetside (behind the curb) elements — Chapter 1238
- Cross slope and superelevation — Chapter 1250

1231.04 Vehicle Lanes

1231.04(1) Type of Lanes

There are many types of lanes that may exist in a cross section, and each has its own purpose and sizing needs. General-purpose traffic lanes need to accommodate a variety of vehicle types including buses, freight vehicles, personal automotive vehicles, and bicycles. The target speed, modal priority, balance of performance needs, and transportation context are all considerations when determining size, type, and number of lanes.

Some common types of vehicle lanes include:

Through Lanes

Through lanes are the most common lane type. All highways have at least one lane in each direction to provide unimpeded traffic flow from Point A to Point B.

Turn Lanes

Dedicated turn lanes are separated from the through lanes and provide storage for turning vehicles waiting for a signal or gap in opposing traffic. There are a number of different types of turn lanes which are discussed in detail in Chapter 1310. Turn lanes are critical to meet mobility and accessibility performance for motorized and bicycle modes. Traffic analysis determines the type, storage length, and number of turn lanes that are needed to achieve the balance of multimodal performance needs.

Turn lanes present potential conflicts, particularly with bicyclists and pedestrians. See Chapters 1510 and 1520 for additional discussion on ways to mitigate for these conflicts.

Bicycle Lanes

There are several different types of bicycle lanes and many different ways to arrange bike lanes within the geometric cross section (see Chapter 1520). Shoulders designed to function for bikes are not considered bike lanes.

Transit-Only Lanes

Transit-only lanes are ideal for improving transit mobility performance and segregating heavily used or complex intermodal connections. There are many different ways to configure these within a geometric cross section. Some configurations are limited due to passenger loading needs for both the transit vehicle type and the stop locations. Develop widths for transit-only lanes with the partnering transit agency. See Chapter 1430 for additional information on Transit Facility considerations.

Auxiliary lanes

Auxiliary lanes enhance mobility performance for motor vehicles. See Chapter 1270 for design guidance and a detailed discussion on the types of auxiliary lanes.

Managed and Shared Lanes

There are many different types of managed and shared lanes. Some examples include:

- High occupancy vehicle (HOV) lanes (see Chapter 1410)
- High occupancy toll lanes (discuss with Tolling Division and see Chapter 1410)
- Hard shoulder running
- Peak hour use
- Bicycle shared lane (see Chapter 1520)
- Business access and transit (BAT) lane (see Chapter 1410, Arterial Street HOV)

1231.04(2) Lane Width

Lane width ranges for highways are listed in Exhibit 1231-1.

Exhibit 1231-1 Lane Widths for Highways

Speed	Highway Type	Lane Width Range*
High Speed (≥50mph)	Freeway (incl. Interstate)	See Chapter 1232
	Other Highway	11' - 12'
Intermediate Speed (40 & 45 mph)	All	11' - 12'
Low Speed (≤35mph)	All	10' - 12'

* The width shown is exclusive of the gutter if the gutter is a color that contrasts with the roadway.

1231.04(2)(a) Lane Width Considerations

Exhibit 1231-2 lists some considerations that may be helpful in choosing the most appropriate lane width from the range given in Exhibit 1231-1. This is not a comprehensive list. The considerations listed are meant to help understand the modal needs and function associated with different lane widths. Work with your Region Traffic Office when choosing lane widths.

Exhibit 1231-2 Lane Width Considerations

Lane Width Considerations	
General	Roadways on curves, see Chapter 1240 Turning Roadway Widths
	Narrower lanes may be used as part of a speed reduction strategy
	Two-lane, two-way rural highways: 12 ft lanes provide clearance between large vehicles traveling in opposing directions. Especially beneficial when high volumes or high truck percentages expected
	On multilane facilities with width constraints, utilizing narrower inside lanes may permit wider outside lanes for bicycles, freight, and transit
	Reduced lane widths allow more lanes to be provided in areas with constraints and allow shorter pedestrian crossing times because of reduced crossing distances
Intermediate to High Speed	12 ft lanes provide increased benefit on high speed, free-flowing principle arterials
	12 ft lanes provide increased benefit where there are higher truck volumes, especially for intermediate and high speed facilities
	Safety and mobility performance difference between 11 ft and 12 ft lanes can be negligible. Work with Region Traffic Office to evaluate performance differences for the subject roadway
Low Speed	11 ft lanes are common on urban arterials
	Lane widths of 10 ft may be appropriate in constrained areas with low truck and bus volume
	In pedestrian oriented sections, 10 ft lanes can be beneficial in minimizing crossing distance

1231.05 Modally Integrated Cross Sections

WSDOT's goal is to optimize existing system capacity through better interconnectivity of all transportation modes. Choosing the appropriate geometric cross section relies heavily on designing for the appropriate modes. See Chapter 1103 for guidance in selecting modes to accommodate and choosing modal priorities.

Once a decision is made regarding which modes to accommodate and which modes will have priority, a geometric cross section can be developed. The cross sections in this chapter are organized by modal priority for the following primary modes:

Motor Vehicles, including freight

Bicycles

Pedestrians

Transit

The cross-section examples shown in Exhibits 1231-3 through 1231-7 depict various combinations of elements that may be included in a cross section. The examples are intended to stimulate designer creativity and awareness of modal accommodations, and are not intended to be standard cross sections to be reproduced for a given modal priority. It is expected that innovative project alternatives will result in diverse configurations that best balance baseline and contextual needs (see Chapter 1101).

Since the cross-sections shown are only examples, and are really combinations of various elements, it is important to read the guidance associated with the specific elements (see 1231.03) in order to understand the considerations that may affect a choice of width, and to understand documentation requirements.

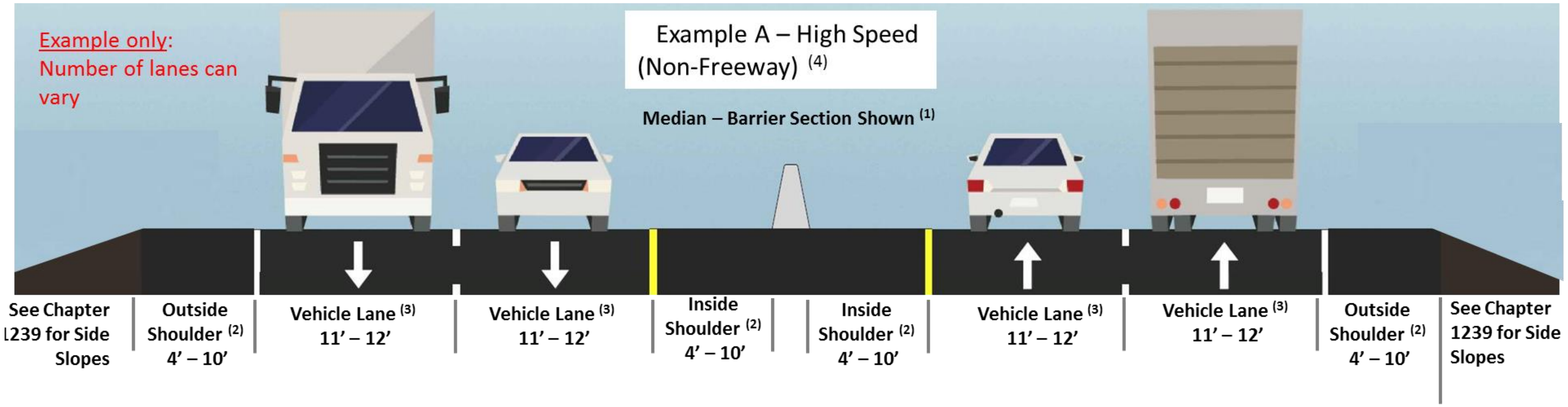
The cross section examples provide a range of dimensions for different design elements. See Chapter 1106 for guidance regarding choosing a width when a range of widths is given.

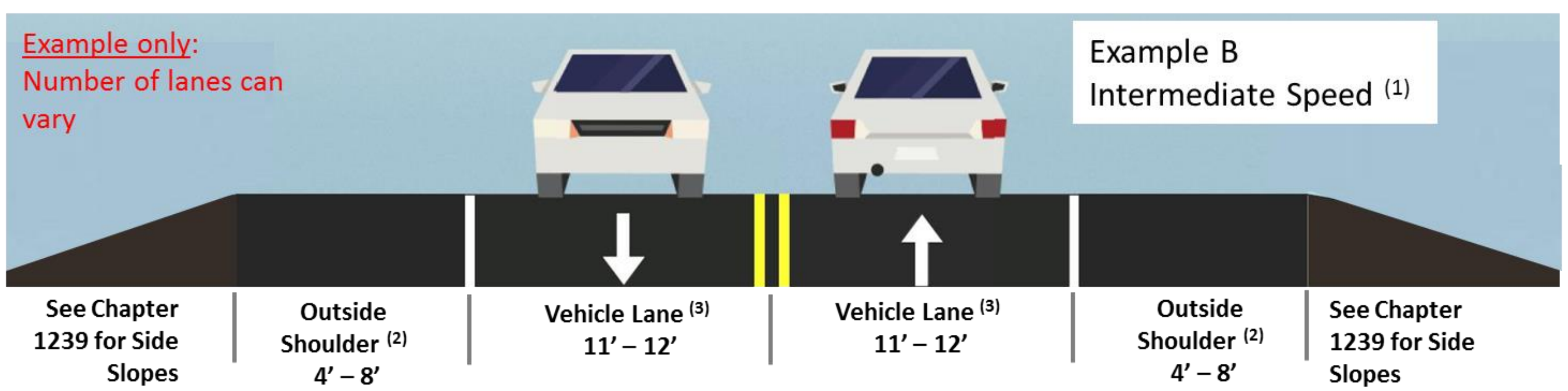
Maintaining the continuity of a roadway is an important consideration, particularly for limited access and other high-speed highways. However, it is also appropriate to change continuity as context changes in order to influence driver behavior. When designing intentional changes to the continuity of the geometric cross section, consider what is needed to enable the transition. High-speed to low-speed changes will need to transition the geometric cross section over a distance utilizing a speed transition segment (see Chapter 1103).

1231.05(1) Auto-and Freight Oriented Cross Sections

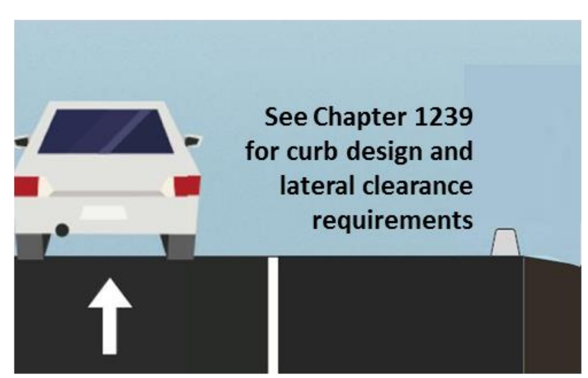
Exhibit 1231-3 shows examples of motorized vehicle-oriented designs. Motorized vehicles come in a variety of types which are operated on many vehicle lanes and parking areas. The performance needs of freight and other automotive vehicle types are often similar. However, certain truck vehicle types may require additional turning roadway width for off-tracking (see Chapter 1240), or at other locations a truck climbing lane may be needed to facilitate mobility performance (see Chapter 1270). Generally, lane width within suburban and urban contexts is less critical for mobility and safety performance than in rural and high-speed contexts. Within urban areas, placement of and sizing for loading areas within the parking areas can depend on the freight vehicle type.

Exhibit 1231-3 Motor Vehicle Oriented Cross Sections





Barrier Present



Curb Present

Notes:

[1] Overall median width and design will vary. Some median designs include barrier and some do not. See Chapters 1239 and 1600.

[2] See Chapter 1239 for guidance on choosing a dimension from the range given.

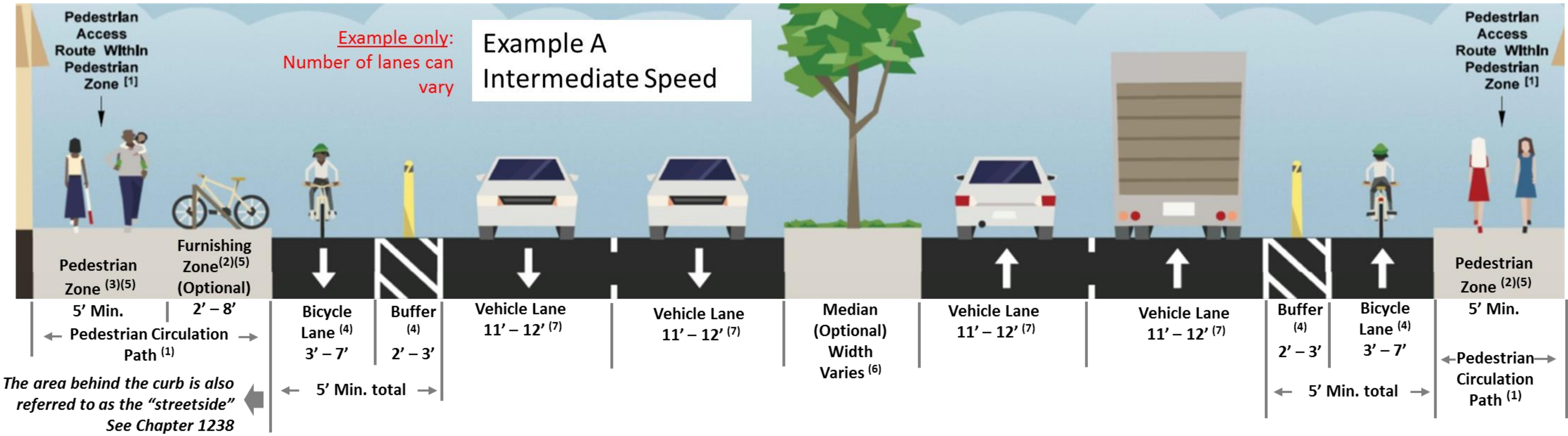
[3] See 1231.04 for guidance on choosing a dimension from the range given. See Chapter 1410 for guidance on HOV facilities.

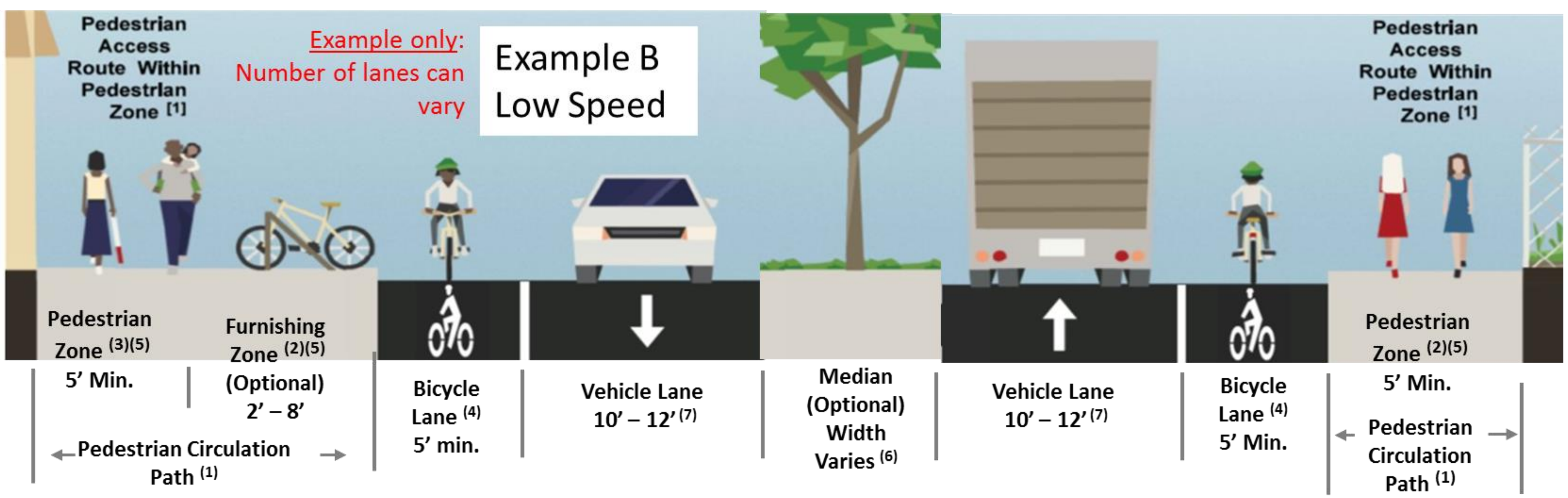
[4] See Chapter 1232 to see if your roadway meets the definition of a freeway.

1231.05(2) Cross Sections Featuring Bicycle Facilities

Exhibit 1231-4 Example A features bicycle facilities at an intermediate-speed location. Bike lane location within the cross section depends largely on how cyclists will interact with the land use and potential modal conflicts. Locating bike lanes on the outside of the motor vehicle lanes can improve accessibility for bicyclists. If cyclist mobility performance is a primary concern or intermodal conflicts (such as transit stop locations) are present, locating bike facilities in the center of the roadway may be more appropriate. Whether or not a bike lane buffer is needed depends mostly on the target speed and average daily traffic (ADT) of the facility; the intent of bike buffers or other protected bike facilities is to address safety performance for cyclists. Buffers and other means of modal segregation also benefit motor vehicle drivers and pedestrians by showing allocated spaces. Both roadway bike lane configurations and bike facility selection are discussed in more detail in Chapter 1520.

Exhibit 1231-4 Cross Sections Featuring Bicycle Facilities





Notes:

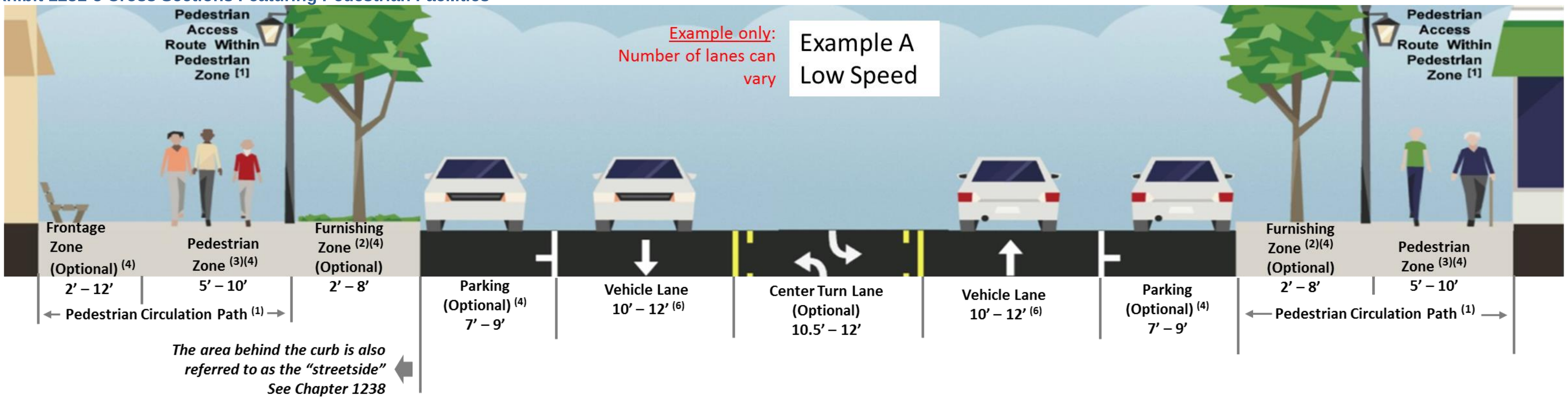
[1] See Chapter 1510.
[2] Minimum width specified is exclusive of the curb width.
[3] If no furnishing zone is provided, minimum width is exclusive of the curb width.
[4] See Chapter 1520 for bike facility options.
[5] See Chapter 1238.
[6] Overall median width and design will vary. See Chapter 1239 .
[7] See 1231.04 for guidance on choosing a dimension from the range given.

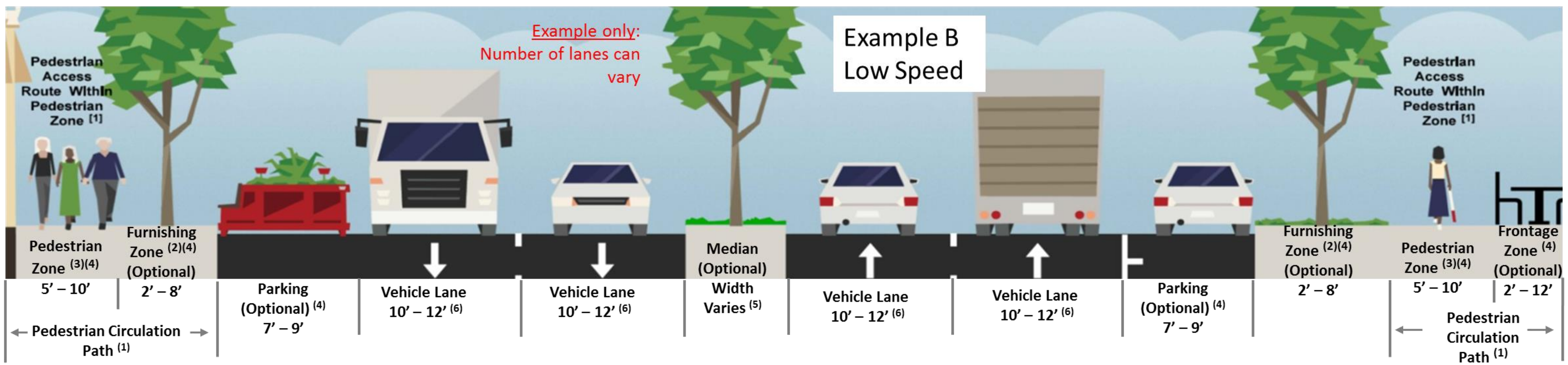
1231.05(3) Cross Sections Featuring Pedestrian Facilities

Exhibit 1231-5 shows cross-section examples featuring pedestrian facilities. The pedestrian mode is a vital transportation mode since, for most people, nearly every trip at least begins and ends by walking. Roadway facilities prioritized for pedestrians emphasize streetside elements. See Chapter 1238 for guidance regarding streetside elements.

The objective is to achieve the Pedestrian Circulation Path (PCP) necessary to support mobility, socioeconomic, and accessibility needs and provide access to intermodal connections. The configuration and dimension of streetside elements varies significantly depending on the performance needs being addressed. See Chapter 1510 for additional pedestrian design requirements and considerations.

Exhibit 1231-5 Cross Sections Featuring Pedestrian Facilities





Notes:

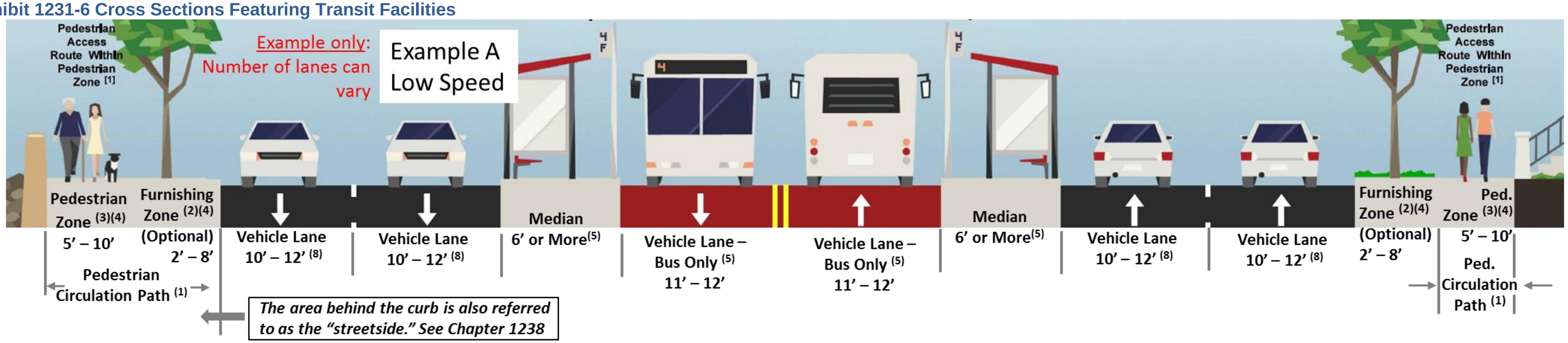
[1] See Chapter 1510.
[2] Minimum width specified is exclusive of curb width.
[3] If no furnishing zone is provided, minimum width is exclusive of the curb width.
[4] See Chapter 1238.
[5] Overall median width and design will vary. See Chapter 1239.
[6] See 1231.04 for guidance on choosing a dimension from the range given.

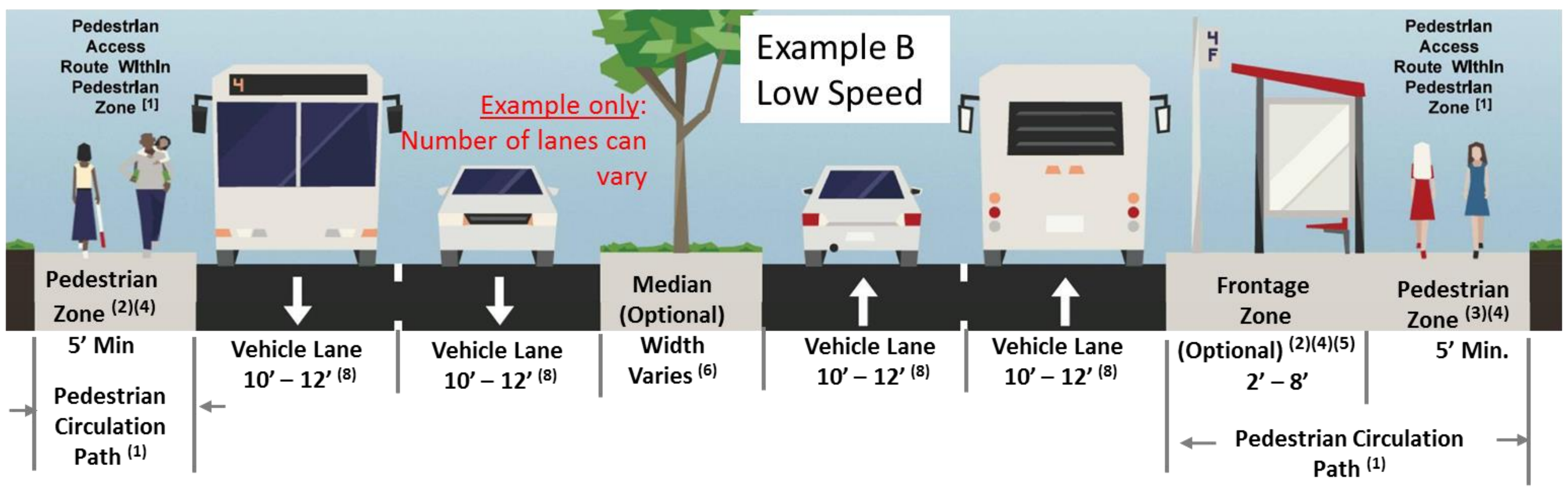
1231.05(4) Cross Sections Featuring Transit Facilities

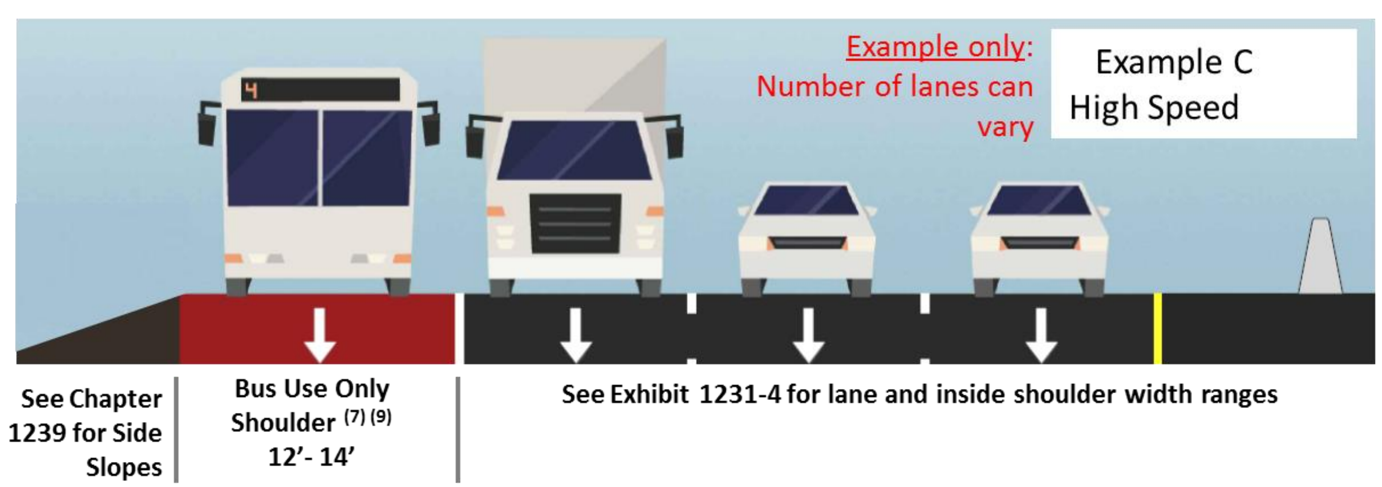
Exhibit 1231-6 provides examples of different potential configurations oriented for the transit mode. Work with the transit provider to determine their ability to operate within a given cross-sectional arrangement. In general, transit configurations can be positioned toward the side or center of a roadway. Both side and center configurations can be implemented with medians or outer separations to improve safety performance for intermodal connections, or mobility performance for the transit service.

Exhibit 1231-6 Example A shows a central configuration for transit service that provides a separated bus-only lane. Other transit vehicle types may require different widths and may also require other center cross section configurations for passenger loading. Exhibit 1231-6 Example B shows a side configuration where transit vehicles occupy the outside lane. This example can also be configured as business access and transit [BAT] lanes. Note the importance of streetside elements to assist with intermodal connections. Exhibit 1231-6 Example C is an example of a type of special use lane for high-speed routes that are routinely congested. In this example, the shoulder allows the restricted use for buses.

Exhibit 1231-6 Cross Sections Featuring Transit Facilities







Notes:

[1] See Chapter 1510.
[2] Minimum width specified is exclusive of the curb width
[3] If no furnishing zone is provided, minimum width is exclusive of the curb width.
[4] See Chapter 1238.
[5] Verify width needs with transit provider, including lift extension needs. See Chapter 1510 for Pedestrian Access Route requirements, which may be affected by presence of a shelter. See Chapter 1430 Transit Facilities.
[6] Median width and design will vary. See Chapter 1239
[7] Verify width needs with transit provider. See Chapter 1239 for bus use only shoulder, requires a Design Analysis.
[8] See 1231.04 for guidance on choosing a dimension from the range given.
[9] See Chapter 1239 for guidance on choosing a dimension from the range given.

1231.05(5) Example Cross-Sections – Complete Streets

Complete street configurations attempt to balance the performance needs of all users, regardless of age, ability, or mode. The general intent is to provide context-appropriate designs that enable safe access for all design users. It is always important to consider modal connectivity and conflicts that may occur with complete street configurations, particularly at intersections and/or transit stop locations.

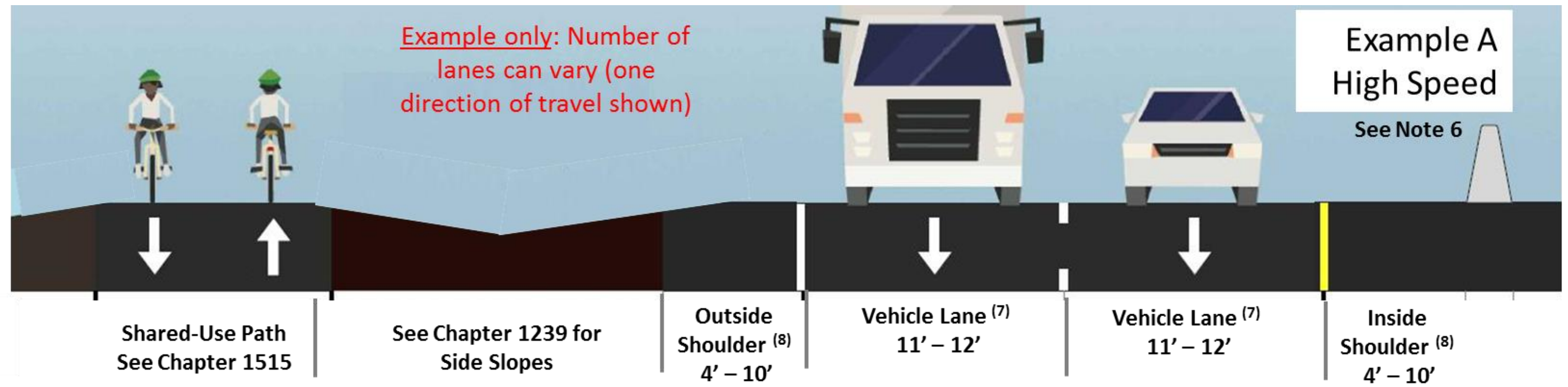
There are different potential configurations for complete streets, such as:

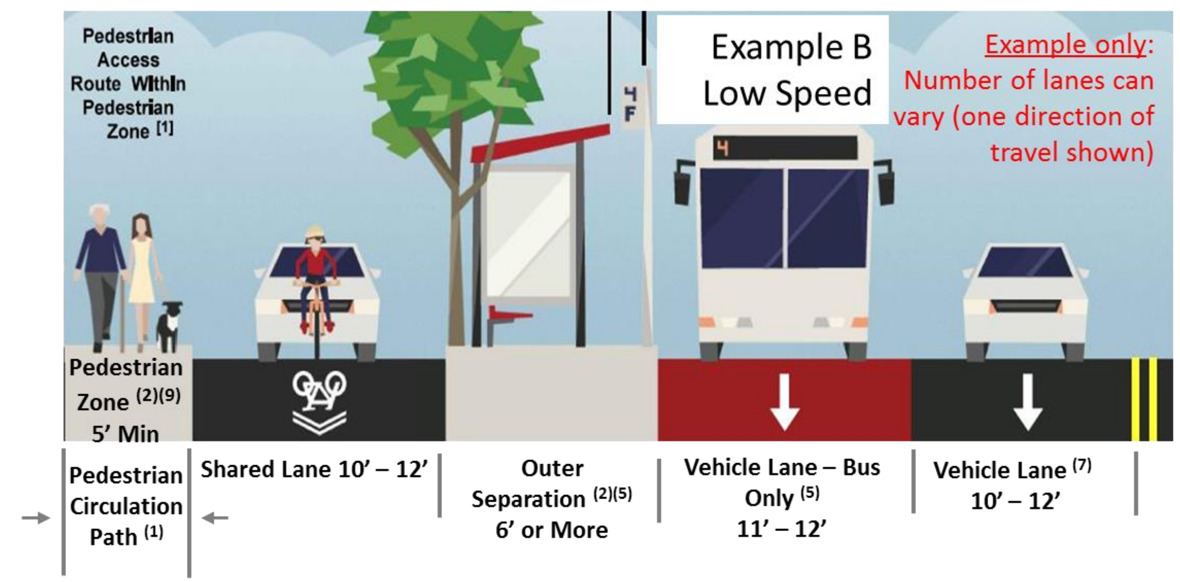
- A rural two-lane highway with wide shoulders; the shoulders can be used by motor vehicles in emergencies and by pedestrians and bicyclists.
- An urban highway or street with vehicle lanes, bike lanes, bus lanes, and sidewalks.
- Retrofitting a highway or street to clearly mark and sign a shared-use lane.
- An urban highway that undergoes a “road diet” (see 1231.06) or installation of additional pedestrian crossings.

The low speed examples in Exhibit 1231-7 illustrate roadway cross sections that:

- Separate access lanes from through traffic lanes using curbed islands.
- Reduce conflicts between pedestrian, bike, transit and auto modes by separating them.
- Provide transit stops integrated with raised islands.
- May result in improved operations for all modes.

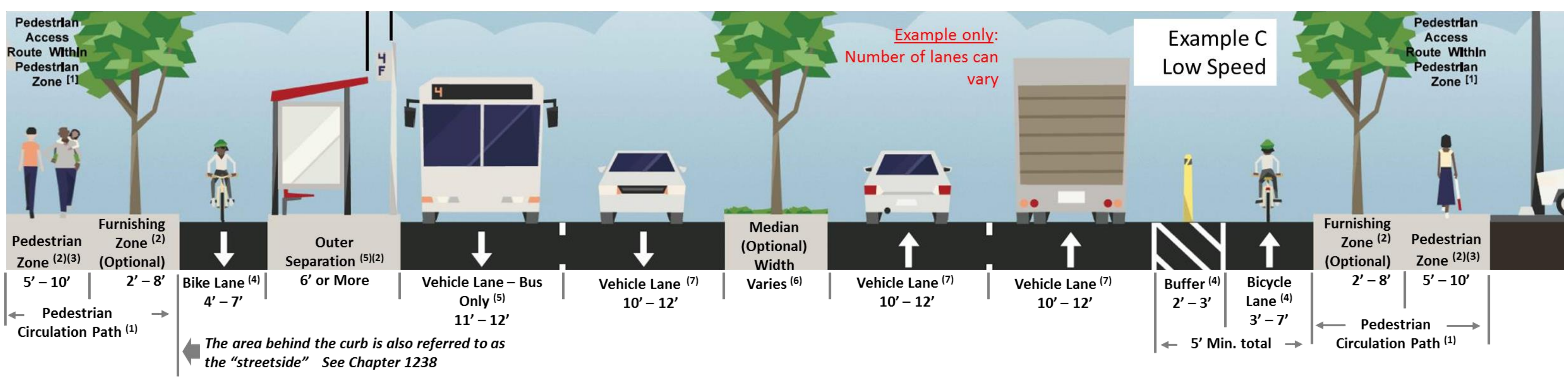
Exhibit 1231-7 Complete Street Cross Sections





Notes:

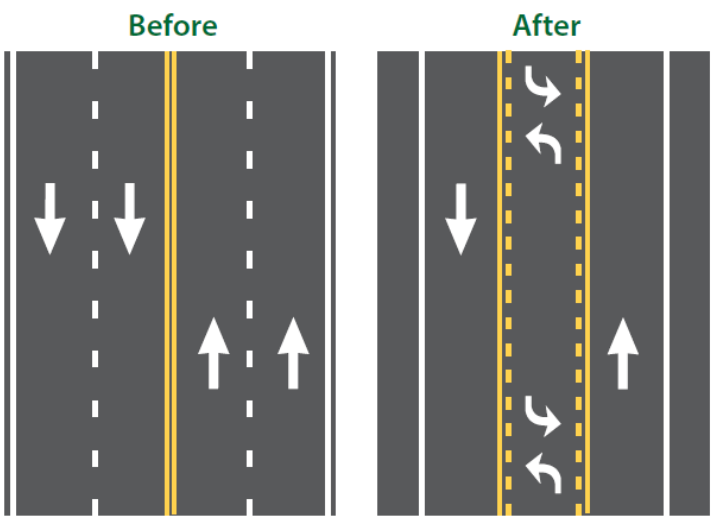
[1] See Chapter 1510.
[2] See Chapter 1238.
[3] If no furnishing zone is provided, minimum width is exclusive of the curb width.
[4] See Chapter 1520 for bike facility options.
[5] Verify width needs with transit provider. See Chapter 1430.
[6] Overall median width and design will vary. See Chapter 1239.
[7] See 1231.04 for guidance on choosing a dimension from the range given.
[8] See Chapter 1239 for guidance on choosing a dimension from the range given.
[9] Minimum width specified is exclusive of the curb width.



1231.06 Road Diets and Retrofit Options

Generally, road diets refer to converting four-lane undivided highways to three lanes with the center lane for left turning movements and the remaining outside space repurposed for bicyclists or other functions. The center lane can consist of a two-way left-turn lane (TWLTL) or can be dedicated for directional left turns either by paint or other median treatments. The choice of how to configure the center lane depends largely on balancing the resulting safety and accessibility performance of different modes and land uses.

The application of road diets also has the benefit of reallocating existing space within a cross section, which provides distinct opportunities to improve roadway bicycle facilities and/or elements of the streetside. At intersections and access points, a road diet can improve sight distance, may improve access management along the road, and in some cases, improve mobility performance for motorists.



Typical Road Diet Basic Design from FHWA Road Diet Informational Guide

The success of road diet implementation varies due to a number of factors such as signal spacing and timing, access connection density, modal priority, and average daily traffic (ADT). ADT is a reasonable indicator for implementation. FHWA recommends limiting road diet applications to roadways of 20,000 ADT or less, although road diets have been successful at locations with 25,000 ADT in various parts of the country (see Chapter 540 for additional restrictions on the use of TWLTLs). Motor vehicle mobility performance is most likely deemed the primary measure of success for the road diet configurations with higher ADT values described. However, locations with a different modal priority and higher ADT may still be candidates for road diets. The Region Traffic Engineer must approve road diet applications on state highways.

Retrofit options refer to the application of lower-cost treatments that utilize paint and other delineation devices rather than hardscape features. See Chapter 1238 for more information on retrofit options such as relocating the curb, parklets and plazas.

1231.07 References

1231.07(1) 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, M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction, M 41-10, WSDOT

1231.07(2) Supporting Information

FHWA Road Diet Informational Guide, FHWA, 2014
www.safety.fhwa.dot.gov/road_diets/info_guide/

Understanding Flexibility in Transportation Design – Washington, WA-RD 638.1, Washington State Department of Transportation, 2005
www.wsdot.wa.gov/research/reports/fullreports/638.1.pdf

Urban Bikeway Design Guide, National Association of City Transportation Officials, New York, NY, 2012 revised 2013
www.nacto.org

Urban Street Design Guide, National Association of City Transportation Officials, New York, NY, 2013
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Designing Walkable Thoroughfares: A Context Sensitive Approach, Institute of Transportation Engineers, Washington D.C., 2010.
www.ite.org

Guide for Geometric Design of Transit Facilities on Highways and Streets, AASHTO, Washington, D.C., 2011
www.transportation.org/Pages/Default.aspx

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition
www.transportation.org/Pages/Default.aspx

A Policy on Design Standards Interstate System, AASHTO, 2005
www.transportation.org/Pages/Default.aspx

NCHRP Synthesis 443 – Practical Highway Design Solutions, Transportation Research Board, Washington D.C., 2013
http://www.trb.org/Main/Blurbs/168619.aspx

NCHRP Report 785 – Performance-Based Analysis of Geometric Design of Highways and Streets, Transportation Research Board, Washington D.C., 2014
www.trb.org/Main/Blurbs/171431.aspx

NCHRP Report 783 – Evaluation of the 13 Controlling Criteria for Geometric Design, Transportation Research Board, Washington D.C., 2014
www.trb.org/Main/Blurbs/171358.aspx

NCHRP Report 505 – Review of Truck Characteristics as Factors in Roadway Design, Transportation Research Board, Washington D.C., 2003
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_505.pdf

Chapter 1239 Geometric Cross Section – Shoulders, Side Slopes, Curbs, and Medians

1239.01 Introduction

This chapter provides information on geometric cross section components that are common to many facility types. Cross section elements include: shoulders, medians and outer separations, side slopes, and curbing.

1239.02 Shoulders

Shoulders are typically used on high, or intermediate speed limited and non-limited access facilities, some rural contexts, as well as intermediate-speed locations that do not have streetsides (curb-sections) (see Chapter 1238). Intermediate-speed locations in suburban and urban contexts that utilize streetsides do not need to include a shoulder unless determined to be necessary by shoulder function, (where intended for bicyclists for example) or safety performance analysis, hydraulic analysis or engineering judgment.

Shoulders provide space to escape potential collisions or reduce their severity. They also provide a sense of openness, contributing to driver ease at higher speeds. Shoulders also convey drainage away from the traveled way as determined by hydraulic analysis.

1239.02(1) Shoulder Width

Shoulder width ranges for highways are shown in Exhibit 1239-1. Use the mode/function/performance approach (Chapter 1106) to choose a dimension from the range given.

Exhibit 1239-1 Shoulder Widths for Highways

Posted Speed	Highway Type	Shoulder Width [1] [2]	
		Inside (median)	Outside
High speed (≥50mph)	Freeway (including Interstate)	See Chapter 1232	
	Other highway	4' – 10'	4' – 10'
Intermediate speed (40 & 45 mph)	All	4' – 8'	4' – 8'[3]
Low speed (≤35mph)	All	0' – 8' [2]	2' – 8'[3]

Notes:

[1] Bus use only shoulder width range is 12-ft to 14-ft.

[2] If curb or barrier present, see Exhibit 1239-10.

[3] Intermediate-speed and low-speed locations in urban and suburban contexts utilizing streetsides do not need to include a shoulder unless necessary for safety performance, hydraulic performance or engineering judgment. See Exhibit 1231-5, Exhibit 1231-6 (A & B), Exhibit 1231-7 (B & C), and Section 1239.02.

1239.02(1)(a) Shoulder Width Considerations

Exhibit 1239-2 lists considerations for choosing an appropriate shoulder width from the range given. The considerations listed help one to understand the modal needs and function associated with different shoulder widths.

Contact the Area Maintenance Superintendent to determine/verify the shoulder width appropriate for maintenance operations. In some cases, a continuous width is not necessary; instead, the focus is placing the shoulder width near assets with high-frequency maintenance needs. Compare the added cost of the wider shoulders to the added benefits to maintenance operations as well as other benefits that may be derived (see Chapter 301).

The usable shoulder is the width necessary to provide the desired function (see Exhibit 1239-2). 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 roadway users tend to shy away from the vertical feature. For widening for traffic barrier, see Chapter 1610. For requirements for lateral clearance to barrier or curb, see Section 1239.06. When walls are placed adjacent to shoulders, see Chapters 730 and 740 for barrier guidance.

Shoulder widths greater than 10 feet may encourage use as a travel lane. Therefore, use shoulders wider than 10 feet only to meet one of the listed functions (see Exhibit 1239-2).

Exhibit 1239-2 Shoulder Function & Modal Accommodation Width Considerations

Shoulder Function	Shoulder Width Guidance [7]
Stopping out of the traffic lanes	8 ft – 12 ft [1]
Minimum lateral clearance to curb or barrier	See Section 1239.06
Part time shoulder use. (Requires a Design Analysis) [6]	11 ft to 14 ft [2] See Section 1232.03 See 1410.02(3)(c) for HOV
Bicyclist use	4 ft of usable shoulder [3]
Pedestrian use	See Section 1510.06
Off-tracking of large accommodated vehicles	See Section 1310.02(5)
U-turn turnouts	Varies – See Chapter 1310
Maintenance operations (Consult Area Superintendent)	Varies [4] [5]
Law enforcement, emergency services & incident response	8 ft [5]
Transit stops	See Section 1430.02 and Exhibit 1430-2
Slow-vehicle turnouts	See Section 1270.04
Slow-vehicle shoulder driving	See Section 1270.05
Ramp meter storage (Requires a Design Analysis)	8 – 12 ft [1]
HOV ramp meter bypass (Requires a Design Analysis)	10 – 14 ft [6]
Ferry holding	8 ft – 12 ft [1]
For use as a lane during reconstruction of the through lanes	8 ft – 12 ft [1]
Structural support of pavement	2 ft
Improve horizontal sight distance in cut sections or sections with barrier or fixed objects that block sight lines.	See Chapter 1260
Chain-Up and Chain-Off Areas	20 ft [8]

Notes:

[1] 10 foot minimum for freight or transit vehicles.

[2] For bus use only shoulder, the range is 12 ft to 14 ft and the selected width should be determined with transit provider. For lateral clearance requirements see 1239.06.

[3] Minimum usable shoulder function width for bicyclists. Additional width may be needed when combined with shoulder rumble strips, rumble stripes, profiled or embossed lines, curb, or barrier (see Chapter 1600 and the *Standard Plans*). For guidance, see Chapter 1520 for accommodating bicyclists.

[4] 10 foot usable width to park a maintenance truck out of the through lane; 14 foot width for equipment with outriggers to work out of traffic (consult Area Maintenance Superintendent).

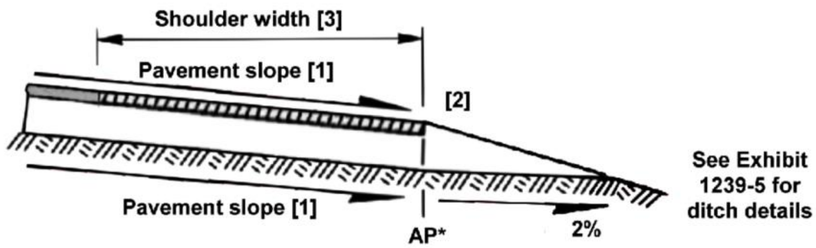
[5] For additional information, see Chapters 1370, 1410 and 1720.

[6] Determine width with transit provider, and see Section 1239.06 for lateral clearance requirements.

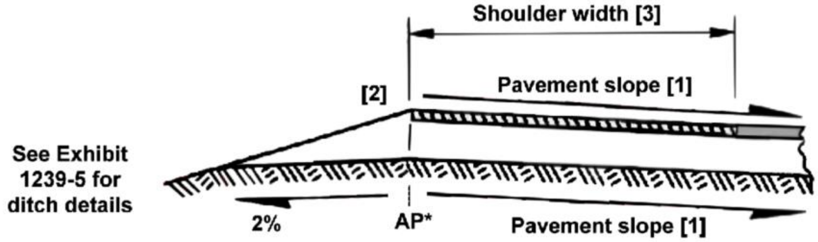
[7] Presence of barrier or curb may require additional width for lateral clearance See Section 1239.06. Use auto turn studies for non-tangent alignments based on the design vehicle and the accommodated vehicle.

[8] Where traffic volumes are low and trucks are not present, the width may be reduced to 15 ft.

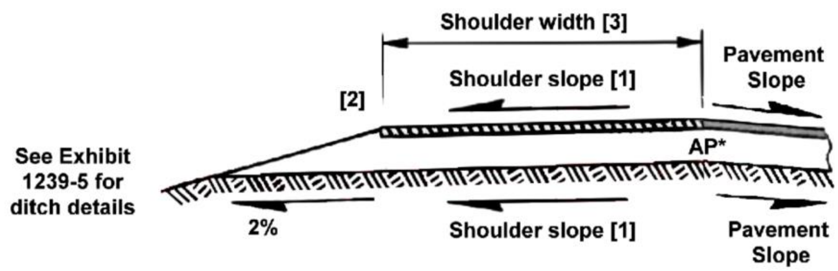
Exhibit 1239-3 Shoulder Grading Details



Shoulder Design on the Low Side of the Roadway for Cross Slopes Steeper Than 2%
(4H:1V or Flatter Side Slope Shown See Exhibit 1238-4 for Steeper Than 4H:1V)



Shoulder Design on High Side Divided Roadways and Outsides of Curves
(4H:1V or Flatter Side Slope Shown See Exhibit 1238-4 for Steeper Than 4H:1V)



Shoulder Design on the High Side of Divided Roadways and Outsides of Curves where the Shoulder Slopes Away From the Roadway
(4H:1V or Flatter Side Slope Shown See Exhibit 1238-4 for Steeper Than 4H:1V)

*AP = Angle point in the subgrade

Notes:

[1] Shoulder cross slopes are normally the same as the cross slopes for adjacent lanes. (For examples and additional information for locations where it may be desirable to have a shoulder cross slope different than the adjacent lane, see Chapter 1250).

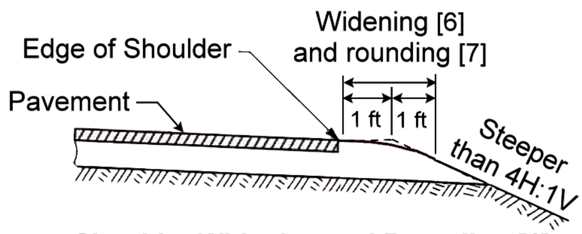
[2] Provide widening and slope rounding outside the usable shoulder when foreslope is steeper than 4H:1V.

[3] For shoulder width guidance, see Exhibit 1239-1.

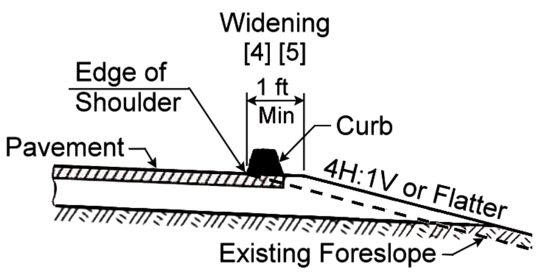
General:

These drawings illustrate the location of the subgrade angle points to drain stormwater away from the roadbed.

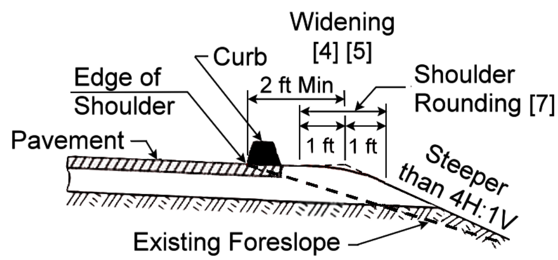
Exhibit 1239-4 Shoulder Widening Details



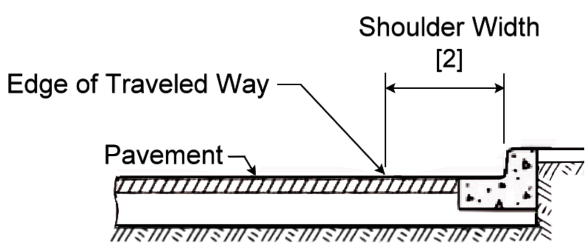
Shoulder Widening and Rounding [1]
for Slopes Steeper than 4H:1V



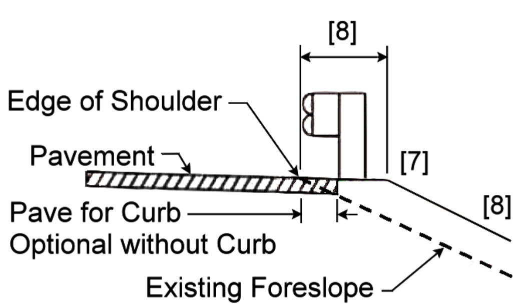
Shoulder Widening for Curb
(Side Slope 4H:1V or Flatter)



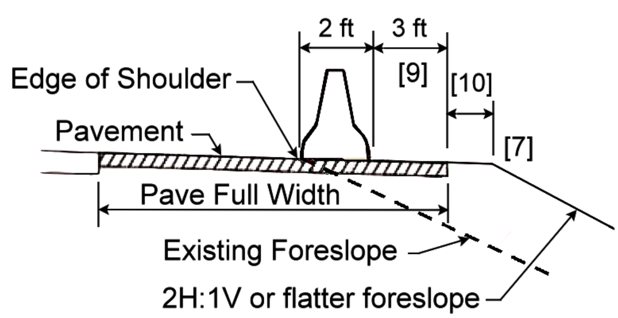
Shoulder Widening for Curb
(Side Slope Steeper than 4H:1V)



For Adding Curb and Gutter [3] [4]
A gutter pan of a differant color than the roadway can be part of the shoulder but, cannot be part of a lane or travled way



Shoulder Widening for Guardrail



Shoulder Widening for Permanent Barrier
(Precast Unanchored Barrier)

Notes:

[1] Provide widening and slope rounding outside the shoulder when foreslope is steeper than 4H:1V.

[2] For shoulder width guidance, see Exhibit 1239-1.

[3] For additional requirements for sidewalks, see Chapter 1510.

[4] See 1239.05 for curb design guidance.

[5] Provide paved shoulders wherever extruded curb is placed. (See the *Standard Plans* for additional details and dimensions.)

[6] Consider using the same application of slope rounding on all ramps and crossroads, as well as the main roadway. Use end rounding on the crossroad just beyond the ramp terminals and at a similar location where only a grade separation is involved.

[7] When widening beyond the edge of usable shoulder for curb or barrier, additional widening for slope rounding may be omitted.

[8] For widening guidelines for guardrail and concrete barrier, see Chapter 1610 and Exhibit 1610-9.

[9] Permanent precast unanchored barrier shown above. See Exhibit 1610-3 for other barrier deflection distances.

[10] There is no minimum width between pavement and break point for side slopes 4H:1V or flatter and 1 foot minimum width between pavement and break point for side slopes steeper than 4H:1V.

General:

On divided multilane highways, see Exhibits 1239-14a through 1239-14c for additional details for median shoulders.

1239.03 Fill Sections, Cut Sections, and Ditch Sections

The design for side slopes can affect shoulder design, clear zone requirements, and whether or not traffic barrier is warranted.

There are three basic roadway sections for side slopes.

Fill sections – Roadway sections where the height of the roadway is higher than the existing natural ground.

Ditch sections - Roadway sections where the height of the roadway is higher than the existing natural ground but not as high as the needed roadside ditch so that after the needed ditch is installed there is a foreslope into the ditch and a back slope out of the ditch up to where it catches the natural ground.

Cut sections - Roadway sections where the height of the roadway is lower than the existing ground. This typically produces a foreslope into the ditch and a back slope out of the ditch up to where it catches the natural ground.

When designing side slopes, attempt to fit the slope selected for any fill section, ditch section, or cut section into the existing terrain to give a smooth transitional blend from the construction to the existing landscape when practicable. Flatter slopes are desirable, especially with higher posted speeds and when the associated cost does not significantly exceed other design options. Fill side 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. Fill side slopes designed to 4H:1V or flatter are preferred. Provide widening and slope rounding outside the usable shoulder when the foreslope is steeper than 4H:1V (see Exhibit 1239-3). Do not disturb existing stable cut slopes just to meet the 4H:1V foreslope preference.

Fill-slopes steeper than 4H:1V but flatter than 3H:1V are considered traversable, but not recoverable. When providing a slope that meets these characteristics, placement of a clear area extending from the toe of the slope to the outside edge of the design clear zone is needed for an errant vehicle runout and stop (see Chapter 1600 for design clear zone guidance). Consult with Region Maintenance to determine if mowing is contemplated. When providing fill-slopes steeper than 3H:1V, it is a best practice to document the reason for the decision in the design documentation package. When mowing is contemplated, provide slopes not steeper than 3H:1V.

Where unusual geological features or soil conditions exist, treatment of the slopes depends upon results of a review of the location by the Region Materials Engineer.

See Section 1600.03(1) for when to use traffic barrier to mitigate a side slope. Unmitigated critical slopes will require a Design Analysis. The steepest slope allowed is determined by the Region Materials Engineer based on soil conditions. If more material is needed to build the roadway, consider obtaining it by flattening cut slopes uniformly on one or both sides of the highway. Consult the Region Materials Engineer to determine what percentage of the excavated material will likely be suitable for fill material. Where considering wasting excess material on an existing fill side slope, consult the Region Materials Engineer to verify that the subgrade will support the additional material.

Provide for drainage from the roadway surface and drainage in ditches (see Chapter 800). For drainage ditches, see Section 1239.03(1). 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.)

It is desirable to plant and establish low-growing vegetation on non-paved 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 or HQ Landscape Architect to determine the appropriate configuration of the roadway cross section and soil and plant specifications. This kind of treatment would not be done where barrier is installed along the roadway as the lift of compost or topsoil is not a suitable barrier foundation.

Flatten freeway section median cross-over foreslopes to 10H:1V (See Section 1370.03). Flatten crossroad and road approach foreslopes not steeper than 6H:1V on other highways. Grade crossroad and road approach foreslopes flatter than 6H:1V where feasible. Provide smooth transitions between the main line foreslopes and the crossroad or road approach foreslopes. Move the crossroad or road approach drainage as far away from the main line as feasible. This can locate the pipe outside the Design Clear Zone and reduce the length of pipe.

Provide slope treatment as shown in the *Standard Plans* (Slope treatment) at the top of 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.

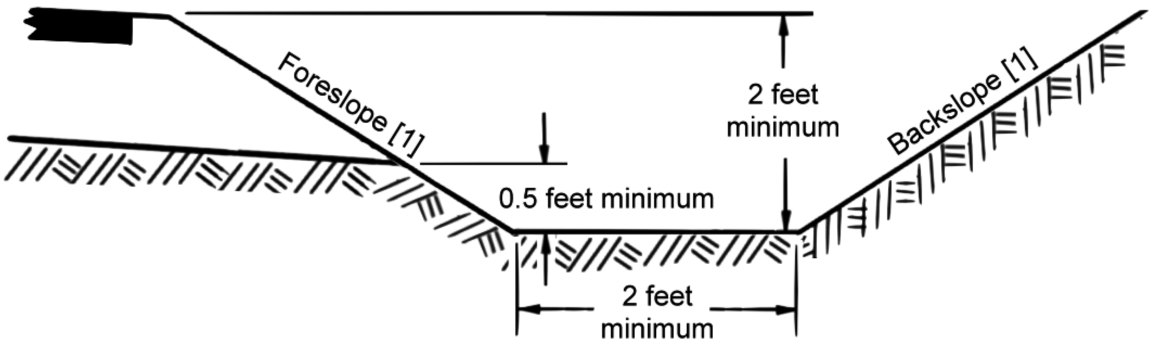
1239.03(1) Drainage Ditches

Exhibit 1239-5 shows the preferred trapezoidal ditch section and the alternative V bottom ditch section. The trapezoidal ditch design is preferred as V bottom ditches tend to silt up faster than flat bottom trapezoidal ditches and Trapezoidal ditches convey more drainage than V ditches. On the other hand, Trapezoidal ditches can be more difficult to construct than V bottom ditches. The trapezoidal ditch is preferred, but a 'V' bottom ditch can be used where constraints, such as limited right of way or sensitive areas, preclude a trapezoidal ditch. Consult with the Region Hydraulic Engineer to determine if the chosen design meets the needed hydraulic performance. Consult with the Region Materials Engineer about the chosen ditch foreslope and backslope.

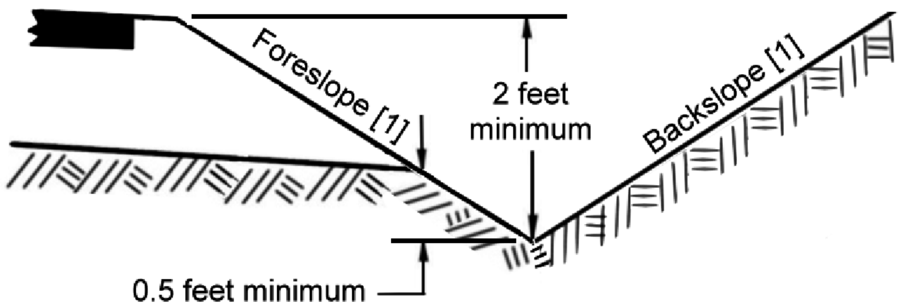
When topographic restrictions exist, consider an enclosed drainage system with appropriate inlets and outlets.

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 as close to the right of way line as feasible.

Exhibit 1239-5 Drainage Ditch Details



Trapezoidal Ditch "Preferred"



'V' Bottom Ditch "Alternative"

Notes:

[1] Side slopes:

- Foreslopes 4H:1V or flatter are desirable. See Exhibit 1239-3 for requirements for slopes steeper than 4H:1V
- Foreslopes and backslopes 3H:1V or flatter support mowing operations.
- Do not design foreslopes and/or backslopes steeper than 2H:1V without Region Materials Engineer and Region Hydraulics Engineer concurrence. See Exhibit 1600-6 for foreslopes steeper than 3H:1V.

1239.03(2) Bridge End Slopes

Bridge end slopes are determined by several factors, including context, fill height, depth of cut, soil stability, and horizontal and vertical alignment. Coordinate bridge end slope treatment with the HQ Bridge and Structures Office (see Chapter 720). Whenever possible, design to avoid creating environments that might be desirable to the homeless, both for their safety and the safety of maintenance staff.

Early in the bridge plan development, determine preliminary bridge geometrics, end slope rates, and toe of slope treatments. Exhibit 1239-6a provides guidelines for use of slope rates and toe of slope treatments for overcrossings. Exhibit 1239-6b shows toe of slope treatments to be used on the various toe conditions.

Exhibit 1239-6a Bridge End Slopes

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:

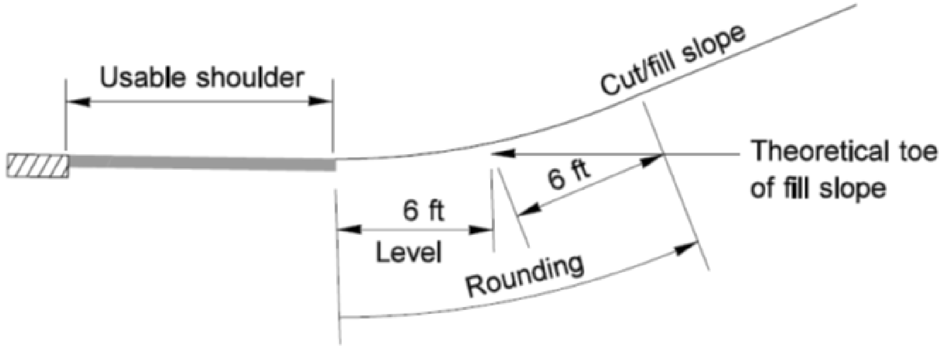
[1] See Exhibit 1239-6b.

[2] Slope may be 1¾H:1V in special cases.

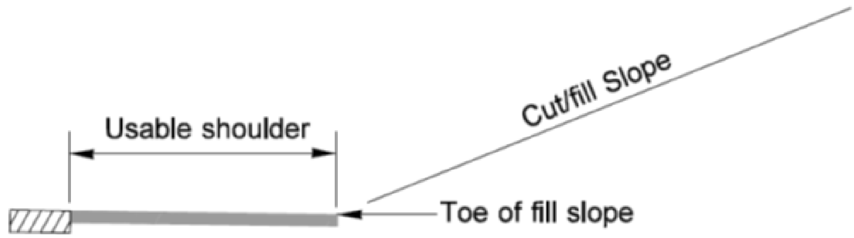
[3] In interchange areas, continuity may require variations.

[4] See Section 1239.03.

Exhibit 1239-6b Bridge End Slope Details



Rounding



No Rounding

Toe at ℄ of Roadway Ditch

1239.04 Roadway Sections in Rock Cuts

There are two basic design treatments applicable to rock excavation. Typical sections for rock cuts, illustrated in Exhibits 1239-7 and 1239-8, are guides for the design and construction of roadways through rock cuts. Design A applies to most rock cuts. Design B is a talus slope treatment. 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 Materials Engineer and region Landscape Architect. Obtain concurrence from the Headquarters (HQ) Materials Lab.

1239.04(1) 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 Exhibit 1239-7:

- **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 when extreme rockfall conditions exist.

Show Stage 3 as the ultimate stage for future construction in the Plans, Specifications, and Estimates (PS&E) if there is any possibility that it will be needed.

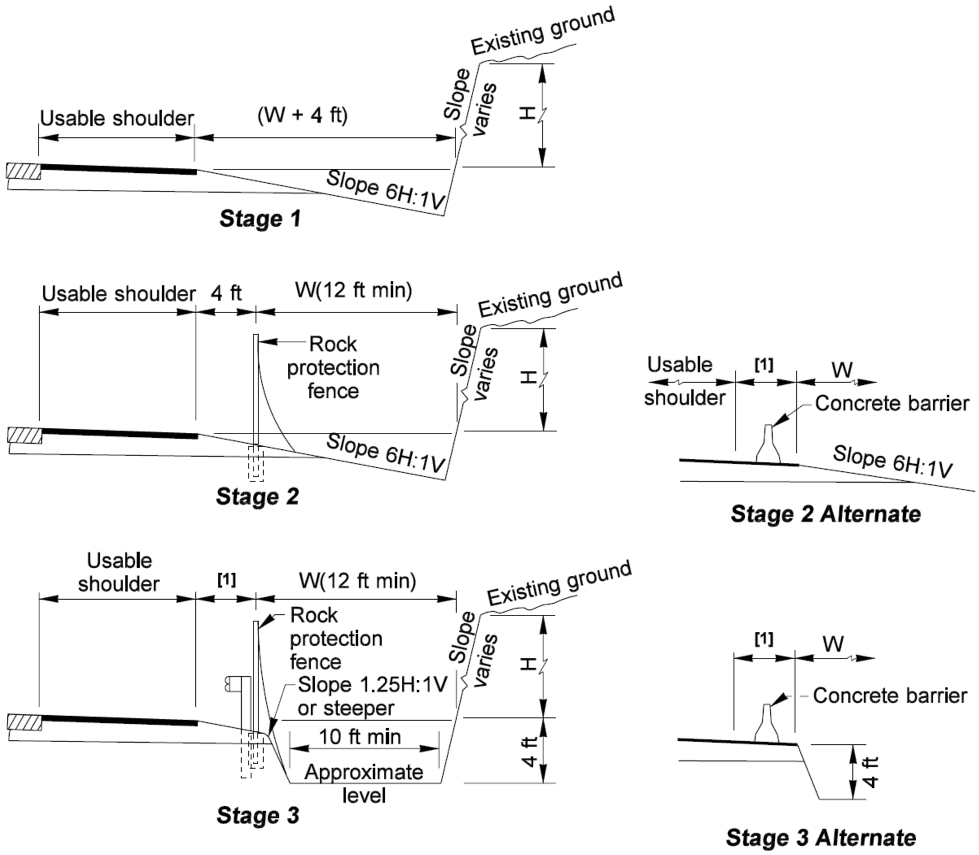
The use of Stage 2 or Stage 3 alternatives (concrete barrier) is based on the designer’s analysis of the particular site. Considerations include maintenance; size and amount of rockfall; probable velocities; availability of materials; ditch capacity; adjacent traffic volumes; distance from traveled lane; and impact severity. Incorporate removable sections in the barrier at approximately 200-foot intervals. Provide appropriate terminal treatment (see Chapter 1610).

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. Select cut slopes for a project that provide stability for the existing material.

Benches may be used to increase slope stability; however, the use of benches may alter the design given in Exhibit 1239-7.

The necessity for benches, as well as their width and vertical spacing, is established 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.

Exhibit 1239-7 Roadway Sections in Rock Cuts: Design A



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:

[1] For widening for guardrail and concrete barrier, see Chapter 1610.

General:

- Treat cut heights less than 20 feet as a normal roadway unless otherwise determined by the Region Materials Engineer.
- Stage 2 and Stage 3 Alternates may be used when site conditions dictate.
- Fence may be used in conjunction with the Stage 3 Alternate. (See Chapter 1600 for clear zone guidelines.)

1239.04(2) Design B

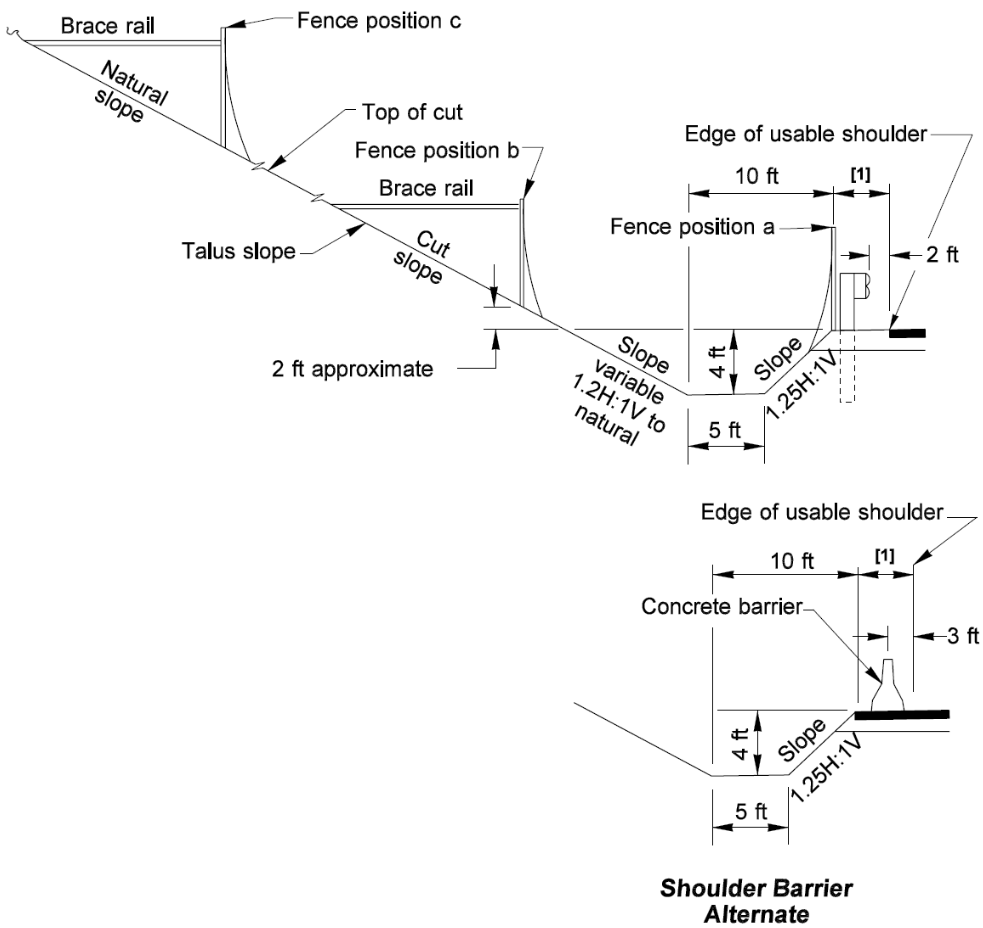
A talus slope treatment is shown in Exhibit 1239-8. The rock protection fence is placed at any one of the three positions shown, but not in more than one position at a particular location. Consult with the RME for the placement of the rock protection fence in talus slope areas.

- **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. Because gabion treatment is considered similar to a wall, provide appropriate face and end protection (see Chapters 730 and 1610).

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.

Evaluate the need for rock protection treatments other than those described above for cut slopes that have relatively uniform spalling surfaces (consult with the RME).

Exhibit 1239-8 Roadway Sections in Rock Cuts: Design B



Notes:

[1] For widening for guardrail and concrete barrier, see Chapter 1610.

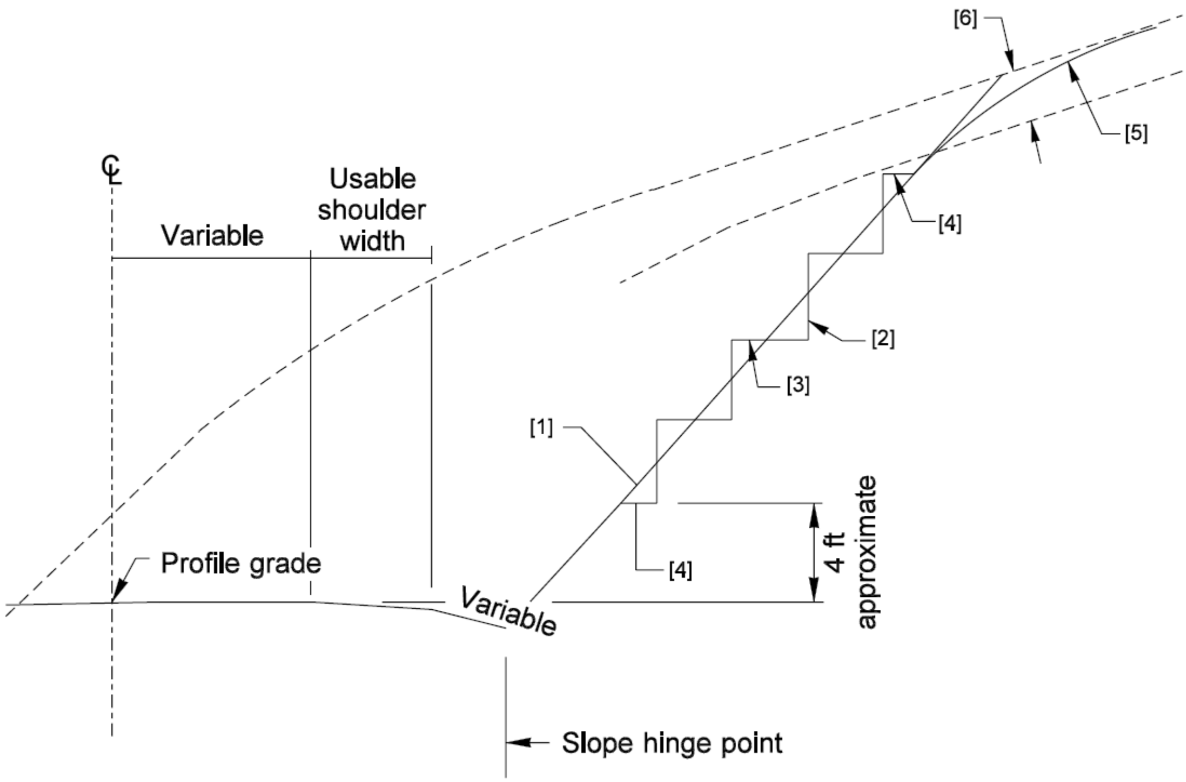
General:

- 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.

1239.04(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 on the recommendation of the RME (see Chapter 610). Consult the region landscape personnel for appropriate design and vegetative materials to be used. Use Exhibit 1239-9 for stepped slope design.

Exhibit 1239-9 Stepped Slope Design



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.

1239.05 Curbs

Vertical curbs with a face slope of 1H:3V or steeper that are more than 4 inches tall are not considered mountable, while vertical curbs that are 4 inches tall or shorter are considered mountable. Curbs with a sloping face (flatter than 1H:3V) that are as tall as 6 inches are mountable, but using curbs 4 inches or less is recommended in order to reduce vehicle underside damage if driven over.

1239.05(1) Non-Mountable Vertical Curb Uses

a) Use vertical curbs with a height of 6 inches or more:
To delineate the traveled way with respect to other features in the roadway cross-section such as medians, sidewalks, landscaped areas, etc.
To delineate separations between walkways and pedestrian refuges.
To provide vertical grade separation between raised islands and the roadway surface.
For expediting transfer times for transit partners on low--speed roadways in urban and suburban contexts (verify curb height needed with transit provider).

b) Consider vertical curbs with a height of 6 inches or more:
To indicate to drivers where midblock left turns are not allowed.
To delineate divisional and channelizing islands.
To provide a hardscape boundary for raised landscaped islands.
To convey stormwater.

1239.05(2) Mountable Curb Uses

a) Provide mountable curbs where a curb is needed but vertical curb is not suitable for specific design user(s).

b) Use mountable curbs in roundabouts. See Chapter 1320 and Standard Plan F-10.18-01.

1239.05(3) Curb Use Based On Speed

In general, curbs are not recommended on facilities with a speed of 40 mph and faster. Avoid using curbs if the same objective can be attained with pavement markings. However, 4-inch-high mountable curbs may be used on facilities with a speed of 40 mph and faster to control drainage or for access control. Locate mountable curb no closer to the traveled way than the outer edge of the shoulder. Provide sloping end treatments where the curb is introduced and terminated. 6-inch-high mountable curbs may be considered on urban and suburban highways with a speed of 40 mph and faster where streetside zones are provided or where traffic movements are to be restricted. Provide justification for the use of vertical curb when applied to facilities with a speed of 40 mph and faster.

Intermediate speed facilities may use vertical curbs; however, consider mountable curbs for intermediate target speeds. All curb types are appropriate for low-speed facilities.

1239.05(4) Curb Used For Drainage

Where curbing is provided to direct drainage, provide a design that collects the surface water at the curb and drains it without ponding in the traveled way or flowing across the roadway.

In some areas, curb may be needed to control runoff water until ground cover is attained to control erosion. Document the plan to remove the curb when the ground cover becomes adequate. A best practice is to arrange for curb removal with region maintenance staff as part of the future maintenance plans (see Maintenance Owner's Manual guidance in Chapter 301).

When curb is used in conjunction with guardrail, see Chapter 1610 for guidance. For existing curb, particularly on facilities with a speed of 40 mph and faster, evaluate the continued need for the curb. Remove curbing that is no longer needed.

1239.05(5) Curb Use Considerations

Curbs can provide physical guidance to drivers, but curbs are not intended to redirect errant vehicles.

When an overlay will reduce the height of a curb, evaluate grinding (or replacing the curb) to maintain curb height if needed for pavement or drainage performance. (See Section 1250.02(2) for shoulder cross slope considerations.) To maintain or restore curb height, consider lowering the existing pavement level and improving cross slope by grinding before an asphalt overlay or as determined by the pavement design. The cross slope of the shoulder may be steepened to maximize curb height and minimize other related impacts. Note that grinding can cause issues with meeting ADA criteria at curb ramps for counter slope and crosswalk running slope. See Chapter 1510 for more information.

Curbs can hamper snow-removal operations. In areas of heavy snowfall, ask the Area Maintenance Superintendent to review and concur with the use of curbing.

For curbs at traffic islands, see Chapter 1310. For curbs at roundabouts, see Chapter 1320 and Standard Plan F-10.18-01.

1239.06 Lateral Clearance to Curb and Barrier

Lateral clearance to curb or barrier is the perpendicular distance from edge of traveled way to the face of a curb or a traffic barrier (guardrail, concrete barrier, etc.). Lateral clearance includes the shoulder width. The minimum lateral clearance to the face of a curb or barrier is shown in Exhibit 1239-10. See also Chapter 1310 for intersections including clearance to curb at traffic islands.

Exhibit 1239-10 Minimum Lateral Clearance to Barrier and Curb

Posted Speed	Curb - Median [1] [2]	Curb - Right [1] [2]	Barrier
High Speed (≥50mph)	4 ft; curb not recommended [4]	4 ft; curb not recommended [4]	4 ft
Intermediate Speed (40 & 45mph)	4 ft; curb not recommended [4]	4 ft; curb not recommended [4]	
Low Speed (≤35mph)	2 ft Preferred [3]	2 ft Preferred [3]	
Ramps [5]	[6]	4 ft	

Notes:

[1] For HOV lanes on arterials streets, see Section 1410.06(4)(d)

[2] Measured from the edge of traveled way to the face of curb.

[3] On low speed urban roadways (35 mph or less), maintaining shoulder width is desirable; however, with justification, curb (mountable or vertical) may be placed at the edge of traveled way.

[4] With justification, mountable curb may be placed at the edge of traveled way for access management in urban areas. Adding mountable curb reduces lane and/or shoulder width and may require additional documentation.

[5] Raised median for two-way ramps (see Section 1360.03(5).)

[6] 2 ft min. for ramp design where speeds are ≤35mph (usually near the ramp terminal intersection) and 4 ft. min. where design speeds are > 35mph.

1239.07 Chain-Up and/or Chain-Off Areas

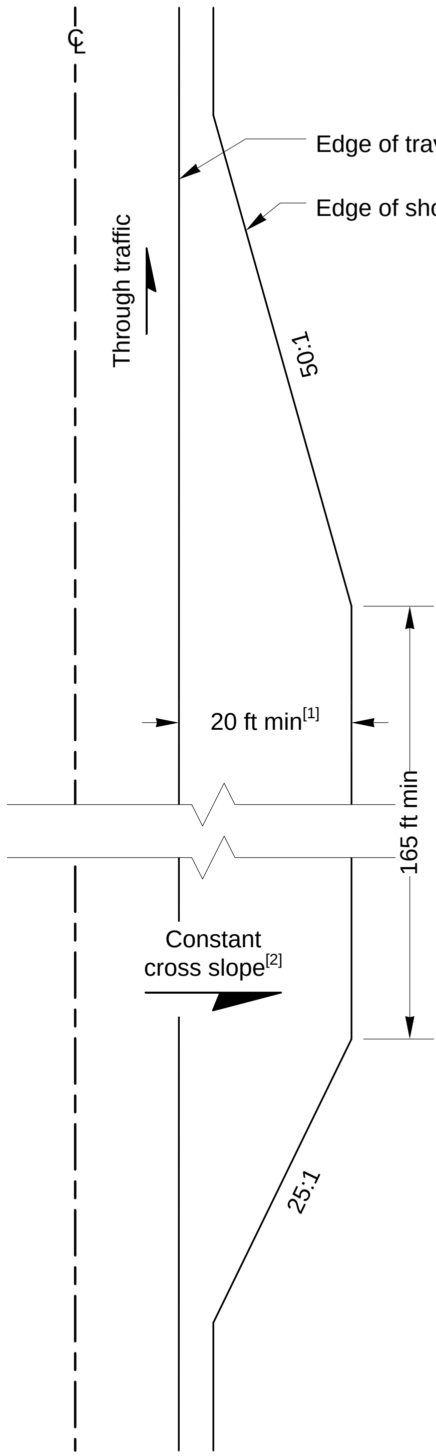
Provide chain-up areas in order to allow chains to be put on vehicles out of the through lanes at locations where traffic enters chain enforcement areas. Provide chain-off areas to remove chains out of the through lanes for traffic leaving chain enforcement areas.

Chain-up or chain-off areas are widened shoulders designed as shown in Exhibit 1239-11. Locate chain-up and chain-off areas where the grade is 6% or less and desirably 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. See Section 1040.04(16)

The wide shoulders at chain-up and chain-off areas may encourage parking. When parking is undesirable, consider parking restrictions.

Exhibit 1239-11 Chain-Up/Chain-Off Shoulders



Notes:

[1] Where traffic volumes are low and trucks are prohibited, the width may be reduced to 15 ft.

[2] 2% desirable. (See Chapter 1250 for traveled way cross slope.)

1239.08 Medians and Outer Separations

Medians are either restrictive or nonrestrictive. Restrictive medians physically limit motor vehicle encroachment, using raised curb, median barrier, fixed delineators, vegetative strips, or vegetative depressions. Nonrestrictive medians limit motor vehicle encroachment legally, and use pavement markings to define locations where turns are permissible. The main functions of an outer separation are to separate the main roadway from a frontage road or service lane, or to provide modal segregation. Consider medians or outer separations to optimize the desired performance objective, such as safety, throughput operations, pedestrian mobility needs, etc.

Provide a median or outer separation to:

- Separate traffic lanes such as HOT lanes, HOV lanes, bike lanes, etc.
- Separate divided highways with differing alignments.
- Separate opposing traffic to reduce the risk of head-on collisions.
- Manage speed.
- Provide a refuge area for emergency parking.
- Allow for future widening of a planned phase.
- Separate collector-distributor lanes, frontage roads, weigh sites, or rest areas.
- Accommodate drainage facilities.
- Accommodate bridge piers at undercrossings.
- Provide vehicle storage space for crossing and left-turn movements at intersections.
- Accommodate headlight glare screens, including planted or natural foliage.
- Provide recovery areas for errant or disabled vehicles.
- Provide a pedestrian refuge area at crossing locations.
- Provide storage space for snow and water away from traffic lanes.
- Separate modes for increased safety, comfort, and ease of operations.
- Control access.
- Provide enforcement areas.

The width of a median is measured from edge of traveled way to edge of traveled way and includes shoulders. Median widths can vary greatly based on the functional use of the median, the functional use of the shoulders, target speed, and context. Guidance for median and shoulder widths depending on their function and context is given in:

- Exhibit 1239-12 (high & intermediate speed medians),
- Exhibit 1239-13 (low & intermediate speed medians), and
- Exhibit 1239-2 (shoulders).

1239.08(1) Median Design: High and Intermediate Speed

Exhibit 1239-12 lists width considerations for median functions common on high and intermediate speed facilities.

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 1239.03 and Chapters 1600 and 1610. Independent horizontal and vertical alignment, rather than parallel alignment, can allow for reduced grading or cut sections.

Considerable latitude in grading treatment is intended on wide, variable-width medians, provided the minimum performance needs are met or exceeded. Unnecessary clearing, grubbing, and grading are undesirable within wide medians. Use selective thinning and limited reshaping of the natural ground when feasible. For median clear zone criteria see Chapter 1600, and for slopes between the face of traffic barriers and the traveled way see Chapter 1610.

In areas where land is expensive, make an economic comparison of wide medians to narrow medians with barrier. Consider right of way, construction, maintenance, and safety performance. The widths of medians need not be uniform. Make the transition between median widths as long as practical. (See Chapter 1210 for minimum taper lengths.)

When using concrete barriers in depressed medians or on the insides of curves, provide for surface drainage on both sides of the barrier or provide MASH compliant scupper barrier.

At locations where the median will be used to allow vehicles to make a U-turn, provide the widths in Exhibit 1310-18. (For information on U-turns, see Section 1310.03(8)) Document the selected design vehicle and provide alternate route information for vehicles not serviced by the U-turn.

Where feasible, widen medians at intersections on rural divided multilane highways. Provide sufficient width to store vehicles crossing the expressway or entering the expressway with a left turn.

When the median is to be landscaped, or where fixed objects are to be placed in the median, see Chapter 1600 for traffic barrier and clear zone guidance. When the median will transition for use as a left-turn lane, see Chapter 1310 for left-turn lane design considerations.

Exhibit 1239-12 Median Functions and Guidance: High and Intermediate Speeds

Median Functional Use	Width Guidance
Separating opposing traffic	Varies[1] and see Chapters 1600 and 1610
Separating alignments	Varies See 1239.03 and Chapters 1600 and 1610 [2]
Recovery/Refuge areas for errant vehicles	See 1239.03 and Chapter 1600
Storage space for snow	Consult Region Maintenance and Representatives of affected modes.
Raised island with signing	Width of the sign plus 2 feet on either side minimum. (See Exhibit 1310-3
Raised island with illumination (no signing)	Width of the luminaire plus 2 feet on either side minimum.
Enforcement/observation areas	See Chapters 1370 and 1410, and consult with Washington State Patrol and/or city/town police
Vehicle storage space for crossing at intersections	See Chapter 1310, and consult with region traffic engineer
Median U-turn or Median crossover	See Chapters 1310 and 1370
Outer separation for frontage or collector-distributer roads	12 ft min plus shoulders [1] See Exhibit 1360-15a and Chapters 1360, 1600 and 1610
Transit use	Varies; see Chapter 1420 and discuss with Transit Agency [3]
Pedestrian and bicyclist refuge for crossing locations	6 ft minimum, excluding curb width (see Section 1510.11 & Exhibit 1510-22 for pedestrians and See Section 1520.04(5) & Exhibit 1520-10 for bicyclists.)

Notes:

[1] Conduct a safety performance analysis and include potential countermeasures identified to obtain the desired safety performance. Consult with maintenance; additional width may be appropriate for unconstrained right of way locations, maintenance functions, or for divided highways on independent alignments.

[2] An economic comparison of wide medians to narrow medians with barrier is recommended.

[3] For planning and scoping purposes, 32 ft can be the assumed minimum for two-way transit operations or 22 ft for one-way transit operations.

1239.08(2) Median Design: Low and Intermediate Speeds

Exhibit 1239-13 provides design guidance for medians within low and intermediate speed transportation contexts. In low-speed urban and suburban contexts, see Chapter 1600 for Design Clear Zone requirements.

A common form of restrictive median on urban managed access highways is the raised median. For more information on traffic volume thresholds for restrictive medians on managed access highways, see Chapter 540.

Exhibit 1239-13 Median Functions and Guidance: Low and Intermediate Speeds

Median Functional Use	Width Guidance
Access Control – Restrictive	Width of raised median feature[1] [2]
Access Control – Non-restrictive	1 ft minimum[3] (see Chapter 540)
Raised median/cut-through island for a pedestrian and/or bicyclist refuge that allows crossing in two stages	6 ft minimum, excluding curb width (see Section 1510.11 & Exhibit 1510-22 for pedestrians and See Section 1520.04(5) & Exhibit 1520-10 for bicyclists.)
Raised island with signing	Width of the sign plus 2 feet on either side minimum. (See Section 1310
Raised island with illumination (no signing)	Width of the luminaire plus 2 feet on either side minimum.
Speed management and/or aesthetic design – Vegetated	Varies[2] [4] (see Chapter 1103)
Drainage or treatment facilities	Varies[5]
Bicyclist buffer treatment	2 ft – 3 ft (see Chapter 1520)
Outer separation for frontage or collector- distributer roads	12 ft min. plus shoulders[4] [6] [7] See Exhibit 1360-15a, Design B

Notes:

[1] 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.

[2] Consider width necessary for lateral clearance. See Section 1239.06.

[3] 2 ft minimum if adjacent lane widths are less than 11 ft.

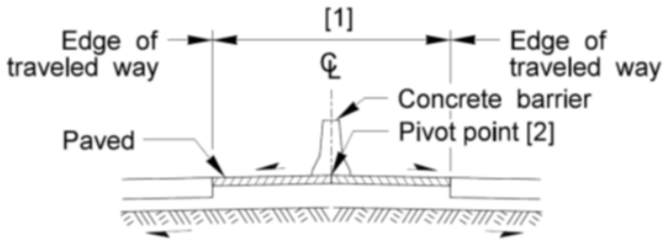
[4] Consult Region Landscape Architect; width will depend on type of plantings. Over-excavation may be necessary to prepare soil for the selected plantings to ensure mature heights are obtained.

[5] Consult Hydraulic Manual for width necessary for drainage or treatment facilities.

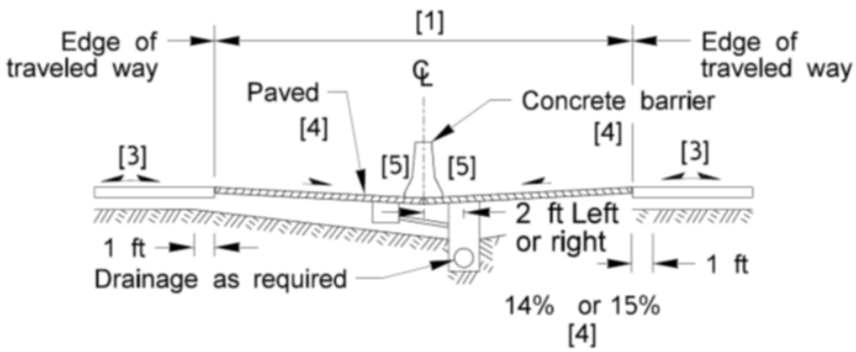
[6] Consider width needed for plantings or street furniture to create the appropriate pedestrian zone segregation and environment.

[7] See also Chapter 1510

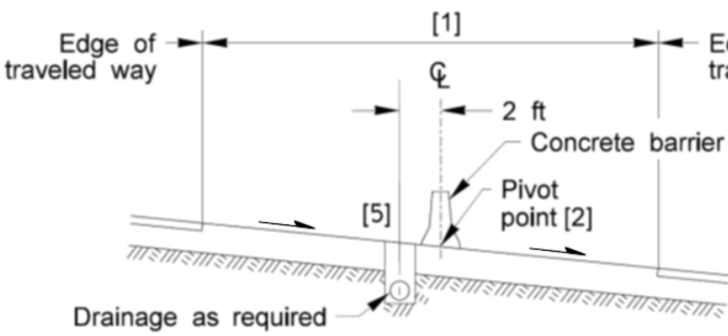
Exhibit 1239-14a Divided Highway Median Sections



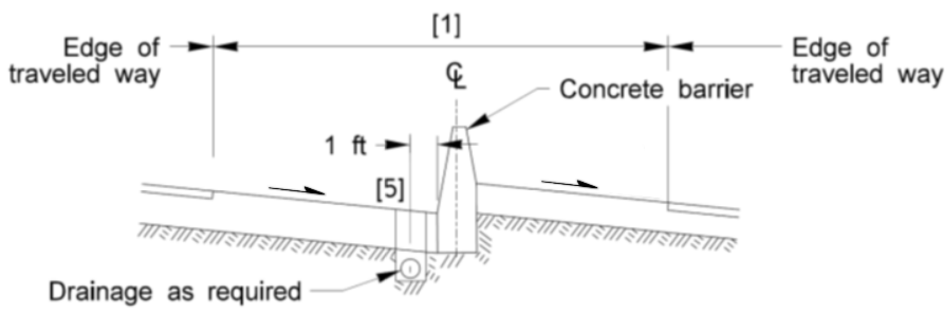
Design A: Crowned Median



Design B: Depressed Median



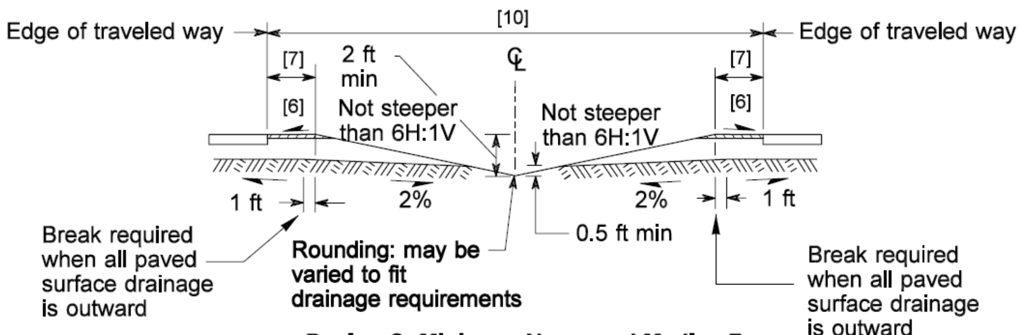
Alternate Design 1: Treatmet on Curves (Single Pivot Point)



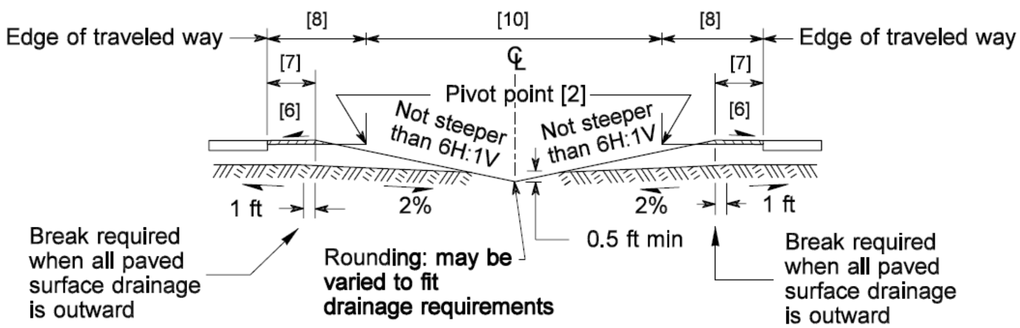
Alternate Design 2: Treatment on Curves (Seporate Pivot Points) [2]

Note:
For applicable notes, see Exhibit 1239-14c.

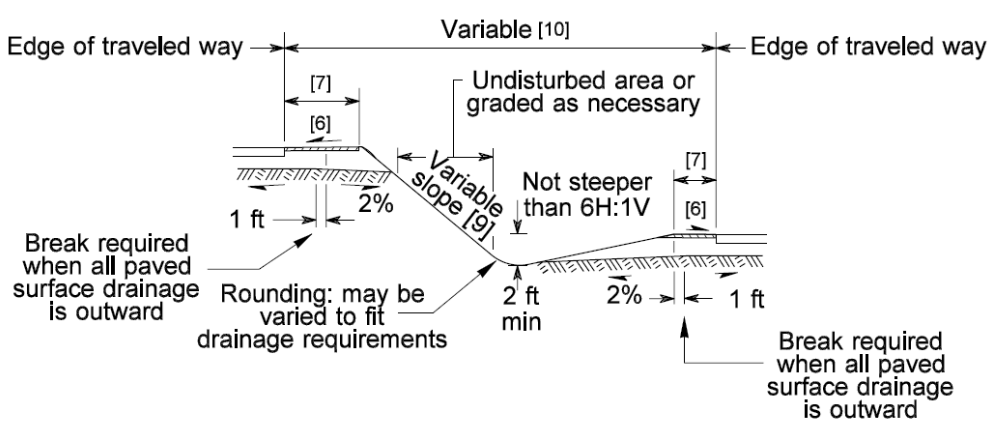
Exhibit 1239-14b Divided Highway Median Sections



Design C: Minimum Nonpaved Median For 4 or More Lanes [2]



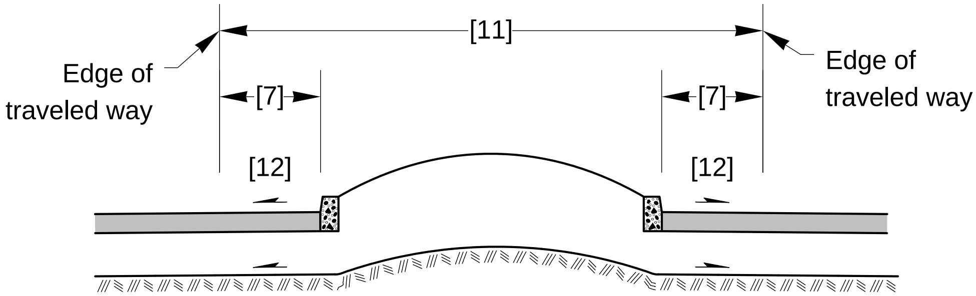
Design D: Minimum for 4 or More Lanes With Future Lanes in Median



Design E: Minimum for 4 or More Lanes With Independent Alignment

Note:
For applicable notes, see Exhibit 1239-14c.

Exhibit 1239-14c Divided Highway Median Sections



Design F: Raised Median[13]

Notes:

[1] For guidance on median widths, see Exhibits 1239-12 and -13

[2] Consider vertical clearances, drainage, and aesthetics when locating the pivot point.

[3] Generally, slope pavement away from the median. When barrier is present and the roadway is in a superelevation, size the shoulder so that standing water is not in the travel lane. Where appropriate, a crowned roadway section may be used in conjunction with the depressed median.

[4] Design B may be used uniformly on both tangents and horizontal curves. Use Alternate Design 1 or Alternate Design 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 Section 1250.02(2) for examples and additional information for locations where it may be desirable to have a shoulder cross slope different than the adjacent lane.

[7] For guidance on shoulder widths, see 1239.02.

[8] Future lane width of a planned phase.

[9] Widen and round foreslopes steeper than 4H:1V as shown in Exhibit 1239-3. See Chapter 1600 for barrier recommendations.

[10] Designs C, D, and E are rural high-speed median designs. See Exhibit 1239-12 for recommended median widths.

[11] Raised medians may be paved or landscaped. For clear zone and barrier guidelines when fixed objects or trees are in the median, see Chapter 1600.

[12] Lane and shoulders normally slope away from raised medians. When they slope toward the median, provide for drainage.

[13] See Sections 1239.05 and 1239.06 for curb design guidance.

1239.09 Documentation

Refer to Chapter 300 for design documentation requirements and approving authorities.

Chapter 1250 Cross Slope and Superelevation

1250.01 General

Use this chapter to design roadway cross slopes and superelevation. Cross slopes function to drain water away from the roadway and 2% is a commonly used slope rate. To maintain the design speed, highway and ramp curves are usually superelevated to overcome part of the centrifugal force that acts on a vehicle.

1250.02 Roadway Cross Slope

1250.02(1) Lanes

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 the following two contradicting controls:

- Reasonably steep cross slopes aid in water runoff and minimize ponding as a result of pavement imperfections and unequal settlement.
- Steeper cross slopes are noticeable in steering, increase the tendency for vehicles to drift to the low side of the roadway, and increase the susceptibility of vehicles to slide 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, although cross slopes may vary from the target 2%.

The algebraic difference in cross slopes is an operational factor that can affect vehicles making a lane change across a grade-break 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.

On ramps with metering, consider how cross slopes can impact driver comfort within the queue. Additionally, larger cross slopes may present concerns about maintaining vehicle lateral position within the queue lane, depending on weather and resulting pavement conditions.

A somewhat steeper cross slope may be needed to facilitate recommended drainage design, even though this might be less desirable from an operational point of view. In such areas, consider not exceeding design cross slopes of 2.5% with an algebraic difference of 5%.

For a two-lane two-way roadway, provide an algebraic difference to meet the appropriate conditions stated above except when drainage design recommends otherwise.

1250.02(2) Shoulders

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%. 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.
- At intersections where pedestrian signal accommodations are provided within the shoulder

Where extruded curb is used, see the *Standard Plans* for placement (see Chapter 1239 for information on curbs). Widening is also normally provided where traffic barrier is installed (see Chapter 1610 and the *Standard Plans*).

On ramps with metering, where the shoulder is or could be utilized for queuing, consider how the shoulder cross slope can impact driver comfort within the queue. Additionally, larger shoulder cross slopes may present concerns of maintaining vehicle lateral position within the queue lane, depending on weather and resulting pavement conditions.

The remainder of this chapter provides information to design superelevation.

1250.03 Superelevation Rate Selection

The maximum superelevation rate allowed is 10%.

Depending on design speed, construct large-radius curves with a normal crown section. The minimum radii for normal crown sections are shown in Exhibit 1250-1. Superelevate curves with smaller radii as follows:

- Exhibit 1250-4a (emax=10%) is desirable for all open highways, ramps, and long-term detours, especially when associated with a main line detour.
- Exhibit 1250-4b (emax =8%) may be used for freeways in urban design areas and areas where the emax =6% rate is allowed but emax =8% is preferred.
- Exhibit 1250-4c (emax =6%) may be used—with justification—for non-freeway highways in urban design areas, in mountainous areas, and for short-term detours, which are generally implemented and removed in one construction season.
- Exhibit 1250-5 may be used for turning roadways at intersections, urban managed access highways with a design speed of 40 mph or less, and—with justification—ramps in urban areas with a design speed of 40 mph or less.

When selecting superelevation for a curve, consider the existing curves on the corridor. To maintain route continuity and driver expectance on open highways, select the chart (see Exhibits 1250-4a, 4b, or 4c) that best matches the superelevation on the existing curves.

In locations that experience regular accumulations of snow and ice, limit superelevation from the selected chart to 6% or less. In these areas, provide justification for superelevation rates greater than 6%. Vehicles moving at slow speeds or stopped on curves with supers greater than 6% tend to slide inward on the radius (downslope).

Round the selected superelevation rate to the nearest full percent.

Exhibit 1250-1 Minimum Radius for Normal Crown Section

Design Speed (mph)	Minimum Radius for Normal Crown Section (ft)
15	945
20	1,680
25	2,430
30	3,325
35	4,360
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

1250.04 Existing Curves

Evaluate the superelevation on an existing curve to determine its adequacy. Use the equation in Exhibit 1250-2 to determine the minimum radius for a given superelevation and design speed.

Exhibit 1250-2 Minimum Radius for Existing Curves

$$R = \frac{6.68V^2}{e + f}$$

Where:

- R = The minimum allowable radius of the curve (ft)
- V = Design speed (mph)
- e = Superelevation rate (%)
- f = Side friction factor from Exhibit 1250-3

Address 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. When modifying the superelevation of an existing curve, provide superelevation as given in 1250.02.

Exhibit 1250-3 Side Friction Factor

Design Speed (mph)	Side Friction Factor (f)
15	32
20	27
25	23
30	20
35	18
40	16
45	15
50	14
55	13
60	12
65	11
70	10
75	9
80	8

1250.05 Turning Movements at Intersections

Curves associated with the turning movements at intersections are superelevated using Exhibit 1250-5. Use superelevation rates as high as practicable, consistent with curve length and climatic conditions. Exhibit 1250-5 shows the minimum radius for a selected superelevation and given design speed for intersections and low-speed curves. When using high superelevation rates on short curves, provide smooth transitions with merging ramps or roadways.

1250.06 Runoff for Highway Curves

Provide transitions for all superelevated highway curves as specified in Exhibits 1250-6a through 6e. Which transition to use depends on the location of the pivot point, the direction of the curve, and the roadway cross slope. The length of the runoff is based on a maximum allowable difference between the grade at the pivot point and the grade at the outer edge of traveled way for one 12-foot lane.

Pay close attention to the profile of the edge of traveled way created by the superelevation runoff; do not let it appear distorted. The combination of superelevation transition and grade may result in a hump and/or dip in the profile of the edge of traveled way. When this happens, the transition may be lengthened to eliminate the hump and/or dip. If the hump and/or dip cannot be eliminated this way, pay special attention to drainage in the low areas to prevent ponding. Locate the pivot point at the centerline of the roadway to help minimize humps and dips at the edge of the traveled lane and reduce the superelevation runoff length.

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 Exhibits 1250-6c and 6d, except that full super will be attained rather than the normal pavement slope as shown.

Superelevation runoff on structures is permissible but not desirable. Whenever practicable, strive for full super or normal crown slopes on structures.

1250.07 Runoff for Ramp Curves

Superelevation runoff for ramps use the same maximum relative slopes as the specific design speeds used for highway curves. Multilane ramps have a width similar to the width for highway lanes; therefore, Exhibits 1250-6a through 6e are used to determine the superelevation runoff for ramps. Superelevation transition lengths (L_T) for single-lane ramps are given in Exhibits 1250-7a and 7b. Additional runoff length for turning roadway widening is not required.

1250.08 Documentation

Refer to Chapter 300 for design documentation requirements.

1250.09 References

1250.09(1) Design Guidance

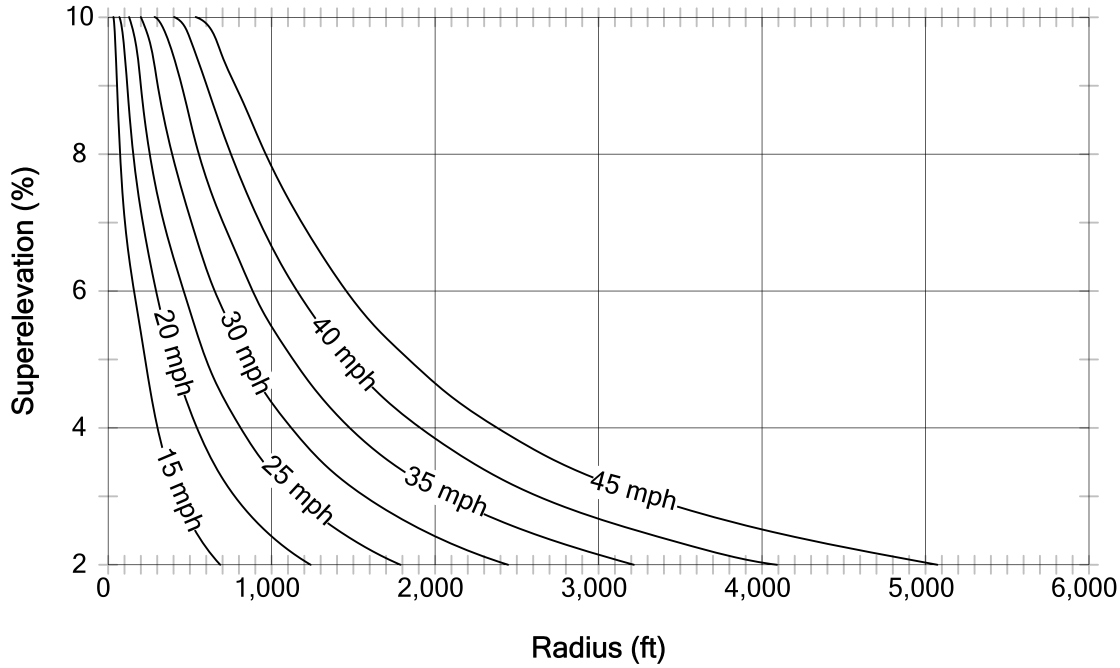
Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

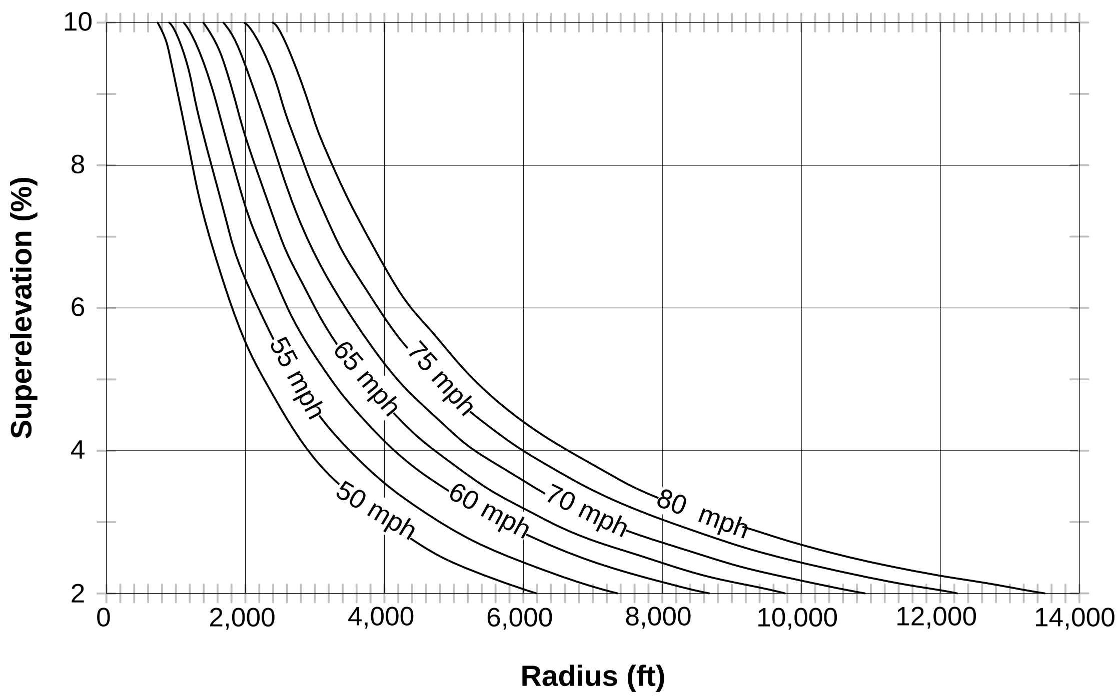
Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

1250.09(2) Supporting Information

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

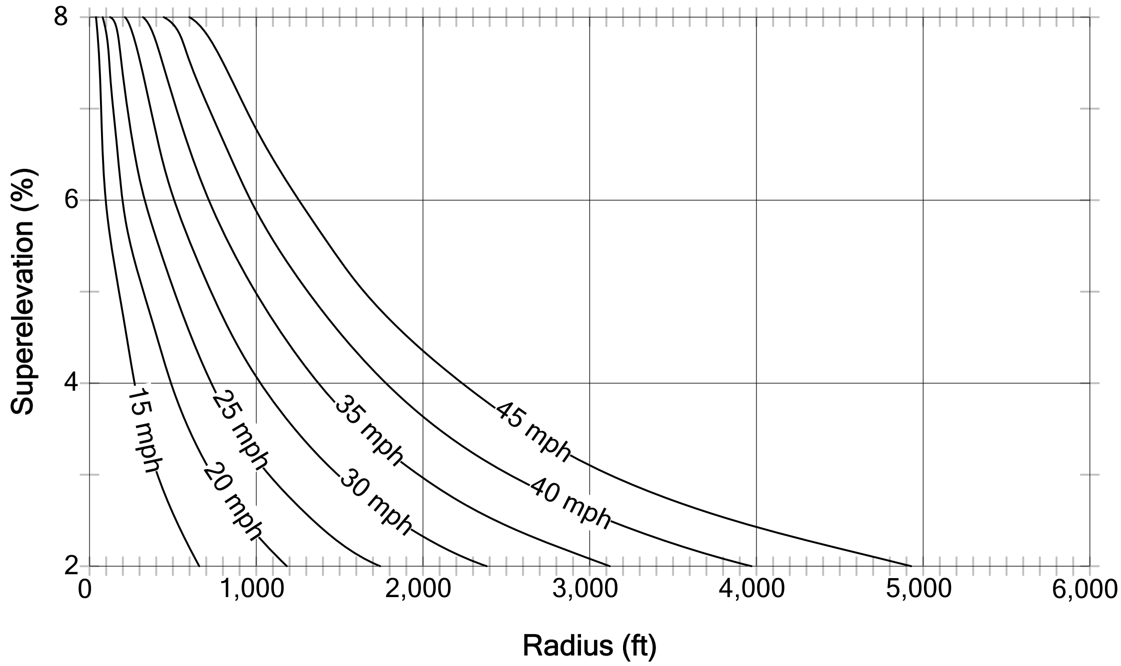
Exhibit 1250-4a Superelevation Rates (10% Max)

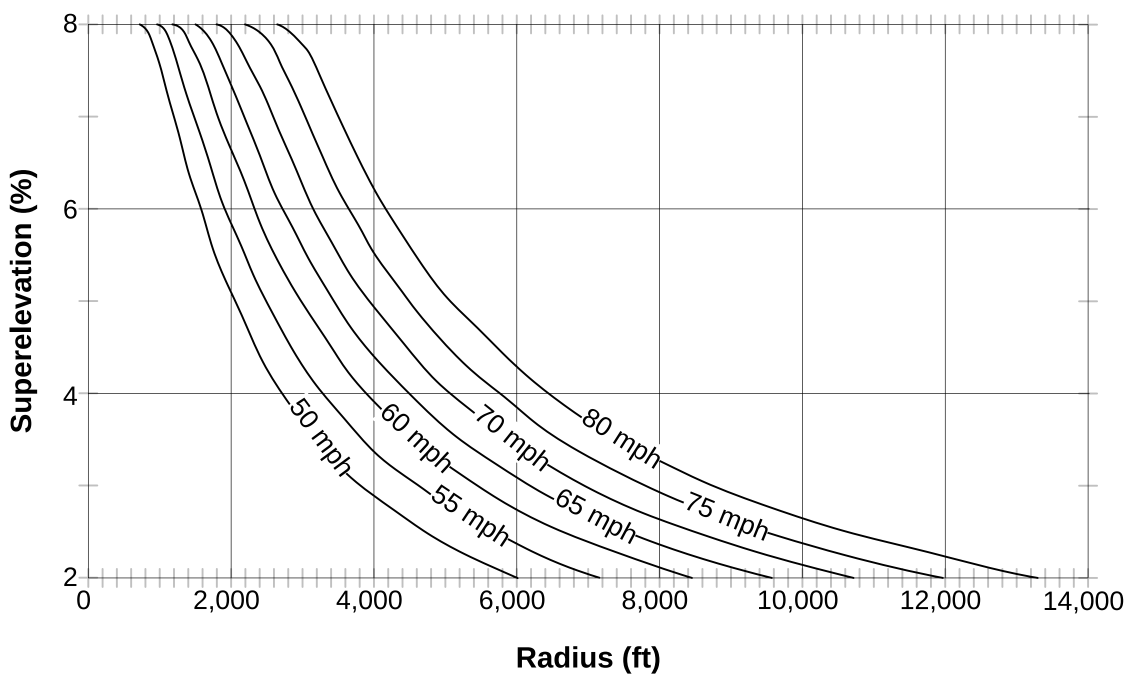




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	40	75	130	205	295	415	545	700	880	1,095	1,345	1,640	1,980	2,380

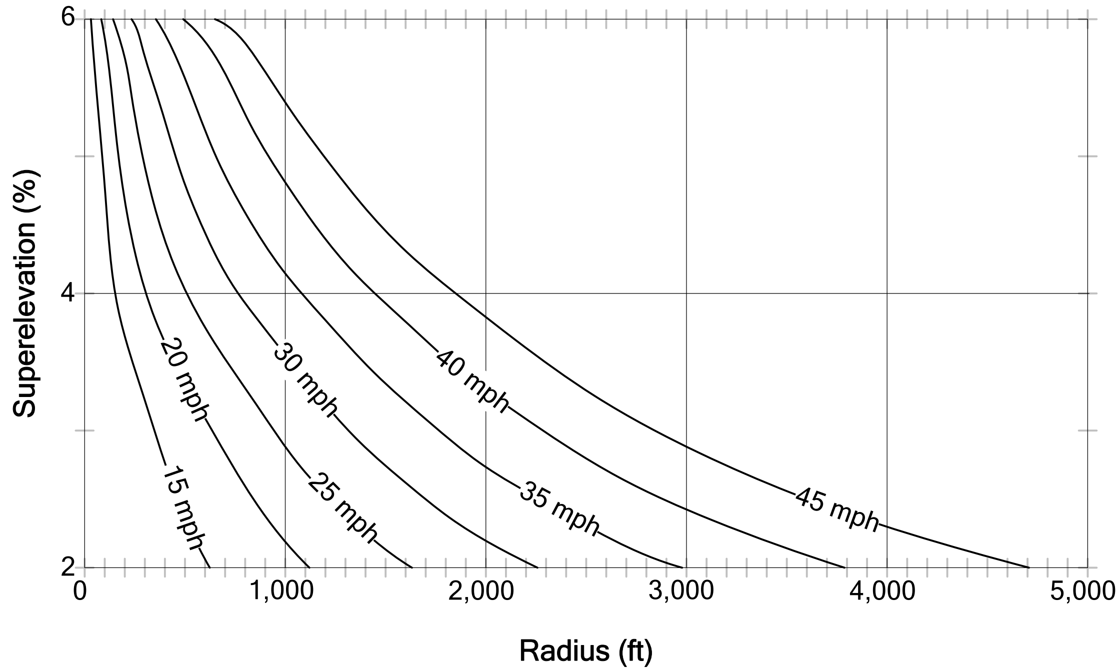
Exhibit 1250-4b Superelevation Rates (8% Max)

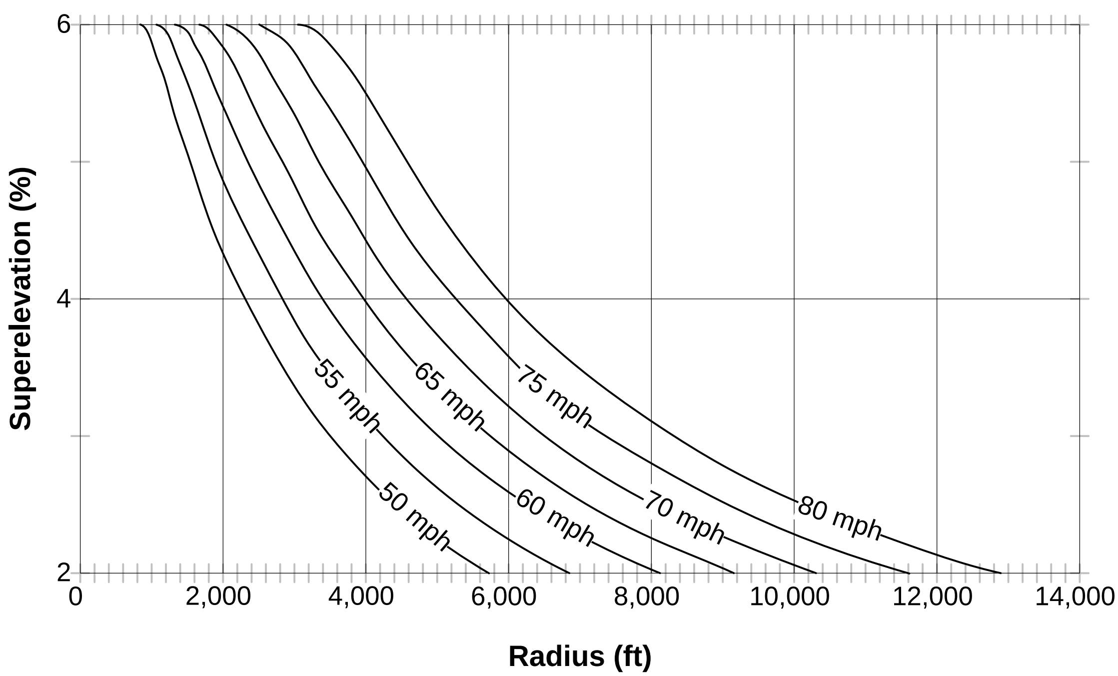




Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	40	80	135	215	315	450	590	760	965	1,205	1,490	1,820	2,215	2,675

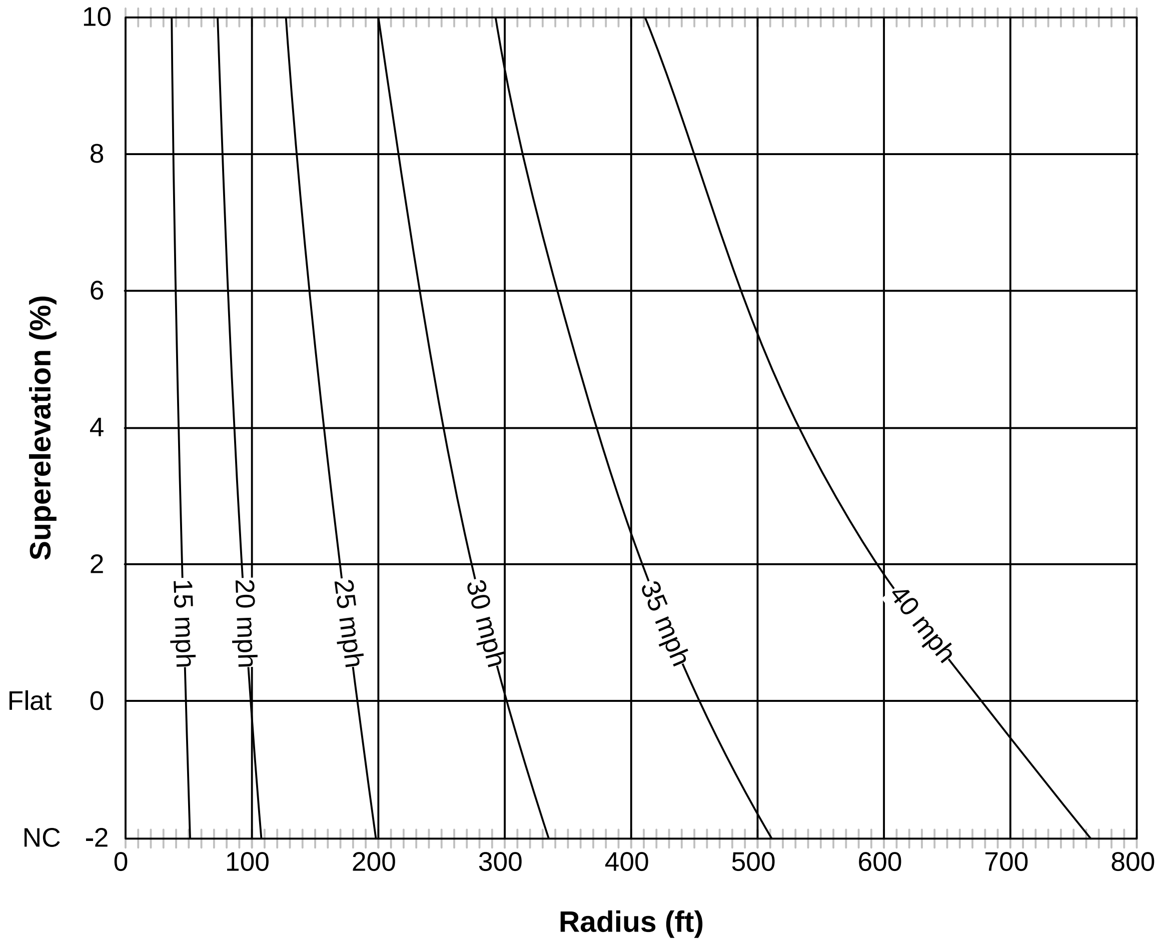
Exhibit 1250-4c Superelevation Rates (6% Max)





Design Speed (mph)	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Minimum Radius (ft)	40	85	145	235	345	490	645	840	1,065	1,340	1,665	2,050	2,510	3,055

Exhibit 1250-5 Superelevation Rates for Intersections and Urban Roadways <u>40 mph and slower</u>



NC = Normal crown

Exhibit 1250-6a Superelevation Transitions for Highway Curves

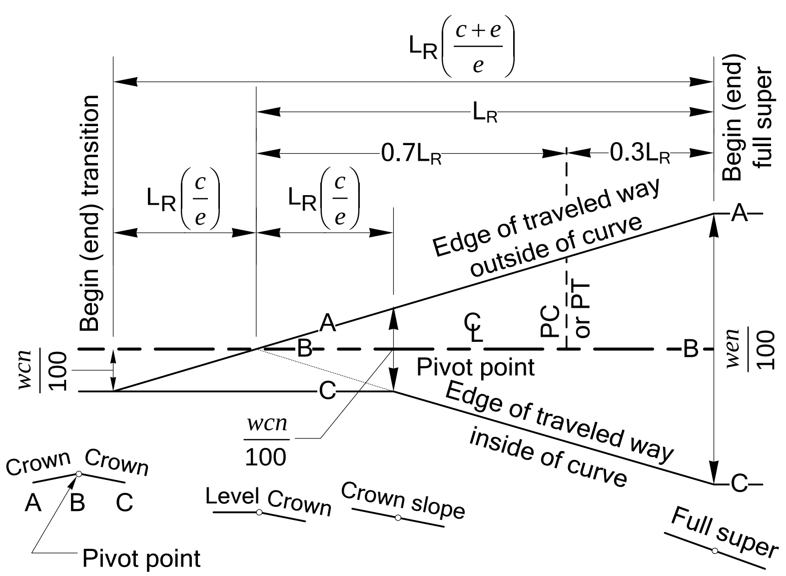
e (%)	L_B=Basic Runoff in Feet for Design Speed*													
	15 mph	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph	65 mph	70 mph	75 mph	80 mph
2	30	30	35	35	40	40	45	50	50	55	55	60	65	70
3	45	50	50	55	60	60	65	70	75	80	85	90	95	105
4	60	65	70	75	75	85	90	95	100	105	110	120	125	135
5	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:

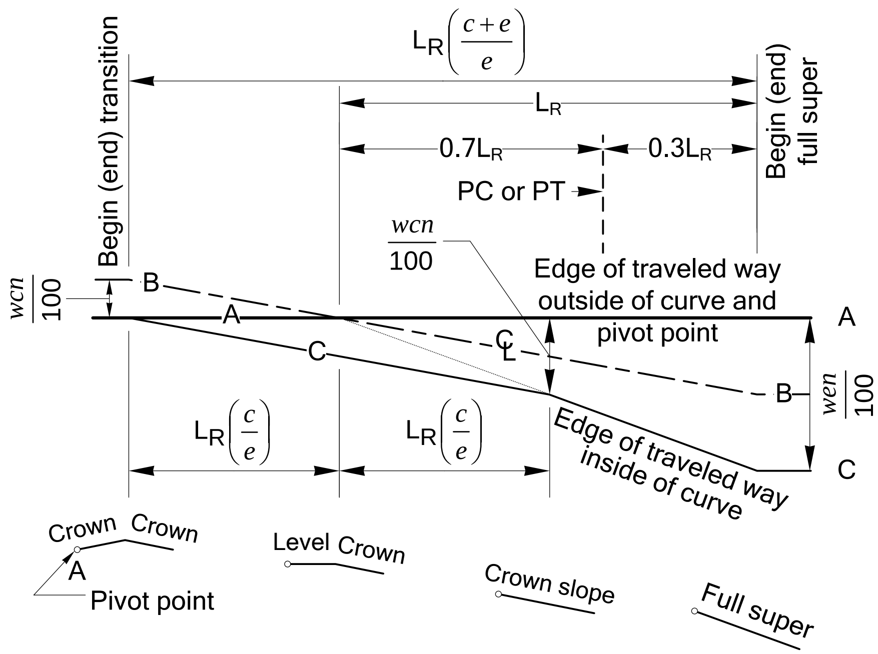
X = The distance in excess of 12 ft between the pivot point and the farthest edge of traveled way, in ft.



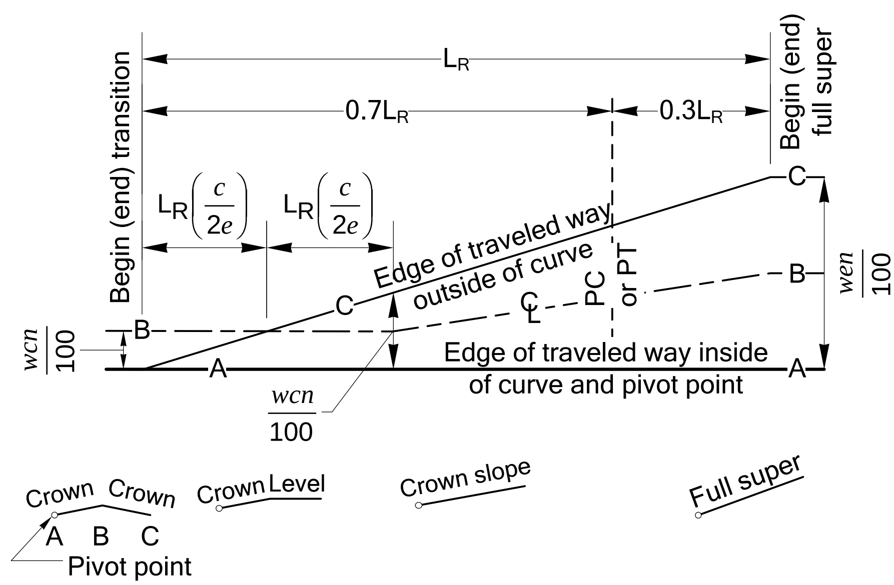
Design A – Pivot Point on Centerline Crown Section

c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

Exhibit 1250-6b Superelevation Transitions for Highway Curves



Design B[1] – Pivot Point on Edge of Traveled Way: Outside of Curve Crowned Section

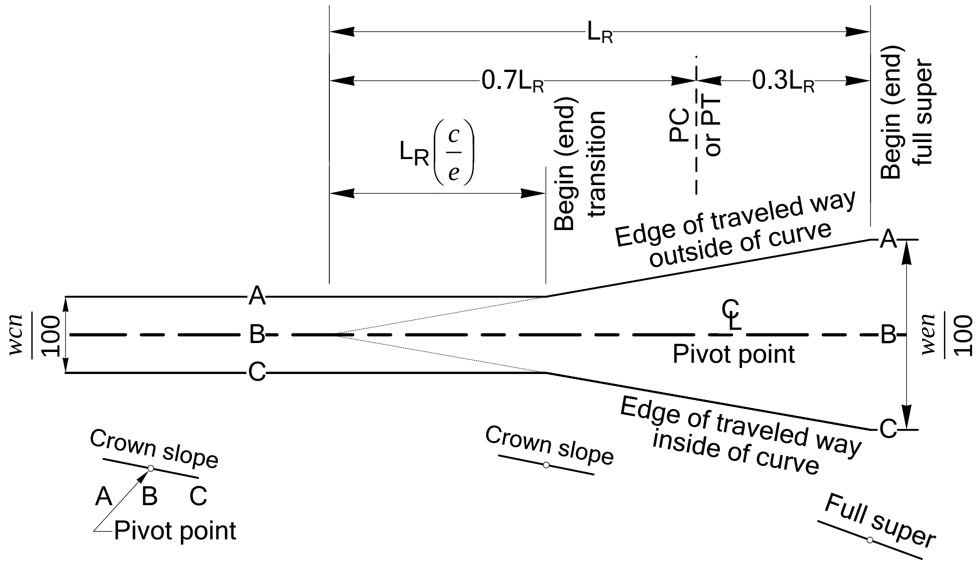


Design B[2] – Pivot Point on Edge of Traveled Way: Inside of Curve Crowned Section

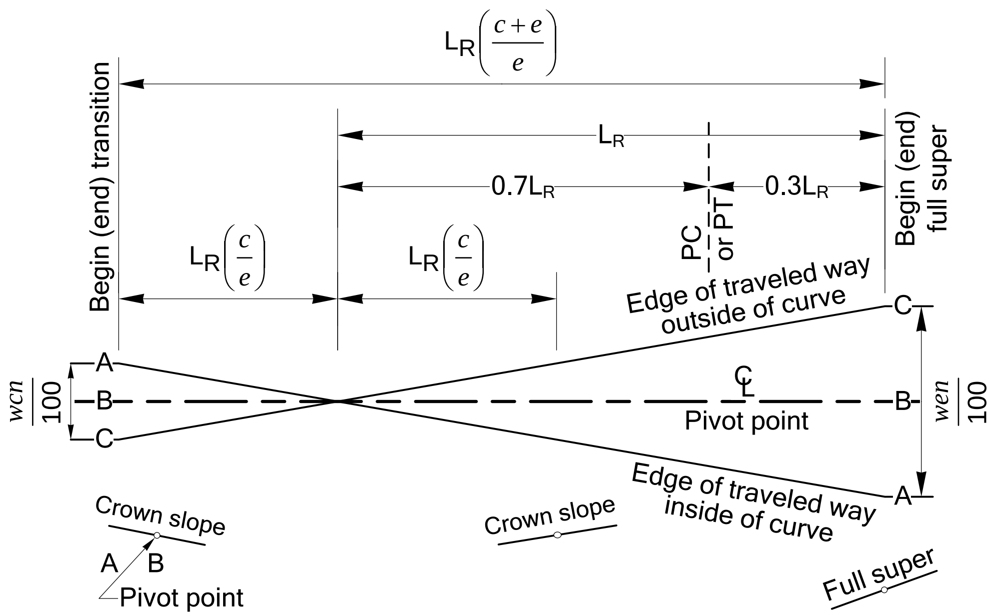
c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

B C

Exhibit 1250-6c Superelevation Transitions for Highway Curves



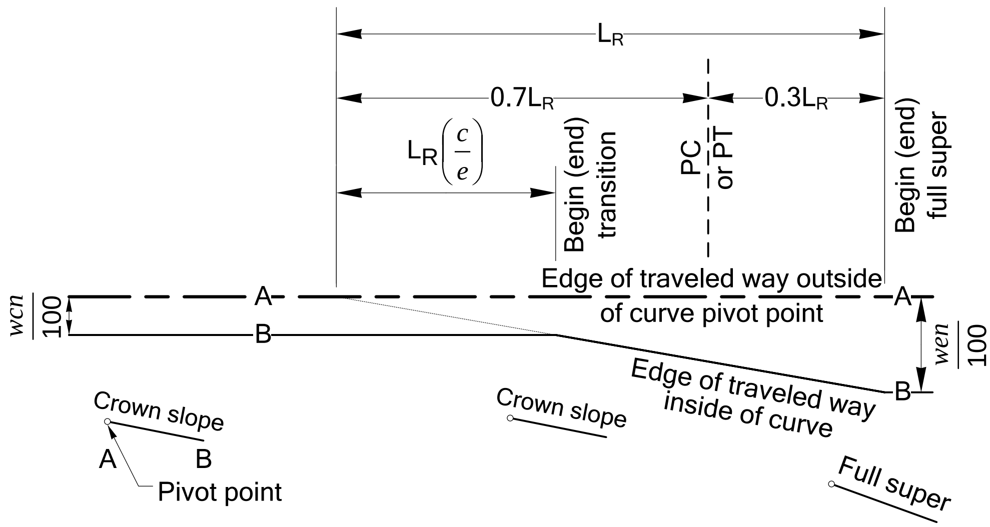
Design C[1] – Pivot Point on Centerline Curve in Direction of Normal Pavement Slope: Plane Section



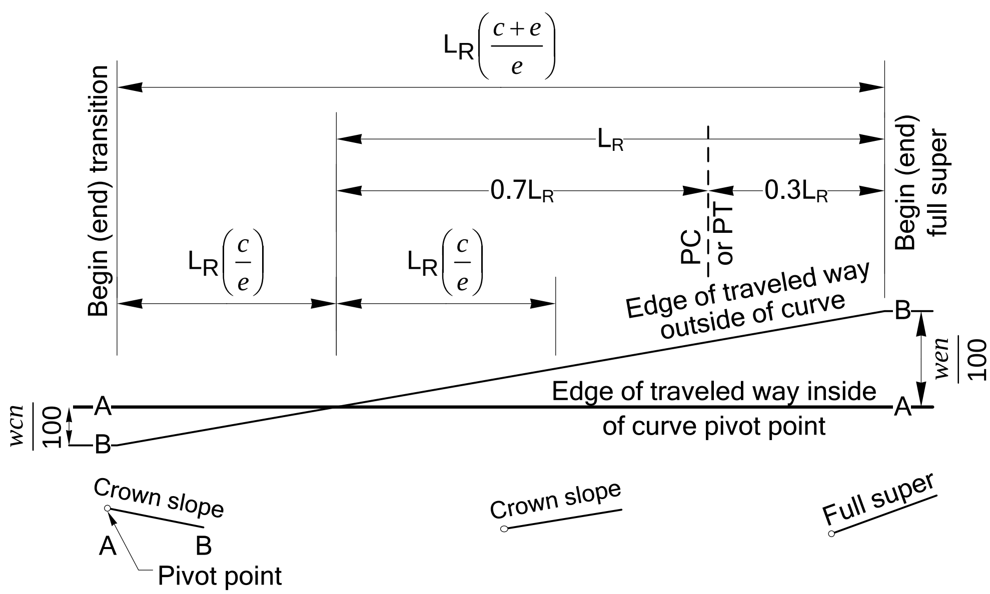
Design C[2] – Pivot Point on Centerline Curve Opposite to Normal Pavement Slope: Plane Section

c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

Exhibit 1250-6d Superelevation Transitions for Highway Curves



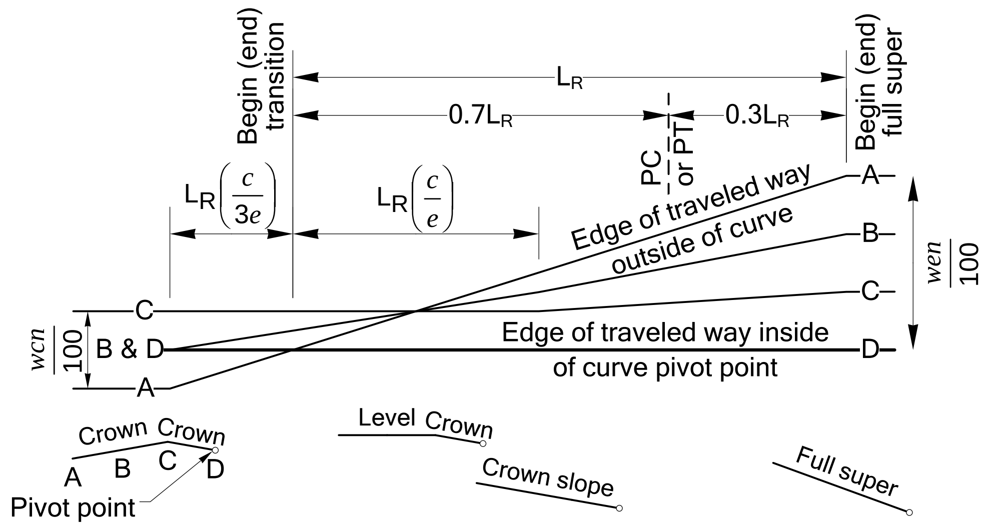
Design D[1] – Pivot Point on Edge of Traveled Way Curve in Direction of Normal Pavement Slope: Plane Section



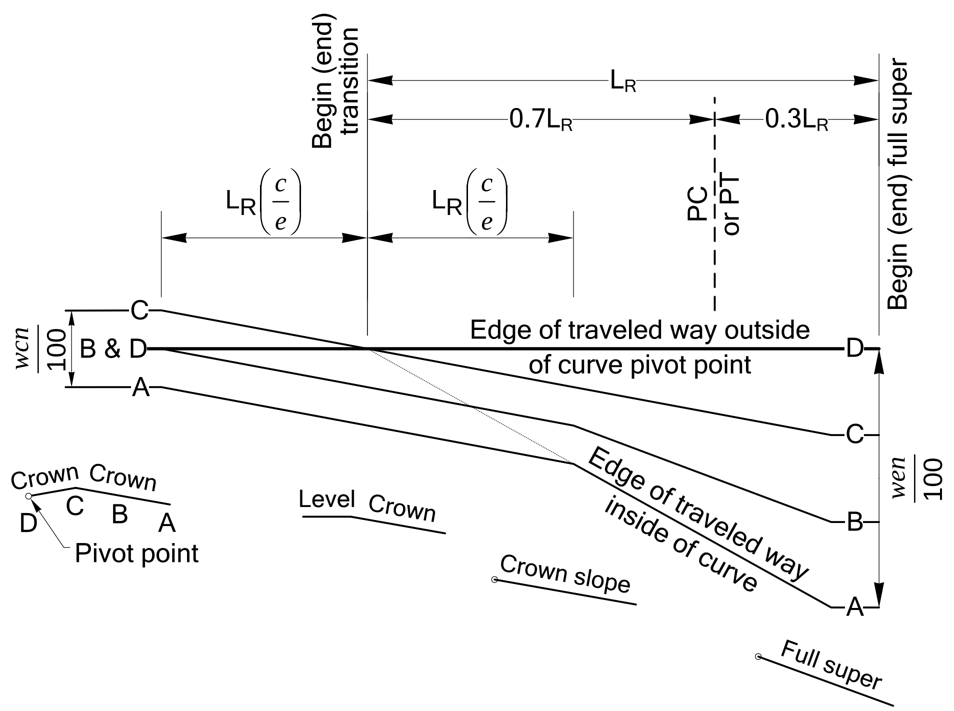
Design D[2] – Pivot Point on Edge of Traveled Way Curve Opposite to Normal Pavement Slope: Plane Section

c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

Exhibit 1250-6e Superelevation Transitions for Highway Curves



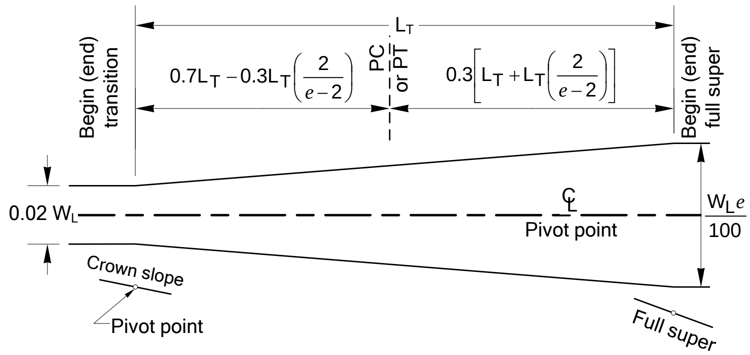
Design E[1] – Six-Lane With Median, Pivot Point on Edge of Traveled Way: Inside of Curve Crown Section



Design E[2] – Six-Lane With Median, Pivot Point on Edge of Traveled Way: Outside of Curve Crown Section

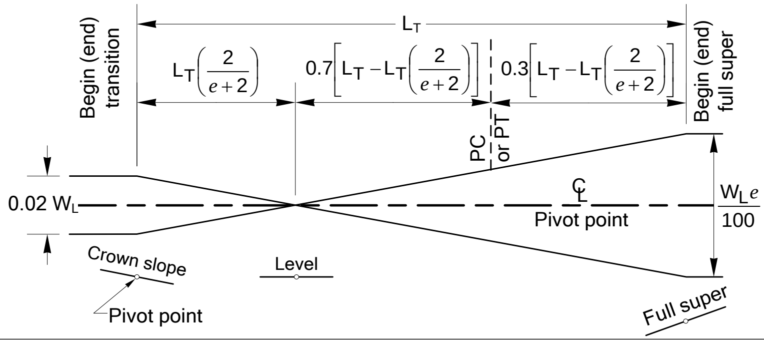
c = Normal crown (%)
e = Superelevation rate (%)
n = Number of lanes between points
w = Width of lane

Exhibit 1250-7a Superelevation Transitions for Ramp Curves



e (%)	Length of Transition in Feet for Design Speed							
	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 Centerline: Curve in Direction of Normal Pavement Slope

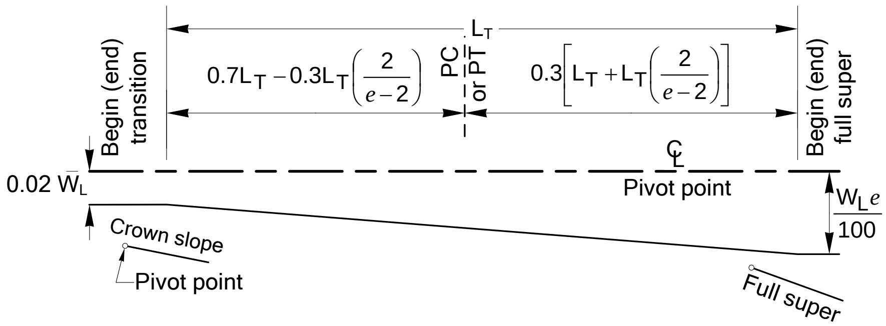


e (%)	Length of Transition in Feet for Design Speed							
	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
	L_T	L_T	L_T	L_T	L_T	L_T	L_T	L_T
2	40	40	45	50	55	55	60	65
3	50	55	55	60	65	70	75	80
4	60	65	70	75	80	85	90	95
5	70	75	80	85	90	100	105	110
6	80	85	90	95	105	115	120	130
7	90	95	100	110	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 Centerline: Curve in Direction Opposite to Normal Pavement Slope

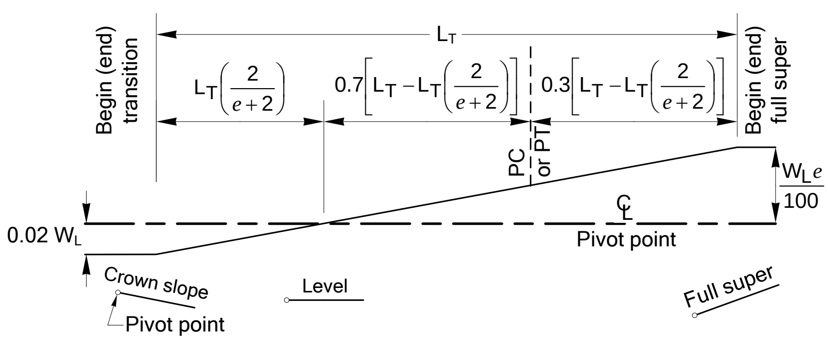
W_L = Width of ramp lane

Exhibit 1250-7b Superelevation Transitions for Ramp Curves



e (%)	Length of Transition in Feet for Design Speed							
	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



e (%)	Length of Transition in Feet for Design Speed							
	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

1270.01 General

Auxiliary lanes are used to comply with capacity demand; maintain lane balance; accommodate speed change, weaving, and maneuvering for entering and exiting traffic; and encourage carpools, vanpools, and the use of transit.

For signing and delineation of auxiliary lanes, see the *Standard Plans*, the *Traffic Manual*, and the MUTCD. Contact the region Traffic Engineer for guidance.

Although slow-moving vehicle turnouts and shoulder driving for slow vehicles 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
1103	Design controls, including speed
1230	Geometric cross section components
1310	Turn lanes
1310	Speed change lanes at intersections
1360	Collector-distributor roads
1360	Weaving lanes
1410	High-occupancy vehicle lanes

1270.02 Climbing Lanes

1270.02(1) General

Climbing lanes (see Exhibit 1270-1) are normally 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.

1270.02(2) Climbing Lane Warrants

Generally, climbing lanes are provided when two warrants—speed reduction and level of service—are met. Either warrant may be waived if, for example, slow-moving traffic is causing an identified collision trend or congestion that could be corrected by the addition of a climbing lane. However, under most conditions, climbing lanes are built when both warrants are met.

1270.02(2)(a) Warrant No. 1: Speed Reduction

Exhibit 1270-2a shows how the percent and length of grade affect vehicle speeds. The data is based on a typical commercial truck.

The maximum entrance speed, shown in the graphs, is 60 mph. This is the maximum value regardless of the posted speed of the highway. When the posted speed is above 60 mph, use 60 mph in place of the posted speed. Examine the profile at least ¼ 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 mph speed reduction below the posted speed limit for a typical truck for either two-lane or multilane highways, the speed reduction warrant is met (see Exhibit 1270-2b).

1270.02(2)(b) Warrant No. 2: Level of Service (LOS)

The level of service warrant for two-lane highways is met when the upgrade traffic volume exceeds 200 vehicles per hour and the upgrade truck volume exceeds 20 vehicles per hour. On multilane highways, a climbing lane is warranted when a capacity analysis shows the need for more lanes on an upgrade than on a downgrade carrying the same traffic volume.

Exhibit 1270-1 Climbing Lane Example

1270.02(3) Climbing Lane Design

When a climbing lane is justified, design it in accordance with Exhibit 1270-3. 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. Whenever possible, maintain a shoulder width equal to the adjacent roadway segments (preserve shoulder width continuity). On two-way two-lane highways, the shoulder may be reduced to 4 feet. If the shoulder width is reduced to 4 feet document the reasoning for the decision in the design parameter sheets. If the shoulder width is reduced to less than 4 feet, a design analysis is required.

Exhibit 1270-2a Speed Reduction Warrant: Performance for Trucks

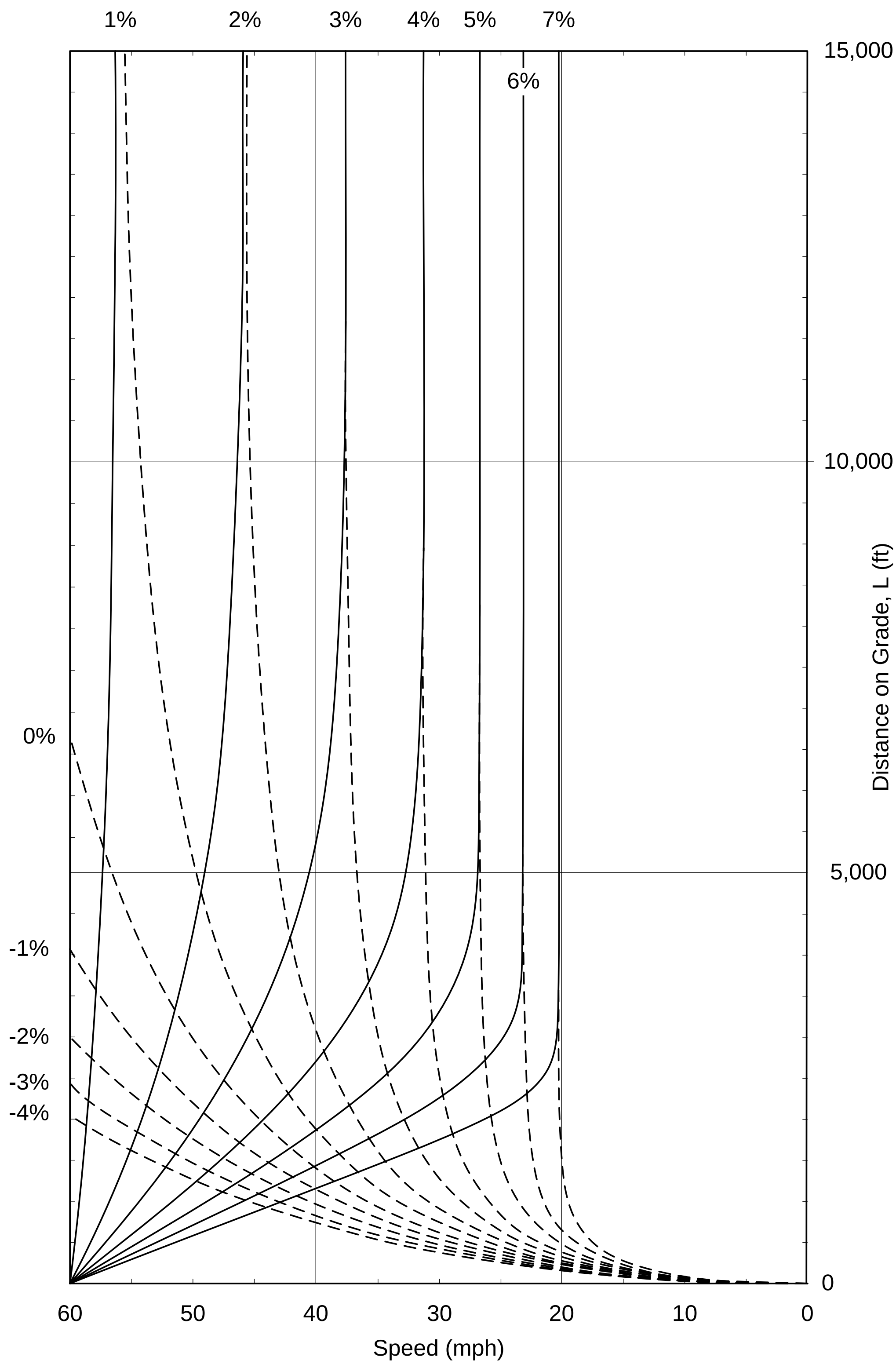
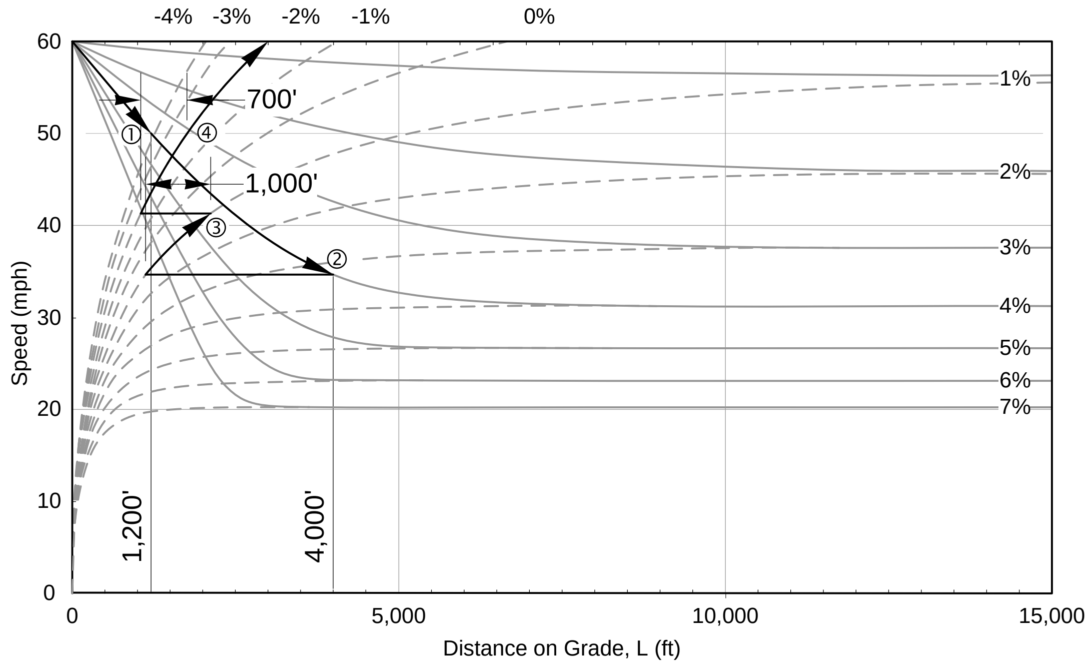
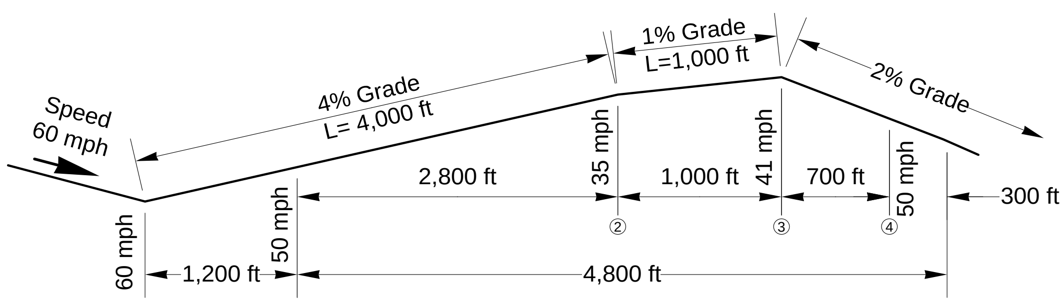


Exhibit 1270-2b Speed Reduction Warrant Example





Given:

A two-lane highway meeting the level of service warrant, with the above profile, and a 60 mph posted speed.

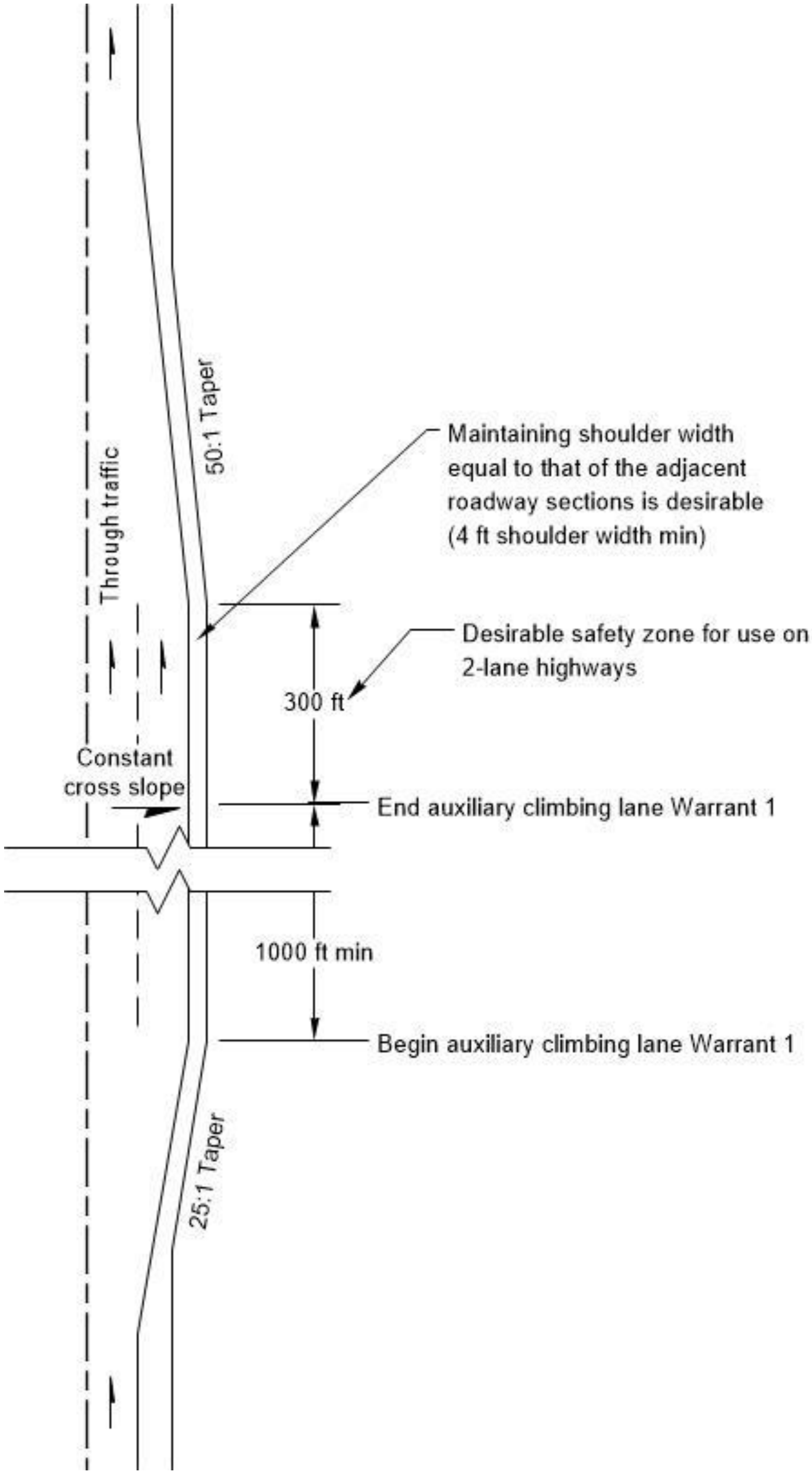
Determine:

Is the climbing lane warranted? If so, what is its length?

Solution:

1. Follow the 4% grade deceleration curve from a speed of 60 mph to a speed of 50 mph at 1,200 ft. The speed reduction warrant is met and a climbing lane is needed.
2. Continue on the 4% grade deceleration curve to 4,000 ft. 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 ft. 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 that the distance is 700 ft.
5. The total auxiliary lane length is (4,000-1,200)+1,000+700+300=4,800 feet. 300 ft is added to the speed reduction warrant for a two-lane highway (see 1270.02(3) and Exhibit 1270-3).

Exhibit 1270-3 Auxiliary Climbing Lane



1270.03 Passing Lanes

1270.03(1) Passing Lane Benefits

A passing lane (see Exhibit 1270-4) is an auxiliary lane provided in one or both directions of travel on a two-lane highway to improve passing opportunities. They may be intermittent or continuous passing lanes in level or rolling terrain and short four-lane sections. The objectives of passing lanes are to:

- Improve overall traffic operations on two-lane highways by breaking up traffic platoons and reducing delays caused by inadequate passing opportunities over substantial lengths of highway.
- Increase average travel speed within the passing lane itself; the speed benefits of passing lanes continue downstream of the lane. Passing lanes typically reduce the percent time spent following within the passing lane itself. These "percent time spent following" benefits can continue for some distance downstream of the passing lane.
- Improve safety by providing assured passing opportunities without the need for the passing driver to use the opposing traffic lane. Safety evaluations have shown that passing lanes and short four-lane sections reduce collision rates and severity.

1270.03(2) Passing Lane Length

Design passing lanes long enough to provide a reduction in traffic platooning. To maximize the traffic operational efficiency of a passing lane in level or rolling terrain, its length can vary from 0.5 mile to 2.0 miles depending on the directional flow rate, as shown in Exhibit 1270-5. Passing lanes longer than 2 miles can cause the driver to lose the sense that the highway is a two-lane facility. However, these lengths may vary for other reasons such as addressing safety-related issues. Passing lanes longer than 2.0 miles or shorter than 0.5 miles in length may be used depending on the identified need or other operational considerations within the design. Lengths shown do not include passing lane tapers at the beginning or end of the passing lane.

Exhibit 1270-4 Passing Lane Example

Exhibit 1270-5 Length of Passing Lanes

Directional Flow Rate (pc/h)	Passing Lane Length (mi)
100	≤0.50
200	>0.50-0.75
400	>0.75-1.00
≥700	>1.00-2.00

Source: Transportation Research Board, Highway Capacity Manual, 2000

For assistance in developing a passing lane length, see the following website for an example of a self-modeling spreadsheet. This spreadsheet develops passing lane lengths based primarily on vehicle speed differentials and is to be used in conjunction with traffic modeling efforts. Contact the Headquarters Design Office for assistance (www.wsdot.wa.gov/design/policy/default.htm).

1270.03(3) Passing Lane Location

A number of factors are considered when selecting an appropriate location for a passing lane, including the following:

- Locate passing lanes where decision sight distance (see Chapter 1260) at the lane decrease tapers can be provided.
- Provide stopping sight distance continuously along the roadway
- Avoid locating passing lanes near high-volume intersections, existing structures, railroad crossings, areas of dense development, and two-way left-turn lanes.
- Locate passing lanes where they appear logical to the driver.
- When designing the addition of passing lanes, make sure existing curves at the desired location have adequate supereleveation to provide speeds suitable for passing. For information on superelevation, see Chapter 1250.
- Avoid other physical constraints, such as bridges and culverts, if they restrict the provision of a continuous shoulder.
- Consider the number, type, and location of intersections and road approaches.
- Consider grades when choosing the side on which to install the passing lane. Uphill grades are preferred but not mandatory.
- Preference for passing is normally given to the traffic departing a developed area such as a small town.

1270.03(3)(a) Traffic Operational Considerations

When passing lanes are provided at an isolated location, their typical objective is to reduce delays at a specific bottleneck; for example, climbing lanes (see 1270.02). The location of the passing lane is dictated by the needs of the specific traffic operational problem encountered.

When passing lanes are provided to improve traffic operations over a length of road, there is flexibility in the choice of passing lane locations to maximize their operational effectiveness and minimize construction costs.

If delay problems on an upgrade are severe, the upgrade will usually be the preferred location for a passing lane.

Passing lanes at upgrades begin before speeds are reduced to unacceptable levels and, where possible, continue over the crest of the grade so that slower vehicles can regain some speed before merging.

1270.03(3)(b) Construction Cost Considerations

The cost of constructing a passing lane can vary substantially, depending on terrain, highway structures, shoulders, and adjacent development. Thus, the choice of a suitable location for a passing lane may be critical to its cost-effectiveness.

Generally, passing lanes in level and rolling terrain can be placed where they are least expensive to construct, avoiding locations with high cuts and fills and existing structures that would be expensive to widen.

1270.03(3)(c) Intersection-Related Considerations

Consider a corridor evaluation of potential passing lane locations for each direction, avoiding placement of passing lanes near intersections. Avoid or minimize turning movements on a road section where passing is encouraged.

Low-volume intersections and driveways are allowed within passing lanes, but not within the taper transition areas.

Where the presence of higher-volume intersections and driveways cannot be avoided, consider including provisions for turning vehicles, such as left-turn lanes.

Provide right- and left-turn lanes in passing lane sections where they would be provided on a conventional two-lane highway.

Left turns within the first 1,000 feet of a passing lane are undesirable. Strategies to address the turning movement could include left-turn lanes, right-in/right-out access, beginning the passing lane after the entrance, and so on.

1270.03(4) Passing Lane Design

Where a passing lane is planned, evaluate several possible configurations (see 1270.03(4)(a)) that are consistent with the corridor and fit within the constraints of the specific location.

The recommended minimum transition distance between passing lanes in opposing directions is 500 feet for “tail-to-tail” and 1,500 feet for “head-to-head” (see Exhibit 1270-7).

Some separation between lanes in opposite directions of travel is desirable; however, passing lanes can operate effectively with no separation. In either situation, address pavement markings and centerline rumble strips as appropriate.

It is desirable to channelize the beginning of a passing lane to move traffic to the right lane in order to promote prompt usage of the right lane by platoon leaders and maximize passing lane efficiency.

Widening symmetrically to maintain the roadway crown at the centerline is preferred, including in continuous passing lane configurations. However, the roadway crown may be placed in other locations as deemed appropriate. Considerations for crown locations might include: costs, constructability, right of way, environmentally sensitive roadsides, or other factors.

1270.03(4)(a) Alternative Configurations

Where a passing lane will be provided, evaluate the configurations shown in Exhibit 1270-6. In the exhibit, general passing lane configurations and their typical applications are described in the following:

a. Isolated Passing Lane – Exhibit 1270-6 (a)

- Two-lane highway with passing lane provided at a spot location to dissipate queues.
- For isolated grades, consider climbing lanes (see 1270.02).

b. Intermittent Passing Lanes, Separated – Exhibit 1270-6 (b)

- Often pairs are used at regular intervals along a two-lane highway.
- Frequency of passing lanes depends on desired level of service.
- The spacing between passing lanes and between pairs may be adjusted to fit the conditions along the route (see 1270.03(3)).

c. Continuous Passing Lanes – Exhibit 1270-6 (c)

- Use only when constraints do not allow for the use of other configurations. The use of this configuration requires concurrence from the region Traffic Engineer. (See Exhibit 1270-7 for additional information regarding buffer areas.)
- Appropriate for two-lane roadways carrying relatively high traffic volumes where nearly continuous passing lanes are needed to achieve the desired level of service.
- Particularly appropriate over an extended section of roadway where a wide pavement is already available.
- May be used as an interim stage for an ultimate four-lane highway.

d. Short Four-Lane Section – Exhibit 1270-6 (d)

- Sufficient length for adjoining passing lanes is not available.
- Particularly appropriate where the ultimate design for the highway is four lanes.

e. Intermittent Three-Lane Passing Lanes – Exhibit 1270-6 (e)

- Does not require the slow vehicle to change lanes to allow passing.
- Requires the widening to transition from one side of the existing roadway to the other.
- Eliminates the head-to-head tapers.

1270.03(4)(b) Geometric Aspects

Carefully design transitions between passing lanes in opposing directions. Intersections, bridges, other structures, two-way left-turn lanes, painted medians, or similar elements can be used to provide a buffer area between opposing passing lanes. The length of the buffer area between adjoining passing lanes depends on the configuration (see Exhibit 1270-7).

Exhibit 1270-6 illustrates five passing lane design configurations. Part (c) illustrates a continuous three-lane section with alternating passing lanes. Consider a four-lane cross section when volume demand exceeds the capacity of a continuous three-lane roadway.

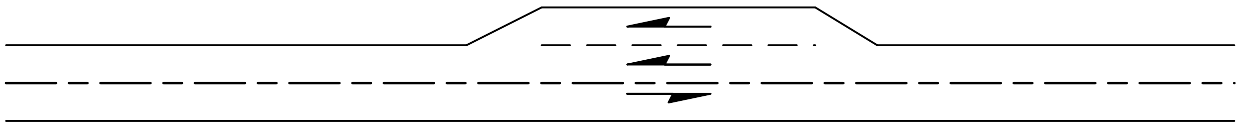
Exhibit 1270-8 illustrates taper rates, cross slopes, and section lengths for three and four-lane passing sections. Where practicable provide shoulder width in a passing lane section equal to the shoulder width on the adjacent segments of a two-lane highway. However, the shoulder may be reduced to 4 feet. If the shoulder width is reduced to 4 feet, document the reason for the decision on the design parameter sheets. If the shoulder width is reduced to less than 4 feet, a design analysis is required. See Chapter 1600 for shoulder rumble strip criteria and considerations.

Where practicable, design the passing lane width the same as the lane width on the adjacent segments of the two-lane highway.

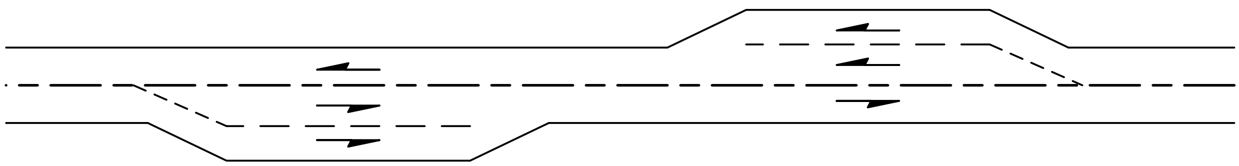
Provide a 25:1 or flatter taper rate to increase the width for a passing lane. When all traffic is directed to the right lane at the beginning of the passing lane, provide a taper rate of the posted speed:1. Provide a posted speed:1 taper rate for the merging taper at the end of a passing lane. (Refer to the Lane Transitions section in Chapter 1210 for additional information on taper rates.) Consider a wide shoulder at the lane drop taper to provide a recovery area for drivers who encounter a merging conflict.

Provide signing and delineation to identify the presence of an auxiliary passing lane. Refer to the *Standard Plans*, the *Traffic Manual*, and the MUTCD for passing lane signing and marking guidance.

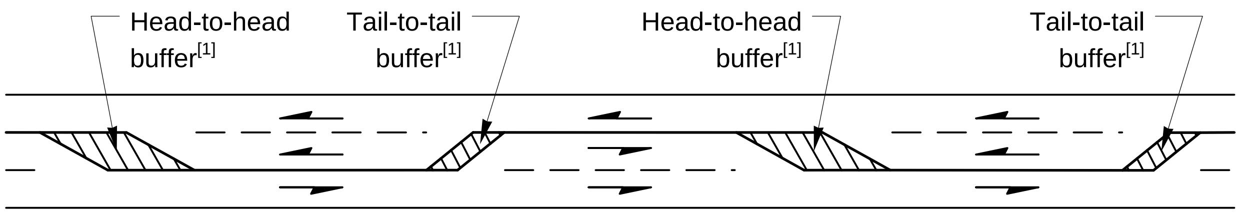
Exhibit 1270-6 Passing Lane Configurations



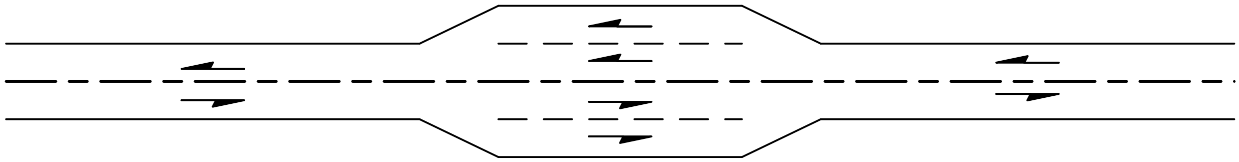
(a) Isolated Passing Lane



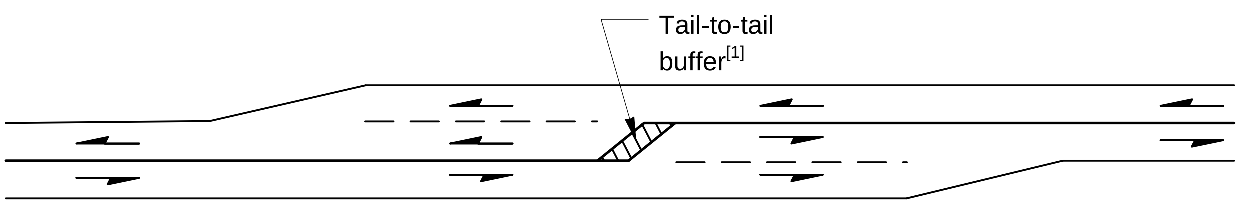
(b) Intermittent Passing Lane



(c) Continuous Three-Lane Section



(d) Short Four-Lane Section



(e) Intermittent Three-Lane Passing Lanes

Note:

[1] See Exhibit 1270-7 for buffer design.

Exhibit 1270-7 Buffer Between Opposing Passing Lanes

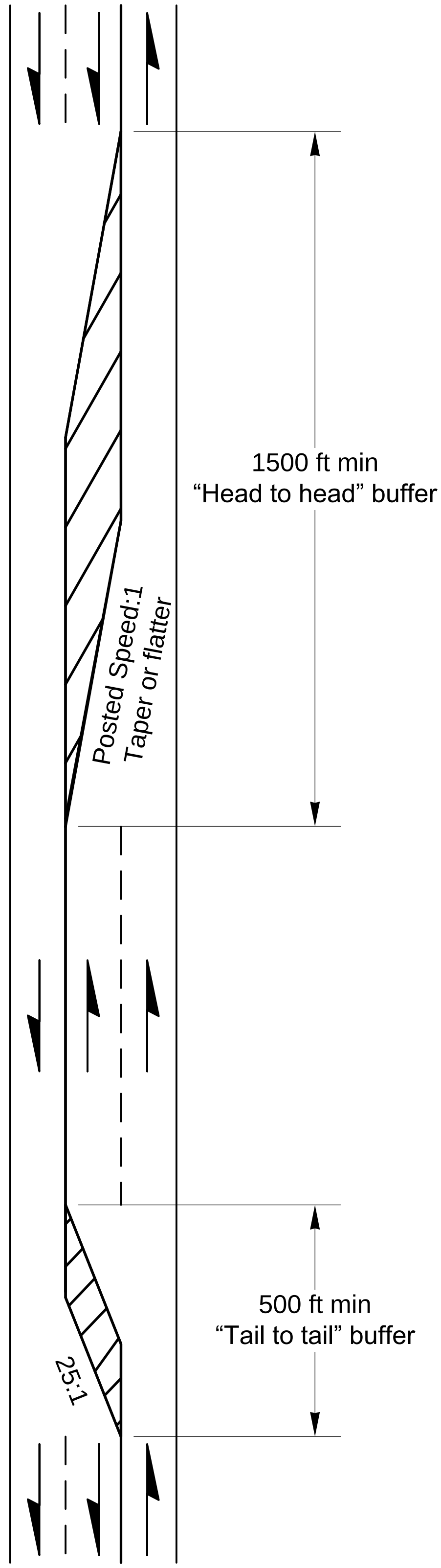
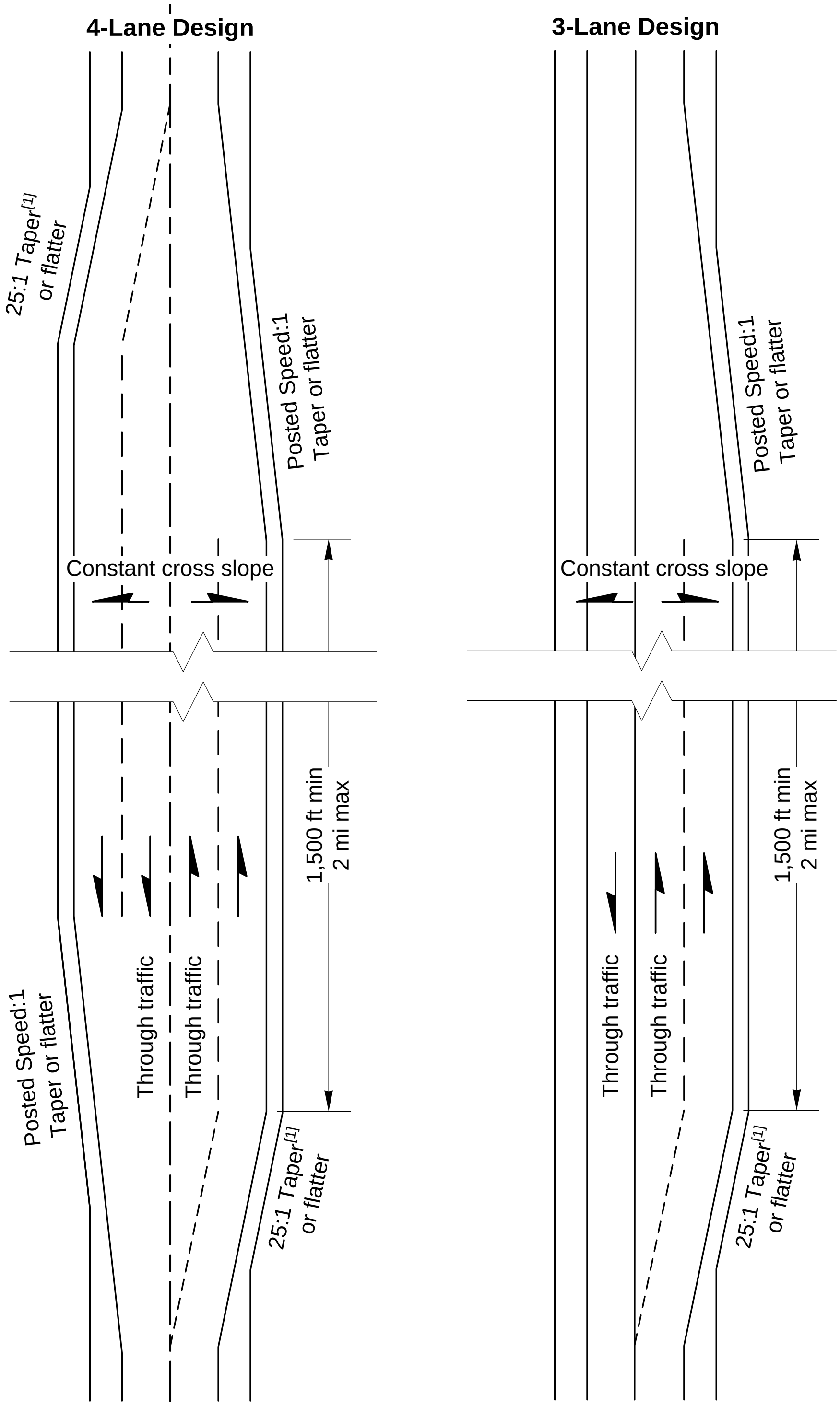


Exhibit 1270-8 Auxiliary Passing Lane



Notes:

[1] Provide a posted speed:1 taper when all traffic is directed to the right lane at the beginning of the passing lane.

[2] Where practicable provide the same lane and shoulder widths in the passing section as on adjacent segments. See 1270.03(4)(b).

1270.04 Slow-Moving Vehicle Turnouts

1270.04(1) General

RCW 46.61.427 states:

> *On a two-lane highway where passing is unsafe … a slow-moving vehicle, behind which five or more vehicles are formed in a line, shall turn off the roadway wherever sufficient area for a safe turn-out exists, in order to permit the vehicles following to proceed…*

A slow-moving vehicle turnout is not an auxiliary lane. Its purpose is to provide sufficient room for a slow-moving vehicle to pull out of through traffic and stop if necessary, allow vehicles to pass, and 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.

1270.04(2) Design

Base the design of a slow-moving vehicle turnout primarily on sound engineering judgment. Designs may vary from one location to another. Provide a length between 100 and 1,320 feet, excluding tapers. Select a width adequate for the vehicle type expected to use the turn-out, between 8 to 12 feet in width. Surface the turnouts with a stable, unyielding material (such as BST or HMA) with adequate structural strength to support the heavier traffic.

To improve the ability of a vehicle to safely reenter through traffic, locate slow-moving vehicle turnouts where adequate sight distance is available. The minimum design range for slow-vehicle turnouts may be where at least design stopping sight distance is available. See Chapter 1260.

Sign slow-moving vehicle turnouts to identify their presence. For guidance, see the Standard Plans, the Traffic Manual, and the MUTCD.

1270.05 Shoulder Driving for Slow Vehicles

1270.05(1) General

Use of a shoulder driving section is an alternative means to meet the performance objectives provided by climbing or passing lanes.

Review the following when considering a shoulder driving section:

- Horizontal and vertical alignment
- Character of traffic
- Presence of bicycles
- Road approaches and intersections
- Clear zone (see Chapter 1600)

1270.05(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. When barriers 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. Reconstruct the shoulders to provide adequate structural strength for the anticipated traffic. Select locations where the side slope meets the criteria of Chapter 1239. When providing a transition at the end of a shoulder driving section, use a 50:1 taper.

Signing for shoulder driving is required (see the Standard Plans, the Traffic Manual, and the MUTCD). Install guideposts when shoulder driving is to be permitted at night.

1270.06 Emergency Escape Ramps

1270.06(1) General

Consider an emergency escape ramp (see Exhibit 1270-9) whenever a long, steep downgrade is 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 crash data to determine whether or not an escape ramp is justified.

Exhibit 1270-9 Emergency Escape Ramp Example

1270.06(2) Design

1270.06(2)(a) Types

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 and are the most desirable design. Arrester beds are commonly built on an upgrade 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 consists of chain link or fiber net that is attached to energy-absorbing units. (See Chapter 1610 for additional information.)

1270.06(2)(b) Locations

The location of an escape ramp depends on terrain, length of grade, sight distance, and roadway geometrics. Desirable locations include before 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 downgrade.

1270.06(2)(c) Lengths

The length of an escape ramp depends on speed, grade, and type of design used. The minimum length is 200 feet. Calculate the stopping length using the equation in Exhibit 1270-10.

Exhibit 1270-10 Emergency Escape Ramp Length

$$L = \frac{V^2}{0.3(R \pm G)}$$

Where:

L = Stopping distance (ft)
V = Entering speed (mph)
R = Rolling resistance (see Exhibit 1270-11)
G = Grade of the escape ramp (%)

Speeds of out-of-control trucks rarely exceed 90 mph; therefore, the desirable entering speed is 90 mph. Other entry speeds may be used when justification and the method used to determine the speed are documented.

Exhibit 1270-11 Rolling Resistance (R)

Material	*R*
Roadway	1
Loose crushed aggregate	5
Loose non-crushed gravel	10
Sand	15
Pea gravel	25

1270.06(2)(d) Widths

The width of each escape ramp depends 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.

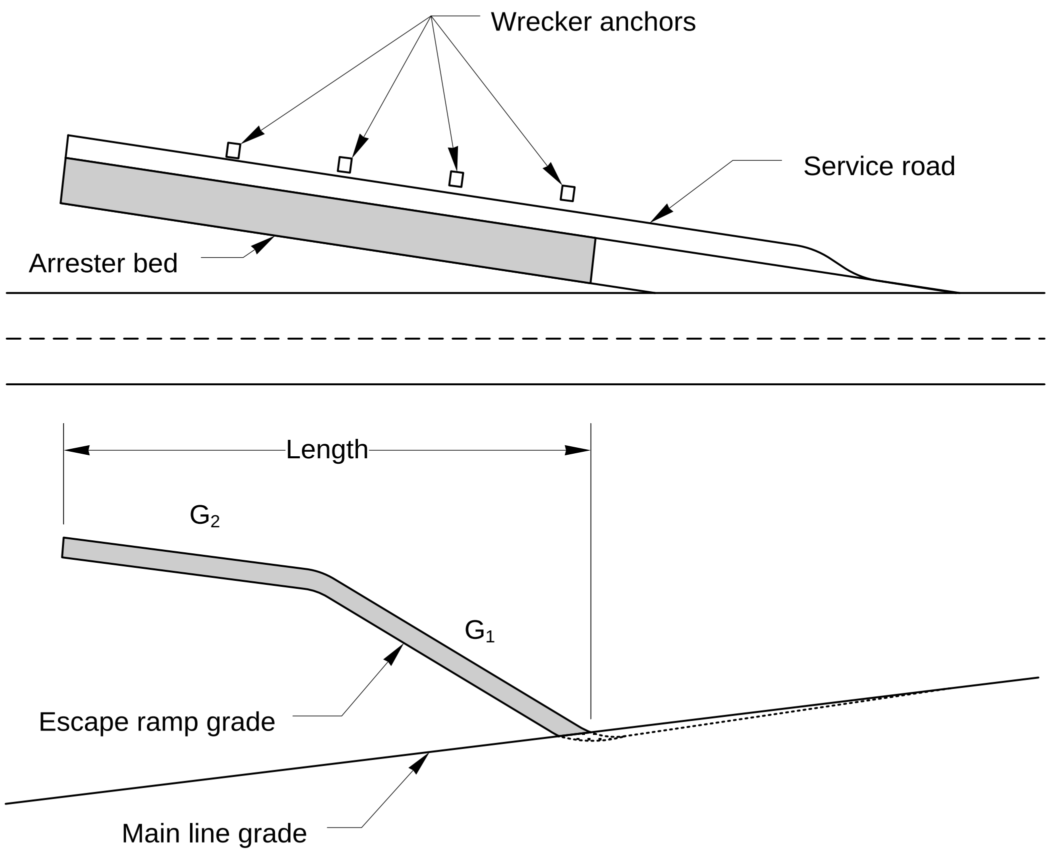
The following items are additional considerations in the design of emergency escape ramps:

- If possible, at or near the summit, provide a pull-off brake check area. Also, include in this area informative signing about the upcoming escape ramp.
- Free-draining, smooth, non-crushed gravel is desirable 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 inches 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.

Typical examples of arrester beds are shown in Exhibits 1270-9 and 1270-12.

Include justification, all calculations, and any other design considerations in the emergency escape ramp documentation.

Exhibit 1270-12 Typical Emergency Escape Ramp



1270.07 Documentation

Refer to Chapter 300 for design documentation requirements.

1270.08 References

1270.08(1) Federal/State Laws and Codes

Revised Code of Washington (RCW) 46.61, Rules of the road

1270.08(2) Design Guidance

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC “Manual on uniform traffic control devices for streets and highways” (MUTCD)

Standard Plans for Road, Bridge, and Municipal Construction (*Standard Plans*), M 21-01, WSDOT

Traffic Manual, M 51 02, WSDOT

1270.08(3) Supporting Information

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

Emergency Escape Ramps for Runaway Heavy Vehicles, FHWA-T5-79-201, March 1978

Highway Capacity Manual, latest edition, Transportation Research Board, National Research Council

Truck Escape Ramps, NCHRP Synthesis 178, Transportation Research Board

Chapter 1310 Intersections

1310.01 General

Intersections are a critical part of Washington State Department of Transportation (WSDOT) highway design because of increased conflict potential. Traffic and driver characteristics, bicycle and pedestrian needs, physical features, and economics are considered during the scoping and design stages to develop channelization and traffic control to provide multimodal traffic flow through intersections.

See chapters in the 1100 series for instruction on multimodal practical design, including identifying project needs, context, design controls, modal performance, alternatives analysis, and design element dimensioning.

This chapter provides guidance for designing intersections, including ramp terminals. Refer to the following chapters for additional information:

Chapter	Subject
1103	Design controls
1106	Design element dimensions
1230	Geometric cross section
1300	Intersection control type
1320	Roundabouts
1330	Traffic signals
1340	Driveways
1360	Interchanges
1510	Pedestrian facilities
1520	Roadway bicycle facilities

For assistance with intersection design, contact the Headquarters (HQ) Design Office.

1310.02 Design Considerations

Consider all potential users of the facility in the design of an intersection. 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 results in 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 design vehicle (see Chapter 1103). This is done to control the speed of turning vehicles and reduce the area of exposure for vehicles, bicycles, and pedestrians. For additional information on pedestrian needs, see Chapter 1510. For intersections with shared-use paths, see Chapter 1515. For bicycle considerations at intersections, see Chapter 1520.

1310.02(1) Non-Geometric Considerations

Geometric design considerations, such as sight distance and intersection angle, are important. Equally important are perception, contrast, and a driver’s age. Perception is a factor in the majority of crashes. Regardless of the type of intersection, the function depends on the driver’s ability to perceive what is happening with respect to the surroundings and other vehicles. When choosing an acceptable gap, the driver first identifies the approaching vehicle and then determines its speed. The driver uses visual clues provided by the immediate surroundings in making these decisions. Thus, given equal sight distance, it may be easier for the driver to judge a vehicle’s oncoming speed when there are more objects to pass by in the driver’s line of sight. Contrast allows drivers to discern one object from another.

1310.02(2) Intersection Angle and Roadway Alignment

An important intersection design characteristic is the intersection angle. The desirable intersection angle is 90°, with 60° to 120° allowed. 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. However, angle points within the intersection are allowed at intersections with a minor through movement, such as at a ramp terminal (see Exhibit 1310-2).

When feasible, locate intersections such that curves do not begin or end within the intersection area. It is desirable to locate the PC and PT 250 feet or more from the intersection so that a driver can settle into the curve before the gap in the striping for the intersection area. Do not locate short curves where both the PC and PT are within the intersection area.

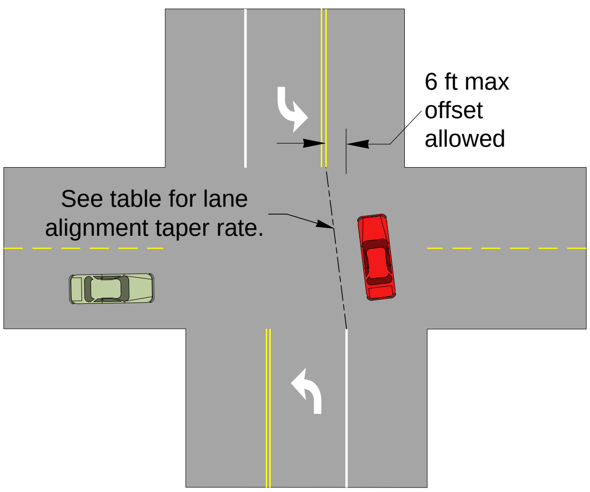
1310.02(3) Lane Alignment

It is desirable that entering through traffic is aligned with the exit lanes. However, the entering and exit lanes may be offset up to 6 feet when the following conditions are met:

- Illumination is provided.
- The intersection is not within a horizontal curve, nor is it within a crest vertical curve.
- The taper rates provided in Exhibit 1310-1 are used.
- There is a posted speed of 55 mph or less.

Consider dotted extension lines that continue through the intersection.

Exhibit 1310-1 Lane Alignment Taper Rate



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

1310.02(4) Intersection Spacing

Provide intersection spacing for efficient operation of the highway. The minimum design intersection spacing for highways with limited access control is covered in Chapter 530. For other highways, the minimum design intersection spacing is dependent on the managed access highway class. (See Chapter 540 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. Space intersections so that queues will not block an adjacent intersection.

Evaluate existing intersections that are spaced less than shown in Chapters 530 and 540. Also, evaluate closing or restricting movements at intersections with operational issues. Document the spacing of existing intersections that will remain in place and the effects of the spacing on operation, capacity, and circulation.

1310.02(5) Accommodating vs. Designing for Vehicles

Accommodating for a vehicle allows encroachment of other lanes, shoulders, or other elements to complete the required maneuver. Designing for a vehicle does not require encroachment on those elements.

There are competing design objectives when considering the crossing needs of pedestrians and the turning needs of larger vehicles. To design for large design vehicles, larger turn radii are used. This results in increased pavement areas, longer pedestrian crossing distances, and longer traffic signal arms. (See Chapter 1103 for design vehicle selection criteria.)

When appropriate, to reduce the intersection area, consider accommodating for large vehicles instead of designing for them. This reduces the potential for vehicle/pedestrian conflicts, decreases pedestrian crossing distance, and controls the speeds of turning vehicles. Use turn simulation software (such as AutoTURN®) to verify the design.

1310.02(6) Sight Distance

For stopping and decision sight distance criteria, see Chapter 1260. Intersection sight distance criteria are discussed in section 1310.05.

1310.02(7) Crossroads

When the crossroad is a city street or county road, design the crossroad beyond the intersection area in cooperation with the local agency.

When the crossroad is a state facility, design the crossroad according to the *Design Manual*. 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.

Evaluate the profile of the crossroad in the intersection area. The crown slope of the main line might need to be adjusted in the intersection area to improve the profile for the cross traffic.

Design the grade at the crosswalk to meet the requirements for accessibility. (See Chapter 1510 for additional crosswalk information.)

In areas that experience accumulations of snow and ice for all legs that require traffic to stop, design a maximum grade of ±4% for a length equal to the anticipated queue length for stopped vehicles.

1310.02(8) Rural Expressway At-Grade Intersections

Evaluate grade separations at all intersections on rural expressways.

Design high-speed at-grade intersections on rural expressways as indirect left turns, split intersections, or roundabouts.

The State Traffic Engineer’s approval is required for any new intersection or signal on a rural expressway.

1310.02(9) Interchange Ramp Terminals

When stop control or traffic signal control is selected, the design to be used or modified is shown in Exhibit 1310-2. Higher-volume intersections with multiple ramp lanes are designed individually. Provide ramp terminal designs consistent with the speed of the crossroad.

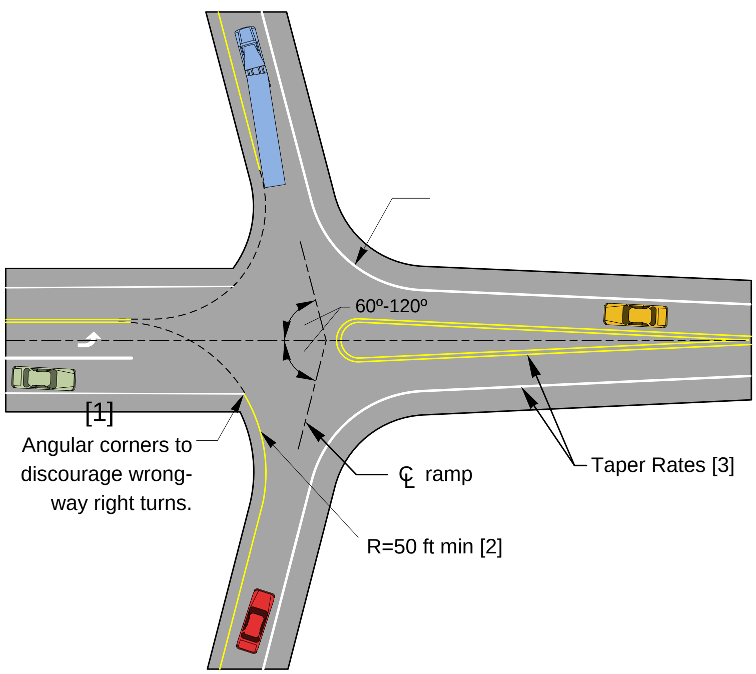
Where stop control or signal control is implemented, the intersection configuration criteria for ramp terminals are normally the same as for other intersections. One exception is that an angle point is allowed between an off-ramp and an on-ramp. This is because the through movement of traffic getting off the freeway, going through the intersection, and getting 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.

Due to the probable development of large traffic generators adjacent to an interchange, width for a median on the local road is desirable whenever such development is expected. 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.

Adjust the alignment of the intersection legs to fit the traffic movements and to discourage wrong-way movements. Use the allowed intersecting angles of 60° to 120° in designing the best alignment for efficiency and intersection operations.

Exhibit 1310-2 Ramp Terminal Intersection Details



Notes:

[1] For right-turn corner design, see Exhibit 1310-6.
[2] Use turn simulation software to verify that the design vehicle can make the turn.
[3] For taper rates, see Exhibit 1310-10a, Table 1.

1310.02(10) Wrong-Way Movement Countermeasures

Wrong-way crashes, though infrequent, have the potential to be more serious than other types of crashes, especially on high-speed facilities. Crash data show that impaired and older drivers are overrepresented and that a high percentage of these crashes occur at night. Washington State data show approximately equal numbers of crashes on the Interstate and multilane urban principal arterial highways. Discourage wrong-way maneuvers at all stages of design.

1310.02(10)(a) Wrong-Way Driving Countermeasure Categories

There are three categories of countermeasures used to discourage wrong-way driving:

- Signing and delineation
- Intelligent transportation systems
- Geometric design

1310.02(10)(a)(1) Signing and Delineation

Signing and delineation countermeasures include:

- DO NOT ENTER and WRONG WAY signs.
- ONE WAY signs.
- Turn restriction signs.
- Guideposts with red delineation.
- Red-backed raised pavement markers (RPMs).
- Directional pavement arrows.
- Yellow edge line on left and white edge line on right side of exit ramps.
- Pavement marking extension lines to direct drivers to the correct ramp.

DO NOT ENTER and WRONG WAY signs may be more effective when they are lowered to 4 feet above the edge of traveled way as they are better illuminated by low-beam headlights. Do not lower these signs when the height obscures intersection sight distance, interferes with pedestrian or bicyclists movements, or where snow or vegetation will block viewing of the sign.

1310.02(10)(a)(2) Intelligent Transportation Systems (ITS)

Wrong-way ITS countermeasures are wrong-way detection and warning systems. Contact the region Traffic Office for assistance when considering an ITS wrong-way warning system.

1310.02(10)(a)(3) Geometric Design

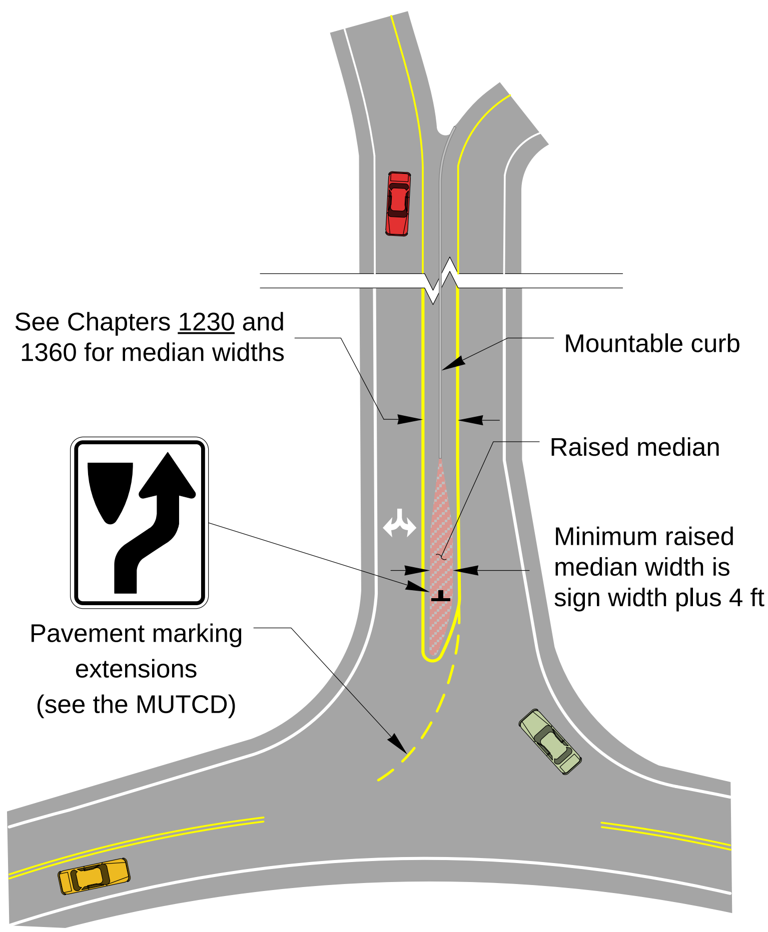
Geometric countermeasures include separating wrong-way movements from other movements, discouraging wrong-way movements, encouraging right-way movements, and improving the visibility of the right-way movement.

a. Separate On- and Off-Ramp Terminals

Consider the separation of on- and off-ramp terminals, particularly at interchanges where the ramp terminals are closely spaced (for example, partial cloverleaf ramps combined with other ramps). Wider medians between off- and on-ramp terminals provide room for signing and allow the median end to be shaped to help direct vehicles onto the correct roadway. The minimum width of the raised median is 7 feet, face of curb to face of curb, to accommodate a 36 inch sign.

Extend the raised median on a two-way ramp from the ramp terminal intersection to the split of the on- and off-ramps. The median outside of the intersection area may be reduced to the width of a dual-faced mountable curb. (See Exhibit 1310-3 for an example of the minimum median at the terminal of a two-way ramp.)

Exhibit 1310-3 Median at Two-Way Ramp Terminal



b. Reduced Off-Ramp Terminal Throat Width

Reducing the width of the off-ramp throat has been a successful method of discouraging wrong-way movements. A smaller opening makes the wrong-way entry less inviting, particularly for closely spaced ramps. When off-ramp terminals have right-turn lanes, a raised island will reduce the potential for a wrong-way movement.

c. Increased On-Ramp Terminal Throat Width

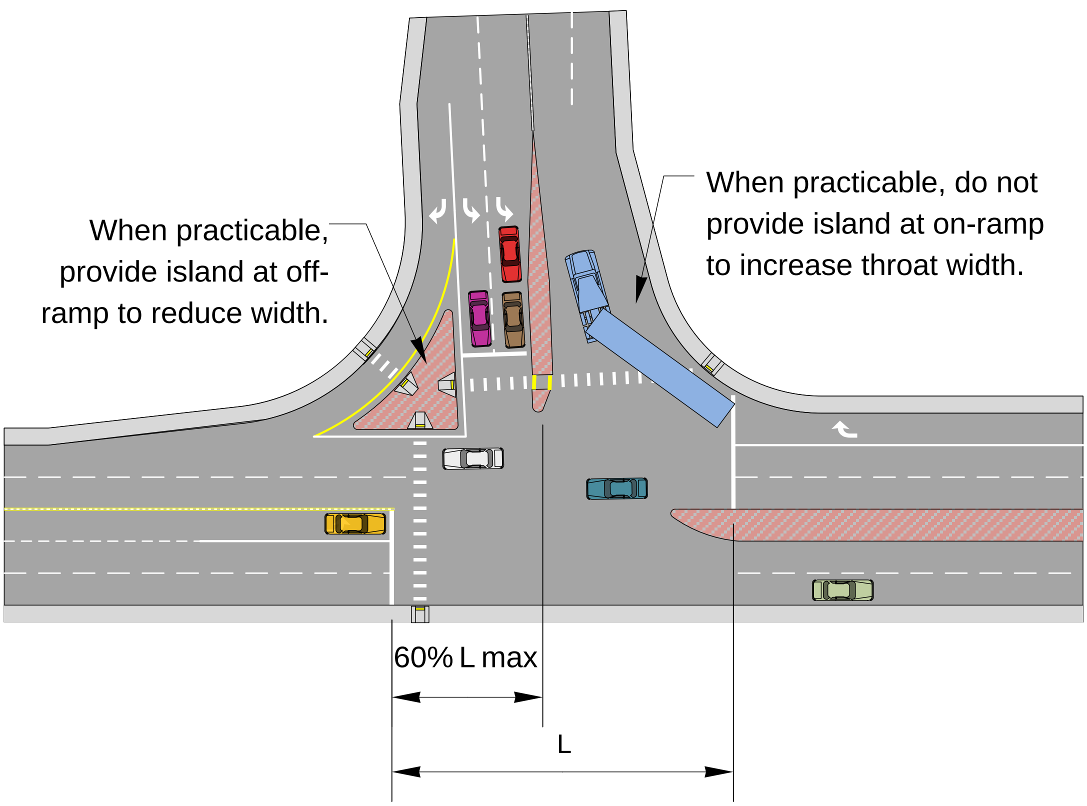
Increasing the width of the on-ramp throat can encourage right-way movements. A larger opening for the on-ramp makes it easier to turn into. To increase the throat width of on-ramps, use flat radii for left- and right-turning traffic and remove islands.

d. Intersection Balance

When drivers make a left turn, they are required to leave the intersection in the extreme left-hand lane lawfully available. As a result, left-turning drivers tend to head for a point between 50% and 60% of the way through the intersection.

At a two-way ramp terminal, the desirable throat width for the on-ramp roadway is not less than the off-ramp roadway width to accommodate this behavior (see Exhibit 1310-4). Much of this can be achieved by adjusting the stop bar position on the interchange cross street.

Exhibit 1310-4 Intersection Balance Example



e. Visibility

When drivers can see and recognize the roadway they want to turn onto, they are less likely to make a mistake and turn onto the wrong roadway. For two-way ramps and divided multilane roadways with barrier in the median, end the barrier far enough from the intersection that a left-turning driver can see and recognize the roadway going the correct direction. Drivers need to see the delineation pavement markings, curbs, or other elements to locate the correct roadway.

f. Angular Corners on the Left of Off-Ramp Terminals

Angular corners on the left side of off-ramp terminals will discourage wrong-way right turns. Provide a corner design as angular as feasible that will provide for the left turn from the off-ramp. Circular curves can look inviting for a wrong-way right turn onto the off-ramp (see Exhibit 1310-2).

1310.02(10)(b) Countermeasure Applications

Following are applications of wrong-way countermeasures for some common locations. For assistance with signing and delineation, contact the region Traffic Office.

1310.02(10)(b)(1) All Ramps

Countermeasures that can be used on almost any ramp or intersection with potential wrong-way concerns include:

- Enlarged warning signs.
- Directional pavement arrows at ramp terminals.
- Redundant signing and pavement arrows.
- Roundabout ramp terminal intersections, where room is available.
- Red-backed RPMs.

1310.02(10)(b)(2) One-Way Diamond Off-Ramp

Diamond interchanges are common, and although drivers are familiar with them, they can still get confused and go the wrong way. In addition to signing and pavement markings for these interchanges, provide:

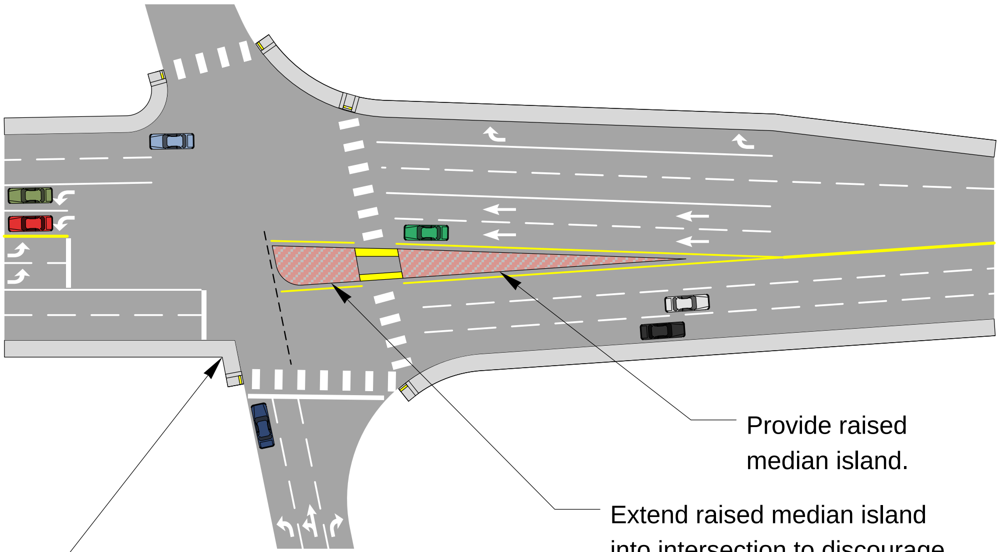
- Angular corners to discourage wrong-way right turns.

1310.02(10)(b)(3) Diamond Interchange With Advance Storage

Diamond interchanges with advance storage have left-turn storage lanes that extend from the on-ramp past the off-ramp (see Exhibit 1310-5). This allows for a potential early left turn onto the off-ramp. Following are additional countermeasures for interchanges with advanced left-turn storage:

- Provide a raised median to discourage the wrong-way left turn.
- Provide signing and directional arrows to direct traffic to the correct left-turn point.

Exhibit 1310-5 Diamond Interchange with Advance Storage



1310.02(10)(b)(4) Two-Way Ramps

Two-way ramps have the on- and off-ramp adjacent to each other. They are used at partial cloverleaf, trumpet, and button hook interchanges. Because the on and off roadways are close to each other, they are more vulnerable to wrong-way driving. Also, when the separation between on and off traffic is striping only, the ramps are susceptible to drivers entering the correct roadway and inadvertently crossing to the wrong ramp. In addition to signing and delineation, the following are countermeasures for two-way ramps:

- Separate the on- and off-ramp terminals.
- Reduce off-ramp terminal throat width.
- Increase on-ramp terminal throat width.
- Maintain intersection balance.
- Improve on-ramp visibility.
- Provide a raised median or dual-faced curb from the ramp terminal intersection to the gore nose.

1310.02(10)(b)(5) HOV Direct Access Ramps

HOV direct access ramps are two-way ramps in the median; therefore, the ability to provide separation between the on and off traffic is limited by the width of the median. An additional concern is that HOV direct access ramps are left-side ramps. Drivers normally enter the freeway using a right-side ramp and they may mistakenly travel the wrong way on a left-side ramp. Review existing and proposed signing for inadvertent misdirection. (See Chapter 1420 for HOV direct access and countermeasures for wrong-way driving at HOV direct access ramps.)

1310.02(10)(b)(6) Multilane Divided Roadways

Wrong-way driving can also occur on multilane divided nonfreeway facilities. Wrong-way drivers may enter multilane divided facilities at driveways and at-grade intersections. Countermeasures for wrong-way driving on nonfreeway multilane divided highways include:

- Wrong-way signing and delineation at the intersections.
- Right-in/right-out road approaches.

1310.03 Design Elements

When designing an intersection, identify and address the needs of all intersection users.

If pedestrian facilities are present, the design objective becomes one of reducing the potential for vehicle/pedestrian conflicts. This is done by minimizing pedestrian crossing distances and controlling the speeds of turning vehicles. Pedestrian refuge islands can be beneficial. They minimize the pedestrian 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. Use turn simulation software (such as AutoTURN®) to verify the design.

Channelization, the separation or regulation of traffic movements into delineated paths of travel, can facilitate the orderly movement of pedestrians, bicycles, and vehicles. Channelization includes left-turn lanes, right-turn lanes, speed change lanes (both acceleration and deceleration lanes), and islands.

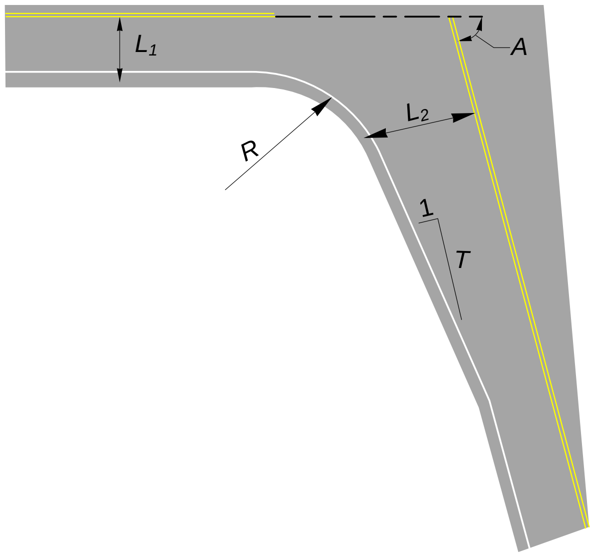
1310.03(1) Right-Turn Corners

Exhibit 1310-6 shows initial ranges for right-turn corner designs using a simple curve with a taper. These are considered approximate pavement areas to accommodate the design vehicles without encroachment on the adjacent lane at either leg of the curve.

Depending on the context of the roadway and right-turn corner (and whether the right-turn corner will be designed for or will accommodate a design vehicle), there may be several design considerations. Consider 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.

Other design considerations may include a combination of simple or compound curves, tapers at the beginning or end of the turn, and so on. Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

Exhibit 1310-6 Initial Ranges for Right-Turn Corner (Simple Curve-Taper)



L_1 = Available roadway width [2] that the vehicle is turning from

L_2 = Available roadway width [2] for the vehicle leaving the intersection

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 [2]*	*T*
P	All	30	11	11	25
SU-30 & CITY-BUS	All	50	11	11	25
WB-40	All	55	11	15	7.5
WB-67	All	50-85	11	22-24	7

Notes:

[1] When available roadway width is less than 11 ft, widen at 25:1.

[2] Available roadway width includes the shoulder, less a 2-ft clearance to a curb, and all the same-direction lanes of the exit leg at signalized intersections.

General:

All distances given in feet and angles in degrees

1310.03(2) Left-Turn Lanes and Turn Radii

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 1310.03(4) for a discussion on speed change lanes.)

Design left-turn channelization to provide sufficient operational flexibility to function under peak loads and adverse conditions.

1310.03(2)(a) One-Way Left-Turn Lanes

One-way left-turn lanes are separate storage lanes for vehicles turning left from one roadway onto another. One-way left-turn lanes may be an economical way to lessen delays and crash potential involving left-turning vehicles. In addition, they can allow deceleration clear of the through traffic lanes. Provide a minimum storage length of 100 feet for one-way left-turn lanes. When evaluating left-turn lanes, include impacts to all intersection movements and users.

At signalized intersections, use a traffic signal analysis to determine whether a left-turn lane is needed and the storage length. If the length determined is less than the 100-foot minimum, make it 100 feet (see Chapter 1330).

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 congestion reduction with a left-turn lane. On two-lane highways, use Exhibit 1310-7a, based on total traffic volume (DHV) for both directions and percent left- turn traffic, to determine whether further investigation is needed. On four-lane highways, use Exhibit 1310-7b to determine whether a left-turn lane is recommended.
- A study indicates crash reduction with a left-turn lane.
- Restrictive geometrics require left-turning vehicles to slow greatly below the speed of the through traffic.
- There is less than decision sight distance for traffic approaching a vehicle stopped at the intersection to make a left turn.

A traffic analysis based on the *Highway Capacity Manual* (HCM) may also be used to determine whether left-turn lanes are needed to maintain the desired level of service.

Exhibit 1310-7a Left-Turn Storage Guidelines: Two-Lane, Unsignalized

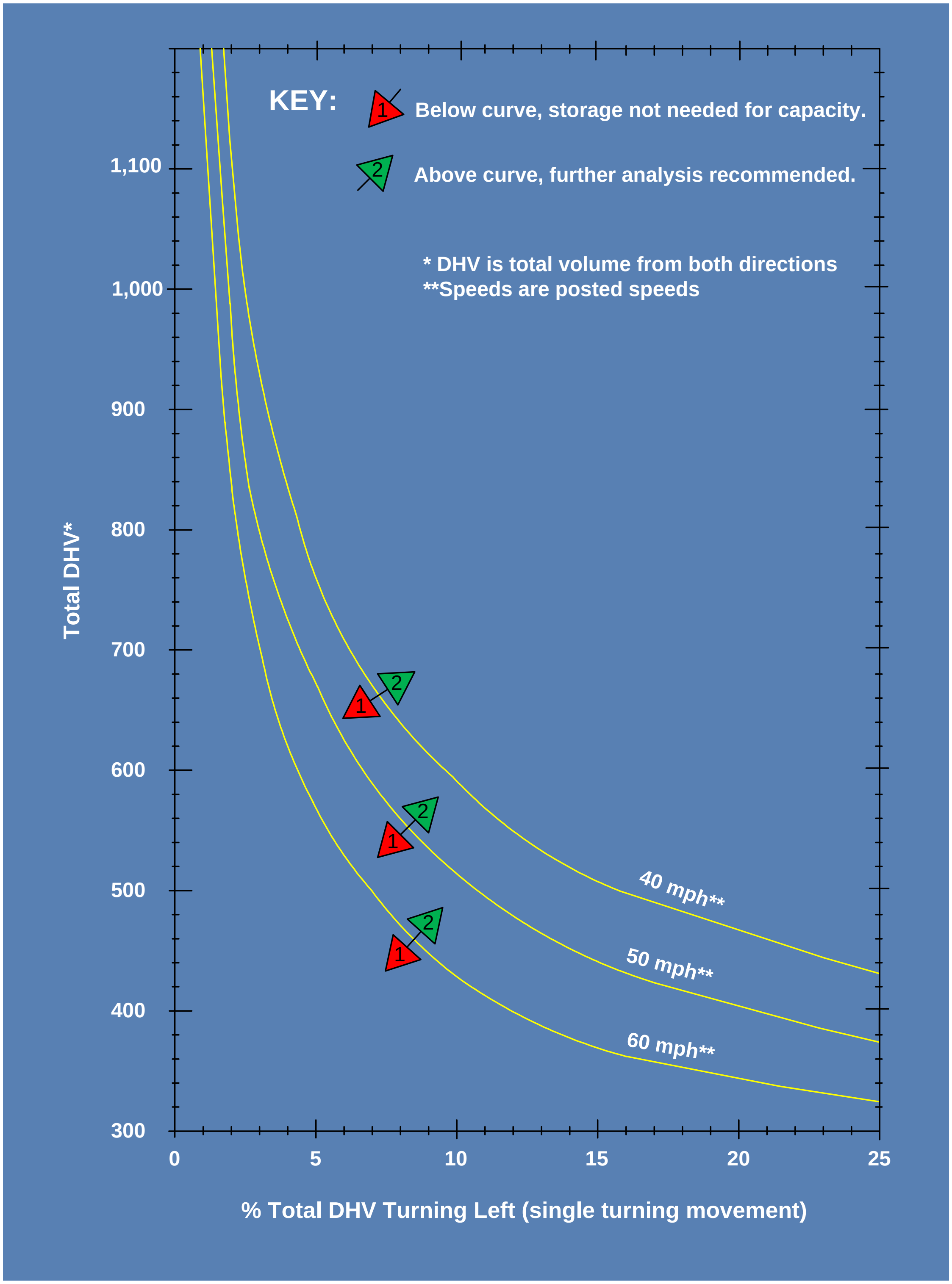
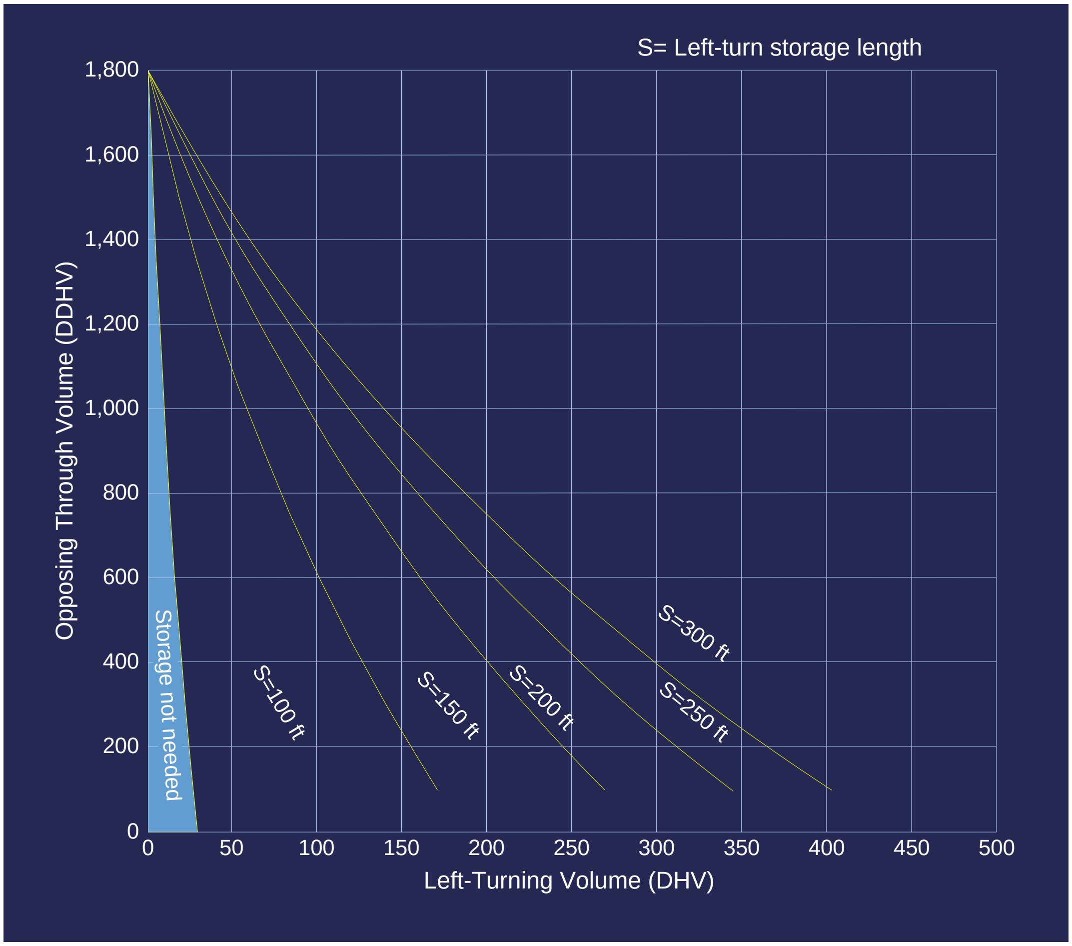


Exhibit 1310-7b Left-Turn Storage Guidelines: Four-Lane, Unsignalized



Determine the storage length on two-lane highways by using Exhibits 1310-8a through 8c. On four-lane highways, use Exhibit 1310-7b. These lengths do not consider trucks. Use Exhibit 1310-9 for storage length when trucks are present.

Use turn simulation software (such as AutoTURN®) to verify that left-turn movements for the design vehicle(s) do not have conflicts. Design opposing left-turn design vehicle paths with a minimum 4-foot (12-foot desirable) clearance between opposing turning paths.

Where one-way left-turn channelization with curbing is to be provided, evaluate surface water runoff and design additional drainage facilities if needed to control the runoff.

Provide illumination at left-turn lanes in accordance with the guidelines in Chapter 1040.

Exhibit 1310-8a Left-Turn Storage Length: Two-Lane, Unsignalized (40mph)

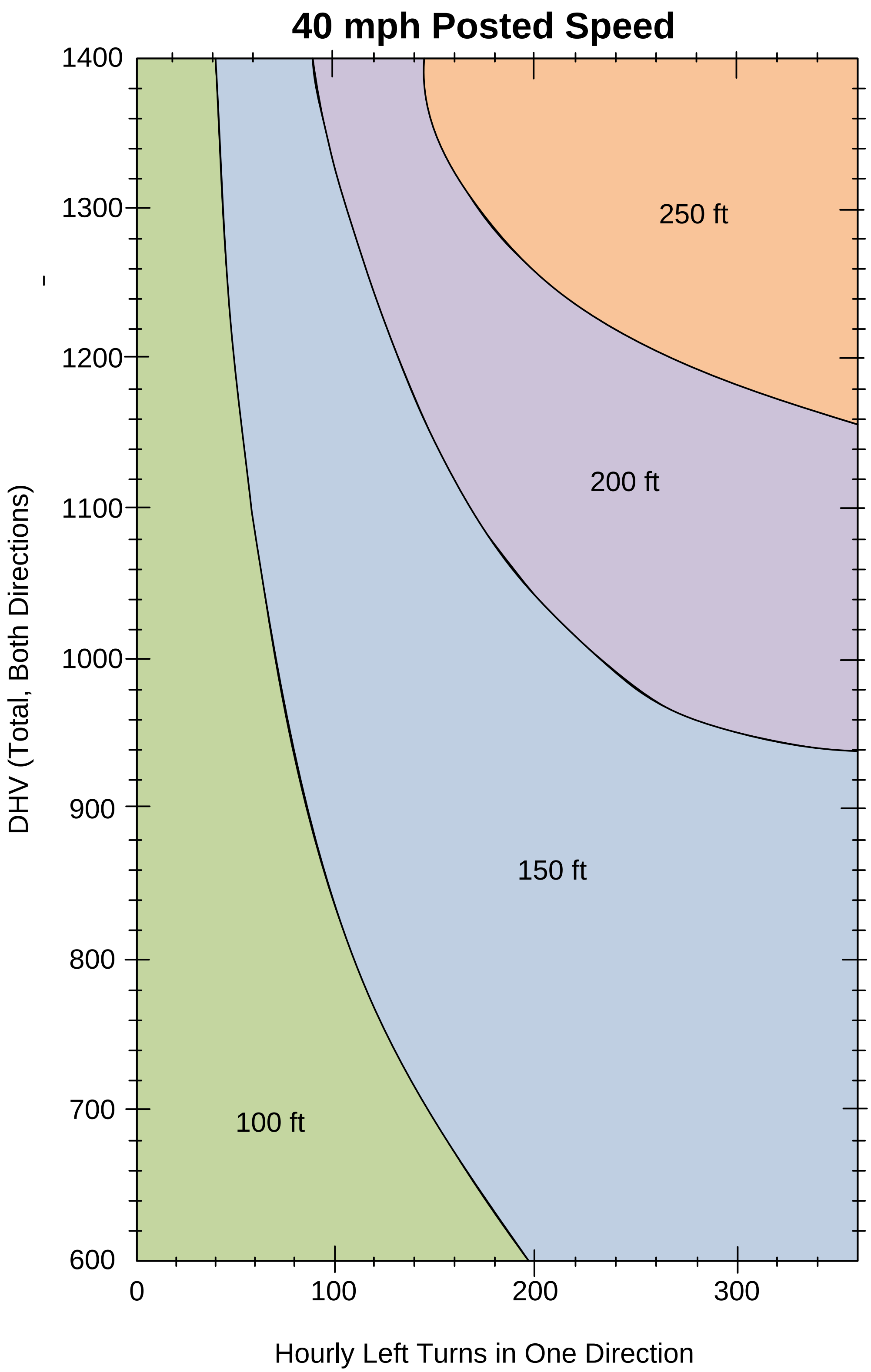


Exhibit 1310-8b Left-Turn Storage Length: Two-Lane, Unsignalized (50 mph)

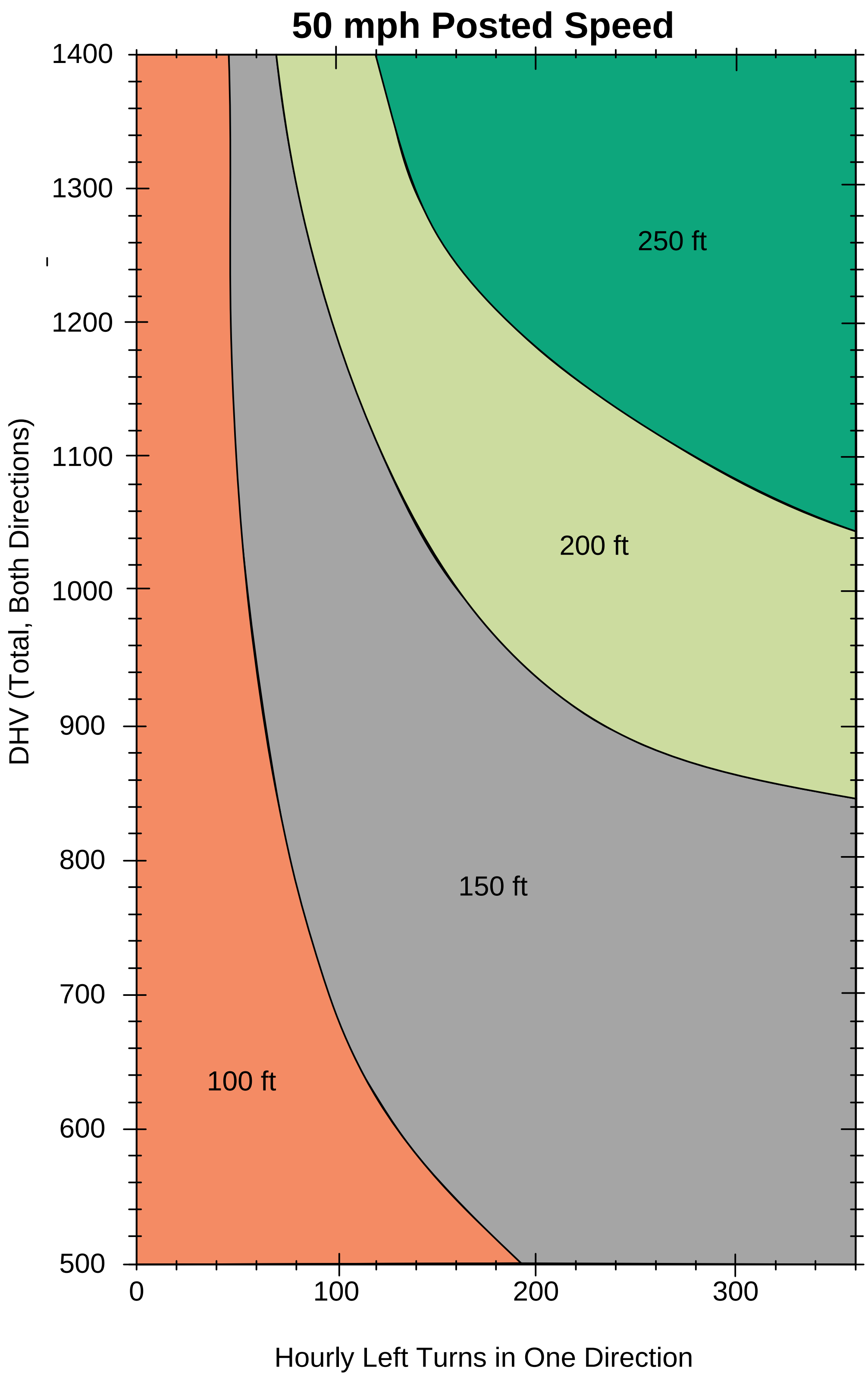


Exhibit 1310-8c Left-Turn Storage Length: Two-Lane, Unsignalized (60 mph)

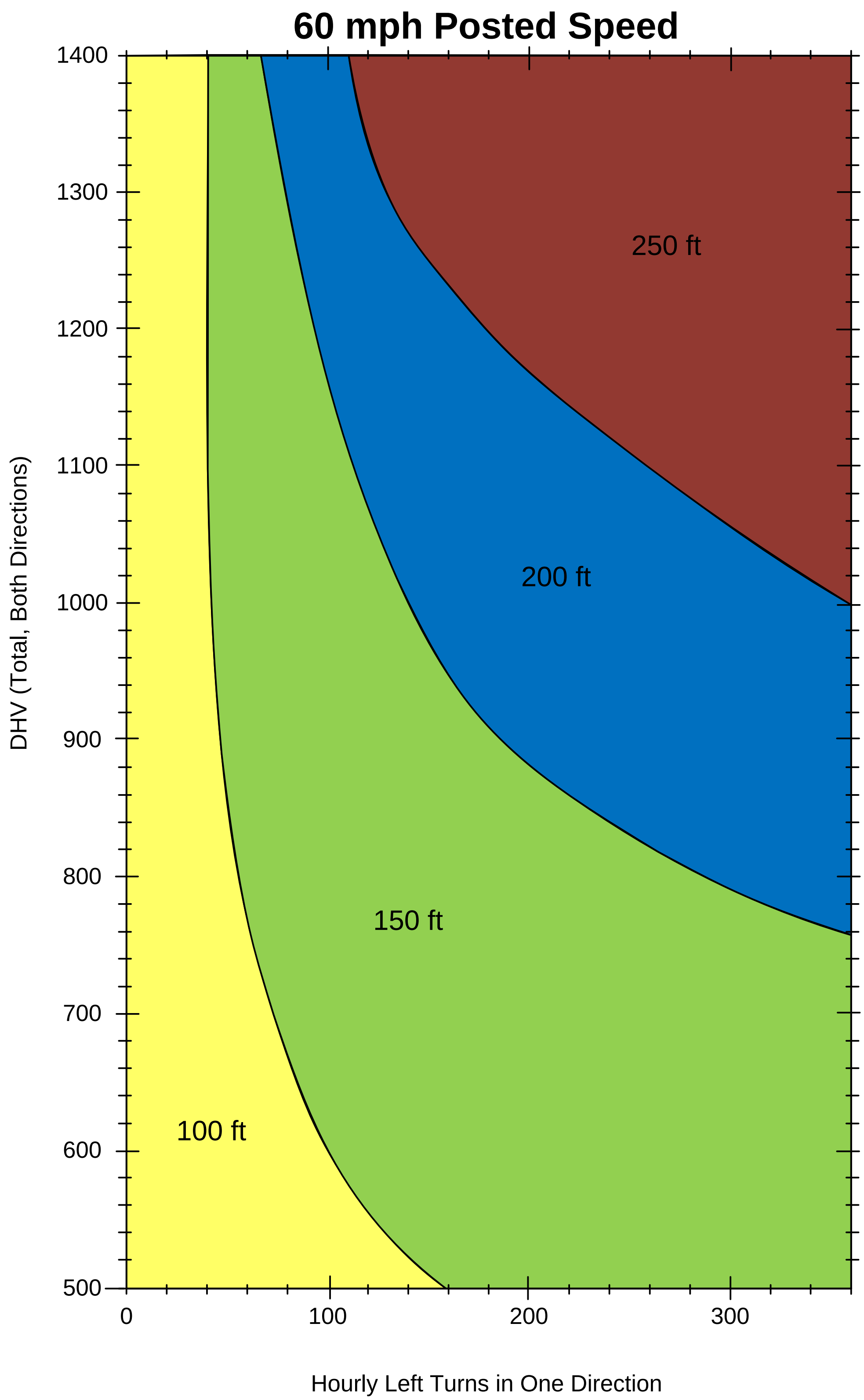


Exhibit 1310-9 Left-Turn Storage with Trucks (ft)

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 Exhibits 1310-7b and 1310-8a, 8b, or 8c.

At signalized intersections with high left-turn volumes, double (or triple) left-turn lanes may be needed to maintain the desired level of service. For a double left-turn, 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 turn simulation software (such as AutoTURN®) to verify that the design vehicle can complete the turn. Where the design vehicle is a WB 40 or larger, it is desirable to provide for the design vehicle in the outside lane and an SU-30 vehicle turning abreast rather than two design vehicles turning abreast.

Exhibits 1310-10a through 10f show left-turn lane geometrics, which are described as follows:

1310.03(2)(a)(1) Widening

It is desirable that offsets and pavement widening (see Exhibit 1310-10a) be symmetrical about the centerline or baseline. Where right of way or topographic restrictions, crossroad alignments, or other circumstances preclude symmetrical widening, pavement widening may be on one side only.

1310.03(2)(a)(2) Divided Highways

Widening is not needed for left-turn lane channelization where medians are 11 feet wide or wider (see Exhibits 1310-10b through 10d). 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 (see Exhibit 1310-10b) to improve sight distance and increase opposing left-turn clearances.

A median acceleration lane (see Exhibits 1310-10c and 10d) may be provided where the median is 23 feet or wider. The median acceleration lane might not be needed at a signalized intersection. When a median acceleration lane is to be used, design it in accordance with 1310.03(4), Speed Change Lanes. Where medians have sufficient width, provide a 2-foot shoulder adjacent to a left-turn lane.

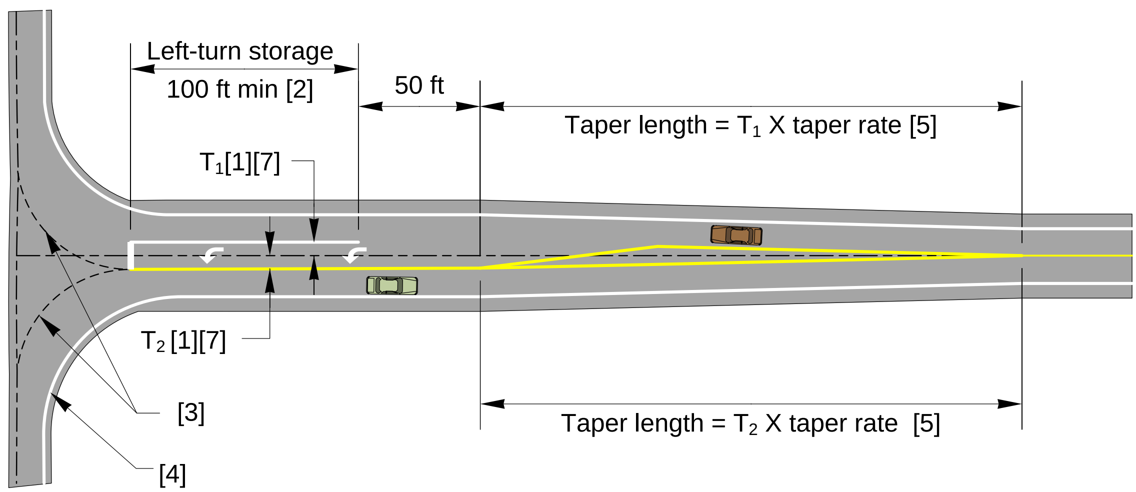
1310.03(2)(a)(3) Minimum Protected Left Turn With a Median

At intersections on divided highways where channelized left-turn lanes are not provided, provide the minimum protected storage area (see Exhibit 1310-10e).

1310.03(2)(a)(4) Modifications to Left-Turn Designs

The left-turn lane designs discussed above and given in Exhibits 1310-10a through 10e may be modified when determined by design element dimensioning (see Chapter 1106.) 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. Provide a modified design that is able to accommodate the design vehicle, and provide for the striping (see the *Standard Plans* and the MUTCD). Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®); include a plot of the design and verification.

Exhibit 1310-10a Median Channelization: Widening



Notes:

[1] The minimum width of the left-turn storage lane (T1+T2) is 11 ft.

[2] For left-turn storage length, see Exhibits 1310-7b for 4-lane roadways or 1310-8a through 8c for 2-lane roadways.

[3] Use turn simulation software (such as AutoTURN®) to verify the design vehicle can make the turn.

[4] For right-turn corner design, see Exhibit 1310-6.

[5] For desirable taper rates, see Table on this Exhibit. With justification, taper rates from the Table in Exhibit 1310-10c may be used.

[6] For pavement marking details, see the *Standard Plans* and the MUTCD.

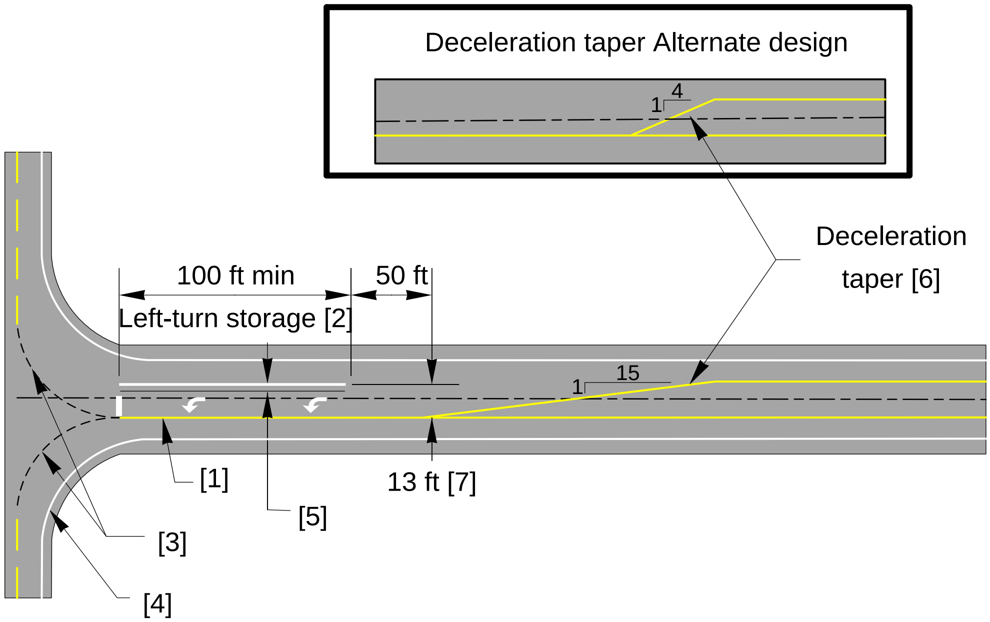
[7] Where curb is provided, add the width of the curb and the shoulders to the left-turn lane width. For shoulder widths at curbs, see 1310.03(6) and Chapter 1230.

T_1 = Width of left-turn lane on approach side of centerline

T_2 = Width of left-turn lane on departure side of centerline

Posted Speed	Desirable Taper Rate [6]
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

Exhibit 1310-10b Median Channelization: Median Width 11 ft or More



Notes:

[1] Where curb is provided, add the width of the curb and the shoulders. For shoulder widths at curbs, see 1310.03(6) and Chapter 1230.

[2] For left-turn storage length, see Exhibits 1310-7b for 4-lane roadways or 1310-8a through 8c for 2-lane roadways.

[3] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[4] For right-turn corner design, see Exhibit 1310-6.

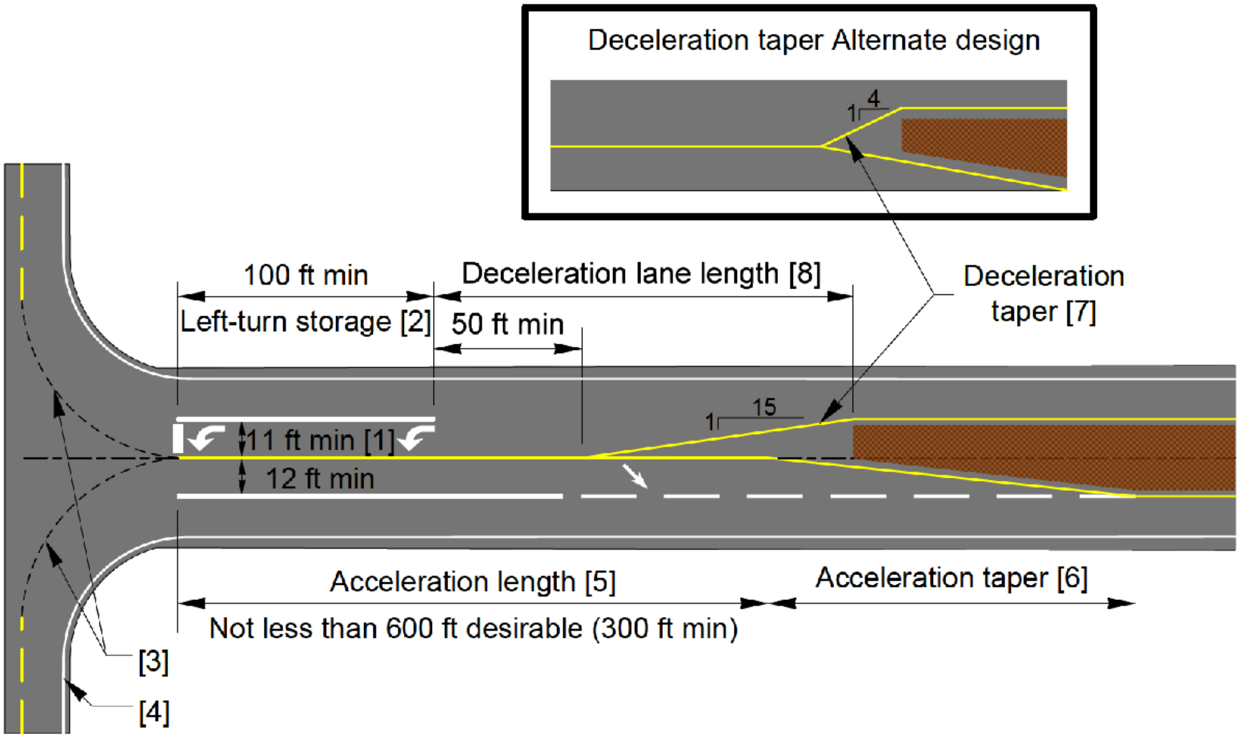
[5] For median widths greater than 13 ft, it is desirable to locate the left-turn lane adjacent to the opposing through lane with excess median width between the same-direction through lane and the turn lane.

[6] For increased storage capacity, the left-turn deceleration taper alternate design may be used.

[7] Reduce to lane width for medians less than 13 ft wide.

General:
For pavement marking details, see the *Standard Plans* and the MUTCD.

Exhibit 1310-10c Median Channelization: Median Width 23 ft to 26 ft



Notes:

[1] When curb is provided, add the width of the curb.

[2] For left-turn storage length, see Exhibits 1310 7b
for 4-lane roadways or 1310-8a through 8c for 2-lane roadways.

[3] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[4] For right-turn corner design, see Exhibit 1310 6.

[5] The minimum total length of the median acceleration lane is shown in Exhibit 1310-14.

[6] For acceleration taper rate, see Table on this exhibit.

[7] For increased storage capacity, the left-turn deceleration taper alternate design may be used.

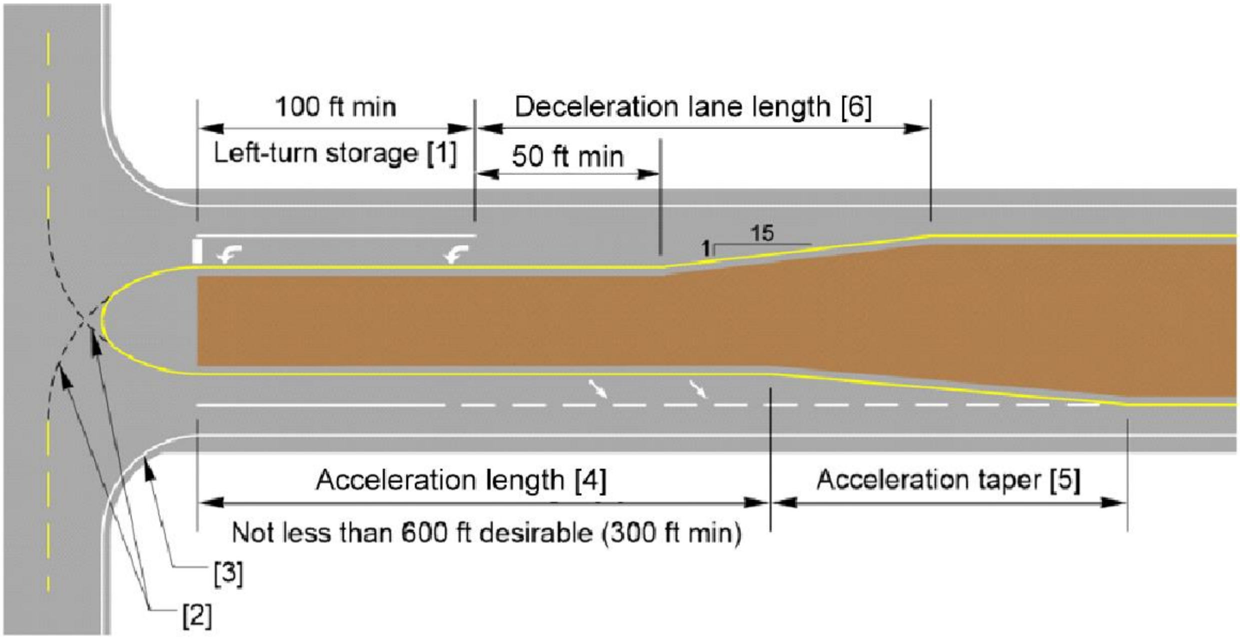
[8] The desirable length of the left-turn deceleration lane including taper is shown in Exhibit 1310-13.

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

General:

For pavement marking details, see the *Standard Plans* and the MUTCD.

Exhibit 1310-10d Median Channelization: Median Width of More Than 26 ft



Notes:

[1] For left-turn storage length, see Exhibits 1310-7b for 4-lane roadways or 1310-8a through 8c for 2 lane roadways.

[2] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[3] For right-turn corner design, see Exhibit 1310-6.

[4] The minimum length of the median acceleration lane is shown in Exhibit 1310-14.

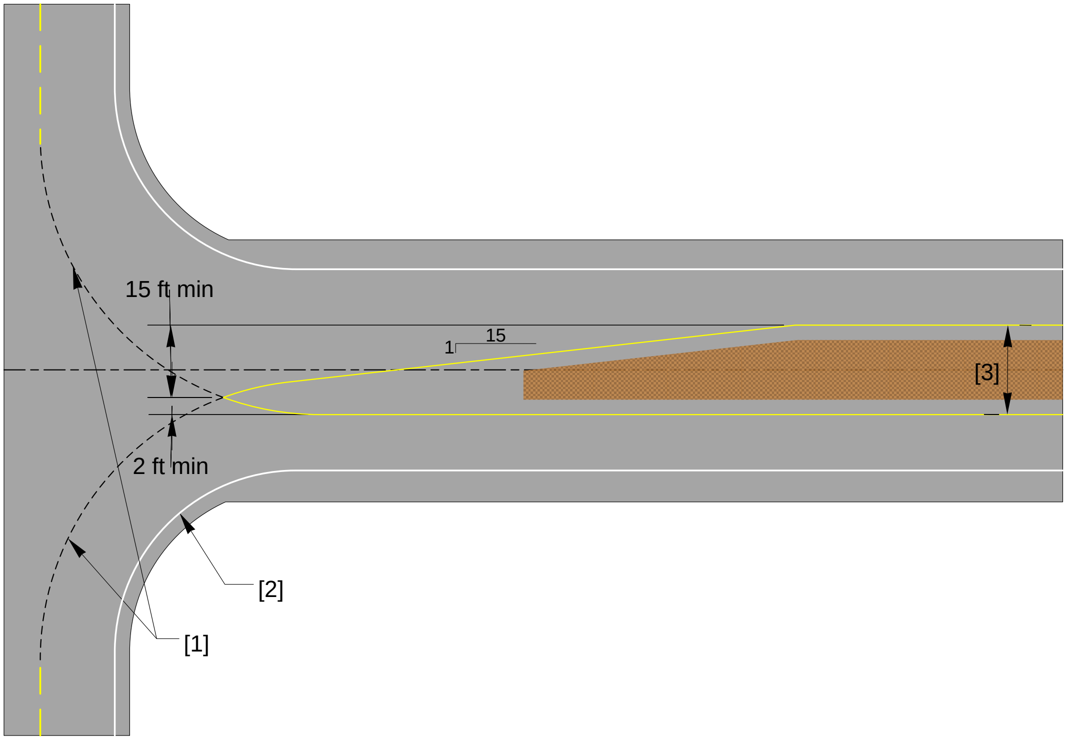
[5] For acceleration taper rate, see the Table on Exhibit 1310-10c.

[6] The desirable length of the left-turn deceleration lane including taper is shown in Exhibit 1310-13.

General:

For pavement marking details, see the *Standard Plans* and the MUTCD.

Exhibit 1310-10e Median Channelization: Minimum Protected Storage



Notes:

[1] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[2] For right-turn corner design, see Exhibit 1310-6.

[3] For median width 17 ft or more. For median width less than 17 ft, widen to 17 ft. or use Exhibit 1310-10b.

General:

For pavement marking details, see the *Standard Plans* and the MUTCD.

1310.03(2)(b) Two-Way Left-Turn Lanes (TWLTL)

Two-way left-turn lanes are located between opposing lanes of traffic. They are used by vehicles making left turns from either direction, from or onto the roadway.

Use TWLTLs only on managed access highways where there are no more than two through lanes in each direction. Evaluate installation of TWLTLs where:

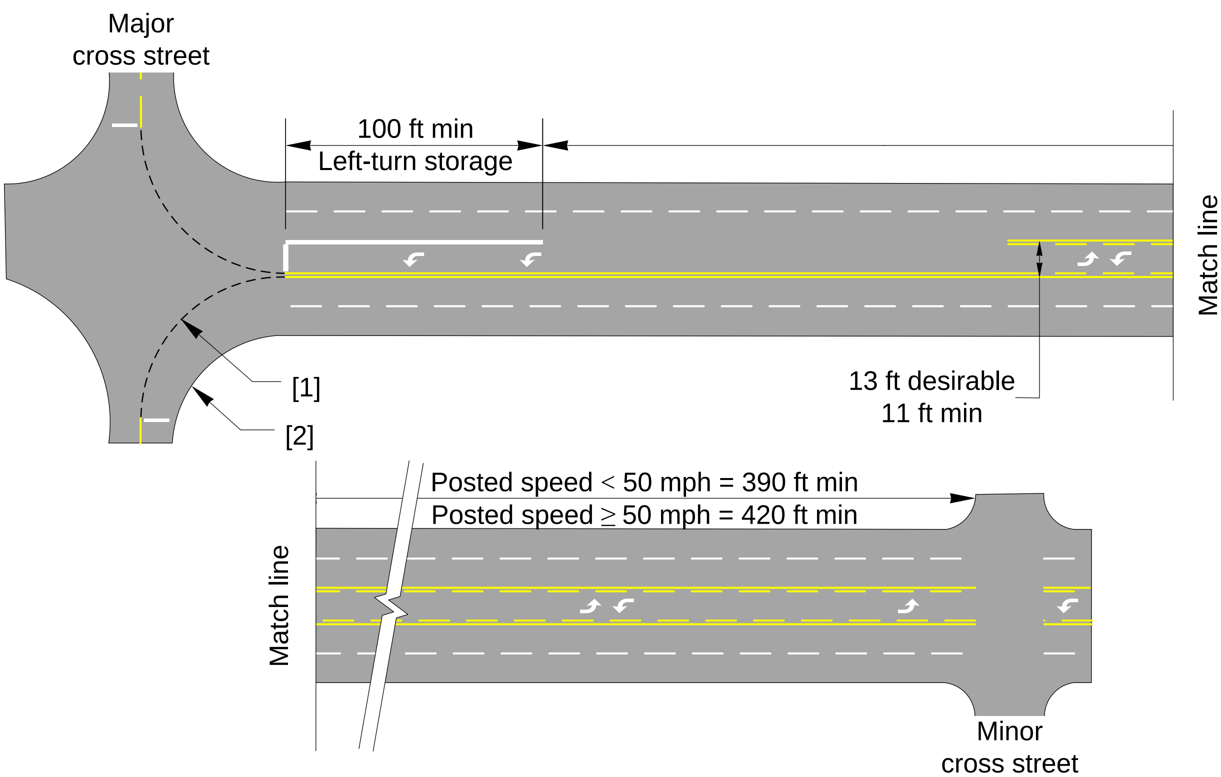
- A crash study indicates reduced crashes with a TWLTL.
- There are existing closely spaced access points or minor street intersections.
- There are unacceptable through traffic delays or capacity reductions because of left-turning vehicles.

TWLTLs can reduce delays to through traffic, reduce rear-end crashes, and provide separation between opposing lanes of traffic. However, they do not provide refuge for pedestrians and can encourage strip development with additional closely spaced access points. Evaluate other alternatives (such as prohibiting midblock left turns and providing for U-turns) before using a TWLTL. (See Chapter 540 for additional restrictions on the use of TWLTLs, and Chapter 1230 for discussion of road diets, which commonly employ a center turn lane.)

The basic design for a TWLTL is illustrated in Exhibit 1310-10f. Additional criteria are as follows:

- The desirable length of a TWLTL is not less than 250 feet.
- Provide illumination in accordance with the guidelines in Chapter 1040.
- 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 TWLTLs to one-way left-turn lanes at an intersection.

Exhibit 1310-10f Median Channelization: Two-Way Left-Turn Lane



Notes:

[1] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[2] For right-turn corner design, see Exhibit 1310-6.

General:

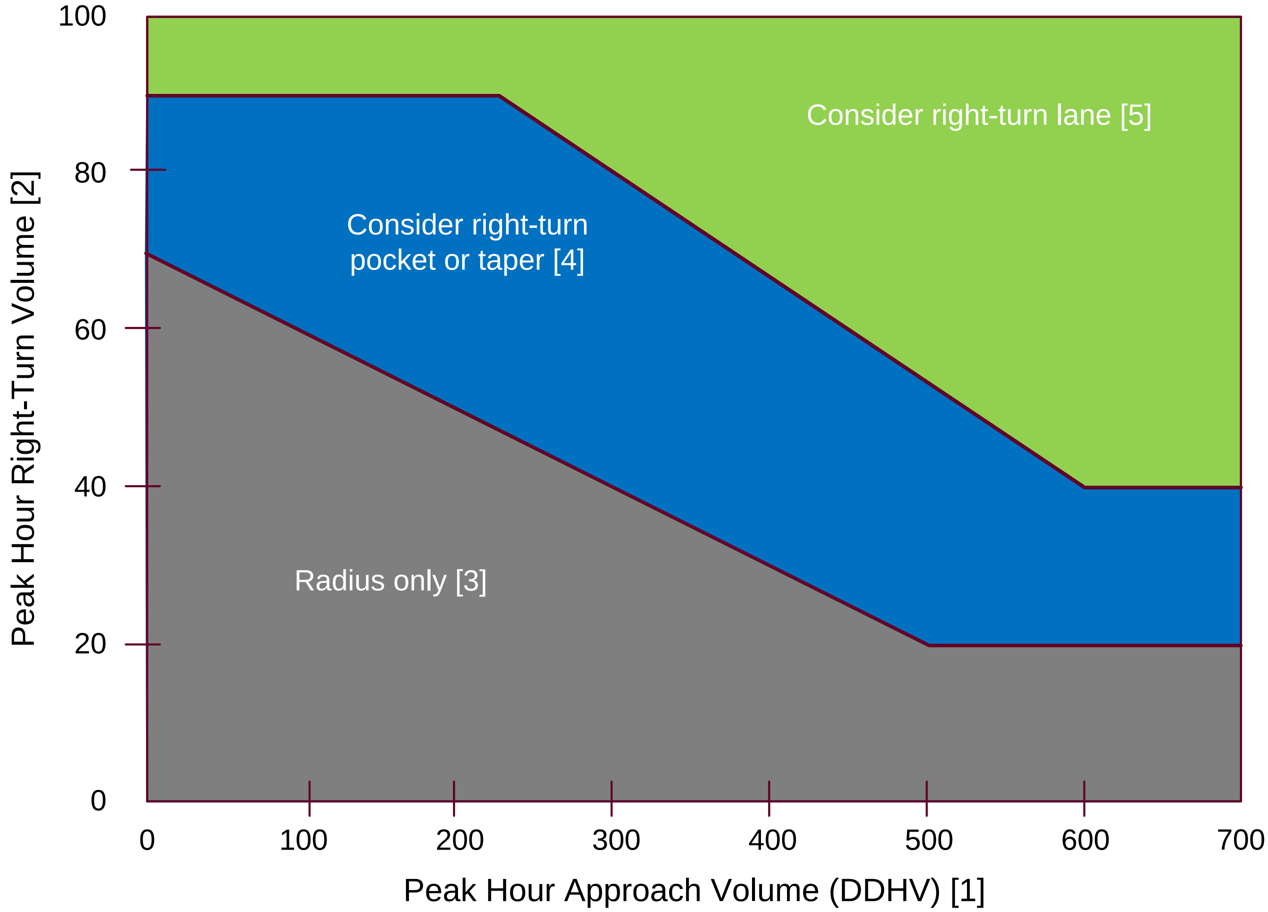
For pavement marking details and signing criteria, see the *Standard Plans* and the MUTCD.

1310.03(3) Right-Turn 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 to determine when to consider right-turn lanes at unsignalized intersections:

- For two-lane roadways and for multilane roadways with a posted speed of 45 mph or above, when recommended by Exhibit 1310-11.
- A crash study indicates an overall crash reduction with a right-turn lane.
- The presence of pedestrians requires right-turning vehicles to stop.
- Restrictive geometrics require right-turning vehicles to slow greatly below the speed of the through traffic.
- There is less than decision sight distance for traffic approaching the intersection.
- For unsignalized intersections, see 1310.03(4) for guidance on right-turn lane lengths. For signalized intersections, use a traffic signal analysis to determine whether a right-turn lane is needed and what the length is (see Chapter 1330).
- A capacity analysis may be used to determine whether right-turn lanes are needed to maintain the desired level of service.
- Where adequate right of way exists, providing right-turn lanes is relatively inexpensive and can provide increased operational efficiency.
- The right-turn pocket or the right-turn taper (see Exhibit 1310-12) may be used at any minor intersection where a right-turn lane is not provided. These designs reduce interference and delay to the through movement by offering an earlier exit to right-turning vehicles.
- If the right-turn pocket is used, Exhibit 1310-12 shows taper lengths for various posted speeds.

Exhibit 1310-11 Right-Turn Lane Guidelines



Notes:

[1] For two-lane highways, use the peak hour DDHV (through + right-turn).
For multilane, 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:

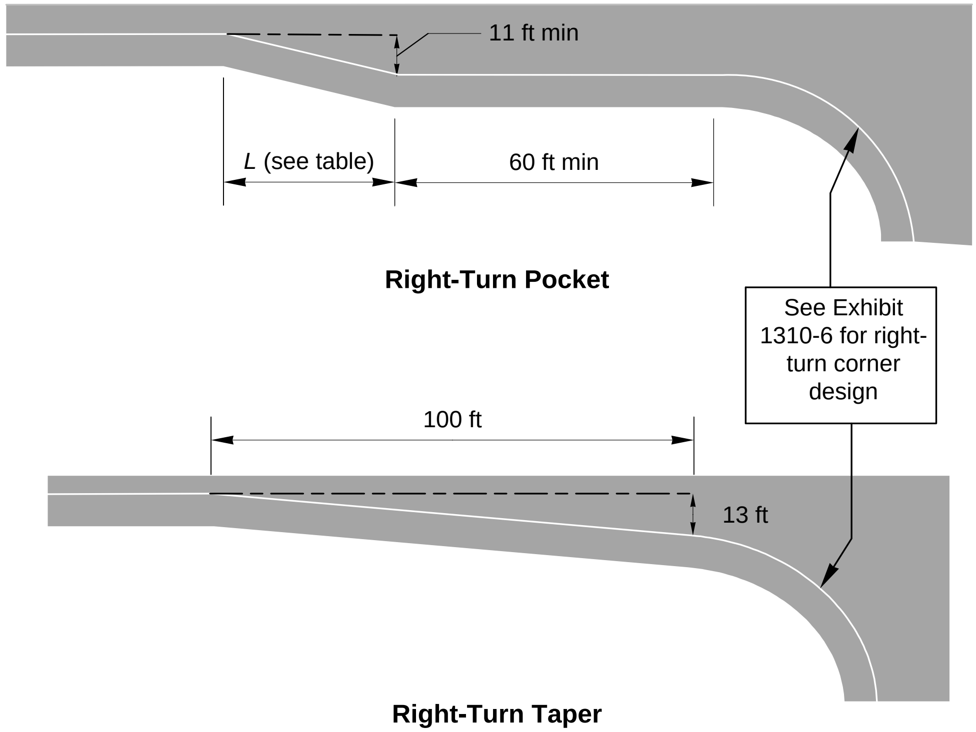
- The posted speed is 45 mph or below
- The right-turn volume is greater than 40 VPH
- The peak hour approach volume (DDHV) is less than 300 VPH

[3] For right-turn corner design, see Exhibit 1310-6.

[4] For right-turn pocket or taper design, see Exhibit 1310-12.

[5] For right-turn lane design, see Exhibit 1310-13.

Exhibit 1310-12 Right-Turn Pocket and Right-Turn Taper



Posted Speed Limit	*L*
Below 40 mph	40 ft
40 mph or above	100 ft

1310.03(4) Speed Change Lanes

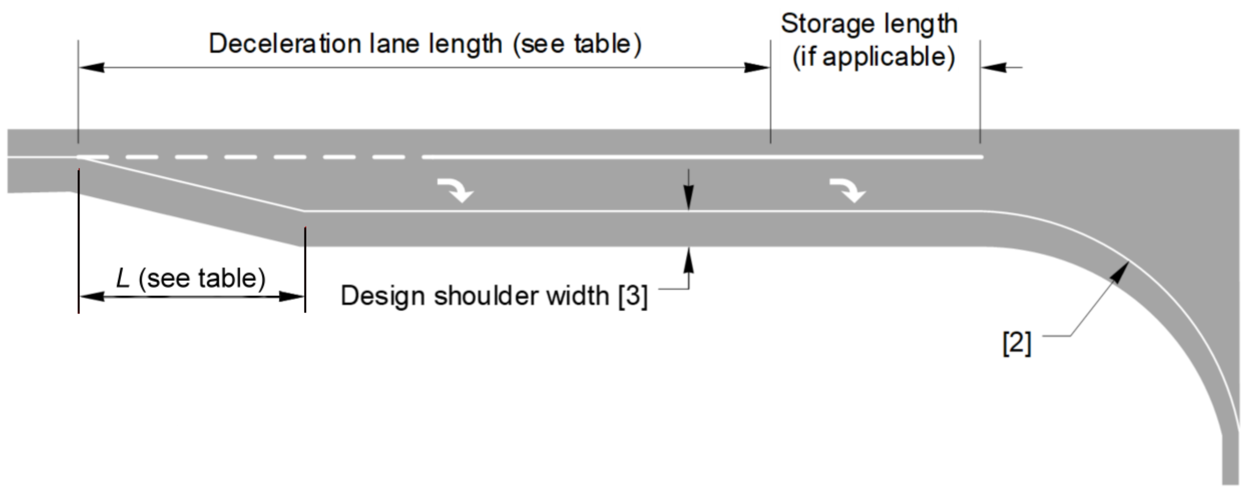
A speed change lane is an auxiliary lane primarily for the acceleration or deceleration of vehicles entering or leaving the through traveled way. Speed change lanes are normally provided for at-grade intersections on multilane divided highways with access control. Where roadside conditions and right of way allow, speed change lanes may be provided on other through roadways. Justification for a speed change lane depends on many factors, including speed; traffic volumes; capacity; type of highway; design and frequency of intersections and crash history

When either deceleration or acceleration lanes are to be used, design them in accordance with Exhibits 1310-13 and 1310-14. When the design speed of the turning traffic is greater than 20 mph, design the speed change lane as a ramp in accordance with Chapter 1360. When a deceleration lane is used with a left-turn lane, add the deceleration length to the storage length.

A dedicated deceleration lane (see Exhibit 1310-13) is advantageous because it removes slowing vehicles from the through lane.

An acceleration lane (see Exhibit 1310-14) is not as advantageous because entering drivers can wait for an opportunity to merge without disrupting through traffic. However, acceleration lanes for left-turning vehicles provide a benefit by allowing the turn to be made in two movements.

Exhibit 1310-13 Right-Turn Lane



Highway Design Speed (mph)	Deceleration Lane Length (ft)
30	160 [1]
35	220
40	275
45	350
50	425
55	515
60	605
65	715
70	820

Minimum Deceleration Lane Length (ft)

Posted Speed Limit	*L*
Below 40 mph	40 ft
40 mph or above	100 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] When adjusting for grade, do not reduce the deceleration lane to less than 150 ft.

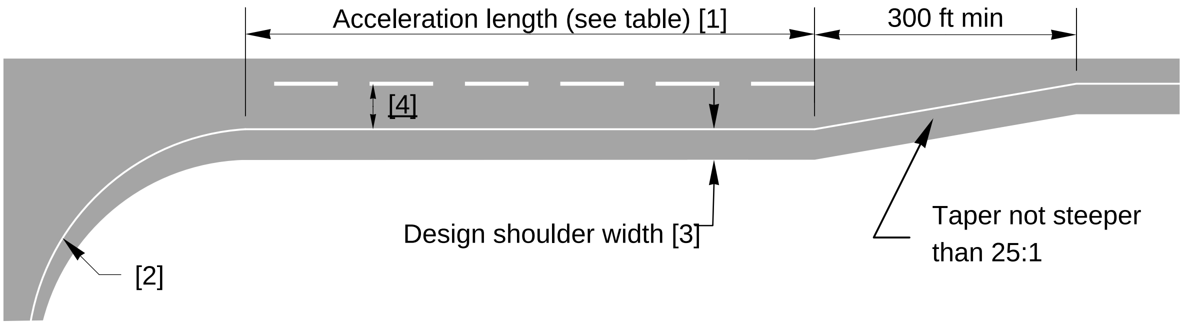
[2] For right-turn corner design, see Exhibit 1310-6.

[3] See 1310.03(6) and Chapter 1230.

General:

For pavement marking details, see the *Standard Plans* and the MUTCD.

Exhibit 1310-14 Acceleration Lane



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	1,200	1,140	1,100
65	1,410	1,350	1,310
70	1,620	1,560	1,520

Minimum Acceleration 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] For right-turn corner design, see Exhibit 1310-6.

[3] See 1310.03(6) and Chapter 1230.

[4] Lane width as determined by Chapters 1106 and 1230.

General:

For pavement-marking details, see the *Standard Plans* and the MUTCD.

1310.03(5) Drop Lanes

A lane may be dropped at an intersection with a turn-only lane or beyond the intersection. Do not allow a lane-reduction taper to cross an intersection or end less than 100 feet before an intersection. (See Chapter 1210 for lane reduction pavement transitions.)

When a lane is dropped beyond signalized intersections, provide a lane of sufficient length to allow smooth merging. For facilities with a posted speed of 45 mph or higher, use a minimum length of 1,500 feet. For facilities with a posted speed lower than 45 mph, provide a lane of sufficient length that the advanced lane reduction warning sign can be placed not less than 100 feet beyond the intersection area.

When a lane is dropped beyond unsignalized intersections, provide a lane beyond the intersection not less than the acceleration lane length from Exhibit 1310-14.

1310.03(6) Shoulders

Shoulder width is controlled by its intended functional use and its contribution to achieving the desired safety performance when balanced with other design elements. See Exhibit 1239-2 for functional uses and recommended shoulder widths.

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.

1310.03(7) 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 the following functions:

- Channelization islands control and direct traffic movements.
- Divisional islands separate traffic movements.
- Refuge islands provide refuge for pedestrians and bicyclists crossing the roadway.
- Islands can provide for the placement of traffic control devices and luminaires.
- Islands can provide areas within the roadway for landscaping.

1310.03(7)(a) Size and Shape

Divisional islands are normally elongated and at least 4 feet wide and 20 feet long.

Channelization islands are normally triangular. In rural areas, 75 ft2 is the minimum island area and 100 ft2 is desirable. In urban areas where posted speeds are 25 mph or below, smaller islands are acceptable. Use islands with at least 200 ft2 if pedestrians will be crossing or traffic control devices or luminaires will be installed.

Design triangular-shaped islands as shown in Exhibits 1310-15a 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 1240 for desirable turning roadway widths.)

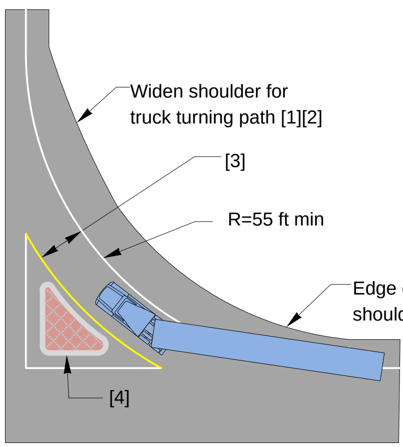
Island markings may be supplemented with reflective raised pavement markers.

Provide barrier-free access at crosswalk locations where raised islands are used. For pedestrian refuge islands and barrier-free access requirements, see Chapter 1510.

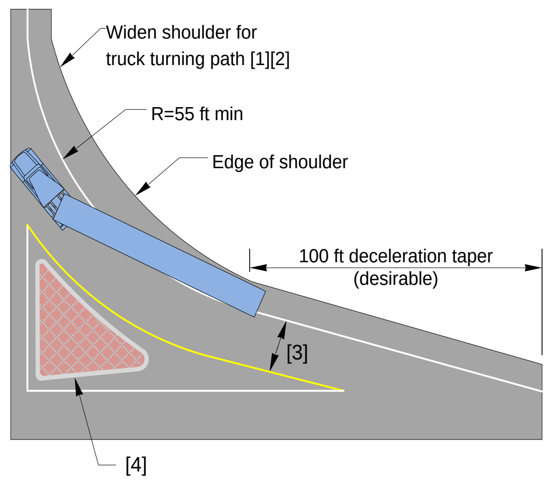
1310.03(7)(b) Location

Design the approach ends of islands so they are visible to motorists. 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 sight distance, illumination, or extension of the island.

Exhibit 1310-15a Traffic Island Designs



Small Traffic Island Design [5]



Large Traffic Island Design [5]

Notes:

[1] Widen shoulders when 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 turn simulation software (such as AutoTURN®) for the intersection design vehicle

[3] For turning roadway widths, see Chapter 1240.

[4] For additional details on island placement, see Exhibit 1310-15c.

[5] Small traffic islands have an area of 100 ft2 or less; large traffic islands have an area greater than 100 ft2.

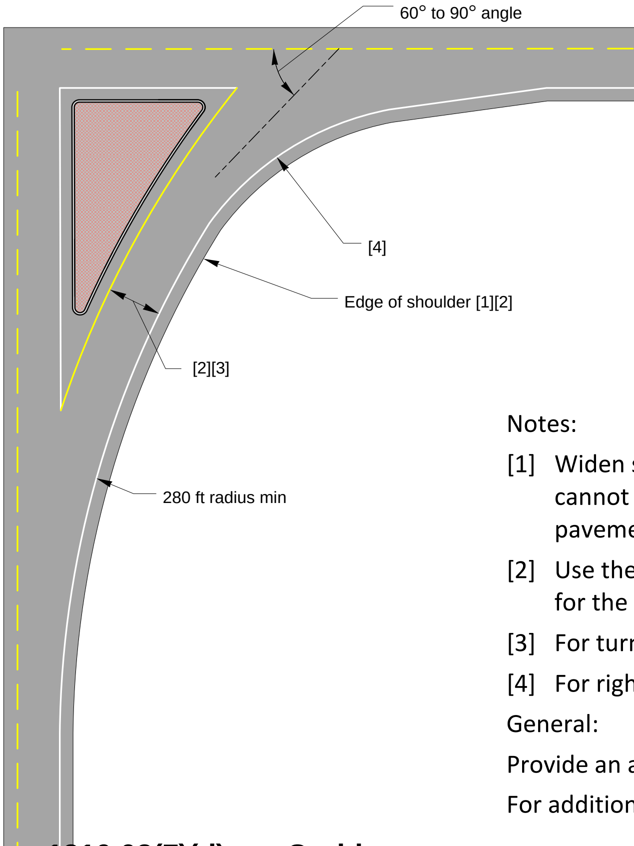
General:

- Provide an accessible route for pedestrians (see Chapter 1510).
- 60° to 90° angle at stop or yield control.
- For right-turn corner design, see Exhibit 1310-6.

1310.03(7)(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 (see Exhibit 1310-15b). This design forces the turning traffic to slow down.

Exhibit 1310-15b Traffic Island Designs: Compound Curve



Notes:

[1] Widen shoulders when 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 turn simulation software (such as AutoTURN®) for the intersection design vehicle.

[3] For turning roadway widths, see Chapter 1240.

[4] For right-turn corner design, see Exhibit 1310-6.

General:

Provide an accessible route for pedestrians (see Chapter 1510).

For additional details on island placement, see Exhibit 1310-15c.

1310.03(7)(d) Curbing

Provide vertical curb 6 inches or higher for:

- Islands with luminaires, signals, or other traffic control devices.
- Pedestrian refuge islands.

Also consider curbing for:

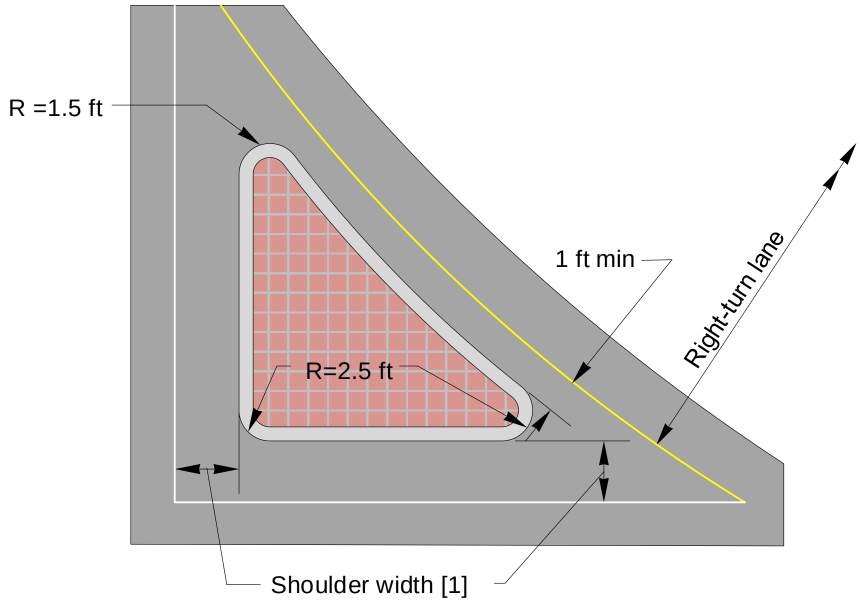
- Divisional and channelizing islands.
- Landscaped islands.
- Stormwater conveyance.

In general, except to meet one of the uses listed above, it is desirable not to use curbs on facilities with a posted speed of 45 mph or above.

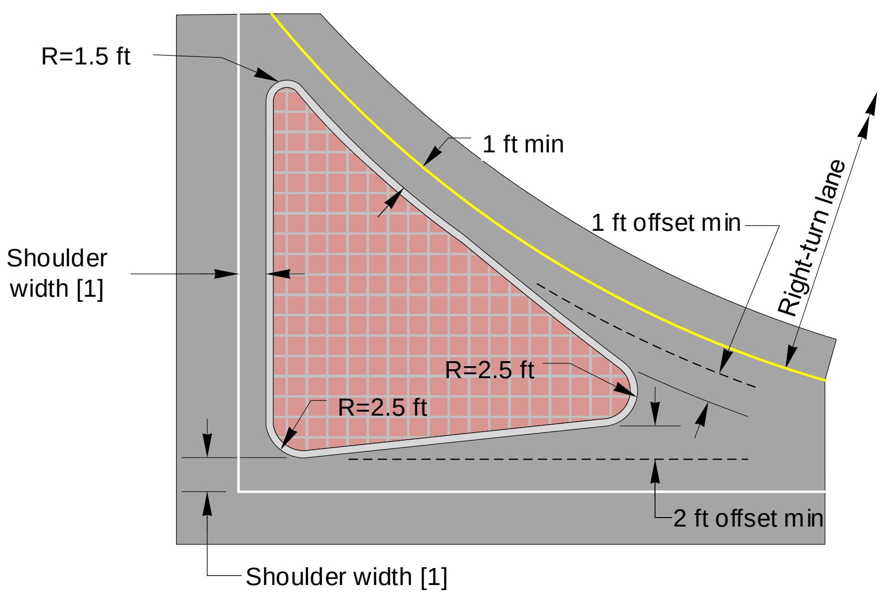
Avoid using curbs if the same objective can be attained with pavement markings.

Refer to Chapter 1230 for additional information and design criteria on the use of curbs.

Exhibit 1310-15c Traffic Island Designs



Small Raised Traffic Island [2]



Large Raised Traffic Island [2]

Notes:

[1] For shoulder width at curbs, see Chapter 1230. For additional information on shoulders at turn lanes, see 1310.03(6).

[2] Small traffic islands have an area of 100 ft2 or less; large traffic islands have an area greater than 100 ft2.

General:

Provide an accessible route for pedestrians (see Chapter 1510).

1310.03(8) U-Turns

For divided multilane highways without full access control that have access points where the median prevents left turns, evaluate the demand for locations that allow U turns. Normally, U turn opportunities are provided at intersections. However, where intersections are spaced far apart, U-turn median openings may be provided between intersections to accommodate U-turns. Use the desirable U-turn spacing (see Exhibit 1310-16) as a guide to determine when to provide U-turn median openings between intersections. Where the U-turning volumes are low, longer spacing may be used.

Locate U-turn median openings where intersection sight distance can be provided.

Exhibit 1310-16 U-Turn Spacing

Urban/Rural	Desirable	Minimum
Urban [1]	1,000 ft	[2]
Suburban	½ mile	¼ mile [3]
Rural	1 mile	½ mile

Notes:

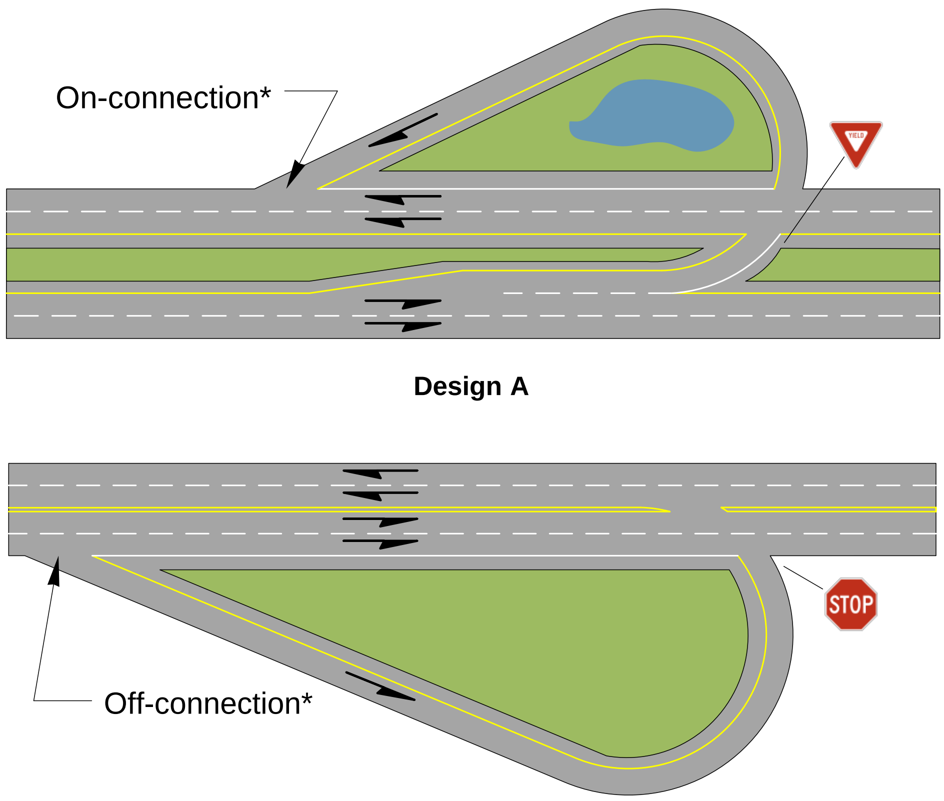
[1] For design speeds higher than 45 mph, use suburban spacing.

[2] The minimum spacing is the acceleration lane length from a stop (see Exhibit 1310-14) plus 300 ft.

[3] For design speeds 60 mph or higher, the minimum spacing is the acceleration lane length from a stop (see Exhibit 1310-14) plus 300 ft.

When designing U-turn median openings, use Exhibit 1310-18 as a guide. Where the median is less than 40 feet wide, with a large design vehicle, provide a U-turn roadway (see Exhibit 1310-17). Design A, with the U-turn roadway after the left-turn, is desirable. Use Design A when the median can accommodate a left-turn lane. Use Design B only where left-turn channelization cannot be built in the median.

Exhibit 1310-17 U-Turn Roadway



Design A

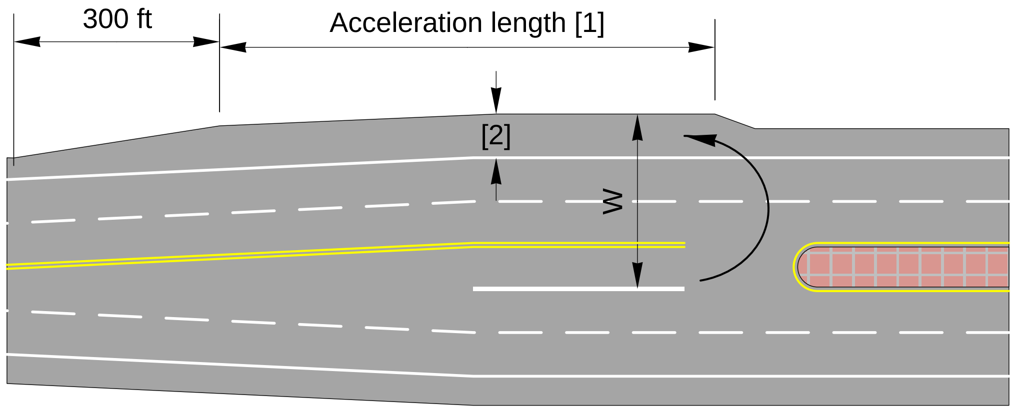
Design B

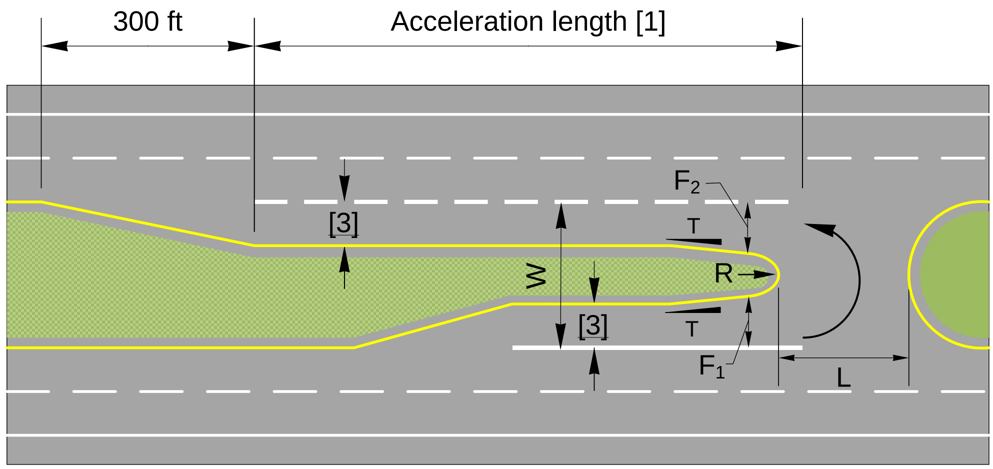
*Design on- and off-connections in accordance with Chapter 1360.

Document the need for U-turn locations, the spacing used, and the selected design vehicle. If the design vehicle is smaller than the largest vehicle using the facility, provide an alternate route.

U-turns at signal-controlled intersections do not need the acceleration lanes shown in Exhibit 1310-18. For new U-turn locations at signal-controlled intersections, evaluate conflicts between right-turning vehicles from side streets and U-turning vehicles. Warning signs on the cross street might be appropriate.

Exhibit 1310-18 U-Turn Median Openings





Vehicle	W	R	L	F_1	F_2	T
P	52	14	14	12	12	—
SU-30	87	30	20	13	15	10:1
CITY-BUS	87	28	23	14	18	10:1
WB-40	84	25	27	15	20	6:1
WB-67	94	22	49	15	35	6:1
U-Turn Design Dimensions						

Notes:

[1] The minimum length of the acceleration lane is shown in Exhibit 1310-14. Acceleration lane may be eliminated at signal-controlled intersections.

[2] When U-turn uses the shoulder, provide shoulder width sufficient for the intersection design vehicle to make the turn and shoulder pavement designed to the same depth as the through lanes for the acceleration length and taper.

[3] Lane width as determined by Chapters 1106 and 1230.

General: All dimensions are in feet.

1310.04 Intersection Sight Distance

Providing drivers the ability to see stop signs, traffic signals, and oncoming traffic in time to react accordingly will reduce the probability of conflicts occurring at an intersection. Actually avoiding conflicts is dependent on the judgment, abilities, and actions of all drivers using the intersection.

The driver of a vehicle that is stopped and waiting to cross or enter a through roadway needs obstruction-free sight triangles in order to see enough of the through roadway to complete all legal maneuvers before an approaching vehicle on the through roadway can reach the intersection. Use Exhibit 1310-19a to determine minimum intersection sight distance along the through roadway.

The sight triangle is determined as shown in Exhibit 1310-19b. Within the sight triangle, lay back the cut slopes and remove, lower, or move hedges, trees, signs, utility poles, signal poles, and anything else large enough to be a sight obstruction. Eliminate parking to remove obstructions to sight distance. In order to maintain the sight distance, the sight triangle must be within the right of way or a state maintenance easement (see Chapter 510).

The 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 are added to the setback. When the stop bar is placed more than 10 feet from the edge of traveled way, providing the sight triangle to a point 8 feet back of the stop bar is desirable.

Provide a clear sight triangle for a P vehicle at all intersections. In addition, provide a clear sight triangle for the SU-30 vehicle for rural highway conditions. If there is significant combination truck traffic, use the WB-67 rather than the SU-30. In areas where SU-30 or WB vehicles are minimal and right of way restrictions limit sight triangle clearing, only the P vehicle sight distance needs to be provided.

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. Drivers who do not have the desired sight distance creep out until the sight distance is available; therefore, the setback may be reduced to 10 feet. 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 no identified crash trend at the intersection. Document the intersection location and the available sight distance as a Design Analysis.

If the intersection sight distance cannot be provided using the reductions in the preceding paragraph, where stopping sight distance is provided for the major roadway, the intersection sight distance, at the 10-foot setback point, may be reduced to the stopping sight distance for the major roadway, with a Design Analysis and HQ Design Office review and concurrence. (See Chapter 1260 for required stopping sight distance.) 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 no identified crash trend at the intersection. Document the intersection location and the available sight distance as a Design Analysis.

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, intersection sight distance can be restored through the periodically scheduled maintenance of vegetation in the sight triangle within the WSDOT right of way or state maintenance easement.

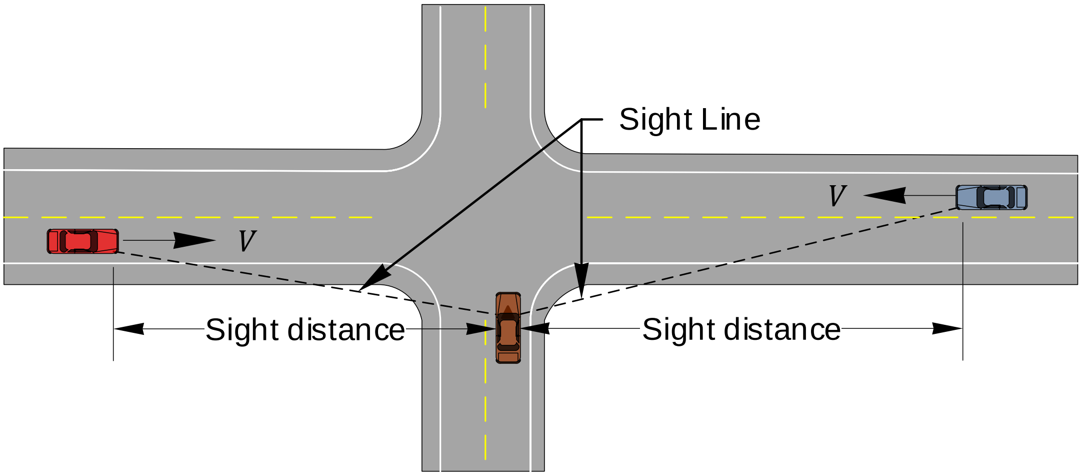
At intersections controlled by traffic signals, provide sight distance for right-turning vehicles. For intersections controlled by the geometry of roundabouts, see Chapter 1320.

Designs for movements that cross divided highways are influenced by median widths. If the median is wide enough to store the design vehicle, with a 3-foot 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 sight distance for ramp terminals as at-grade intersections with only left- and right-turning movements. An added element at ramp terminals is the grade separation structure. Exhibit 1310-19b gives the sight distance guidance 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.

Exhibit 1310-19a Sight Distance at Intersections



$S_i = 1.47Vt_g$
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)	7.5
Single-unit trucks and buses (SU-30 & CITY-BUS)	9.5
Combination trucks (WB-40 & WB-67)	11.5
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.	

Intersection Sight Distance Time Gaps (t_g)
Table 2

Notes:

Adjust the tg values listed in Table 2 as follows:

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

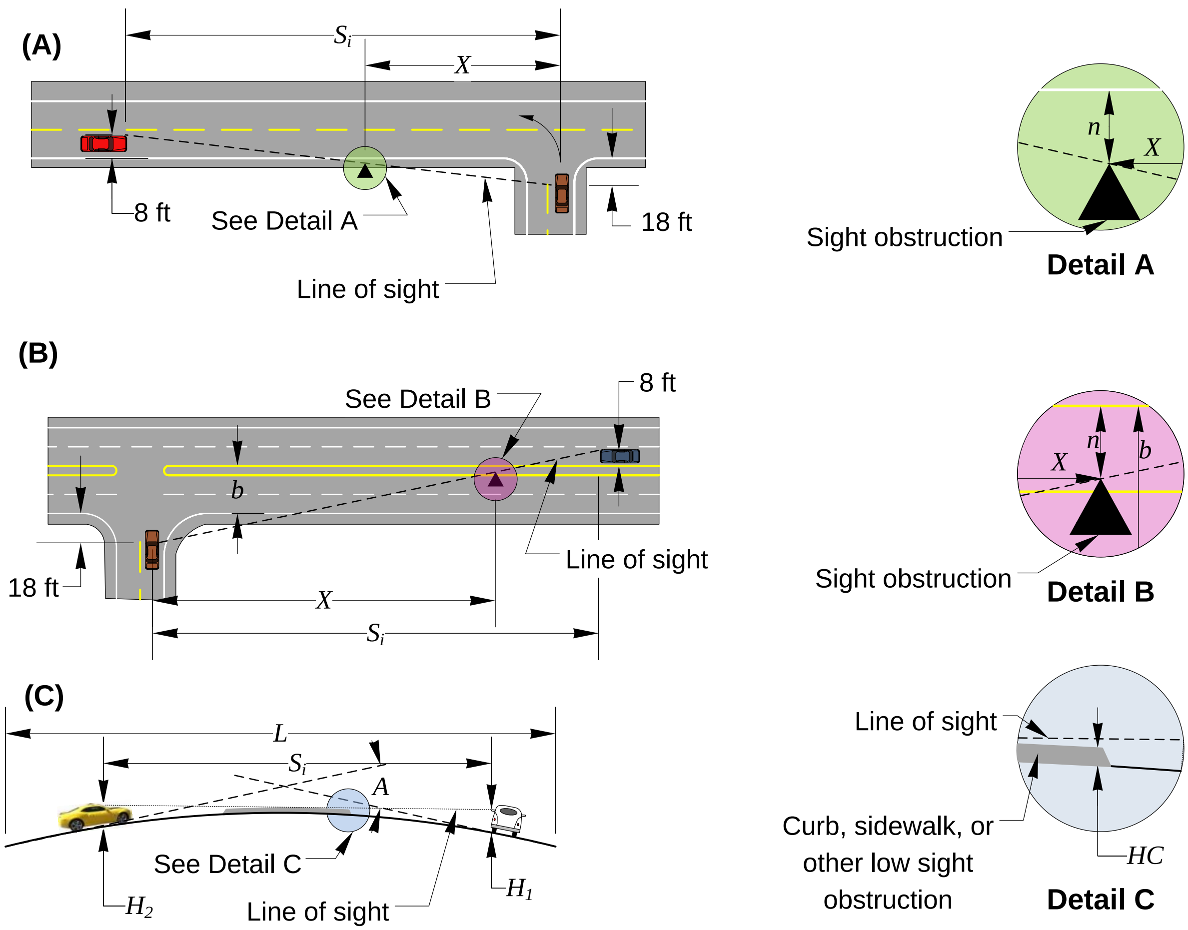
Where medians are wide enough to store the design vehicle, determine the sight distance as two maneuvers.

Crossroad grade greater than 3%:

All movements upgrade for each percent that exceeds 3%:

All vehicles add 0.2 sec

Exhibit 1310-19b Sight Distance at Intersections



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 centerline of lane to sight obstruction (ft)

For crest vertical curve over a low sight obstruction when S<L:

$$S_i = \sqrt{\frac{100L\left[\sqrt{2(H_1-HC)}+\sqrt{2(H_2-HC)}\right]^2}{A}}$$

$$L = \frac{AS_i^2}{100\left[\sqrt{2(H_1-HC)}+\sqrt{2(H_2-HC)}\right]^2}$$

Where:

- Si = Available sight distance (ft)
- H_1 = Eye height (3.5 ft for passenger cars; 6 ft for all trucks)
- H_2 = Approaching vehicle height (3.5 ft)
- HC = Sight obstruction height (ft)
- L = Vertical curve length (ft)
- A = Algebraic difference in grades (%)

1310.05 Signing and Delineation

Use the MUTCD and the *Standard Plans* for signing and delineation criteria. Provide a route confirmation sign on all state routes shortly after major intersections. (See Chapter 1020 for additional information on signing.)

Painted or plastic pavement markings are normally used to delineate travel paths. For pavement marking details, see the MUTCD, Chapter 1030, and the *Standard Plans*.

Contact the region or HQ Traffic Office for additional information when designing signing and pavement markings.

1310.06 Procedures

Document design decisions and conclusions in accordance with Chapter 300. For highways with limited access control, see Chapter 530.

1310.06(1) Approval

An intersection is approved in accordance with Chapter 300. Complete the following items, as needed, before intersection approval:

- Intersection Control Type Approval (see Chapter 1300)
- Design Analyses approved in accordance with Chapter 300
- Approved Traffic Signal Permit (DOT Form 242-014 EF) (see Chapter 1330)

1310.06(2) Intersection Plans

Provide intersection plans for any increases in capacity (turn lanes) at 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; etc.

For information to be included on the intersection plan for approval, see the Intersection/ Channelization Plan for Approval Checklist on the following website:

www.wsdot.wa.gov/design/projectdev/

1310.06(3) Local Agency or Developer-Initiated Intersections

Intersections in local agency and developer projects on state routes must receive the applicable approvals in section 1310.07(1) as part of the intersection design process.

The project initiator submits an intersection plan and the documentation of design decisions that led to the plan to the region for approval. For those plans requiring a Design Analysis, the Design Analysis must be approved in accordance with Chapter 300 prior to approval of the plan. After the plan approval, the region prepares a construction agreement with the project initiator (see the *Utilities Manual*).

1310.07 Documentation

Refer to Chapter 300 for design documentation requirements.

1310.08 References

1310.08(1) Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 36, Appendix A)

Revised Code of Washington (RCW) 35.68.075, Curb ramps for persons with disabilities – Required – Standards and requirements

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

1310.08(2) Design Guidance

Local Agency Guidelines (LAG), M 36-63, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC “Manual on uniform traffic control devices for streets and highways” (MUTCD)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

1310.08(3) Supporting Information

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

Aspects of Traffic Control Devices, Highway Research Record No. 211, pp 1 18, “Volume Warrants for Left-Turn Storage Lanes at Unsignalized Grade Intersections,” Harmelink, M.D.

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

Intersection Channelization Design Guide, NCHRP 279

Chapter 1320 Roundabouts

1320.01 General

Modern roundabouts are near-circular intersections at grade. They are an effective intersection type with fewer conflict points and lower speeds, and they provide for easier decision making than other intersection types. They also require less maintenance than traffic signals. Well-designed roundabouts have been found to reduce crashes (especially fatal and severe injury collisions), traffic delays, fuel consumption, and air pollution. They also have a traffic-calming effect by reducing vehicle speeds using geometric design rather than relying solely on traffic control devices.

Roundabout design is an iterative process.

A well-designed roundabout achieves a balance of safety and efficiency.

Good design is a process of creating the smooth curvature, channelization, and deflection required to achieve consistent speeds, well-marked lane paths, and appropriate sight distance.

Roundabout

The decision to install a roundabout is the result of an Intersection Control Evaluation (ICE) (see Chapter 1300) approved by the region Traffic Engineer or other designated authority.

New roundabouts and changes to existing roundabouts that either add or reduce capacity, or change the geometric configuration require a Peer Review (see Section 1320.11)

1320.02 Roundabout Types

There are five basic roundabout types: mini, compact, single-lane, multilane, and teardrop described in the following sections.

1320.02(1) Mini-Roundabouts

Mini-roundabouts are small single-lane roundabouts generally used in 25 mph or less urban/suburban environments. Because of this, mini-roundabouts are typically not suitable for use on higher-volume (greater than 6,000 AADT) state routes. In retrofit applications, mini-roundabouts are relatively inexpensive because they normally require minimal additional pavement at the intersecting roads. A 2-inch mountable curb for the splitter islands and the central island is desirable because larger vehicles might be required to cross over it.

A common application is to replace a stop-controlled or uncontrolled intersection with a mini-roundabout to reduce delay and increase capacity. With mini roundabouts, the existing curb and sidewalk at the intersection can sometimes be left in place.

1320.02(2) Compact Roundabouts

Compact roundabouts are a hybrid of attributes found in mini- and single-lane roundabouts. Similar to a mini-roundabout, a compact roundabout may require minimal additional pavement, has a completely mountable center island, and in many cases existing curb or sidewalk can be left in place. As a result, compact roundabouts rarely require the purchase of right of way. Compact roundabouts are similar to single-lane roundabouts regarding design vehicle assumptions, ability to process traffic volumes, and signing.

Compact roundabouts

1320.02(3) Single-Lane Roundabouts

Single-lane roundabouts have single-lane entries at all legs and one circulating lane. They typically have mountable raised splitter islands, a mountable truck apron, and a landscaped central island.

Single-lane roundabout

1320.02(4) Multilane Roundabouts

Multilane roundabouts have at least one entry or exit with two or more lanes and more than one circulating lane. The operational practice for trucks negotiating roundabouts is to straddle adjacent lanes.

Multilane roundabout

1320.02(5) Teardrop Roundabout

Teardrops are usually associated with ramp terminals at interchanges: typically, at diamond interchanges. Teardrop roundabouts allow the “wide node, narrow link” concept. Unlike circular roundabouts, teardrops do not allow for continuous 360° travel resulting in less vehicle conflicts as traffic traveling on the crossroad (link) between ramp terminal intersections (nodes) does not encounter a yield as it enters the teardrop intersections. At higher ADT locations this lack of conflicting vehicles can result in a higher throughput, but can also result in limited gaps for the off ramp approach. Consult HQ or region Traffic Office for guidance.

Teardrop roundabouts

1320.03 Capacity Analysis

Use the capacity analysis completed as part of the Intersection Control Evaluation (see Chapter 1300) to verify the number of lanes required for every individual movement in the design year.

1320.04 Geometric Design

1320.04(1) Selecting Shape and Placement

Roundabout shape is an important decision, because the shape can affect design elements that affect safety performance and operation of the roundabout.

1320.04(1)(a) Circular

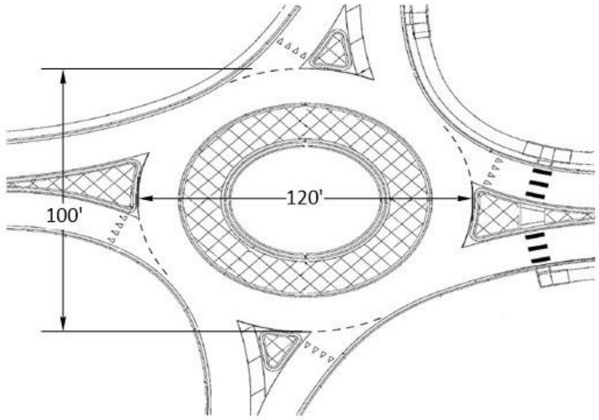
The circular shape is the most desirable roundabout shape when constraints allow. If a circular shape is not feasible, contact the region Traffic Office to investigate other shapes described below. Sometimes a circular shape can be used by slightly offsetting the placement of the roundabout.

Circular shape

1320.04(1)(b) Non-Circular

A non-circular roundabout is a good choice when constraints such as right of way, existing roadway alignments, buildings, and/or environmentally sensitive areas influence the shape.

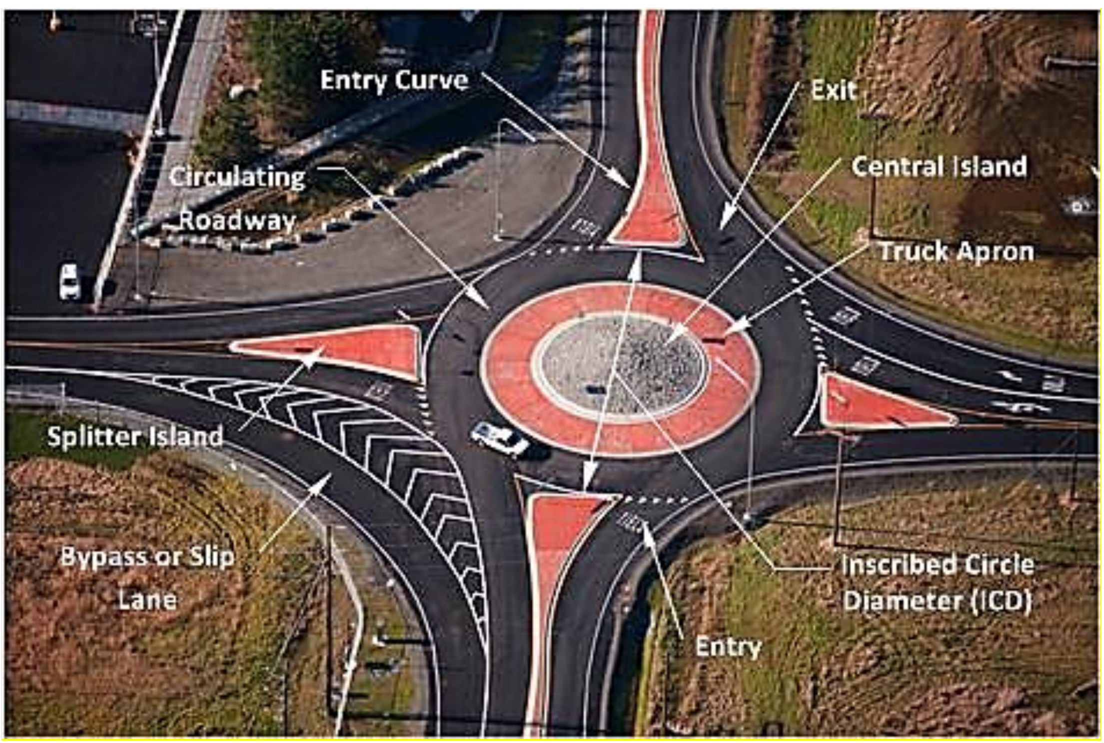
Experiment with different roundabout sizes and radii, and use design vehicle turning software (such as AutoTURN®) to refine the shape to find the best operation while retaining desired speeds.



Non-circular roundabout with example dimensions

1320.04(2) Roundabout Design Elements

This section provides guidance for roundabout design elements. The photo below labels many of them.



Roundabout design elements

1320.04(2)(a) Curbing

All curbing within a roundabout should be rolled. The type of rolled curbing appropriate for a roundabout is shown in the Standard Plan Roundabout Cement Concrete Curbs: F-10.18.

Exception: existing curb untouched as part of a mini or compact roundabout installation may remain.

1320.04(2)(b) Truck Apron

A truck apron is the mountable portion of the central island used to accommodate the turning path of a design vehicle larger than a passenger vehicle or BUS, and helps to minimize the overall footprint of the roundabout. Generally, the truck tractor can traverse the roundabout in the circulating lane while the trailer is allowed to off track onto the apron. The apron is raised above the circulating path to provide guidance for drivers in the circulating lane.

A truck apron’s width is based on the needs of the design vehicle. If buses are a consistent vehicle using the intersection try to minimize apron use for all movements, however this is not a requirement. Use turn simulation software (such as AutoTURN®) to fine tune the width of apron needed, so as not to design an apron that won’t be used.

The apron color should be easily distinguishable in contrast with the adjacent circulating roadway and pedestrian facilities. Work with the region Landscape Architect (HQ Roadside and Site Development Section for regions without a Landscape Architect) for concrete color and texture.

Roundabout showing colored truck apron at central island and at buffer area between travel lanes and sidewalk

1320.04(2)(c) Central Island

The central island is the portion of the roundabout that is inside of the circulating roadway and typically includes an inside truck apron and a landscaped area (except for mini-roundabouts and compact roundabouts, which have no landscaped area and are entirely mountable).

Central island shape is a function of the site-specific needs of a roundabout intersection. It doesn’t have to be an identical shape of the inscribed circle diameter (ICD) dimensions, but should support the design principles of deflection and low speeds, and the accommodation of the design vehicle.

Roundabouts present opportunities to create community focal points, landscaping, and other gateway features within an intersection. The central island may include enhancements (such as landscaping, sculptures, or fountains), which serve both an aesthetic purpose and provide visual indication of the intersection for approaching motorists (this is particularly important for high speed approaches). Ideal central island treatments fit the context and result in minimal consequence to any vehicle that may encroach on the non-mountable portion of the central island. These treatments should not attract pedestrians to the central island, as pedestrians should never cross the circulating roadway. Work with the region Landscape Architect (HQ Roadside and Site Development Section for regions without a Landscape Architect) for central island features. See Chapter 950 Public Art for policy and guidance.

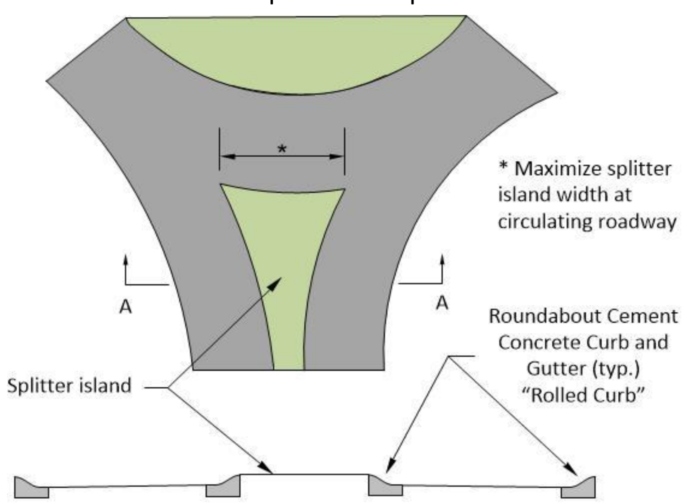
1320.04(2)(d) Splitter Island

A splitter island is the raised island at each two-way leg between entering and exiting vehicles, designed primarily to control the entry and exit speeds by providing deflection. They also discourage wrong-way movements, and provide pedestrian refuge. Splitter islands can have different shapes based on entry angle requirements and exit design speeds.

Raised channelization, or the appearance of raised curbing, is important, as research shows that drivers will slow down when they perceive that the driving width is narrowing.

The length of the splitter island will vary (typical lengths: 30 ft. to 350 ft.) based on the terrain, access considerations, site-specific mainline and crossroad operational speeds and the stepdown speeds to the final desired entry speed, which is usually 15–25 mph. (See 1320.04(3)(a) for using chicanes on higher-speed roadways.)

Try to maximize the splitter island width adjacent to the circulating roadway. The larger achieved width, the better a driver approaching the roundabout can perceive whether a driver in the circulating lane will exit or continue inside the roundabout. This results in better gap acceptance. This may also support a better pedestrian refuge design.



Splitter Island

1320.04(2)(e) Inscribed Circle Diameter (ICD)

The Inscribed Circle Diameter (ICD), that is, the overall outside diameter of a roundabout, is determined by the variables design vehicle, design speed, and the number of circulatory lanes.

The ranges of ICD in Exhibit 1320-1 are only suggestions to start a roundabout design. The ICD for noncircular shapes should be defined with dimensions along the X and Y axis.

Exhibit 1320-1 Suggested Initial Design Ranges

Design Element	Mini [1]	Compact	Single-Lane	Multilane
Number of Lanes	1	1+	1	2+
Inscribed Circle Diameter [2]	45' – 80'	65' – 120'	80' – 150'	120' – 165'
Circulating Roadway Width	N/A	N/A	14' – 19'	29'
Entry Widths	N/A	N/A	16' – 18'	25'

Notes:

The "+" symbol used here means that a portion of the circulating roadway may have more than one lane.

[1] Reserved for urban/suburban intersections with a 25 mph or less posted speed.

[2] The given diameters assume a circular roundabout; adjust accordingly for other shapes. Some conditions may require ICDs outside ranges shown here.

1320.04(2)(f) Entry

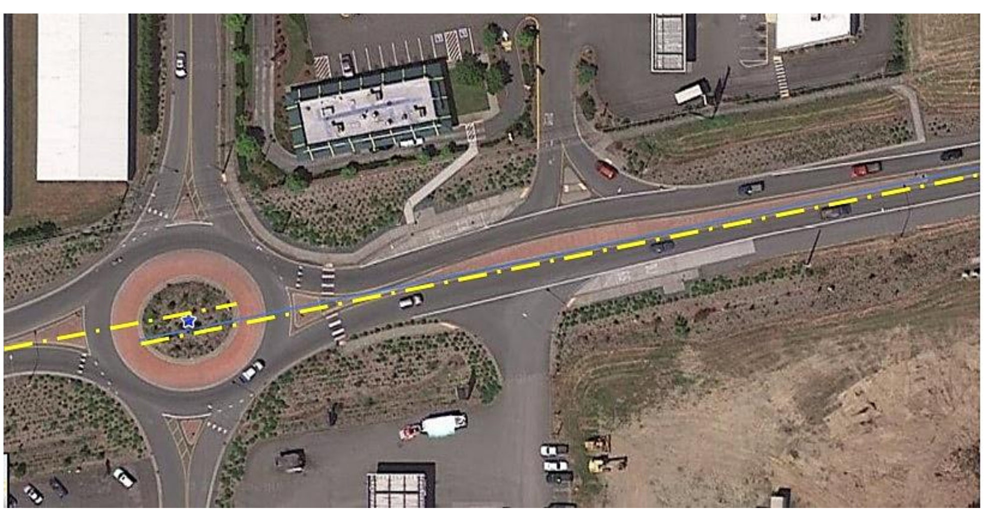
1. Deflection

Ideal alignment offers an entry design that provides deflection, speed control, and reasonable view angles to drivers while balancing property impacts and costs. While most intersections are at 90º angles and most through movements are straight, deflection contributes to the safety performance of a roundabout. Deflection is primarily achieved with the central island and supporting it with splitter islands on all entries to the roundabout.

2. Alignment Offset

There are three alignment choices for attaching entry legs to the circulatory roadway:

- The offset left alignment is preferred. It constrains the entry, slowing a vehicle's approach speed, and opens up the exit for efficient egress.
- The symmetrical alignment (if needed) is acceptable for lower speed contexts such as 30 mph.
- The offset right alignment tends to allow faster entry speeds and constrains the exit; it is undesirable.



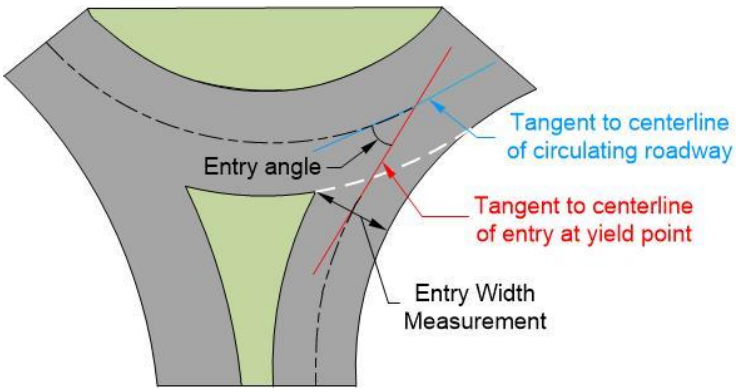
Offset left alignment (preferred)

3. Entry Angle

To achieve the proper amount of deflection for each approach to a roundabout, there is a range of angle values that are desirable. This range is usually between 20 and 40 degrees. The purpose of entry angle is so vehicles don't hit broadside.

4. Entry Width

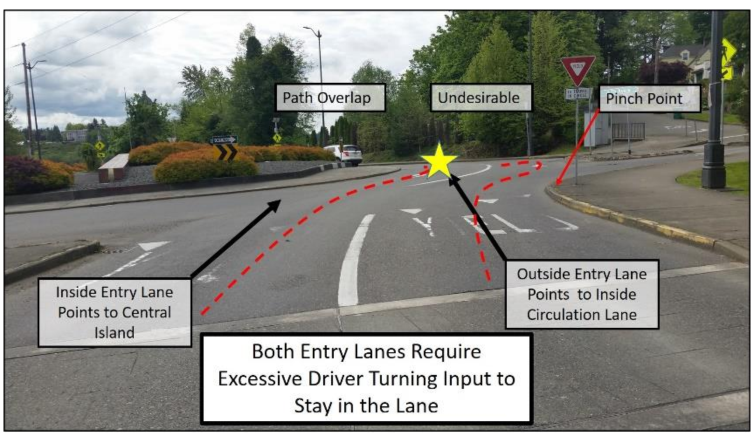
Entry width is determined by the turning template of the design vehicle turning through the entry curve at the desired entry speed. The ranges of entry widths in Exhibit 1320-1 are only suggestions to start a roundabout design.



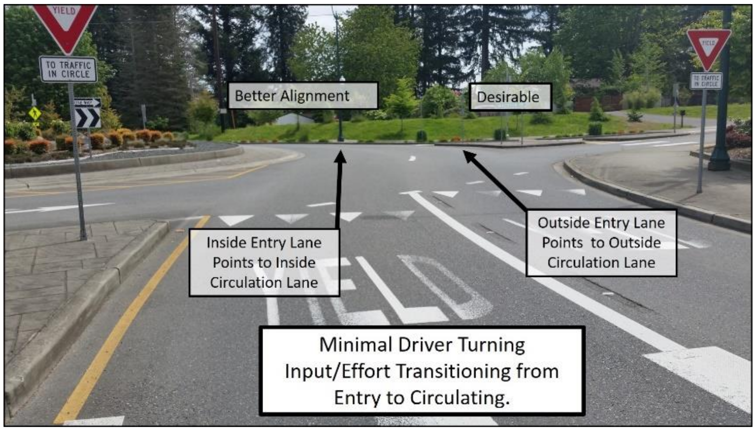
Entry angle and width

5. Path Overlap

In a multilane roundabout, if the vehicles in the entry are aligned toward the central island or the truck apron, the vehicle on the right is pointed toward the inside lane and tends to go in that direction, while the vehicle on the left tends to be squeezed to the right toward the vehicle on the right. Avoid path overlap. Avoid a design that aligns an entering vehicle at the incorrect lane in the circulatory roadway. As a vehicle enters the circulating roadway it should be headed directly toward its respective lane within the circulating roadway. For multilane roundabouts, if inside lane is pointing at truck apron this is also considered to be path overlap. If right entry lane is pointing to left circulatory lane, then there is path overlap.



Path overlap conflict

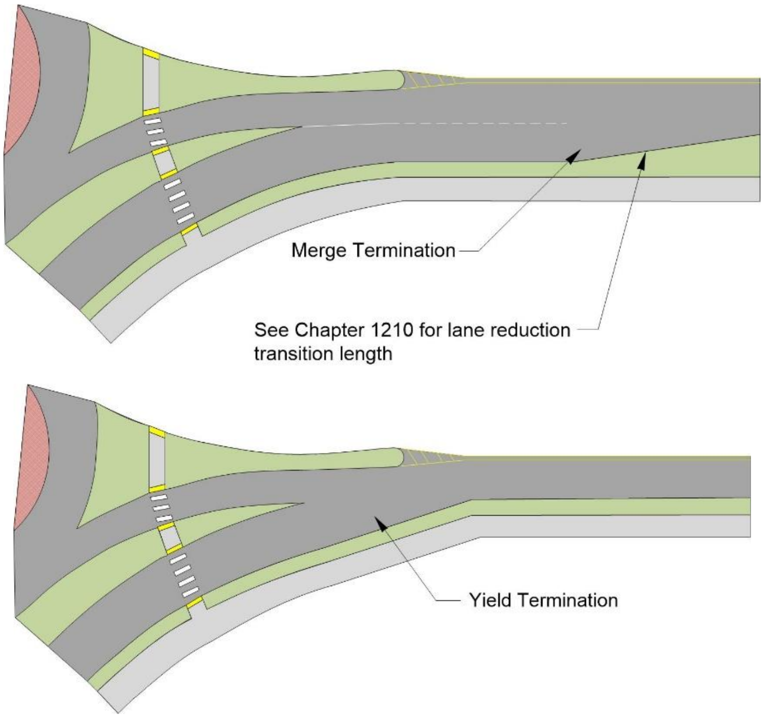


Good path alignment

1320.04(2)(g) Right-Turn Slip Lanes

Right-turn slip lanes are a proven way to increase the "life" of an intersection by removing traffic that would otherwise enter the roundabout and reduce the available capacity to other movements. If a right-turn movement has 250 vehicles/hour or more, or if over 40% of the total approach volume is taking right turns, a slip lane should be considered.

The conflicting volume of vehicles on the merge will influence the length of merge lane prior to termination. Speeds can be very low and vehicles can take turns at these low speeds. Multimodal considerations will influence the length based on crosswalk location and bicycle use.



Right-turn slip lanes showing merge and yield termination

1320.04(3) Speed Control

Roundabout operation performance is dependent on low, consistent vehicle speeds. Low and consistent operating speeds facilitate appropriate gap acceptance by an entering driver. Design for travel path operating speeds between 15 mph and 25 mph (see 1320.04(3)(b)). Design to have low-speed differentials (12 mph or under) between entering and circulating traffic. Multilane roundabouts might have higher speeds along their respective travel paths, but generally 30 mph or less.

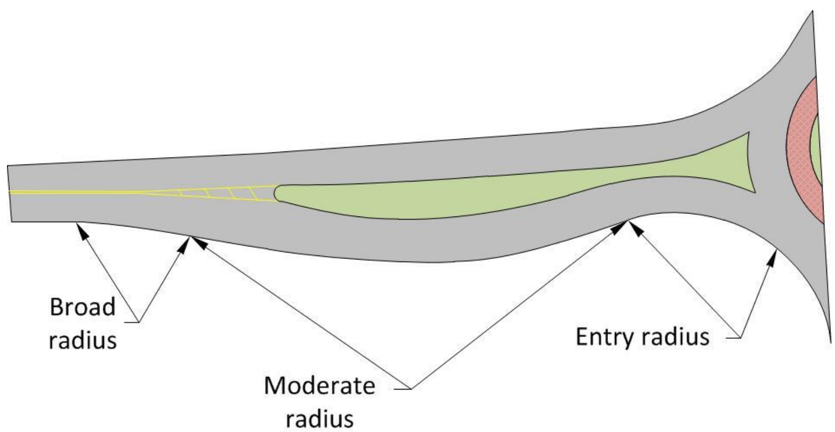
The ideal design speed mechanism has the entry and circulating speeds being similar. This varies due to size, shape and context of the roundabout.

The vehicle then moves into and through the circulation lane, being controlled all along by the design speed of the circulating lane. The circulating design speed controls the exit speed; therefore, the exit design speed, as calculated in the Travel Path section below, is not as critical.

Designing geometric entry speed control encourages lower speeds and lower speed differentials at conflict points, which reduces the potential for collisions.

1320.04(3)(a) Chicanes

Chicanes are a type of horizontal deflection used in traffic calming to reduce the speed of vehicles. Research has shown that chicanes have value in slowing down higher approach speeds.



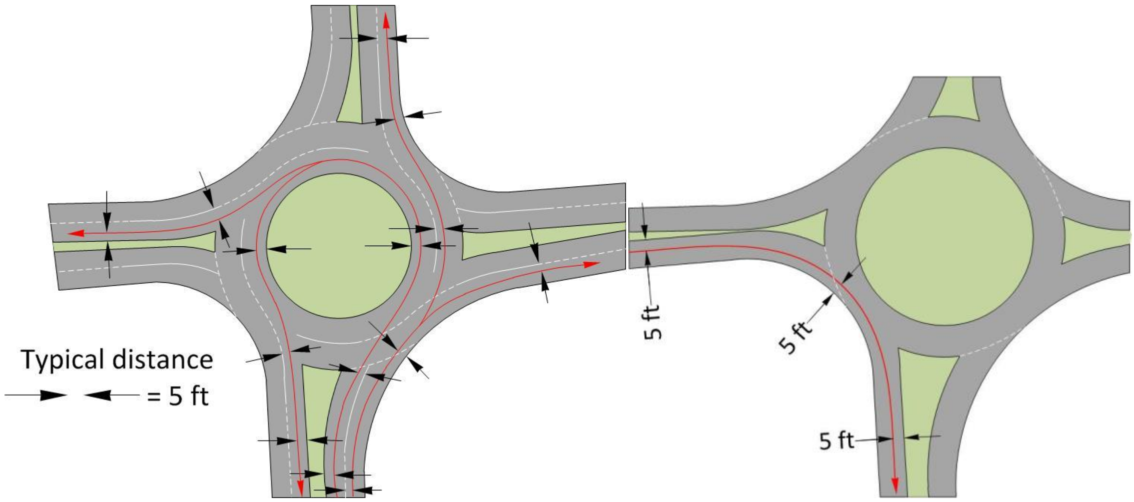
Chicane

Consider chicanes where posted speeds near the roundabout are 45 mph or higher. Design chicane curves with successively smaller radii in order to successively reduce vehicle speeds approaching the roundabout entry. Use Exhibit 1320-2 to determine the radii-speed relationship (the radii are measured using the offsets recommended in the Travel Paths section). The normal cross slope (superelevation in 1320-2) is 2% however, site conditions may require more based on how you tilt the plane of the roundabout for site specific conditions. A minus (-) 2% drains toward the central island.

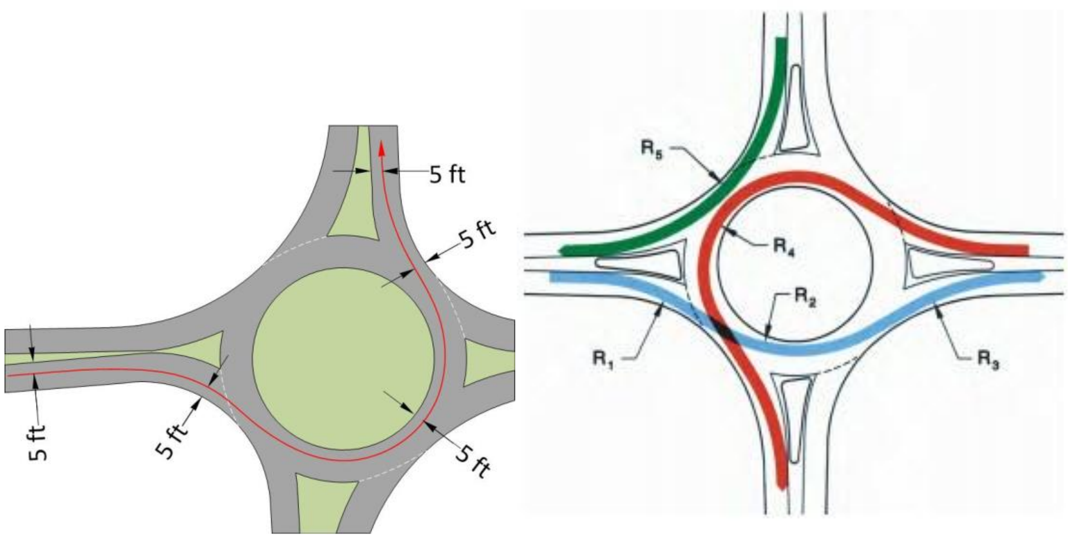
Also, consider the grade of the roadways that enter the roundabout, because a vehicle can more easily slow down on an upgrade than on a downgrade. Adjust the length of the deceleration based on the "Adjustment Factors for Grades Greater Than 3%" in Design Manual Exhibit 1360-10.

1320.04(3)(b) Travel Paths

Travel path calculations can be used on all roundabout designs to get an understanding of speeds for different paths throughout the roundabout. A travel path is the shortest path through the roundabout, no closer than 5 feet from any curb face or lane line as shown. Use Exhibit 1320-2 and R1 through R5 to determine Travel Path speeds.

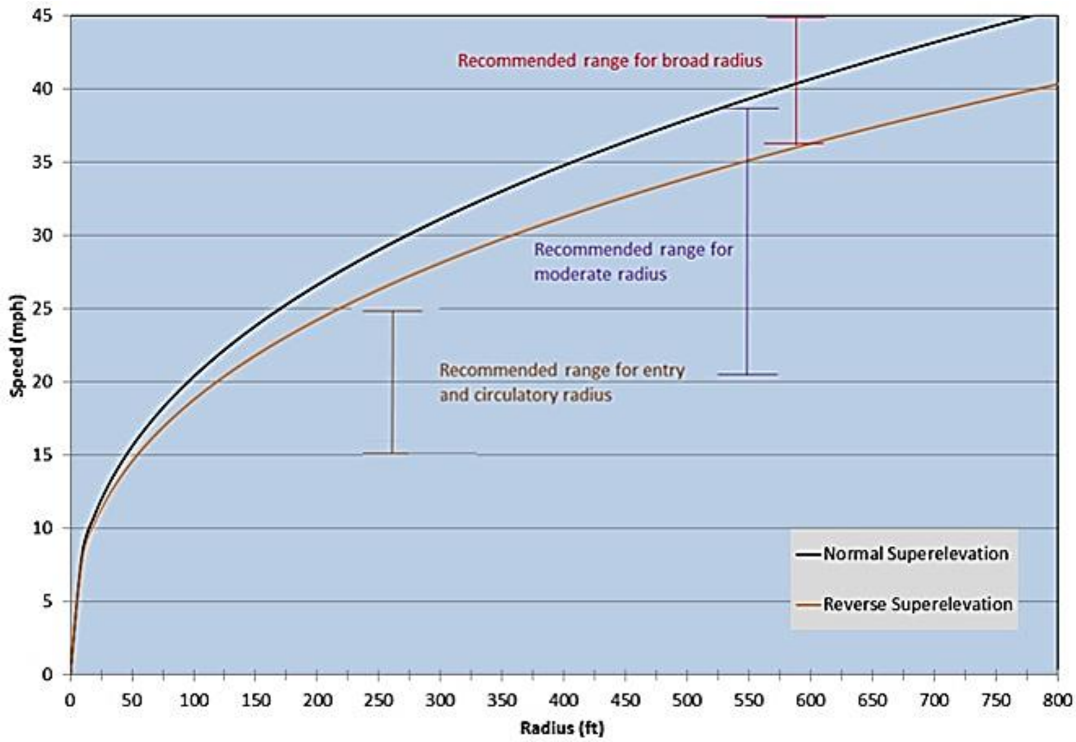


Travel paths



Source: NCHRP

Exhibit 1320-2 Radii-Speed Relationship on Approach Legs and R Value Relationships



1320.04(4) Grades

Do not use grades as a constraint during scoping to rule out a roundabout. Be aware of how the profiles mesh with sight distances and ADA pedestrian requirements.

1320.04(4)(a) Circulatory Roadway

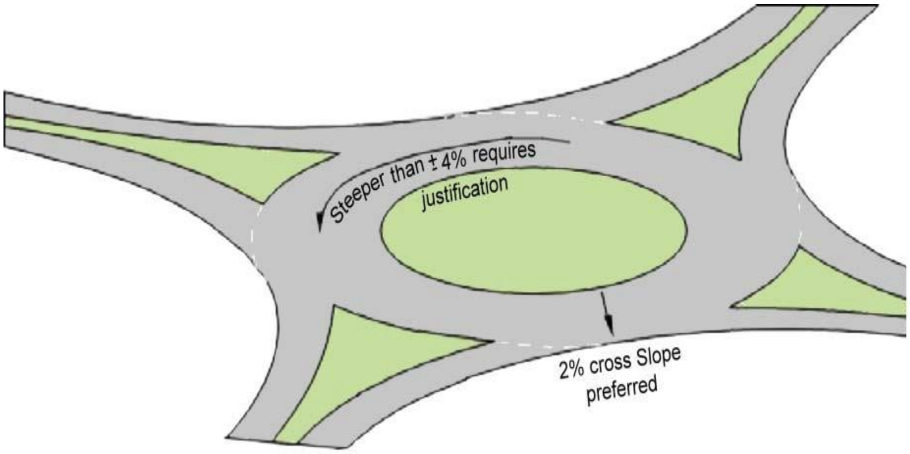
The circulatory roadway grade value should not exceed 4%. Terrain may require benching the roundabout to fit conditions.

1320.04(4)(b) Grade Transitions for Roadway Entry and Exit to the Circulatory Roadway

Consider the grade transitions and make them as long as feasible. When designing for pedestrians see Chapter 1510 and work with region ADA subject matter expert to ensure that grades for ADA compliance at all pedestrian crossing are met.

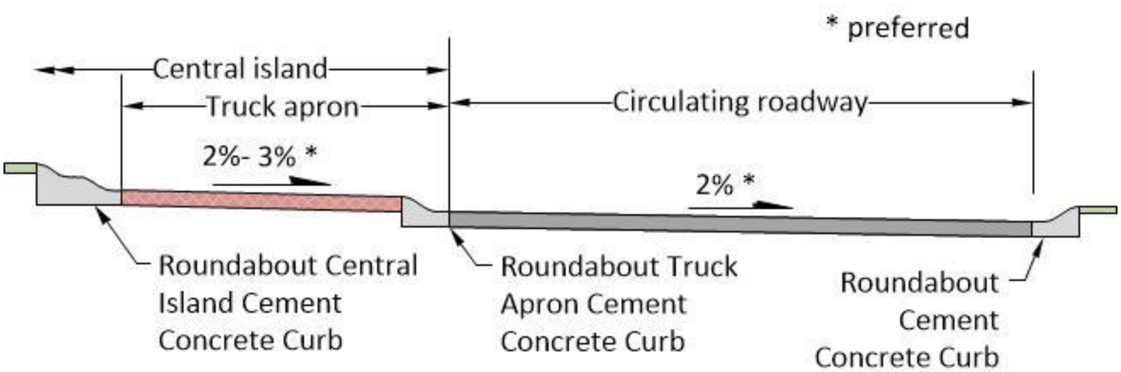
1320.04(5) Circulatory Roadway Profile and Cross Slope

The preferred profile grades of the circulatory roadway of a roundabout are ±4% or flatter radially around the circulatory lane(s). Profile grades steeper than ±4% require **justification**. It is preferred to bench the roundabout if practicable to reduce profile grade.



Preferred grades and cross slopes

The preferred circulatory roadway cross slope may range from 1.5% to 4.0% (2.0% preferred), away from the central island to promote lower circulating speeds, improve central island visibility, minimize breaks in cross slope of entry and exit lanes, and facilitate drainage of water to the outside of the roundabout.



Drawing shows preferred cross slopes. Site conditions and drainage may require slopes outside these ranges.

1320.04(6) Design Tools

During the scoping or preliminary geometric design process, do not to use truck turning paths alone as a constraint to eliminate a roundabout at an intersection. There are several design tools available to aid in the design of a roundabout. It is important to understand how the software works, its default settings, and its application to the design process.

1320.04(6)(a) Design Vehicle Assumptions

While all highway-to-highway movements require accommodating a WB-67, there are certain assumptions that must be made with software programs that replicate truck swept paths. Determine which truck percentage defaults are to be used (recognizing that truck percentages can range from 2% to 20%) so that different segments can be modeled accurately. Recognize that within a set percentage, WB-67s may only represent a small sample of the entire truck volume on any given day. Therefore, consider whether a WB-67 should be designed for, or accommodated (also see Chapter 1103).

1. Designing for a WB 67

A roundabout that is being designed for a WB-67 may result in wider lane widths and a larger Inscribed Circle Diameter. For this situation, rolled curb design is critical to the truck's traversing the roundabout (see *Standard Plan* F-10.18 for curb details). Outside aprons may not be needed in many situations based on AutoTurn® modeling and knowledge of driver turning behavior when encountering geometric features.

2. Accommodating a WB 67

A roundabout that is designed to accommodate a WB-67 assumes that a WB-67 could utilize truck aprons to maneuver through the roundabout, if necessary, which should reduce the overall footprint of the roundabout. For this situation, rolled curb is critical to the truck's traversing the roundabout confidently. Although outside truck aprons are needed infrequently, there may be situations where the design may need to incorporate them. Contact HQ Traffic for guidance.

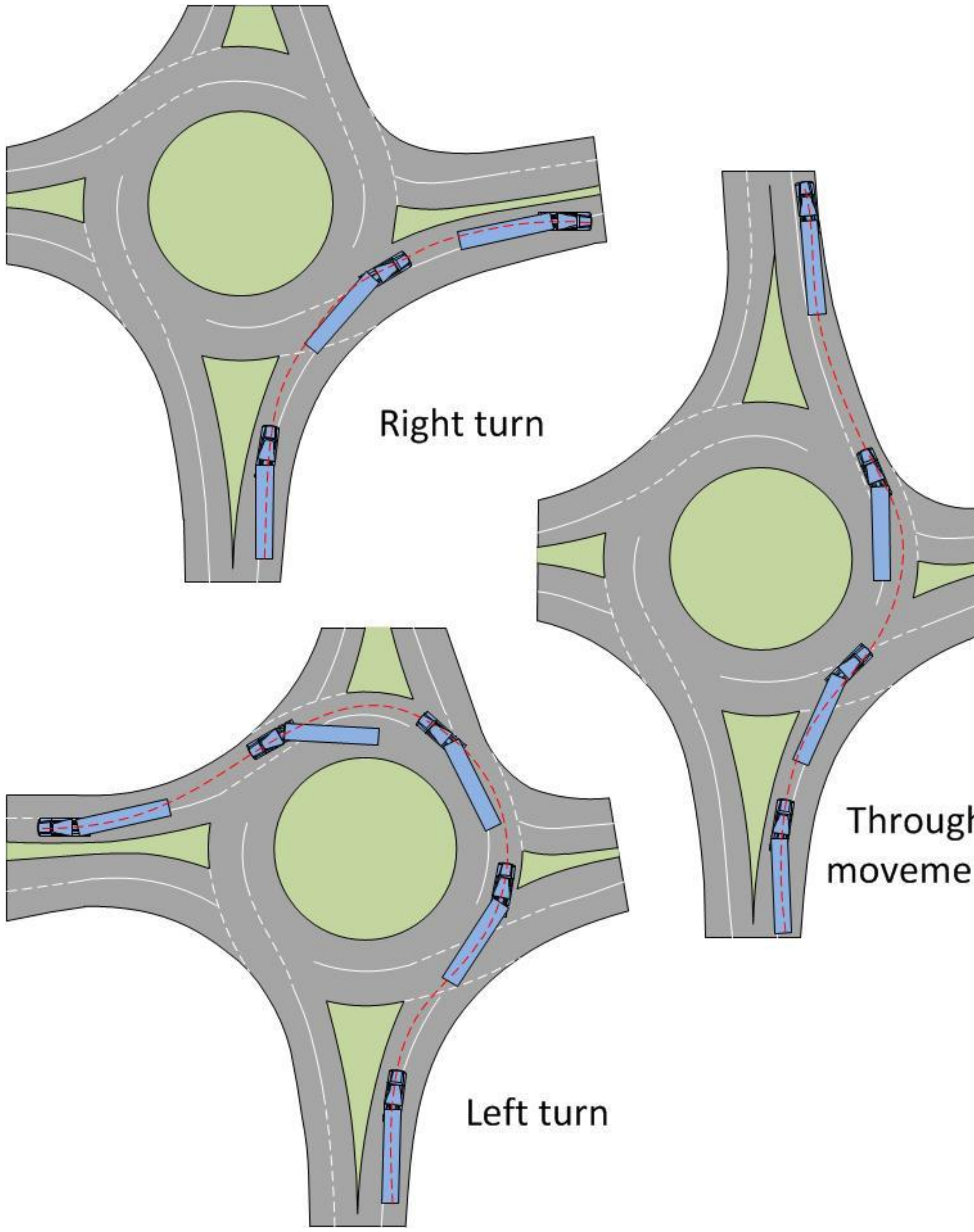
1320.04(6)(b) Truck Swept Path

In some cases, roundabouts of the perfect circular variety with symmetrical roadway attachments require less specific knowledge of truck-turning software and its applications. However, when looking at a non-circular shaped roundabout where the combination of the truck's speed, its turning angle settings, its rear axle locations, and its alignment are the critical design elements to address, a mastery of the software is required. Designers that are unfamiliar with how to apply the software inputs accurately to model a truck's swept path need to contact HQ Traffic Office for guidance. Poor alignment of a truck swept path can result in unnecessarily large roundabout footprints, higher than desired Travel Path speeds, or uncomfortable driving maneuvers by the freight community.

Assume that a truck will travel much slower through a roundabout than the Travel Path speed calculated for passenger vehicles (see 1320.04(3)(b)). Adjust the software input to allow a slower truck speed in order to make a good engineering judgment about how fast a truck may use a roundabout (for example, for AutoTURN® use 5 mph). Design tool default settings don't necessarily allow the maximization of the tool and can prohibit the designer from getting a good, balanced design between passenger car speeds and truck accommodation.

Single lane roundabout - Truck using the truck apron

When using a truck-turning software tool like AutoTURN® on multilane roundabouts, assume a truck's travel path will occupy (straddle) parts of two adjacent lanes.



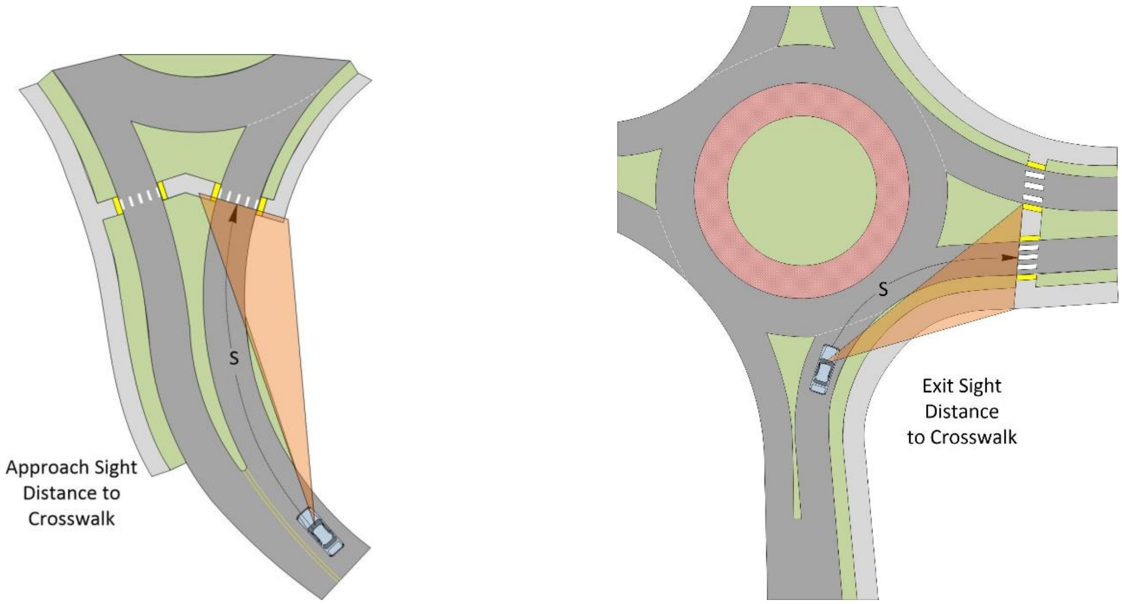
Multilane roundabout - truck straddles lanes

1320.04(7) Sight Distance

Sight distance is an important design consideration at roundabouts. Restricting sight distance across the central island with strategic landscaping may enhance the intersection by making the intersection a focal point and encouraging lower speeds. Work with the region Traffic Engineer and Landscape Architect (HQ if there is no region contact) to determine this balance. Provide sight triangle plan sheets for consideration of landscape design.

1320.04(7)(a) Stopping

Use the design stopping sight distance in Chapter 1260. Anticipated speeds throughout the roundabout can be calculated using Exhibit 1320-2, based on the Travel Path radius and direction of the particular curve. The design stopping sight distance is measured along the vehicle's path as it follows the curvature of the roadway; it is not measured as a straight line.



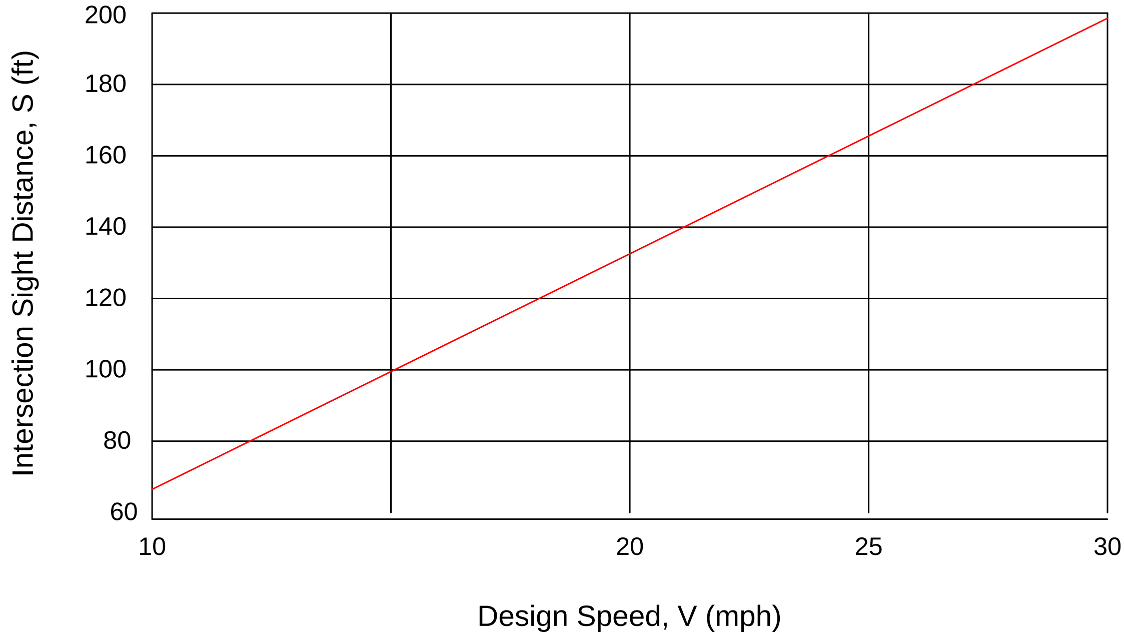
Sight distance – Approach and Exit

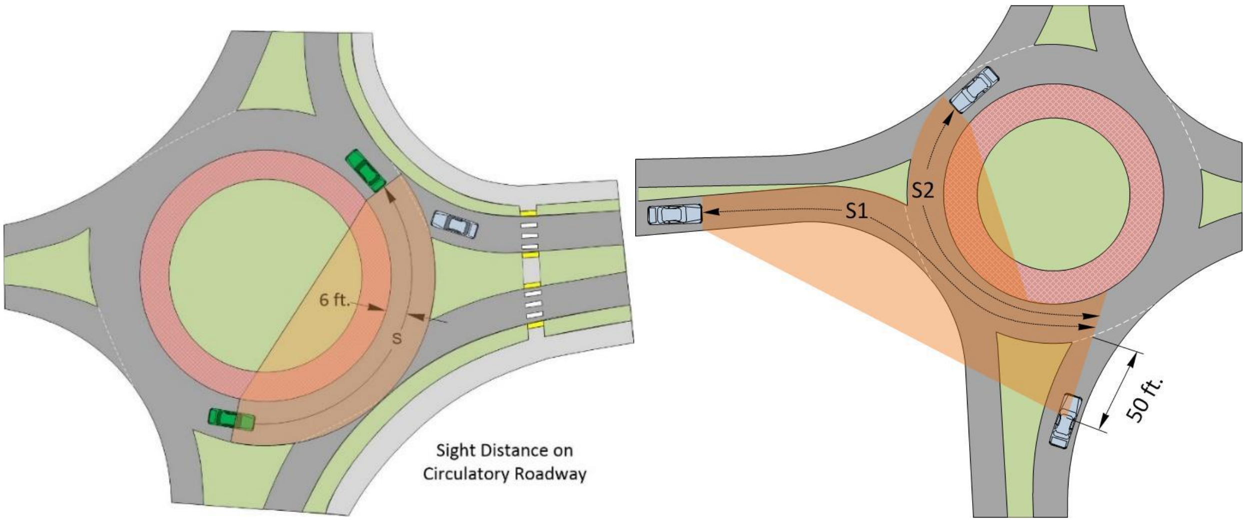
1320.04(7)(b) Intersection

Provide minimum intersection sight distance. Longer sight distances can lead to higher vehicle speeds that reduce gap opportunities for entering vehicles. For intersection sight distance at roundabouts, provide entering vehicles a clear view of traffic on the circulating roadway and on the immediate upstream approach in order to aid in judging an acceptable gap.

The intersection sight distance at roundabouts is given in Exhibit 1320-3. The S1 intersection sight distance is based on the average of the entering and circulating speeds, and the S_2 intersection sight distance is based on the left-turning speed. The sight distance may also be calculated using the intersection sight distance equation given in Chapter 1310 using a time gap (tg) of 4.5 seconds.

Exhibit 1320-3 Intersection Sight Distance





1320.04(8) Railroad Crossings

Although it is undesirable to locate any intersection near an at-grade railroad crossing, this situation exists at many locations on the highway system. Experience shows that a roundabout placed near a crossing has some operational advantages. If there is a railroad crossing near the roundabout contact HQ Traffic Office for further guidance.

1320.05 Pedestrians

As part of the approved ICE it has already been determined whether pedestrians will use the roundabout and, if so, which legs (see Chapter 1300).

With the knowledge of where pedestrian facilities are needed, design the roundabout while keeping in mind the ADA requirements for crosswalks, sidewalks, paths, and other pedestrian facilities.

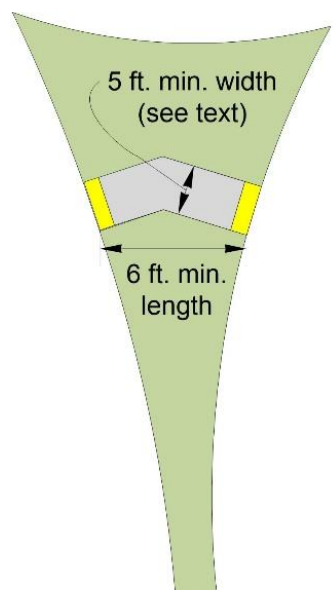
1320.05(1) Crossing Location

The pedestrian crossing located on the entry side of a roundabout leg should be at least 20 feet from the yield line so that a pedestrian can walk behind a vehicle that is waiting at the yield line. If there is an extremely large truck percentage, consider moving the crossing to accommodate the most common truck.

The crossing located in the exit side of the roundabout leg can be closer to the roundabout, because as the vehicles leave the roundabout, they accelerate and make it harder to find a break in traffic. As speed increases, drivers are less likely and less able to stop. Verify that no significant, large sight obstructions are located within the sight lines.

1320.05(2) Splitter Island Pass Through

Design the splitter island pass through a minimum of 5 feet wide, or the width of the sidewalk, whichever is greater. The length of the pass through (measured back of curb to back of curb of the splitter island) is to be a minimum of 6 feet long measured along the shortest section of the pedestrian path. Consider a “V” shape pass through as shown.



Splitter island pass through

1320.05(3) Buffers

Wherever feasible, separate sidewalks from the curb with a buffer. Landscaping or colored concrete are acceptable for the buffer. See WSDOT *Standard Plan F10-18* for dimension details. Do not compromise required vehicle sight triangle needs.

The buffer discourages pedestrians from crossing to the central island or cutting across the circulatory roadway of the roundabout. It also helps guide pedestrians with vision impairments to the designated crosswalks, and can accommodate the occasional inexperienced truck driver who encroaches up onto a curb while traversing through the roundabout.

1320.05(4) Curb Ramps

Roundabouts with buffers typically have combination-type curb ramps; otherwise, parallel curb ramps are normally used. (See Chapter 1510 and the *Standard Plans* for curb ramp information.)

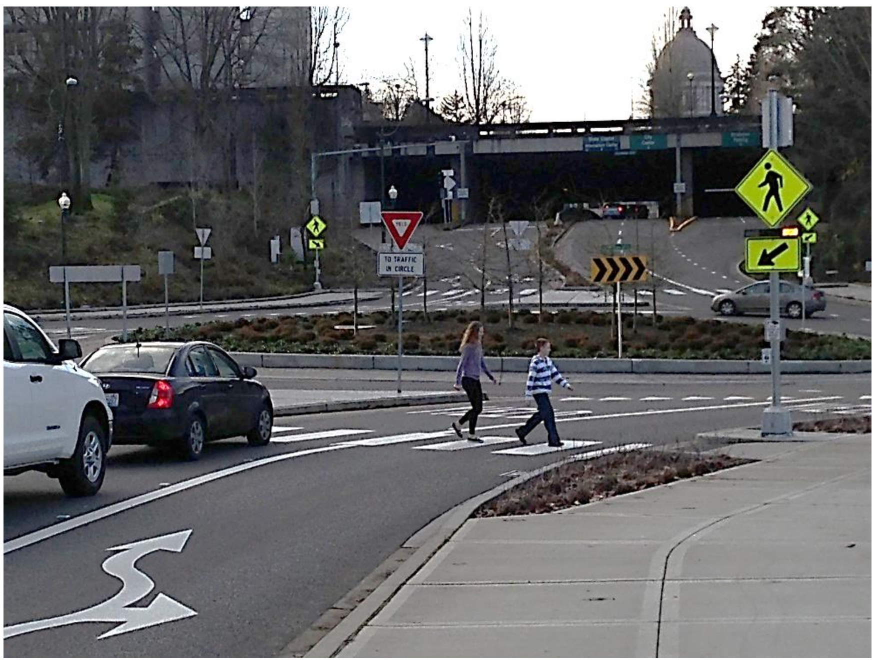
1320.05(5) Sight Triangles

A vehicle sight triangle specific to pedestrians (see 1320.04(7)) must include the whole curb ramp, including the landing, where pedestrians are likely to wait to cross.

It is also important that pedestrians are also able to see approaching vehicles.

1320.05(6) Pedestrian Beacons

On multilane roundabouts, consider installing pedestrian beacons to warn drivers when a pedestrian wants to cross the roadway. Work with the region Traffic Engineer on types and locations of pedestrian beacons.



Pedestrian beacons

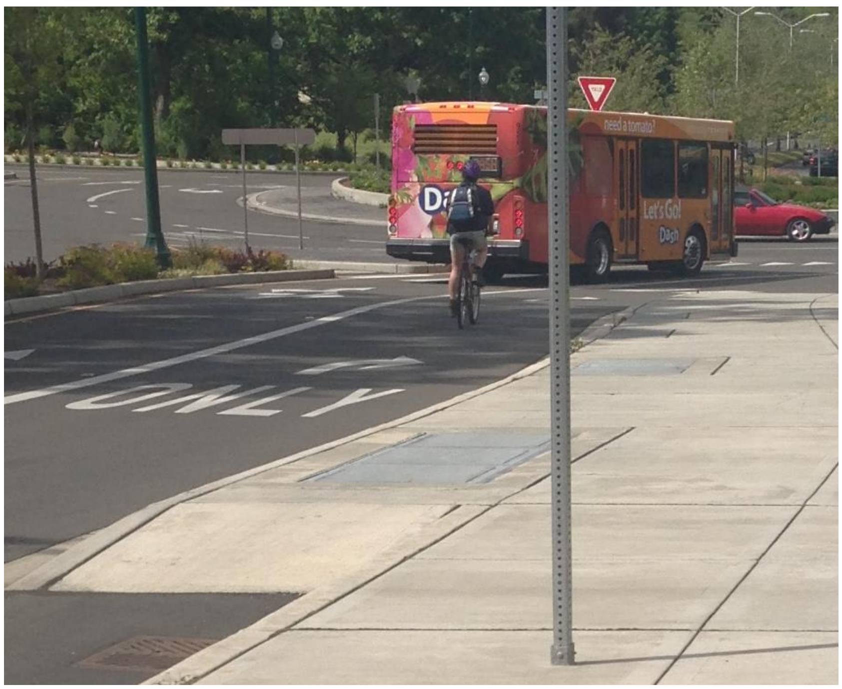
1320.06 Bicycles

Provide bicyclists with similar options to negotiate roundabouts as they have at other intersections. Consider how they navigate either as motor vehicles or pedestrians depending on the size of the intersection, traffic volumes, their experience level, and other factors.

Bicyclists are often comfortable riding through single-lane roundabouts in low-volume environments in the travel lane with motor vehicles, as speeds are comparable and potential conflicts are low.

At larger or busier roundabouts, cyclists may be more comfortable using ramps connecting to a sidewalk around the perimeter of the roundabout as a pedestrian. Where bicycle lanes or shoulders are used on approach roadways, they should end before the geometry changes the approach to the roundabout.

Contact the HQ Design Office for bicycle ramp design options.



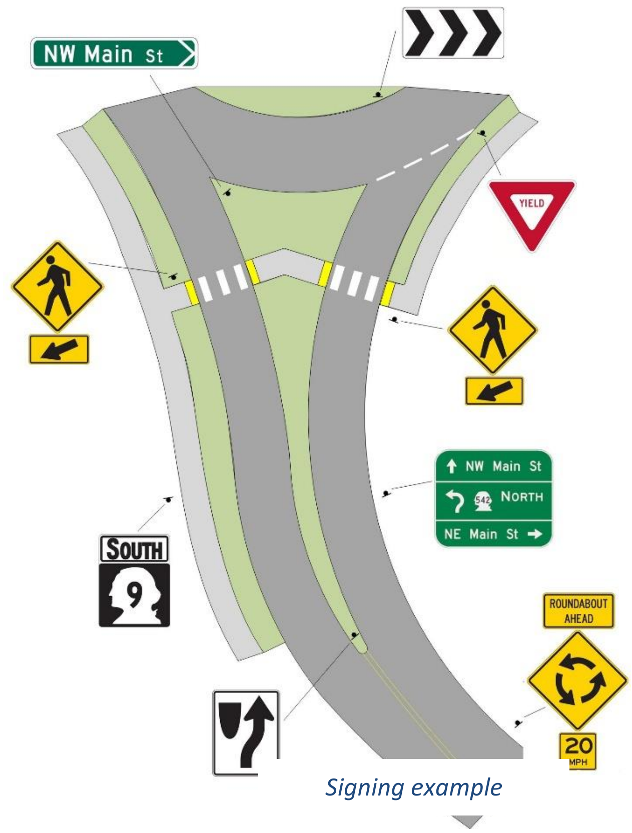
Bicycle rider using lane

1320.07 Signing

The graphic shown is an example of potential signing for a single-lane roundabout. For additional information, refer to the MUTCD, Plan Sheet Library, and the *Standard Plans* for details on signing.

A preliminary sign plan is developed to identify existing and proposed signing on state highways. Sign plans on state routes are to be reviewed and approved by the region Traffic Engineer and then furnished to the HQ Traffic Office for review.

The plan provides an easily understood graphic representation of the signing, and it provides statewide uniformity and consistency for regulatory, warning, and guide signs at roundabouts on the state highway system. For roundabouts located near a port, industrial area, or route that accommodates oversize loads, consider using perforated square steel posts.



Signing example

1320.08 Pavement Marking

See *Standard Plan* M-12.10 for roundabout pavement marking details. Consult region Traffic on traffic pavement markings and materials.

1320.09 Illumination

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. Illuminate raised channelization or curbing. Position the luminaires on the upstream side of each crosswalk to improve the visibility of pedestrians. Light the roundabout from the outside in toward the center. This improves the visibility of the central island and circulating vehicles to motorists approaching the roundabout. Ground-level lighting within the central island that shines upward toward objects in the central island can also improve their visibility. Consult with the region Traffic office for illumination design. (See Chapter 1040 for additional information on illumination.) On higher-speed approaches, consider internally illuminated bollards (IIB) in lieu of other illumination.

1320.10 Road Approach, Parking, and Transit Facilities

Road approach (road or driveway) connections to the circulating roadway are not allowed at roundabouts unless they are designed as a leg to the roundabout. It is desirable 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 corner clearance using the outside edge of the circulating roadway as the crossroad. When minimum corner clearance cannot be met, document the decision in accordance with Chapters 530 and 540.

If a parcel adjoins two legs of the roundabout, it is acceptable to provide a right-in/right-out driveway within the length of the splitter islands on both legs. This provides for all movements; design both driveways to accommodate their design vehicles.

Roadways between roundabouts may have restrictive medians with left-turn access provided with U-turns at the roundabouts.

Parking is not allowed in the circulating roadway or on the entry or exit roadway within the length of the splitter island.

Transit stops are not allowed in the circulating roadway, in the approach lanes, or in the exit lanes prior to the crosswalk. Locate transit stops on the roadway before or after the roundabout, in a pullout, or where the pavement is wide enough that a stopped bus does not block the through movement of traffic or impede sight distance.

Right in / right out driveways

1320.11 Geometric Design Peer Review

Conduct a peer review for new roundabouts and changes to existing roundabouts that either add or reduce capacity, or change the geometric configuration. The Peer review should be held soon after the conceptual roundabout layout is developed.

Invite the following participants:

- Region Traffic Office
- Assistant State Traffic Engineer
- Region Project Development Engineer or Engineering Manager
- Assistant State Design Engineer

The intent of this peer review is to review, discuss, evaluate, and provide feedback on the 2-D roundabout layout design in order to finalize the channelization plan.

1320.12 Documentation and Approvals

Refer to Chapter 300 for design documentation and approval requirements.

1320.13 References

1320.13(1) Federal/State Laws and Codes

See Chapter 1510 for Americans with Disabilities Act Policy and references

Revised Code of Washington (RCW) 47.05.021, Functional classification of highways

Washington Administrative Code (WAC) 468-58-080, Guides for control of access on crossroads and interchange ramps

1320.13(2) Design Guidance

Roundabout Cement Concrete Curbs: *Standard Plan F-10.18-01*

Roundabout Pavement Markings: *Standard Plan M-12.10*

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA, as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

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

1320.13(3) Supporting Information

Roundabouts: An Informational Guide (First edition 2000), FHWA-RD-00-067, USDOT, FHWA http://www.fhwa.dot.gov/publications/research/safety/00067/index.cfm

Roundabouts: An Informational Guide (Second Edition 2010), NCHRP Report 672, Transportation Research Board, 2010 http://nacto.org/docs/usdg/nchrprpt672.pdf

Highway Capacity Manual 2010 (HCM 2010), Transportation Research Board, National Research Council, Washington D.C., 2000

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

"Crash Reductions Following Installation of Roundabouts in the United States," Insurance Institute for Highway Safety, March 2000
🖰 https://www.dot.ny.gov/main/roundabouts/files/insurance_report.pdf

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005
🖰 www.wsdot.wa.gov/research/reports/600/638.1.htm

Chapter 1330 Traffic Control Signals

1330.01 General

Traffic control signals are automated traffic control devices that warn or direct motorists to take a specific action. Traffic control signals are used to control the assignment of right of way at locations where conflicts with motorists, bicyclists, and pedestrians exist or where passive devices such as signs and markings do not provide the necessary flexibility of control to move motorists, bicyclists, and pedestrians in an efficient manner.

The decision to install a traffic signal is the result of an Intersection Control Evaluation (ICE) (see Chapter 1300) that is approved by the region Traffic Engineer or other designated authority.

1330.02 Procedures

1330.02(1) Traffic Signal Permit

State statutes (RCWs) require WSDOT 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 WSDOT 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 signal warrant analysis required by the MUTCD and the department's approval of the installation and type of signal. Permits are required for the following types of signal installations:

- Conventional traffic signals
- Emergency vehicle signals
- Intersection control beacons
- Lane control signals
- Movable bridge signals
- Ramp meter signals
- Pedestrian signals
- Pedestrian Hybrid Beacon signals ("HAWK" signals)
- Temporary traffic signals (only when not being used in place of a permanent, permitted signal)
- Queue-cutter traffic signals

The Permit and its supporting data must be included in the Design Documentation Package (DDP.) The permit is completed by the requesting agency and submitted, complete with supporting data, through the region Traffic Office to the approving authority for approval. See 1330.02(1)(a) for Signal Warrant information required as part of the supporting documentation.

The approving authority is the Regional Administrator or authorized delegate. The approving authority approves or denies the application and sends it back to the region Traffic Office. The region Traffic Office retains a record of the approved permit and supporting data and forwards a copy of the Permit and the supporting data to the State Traffic Engineer at WSDOT Headquarters (HQ). Preserve the approved permit as required by 1330.07 Documentation.

Emergency vehicle signals require annual permit renewal. The region Traffic Office reviews the installation for compliance with requirements. If satisfactory, the permit is renewed by the Regional Administrator with a letter to the operating agency. A copy of this letter is also sent to the State Traffic Engineer.

Permits are not required for portable traffic signals, speed limit sign beacons, stop sign beacons, or lane assignment signals at toll facilities.

A new permit application is required when the level of control is increased, such as changing from an intersection control beacon to a conventional traffic signal or adding an approach to an existing signal system.

For a reduction in the level of control, such as converting a conventional signal to a flashing intersection beacon or removal of the signal, submit the "Report of Change" portion of the traffic signal permit, complete with supporting data, to the approving authority, with a copy to the region Traffic Office and State Traffic Engineer.

If experimental systems are proposed, region Traffic Engineer review and approval is required. The region Traffic Office will send the approved proposal to the State Traffic Engineer for review and approval. The State Traffic Engineer will forward the approved proposal to FHWA for their approval. A copy of the approval from FHWA will be returned and must be preserved as required by 1330.07 Documentation.

Any signal system requiring a permit, with the exception of Ramp Meter signals, also requires Preliminary Signal Plan approval from the WSDOT HQ Traffic Office (see 1330.05).

1330.02(1)(a) Signal Warrants

A signal warrant is a minimum condition that is to be met before a signal may be considered for installation. Satisfying a warrant does not mandate the installation of a traffic signal. The warranting condition(s) supports the inclusion of a traffic signal for consideration as part of the ICE performed during the scoping of the project (see Chapter 1300). For a list of the traffic signal warrants and information on how to use them, see the *Manual on Uniform Traffic Control Devices* (MUTCD). Contact the region Traffic Engineer for region specific practices.

Address all warrants listed in the currently adopted MUTCD as part of the Signal Warrant Analysis. Mark warrants which do not apply as "Not Applicable" and include a basic supporting statement or similar justification. Include the Signal Warrant Analysis in the Signal Permit supporting data. For Warrant 7, the three year period must be used for all traffic signals installed on state highways as described in FHWA Interim Approval IA-19 (https://mutcd.fhwa.dot.gov/resources/interim_approval/ia19/index.htm).

1330.02(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 Exhibit 1330-1). 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 that has been established as identified in the Access Control Tracking System:
http://www.wsdot.wa.gov/design/accessandhearings/

Exhibit 1330-1 Responsibility for Facilities

Responsibility for Various Types of Facilities on State Highways				
Area	**Responsibility**	**Emergency Vehicle Signals**	**Traffic Signals, Pedestrian Signals, & Intersection Control Beacons**	**Reversible Lane Signals & Movable Bridge Signals**
Cities with a population of 27,500 or greater	Finance Construct Maintain Operate	ESD [1] ESD [1] ESD [1] ESD [1]	City [2] City [2] City [2] City [2]	City [2] City [2] City [2] City [2]
All other locations	Finance Construct Maintain Operate	ESD [1] ESD [1] ESD [1] ESD [1]	State/County [3] /Other [4] State/County [3] /Other [4] State State	State State State State

Notes:
[1] ESD refers to the applicable Emergency Service Department.
[2] Does not apply to state highways with established limited access control (see 1330.02(2)(c)).
[3] Beyond corporate limits due to county activity (see 1330.02(2)(d)).
[4] Other refers to signals proposed by or required due to third party activity (see 1330.02(2)(g)).

(a) **Inside the corporate limits of cities with a population of 27,500 or greater where there is no established limited access control:** The city is responsible for the funding, construction, maintenance, and operation of traffic signals. Population figures can be found at: www.ofm.wa.gov/pop/

(b) **Inside the corporate limits of cities with a population of less than 27,500:** WSDOT is responsible for funding, construction, maintenance, and operation of traffic signals. Population figures can be found at: www.ofm.wa.gov/pop/

(c) **Inside the corporate limits of cities with a population of 27,500 or greater where there is established limited access control:** WSDOT is responsible for funding, construction, maintenance, and operation of traffic signals. Population figures can be found at: www.ofm.wa.gov/pop/

(d) **Outside the corporate limits of cities and outside established limited access control areas:** WSDOT is responsible for funding, construction, maintenance, and operation of a traffic signal when a new state highway crosses an existing county road. When a new county road intersects an existing state highway, WSDOT is responsible for only the maintenance and operation of a traffic signal. The county is responsible for the construction costs of the traffic 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 50%. The state is responsible for maintenance and operation (WAC 468-18-040).

(e) Outside the corporate limits of cities and inside established limited access control areas: WSDOT 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 WSDOT is responsible for traffic signals and third party activity justifies the installation of a traffic signal, as determined by an ICE, the following rules apply:

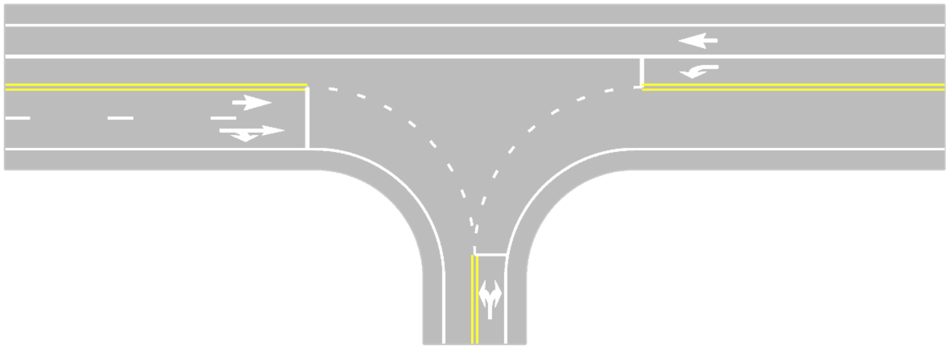
- The third party is responsible for funding the design and construction of the traffic signal system, unless another arrangement is agreed upon with WSDOT.
- The third party obtains a traffic signal permit.
- The third party agrees to design and construct the traffic signal in conformance with WSDOT's guidelines and requirements.
- The third party agrees to submit the design and construction documents to WSDOT for review and approval by the region Traffic Engineer.
- Preserve all third party provided documents and any third party agreement(s) as required by 1330.07 Documentation.

1330.03 Intersection Design Considerations

Signalized intersections require different design considerations than non-signalized intersections. These elements should be considered as early as the ICE process (see Chapters 1300 and 1310 for further guidance.) This Section discusses basic intersections with relatively simple geometry. For more complex or innovative intersection layouts such as Diverging Diamond Interchanges, Displaced Left Turns, or Single Point Urban Interchanges, contact the WSDOT HQ Traffic Office for support.

Consider providing an unrestricted through lane on the major street of a T intersection (sometimes referred to as a Continuous Green "T" (CGT) intersection). This design allows for one traffic movement to flow without restriction. When this is used on through roadways with a posted speed of 45 MPH or greater, the through lane must be separated by a physical barrier or the through movement must also be signalized. If there is a crosswalk across the through lane, the through lane must be signalized. Exhibit 1330-2 shows an example of a CGT intersection.

Exhibit 1330-2 Example Continuous Green "T" (CGT) Intersection Layout



1330.03(1) Left Turns

It is recommended that a left turn storage lane be provided for all main line roadways where left turns are allowed. This helps to avoid having stopped traffic in a through lane with a green through signal display. This also helps to support potential future changes in left turn operations. See Section 1330.06(1) for additional discussion.

Left-turning traffic can operate more efficiently when the opposing left-turn lanes are directly opposite each other. When a left-turn lane is offset into the path of an opposing through lane, the left-turning driver may assume the opposing vehicles are also in a left-turn lane and fail to yield. To prevent this occurrence, less efficient split phasing may be necessary. (See Chapter 1310 for guidance on lane offsets and opposing left-turn clearance.) Where there are opposing through lanes but no opposing left turn lane, install a striped or raised median area opposite the left turn lane if possible.

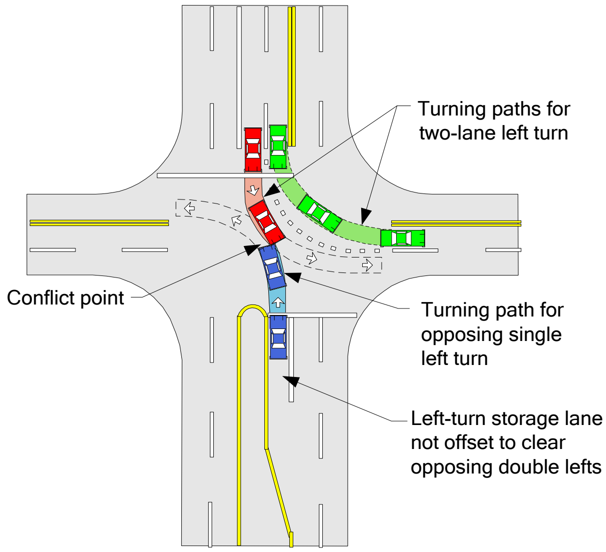
Place stop lines so that they are out of the path of conflicting left turns. Check the geometric layout by using turning templates or a computerized vehicle turning path program (such as AutoTURN®) to determine whether the proposed layout and phasing can accommodate the design vehicles. Also, check the 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. The intersection should be large enough to accommodate opposing left turning vehicle paths with a 4-foot minimum (12-foot desirable) separation between them. Where this separation cannot be achieved, less efficient signal phasing may be required to accommodate opposing left turns.

Some intersections may have multi-lane left turns. At locations with closely spaced intersections, a multi-lane left-turn storage area might be the only solution to reduce the potential for the left-turn volume to back up into an adjacent intersection. As with single left turn lanes, the intersection should be large enough to accommodate opposing left turning vehicle paths with a 4-foot minimum (12-foot desirable) separation between them. Where this separation cannot be achieved, less efficient signal phasing may be required to accommodate opposing left turns.

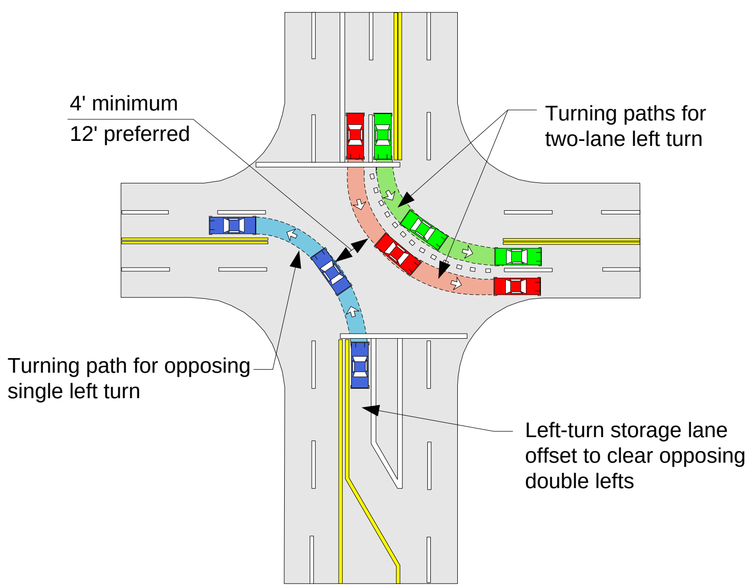
At smaller intersections, the opposing single-lane left-turn movement might not be able to turn during the two-lane left-turn phase and it might be necessary to reposition this lane. If the opposing left turns cannot time together, the reduction in delay from the two-lane left-turn phase is likely to be nullified by the requirement for a separate opposing left-turn phase. Exhibit 1330-3 shows two examples of two-lane left turns with opposing single-left arrangements.

Two receiving lanes are required for two-lane left-turn movements. In addition, these receiving lanes are to extend well beyond the intersection before reducing to one lane. A lane reduction immediately beyond the intersection can cause delays and backups into the intersection because the left-turning vehicles usually move in dense platoons, which may make merging and lane changes difficult. (See Chapter 1310 for guidance on lane reductions on intersection exits.)

Exhibit 1330-3 Left-Turn Lane Configuration Examples



Left-Turn Lane Configuration Preventing Concurrent Phasing
Single left turn lane not offset – overlapping left turn paths



Left-Turn Lane Configuration With Concurrent Phasing
Offset single left turn lane – opposing lefts no longer in conflict

1330.03(2) Right Turns

Large right-turn curb radii at intersections sometimes have impacts on traffic signal operation. Larger radii allow faster turning speeds and might move the pedestrian entrance point farther away from the intersection area. Pedestrian crossing times are increased because of the longer crossing, thereby reducing the amount of time available for vehicular traffic. (See Chapter 1310 for guidance on determining these radii.)

At intersections with large right-turn radii, consider installing raised traffic islands. These islands are primarily designed as pedestrian refuge areas. (See Chapter 1510 for pedestrian refuge islands and traffic island designs.) Traffic islands may decrease the required pedestrian clearance intervals; however, large radii and raised traffic islands may make it difficult for pedestrians to navigate the intersection. Where pedestrians are expected to cross a right turn lane to a traffic island, it is recommended to use a compound right turn-lane design as shown in Chapter 1310.

1330.03(3) Pedestrian Features

See Chapter 1510.

1330.03(4) Road Approaches and Driveways

If roadway approaches and driveways are located too close to an intersection, the traffic from these facilities can affect signal operations. Consider eliminating the accesses or restricting them to “right in/right out”. If a driveway or road approach is directly opposite a leg of the intersection, that approach may be signalized. If the approach is signalized, it must be signalized as if it were a standard intersection leg, and the pedestrian crossing across the approach must also be signalized as if it were a standard crosswalk.

Management of driveways and road approaches should be determined early (preferably no later than scoping) so that they can be considered and addressed in the design. (See Chapters 530 and 540 for further guidance.) Consider shifting the location of advance detection upstream to clear an access point so that vehicles entering from the access point will not affect detection and operation of the signal.

1330.03(5) Skewed Intersections

Skewed intersections, because of their geometry, are challenging to signalize and delineate. Where feasible, modify the skew angle to provide more normal approaches and exits. In many cases, the large paved areas for curb return radii at skewed intersections can be reduced when the skew angle is reduced. (See Chapter 1310 for requirements and design options.) Visibility of pedestrians is of particular concern, and must also be taken into consideration.

1330.03(6) Transit Stops

Transit stop and pullout locations should be located on the far side of the intersection to minimize their impacts on signal operation. (See Chapter 1430 for transit stop and pullout designs.)

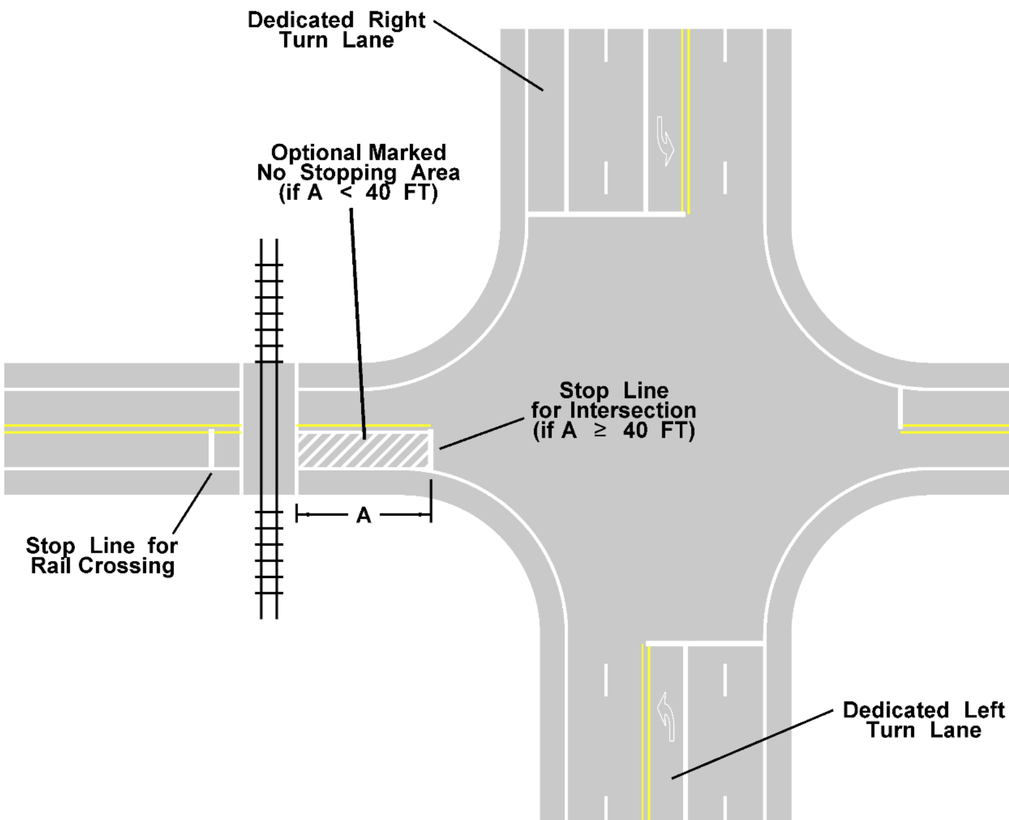
1330.03(7) Railroad Crossings

Where railroad preemption is used at a signalized intersection, install left and right turn lanes for the movements leading to the leg of the intersection with the railroad crossing if possible. This greatly improves the efficiency of the signal during railroad preemption when turns are restricted. Also consider providing a left-turn lane for the minor leg opposing the railroad crossing. This will allow for more effective signal operations during long periods of railroad preemption.

Where there is less than 40 feet between the nearest rail and the normal location of the stop line, do not install a stop line between the tracks and the intersection. Use the same stop line for the traffic signal and the rail crossing instead. Exhibit 1330-4 shows recommended intersection features for intersections near rail crossings.

Contact the WSDOT HQ Traffic Office for assistance with standalone queue-cutter signals.

Exhibit 1330-4 Recommended Features for Intersections near Rail Crossings



1330.04 Conventional Traffic Signal Design

1330.04(1) General

The goal of any traffic 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.

An advanced signalized intersection warning sign and beacon assembly to warn motorists of a signalized intersection should be installed when either of the two following conditions exists:

(a) The visibility requirements in the MUTCD are not achievable.

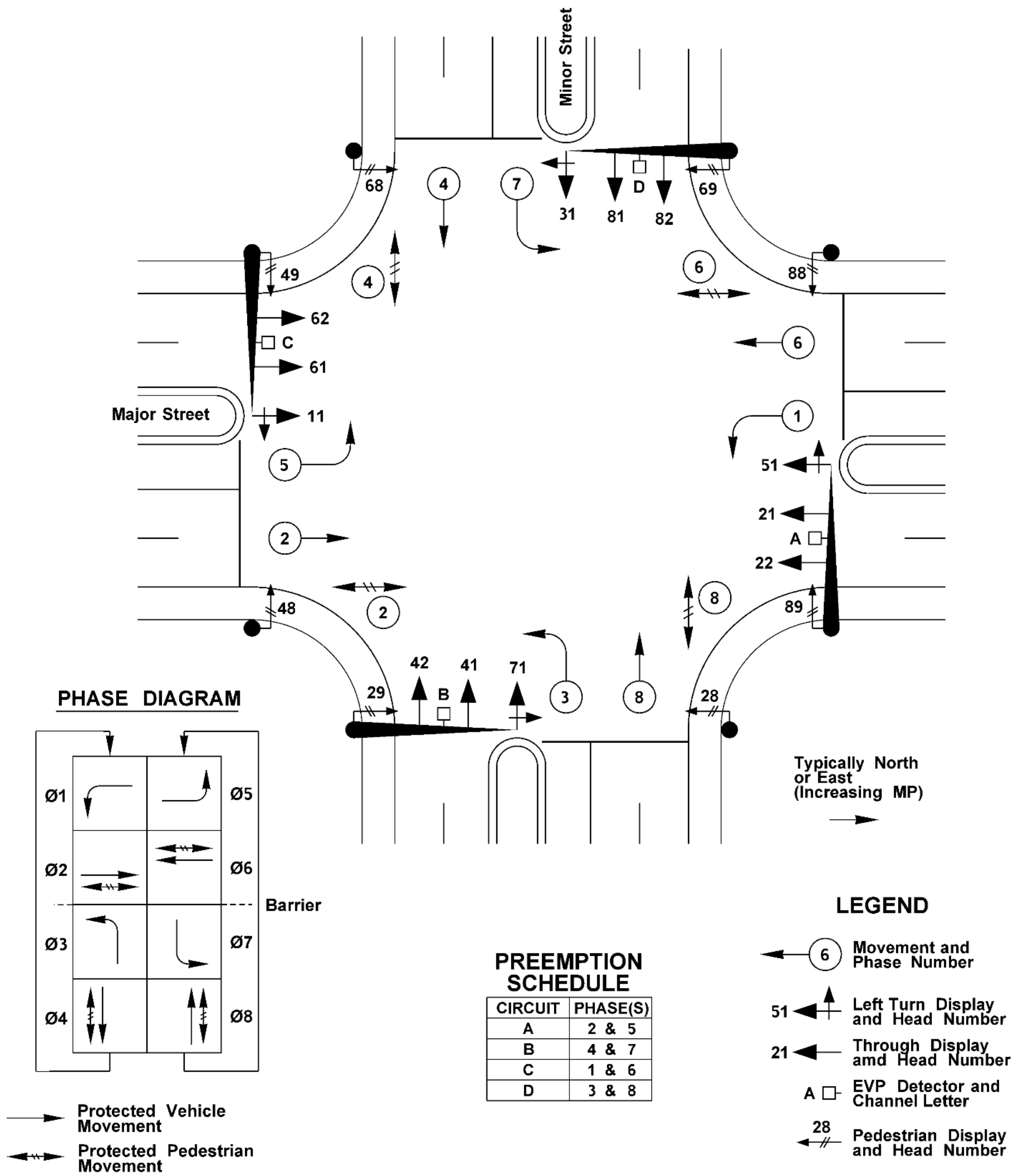
(b) The posted speed is 55 mph or higher and the next nearest signalized intersection is more than 2 miles away; this does not apply to freeway off-ramps.

This warning sign and beacon assembly consists of a W3-3 sign with Type IV reflective sheeting and one or two continuously flashing beacons. Where two beacons are used, the beacons should flash alternately instead of simultaneously. Locate the sign in advance of the intersection in accordance with Table 2C-4 (Condition A) of the MUTCD. The warning sign and beacon assembly may be omitted with approval from the region Traffic Engineer.

1330.04(2) Signal Phasing

With some exceptions, the fewer the traffic signal phases, the more efficient the operation of the traffic signal. The number of phases required for efficient operation is related to intersection geometrics, traffic volumes, composition of traffic flow, turning movement demands, and desired level of driver comfort. The traffic movements at an intersection have been standardized to provide consistency in both traffic signal design and driver expectations. (See Exhibit 1330-5 for standard intersection movements, signal head (display) numbering, and standard phase operation.)

Exhibit 1330-5 Standard Intersection Movements, Head Numbers, and Phase Operation



PREEMPTION SCHEDULE

CIRCUIT	PHASE(S)
A	2 & 5
B	4 & 7
C	1 & 6
D	3 & 8

For WSDOT operated signals, the region Signal Operations Engineer will develop the signal phasing plan or review proposed phasing for systems designed by others. For signals operated by other jurisdictions, the operating jurisdiction should be involved in signal phasing development. Phasing development is addressed in 1330.06 Operational Considerations for Design. Phasing development should begin as soon as the decision is made to install a traffic signal and may begin as early as the intersection control evaluation. Provide the proposed channelization plans and traffic count data to the region Signal Operations Engineer or phasing designer as early as possible, as phasing information is required to complete the signal system design.

For WSDOT owned and operated signals, vehicle and pedestrian movement phase numbering is standardized to provide uniformity in signal phase numbering, signal display numbering, preemption channel identification, detection numbering, and circuit identification. For signals owned and operated by other jurisdictions, refer to that jurisdiction’s guidelines for phase and equipment numbering. The following are general guidelines for the WSDOT numbering system:

1. Phases 2 and 6 are normally assigned to the major street through movements, with phase 2 assigned to the northbound or eastbound direction of the major street. This results in phase 2 being aligned with the direction of increasing mileposts.
2. Phases 1 and 5 are normally assigned to the major street protected left-turn movements.
3. Phases 4 and 8 are normally assigned to the minor street through movements, with phase 4 normally assigned to the approach to the left of the phase 2 approach (as viewed from the phase 2 stop line).
4. Phases 3 and 7 are normally assigned to the minor street protected left-turn movements.
5. Phasing on new signals installed within an already signalized corridor should be assigned to match the existing corridor phasing – even if it doesn’t follow the standard phasing conventions listed above.
6. At T intersections, the movement on the stem of the T is normally assigned to either phase 4 or phase 8. Which phase is used will normally depend on the major street phase assignments.
7. At intersections where split phasing is used (opposing directions time separately) assign phases normally but show the split phase phasing diagram, unless otherwise directed by maintenance and operations staff.
8. Signal displays are numbered as follows:

    a. The first number indicates the signal phase and the second number is the number of the signal head, counting from centerline (or left edge line) to the right edge line of the approach. For example, signal displays for phase 2 are numbered, as viewed from left to right, 21, 22, 23, and so on. If the display is an overlap, the designation is the letter assigned to that overlap. For example, signal displays for overlap A are number A1, A2, A3, and so on.

    b. 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. For example, a protected/permissive signal display for phase 1 (the left-turn movement) and phase 6 (the compatible through movement) is numbered 61/11. For overlap right turns, the protected portion may either be an overlap phase, or it may be the same phase as the complementing left turn phase.

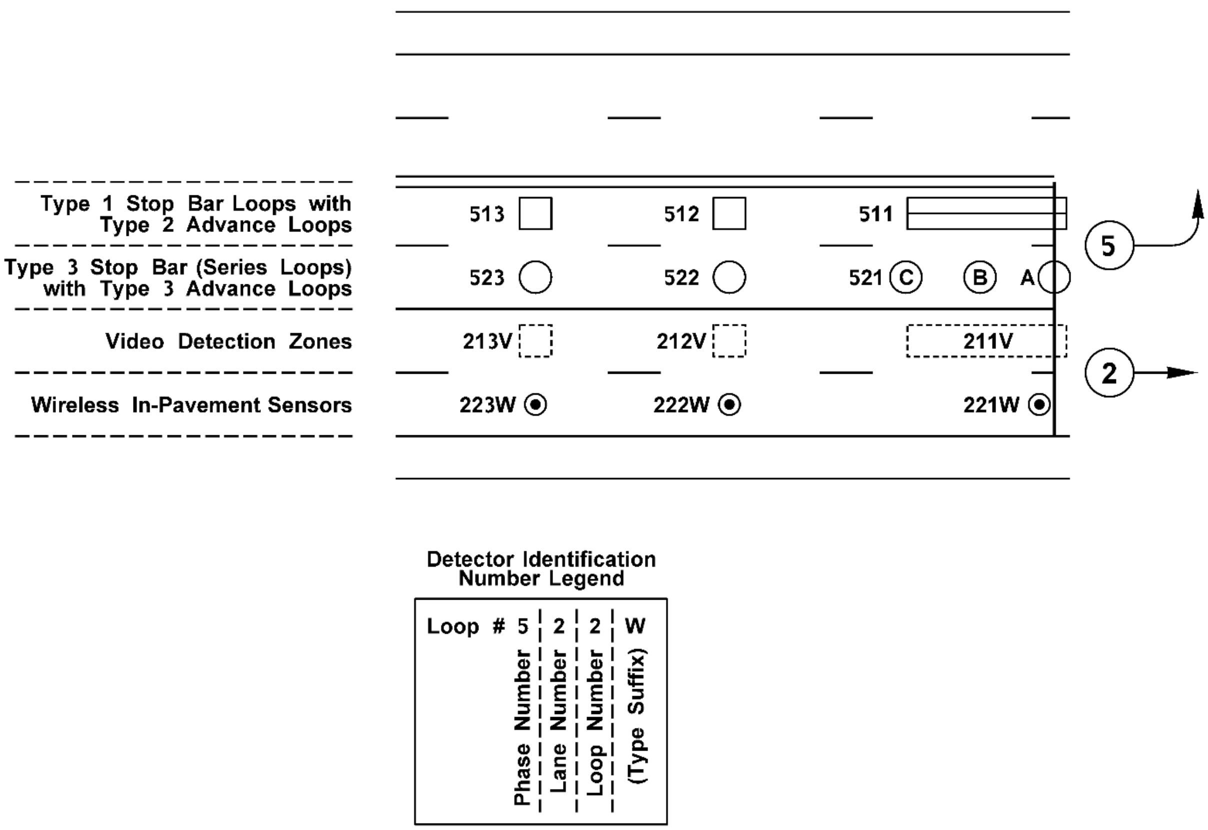
       With a conventional protected/permissive left-turn display, the circular red, yellow, and green displays are connected to the through phase (phase 6, in this example) controller output and the steady yellow and green arrow displays are connected to the left turn phase (phase 1, in this example) controller output.

       When a flashing yellow arrow display is used, coordinate with the Signal Operations Engineer and signal maintenance group to determine appropriate wiring. For new cabinets, always specify an auxiliary output rack when protected/permissive phasing will be used.

9. Pedestrian displays and detectors are numbered with the first number indicating the signal phase and the second number as either an 8 or 9. For example, pedestrian displays and detectors 28 and 29 are assigned to phase 2. If there are more than two displays or detectors for a single pedestrian phase, use letter suffixes for additional displays and detectors (28A / 29A, 28B / 29B, etc.).
10. Vehicle detector numbering depends on the type of detection:
    a. Induction loop detectors use three digit numbers for designation. The first number represents the phase. The second number represents the lane number, starting from the left lane and moving towards the right edge line. The third number represents the loop number counting from the stop line back. For example, detection loops for phase 2 detectors are numbered 211, 212, 213 for lane 1; 221, 222, 223 for lane 2; and so on. For loops tied together in series for a single detection channel, such as a three loop series stop line detector, the individual loops in the series use a letter suffix. For a stop line detector in lane 1 for phase 2, using three loops in series, the loops would be designated 211A, 211B, and 211C.
    b. Video detectors are designated V#, where "#" is the through phase number for that approach, even if it will cover additional phases (such as left turn or overlap) for that approach. If the video detector is for advance detection, the suffix "A" is added. For example, the advance video detector for phase 6 would be V6A.

       Video detection zones may be drawn on the contract plans if desired, but these will normally be field established and adjusted and may not end up as shown in the plans. If used, video detection zones are labeled the same as loop detectors, but with a "V" suffix. For example, the stop line video detection zone for phase 5 would be 511V.
    c. Radar detectors are designated similar to video detectors, but use an "R" prefix in place of the "V". For example, the advance radar detector for phase 4 would be R4A.
    d. Wireless in pavement sensors use the same numbering scheme as induction loops, but add a "W" suffix. For example, the phase 7 stop line sensor would be 711W.
    e. Exhibit 1330-6 shows examples of standard detector numbering.
11. Emergency vehicle detectors use letter designations: Channel A detectors cover phase 2 and phase 5; Channel B detectors cover phase 4 and phase 7; Channel C detectors cover phase 1 and phase 6; and Channel D detectors cover phase 3 and phase 8. When there are multiple detectors for the same channel, the first detector uses the letter, and all other detectors use a number suffix (C, C1, C2, etc.).

Exhibit 1330-6 Detector Numbering Examples



1330.04(3) Vehicle Signal Displays

Signal displays are the devices used to convey right of way assignments and warnings from the signal controller 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, concise, and uniform manner.

The use of ball, steady arrow, or flashing yellow arrow displays is dependent upon the signal phasing. Use the approved signal phasing diagram to determine which display types can be used for which movements. Typical vehicle signal displays are shown in Exhibits 1330-7a through 7h. In addition to the display requirements contained in the MUTCD, the following also apply:

1. A minimum of two indications for the through movement, if one exists at an intersection, must be provided - even if it is not the primary (predominant) movement. Provide a minimum of two indications for the major signalized turn movement of an intersection if no through movement exists, such as on the stem of a T intersection. These signal faces are to be spaced a minimum of 8 feet apart. At a T 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. At an intersection where left turns are prohibited, the leftmost through display may use a green up arrow in place of the green ball display. At an intersection where right turns are prohibited, the rightmost through display may use a green up arrow in place of the green ball display.

2. All displays for an approach, regardless of phase served, are to be a minimum of 8 feet apart.
3. Locate displays directly overhead and centered over the associated lane of the applicable vehicular traffic as it moves through the intersection. (See Exhibits 1330-7a through 7h for signal head locations.) For intersections with a skew for through traffic, locate signal displays for through traffic in one of the following ways:

   a. Over the center of the outbound (far side) lane

   b. Over a line drawn between the center of the approaching lane and the center of the associated outbound lane, ending at the stop lines

   Left turn displays may either be located relative to the through displays or in line with approaching traffic, dependent on ability to mount the display(s). (See Exhibit 1330-8 for skew placement examples.)
4. Locate displays a minimum of 50 feet and a maximum of 180 feet from the stop line. The preferred location of the signal heads is between 60 and 120 feet from the stop line. When the nearest signal face is located between 150 and 180 feet beyond the stop line, engineering judgment of conditions, including worst-case visibility conditions, is to be used to determine whether the provision of a supplemental or nearside signal face would be beneficial. When it is not physically possible to locate displays at least 50 feet from the stop line, the distance to the displays may be reduced as follows:

   a. 3-section vertical and 5-section cluster (doghouse) displays may be located between 40 and 50 feet from the stop line.

   b. 4-section vertical displays may be located between 41 and 50 feet from the stop line.

   c. 5-section vertical displays may be located between 45 and 50 feet from the stop line.

   The distances listed above are the minimums required to maintain 16.5 feet of clearance over the roadway with a backplate installed.

   Overhead displays should always be located on the far side of the crossing roadway for the best visibility. Locating overhead displays on the near side of the roadway results in issues with visibility and driver compliance with stop lines. When an overhead display is located on the near side of the crossing roadway, the stop line typically has to be pushed back so that the minimum visibility distance is met. However, this also pushes the stop line back too far for drivers to see cross traffic, resulting in drivers creeping past the stop line towards the intersection – especially for turning traffic. This results in both the driver being stopped past the stop line and being unable to see the signal displays.

   For ramp meter signals, place Type RM signal standards and displays at the stop line.
5. Use vertical vehicle-signal display configurations. Horizontal displays are not allowed unless clearance requirements cannot be achieved with vertical displays or unless they are being installed at an intersection to match other displays in the intersection. Approval by the State Traffic Engineer is required for the installation of horizontal displays.
6. Use 12-inch signal sections for all vehicle displays except the lower display for a post mounted ramp meter signal.
7. Provide displays for turning movements with dedicated lanes as follows:

a. For protected movements, use all arrow displays.

b. For protected / permissive movements, use four section arrow displays. Alternatively, a shared five section cluster (doghouse) display may be used for both the turn lane and the adjacent through lane. Note: A three section arrow display, with bi-modal flashing yellow arrow / steady green arrow may be used in cases where windload or vertical roadway clearance will not allow for the use of a four-section display. If vertical clearance can be accommodated through adjustments to the signal display mount, such as mounting the Type M mount between different display sections, a four section arrow display should be used.

c. For permissive right turns, a three-section arrow display with flashing yellow arrow (Exhibit 1330-7g) is optional. This display is highly recommended where there are concerns regarding permissive right turns and the conflicting pedestrian crossing movement, such as known incidents or high volumes of both pedestrian crossings and right turn movements.

8. Use steady green 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. At T intersections, steady green arrow displays may not be used for a movement that has a conflicting pedestrian movement.

9. Use either Type M or Type N mountings for vehicle display mountings on mast arms, as directed by the region maintenance staff or owning agency. 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.

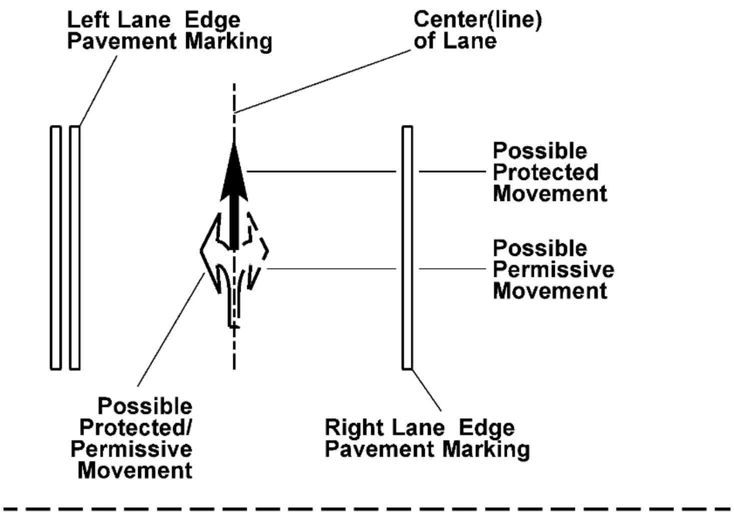
10. Use backplates for all overhead-mounted displays for new, updated, or rebuilt signal faces. Add backplates to all existing signal displays that do not already have them.

11. Use Type E mountings for pedestrian displays mounted on signal standard shafts unless otherwise approved by region maintenance staff or the owning agency.

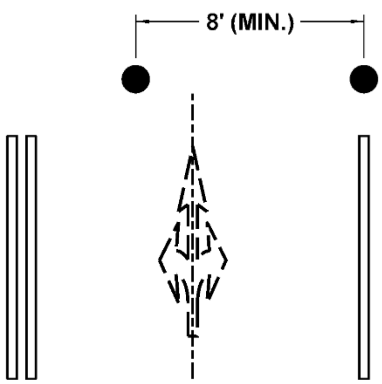
12. Include supplemental signal displays when the approach is in a horizontal or vertical curve and the intersection visibility requirements of this section and the MUTCD cannot be met, unless approved otherwise by the region Traffic Engineer.

    Supplemental far side displays are recommended at intersections with higher truck volumes, as the trucks will frequently block visibility of overhead displays for following drivers. Supplemental far side protected left turn displays are recommended for long left turns.

Exhibit 1330-7a Signal Display Placements – Key to Diagrams

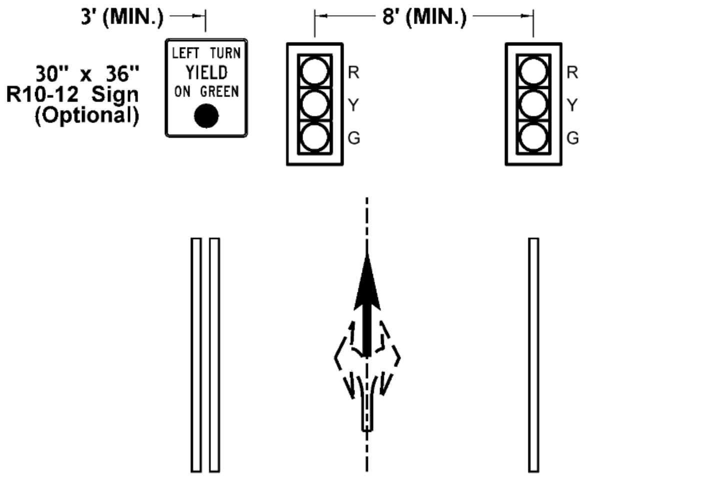


Pavement markings are used to represent possible lane lines and vehicular movements.
The lane lines shown are typical, but not necessarily required.

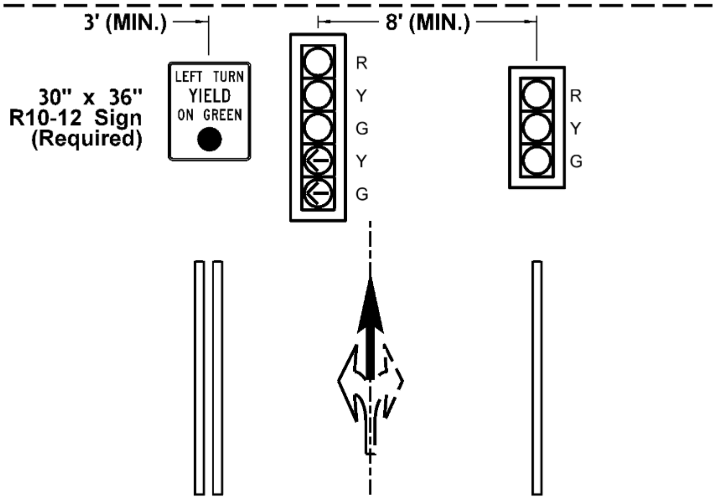


All signal mounts must be a minimum of 8 feet apart, measured center to center.
This example shows typical mount locations for a single approach lane.

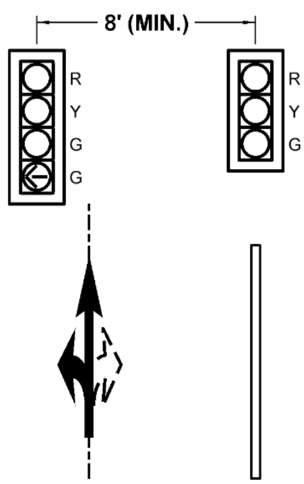
Exhibit 1330-7b Signal Displays for Single Lane Approach



Single lane approach with permissive (or no left turns).
R10-12 sign optional.
Where left turns are prohibited, install a 30” x 30” R3-2 No Left Turn (Symbol) Sign in place of the R10-12 sign shown here.

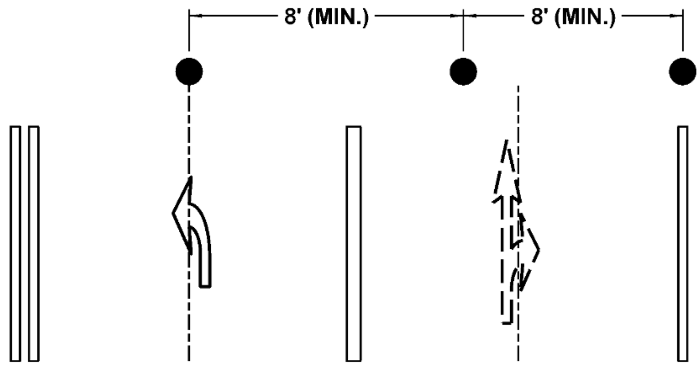


Single lane approach with protected / permissive left turns.
R10-12 sign required.

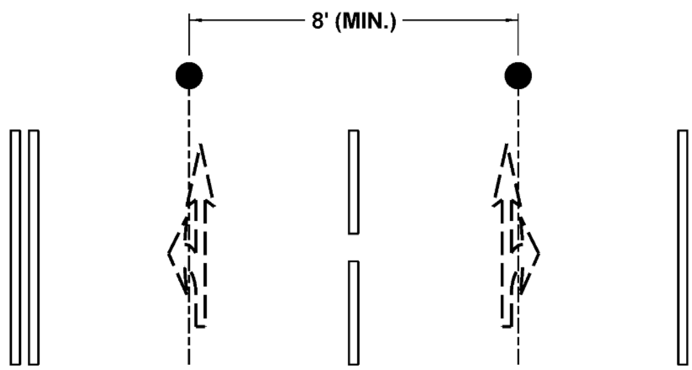


Single lane approach with protected left turns.

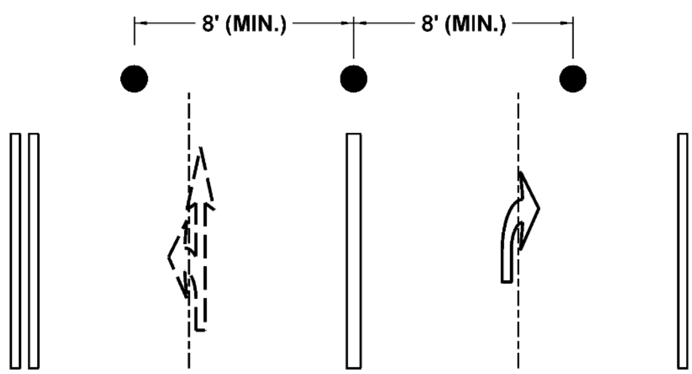
Exhibit 1330-7c Signal Display Mounting Locations for Multi-Lane Approaches



Single through lane with left turn lane(s).
Through lane displays arranged the same as for a single lane approach.
Left turn display(s) centered over lane(s).

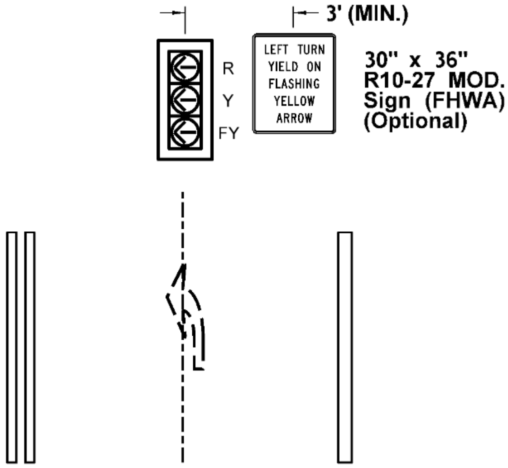


Multiple through lanes.
Center displays over each lane.

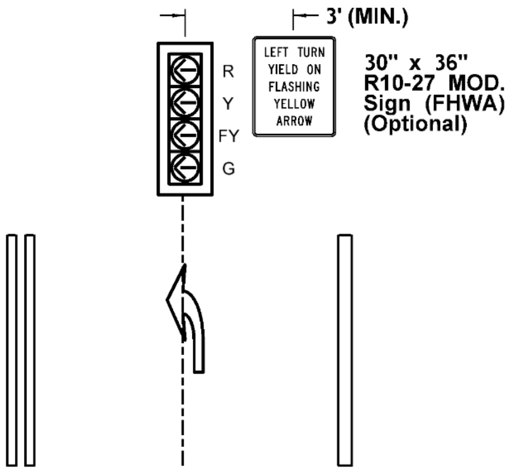


Single through lane with right turn lane(s).
Through lane displays arranged the same as for a single lane approach.
Ensure that the 8-foot spacing requirement is met if a right turn display is installed overhead.

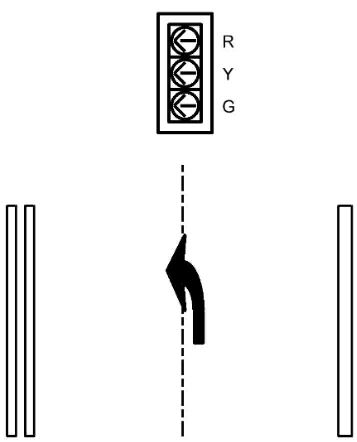
Exhibit 1330-7d Signal Displays for Dedicated Left Turn Lanes



Dedicated left turn lane with permissive left turns.
R10-27 (Modified) sign optional.

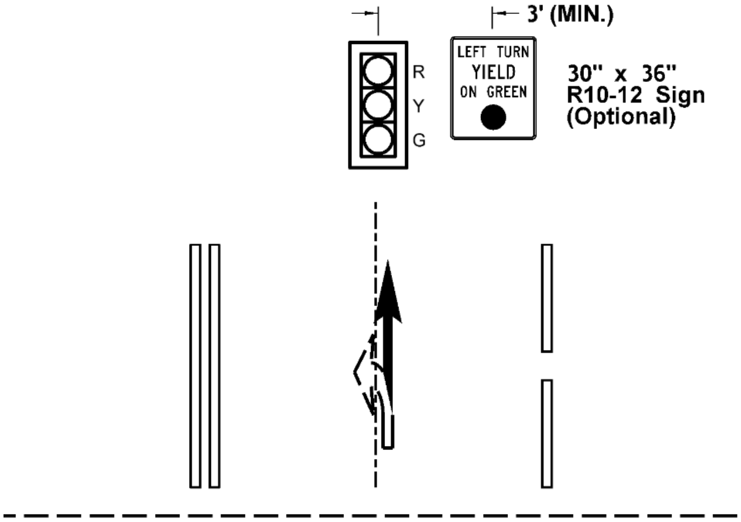


Dedicated left turn lane with protected / permissive left turns.
R10-27 (Modified) sign optional.

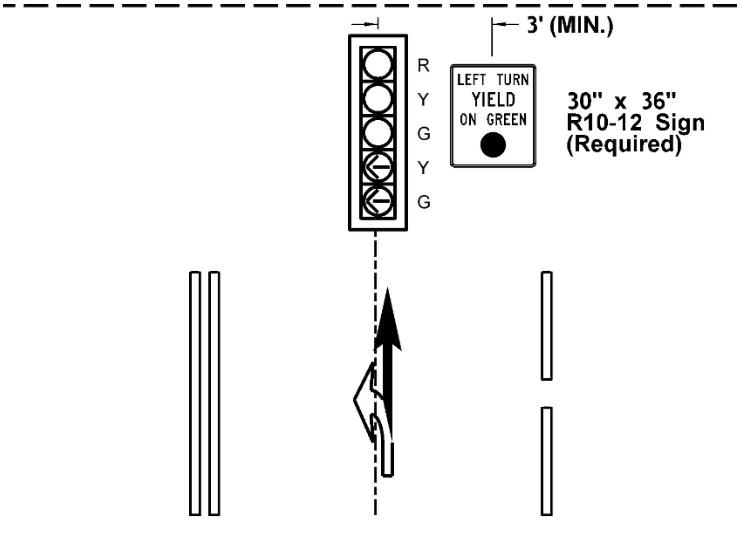


Dedicated left turn lane with protected left turns.

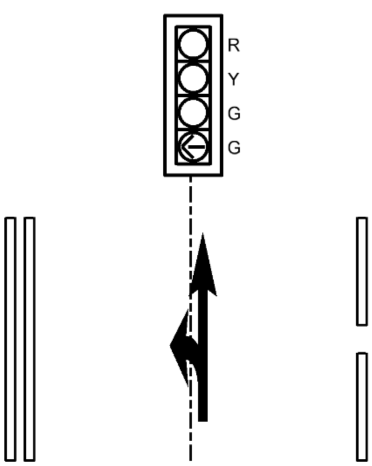
Exhibit 1330-7e Signal Displays for Shared Through-Left Lanes – Multiple Through Lanes



Shared through-left lane with permissive left turns.
R10-12 sign optional.

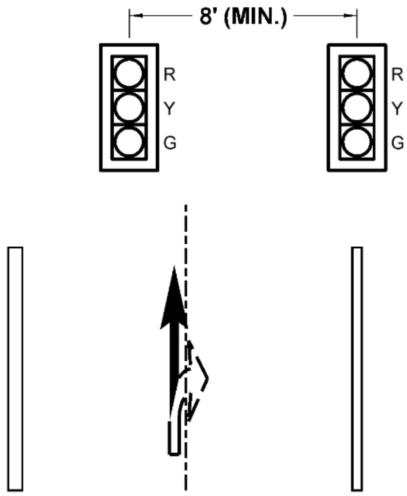


Shared through-left lane with protected / permissive left turns.
R10-12 sign required.

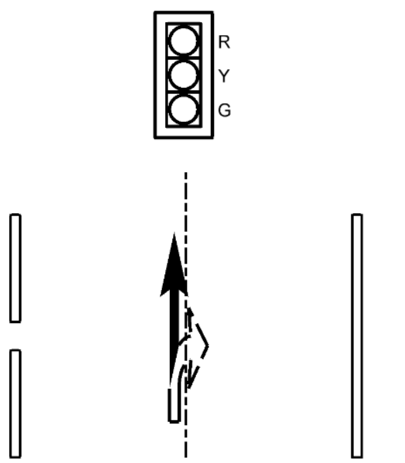


Shared through-left lane with protected left turns.

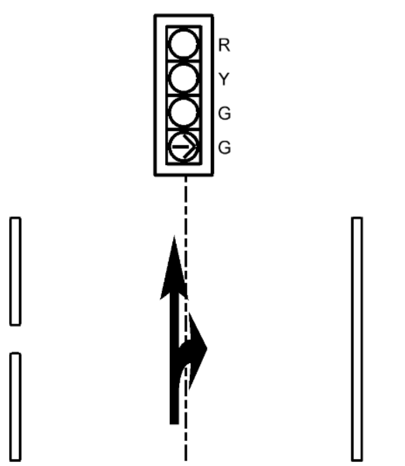
Exhibit 1330-7f Signal Displays for Shared Through-Right Lanes



Single shared through-right lane with permissive right turns.

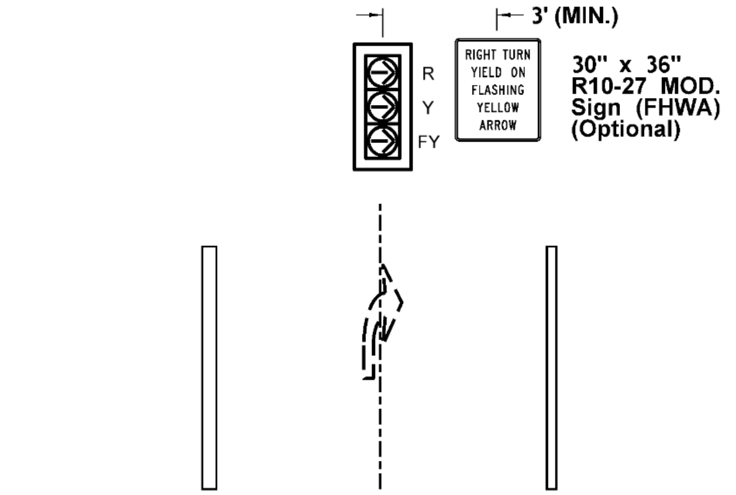


Shared through-right lane, multiple through lanes, with permissive right turns.

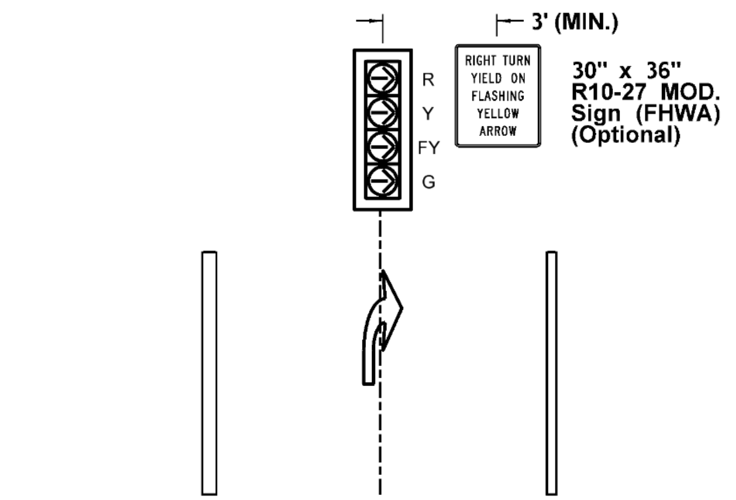


Shared through-right lane, multiple through lanes, with protected right turns.
For protected / permissive right turns, mirror protected / permissive left turn display from Exhibit 1330-7e.

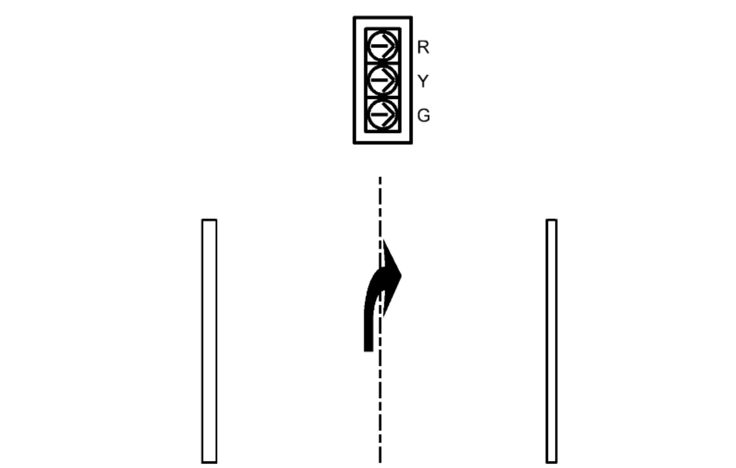
Exhibit 1330-7g Signal Displays for Dedicated Right Turn Lanes



Dedicated right turn lane with permissive right turns.
R10-27 (Modified) sign optional.

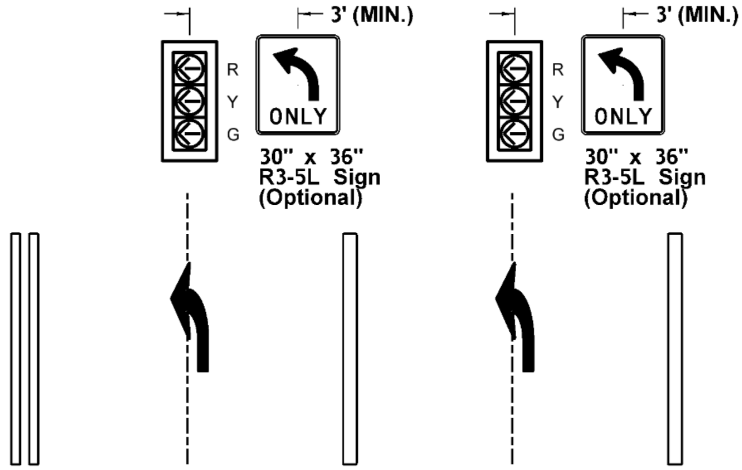


Dedicated right turn lane with protected / permissive right turns.
R10-27 (Modified) sign optional.

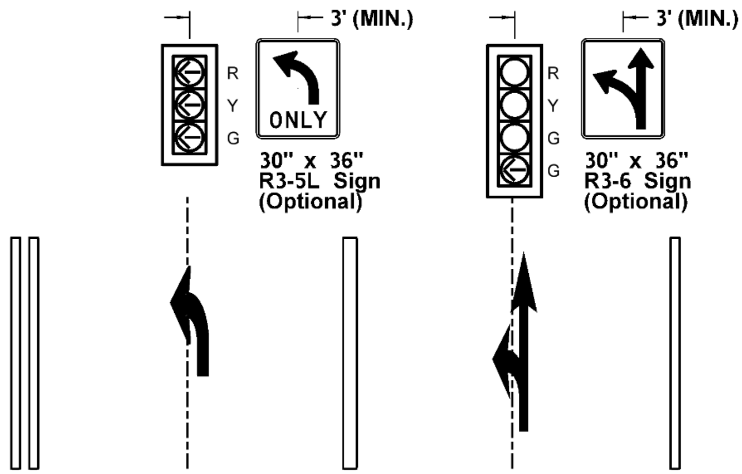


Dedicated right turn lane with protected right turns.

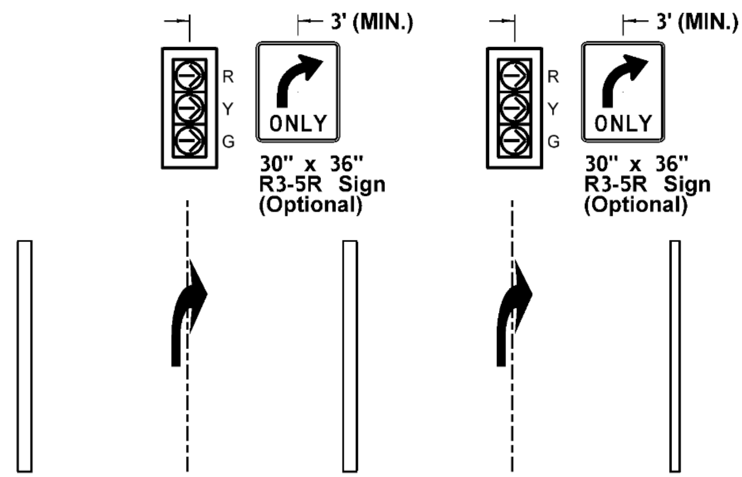
Exhibit 1330-7h Signal Displays for Multiple Turn Lanes



Multiple left turn lanes.
R3-5L signs optional.

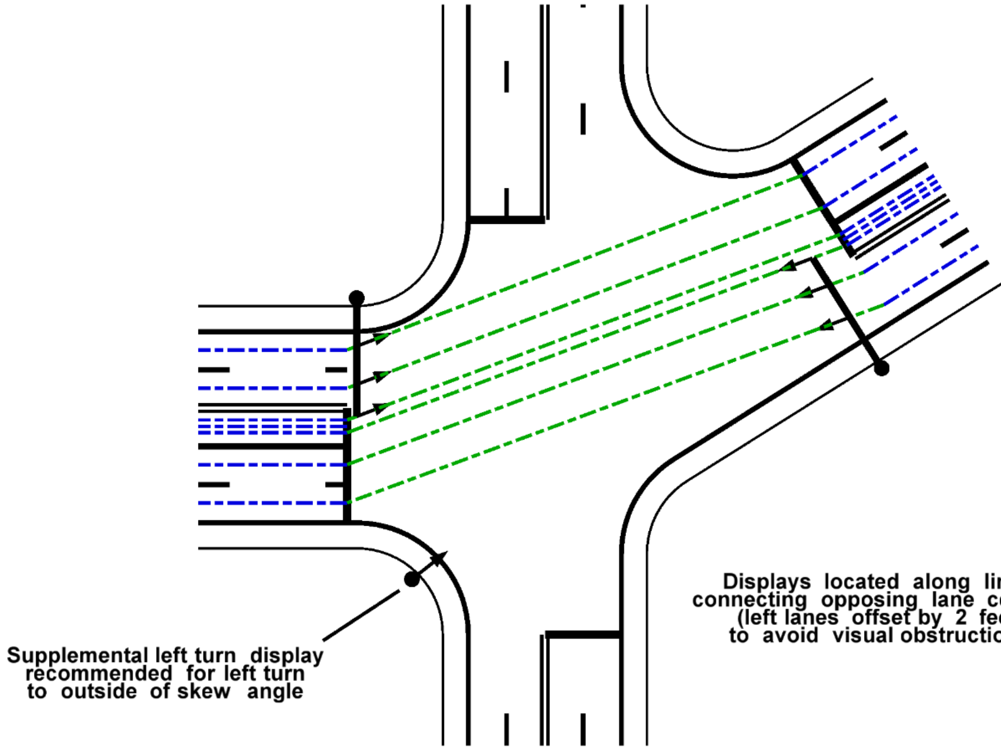


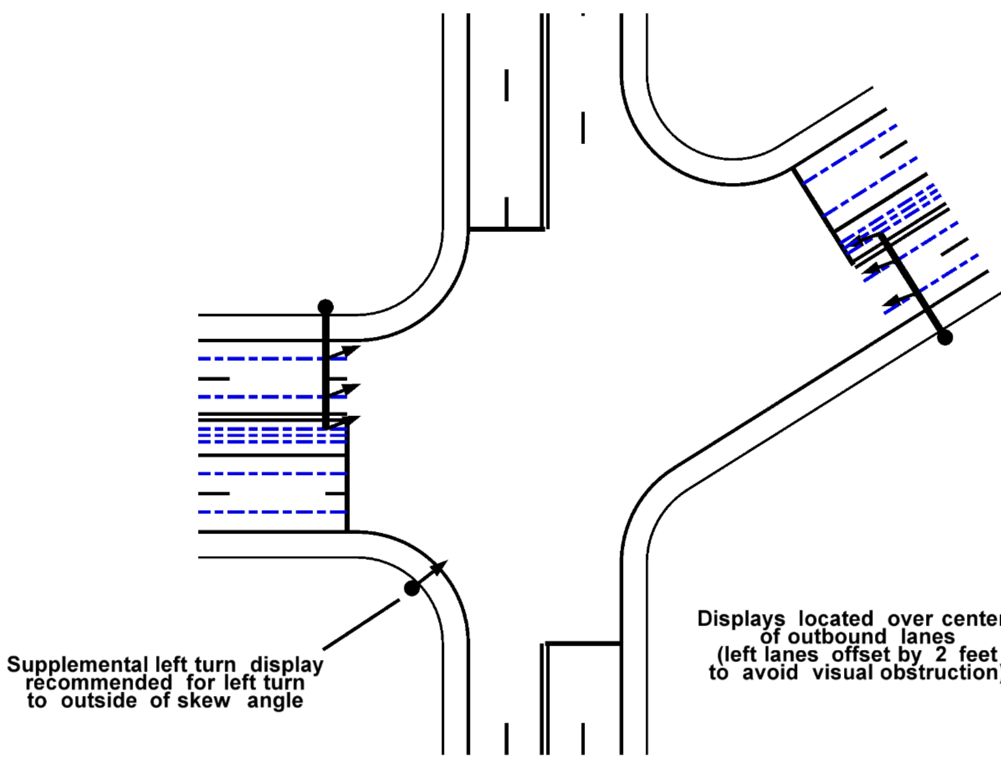
Multiple left turn lanes, with a shared through-left lane.
R3-5L and R3-6 signs optional.
Mirror for right turns.



Multiple right turn lanes.
R3-5R signs optional.

Exhibit 1330-8 Example Signal Display Placement for Skew Intersection





The minimum mounting height for overhead signal displays is 16.5 feet from the roadway surface to the bottom of the signal housing, including the backplate. There is also a maximum height for signal displays allowed by the MUTCD, since the roof of a vehicle can obstruct a motorist's view of a signal display. The maximum heights from the roadway surface to the bottom of the signal display housing with 12-inch displays are shown in Exhibit 1330-9.

Exhibit 1330-9 Signal Display Maximum Heights

Distance to Stop Line (ft)	Signal Display Arrangement	Maximum Height (to bottom of display housing [3])
40 [1]	Vertical 3-section	17.5 ft
42 [1]	Vertical 4-section	17.0 ft
45 [1]	Vertical 5-section [2]	17.0 ft
53 to 180	Vertical 3-section	22.0 ft
	Vertical 4-section	20.8 ft
	Vertical 5-section [2]	19.6 ft

Notes:

[1] Minimum distance required to achieve 16.5 feet of clearance with backplate installed.

[2] For 5-section cluster displays, use the Vertical 3-section heights.

[3] Subtract 0.5 ft for height to bottom of backplate.

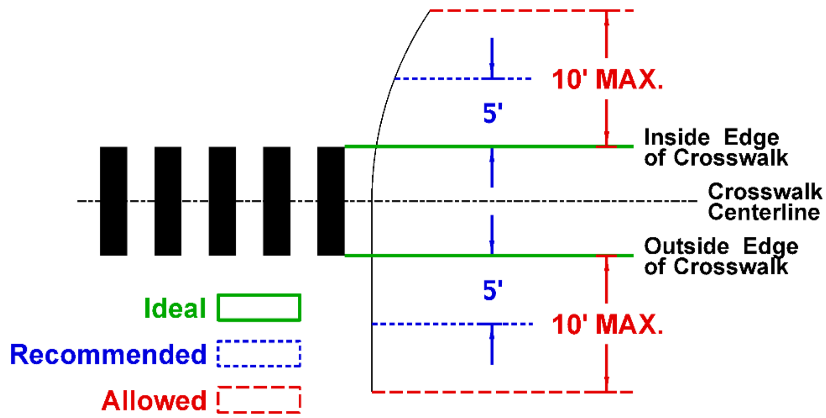
At signalized intersections with railroad preemption, install blankout signs for turning movements that do not have a dedicated signal display (3-section arrow display). Blankout signs are 36" x 36" and will display either a No Right Turn symbol (R3-1) or No Left Turn symbol (R3-2) when activated, as appropriate. Blankout signs should be placed the same as equivalent static signs.

1330.04(4) Pedestrian Equipment

Pedestrian equipment consists of pedestrian signal displays and pedestrian detectors (pushbuttons). New signal systems are required to use countdown displays and Accessible Pedestrian Signal (APS) pushbuttons. See 1330.04(4)(a) for pedestrian display and detection requirements for existing signal systems. No intersection may have a mix of APS and non-APS pushbuttons, nor may any intersection have a mix of countdown and non-countdown pedestrian displays.

Pedestrian displays are required to be installed with the bottom of the display housing no less than 7 feet or more than 10 feet above the sidewalk surface. Pedestrian displays are required to be installed to provide maximum visibility at the beginning of the controlled crosswalks. To accomplish this, pedestrian displays should be located no more than 5 feet from the outside edge of the crosswalk, as measured on a line perpendicular to the crosswalk centerline (See Exhibit 1330-10). The offset distance may be offset up to a maximum of 10 feet from the outside edge of the crosswalk if physical constraints prevent the display from being placed no more than 5 feet from the outside edge of the crosswalk.

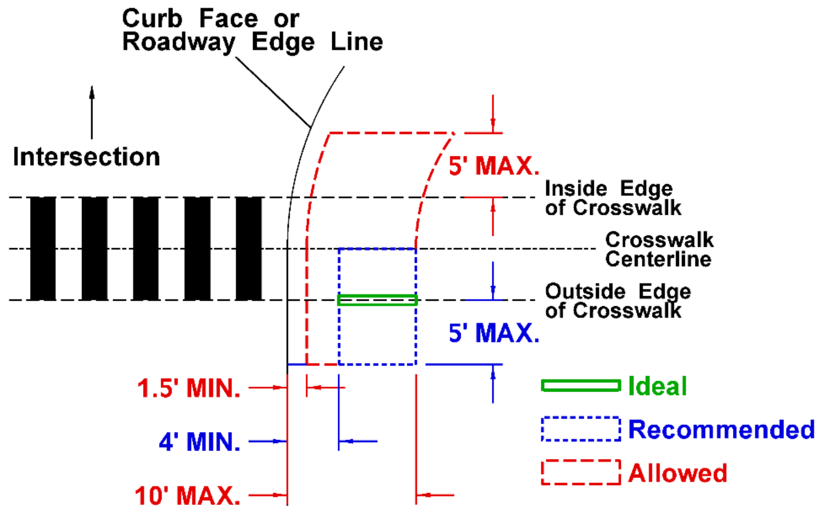
Exhibit 1330-10 Pedestrian Display Placement Requirements



Pedestrian pushbuttons (PPBs) are required to be located within a certain distance of the crosswalk being served and oriented such that the sign on the pushbutton is parallel to the crosswalk served. Pedestrian pushbutton location requirements are as follows:

- The PPB should be between 4 and 6 feet from the face of curb, where sidewalk is present, or the edge line of the roadway where there is no sidewalk. The PPB may be between 1.5 and 4 feet from the curb face or edge line, but this is not recommended due to proximity to the roadway. The PPB may not be closer than 1.5 feet from the curb face or edge line. If geometric constraints make it impractical to place the PPB within the 4-6 foot range, the PPB should not be further than 10 feet from the edge of curb, shoulder, or pavement. Contact the HQ Traffic Office if the PPB cannot be placed within 10 feet of the curb face or edge line.
- The PPB should be located as close to the outside edge of the crosswalk line as possible, so that for APS PPBs, the button and sign face towards the core of the intersection, rather than back down the adjacent approaching roadway. The PPB may be located no more than 5 feet outside either edge of the crosswalk line.
- If possible, PPBs should be located on separate poles and be separated by a minimum of 10 feet.
- See Exhibit 1330-11 for recommended and allowed PPB placement locations.

Exhibit 1330-11 PPB Placement Requirements



PPBs are required to be located so that the actual button, not just the assembly, is within 9 inches horizontally of a level all-weather surface (generally sidewalk or paved road shoulder) as described in Chapter 1510. To accomplish this, certain criteria must be met depending on the type of pole upon which the pushbutton is installed:

a. For vertical shaft poles (Type PPB, PS, I, FB, or RM), the center of the pole shall be no more than 9 inches from the edge of the level clear space. The pushbutton shall not be oriented more than 90 degrees from facing the level clear space. (See Exhibit 1330-12a.)

b. For larger signal standards (Type II, III, IV, IV, or SD), the button must face the level clear space, with the edge of the pole baseplate no more than 6 inches from the edge of the level clear space. It is recommended that the pole either be in the sidewalk, or the edge of the pole base plate be installed as close to the back of sidewalk as possible. (See Exhibit 1330-12b.) Some minor rotation of the button on the pole is possible, but even smaller angles may quickly exceed the allowed reach limit – particularly on larger poles.

Exhibit 1330-12a PPB Placement on Vertical Shaft Poles

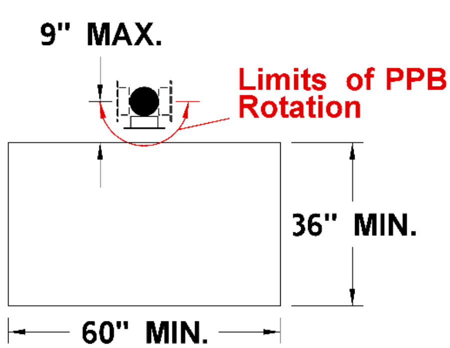
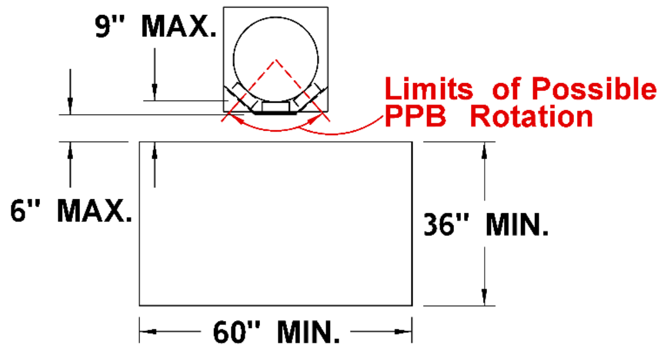


Exhibit 1330-12b PPB Placement on Large Signal Standards



In all cases, it is recommended that the pole be installed in the sidewalk for maximum accessibility. However, the pole and the pushbutton itself are obstructions and must not encroach upon the required minimum pedestrian access route widths (see Chapter 1510).

PPBs are required to be installed at 42 inches above the level clear space, as measured to the center of the actual button. Existing pushbuttons do not require a height adjustment if the center of the actual button is within a range of 36 to 48 inches above the level clear space.

Where there is a median or center island with a pedestrian refuge, consult with signal operations to determine if a pushbutton should be installed in the pedestrian refuge area. This may be justified for locations with particularly long crossings or slower moving pedestrians.

For WSDOT owned systems, pedestrian signal equipment may not be installed on light standards. Do not install pedestrian signal equipment on light standards for systems owned by other jurisdictions unless directed to do so by that jurisdiction.

1330.04(4)(a) Accessible Pedestrian Signals and Countdown Pedestrian Displays

Accessible Pedestrian Signals consist of a pedestrian pushbutton with integrated vibro-tactile and audible versions of the visual indications presented by pedestrian signal displays. APS are required at any location with a pedestrian display – *even if there was no pedestrian detection previously*. This is due to the requirement to provide non-visual indication of the pedestrian phase. All new construction traffic signals are required to include APS.

Countdown pedestrian displays are displays which use a combination of an overlapping person (walk) and hand (don’t walk) indication and an adjacent two digit countdown timer display. The timer counts down the seconds remaining in the pedestrian clearance phase (flashing don’t walk). For WSDOT owned traffic signals, all new construction traffic signals are required to include countdown pedestrian displays. For new construction traffic signals owned by other jurisdictions, countdown pedestrian displays are required unless directed otherwise by the owning jurisdiction.

For existing signalized intersections where pedestrian equipment was not previously installed, the installation of APS and countdown pedestrian displays is required for the entire intersection. This may require new or relocated poles, as well as additional ramp and sidewalk work beyond that necessary for basic sidewalk and ramp ADA compliance.

At signalized intersections with existing pedestrian equipment, the following criteria determine when APS pushbuttons and countdown pedestrian displays shall be installed:

1. The following are considered minor signal upgrades, and do not require the installation of APS pushbuttons or countdown pedestrian displays at that intersection:
    a. Where pushbuttons are only being adjusted in height or orientation.
    b. Where pushbuttons are being relocated on a single corner, including to a new pole, and no other work (including sidewalk or ramp work) is taking place at any other corner, pushbuttons may be relocated or replaced with the same type of pushbutton as currently exists at that intersection. Countdown pedestrian displays are not required to be installed at that intersection. New pole location(s) must meet accessibility requirements for pedestrian pushbuttons (see Chapter 1510.12). Accessibility for any affected poles must be evaluated for both existing pushbuttons and future APS pushbuttons.
2. The following types of work shall include the installation of APS pushbuttons and countdown pedestrian displays as described below:
    a. At any signalized intersection included in a project that is designated as an alteration project, as defined in Chapter 1510.05(2):
        i. For WSDOT owned traffic signal systems, install APS pushbuttons and countdown displays. For any project which has completed its scoping phase before August 1, 2018, consult with your ASDE to determine if APS pushbuttons and countdown pedestrian displays can be added to the project – documentation is not required if the project cannot support the expanded scope of work.
        ii. For traffic signal systems owned by other agencies, install APS pushbuttons and countdown displays if funded by the owning agency.
    b. At any signalized intersection where APS pushbuttons are being installed in response to a public request, replace all pushbuttons and pedestrian displays with APS pushbuttons and countdown pedestrian displays at that intersection. Additional poles may be required and ramp and sidewalk work may be necessary to support access to new APS locations / orientations.
    c. For any other project, not previously described, which requires traffic signal system work affecting pedestrian pushbuttons, replace all pushbuttons and pedestrian displays with APS pushbuttons and countdown pedestrian displays. This may require additional ramp and sidewalk work to provide required accessibility to and for APS locations / orientations beyond that already required for other ADA compliance efforts.

APS pushbuttons are required to include the following features:

1. Audible and vibrotactile indications of the WALK interval.
2. A locator tone which operates only during the DON’T WALK and flashing DON’T WALK intervals.
3. A tactile arrow on the pushbutton (control surface) indicating the crossing direction served. This arrow must be high contrast with the rest of the button – either light on dark or dark on light.

4. An integral 9” x 15” R10-3e sign.
5. If additional crossing time will be provided as part of an extended press feature, a supplemental R10-32P sign is required to be installed adjacent to or integral with the APS PPB.

1330.04(5) Signal Standards (Supports)

Signal standards consist of five main types of supports: Vertical Steel Shaft, Cantilevered Steel Mast Arm, Steel Strain Pole, Wood Strain Pole, and Signal Bridge. The type of support selected will depend on required placement of vehicle signal displays and the ability of the support to reach that location. The MUTCD states that the preferred location for signal displays is overhead on the far side of the intersection.

Signal displays may also be mounted to bridges where clearance will not allow an alternate signal standard type. Installation on bridges requires approval of both the region Traffic Engineer and the HQ Bridge and Structures Office.

Signal Standards shall be considered in the following order of preference:

1. **Cantilevered Steel Mast Arm**. These are the standard support type for permanent systems, and should be used whenever possible. Mast arm installations are preferred because they generally provide better placement of the signal displays, greater stability for signal displays in high-wind areas, and reduced maintenance costs. Mast arm lengths are limited to 65 feet from center of pole to farthest display mount – if additional length is needed, an alternate support type must be used.
2. **Span Wire System (Steel or Wood Strain Poles).** These systems may be used when displays are needed at a greater distance than a mast arm system can support, or if a system is expected to be in place for less than 5 years. Steel poles are required to be used for permanent signal systems. Temporary signal systems (systems to be removed under the same contract as installation) may use wood poles. The use of wood poles beyond the end of a contract or for longer than 5 years requires the approval of the region Traffic Engineer. Individual spans have a limit of 150 feet – longer spans require design by the HQ Bridge and Structures Office.
3. **Signal Bridge.** Signal bridges shall only be used when no other alternative can physically be installed and support displays in the required locations. Diagonal signal bridges are not recommended as they are extremely difficult to maintain and result in displays being too close to at least one of the two cross streets, resulting in poor display visibility. Diagonal spans in general are not recommended as a failure will result in the loss of the entire signal system, rather than just one or two directions.
4. **Vertical Steel Shaft.** Vertical steel shaft supports should only be used for supplemental vehicle displays or pedestrian equipment. In special cases (such as in a small historic town), vertical steel shaft supports may be used without overhead signal displays if approved by the region Traffic Engineer, as allowed by the MUTCD. This practice is not recommended, as displays are too easily obstructed from view.

When placing signal standards, the primary consideration is the visibility of signal faces. Place the signal supports as far as feasible from the edge of the traveled way without adversely affecting signal visibility. (The MUTCD provides additional guidance on 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. Consider the need for future right-turn lanes or intersection widening when choosing the final location of the signal standards. Poles should also be located outside of sight triangles for turning traffic.

If conditions allow and optimal locations are not compromised, pedestrian displays and pedestrian detectors can be installed on the vehicular display supports. However, pole placement cannot encroach on pedestrian access route or maneuvering space requirements. Pole mounted appurtenances, such as pushbuttons, terminal cabinets, and displays, need to be taken into consideration regarding their encroachment into accessible spaces.

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:

a. **Underground Utilities:** Underground utilities must be located, marked, and surveyed. If any underground utility is within 10 feet of any foundation, consider potholing for the utility to find its actual location. Field locates are rarely precise and must be verified if a potential conflict exists.

b. **Overhead Utilities:** Signal standards may be located within close proximity to overhead communications lines (phone, cable, fiber-optic), but the lines should not touch the any part of the signal system and should not pass in front of any displays. Overhead power lines require a minimum 10-foot circumferential clearance for lines rated at 50kV (50,000 V) or below, including the neutral. For lines rated over 50kV, the minimum clearance is 10 feet plus 0.4 inches for each kV over 50kV. Overhead utilities may have to be relocated if a suitable location for signal equipment cannot be found.

Once pole locations have been selected, a soils investigation is required to determine the lateral bearing pressure, the friction angle of the soil, and whether groundwater may be encountered. Standard foundations may be used if the soil lateral bearing pressure is at least 1,000 psf, the friction angle is at least 17°, and the ground slope is 2H : 1V or flatter. Standard foundation information is found in the *Standard Plans*, and depends on the type of support system being used.

Special foundation designs are required if the soil lateral bearing pressure is less than 1,000 psf, the friction angle is less than 17°, or the ground slope is steeper than 2H : 1V. The region materials group works with the HQ Materials Laboratory to determine the bearing pressure and friction angle of the soil at the proposed foundation locations. If soils do not meet these minimum values for lateral bearing pressure and friction angle, the signal standard charts and soil conditions report (summary of geotechnical conditions for foundations) must be forwarded to the HQ Bridge and Structures Office with a request for special foundation design. The HQ Bridge and Structures Office designs foundations for the regions and reviews designs submitted by others.

Where poles are installed on structures, the anchorage must be designed by the Bridge designer. Coordinate with the Bridge designer for placement and design of pole anchorages on structures.

Do not place any signal standard in a median area. The sole exception is a Type PS or Type PPB signal standard as required for median refuge areas for pedestrians.

Coordinate with all stakeholders (Maintenance, Signal Operations, Civil Design Engineer, Drainage Engineer, and so on) in the placement of signal equipment to avoid any possible conflicts. Arrange field reviews with the appropriate stakeholders as necessary.

1330.04(5)(a) Mast Arm Signal Standards and Foundation Design

Mast arm signal standards are designated by the following types:

- Type II: Single mast arm with no luminaire mount.
- Type III: Single mast arm with luminaire mount.
- Type SD: Double mast arm, with or without luminaire mount.

Mast arm signal standards are normally located on the far right corner of the intersection from approaching traffic. A typical mast arm signal standard only has one mast arm, however two may be used. If the angle between the two arms is not exactly 90 degrees, the design must be sent to the bridge and structures office. In most cases, two arms at 90 degrees can support the necessary display positioning. Additionally, signal standards on mast arms may be rotated up to 30 degrees from center. Do not allow a mast arm for one direction to cross in front of the mast arm for a different direction if possible, as it results in a visual obstruction of the signal displays. Where two double arm signal standards are installed on opposite corners, the preferred location for the two poles are the far right corners of the mainline roadway. This way, the mast arms for the mainline traffic will not cross in front of each other.

Mast arm signal standards have a typical arm attachment point of 18 to 20 feet in height. This height range needs to be taken into consideration when placing signal displays in order to ensure that the display height requirements shown in 1330.04(3) are met. The attachment point height may be adjusted throughout this range as necessary, but increments of 0.5 feet are recommended for ease of fabrication. Connection points outside of this range are a special design, and require design support from the Bridge and Structures Office.

Mast arm signal standards are designed based on the total wind load moment on the mast arm. The moment is a function of the surface area of each appurtenance (signal display or sign), X * Y, and the distance between the vertical centerline of each appurtenance and the vertical centerline of the signal pole Z. This determines the total wind load moment, referred to as an XYZ value and measured in cubic feet, which is used to select the appropriate mast arm fabrication plan and foundation design. Preapproved mast arm fabrication plans are available at http://www.wsdot.wa.gov/Bridge/Structures/LSS.htm, and will be listed in the Contract Provisions. To determine the XYZ value for a signal standard, the XYZ value of each appurtenance must be calculated. These values are then totaled to determine the overall XYZ value for the signal standard. For signal standards with two mast arms at 90 degrees apart, the larger of the two XYZ values calculated for each mast arm is used for the overall pole XYZ value.

When determining the XYZ values, use the worst-case scenarios for signal display and sign placements. All signal displays and mast arm-mounted signs, including street name signs, must be included in this calculation. Emergency preemption detectors, preemption indicator lights, cameras, and radar detectors are negligible and are not included in determining the XYZ values. For mast arm-mounted signs, use the actual sign area (in square feet) to determine the XYZ value. For poles with luminaire supports, the luminaire and arm is also included in the total XYZ calculation. Surface areas for vehicle displays are shown in Exhibit 1330-13. Signs are limited in size as follows:

- Street name signs may be a maximum of 36 inches in height and 36 square feet in total area. Design the mast arm to support the widest sign that will fit within these limits (up to 144 inches wide), regardless of the actual sign size needed. This allows for future changes to the street name sign. Street name signs are mounted such that the edge of the pole is no less than 1 foot but no more than 2.5 feet from the vertical pole centerline, as shown in the *Standard Plans*. Use the offset necessary for the largest possible sign in the signal standard chart for the XYZ value, but refer to the *Standard Plans* for actual sign installation requirements using construction notes in the Contract Plans.
- Other mast arm mounted signs may not exceed 36 inches in height and 7.5 square feet in area.
- Signs mounted on the vertical pole may not exceed 36 inches in width and 15 square feet in area. These signs are not included in the XYZ calculation.

After calculating the total XYZ value, adjust the total XYZ value as follows:

If the total XYZ value is less than or equal to 2850 ft^3, round the XYZ value up to the next standard foundation XYZ value or 2850 ft^3, whichever is lower, to determine the design XYZ value. The design XYZ builds in some flexibility for future modifications.

- If the total XYZ value exceeds 2850 ft^3, use the calculated XYZ value. There is limited opportunity for future increased wind load when the XYZ value exceeds 2850 ft^3.

Exhibit 1330-13 Signal Display Surface Areas

Signal Display	Area
Vertical 3-section	9.2 sq ft
Vertical 4-section	11.6 sq ft
Vertical 5-section	14.1 sq ft
5-section cluster	14.4 sq ft

After the total XYZ value is determined, if a standard foundation may be used, select the correct foundation depths for the XYZ values from the table in the *Standard Plans*, using the next higher total XYZ value. For WSDOT systems, only the 700, 1350, 1900, 2600, and 3000 columns may be used. All five foundation options should be provided unless there is a known constraint preventing the use of one of the options, such as insufficient space for 4 ft diameter foundation or expected loose soil requiring the use of the Alternate 2 foundation construction.

1330.04(5)(b) Span Wire Signal Standards and Foundation Design

Span Wire Systems use poles and aerial wires to support signal displays, signs, and emergency preemption equipment. Cameras, radar detectors, and street name signs are installed on the vertical strain poles. When laying out span wires, the preferred layout is similar to mast arm supports. Displays for an approach should be installed on a span on the far side of the intersection, with poles on the two far corners. Do not use diagonal spans unless absolutely necessary, as they are extremely difficult to maintain and if the wire is broken, the entire signal system is lost and blocks the entire intersection, rather than the equipment for only one approach.

Span wire signal standards include both steel and timber strain poles. Steel and timber strain poles are designated by pole class, which is based on the horizontal tension load the pole will support. The loads and resultant forces imposed on strain poles are calculated and a pole class greater than that load is specified. Steel Pole Classes and their allowed tension loads are listed in the *Standard Plans*. Exhibit 1330-14 lists the pole classes and tension loading available for timber strain poles.

Headquarters Traffic and Headquarters Bridge and Structures office support is required for determining span tension load and pole classes. Provide the pole and span layout, the locations and sizes of all signal displays and span wire mounted signs, and the soils report. Span wire mounted signs are limited to a maximum of 36 inches in height and 7.5 square feet in area. Emergency preemption equipment locations do not need to be submitted, as they are not included in load calculations. Spans should not exceed 150 feet, if possible, in order to reduce the complexity of the design.

After the pole classes are provided by the Headquarters Bridge and Structures office, select the appropriate foundation information from the *Standard Plans* using the pole classes and soil conditions. If a standard foundation cannot be used, a foundation design will be provided along with the pole class information.

Exhibit 1330-14 Timber Strain Pole Classes

Pole Class	Tension Load Limit (lbs)
4	2400
3	3000
2	3700
1	4500
H1	5400
H2	6400
H3	7500

Pole Classes from ANSI Standard O5.1

1330.04(5)(c) Special Case Signal Supports

Special case signal supports include signal bridges and structure (typically bridge) mounts. These should only be selected if absolutely necessary, as they are difficult to design, construct, and maintain, and they frequently result in signal display locations that are difficult for drivers to see. Use of these types of supports requires approval from the Headquarters Traffic Office.

Signal bridges function the same as a diagonal span wire system, with the two supports on opposite corners of the intersection. Signal bridges require windload calculations similar to mast arm signal standards, so display and sign locations and offsets must be provided. Signal bridge foundations must be designed by the Headquarters Bridge and Structures office.

Signal displays and other equipment may be installed on structures when there is insufficient clearance below the structure to allow for a different type of signal support. Coordinate with the Bridge designer to place mounts and determine routing paths for conduit and wiring out of the structure. Structure mounts are not desirable, as they typically cannot be modified without reconstruction of the structure itself, and any equipment embedded in the structure is inaccessible after the structure is complete.

Signal displays may not be installed on sign structures such as cantilever sign structures or sign bridges. Signal displays also may not be installed on railroad cantilever structures unless the signal system and the railroad are owned by the same jurisdiction and maintained by the same staff.

1330.04(5)(d) Vertical Steel Shaft Supports

Vertical steel shaft supports include the following types of signal standards:

(a) Type PPB: Sometimes referred to as a “stub pole”, this pole is typically 5 feet tall and 3 inches in diameter. It is used strictly to support pedestrian pushbuttons. Due to the frequency of damage, regardless of location, it is recommended that breakaway bases always be used.

(b) Type PS, I, RM, and FB: These poles are effectively identical, with the difference being the total height to the slipfitter top.

- Type PS are 8 ft tall and may only have pedestrian displays mounted on the top.
- Type I are 10 ft tall and may have vehicle displays mounted on the top and pedestrian displays mounted on the side. Type RM are identical to Type I but are used for ramp meter systems only.
- Type FB are 14 feet tall, and may be used like Type I when additional height is needed for the vehicle display(s).

Placement of vertical steel shaft supports will depend on visibility requirements for displays and accessibility requirements of pedestrian features. Generally, these supports should be located at back of sidewalk, as they are farther from traffic and more likely to be out of both the pedestrian access route and the path of any users. Fixed bases should be used when located at the back of sidewalk, but slip bases may be used if circumstances recommend it. Supports located within sidewalk (includes planter strips) or in locations with only paved shoulders should always use slip bases.

1330.04(6) Vehicle Detection Systems

Vehicle detection systems are necessary for the efficient operation of traffic signals. By responding to the presence of traffic, signal systems do not have to use fixed timing. This improves efficiency by removing unnecessary delay and not providing service to an approach or movement with no traffic.

1330.04(6)(a) Vehicle Detection Zone Placement

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.

There are two basic types of detection zones: stop bar and advance. Stop bar detection is a zone that extends from the stop line to a point 30 to 40 feet in advance of that location. Advance detection is a discrete zone (or zones) placed in advance of the stop line at a distance dependent on vehicle speed.

Basic vehicle detection requirements depend upon the speeds of the approaching vehicles:

(a) When the posted speed is below 35 mph, provide stop bar detection or one advance detection zone. See Exhibit 1330-15 for advance detection zone distances.

(b) When the posted speed is at or above 35 MPH, provide stop bar detection and at least two advance detection zones. Multiple advance detection zones are normally required to accommodate decision zone detection.

(c) Side street advance detection is not required for WSDOT owned signal systems, but may be provided through means that do not require equipment to be installed off of WSDOT right of way. For signals owned by other jurisdictions, the use of side street advance detection is at the discretion of the owning jurisdiction.

A decision zone is a location along the intersection approach where a motorist is forced to make a decision between two alternatives. As applied to vehicle detection design, this situation can occur when two vehicles are approaching a traffic signal and the signal indication turns yellow. The motorist in each vehicle must decide whether to continue through the intersection or stop prior to the intersection. If the lead vehicle decides to brake and the following vehicle does not, there may be a rear-end crash.

For posted speeds of 35 MPH or higher, there are two options for placing advance detectors to address the decision zone:

1. Fixed locations based on posted speed, which is generally the 85th percentile speed. Place loops according to the table in Exhibit 1330-15.
2. Calculated locations based on calculated decision zone detection design. This design increases the opportunity for a range of vehicles from the 90th percentile speed vehicle to the 10th percentile speed vehicle to either clear the intersection or decelerate to a complete stop before reaching the intersection. The method of calculating the decision zone and the required detection loops is shown in Exhibit 1330-16.

Although the exhibits reference loops, advance detectors may be of any approved type.

For new intersection construction where there is no existing traffic, the fixed locations based on posted (target design) speed are to be used. Fixed locations based on posted speed use the same methods as the calculated decision zone detection design, but set V90 at 5 MPH above posted speed and V10 at 5 MPH below posted speed. Engineering judgment based on similar intersections (such as geometrics and traffic volumes) may justify modifying the V90 and V10 speeds used in the calculation, with concurrence from the region Signal Operations Engineer. Both methods require a study of the approach speeds at the intersection. For intersection approaches, conduct the speed study as follows:

- Collect data at the approximate location or just upstream of the decision zone;
- Collect data during off-peak hours in free-flow and favorable weather conditions;
- Collect data during regular commuting hours in a high volume signalized corridor during favorable weather conditions
- Only document the speed of the lead vehicle in each platoon.

It is important that the person conducting the speed study remain inconspicuous so they do not influence drivers to slow down. Normal driving patterns are needed for proper speed studies. Prior speed-study information obtained at this location may be used if it is less than 18 months old and driving conditions have not changed significantly in the area.

Preserve detection zone placements and any supporting calculations as required by 1330.07 Documentation.

Exhibit 1330-15 Fixed Vehicle Detection Placement

Fixed Detection Placement – Below 35 MPH

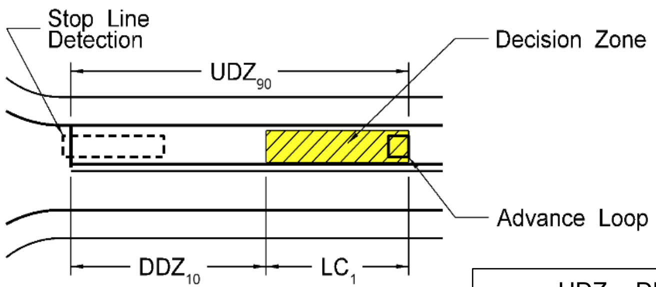
V_{85} =		V_{90} =		V_{10} =		UDZ_{90}	DDZ_{10}	LC_1	P_{MID}	LC_2	Calculated Loop 1	Rounded Loop 1
MPH	ft/s	MPH	ft/s	MPH	ft/s	ft	ft	s	ft	s	ft	ft
25	36.7	30	44.00	20	29.33	165.00	50.84	3.9	107.92	1.9	107.92	105
30	44	35	51.33	25	36.67	216.03	70.28	4	143.15	2	143.15	140

For posted speeds below 35 MPH, only the PMID detection location is used.

Fixed Detection Placement – 35 MPH and Above

V_{85} =		V_{90} =		V_{10} =		UDZ_{90}	DDZ_{10}	LC_1	P_{MID}	LC_2	Calculated Loop 1	Calculated Loop 2	Rounded Loop 1	Rounded Loop 2
MPH	ft/s	MPH	ft/s	MPH	ft/s	ft	ft	s	ft	s	ft	ft	ft	ft
35	51.33	40	58.67	30	44.00	273.78	92.40	4.1	183.09	2.1	183.09	273.78	180	275
40	58.67	45	66.00	35	51.33	338.25	117.21	4.3	227.73	2.2	227.73	338.25	225	340
45	66	50	73.33	40	58.67	409.44	144.71	4.5	277.08	2.3	277.08	409.44	275	410
50	73.33	55	80.67	45	66.00	487.36	174.90	4.7	331.13	2.4	331.13	487.36	330	490
55	80.67	60	88.00	50	73.33	572.00	207.78	5	389.89	2.5	389.89	572.00	385	575
60	88	65	95.33	55	80.67	663.36	243.34	5.2	453.35	2.6	453.35	663.36	450	665

Exhibit 1330-16 Decision Zone Detection Placement



Single Advanced Loop Design

Use when $LC_1 \leq 3$ seconds

$$LC_1 = \frac{UDZ_{90} - DDZ_{10}}{V_{10}}$$

Decision Zone Endpoint Calculation

(for all loop arrangements)

Where grades are flatter than +/- 4%:

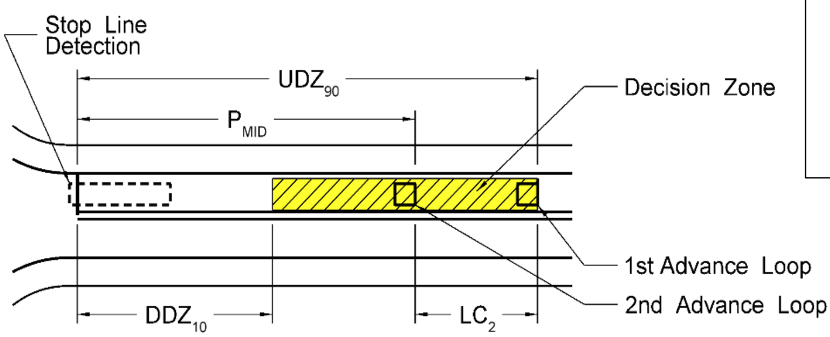
$$UDZ_{90} = \frac{(V_{90})^2}{16} + V_{90}$$

$$DDZ_{10} = \frac{(V_{10})^2}{40} + V_{10}$$

Where grades are +/- 4% or steeper:

$$UDZ_{90} = \frac{(V_{90})^2}{2(8+32.2G)} + V_{90}$$

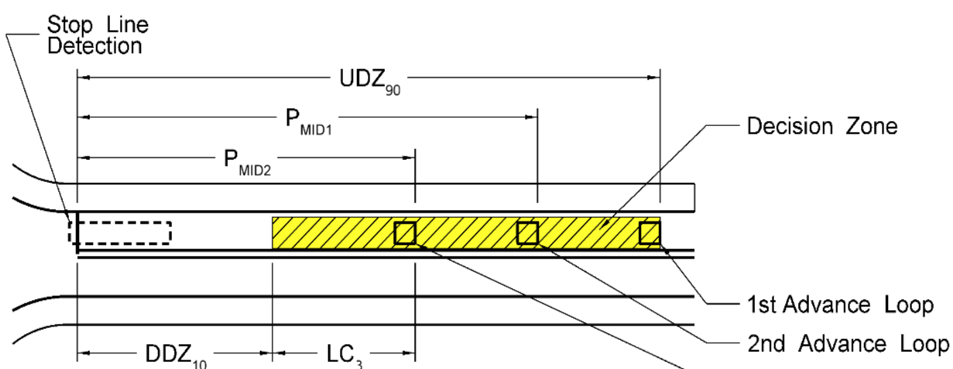
$$DDZ_{10} = \frac{(V_{10})^2}{2(20+32.2G)} + V_{10}$$



Double Advanced Loop Design

Use when $LC_2 \leq 3$ seconds

$$P_{MID} = \frac{UDZ_{90} + DDZ_{10}}{2} \qquad LC_2 = \frac{UDZ_{90} - P_{MID}}{V_{10}}$$



Triple Advanced Loop Design

Use when $LC_3 \leq 3$ seconds

$$LC_3 = \frac{UDZ_{90} - DDZ_{10}}{3V_{10}} \qquad P_{MID1} = \frac{[2(UDZ_{90}) + DDZ_{10}]}{3} \qquad P_{MID2} = \frac{[UDZ_{90} + 2(DDZ_{10})]}{3}$$

Where:

V_{90} = 90th percentile speed, in feet per second

V_{10} = 10th percentile speed, in feet per second

UDZ_{90} = Upstream end of decision zone, for 90th percentile speed

DDZ_{10} = Downstream end of decision zone, for 10th percentile speed

G = Grade of roadway, in decimal form, including + or – (Example: -4% = -0.04)

LC_1 = V_{10} travel time to DDZ_{10}

LC_2 = V_{10} travel time from UDZ_{90} to P_{MID}

LC_3 = V_{10} travel time from P_{MID2} to DDZ_{10}

1330.04(6)(b) Vehicle Detector Types

There are two basic categories of vehicle detectors:

- **Non-Invasive**: These are detectors installed outside of the roadway, typically overhead in a strategic location. These include camera (optical and infra-red) and radar systems.
- **In-Pavement**: These are detectors which are installed in the road itself. These include induction loops and wireless in-pavement sensors.

Non-invasive detection is generally recommended over in-pavement detection, due to the ability to revise non-invasive detection at any time and the ease of installation, repair, and replacement – particularly when supporting traffic control and impacts are taken into account. Additionally, pavement damage due to regular wear or construction activities will disable in-pavement detection, whereas non-invasive detectors will continue to function, and can even be adjusted to accommodate revised lane configurations.

Stop line detection should use non-invasive systems for detection. Although induction loop detectors are typically the most reliable for detecting cars and trucks, they do not consistently detect bicycles and motorcycles. RCW 47.36.025 specifically requires that vehicle-activated traffic control signals be capable of detecting motorcycles and bicycles.

Advanced detection may be either non-invasive or in-pavement, as these improve efficiency of the signal systems but are not as critical as stop line detection. Non-invasive is recommended for posted speeds of 45 MPH or lower, as they are currently only effective for up to about 600 feet from the location of the detector. The advantage is that advance detection can be installed at the intersection, rather than trenching long distances to place advanced detectors in pavement. For speeds over 45 MPH, non-invasive detection systems may be considered, but in-pavement systems will probably be more effective. Advance detection does not need to detect bicycles.

Selection of detector types will depend on a variety of environmental factors and locations available for placement.

1. Radar Detectors

Radar detectors are located on either the signal mast arms or the signal vertical strain poles, depending on lane configuration, detector type, and location availability. Radar detectors are not affected by weather, and are typically minimally affected by mast arm motion in high wind. Consult the detector manufacturer’s installation guidance for placement details. One detector can normally cover all lanes of an approach for that type of detection (stop line or advance).

2. Video Detectors

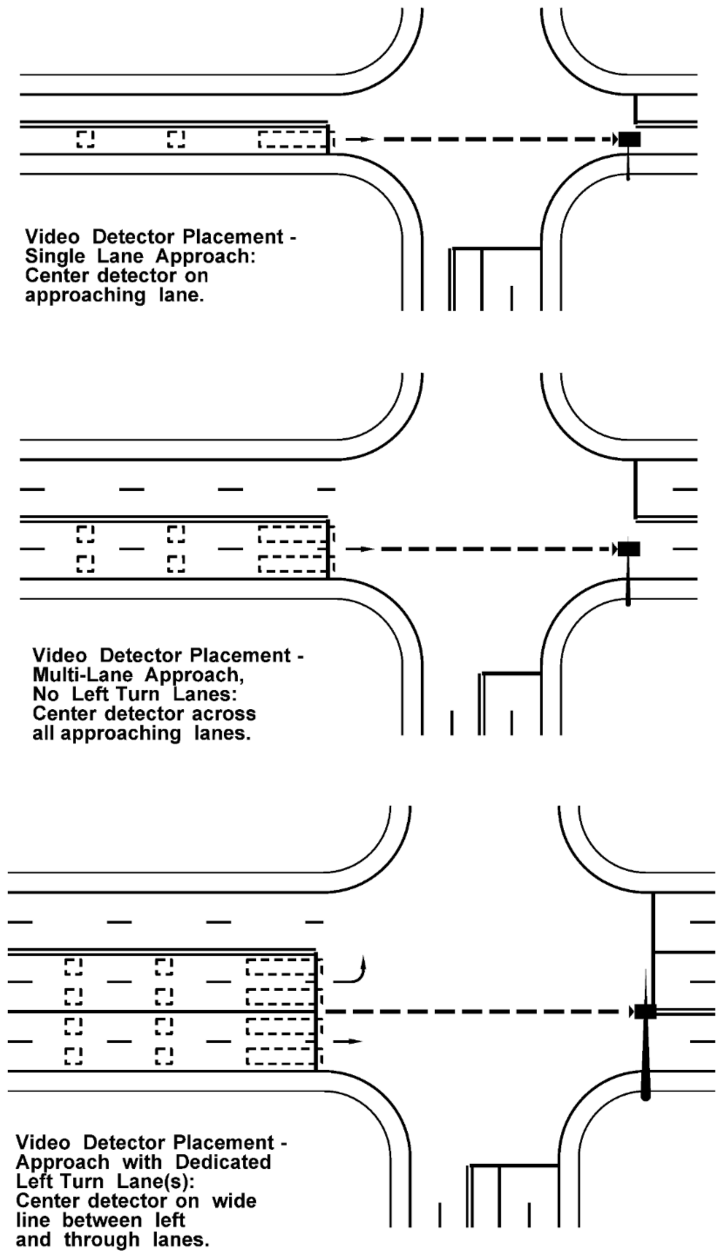
Placement of video detectors depends on the function of the detector. Exhibit 1330-17 provides placement examples.

Stop line detectors should be installed on the same mast arm as the vehicle displays for that approach. The detector should be placed on an extension of the wide line between the left turn and through lanes, if present; if there is no wide line, the detector should be centered on the through lanes. One detector can cover all lanes of an approach for that type of detection (stop line or advance).

Advance detectors should be installed on a luminaire arm, preferably on the adjacent corner to the approaching lanes, as the effectiveness of the advance detection depends on height. Consider requiring a luminaire arm even if no luminaire is needed, in order to provide an optimal installation site for the detector. Advance detectors may be installed on a mast arm, but will typically have less effective range.

Both infra-red and optical cameras are available, but optical cameras are not recommended due to the adverse effects of rain, snow, fog, sun glare, and sharp shadows on their effectiveness. However, infra-red cameras may still be affected by heavy fog or other major thermal events. All video detection may be affected by mast arm motion due to high winds.

Exhibit 1330-17 Video Detector Placement



3. Induction Loops

Induction Loops are coils of wire in the roadway that use the magnetic properties of vehicles to detect them. Induction loops can last a very long time when undisturbed. However, induction loops require bicycles to be in a very specific location in order to be detected, and may not detect carbon fiber bicycles. Induction loops must be installed with one per lane per detection zone – stop line loops may be larger or series loops. Where induction loops are used, loops need to be numbered in order to keep track of the wiring and lanes they are detecting. See 1330.04(2) for detector numbering requirements.

4. Wireless In-Pavement Sensors

Wireless in-pavement sensors are compact detectors installed in pavement, and use either radar or magnetics to detect vehicles. They use a wireless connection to the signal cabinet. The sensors rely on a battery for operation, and require replacement of the entire unit when they fail. Sensor placement is similar to induction loops – one per lane per detection zone. The magnetic versions are subject to the same difficulties with bicycles as loop detectors. All wireless sensors are also subject to various factors that affect wireless signals such as range, signal obstructions, and possible signal interference from other radios depending on the frequency used.

Non-invasive detectors are preferred with concrete (Portland cement concrete pavement) roadway surfaces. In-pavement detectors installed in concrete panels typically cannot be revised or replaced until all affected concrete panels are replaced. In-pavement detectors installed in bridge decks must be installed when the bridge deck is constructed, and cannot be replaced unless the bridge deck is replaced. Non-invasive detection is also useful for approaches where advance detection is desired, but the approach is outside the jurisdiction of the agency that owns the signal, or for non-standard approaches such as driveways.

Temporary detection should be installed for all stop lines where existing detection will be disabled or ineffective (such as lane shifts) during construction. Temporary advance detection is recommended for 45 MPH or higher approaches where the decision zone detection will be disconnected for an extended period of time. Consult with the Signal Operations Engineer to determine if temporary advance detection should be used. Temporary advance detection zone placement should take into account any temporary speed limit revisions.

1330.04(7) Preemption Systems

1330.04(7)(a) Emergency Vehicle Preemption

Emergency vehicle preemption (EVP) is required for all traffic signals unless approved otherwise by the region Traffic Engineer. WSDOT is responsible for installing EVP detection equipment at new and rebuilt signalized intersections on state highways. At existing signalized intersections that do not have EVP detection equipment, or where an emergency service agency requests additional equipment beyond the basic required equipment, the emergency service agency is responsible for all material and installation costs. The emergency service agency is responsible for preemption emitters in all cases.

Optically activated EVP systems are used to ensure compatibility 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.

Locate optical detectors facing each approach to the intersection – only one detector per approach – with a clear view of the approaching roadway. Detectors have a cone of vision of approximately 8 degrees, and an effective range of 200 to 2500 feet. Detectors should have an unobstructed view of the approach for a minimum of 1800 feet. Primary detectors are normally installed on the same support as the vehicle displays for that approach. Place the detector between the left turn lane and through lane displays on approaches with left turn lanes, or centered on the approaching lanes where left turn lanes are absent.

When the approach is in a horizontal or vertical curve, or there are other sight obstructions, non-standard placement of the primary detector or additional supplemental detectors may be necessary. Primary detectors may be located on other signal display supports (arms or spans) or vertical strain poles, depending on visibility requirements. Supplemental detectors may also be located on separate Type I or Type FB poles in advance of the intersection. On higher speed roadways, supplemental detectors can provide extended detection range – one mile in advance of the intersection is usually sufficient.

Preserve any documentation associated with the EVP system, including system type selected and any associated agreements or approvals, as required by 1330.07 Documentation.

1330.04(7)(b) Railroad Preemption

Railroad preemption is used when a railroad is in close proximity to a signalized intersection. If railroad tracks are within 1/4 mile of a signalized intersection, then a Railroad Crossing Evaluation Team is formed to determine the need (if any) for railroad preemption, interconnection, simultaneous preemption, advanced preemption, and so on. The Railroad Crossing Evaluation Team should consist of region and HQ Signal Design Engineers, region and HQ Signal Operations Engineers, HQ Railroad Liaison, HQ Rail Office representative, region Utilities Engineer, region Traffic Design Engineer, region Maintenance Superintendent, and the affected railroad representative. Where the signal is owned, operated, or maintained by a local agency, a local agency representative should also be included.

The Railroad Crossing Evaluation Team will determine what design considerations are needed at all signalized intersections near railroad crossings. For locations where the railroad tracks are located greater than 500 feet from the signalized intersection, and it can be demonstrated that the 95% maximum queue length(s) will not extend to within 200 feet of the tracks, railroad preemption may be omitted with the approval of the Railroad Crossing Evaluation Team. Include the demonstration and approval in the documentation required by 1330.07 Documentation.

Railroad preemption and interconnection are recommended when any of the following conditions occurs:

- The distance from the stop bar to the nearest rail is less than or equal to 200 feet.
- There is no dedicated left turn lane and the distance from the stop bar to the nearest rail is less than or equal to 500 feet.
- The 95% maximum queue lengths from the intersection stop bar are projected to cross the tracks. (Use a queue arrival/departure study or a traffic analysis “micro-simulation model” to determine 95% maximum queue lengths.)
- The 95% maximum queue lengths from the railroad are projected to affect an upstream traffic signal. (Use a queue arrival/departure study or a traffic analysis “micro-simulation model” to determine 95% maximum queue lengths.)

If it is determined that advanced preemption is needed, the HQ and region Signal Operations Engineers will calculate the amount of railroad preemption time required using the *Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings (TxDOT Form 2304)*.

The addition of a pre-signal is recommended when any of the following conditions occurs:

- The distance from the stop bar to the nearest rail is less than 88 feet but is at least 40 feet. (For reference, the 88 feet is derived from: the longest design vehicle permitted by statute (75 feet) + front overhang (3 feet) + rear overhang (4 feet) + downstream clear storage (6 feet)).
- The distance from the stop bar to the nearest rail is > 88 feet and < 120 feet and there are no gates for the railroad crossing.
- The sight distance triangle in Chapter 1350, Exhibit 1350-1 (Sight Distance at Railroad Crossing), cannot be met, and the railroad crossing does not have active control (lights or gates).

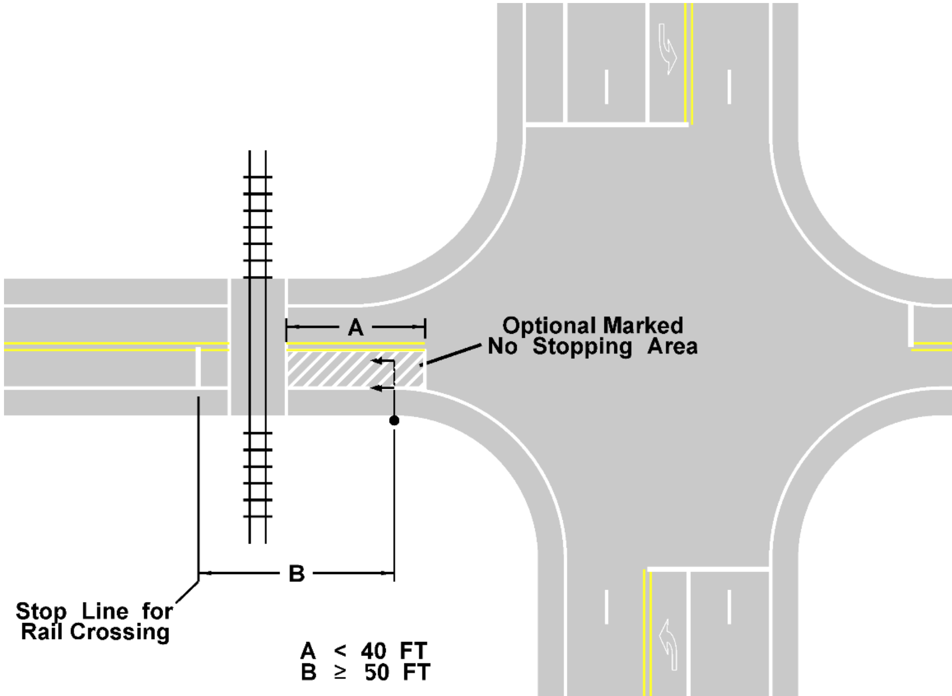
When pre-signals are used, two stop lines are used: one for the rail crossing, and one for the intersection. The pre-signal displays stop traffic at the rail crossing stop line, and the second set of signal displays stop traffic at the intersection. Use louvers on the intersection displays so that they are not visible from the stop line for the rail crossing. Optically programmed displays may be used in place of louvers, but are not recommended due to the limited benefits, complexity of installation and maintenance, and high cost.

Where the distance between the normal location for the stop bar and the approach is less than 40 feet, the same stop bar should be used for both the traffic signal and the rail crossing. Install vehicle displays on the near side of the intersection, but on the far side of the tracks from the stop line, to improve visibility and discourage drivers from stopping between the tracks and the intersection. Do not install vehicle displays on the far side of the intersection.

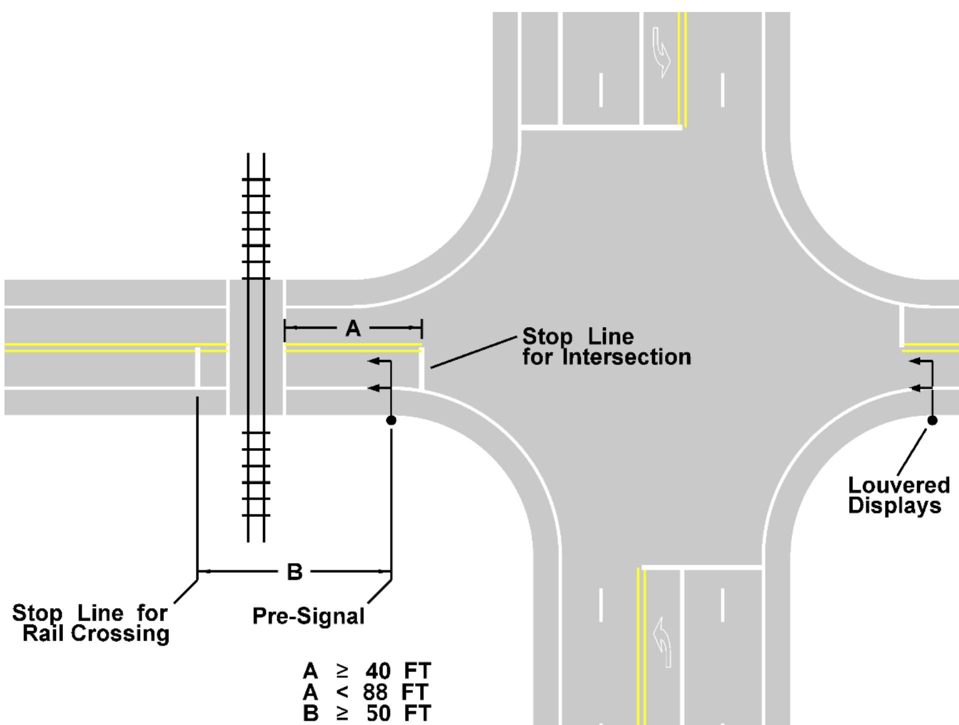
Exhibit 1330-18 shows examples of the distances and typical system layouts referenced above.

The Railroad Crossing Evaluation Team has final review and approval authority for all PS&E documents for signal design and operation at all signalized intersections near railroad crossings. All documentation associated with railroad preemption and a memo with each team member's concurrence with the PS&E documents must be preserved as required by 1330.07 Documentation.

Exhibit 1330-18 Signal Display Layout for Rail Crossings



Display Placement
Less than 40 feet between tracks (dynamic envelope marking) and intersection



Display Placement
40 to 88 feet between tracks and intersection

1330.04(7)(c) Transit Priority Preemption

Transit Priority Preemption allows for transit operations to influence signal timing, similar to emergency vehicle preemption. This can be included in mobility projects, but the transit agency assumes all costs for providing, installing, and maintaining this preemption equipment. WSDOT's role is limited to approving preemption operational strategies (phasing, timing, software, and so on) and verifying the compatibility of the transit agency's equipment with the traffic signal control equipment. Preserve all transit priority preemption decisions and agreements as required by 1330.07 Documentation.

1330.04(8) Control Equipment

The standard WSDOT Signal Controller type for traffic signals is the Type 2070 Controller. Some agencies use National Electrical Manufacturers Association (NEMA) controllers (Type TS1 or TS2). Although not normally used for new construction, WSDOT Ramp Meters and some older systems still use Type 170 Controllers. All traffic signal controllers have the following basic functions:

- Dual ring phase operation
- Eight vehicle phases
- Four pedestrian phases
- Four overlap phases
- Four emergency vehicle preemption channels
- Railroad preemption
- Start and end daylight savings time dates
- Transit preemption (some older controllers may not support this)

Type 2070 controllers and newer NEMA controllers are functionally equivalent for basic signal operations. However, Type 2070 controllers and NEMA controllers use different operating software and communications protocols, and therefore cannot be interconnected together. The type of controller should be specified as follows:

1. For WSDOT traffic signals, specify Type 2070 controllers, unless:
    a. The signal is interconnected with other signals. If the other controllers in the interconnected system are not being replaced, specify a controller (2070, NEMA, or other) that matches the rest of the interconnected system.
    b. The signal is operated by another agency. In this case, work with WSDOT and the other agency's maintenance staff to determine the appropriate controller type.
2. For traffic signals owned by other agencies, specify the controller type used by that agency.

The region or operating agency will determine the controller brand and operating software, which are included in the cabinet specifications. Each region or operating agency will provide specifications for their cabinets and the equipment contained therein. For 2070 controllers, double-width cabinets (two racks) should be specified if physically possible to allow for future communications and ITS equipment.

It is often beneficial for one of the agencies to assume responsibility for the operation of the traffic signals. This is accomplished by negotiating an agreement with the other agency. The designer needs to check region policy and make sure someone initiates the process for setting up an operational agreement with the other agency or modifying an existing agreement when applicable. (See the *Agreements Manual* for more information on signal systems and maintenance agreements.) At a new intersection, where the state owns the signal, but WSDOT has agreed to let another agency operate the signal, the controller should be compatible with that agency's system. When installing a new controller in an existing interconnected corridor, the controller should be capable of operating with the existing controllers in the corridor. In situations where it is necessary to coordinate the traffic movements with another agency, it is important that the agencies work together.

Intersections within ½ mile of each other on state highways should be interconnected. Perform an operational analysis to determine need for interconnection where intersections are within 1 mile of each other on state highways with a posted speed of 45 MPH or higher. The preferred method for interconnection is fiber optic cable, but other methods such as IP over copper or wireless interconnect may be considered after discussion with maintenance staff and approval by the region Traffic Engineer. Where fiber optic cable is used, it must be routed through pull boxes and cable vaults – bending fiber optic cable through standard junction boxes typically results in the cable being broken. Consider using a separate pull box or vault for coiling the fiber optic interconnect cable to allow for the large-bend radii. Add a construction note in the plans stating to coil additional cable in the adjacent pull box or vault, not the controller cabinet. This will save on space in the controller cabinet and provides additional cable in case an errant vehicle hits the cabinet.

Coordinate with the operations and maintenance staff to determine the optimum controller cabinet location and the cabinet door orientation. The controller cabinet is positioned to provide the best maintenance access and clearest view of the intersection possible. Preferred visibility allows for as many signal displays and roadway approaches visible as possible from a single location. Cabinets should not be placed where they might block the view of turning traffic (intersection sight triangle). If possible, position the controller where it will not be affected by future highway construction.

Cabinets require a minimum of 36 inches of level space in front of each door, including the concrete pad. Do not place cabinets where flooding might occur or where the cabinet might be hit by errant vehicles. If there is a steep down slope or drop off near the cabinet, personnel fall protection (such as fencing) is required in accordance with standards established by the Department of Labor and Industries. Fall protection may not encroach on the required clear space for the cabinet. The location must also have adequate room for a maintenance vehicle to park near the cabinet. Sufficient space for a bucket truck to park is preferable.

If a telephone line (voice or DSL), fiber optic, wireless, or other connection is desired for remote access to the equipment in the cabinet, provide the appropriate equipment in the controller cabinet and/or nearby junction box or cable vault with separate conduits and junction boxes for the remote communications equipment. Communications connections to outside utilities require their own separate conduit and box/vault system.

Consult with maintenance and operations staff to determine if a backup power source, such as an Uninterruptible Power Supply (UPS) or backup generator, is needed for the signal cabinet. Install the backup power supply on the same concrete pad as the signal cabinet. Service and other cabinets may also be installed on the same concrete pad as the signal cabinet (see the

Standard Plans for concrete cabinet pad layouts). Refer to Chapter 1040 for electrical service types, overcurrent protection, and descriptions and requirements for other components.

1330.04(9) Wiring, Conduit, and Junction Boxes

Consider cost, flexibility, construction requirements, and ease of maintenance when laying out the electrical circuits for the traffic signal system. Consolidate roadway crossings (signal, illumination, ITS conduits, and so on) whenever possible to minimize the number of crossings and take advantage of single crossing construction (joint trenches or consolidated directional boring). Include all electrical design calculations in the Project File.

1330.04(9)(a) System Wiring

Traffic signal systems use multi-conductor cables to connect most of the equipment. Single conductor cable is limited to cabinet power and street lighting circuits.

The following describes typical WSDOT wire type selection:

- 5c cables for signal displays. One 5c per signal phase may connect the signal cabinet to the terminal cabinet on the pole. Separate 5c cables should connect each signal display to the terminal cabinet. Protected / permissive displays may either use one 7c cable or two 5c cables (one for each phase on the shared display).
- 5c cables for pedestrian displays. Consult with region maintenance to determine if the same 5c cable is used for associated pedestrian detection.
- 3cs cables for emergency preemption detectors.
- 2c cables for induction loop detectors. Shielded cable is not required for modern loop detector cards. Older systems may still need shielded cable (2cs), but it is recommended to replace the loop detector cards instead.
- Manufacturer specified cables for video and radar detectors. Video detectors typically use a combined RG9/5c (#18) cable. Radar detectors typically use proprietary 6c and 8c cables. These cables are roughly the size of 7c cables (for calculating conduit fill).
- Use 2c cables for isolated pedestrian detectors (separate pole from associated pedestrian display). For connecting 4-wire APS units, a 7c cable may be used between the PPB post and the signal pole with the pedestrian display (where the APS control unit is located).

To simplify potential repairs for smaller signal standards (Type FB and smaller), consider routing signal display and detection conductors through terminal cabinets on larger signal standards (Type II and larger) before connecting to smaller signal standards. This reduces the amount of wire which may need to be replaced if a smaller signal standard is knocked down and the wiring damaged.

1330.04(9)(b) Conduit

Refer to the *Standard Specifications* for conduit installation requirements. At existing intersections, where roadway reconstruction is not proposed, conduits are to be placed beyond the paved shoulder or behind existing sidewalks to reduce installation costs. All conduits shall be a minimum of 2 inches in size, with the following exceptions:

1. Conduits entering Type PPB signal standards shall be 1 inch. This may be increased to 1 1/4 inch when two APS PPBs are installed on the same pole.
2. Lighting conduits entering pole foundations (signal or light standards) shall be a minimum of 1 inch. See Chapter 1040 for additional requirements for light standards with slip bases.
3. Conduits entering Type PS, I, RM, and FB poles may be a minimum of 1-inch and a maximum of 2-inch.
4. The conduit for the service grounding electrode conductor may be a minimum of ½-inch.

Install spare conduits at all road crossings. Spare conduits at road crossings should be a minimum of one 3-inch conduit or two 2-inch conduits. Install a minimum 2-inch (preferably 3-inch) spare conduit into the controller cabinet.

It is recommended to use full inch conduit sizes to simplify construction and reduce the different types of conduits required for the system. This helps to provide future capacity and reduce costs through bulk material purchasing. 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 Exhibit 1330-19 for conduit and signal conductor sizes.)

Exhibit 1330-19 Conduit and Conductor Sizes

Conduit Sizing Table			
Trade Size	Inside Diam. (inches)	Maximum Fill (inch^2)	
		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 (inch^2)	Size (AWG)	Area (inch^2)
# 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		

Minimize roadway crossings whenever possible. Usually only three crossings are needed (one main line) for a four-leg intersection, and only two roadway crossings are needed for a T intersection. In most cases, the conduit should cross both the main line and side street from the corner where the controller is located.

Directional boring should normally be used when crossing the state route (main line). Open cut trenching may only be used to install conduits under the following circumstances:

1. Existing roadways where the roadway is being resurfaced.
2. Existing roadways where substantial obstacles under the roadway will be encountered.
3. Where there is insufficient room for jacking or boring pits at the edges of the roadway.

Open cut trenching is not permitted across limited access roadways unless the entire pavement surface is being replaced. Sign or signal bridges may not be used for roadway crossings.

1330.04(9)(c) Junction Boxes

Provide junction boxes at the following locations:

- Adjacent to the signal cabinet. A pull box or larger vault may be used in place of multiple junction boxes.
- Adjacent to each signal pole. One box may serve multiple poles. The distance from a pole to the first junction box should not exceed 10 feet without concurrence from maintenance staff. Pole bases may not be used as junction boxes.
- Adjacent to each set of detector loops. These boxes contain the detector loop splices. One box may serve multiple lanes, but the box should be no more than 50 feet from the detector loop.
- At the end of each road crossing.
- In the middle of conduit runs where the number of bends would equal or exceed 360°.

Where possible, locate junction boxes out of paved areas and adjacent to (but not in) sidewalks. New junction boxes may not to be placed in the pedestrian curb ramp or ramp landing of a sidewalk. If a new junction box must be placed within sidewalk, locate it at the edge of the sidewalk and designate it to be slip-resistant. Existing junction boxes located within new or existing sidewalk, including ramps or landings, must be revised as follows:

- Existing junction boxes containing power conductors for the traffic signal (not including street lighting), or wiring for the signal displays, may remain in place, even if they will be within a sidewalk ramp or ramp landing.
- Existing junction boxes containing detector wiring may remain in sidewalks, but must be relocated outside of sidewalk ramps and ramp landings. Designate that the relocation work, including conduit adjustments and rewiring, be completed within a single shift or provide temporary detection using another conduit path.
- All junction boxes which will be within sidewalk, sidewalk ramps, or ramp landings, must be slip-resistant junction boxes. This includes replacing existing junction boxes with slip-resistant junction boxes.
- Under no circumstances may a junction box be located in a grade break for a sidewalk ramp. Either the ramp must be redesigned or additional accommodations made in construction to allow for the box to be relocated.

The fundamental principle is that if relocating a junction box requires shutting down a traffic signal system, the junction box may remain in its existing location but must be replaced with a slip-resistant junction box. See Chapter 1510 for additional ADA requirements.

Do not place junction boxes within the traveled way unless absolutely necessary. Make every effort to locate new junction boxes and to relocate existing junction boxes outside the travel lane or paved shoulder. If there is no way to avoid locating the junction box in the traveled way or paved shoulder, heavy-duty junction boxes must be used. Avoid placing junction boxes in areas of poor drainage. Do not place junction boxes within 2 feet of ditch bottoms or drainage areas, or within vegetative filter strips or similar water treatment features which may be present. The maximum conduit capacities for various types of junction boxes are shown in the *Standard Plans*.

1330.05 Preliminary Signal Plan

All traffic signal work which installs or modifies detection or display equipment, with the sole exception of projects where induction loops are being removed and replaced in the same location, requires a preliminary signal plan for the Project File. The type of preliminary signal plan depends on the type of work being performed. For a new traffic signal system or complete system replacement, a Full Preliminary Signal Plan is required. For all other work, a Basic Preliminary Signal Plan is required. Include a brief discussion of the issue 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. The plan scale should not be smaller than “1 inch = 30 feet” (“1 inch = 20 feet” is preferable) – plans may be reduced to “1 inch = 40 feet” with prior approval.

Submit a copy of the preliminary signal plan to the State Traffic Engineer for review and comment. A preliminary signal plan must be submitted to the State Traffic Engineer regardless of the originator of the design. Allow two to three weeks for review of the preliminary signal plan. After addressing all review comments, finalize the plan and preserve as required by 1330.07 Documentation. Prepare the contract plans in accordance with the *Plans Preparation Manual.*

If HQ Traffic is preparing the contract Plans, Specifications, and Estimate (PS&E) package for the signal system portion of the project, submit the following items with the preliminary signal plan:

1. Contact person.
2. Charge numbers.
3. Critical project schedule dates.
4. Existing and proposed utilities, both underground and overhead.
5. Existing intersection layout, if different from the proposed intersection.
6. (Turning movement traffic counts (peak hour for isolated intersections) and a.m., midday, and p.m. peak-hour counts if there is another intersection within 500 feet.
7. Electrical service location, source of power, and utility company connection requirements.

After the PS&E package for the signal system portion of the project is prepared, the entire package is transmitted to the region for incorporation into its contract documents.

1330.05(1) Basic Preliminary Signal Plan

The Basic Preliminary Signal Plan includes the following elements, at a minimum:

a. All pavement markings.
b. Sidewalks, curb ramp, and level landing areas.
c. All pole types and locations.
d. All vehicle and pedestrian display types and locations.
e. All vehicle (car and/or bicycle) detector types and locations. Include detection zones for non-loop detectors.
f. All pedestrian pushbutton types and locations.

g. All emergency vehicle preemption (EVP) detector locations.

h. Phase diagram, including pedestrian movements and EVP channel assignments.

1330.05(2) Full Preliminary Signal Plan

The Full Preliminary Signal Plan includes all elements required for the Basic Preliminary Signal Plan, with the following additional items (list is continued from above):

a. Cabinet locations with door orientations.

b. Traffic barrier (guardrail, concrete barrier, etc.) locations.

c. Drainage items.

d. Left-turn radii, including beginning and ending points.

e. Corner radii, including beginning and ending points.

f. Railroad preemption requirements.

g. Illumination treatment, including a calculation summary showing the average light level, average/minimum uniformity ratio, and maximum veiling luminance ratio. (See Chapter 1040 for more information on illumination design requirements.)

h. Traffic counts, including left-turn movements.

i. Speed study information indicating 90th, 85th, and 10th percentile speeds for all approaches. For any new approach, or any approach where the existing speed will change, the design posted speed may be provided instead.

j. Utilities information, for any potential overhead or underground utility conflicts.

1330.06 Operational Considerations for Design

This section describes operational guidance for traffic signals. These operational requirements will directly affect the design of the traffic signal, particularly in regards to signal display types and locations.

All traffic signals should be periodically re-evaluated, to determine if timing or phasing changes would result in more efficient operation of the traffic signal, or in the case of interconnected systems, the corridor or network. Changes in traffic volumes, posted speeds, or other factors may influence turning movement phasing operations (protected, protected/permissive, or permissive), green times, yellow change intervals, and other operational parameters.

1330.06(1) Left-Turn Phasing

Left-turn phasing can either be permissive, protected/permissive, or protected. It is not necessary that the left-turn mode for an approach be the same throughout the day. Varying the left-turn mode on an approach among the permissive only, protected/permissive, and protected-only left-turn modes during different periods of the day is acceptable. Examples are included in the phase diagrams shown in Exhibit 1330-20 and Exhibit 1330-21.

For permissive left turns, the permissive left turn phase shall not terminate separately from the conflicting phase(s) (typically, the opposing through phase). This is to prevent placing left turning traffic in a yellow trap.

1. Permissive Left-Turn Phasing

Permissive left-turn phasing requires the left-turning vehicle to yield to opposing through traffic and pedestrians. Permissive left-turn phasing is used when the following are true:

a. Turning volume is minor.

b. Adequate gaps occur in the opposing through movement.

c. Adequate sight distance beyond the intersection is provided.

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 single-lane approaches with a posted speed of 45 mph or above, or where sight distance approaching the intersection is limited, channelization should include a separate left-turn storage lane for the permissive movement to reduce the potential for rear-end-type collisions and delay to through movements.

Unless there is a dedicated left-turn lane, do not provide a separate display for permissive left turns. When there is a dedicated left-turn lane, a three-section flashing yellow arrow display (with steady red arrow, steady yellow arrow, and flashing yellow arrow displays) should be used for the left-turn lane, as this provides a more positive indication of the permissive turning movement.

2. Protected/Permissive Left-Turn Phasing

Protected/permissive left-turn phasing provides both a protected phase and a permissive phase for the same lane, using the same signal display. 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 "T" intersections, ramp terminal intersections, and intersections of a two-way street with a one-way street where there are no opposing left-turn movements.

Protected/permissive left-turn phasing is NOT allowed under the following conditions:

a. For new signals, on an approach where Warrant 7 is met and there are five or more left-turning collisions on that approach included in the warranting collisions. This condition requires protected left turn phasing.

b. For existing signals, when documentation shows that existing protected left-turn phasing was installed due to left-turn collisions.

c. When sight distance for left-turning vehicles, as outlined in AASHTO's *A Policy on the Geometric Design of Highways and City Streets*, cannot be met.

d. On intersection approaches where the opposing approach has three or more lanes (including right-turn lanes) and either the posted speed limit or 85th percentile speeds for the opposing approach are at or above 45 mph.

e. On intersection approaches that have dual left-turn lanes, including approaches with left only and through-left lanes.

Where there is a separate left-turn lane, protective/permissive displays may use either of the following display arrangements:

- A dedicated four-section arrow display, with steady red arrow, steady yellow arrow, flashing yellow arrow, and steady green arrow displays (four-section FYA). A three-section display with a bi-modal flashing yellow arrow / steady green arrow may only be used if the signal support cannot accommodate a four-section signal display.
- A shared five-section cluster (doghouse) display, placed over the wide line between the left turn lane and the adjacent through lane.

Where there is no separate left-turn lane, only a five-section vertical (recommended) or cluster display may be used. The five-section display is used in place of the left of the two required through displays for that approach.

Protected/permissive displays may run as lead or lag. The display cycle will depend on the display type and whether the protected left leads or lags:

- Leading 4-section FYA: steady green arrow, steady yellow arrow, steady red arrow, flashing yellow arrow, steady yellow arrow, steady red arrow.
- Leading 5-section: green arrow, yellow arrow, red ball, green ball, yellow ball, red ball. Option: green ball may come up with green arrow, but the arrow and ball displays should cycle to yellow and red together (similar to lagging 5-section)
- Lagging 4-section FYA: flashing yellow arrow, steady green arrow, steady yellow arrow, steady red arrow
- Lagging 5-section: green ball, green ball with green arrow, yellow ball with yellow arrow, red.

3. Protected Left-Turn Phasing

Protected left-turn phasing provides the left-turning vehicle a separate phase, and conflicting movements are required to stop.

Use protected left-turn phasing under the following conditions:

a. Multi-lane left turn movements, including left and through-left from the same approach.

b. The left-turn is onto a roadway with a rail crossing.

c. Where Warrant 7 is met and there are five or more left-turning collisions on that approach included in the warranting collisions. Protected left-turn phasing is recommended even when there are as few as three left-turning collisions on that approach. This includes left-turning collisions involving pedestrians.

d. Where the peak-hour turning volume exceeds the storage capacity of the left-turn lane and one or more of the following conditions is present:

   i. The posted speed or the 85th percentile speed of the opposing traffic is 45 mph or higher.

ii. The sight distance to oncoming traffic is less than 250 feet when the posted or 85th percentile speed is 35 mph or below, or less than 400 feet when the posted or 85th percentile speed is above 35 mph.

iii. The left-turn movement crosses three or more lanes (including right-turn lanes) of opposing traffic.

iv. Geometry or channelization is confusing, such as skewed intersections, offset-T intersections, or intersections which require unusual maneuvers to traverse.

There are three typical operational arrangements for protected left turns:

- Leading Lefts: The left turns are served before the associated through movements. This is the most common operational arrangement. Example: Phases 1 and 5 (major street lefts) are served first, then phases 2 and 6 (major street throughs) are served.
- Lagging Lefts: The left turns are served after the associated through movements. Example: Phases 4 and 8 (minor street throughs) are served first, then phases 3 and 7 (minor street lefts) are served.
- Offset (or Lead/Lag) Lefts: One left turn is served before the associated through movements, and the opposing left turn is served after the associated through movements. Example: Phase 1 (one major left turn) is served first (phase 6 may be served at the same time), then phases 2 and 6 (major throughs) are served, and then phase 5 (opposing major left turn) is served (phase 2 may still be served with phase 5).

Check that all turning movements provide turning clearance for opposing turn phases. If the opposing left-turning vehicle paths do not have 4-foot minimum—12-foot desirable—separation between them, split or offset (lead/lag) phasing will have to be used.

1330.06(2) Right-Turn Phasing

Right turns typically do not operate with their own phasing unless there is a dedicated right turn lane. When there is no dedicated right turn lane, right turns are normally a permissive movement from the right most through lane, depending on pedestrian phases in use. When there is a dedicated right turn lane, right-turn phasing effectively operates the same as left-turn phasing.

Dedicated right turn lanes may be operated the same as left turn lanes: permissive, protected/permissive, or protected. However, right turn phase operation needs to take into account any pedestrian crossing on the receiving side of the right turn. If there is a conflicting pedestrian phase – typically a pedestrian phase running concurrent with the through phase from which the right turn is being made – the right turn phase may only be operated as permissive.

Dedicated right turn lanes operated as permissive and protected/permissive are recommended to have their own displays, but may use a shared display with the adjacent through lane. Dedicated right turn lanes operated as protected must use their own display. Right turn displays are arranged and operated the same as those listed for left turns in 1330.06(1). As with left turns, a permissive right turn phase shall not terminate separately from the conflicting phase(s) (typically, the opposing through phase).

Separate right turn phasing also needs to consider some additional operational modes and issues:

1. Right-Turn Overlapped Phasing

A right turn overlap is when a protected right turn is allowed at the same time as a complementary protected left turn, and is recommended when the lane and phase configuration will support this operation. When this operation is used, the left turn must be signed that U-turns are prohibited.

When right turn overlaps are used, the wiring of the right turn displays will depend on the operating mode of each display section:

- Permissive: Connect permissive display sections to the same terminals as the associated through phase.
- Protected: Protected display sections may either be:

  (a) Connected to the complementary left turn phase. Use this arrangement when the protected right turn will only be run concurrent with the complementary left turn phase.

  (b) Connected to an overlap phase. Use this arrangement when the protected right turn will be run with both the complementary left turn phase and with the through phase associated with the right turn.

2. Multiple-Lane Right-Turn Phasing

Multiple-lane right turns may be run independent or overlapped as described above. Multiple-lane right turns can cause operational challenges when “right turn on red” is permitted at the intersection. Verify that there is adequate sight distance and adequate receiving lanes are available to minimize the possibility of collisions. In most cases, a single unrestricted “right-turn-only” lane approach with a separate receiving lane (auxiliary lane) will have a similar capacity as the two lane right-turn phasing.

1330.06(3) Typical Signal Phasing Arrangements

The following diagrams show typical phasing diagrams for four-way and three-way intersections.

Exhibit 1330-20 Phase Diagrams: Four-Way Intersections

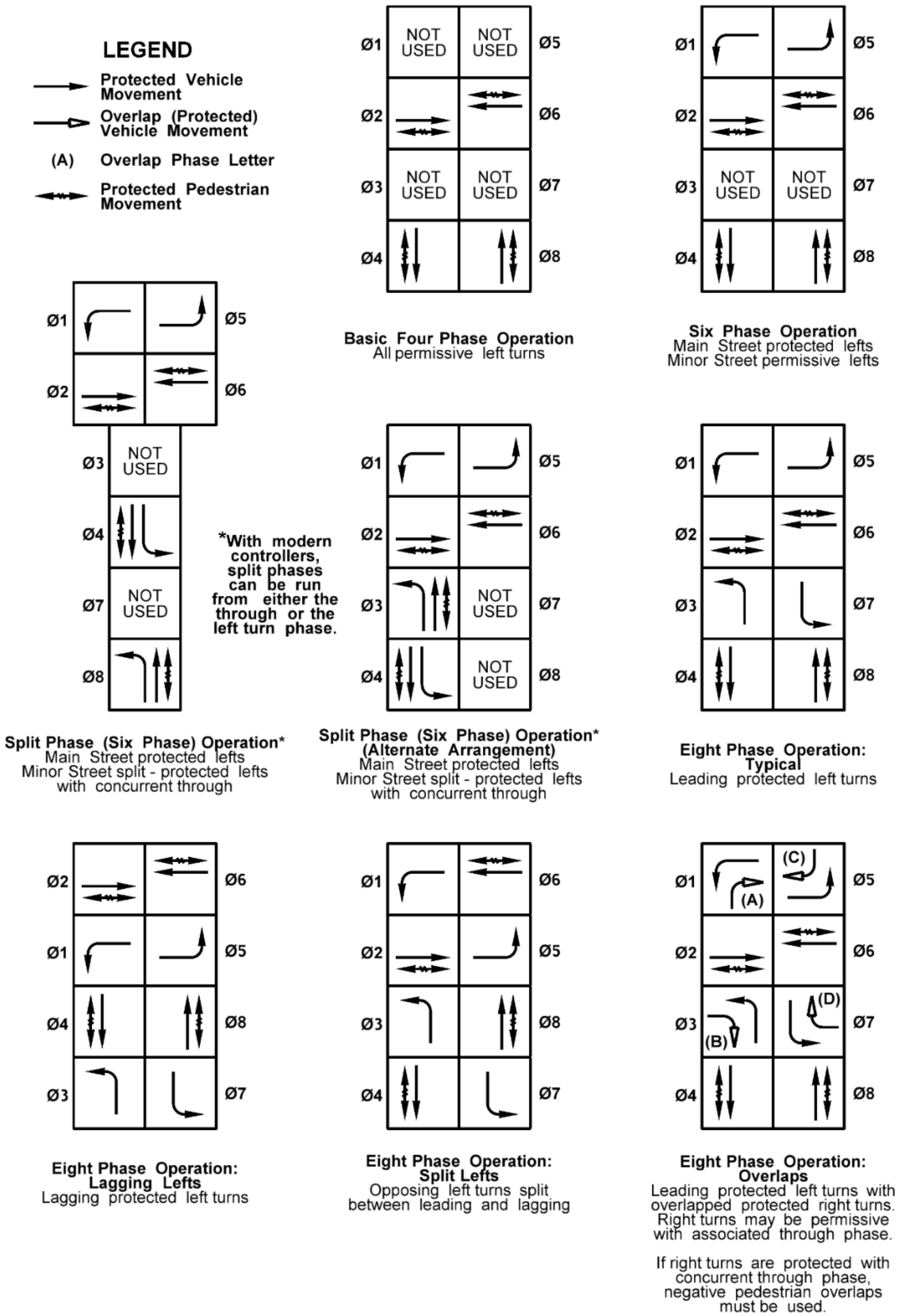
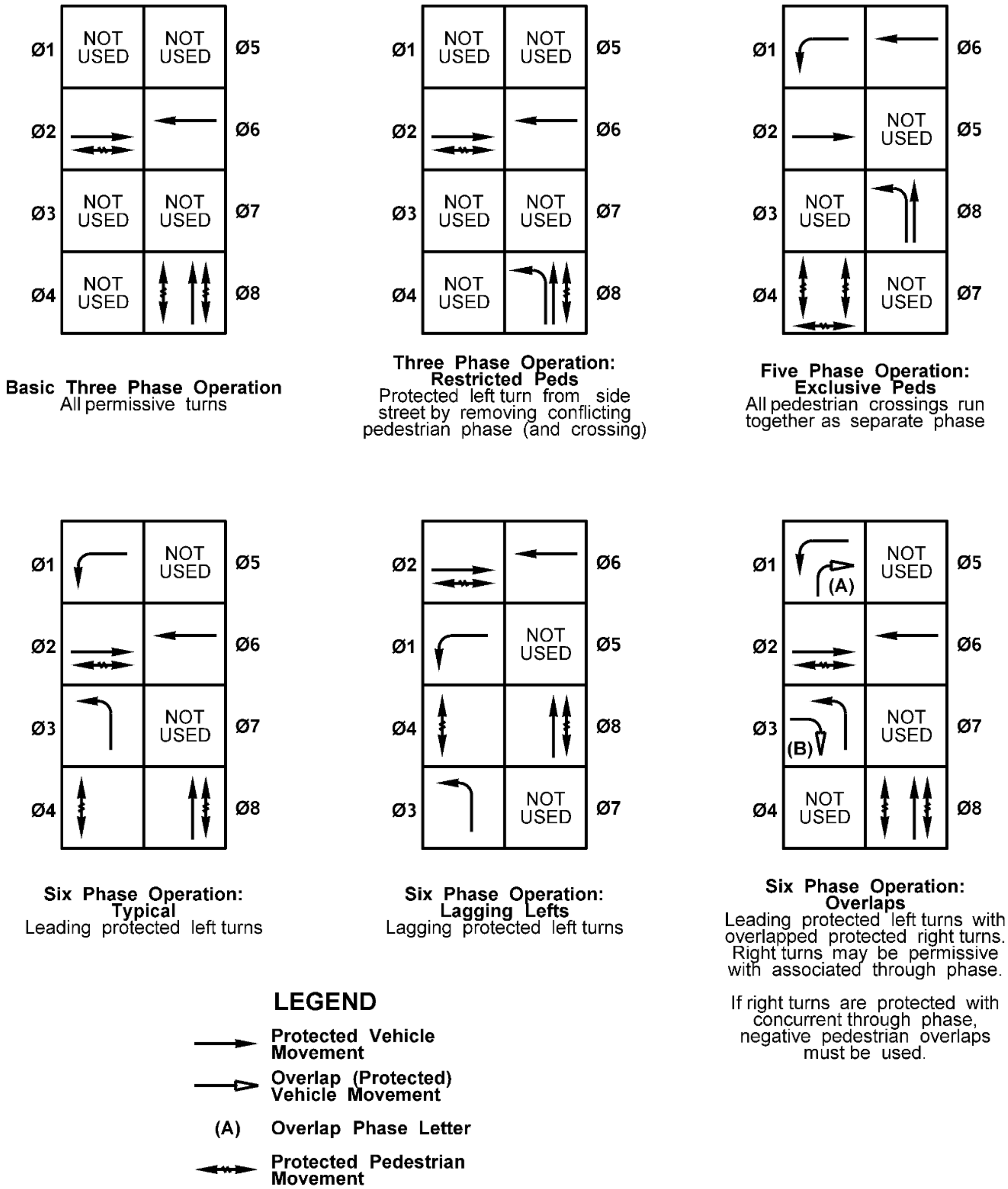


Exhibit 1330-21 Phase Diagrams: Three-Way Intersections

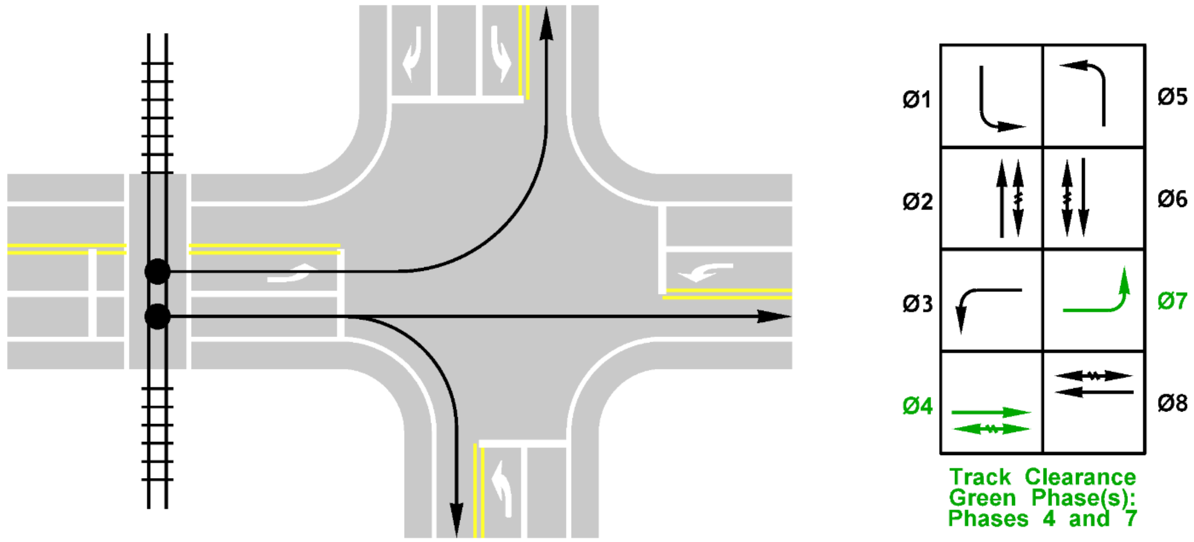


1330.06(4) Phasing at Railroad Crossings

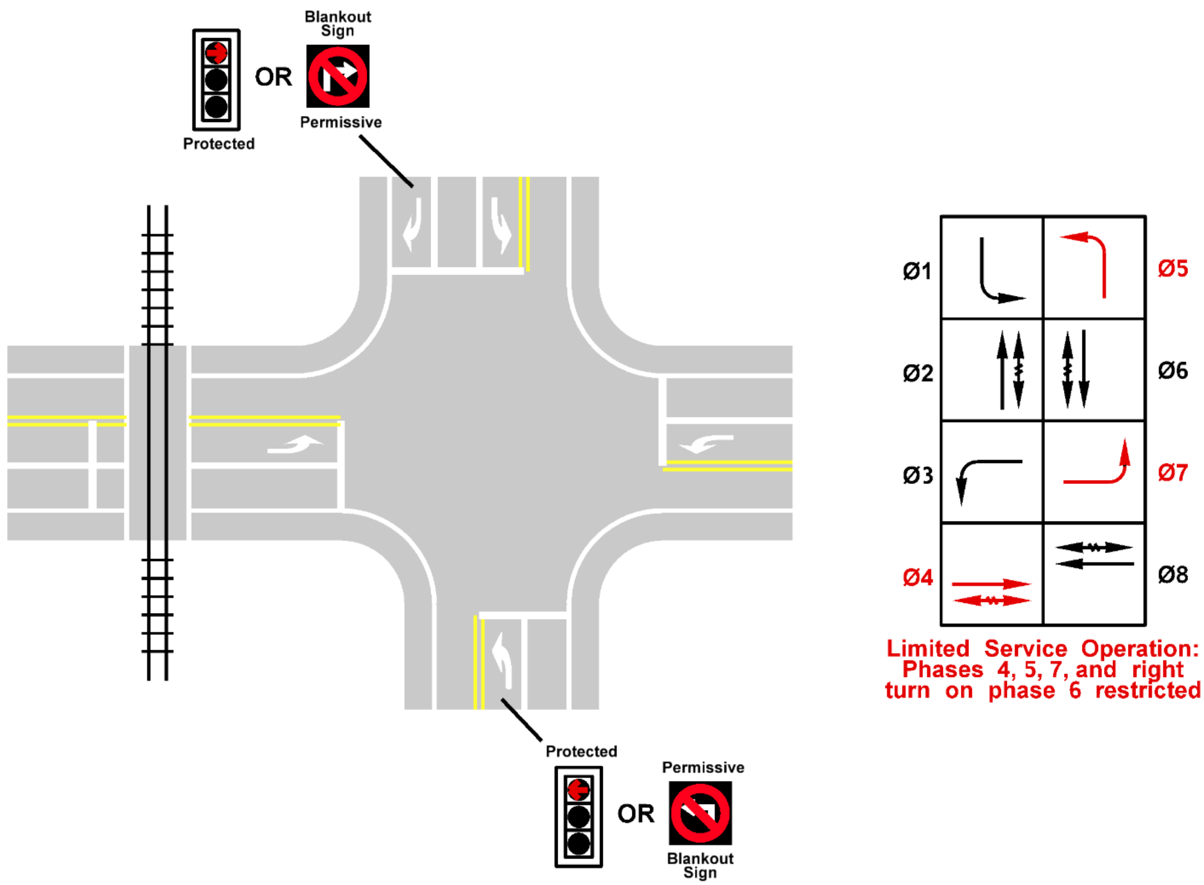
Traffic signals near railroad crossings have additional special phasing arrangements. To provide for efficient signal operations during a rail crossing, ensure that there are dedicated turn lanes for movements turning onto the tracks. These turn lanes should be on their own dedicated phases, so that they may be omitted from the signal timing (held in red) during the rail crossing. This allows for as many of the other intersection movements as possible to continue to operate – a timing scheme referred to as “Limited Service Operation” (LSO).

Just prior to LSO, when railroad preemption is used, the traffic signal will shift to a “Track Clearance Green” (TCG) phase. TCG shifts non-conflicting phases to green to allow vehicles to clear the railroad tracks. Examples of a TCG phase and LSO are shown in Exhibit 1330-22. Standalone queue cutter signals do not have a TCG phase – contact the HQ Traffic Office for operational guidance on standalone queue cutter signals.

Exhibit 1330-22 Phasing at Railroad Crossings



Track Clearance Green



Limited Service Operation

1330.06(5) Accessible Pedestrian Signals (APS)

APS are required to be operated as follows:

1. All APS at an intersection must use either rapid tick or speech messages – mixed operations at a single intersection are not allowed.
2. Street names in speech messages shall be limited to the basic street name. Do not include cardinals (N, S, E, etc.) or street type (street, avenue, road, etc.) unless needed to avoid confusion where two streets have the same name, such as 2nd Avenue and 2nd Street or Center Drive at Center Way.
3. Walk messages shall be in the format “Walk sign is on to cross <street>”.
4. Button press messages during flashing or solid DON’T WALK phases shall be in the following formats:
    a. Short press: “Wait”.
    b. Long press: “Wait to cross <street1> at <street2>”. Street names shall use the same format described above.
    c. Long press with extended crossing time: “Wait to cross <street1> at <street2> with extended crossing time”.
5. Audible countdowns shall not be used. The APS shall default to the locator tone during any phase other than WALK.

1330.07 Documentation

The following original signal design documents shall be included in a Signal System file and provided to the region Traffic Office or owning agency:

1. Signal Permit, including Signal Warrant Analysis and supporting documentation.
2. FHWA Approval for Experimentation.
3. Signal Standard Design Chart, including signal support engineering calculations.
4. Signal Detection Zone Placement. Include calculations if used.
5. Signal Wiring Diagram and Conduit Fill calculations.
6. Railroad preemption calculation and interconnect setup.
7. Any third party documentation provided.
8. Approved Preliminary Signal Plan.
9. Emergency Preemption Equipment selected.
10. Transit Priority Preemption and associated agreements.

Copies of items 1 and 2 are also required to be included in the DDP. Copies of items 3 through 10 are also required to be included in the Project File (PF).

Refer to Chapter 300 for additional design documentation requirements.

1330.08 References

The following references are used in the planning, design, construction, and operation of traffic control signals installed on state highways. The RCWs noted are specific state laws concerning traffic control signals, and conformance to these statutes is required.

1330.08(1) Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35)

Revised Code of Washington (RCW) 35.77, Streets – Planning, establishment, construction, and maintenance

RCW 46.04.450, Railroad sign or signal

RCW 46.04.600, Traffic control signal

RCW 46.04.62250, Signal preemption device

RCW 46.61.050, Obedience to and required traffic control devices

RCW 46.61.055, Traffic control signal legend

RCW 46.61.060, Pedestrian control signals

RCW 46.61.065, Flashing signals

RCW 46.61.070, Lane-direction-control signals

RCW 46.61.072, Special traffic control signals – Legend

RCW 46.61.075, Display of unauthorized signs, signals, or markings

RCW 46.61.080, Interference with official traffic-control devices or railroad signs or signals

RCW 46.61.085, Traffic control signals or devices upon city streets forming part of state highways – Approval by department of transportation

RCW 46.61.340, Approaching train signal

RCW 47.24.020(6) and (13), Jurisdiction, control

RCW 47.36.020, Traffic control signals

RCW 47.36.025, Vehicle-activated traffic control signals – Detection of motorcycles and bicycles

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

WAC 468-18-050, Policy on the construction, improvement and maintenance of intersections of state highways and city streets

"City Streets as Part of State Highways: Guidelines Reached by the Washington State Department of Transportation and the Association of Washington Cities on the Interpretation of

Selected Topics of RCW 47.24 and Figures of WAC 468-18-050 for the Construction, Operations and Maintenance Responsibilities of WSDOT and Cities for Such Streets," April 30, 1997.

WAC 468-95, Manual on Uniform Traffic Control Devices for Streets and Highways (Washington State Supplement)

1330.08(2) Design Guidance

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

Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings (TxDOT Form 2304) and Instructions for Form 2304 (TxDOT Form 2304-I), Texas Department of Transportation
🖰 http://www.txdot.gov/inside-txdot/forms-publications/forms/rail.html

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)

Plans Preparation Manual, M 22-31, WSDOT

Revised Draft Guidelines for Accessible Public Rights-of-Way, (PROWAG), November 23, 2005, United States Access Board

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 Traffic Design Resources
🖰 www.wsdot.wa.gov/design/traffic/

Chapter 1340 Driveways

1340.01 General

For the purpose of this chapter, and to remain consistent with WSDOT's *Standard Plans* and AASHTO terminology, the terms "access" and "approach" will be referred to as "driveway." An access on a managed access highway is defined as an "access connection," while an access on a limited access highway is defined as an "approach."

Driveways are as much about access as they are about driveway design. This chapter describes the pertinent access criteria along with the design guidelines, including two design templates based on design vehicle, sidewalks, and sight distance criteria, for driveway connections on the state highway system. WSDOT controls driveways on all limited access state highways, and regulates driveways on all managed access state highways outside the incorporated limits of a city or town. RCW 47.50.030 states that cities and towns, regardless of population size, are the permitting authority for managed access state highways within their respective incorporated city and town limits. The RCW also requires those cities and towns to adopt standards for access permitting on managed access state highways that meet or exceed WSDOT standards, provided those adopted standards are consistent with WSDOT standards.

1340.02 Access Control

Limited access highways are roadways to which WSDOT has acquired the access rights from abutting property owners. Driveways, if they have been allowed, are documented and recorded in the deed and right-of-way limited access plan. Chapter 530 describes the three levels of limited access highways: full, partial, and modified. Any change to the number, type, and use of a limited access driveway must be approved by Headquarters through the process outlined in Chapter 530 and Chapter 550. A general permit is required to allow any new construction or repairs for a deeded road approach on a limited access highway. Access connection permits are not issued on limited access highways.

Any state highway that is not a limited access highway is a managed access highway. Chapter 540 describes the five classes of managed access highways: Class 1 (most restrictive) to Class 5 (least restrictive). In addition to the five access control classes, there are also corner clearance criteria that must be used for access connections near intersections (see Section 540.04 and Exhibit 540-2). An access connection permit is required to allow the use, operation, and maintenance of a driveway connection on a managed access highway, outside incorporated cities, where WSDOT is the access permitting authority. Check with Development Services to ascertain where WSDOT has permitting authority (such as tribal lands or National Parks).

When evaluating access connections or approaches on a project, review existing driveways for possible alterations, relocations, consolidations, or closures. The first step in that process is to determine the legality of each driveway. The region Development Services Office can provide a list of the permitted driveway connections on a managed access highway, noting that, per RCW 47.50.080, Permit removal, "Unpermitted connections to the state highway system in existence on July 1, 1990, shall not require the issuance of a permit and may continue to provide access to the state highway system, unless the permitting authority determines that such a connection does not meet minimum acceptable standards of highway safety." As a result, driveway connections on a managed access state highway can be considered to be permitted, grandfathered, or unpermitted as described below:

- *Permitted* driveways hold a valid permit and shall remain valid until modified or revoked.
- *Grandfathered* driveways that were in existence and in active use consistent with the type of connection on July 1, 1990, may continue to provide connection to the state highway system. The term "Grandfathered" driveway, or connection, is not a term defined in statute or rule. It is a commonly used term to define legal connections to managed access state highways, in place prior to July 1, 1990. They do not require the issuance of a new permit and may continue to provide access to the state highway system, unless the permitting authority determines that such a connection does not meet minimum acceptable standards of highway safety.
- *Unpermitted* driveways are not allowed. The permitting authority may initiate action to close the unpermitted driveway in compliance with the applicable chapters of 47.50 RCW and 468-51 and 468-52 WAC. These are driveways that do not have a permit and were constructed after July 1, 1990.

If a WSDOT project proposes to alter, relocate, consolidate, or close a driveway—regardless of whether the driveway is permitted, grandfathered, or unpermitted—it is required that a new access connection permit be issued for any driveways that are to remain. If a driveway is to be removed, formal notification to the property owner will be provided as specified in WAC 468-51-040. Unless determined otherwise, the affected property owners of driveways that will be altered, relocated, consolidated, or closed will not have the right of an Adjudicative Hearing. Additional information regarding this process can be obtained by contacting your region's Development Services Office.

On limited access highways, both the region Development Services and Real Estate Services offices may provide assistance to determine the legality of an existing driveway. Federal Highway Administration approval is required for driveway modifications on Interstate facilities.

1340.03 Driveway Design

The design of a driveway is based on the usage, design vehicle, and traffic volumes anticipated for the driveway. Generally, the driveway should be designed to accommodate the largest vehicle that will regularly use the driveway. For example, a residential driveway connection will typically have smaller radii and a narrower access width than a higher-volume commercial driveway.

<u>The turning path width of the design vehicle determines the detailed foot print of the driveway in order for the design vehicle to stay in the lane and not intrude into other traffic lanes. Justification is required to "accommodate the design vehicle", whereby the design vehicle is</u> within the paved surface but allow<u>ed to intrude into other traffic lanes. See section 1310.02(5) for additional information pertaining to accommodating vs. designing for design vehicles.</u>

However, if the property owner regularly has larger-wheelbase vehicles using the driveway, such as a home-based work vehicle, recreational vehicle, or truck and boat trailer combination, then a larger driveway may be appropriate.

Conversely, some driveways, such as a rural locked and gated utility, farm, or logging access that larger vehicles sometimes use, may be better served with a smaller and narrower access. This is based on infrequent use and to prevent unauthorized use or dumping of debris on or near the driveway. Other design considerations are:

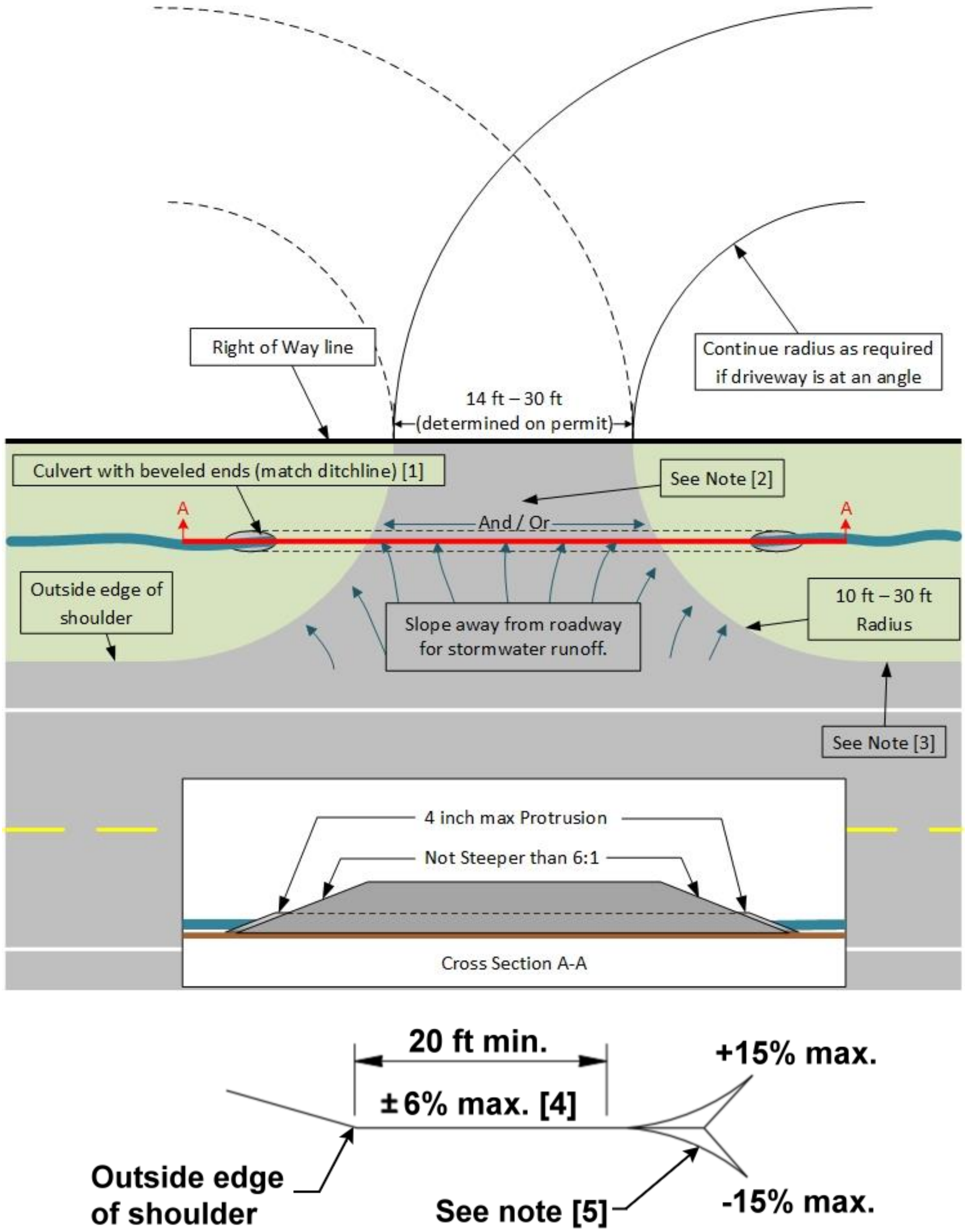
- Prevent stormwater from flowing onto the roadway from the driveway.
- Properly size culverts under the driveway to adequately accommodate the conveyance of stormwater in the roadway ditches and swales.
- Provide driveway sight distance.
- Accommodate for mailbox placement.
- Ensure surfacing materials and depths are appropriate.
- Generally, extend paving to the right of way line depending on the location/purpose of the driveway. The desirable intersection angle of the driveway is 90°, with 60° to 120° allowed.
- Where driveways intersect sidewalks, bike lanes, shared-use paths, or trails especially near schools, consider narrowing the driveway and/or reducing the radii to the minimum required <u>by</u> the design vehicle. Narrower driveway width and/or smaller driveway radii can reduce exposure and speed differentials between vehicles entering / exiting the driveway and pedestrians or bicycles.

1340.03(1) Design Templates

There are two driveway design templates for use where there is no adjacent sidewalk. When a driveway connection has or will have adjacent sidewalk, see Section 1340.04. In both template designs, the sideslopes of the driveway shall not be steeper than 6H:1V. These templates may be used on both limited access and managed access state highways. If an Interstate limited access driveway is allowed, it must be gated. Use the design template dimensions that will accommodate the intended use of the driveway and will not adversely affect the operations of the traveled way of the state highway. See Chapter 530 and Chapter 550 for documentation requirements for access approaches to limited access facilities. Design driveways with as small a foot print as possible while accommodating the design vehicle specific to that driveway. Use turn simulation software (such as AutoTURN®) to verify the driveway design will accommodate the largest vehicle that will regularly use the driveway. Considering the context of use, Exhibit 1340-1 is generally used for private, special use, and low volume commercial driveways with design vehicles of SU-30, BUS, and smaller. Exhibit 1340-2 is generally used for low volume commercial and special use driveways with design vehicles of SU-30, BUS, and larger.

Driveways to developments with greater than 1,500 (estimated) average daily trips both entering and exiting the development (shopping malls, housing developments, commercial complexes, etc.) should be designed as an intersection leg (see Chapter 1310).

Exhibit 1340-1 Driveway Design Template SU-30 and Smaller



Notes:

[1] Culvert pipe with beveled end treatment (see Chapter 1600). See Hydraulics Manual, Road Approach and Driveway Culverts for details.

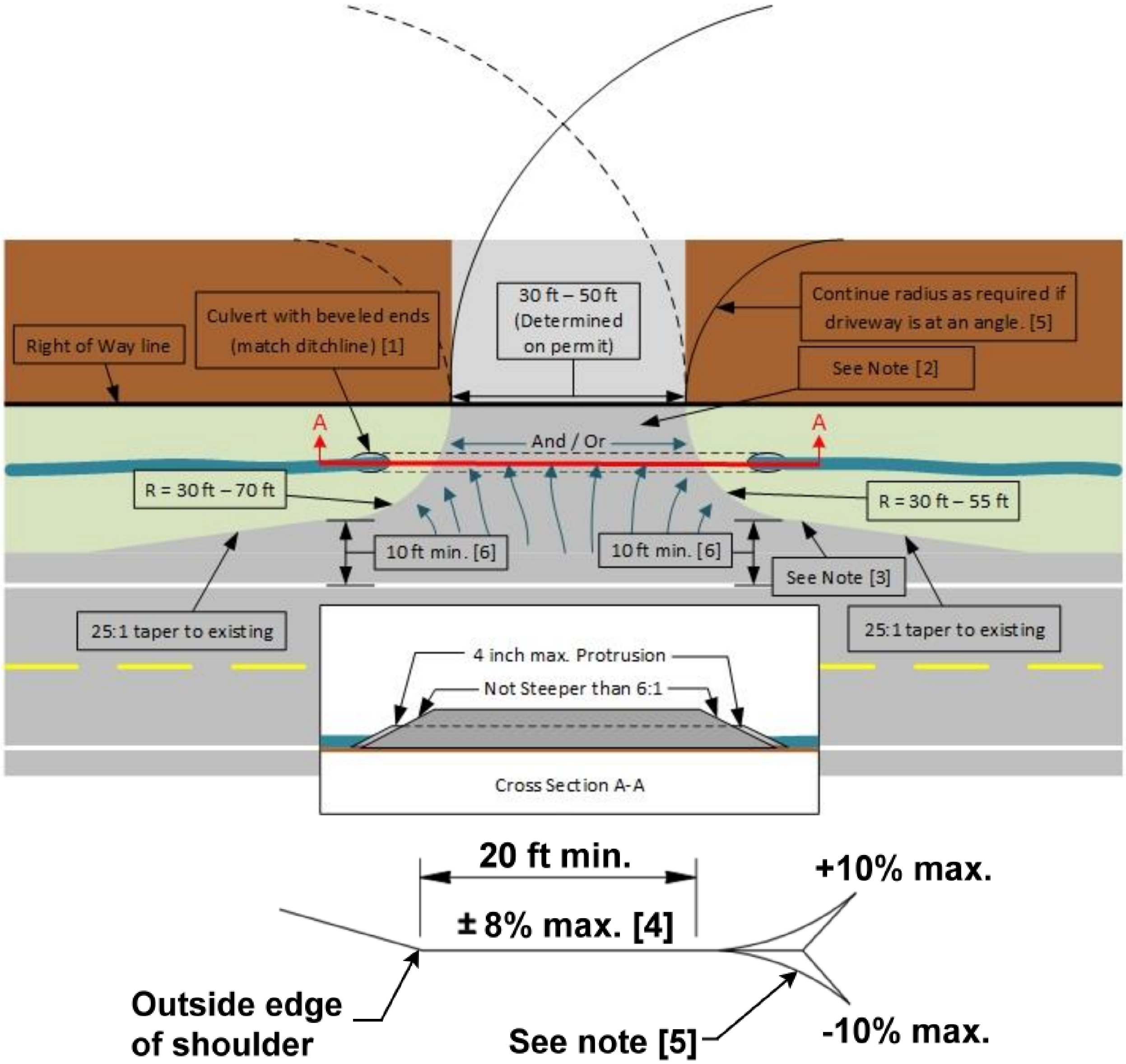
[2] When the travel lanes are bituminous, a similar surface may be used on the approaches.

[3] For mailbox location and type, see Section 1340.07 and Chapter 1600.

[4] Not to exceed ±8% maximum algebraic difference from shoulder slope.

[5] Vertical alignment not to exceed a 3¼-inch hump or a 2-inch depression in a 10-foot chord

Exhibit 1340-2 Driveway Design Template SU-30 and Larger



Notes:

[1] Culvert pipe with beveled end treatment (see Chapter 1600). See Hydraulics Manual, "Private Road Approach and Driveway Culverts" for details.

[2] When the travel lanes are bituminous, a similar surface may be used on the approaches.

[3] For mailbox location and type, see Section 1340.07, Chapter 1600.

[4] Not to exceed ±8% maximum algebraic difference from shoulder slope.

[5] Vertical alignment not to exceed a 3¼-inch hump or a 2-inch depression in a 10-foot chord.

[6] Check turning template of driveway design vehicle

1340.03(2) Sidewalks

Driveways adjacent to sidewalks shall be designed and constructed in accordance with this chapter and Standard Plan F-80.10. Driveway width will be as stated on the access permit. The sidewalk shall be designed and constructed in accordance with Chapter 1510 and Section F of the *Standard Plans*.

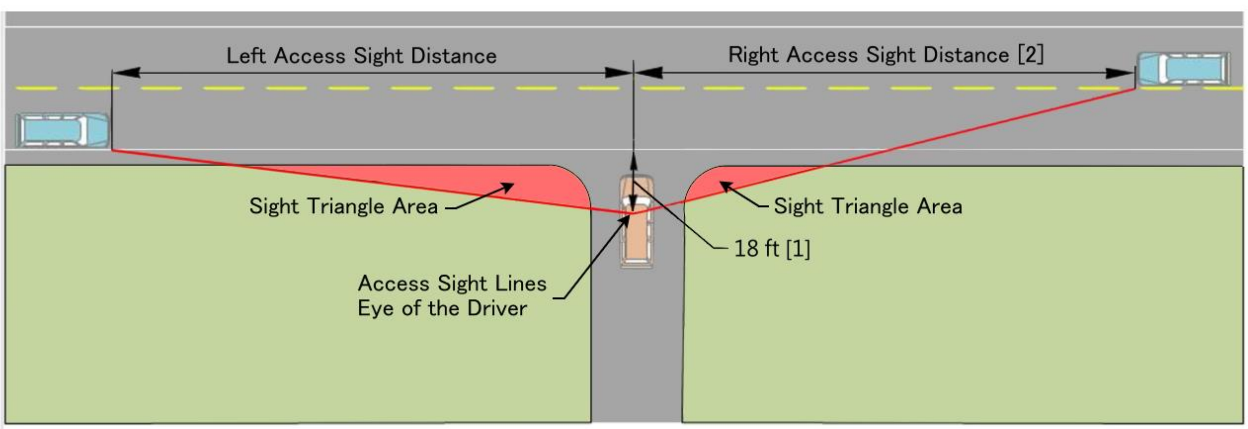
1340.03(3) Sight Distance

A driver on the highway needs to see far enough ahead to understand, react, and take actions appropriate for the conditions, such as a vehicle entering or leaving the highway at a driveway. In addition, drivers entering the highway from a driveway need to see enough of the highway, left and/or right, so they can enter the highway in a reasonably safe manner.

Design and locate driveways such that the sight distances, based on an eye height of 3.5 feet and an object height of 3.5 feet, meet or exceed the distances shown in Exhibit 1340-3; these distances may require an approaching vehicle to reduce speed or stop to prevent a collision. In addition, provide decision sight distance for through traffic at all utility and special-use driveways on facilities with limited access control (see Chapter 1260). The sight triangle areas created by the sight lines should be clear of sight obstructions that might block or affect a driver's view of potentially conflicting vehicles. See Exhibit 1340-3.

Use intersection sight distance (see Section 1310.05) for road approaches with greater than 1,500 (estimated) average daily trips both entering and exiting the development at full build out.

Exhibit 1340-3 Driveway Sight Distance



Mainline Posted Speed (mph)	25	30	35	40	45	50	55	60	65	70
Driveway Sight Distance (ft) Eye and object height 3.5 ft.	155	200	250	305	360	425	495	570	645	730

Notes:

[1] Measured from the edge of traveled way to the drive's eye. If the desirable 18-foot setback cannot be achieved, obtain as much as practicable, down to a 10-foot minimum.

[2] Not required for driveways that are restricted by raised channelization to be right in and right out only.

1340.03(4) Stormwater and Drainage

Slope driveways away from the highway to prevent stormwater and and other debris from flowing onto the highway traveled lanes and shoulders. Use of curbs, catch basins, or other measures may be needed to divert stormwater where it is not feasible to slope the driveway away from the highway. Locate catch basins outside of the vehical paths of the driveway.

Install beveled end culverts sized in accordance with the *Hydraulics Manual* if the driveway traverses an existing ditch or swale in the state highway right of way. Contact either the Region Hydraulic Engineer or the applicable Region Maintenance Office for assistance. Consider placing quarry spalls at each end of the open culvert to prevent erosion.

Profile the road approach as shown in Exhibits 1340-1 or 1340-2 while ensuring that roadway runoff is not a problem. Locate culverts as far from the traveled way as possible. In Exhibits 1340-1 and 1340-2, roadway runoff can be a concern if the grade from the edge of shoulder to the right of way line and the slope parallel to the mainline is a flat or minus grade. If needed, a curb may be placed and if needed, a catch basin can also be placed as shown in Exhibit 1340-2. When considering a curb, see Chapter 1239 as allowable curb locations, heights, and offset distances can vary based on mainline speed. Construct road approaches and related areas such that they do not impair drainage within the right of way or alter the stability of the roadway subgrade.

1340.03(5) Mailboxes

Refer to Chapter 1600, Roadside Safety, Mailboxes, for guidance regarding the placement of mailboxes.

Standard Plans, Mailbox Support Types, H-70.10-01, H-70.20-01, and H-70.30-02

1340.04 Documentation

Refer to Chapter 300 for design documentation requirements.

1340.05 References

1340.05(1) State Laws and Codes

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

Chapter 47.50 RCW, Highway access management

Chapter 47.52 RCW, Limited access facilities

Chapter 468-51 Washington Administrative Code (WAC), Highway access management access permits – Administrative process

Chapter 468-52 WAC, Highway access management – Access control classification system and standards

Chapter 468-58 WAC, Limited access highways

1340.05(2) Design Guidance

Right of Way Manual, M 26-01, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Development Services Manual, M 3007, WSDOT

Limited Access and Managed Access Master Plan, WSDOT
https://www.wsdot.wa.gov/design/accessandhearings/

Chapter 1360 Interchanges

1360.01 General

The primary purpose of an interchange is to reduce conflicts caused by vehicle crossings and minimize conflicting left-turn movements. Provide interchanges on all Interstate highways and freeways, and at other locations where traffic cannot be controlled efficiently by intersections at grade.

For additional information, see the following chapters:

Chapter	Subject
520	Access control
530	Limited access
550	Access Revision Report
1103	Design controls
1106	Design element dimensions
1240	Turning widths
1250	Cross Slope and Superelevation
1310	Intersections
1410	HOV lanes
1420	HOV direct access connections

1360.02 Interchange Design

1360.02(1) General

All freeway exits and entrances, except HOV direct access connections, are to connect on the right of through traffic. Variations from this 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 1420.

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.

Complications are rarely 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. Carefully consider the economic and operational effects of locating traffic interchanges along a freeway through a community, particularly with respect to local access, to provide convenient local service without reducing the capacity of the major route(s).

Where freeway-to-freeway interchanges are involved, do not provide ramps for local access unless they can be added conveniently and without detriment to efficient traffic flow or reduction of capacity, either ramp or freeway main line. When exchange of traffic between freeways is the basic function, and local access is prohibited by access control restrictions or traffic volume, separate interchanges for local service may be needed.

1360.02(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. Consider alternatives in the design of a specific facility; however, the conditions in the area and on the highway involved govern the final design of the interchange.

Selection of the final design is 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, semi directional, cloverleaf, partial cloverleaf, diamond, and single point (urban) interchange (see Exhibit 1360-1).

1360.02(2)(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.

1360.02(2)(b) Semi directional

A semi directional interchange has ramps that loop around the intersection of the highways. This results in multiple single-level structures and more area than the directional interchange.

1360.02(2)(c) Cloverleaf

The full cloverleaf interchange has four loop ramps for the left-turning traffic. Outer ramps provide for the right turns. A full cloverleaf is the minimum type interchange for a freeway-to-freeway interchange. Cloverleaf designs often incorporate a C-D road to minimize signing difficulties and 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 needs a large area. The weaving and the radius of the loop ramps are a capacity constraint on the left-turn movements.

1360.02(2)(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 where ramp cannot be built in one or two quadrants. Outer ramps are provided for the remaining turns. Design the grades to provide sight distance between vehicles approaching these ramps.

1360.02(2)(e) Diamond

A diamond interchange has four ramps that are essentially parallel to the major arterial. Each ramp provides for one right-turn 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.

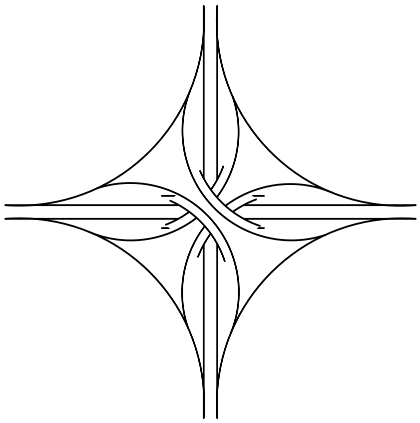
The diamond design is the most generally applicable and serviceable interchange configuration and usually has a smaller footprint than any other type. Consider this design first unless another design is clearly dictated by traffic, topography, or special conditions.

1360.02(2)(f) Single Point Urban (SPUI)

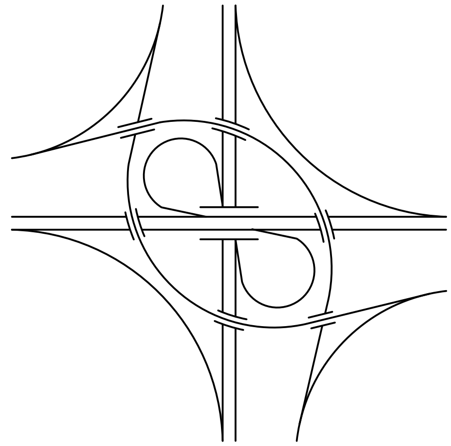
A single point urban interchange is a modified diamond with all of its ramp terminals on the crossroad combined into one signalized at-grade intersection. This single intersection accommodates all interchange and through movements.

A single point urban interchange can improve the traffic operation on the crossroad with less right of way than a typical diamond interchange, but a larger structure.

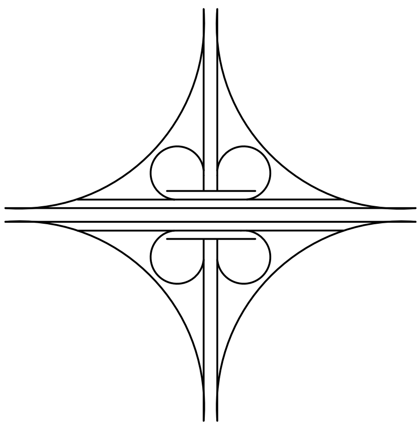
Exhibit 1360-1 Basic Interchange Patterns



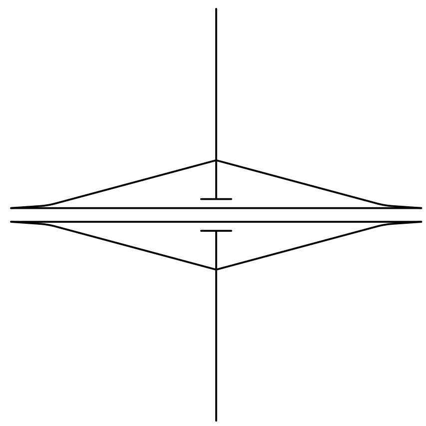
Directional



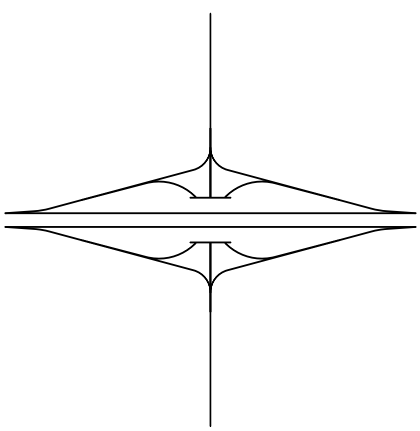
Semidirectional



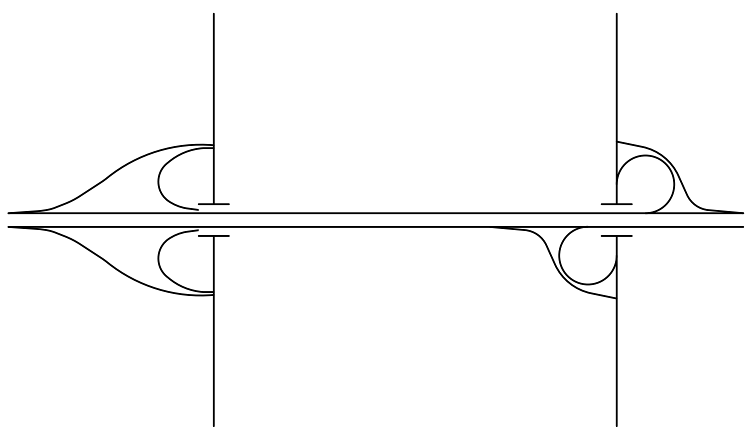
Cloverleaf With C-D Roads



Diamond



Single Point Urban Interchange (SPUI)



Partial Cloverleaf

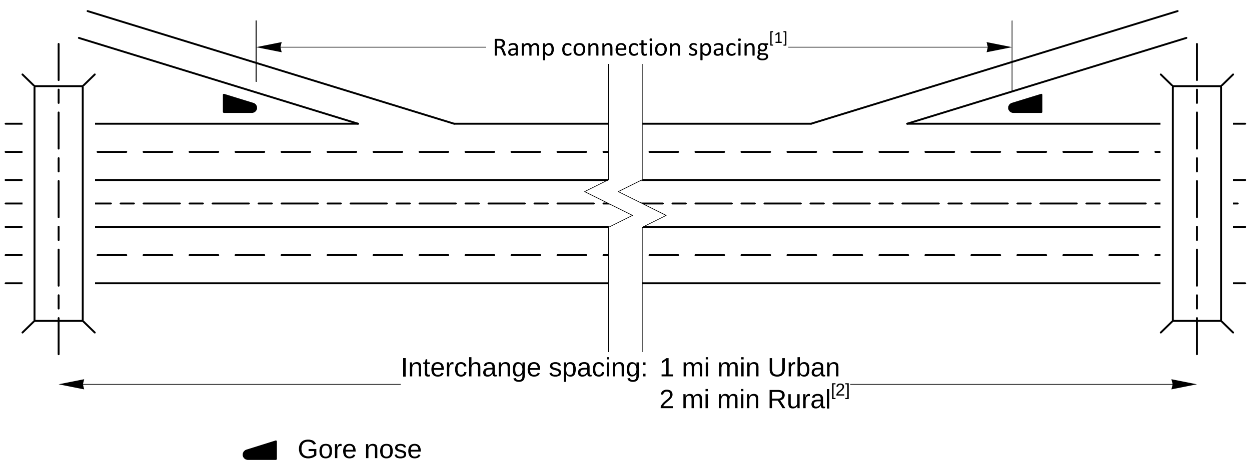
1360.02(3) Spacing

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 mile in urban areas, 3 miles on the Interstate in rural areas, and 2 miles on non-Interstate in rural areas (see Exhibit 1360-2). In urban areas, spacing less than 1 mile may be used with C-D roads or grade-separated (braided) ramps. Interchange spacing is measured along the freeway centerline between the centerlines of the crossroads.

The spacing between interchanges may also be dependent on the spacing between ramp connections. The minimum spacing between the gore noses of adjacent ramps is given in Exhibit 1360-3.

Exhibit 1360-2 Interchange Spacing



Notes:

[1] As a minimum, provide length for weaving and signing, but not less than given in Exhibit 1360-3.

[2] 3 miles on the Interstate System.

Consider either frontage roads or C-D roads to facilitate the operation of near-capacity volumes between closely spaced interchanges or ramp terminals. C-D roads may be needed where cloverleaf loop ramps are involved or where a series of interchange ramps have overlapping speed change lanes. Base the distance between successive ramp terminals on capacity. Check the intervening sections by weaving analyses to determine whether capacity, sight distance, and effective signing can be provided without the use of auxiliary lanes or C-D roads.

Provide justifications for existing interchanges with less-than-desirable spacing or ramp connection spacing to remain in place.

1360.02(4) Route Continuity

Route continuity is providing 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 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.

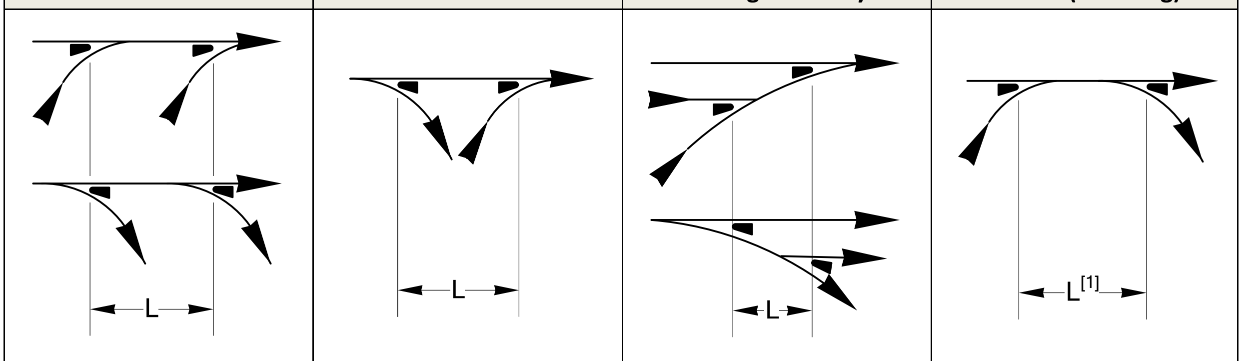
1360.02(5) Drainage

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 stormwater detention facilities.

1360.02(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.

Exhibit 1360-3 Minimum Ramp Connection Spacing



On-On or Off-Off		Off-On		Turning Roadways		On-Off (Weaving)			
Freeway	C-D Road	Freeway	C-D Road	System[2] Interchange	Service[3] Interchange	A	B	C	D
1,000	800	500	400	800	600	2000	1600	1600	1000
Gore nose									

L = Minimum distance in feet from gore nose to gore nose.

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 values are based on operational experience, need for flexibility, and signing. Check them in accordance with Exhibit 1360-12 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.

1360.03 Ramps

1360.03(1) Ramp Design Speed

The design speed for a ramp is based on the design speed for the freeway main line.

It is desirable that 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 Exhibit 1360-4 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 feasible, but not lower 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, use a design speed of 15 mph for turning traffic or 0 mph for a stop condition. 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 Exhibit 1360-4; however, with justification, the midrange values from Exhibit 1360-4 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 criteria if acceleration or deceleration criteria are met (see Exhibit 1360-9 or 1360-10) and superelevation meets the criteria in Chapter 1250.

Exhibit 1360-4 Ramp Design Speed

Main Line Design Speed (mph)		50	55	60	65	70	80
Ramp Design Speed (mph)	Upper Range	45	50	50	55	60	70
	Midrange	30	40	45	45	50	60
	Lower Range	25	25	25	25	25	25

1360.03(2) Sight Distance

Design ramps in accordance with the provisions in Chapter 1260 for stopping sight distances.

1360.03(3) Grade

The maximum grade for ramps for various design speeds is given in Exhibit 1360-5.

Exhibit 1360-5 Maximum Ramp Grade

Ramp Design Speed (mph)		25 – 30	35 – 40	45 and above
Ramp Grade (%)	Desirable	5	4	3
	Maximum *	7	6	5
* On one-way ramps, downgrades may be 2% greater				

1360.03(4) Cross Section

Provide the ramp widths given in Exhibit 1360-6. Ramp traveled ways may need additional width when operational needs exist.

Cross slope and superelevation criteria for ramp traveled ways and shoulders are as given in Chapter 1250 for roadways. At ramp terminals, the intersection lane and shoulder width design guidance shown in Chapter 1310 may be used.

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, provide smooth transitions for the edge of traveled way.

Exhibit 1360-6 Ramp Widths

Number of Lanes			1	2
Ramp Width (ft)	Traveled Way [1]		11-13 [5]	23-25 [3] [5]
	Shoulders	Right	4-8 [2] [5]	4-8 [2] [5]
		Left	2	2-4
	Medians [4]		6	6-8

Notes:

[1] Evaluate shoulder use to accommodate offtracking, if determined inadequate for operational performance needs, apply turning roadway widths in Chapter 1240.

[2] Provide width necessary to accommodate offtracking by large vehicles.

[3] Add 12 ft for each additional lane.

[4] The minimum two-way ramp median width (including shoulders) is given. Wider medians may be required for signs or other traffic control devices and their respective clearances. When either the on- or off-ramp is single-lane, use the one-lane column. If both directions are two lanes, use the two-lane column.

[5] Use the mode/function/performance approach described in Chapter 1106 to choose between the range of widths given.

Ramp shoulders may be used by large trucks for offtracking and by smaller vehicles cutting to the inside of curves. Evaluate the need to pave shoulders full depth for larger vehicle offtracking using turn simulation software on one-way ramps to accommodate this type of use. If operational performance needs demonstrate that accommodation of offtracking on shoulders is inadequate apply turning roadway widths in Chapter 1240.

1360.03(5) Two-Way Ramps

Two-way ramps are on- and off-ramps on a single roadway. Design two-way ramps as separate one-way ramps. Provide a raised median to physically separate the on- and off- ramps. Wider medians than given in Exhibit 1360-6 may be required for signing or other traffic control devices and their clearances. (For signs, it is sign width plus 4 feet.) Where wider medians are required, provide a 2-foot clearance between the face of curb and the edge of traveled way. Where additional width is not required, the raised median width may be reduced to a double-faced mountable or extruded curb. Traffic barrier or a depressed median may be provided in place of the raised median.

1360.03(6) Ramp Lane Increases

When off-ramp traffic and left-turn movement volumes at the ramp terminal at-grade intersection cause excessive queue length, it may be desirable to add lanes to the ramp to reduce the queue length caused by congestion and turning conflicts. Make provision for the addition of ramp lanes whenever ramp exit or entrance volumes are expected to result in an undesirable mobility or safety performance. (See Chapter 1210 for width transition design.)

1360.03(7) 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 criteria. 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 1360.04(4) for information on the design of on-connection acceleration lanes and Chapter 1050 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 metered ramps.

Consider HOV bypass lanes with ramp meters. (See Chapter 1410 for design data for ramp meter bypass lanes.)

1360.04 Interchange Connections

To the extent practicable, provide uniform geometric design and uniform signing for exits and entrances 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.

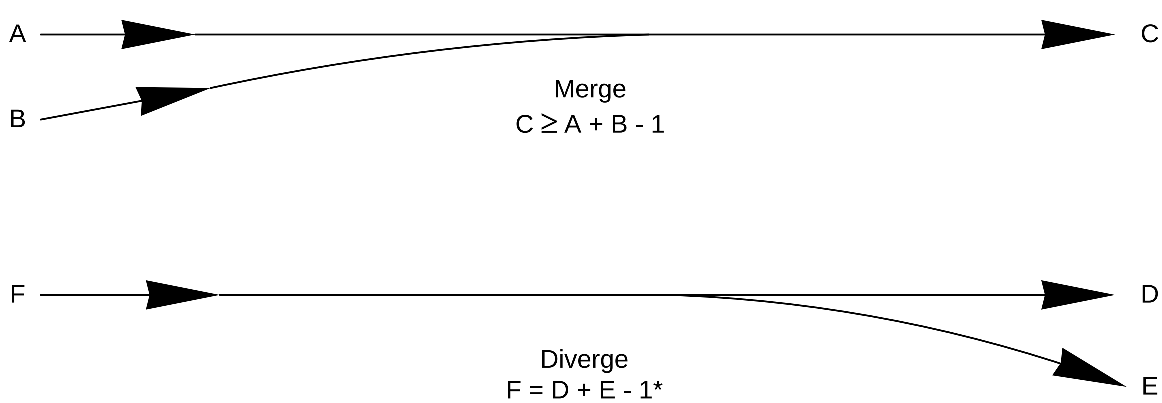
Provide spacing between interchange connections as given in Exhibit 1360-3.

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 results in 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.

Provide justification when curb is used adjacent to traffic with a design speed of 40 mph or higher.

Exhibit 1360-7a Lane Balance



*Note: Number of lanes (F) may increase by one lane, when the lane is an auxiliary lane between closely spaced entrance and exit ramps.

1360.04(1) Lane Balance

Design interchanges to the following principles of lane balance:

1360.04(1)(a) Entrances

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 Exhibit 1360-7a).

1360.04(1)(b) Exits

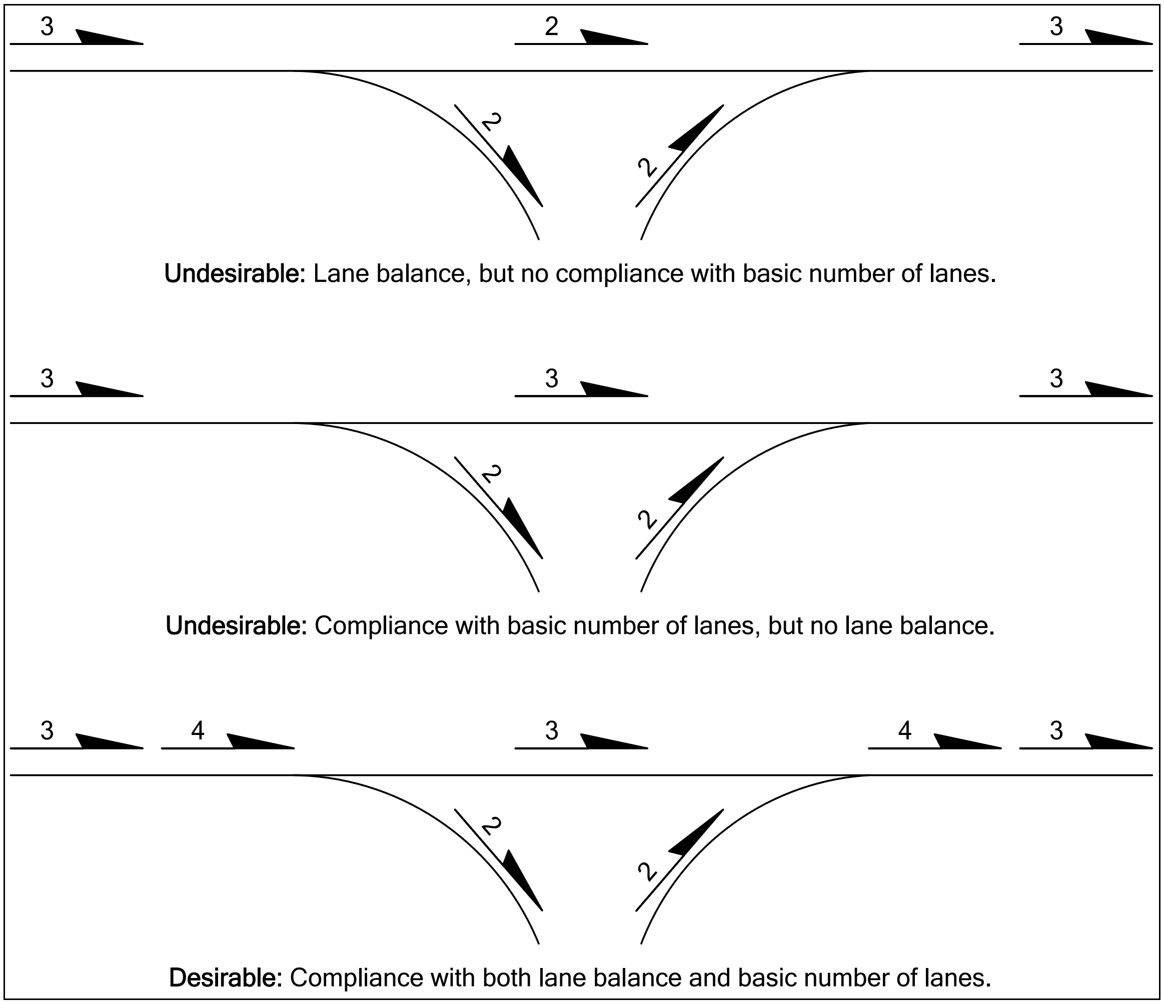
At exits, make the number of approach lanes equal the number of highway lanes beyond the exit plus the number of exit lanes less one (see Exhibit 1360-7a). Exceptions to this are:

- At a cloverleaf.
- 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 (Exhibit 1360-14c), 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 feet between the end of the acceleration lane and the beginning of the deceleration lane.

Maintain the basic number of lanes, as described in Chapter 1210, through interchanges. When a two-lane exit or entrance is used, maintain lane balance with an auxiliary lane (see Exhibit 1360-7b). The exception to this is when the basic number of lanes is changed at an interchange.

Exhibit 1360-7b Lane Balance



1360.04(2) Main Line Lane Reduction

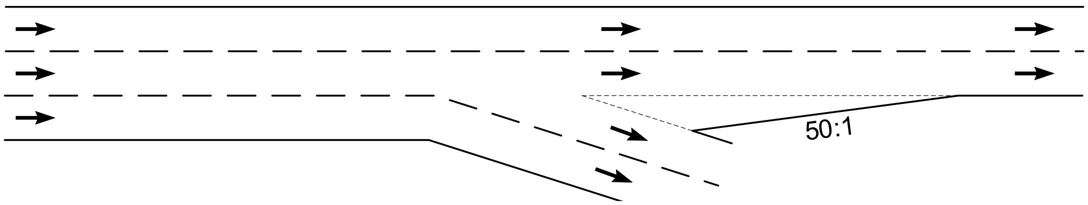
The reduction of a basic lane or an auxiliary lane may be made at a two-lane exit or may be made between interchanges. When a two-lane exit is used, provide a recovery area with a normal acceleration taper. When a lane is dropped between interchanges, drop it 1,500 to 3,000 feet from the end of the acceleration taper of the previous interchange. This allows for signing but will not be so far that the driver becomes accustomed to the number of lanes and will be surprised by the reduction (see Exhibit 1360-8).

Reduce the traveled way width of the freeway by only one lane at a time.

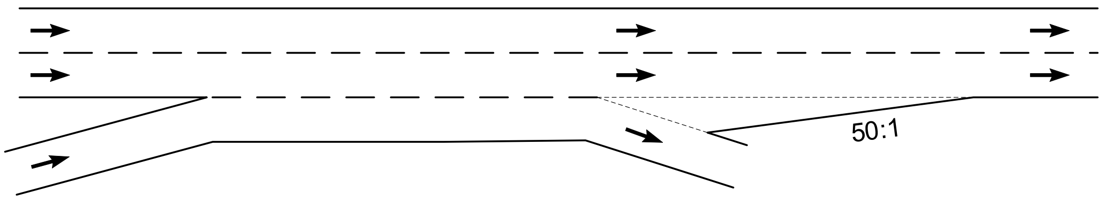
1360.04(3) Sight Distance

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 1260.

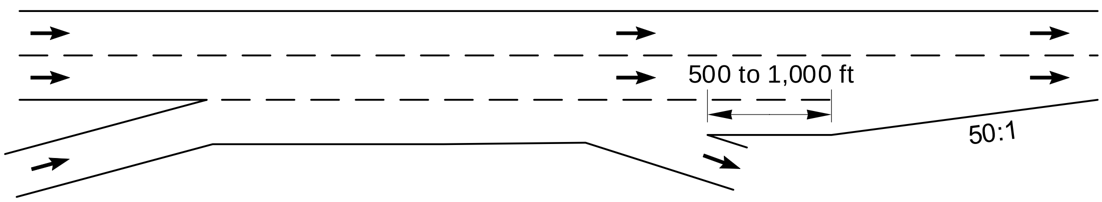
Exhibit 1360-8 Main Line Lane Reduction Alternatives



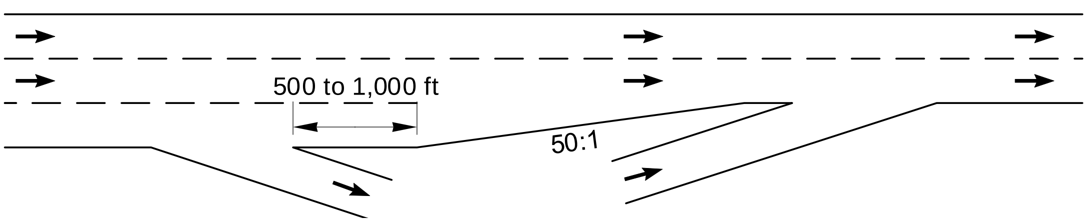
Lane dropped at two-lane off-connection



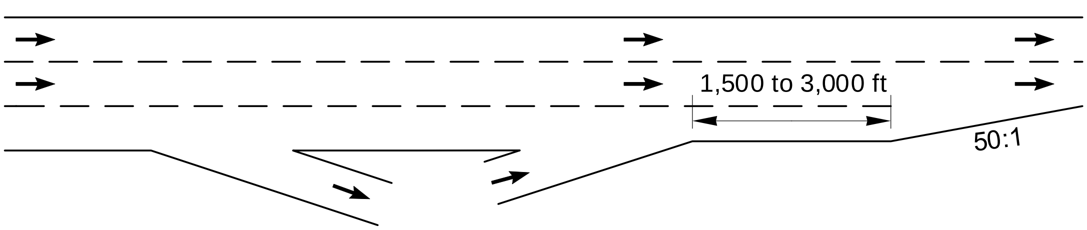
Lane between closely spaced ramps
dropped at single-lane off-connection
(lane imbalance for weaving)



Lane between closely spaced ramps
dropped after single-lane off-connection
(lane balance for weaving)



Lane dropped within interchange



Lane dropped after interchange

1360.04(4) On-Connections

On-connections are the paved areas at the end of on-ramps that connect 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 tapered or parallel. 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 less steering control is needed for the taper, the parallel is narrower at the end of the ramp and has a shorter taper at the end of the acceleration lane.

1360.04(4)(a) Acceleration Lane

Provide the minimum acceleration lane length, given in Exhibit 1360-9, 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.

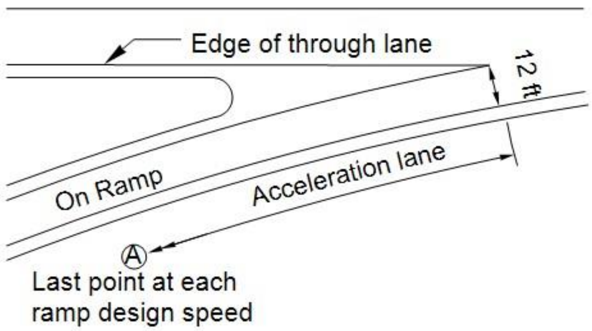
For existing ramps that do not have significant crashes in the area of the connection with the freeway, the freeway posted speed may be used to calculate the acceleration lane length for Preservation projects. If corrective action is indicated, use the freeway design speed to determine the length of the acceleration lane.

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 of the ramp width. Curves designed at higher design speeds may be included as part of the acceleration lane length.

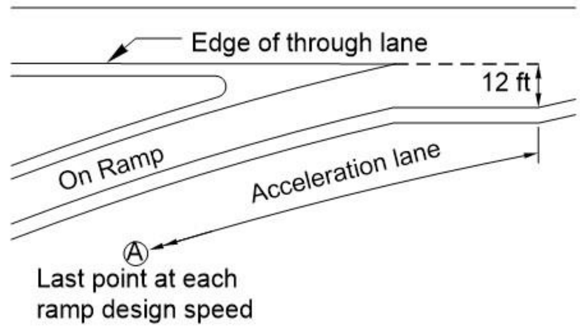
1360.04(4)(b) Gap Acceptance

For parallel on-connections, provide the minimum gap acceptance length (Lg) to allow entering motorists to evaluate gaps in the freeway traffic and position their vehicles 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 Exhibits 1360-13b and 13c). The gap acceptance length and the acceleration length overlap, with the ending point controlled by the longer of the two.

Exhibit 1360-9 Acceleration Lane Length



Tapered On-Connection



Parallel On-Connection

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	Upgrade				Downgrade
		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%

Note: Lane widths are shown for illustrative purposes. Determine lane widths based on Exhibit 1360-6.

1360.04(4)(c) Single-Lane On-Connections

Single-lane on-connections may be either tapered or parallel. Design single-lane tapered on-connections as shown in Exhibit 1360-13a and single-lane parallel on-connections as shown in Exhibit 1360-13b.

1360.04(4)(d) Two-Lane On-Connections

For two-lane on-connections, the parallel is desirable. Design two-lane parallel on-connections as shown in Exhibit 1360-13c. A capacity analysis will normally be the basis for determining whether a freeway lane or an auxiliary lane is to be provided.

Justify the use of a two-lane tapered on-connection. Design two-lane tapered on connections in accordance with Exhibit 1360-13d.

1360.04(5) Off-Connections

Off-connections are the paved areas 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 tapered or parallel. The tapered is desirable because it fits the normal path for most drivers. When a parallel connection is used, drivers tend to drive directly for the ramp and not use the parallel lane. However, when a ramp is on the outside of a curve, the parallel off-connection is desirable. An advantage of the parallel connection is that it is narrower at the beginning of the ramp.

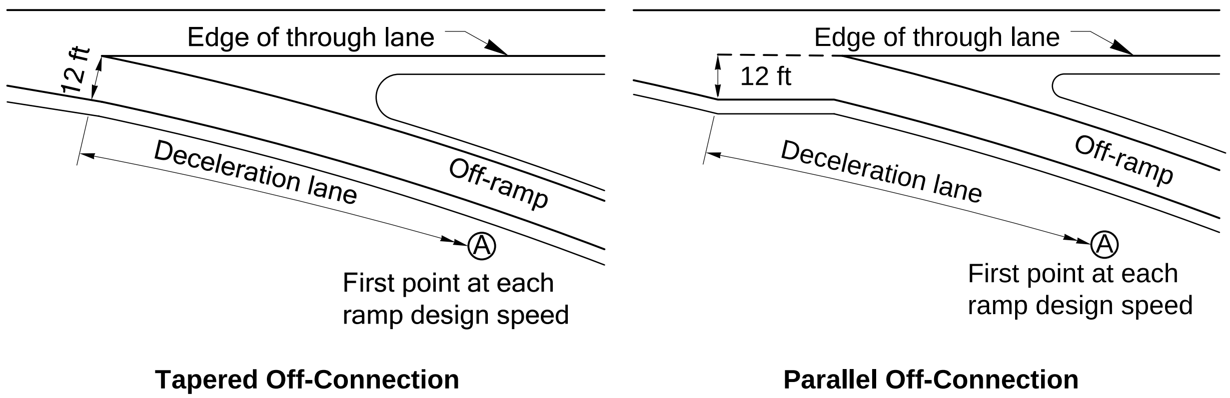
1360.04(5)(a) Deceleration Lane

Provide the minimum deceleration lane length given in Exhibit 1360-10 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 crashes 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.

The deceleration lane is measured from the point where the taper reaches the selected ramp lane width 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.

Exhibit 1360-10 Deceleration Lane Length



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 Lane Length (ft)

Grade	Upgrade	Downgrade
3% to less than 5%	0.9	1.2
5% or more	0.8	1.35

Adjustment Factors for Grades Greater Than 3%

Note: Lane widths are shown for illustrative purposes. Determine lane widths based on Exhibit 1360-6.

1360.04(5)(b) Gores

Gores (see Exhibits 1360-11a and 11b) are decision points. Design them to 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 Exhibits 1360-11a 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.)

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 is placed in a gore area, provide an impact attenuator (see Chapter 1620) and barrier (see Chapter 1610). Place the beginning of the attenuator as far back in the reserve area as possible, desirably after the gore nose.

1360.04(5)(c) Single-Lane Off-Connections

For single-lane off-connections, the tapered is desirable. Use the design shown in Exhibit 1360-14a for tapered single-lane off-connections. Justify the use of a parallel single-lane off-connection, as shown in Exhibit 1360-14b.

1360.04(5)(d) Single-Lane Off-Connection With One Lane Reduction

The single-lane off-connection with one lane reduction, shown in Exhibit 1360-14c, is used when the conditions from lane balance for a single-lane exit, one-lane reduction, are met.

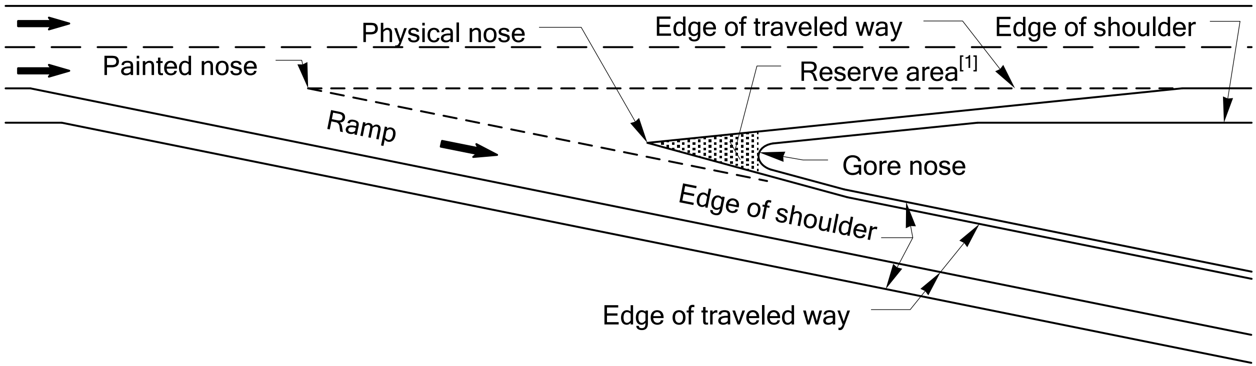
1360.04(5)(e) Tapered Two-Lane Off-Connection

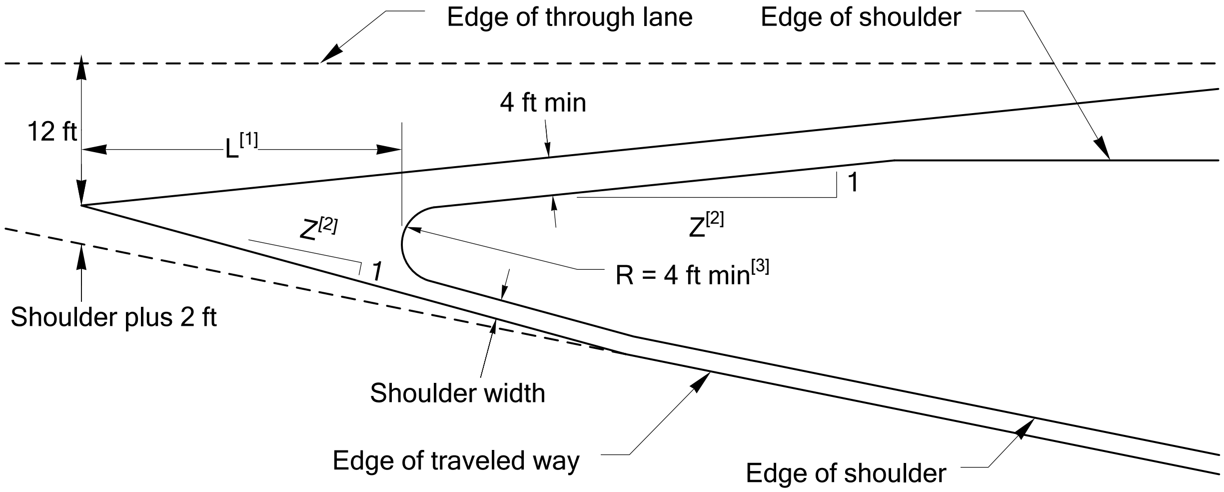
The tapered two-lane off-connection design, shown in Exhibit 1360-14d, is desirable where the number of freeway lanes is reduced or where high-volume traffic operations will be improved by the provision of a parallel auxiliary lane and the number of freeway lanes is unchanged.

1360.04(5)(f) Parallel Two-Lane Off-Connection

The parallel two-lane off-connection, shown in Exhibit 1360-14e, allows less operational flexibility than the taper, requiring more lane changes. Justify the use of a parallel two-lane off-connection.

Exhibit 1360-11a Gore Area Characteristics





Single-Lane Off-Connections: No Lane Reduction

Notes:

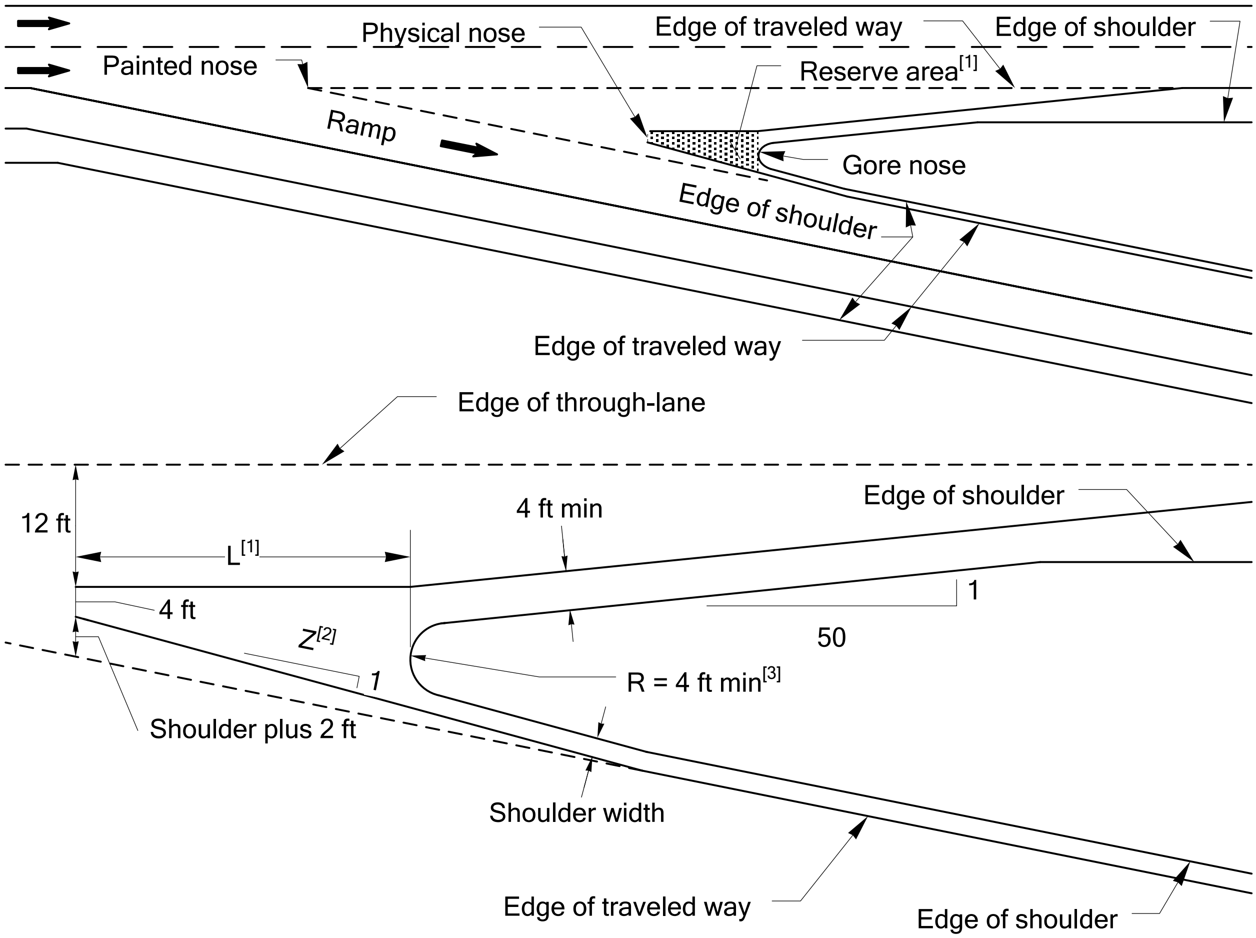
[1] The reserve area length (L) is not less than:

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] Radius may be reduced, when protected by an impact attenuator.

Exhibit 1360-11b Gore Area Characteristics



Single-Lane, One-Lane Reduction Off-Connections
and All Two-Lane Off-Connections

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] Radius may be reduced, when protected by an impact attenuator.

1360.04(6) Collector-Distributor (C-D) 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. Other C-D roads may be one or two lanes in width, depending on capacity. Consider intermediate connections to the main line for long C-D roads.

a. Exhibit 1360-15a shows the designs for 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 when adjacent posted speed does not exceed 40 mph.

b. The details shown in Exhibit 1360-15b apply to single-lane C-D road off-connections. Design a two-lane C-D road off-connection, with the reduction of a freeway lane or an auxiliary lane, as a normal two-lane off-connection in accordance with 1360.04(5).

c. Design C-D road on-connections in accordance with Exhibit 1360-15c.

1360.04(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 in Exhibit 1360-16. 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 in accordance with 1360.04(4) and the off-connection in accordance with 1360.04(5).

1360.04(8) Weaving Sections

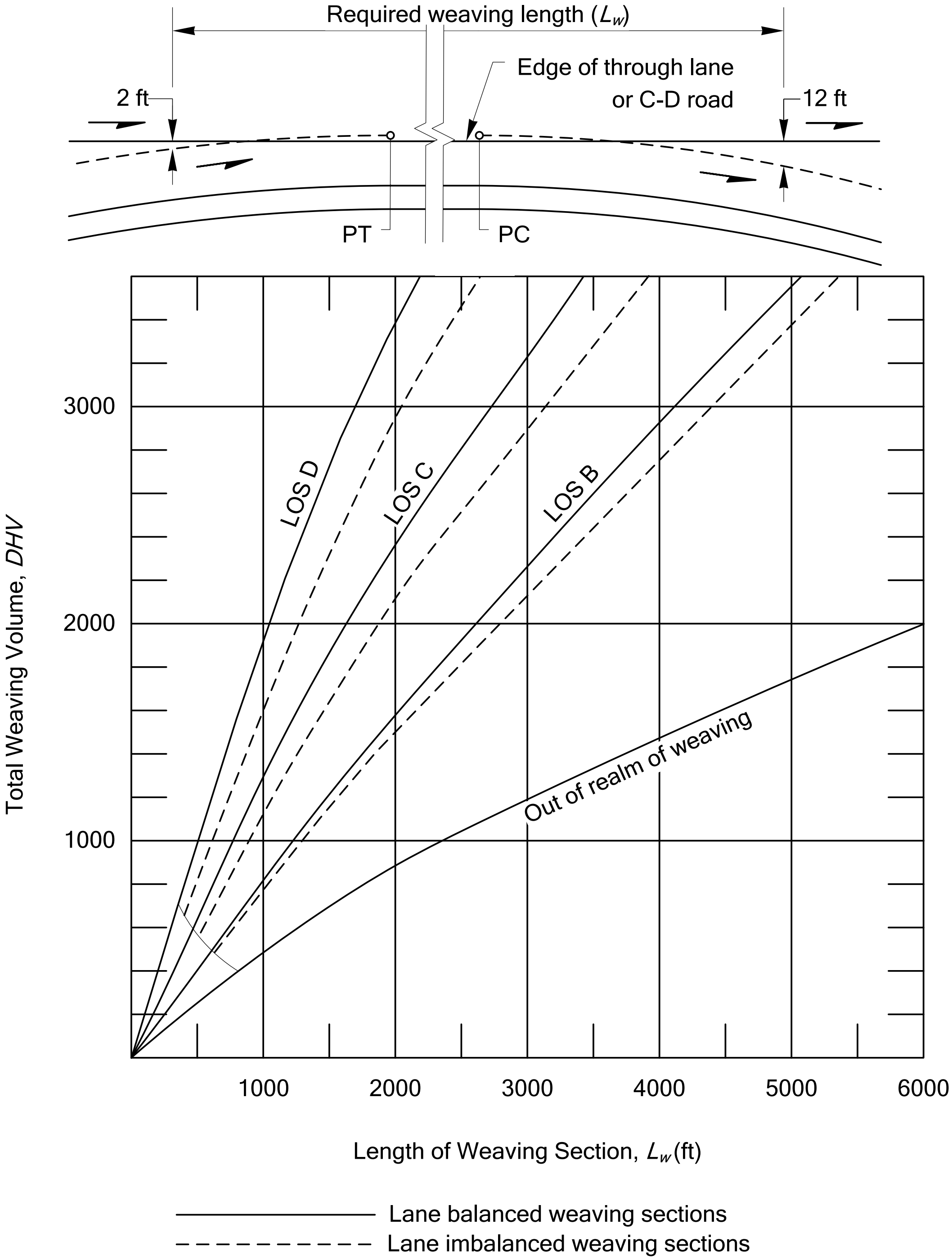
Weaving sections may occur within an interchange, between closely spaced interchanges, or on segments of overlapping routes. Exhibit 1360-12 gives the length of the weaving section for preliminary design. The total weaving traffic is the sum of the traffic entering from the ramp to the main line and 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 needed for weaving on low-speed roads.

1360.05 Ramp Terminal Intersections at Crossroads

Design ramp terminal intersections at grade with crossroads as intersections at grade (see Chapter 1300). Whenever possible, design ramp terminals to discourage wrong-way movements. Locate ramp terminal intersections at grade with crossroads to provide signal progression if the intersection becomes signalized in the future. Provide intersection sight distance as described in Chapters 1310 or 1320.

Exhibit 1360-12 Length of Weaving Sections



Note:

To determine whether or not lane balance for weaving exists, see Exhibit 1360-8.

1360.06 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 cross-centerline crashes 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 a driver's impression that these roads are also multilane.

Provide the deceleration taper for all interchange exit ramps on two-lane highways. Design the entering connection with either the normal acceleration taper or a "button hook" configuration with a stop condition before entering the main line. Consider the following items:

- Design the stop condition connection in accordance with a tee (T) intersection as shown in Chapter 1310. Use this type of connection when an acceleration lane is not possible. Provide decision sight distance as described in Chapter 1260.
- Since designs may vary from project to project, analyze each project for the most efficient signing placement, such as one-way, two-way, no passing, do not enter, directional arrows, guideposts, and traffic buttons.
- Prohibit passing through the interchange area on two-lane highways by means of signing, pavement marking, or a combination of both. The desirable treatment is a 4 foot median island, highlighted with raised pavement markers and diagonal stripes. When using a 4-foot median system, extend the island 500 feet beyond any merging ramp traffic acceleration taper. The width for the median can be provided by reducing each shoulder 2 feet through the interchange (see Exhibit 1360-17).
- Include signing and pavement markings to inform both the entering and through motorists of the two-lane two-way characteristic of the main line.
- 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 stage. Design the connection to meet the needs of the traffic.

1360.07 Interchange Plans for Approval

Exhibit 1360-18 is a sample showing the general format and data for interchange design plans.

Compass directions (W-S Ramp) or crossroad names (E-C Street) may be used for ramp designations.

Include the following, as applicable:

- Design speeds (see Chapter 1103) for main line and crossroads.
- 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; these may be submitted on separate sheets.
- Channelization.
- Stationing of ramp connections and channelization.
- Proposed right of way and access control treatment (see Chapters 510, 520, and 530).
- Delineation of all crossroads, existing and realigned.
- Traffic data for 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.

1360.08 Documentation

Refer to Chapter 300 for design documentation requirements.

1360.09 References

1360.09(1) Design Guidance

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC “Manual on uniform traffic control devices for streets and highways” (MUTCD)

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

1360.09(2) Supporting Information

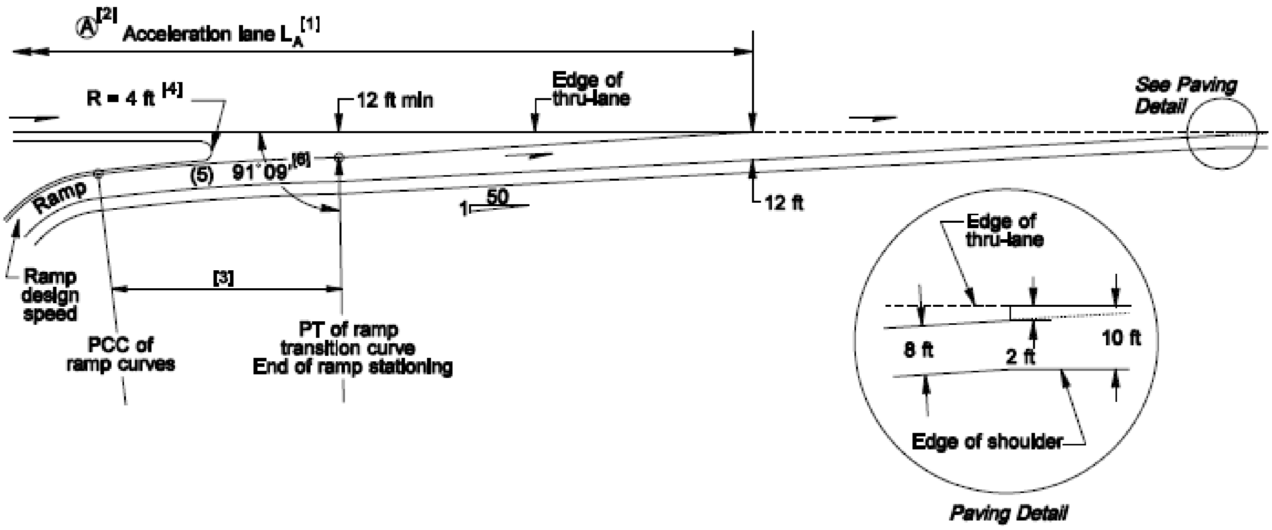
A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition

A Policy on Design Standards – Interstate System, AASHTO, 2005

Highway Capacity Manual (Special Report 209), Transportation Research Board

Procedure for Analysis and Design of Weaving Sections: A User's Guide, Jack E. Leisch, October 1985

Exhibit 1360-13a On-Connection: Single-Lane, Tapered



Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 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 3000-ft radius to tangent to the main line.

[4] Radius may be reduced when concrete barrier is placed between the ramp and main line.

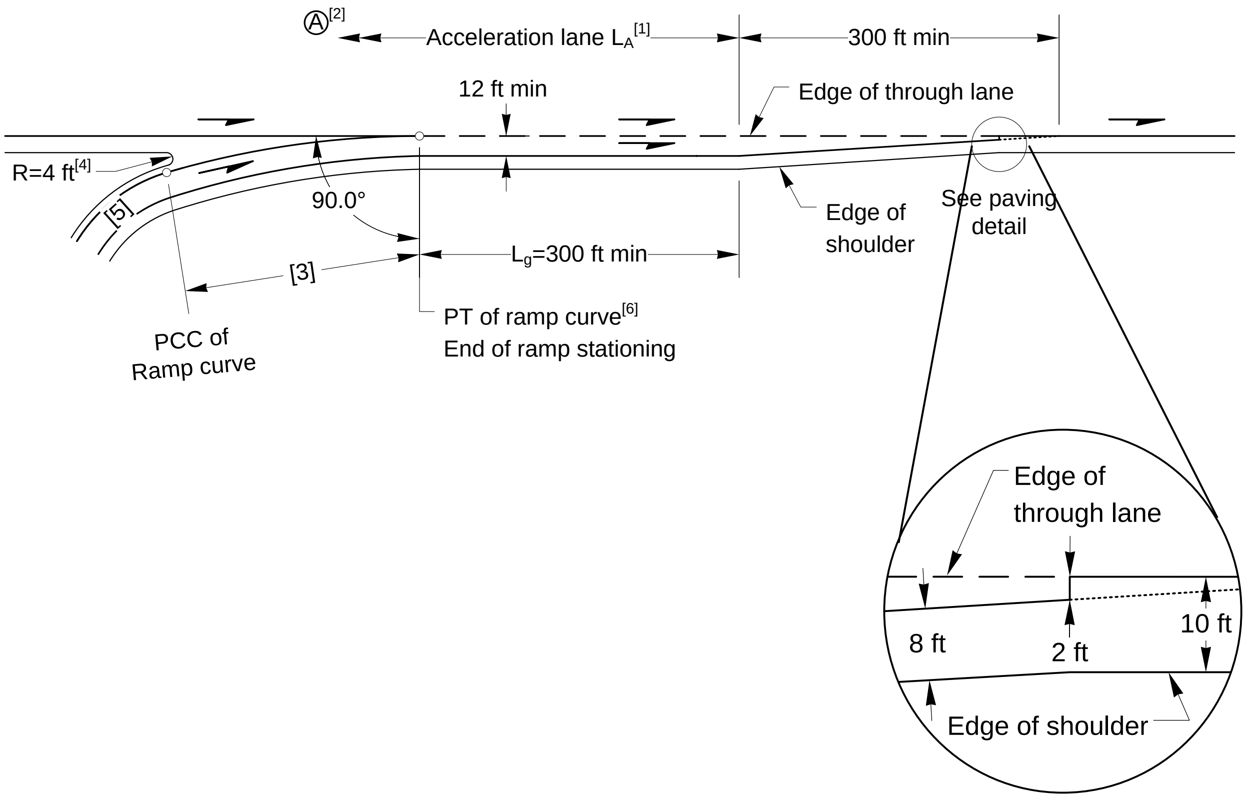
[5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

[6] Approximate angle to establish ramp alignment.

General:

For striping, see the Standard Plans.

Exhibit 1360-13b On-Connection: Single-Lane, Parallel



Paving detail

Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 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 3000-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.

[4] Radius may be reduced when concrete barrier is placed between the ramp and main line.

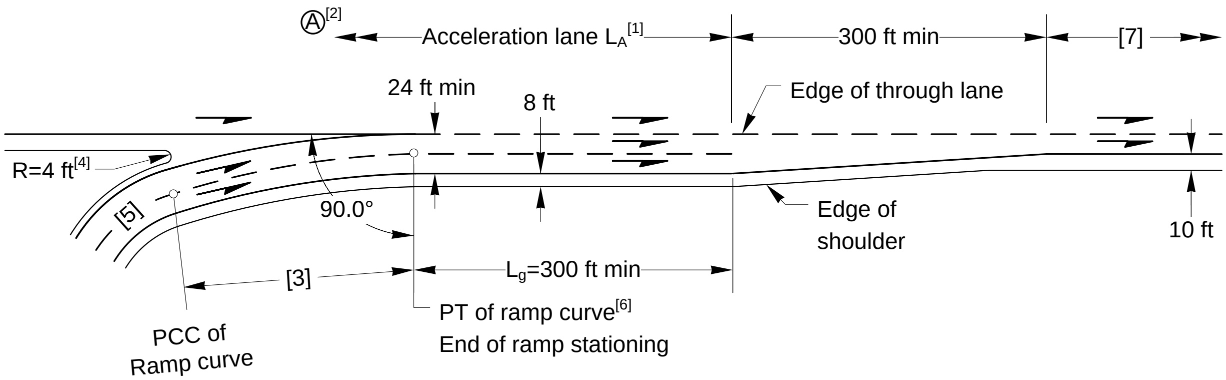
[5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

[6] Ramp stationing may be extended to accommodate superelevation transition.

General:

For striping, see the Standard Plans.

Exhibit 1360-13c On-Connection: Two-Lane, Parallel



Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 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 3000-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.

[4] Radius may be reduced when concrete barrier is placed between the ramp and main line.

[5] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

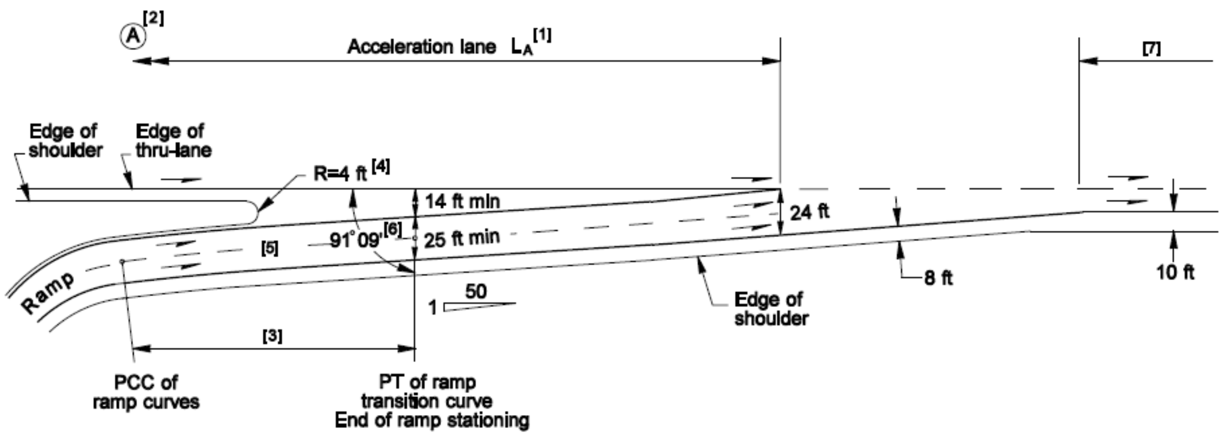
[6] Ramp stationing may be extended to accommodate superelevation transition.

[7] Added lane or 1,500-ft auxiliary lane plus 600-ft taper.

General:

For striping, see the Standard Plans.

Exhibit 1360-13d On-Connection: Two-Lane, Tapered



Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 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 3000-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] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

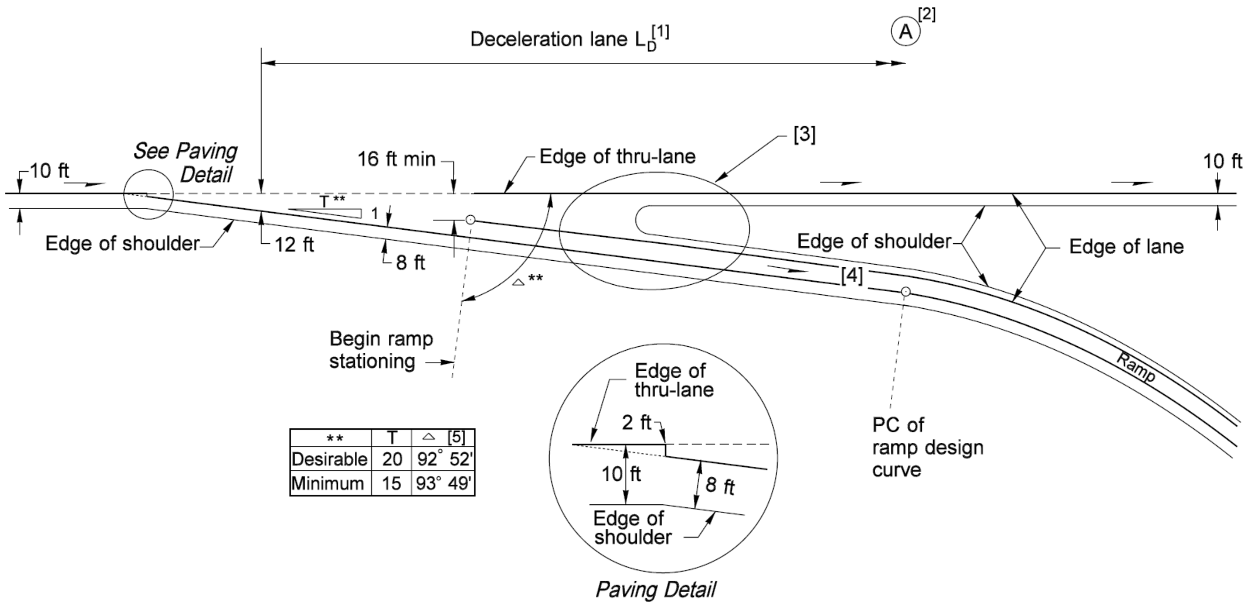
[6] Approximate angle to establish ramp alignment.

[7] Added lane or 1,500-ft auxiliary lane plus 600-ft taper.

General:

For striping, see the Standard Plans

Exhibit 1360-14a Off-Connection: Single-Lane, Tapered



**	T	△ [5]
Desirable	20	92° 52'
Minimum	15	93° 49'

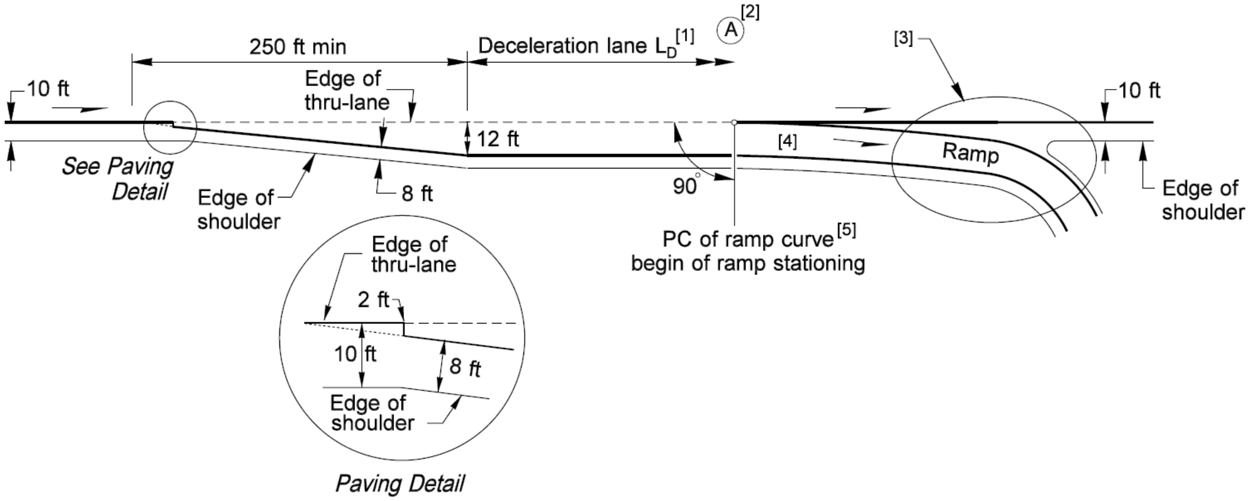
Notes:

- [1] For deceleration lane length L_D, see Exhibit 1360-10.
- [2] Point Ⓐ is the point controlling the ramp design speed.
- [3] For gore details, see Exhibit 1360-11a.
- [4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [5] Approximate angle to establish ramp alignment.

General:

For striping, see the Standard Plans.

Exhibit 1360-14b Off-Connection: Single-Lane, Parallel



Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] For gore details, see Exhibit 1360-11a.

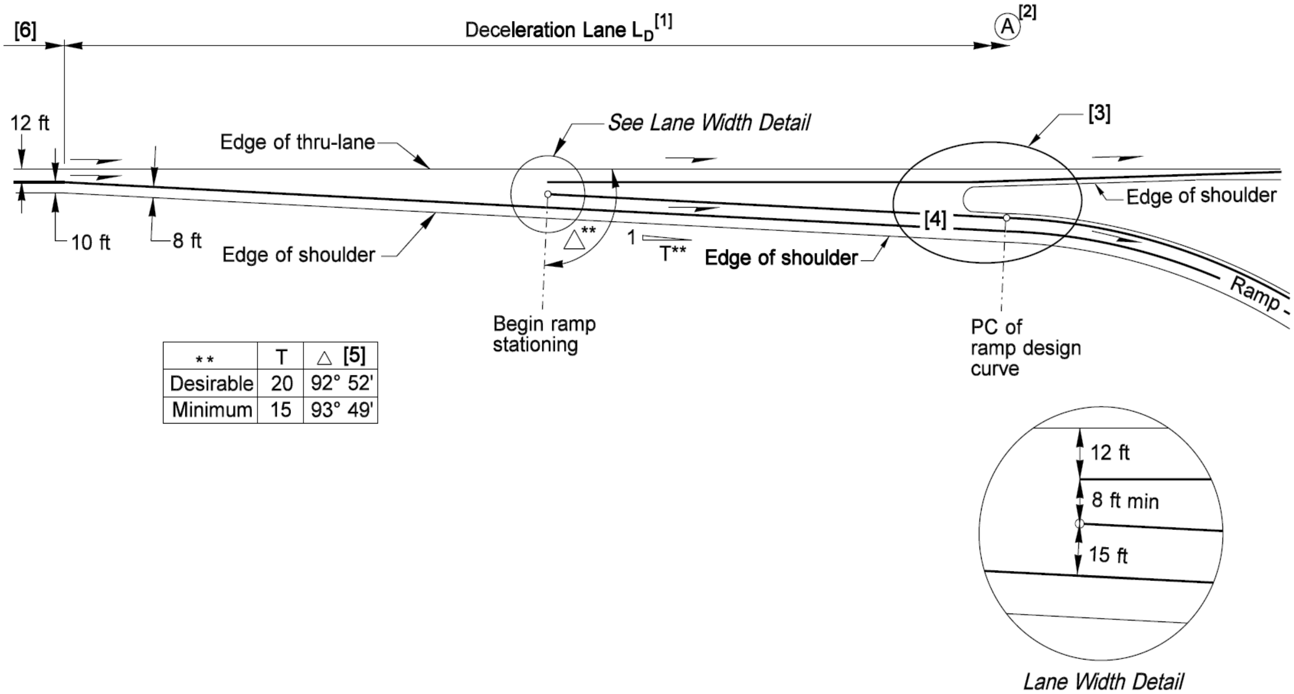
[4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

[5] Ramp stationing may be extended to accommodate superelevation transition.

General:

For striping, see the *Standard Plans*.

Exhibit 1360-14c Off-Connection: Single-Lane, One-Lane Reduction



**	T	△ [5]
Desirable	20	92° 52'
Minimum	15	93° 49'

Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] For gore details, see Exhibit 1360-11b.

[4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

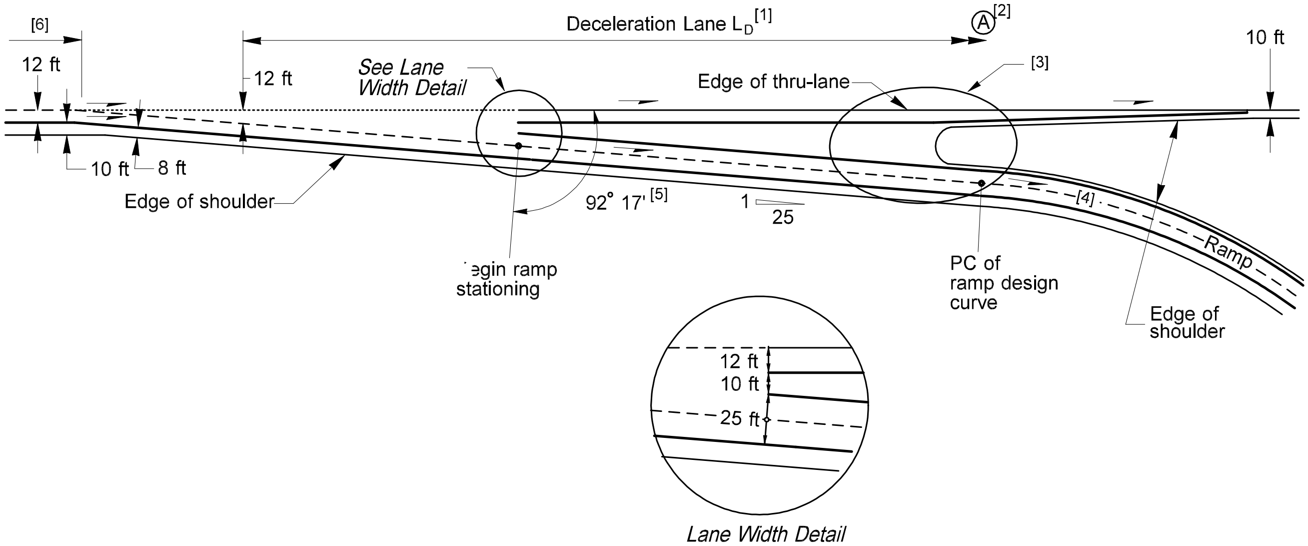
[5] Approximate angle to establish ramp alignment.

[6] Auxiliary lane between closely spaced interchanges to be dropped.

General:

For striping, see the *Standard Plans*.

Exhibit 1360-14d Off-Connection: Two-Lane, Tapered



Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] For gore details, see Exhibit 1360-11b.

[4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.

[5] Approximate angle to establish ramp alignment.

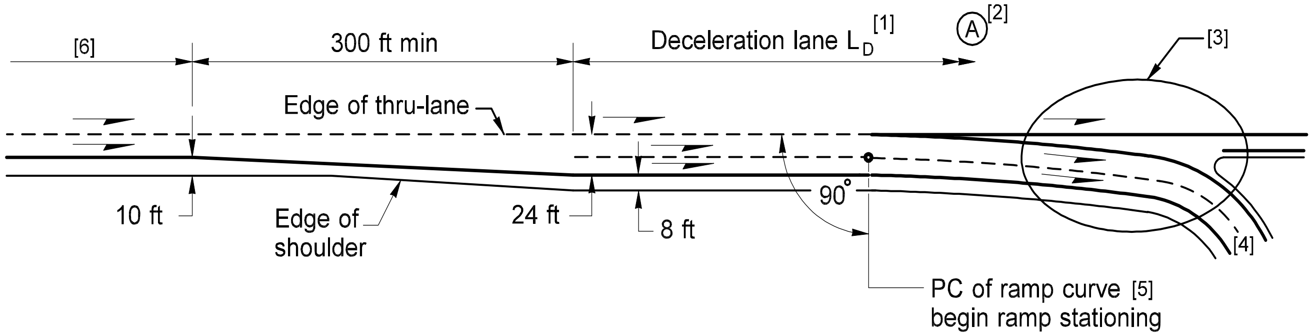
[6] Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300-ft taper.

General:

For striping, see the Standard Plans.

Bc

Exhibit 1360-14e Off-Connection: Two-Lane, Parallel



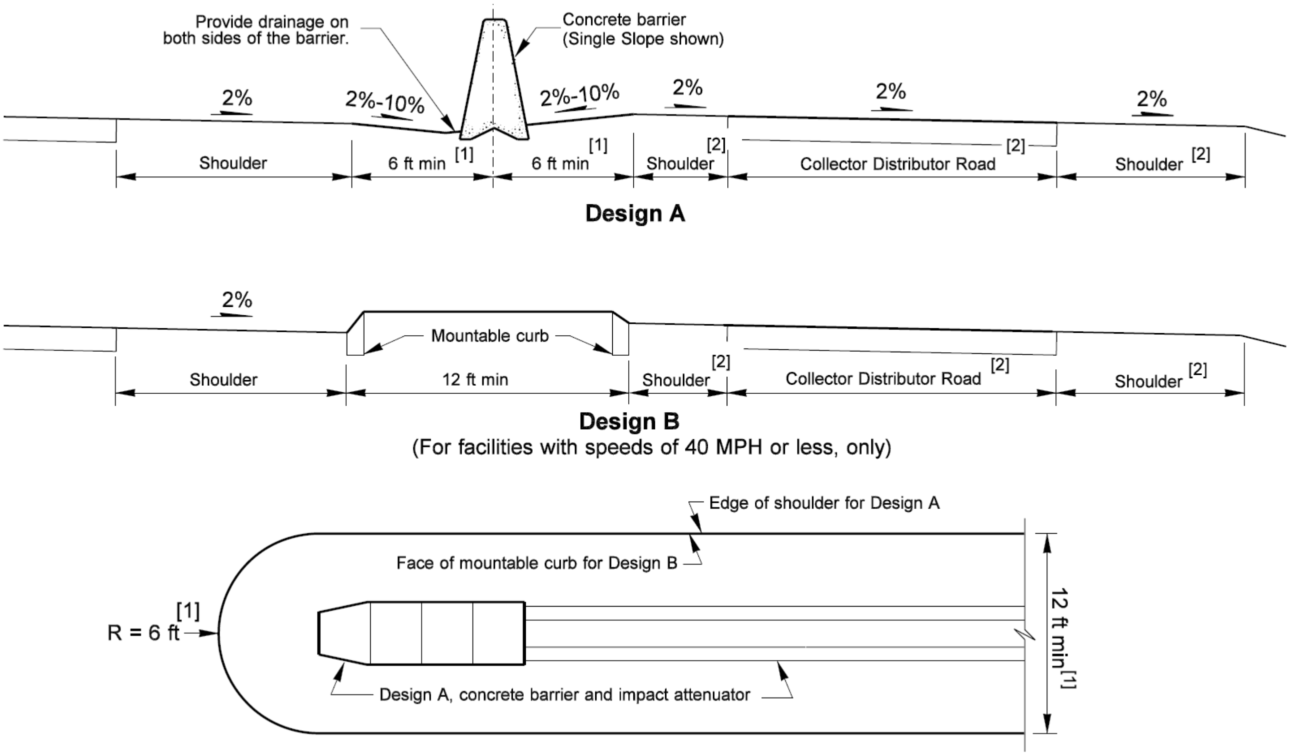
Notes:

- [1] For deceleration lane length L_D, see Exhibit 1360-10.
- [2] Point Ⓐ is the point controlling the ramp design speed.
- [3] For gore details, see Exhibit 1360-11b.
- [4] Lane and shoulder widths are shown for illustrative purposes. For ramp lane and shoulder widths, see Exhibit 1360-6.
- [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.

General:

For striping, see the Standard Plans.

Exhibit 1360-15a Collector-Distributor: Outer Separations

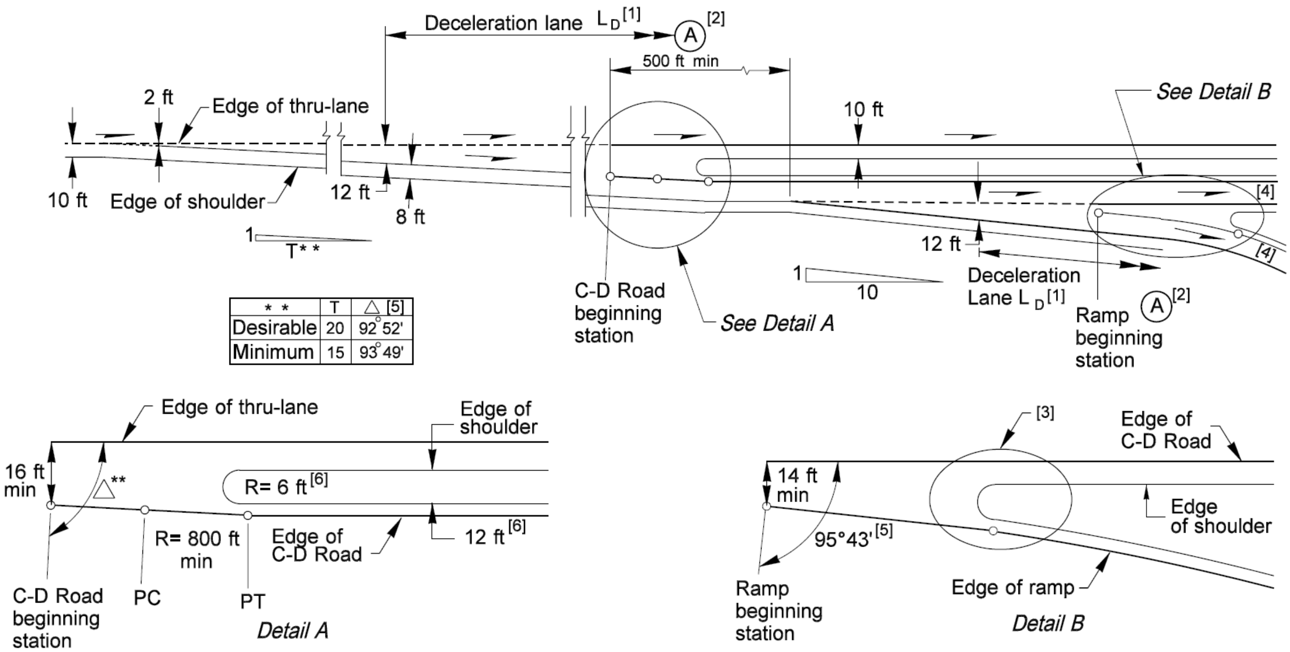


Notes:

[1] With justification, the concrete barrier may be placed with 2 ft between the edge of either shoulder and the face of barrier. This reduces the width between the edge of through-lane shoulder and the edge of C-D road shoulder to 6 ft and the radius at the nose to 3 ft.

[2] For collector-distributor road lane and shoulder widths, see ramp lane and shoulder widths, Exhibit 1360-6.

Exhibit 1360-15b Collector Distributor: Off-Connections



Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point Ⓐ is the point controlling the C-D road or ramp design speed.

[3] For gore details, see Exhibit 1360-11a.

[4] For C-D road and ramp lane and shoulder widths, see Exhibit 1360-6.

[5] Approximate angle to establish alignment.

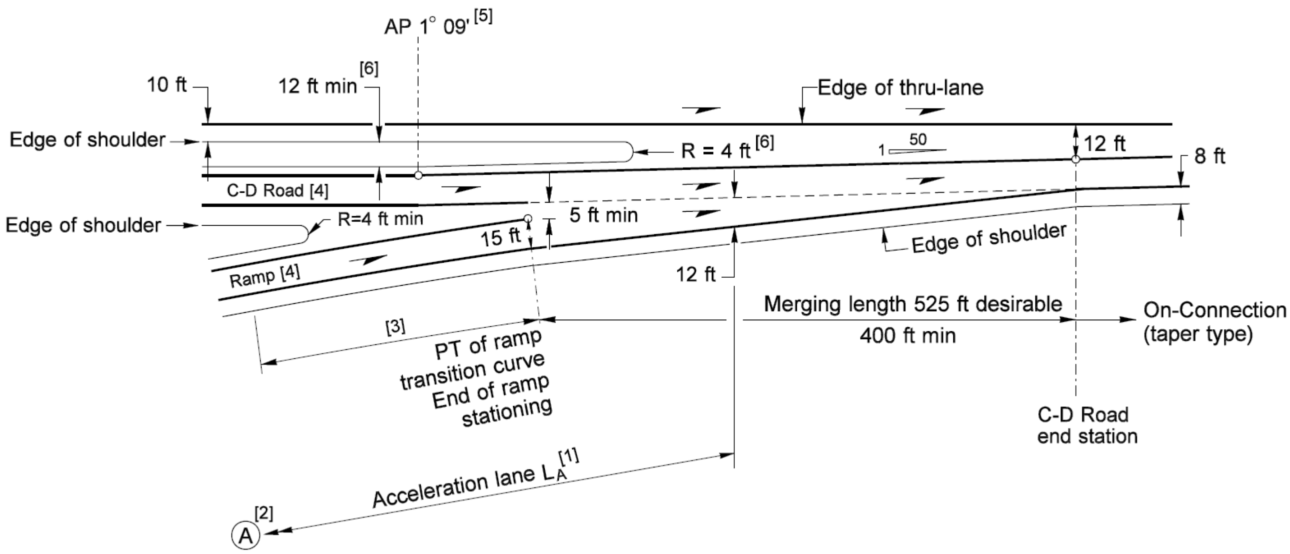
[6] May be reduced with justification (see Exhibit 1360-15a).

General:

For striping, see the Standard Plans.

Lane and shoulder widths are shown for illustrative purposes. Determine lane and shoulder widths based on Exhibit 1360-6.

Exhibit 1360-15c Collector Distributor: On-Connections



Notes:

[1] For acceleration lane length L_A, see Exhibit 1360-9.

[2] Point Ⓐ is the point controlling the ramp design speed.

[3] A transition curve with a minimum radius of 3000 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 3000-ft radius to tangent to the C-D road.

[4] For C-D road and ramp lane and shoulder widths, see Exhibit 1360-6.

[5] Approximate angle to establish alignment.

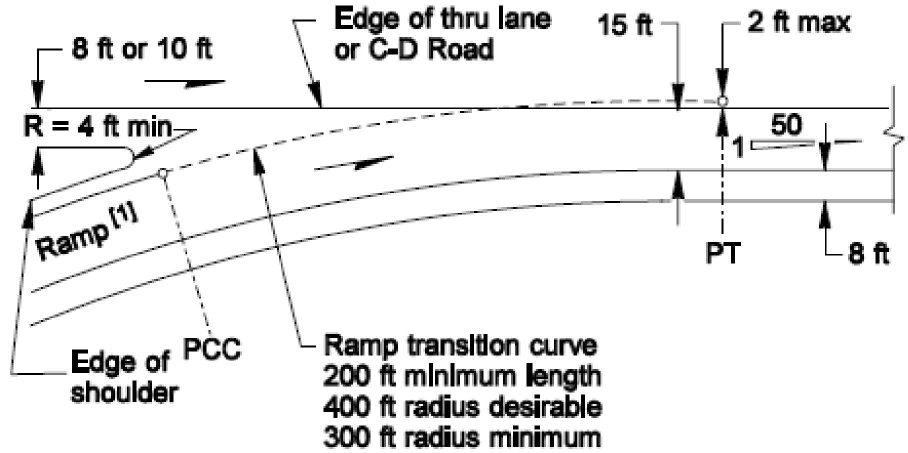
[6] May be reduced with justification (see Exhibit 1360-15a).

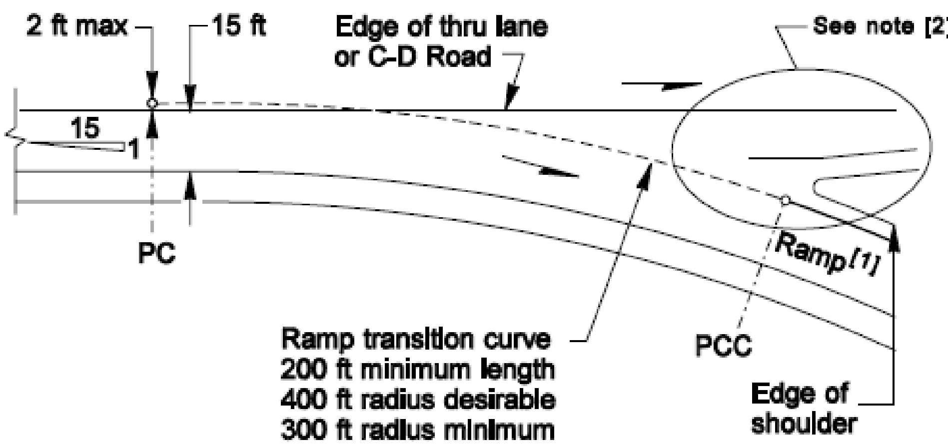
General:

For striping, see the Standard Plans.

Lane and shoulder widths are shown for illustrative purposes. Determine lane and shoulder widths based on Exhibit 1360-6.

Exhibit 1360-16 Loop Ramp Connections





Notes:

[1] [1] For minimum weaving length, see Exhibit 1360-12.

[2] [2] Lane and shoulder widths are shown for illustrative purposes. For minimum ramp lane and shoulder widths, see Exhibit 1360-6.

[3] [3] For gore details, see Exhibit 1360-11b.

General:

For gore details, see Exhibit 1360-11b.

Exhibit 1360-17 Temporary Ramps

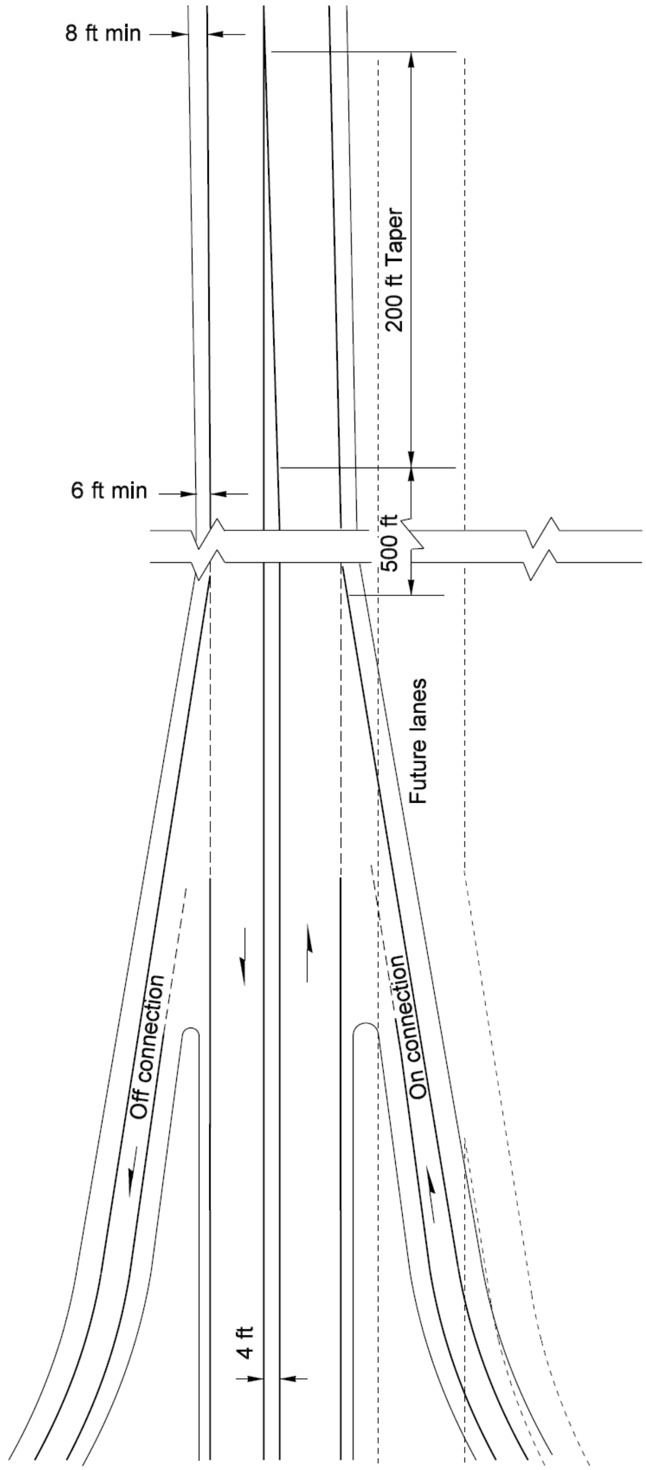
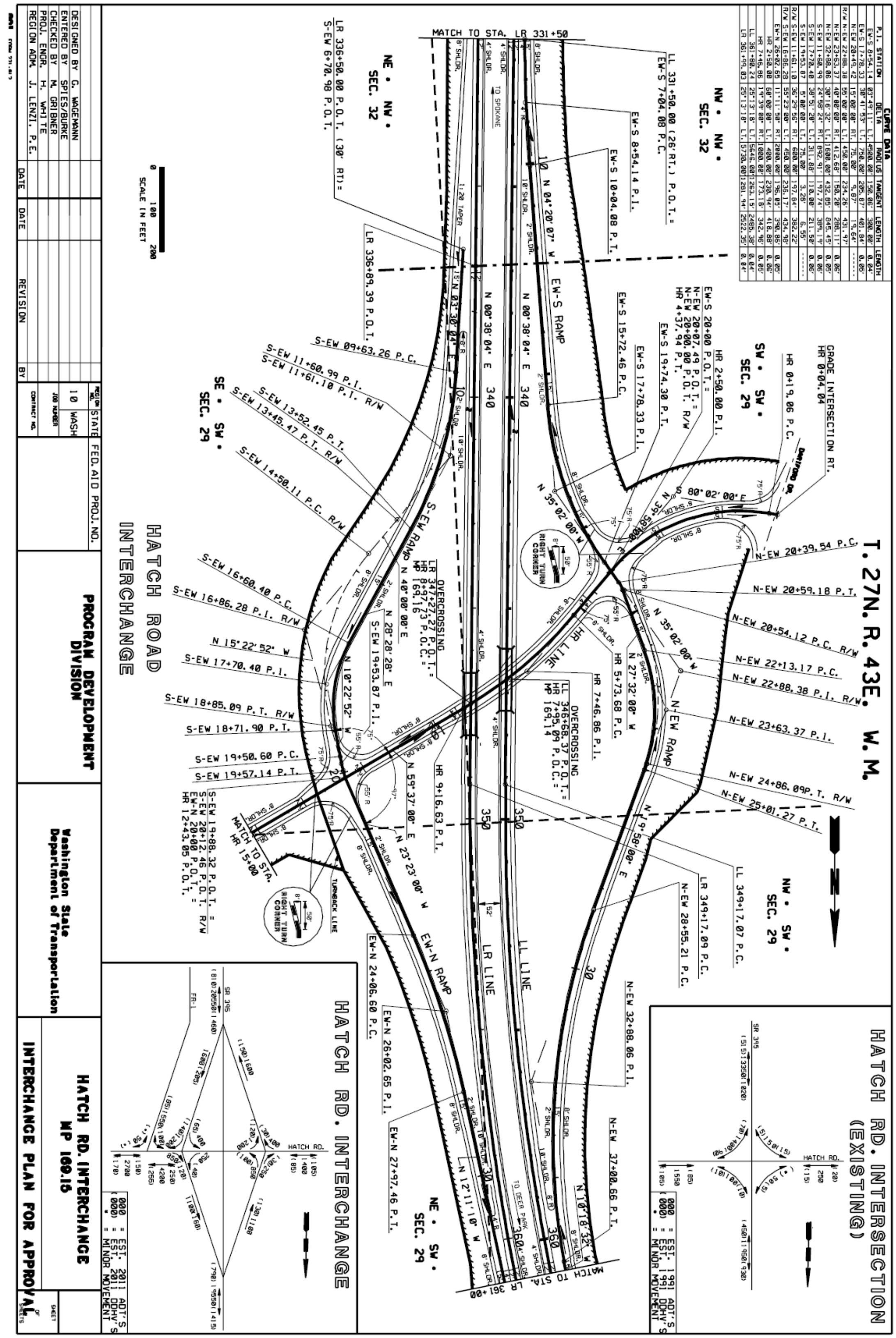


Exhibit 1360-18 Interchange Plan



Chapter 1510 Pedestrian Facilities

1510.01 General

Pedestrian travel is a vital transportation mode. It is used at some point by nearly everyone and is a critical link to everyday life for many. Designers must be aware of the various physical needs and abilities of pedestrians in order to ensure facilities provide universal access.

Section 504 of the Rehabilitation Act and the Americans with Disabilities Act of 1990 (ADA) require pedestrian facilities to be designed and constructed so they are readily accessible to and usable by persons with disabilities. This chapter provides accessibility criteria for the design of pedestrian facilities that meet applicable state and federal standards.

The pedestrian facilities included in a project are determined during the planning phase based on: access control of the highway; local transportation plans; comprehensive plans and other plans (such as Walk Route Plans developed by schools and school districts); the roadside environment; pedestrian volumes; user age group(s); and the continuity of local walkways along or across the roadway.

When developing pedestrian facilities within a limited amount of right of way, designers can be faced with multiple challenges. It is important that designers become familiar with the ADA accessibility criteria in order to appropriately balance intersection design with the often competing needs of pedestrians and other roadway users.

Similar to the roadway infrastructure, pedestrian facilities (and elements) require periodic maintenance in order to prolong the life of the facility and provide continued usability. Title II of the ADA requires that all necessary features be accessible and maintained in operable working condition for use by individuals with disabilities.

1510.02 References

1510.02(1) Federal/State Laws and Codes

ADA – 28 Code of Federal Regulations (CFR) Part 35, as revised September 15, 2010

23 CFR Part 652, Pedestrians and Bicycle Accommodations and Projects

49 CFR Part 27, Nondiscrimination on the Basis of Disability in Programs or Activities Receiving Federal Financial Assistance (Section 504 of the Rehabilitation Act of 1973 implementing regulations)

Revised Code of Washington (RCW) 35.68, Sidewalks, gutters, curbs and driveways – All cities and towns

RCW 35.68.075, Curb ramps for persons with disabilities – Required – Standards and Requirements

RCW 46.04.160, Crosswalk (definition)

RCW 46.61, Rules of the Road

RCW 47.24.020, City streets as part of state highways – Jurisdiction, control

1510.02(2) Design Guidance

ADA Standards for Accessible Design, U.S. Department of Justice (USDOJ), 2010; consists of 28 CFR parts 35 & 36 and the *ADA and Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities* (ADA-ABAAG; also referred to as the 2004 ADAAG), July 23, 2004, U.S. Access Board as modified by USDOT for entities receiving USDOT funding per 49 CFR Part 27. (Applies to new construction or alterations as of November 29, 2006 for entities receiving USDOT funding per 49 CFR Part 27.) 🖰 https://www.access-board.gov/guidelines-and-standards/transportation/facilities/ada-standards-for-transportation-facilities

ADA Standards for Transportation Facilities, USDOT, 2006; consists of 49 CFR Parts 37, 38, & 39, the *ADA Accessibility Guidelines for Transportation Vehicles, September 6, 1991*, and the *ADA and ABA Accessibility Guidelines for Buildings and Facilities* (ADA-ABAAG; also referred to as the 2004 ADAAG), July 23, 2004, U.S. Access Board as modified by USDOT. (For transit, light rail, and similar public transportation facilities under Federal Transit Administration jurisdiction.)

🖰 https://www.access-board.gov/guidelines-and-standards/transportation/facilities/ada-standards-for-transportation-facilities

🖰 https://www.access-board.gov/guidelines-and-standards/transportation/vehicles/adaag-for-transportation-vehicles

Department of Justice/Department of Transportation Joint Technical Assistance on the Title II of the Americans with Disabilities Act Requirements to Provide Curb Ramps when Streets, Roads, or Highways are Altered through Resurfacing, USDOJ and USDOT, July 2013

🖰 http://www.ada.gov/doj-fhwa-ta.htm

🖰 http://www.ada.gov/doj-fhwa-ta-glossary.htm

🖰 https://www.ada.gov/doj-fhwa-ta-supplement-2015.html

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD) 🖰 www.wsdot.wa.gov/publications/manuals/mutcd.htm

Revised Draft Guidelines for Accessible Public Rights-of-Way (PROWAG), November 23, 2005, U.S. Access Board. The current best practices for evaluation and design of pedestrian facilities in the public right of way per the following FHWA Memoranda:

🖰 https://www.fhwa.dot.gov/environment/bicycle_pedestrian/resources/prwaa.cfm

🖰 http://www.fhwa.dot.gov/civilrights/memos/ada_memo_clarificationa.htm

🖰 https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/background/revised-draft-guidelines

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT
🖰 www.wsdot.wa.gov/publications/manuals/m21-01.htm

1510.02(3) Supporting Information

1991 ADA Standards for Accessible Design, USDOJ; consists of 28 CFR parts 35 & 36 and the *ADA Accessibility Guidelines for Buildings and Facilities* (ADAAG), July 1991, U.S. Access Board. (For buildings and on-site facilities: Expired for new construction and alterations. To be used only for evaluating the adequacy of new construction or alteration that occurred prior to November 29, 2006 for entities receiving USDOT funding per 49 CFR Part 27.)

https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/background/adaag

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, Current version adopted by FHWA

Field Guide for Accessible Public Rights of Way, WSDOT, November 1, 2012
http://www.wsdot.wa.gov/publications/fulltext/roadside/ada_field_guide.pdf

Guide for the Planning, Design, and Operation of Pedestrian Facilities, AASHTO, 2004. Provides guidance on the planning, design, and operation of pedestrian facilities along streets and highways. Specifically, the guide focuses on identifying effective measures for accommodating pedestrians on public rights of way. It can be purchased through the AASHTO website.

Highway Capacity Manual, Transportation Research Board (TRB), 2000

Pedestrian Facilities Users Guide – Providing Safety and Mobility, FHWA, 2002. Provides useful information regarding walkable environments, pedestrian crashes and their countermeasures, and engineering improvements for pedestrians.
https://www.fhwa.dot.gov/publications/research/safety/01102/01102.pdf

Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way, July 26, 2011, U.S. Access Board. Federal Notice of Proposed Rule Making that gives a preview of potential future revisions to the PROWAG. https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines

"Special Report: Accessible Public Rights-of-Way – Planning & Design for Alterations," Public Rights-of-Way Access Advisory Committee, July 2007
https://www.access-board.gov/attachments/article/756/guide.pdf

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005
www.wsdot.wa.gov/research/reports/600/638.1.htm

Washington State Bicycle Facilities and Pedestrian Walkways Plan
www.wsdot.wa.gov/bike/bike_plan.htm

Terminal Design Manual, Chapter 300 Accessibility, WSDOT, Washington State Ferries Division
www.wsdot.wa.gov/publications/manuals/m3082.htm

1510.03 Definitions

Refer to the Design Manual Glossary for definitions of many of the terms used in this chapter.

1510.04 Policy

1510.04(1) General

It is WSDOT policy to provide appropriate pedestrian facilities along and across sections of state routes as an integral part of the transportation system. Federal Highway Administration (FHWA) and WSDOT policy is that bicycle and pedestrian facilities be given full consideration in the planning and design of new construction and reconstruction highway projects, except where bicycle and pedestrian use is prohibited.

1510.04(2) Jurisdiction

Proposed projects in public rights of way must address ADA compliance as described in this chapter. (See 1510.05 for ADA requirements by project type.) Regardless of which public agency has jurisdiction within the right of way, the public agency that is sponsoring the project is responsible for ensuring ADA compliance is addressed on its project.

On all state routes outside of incorporated cities and on those with limited access (full, partial, and modified) within incorporated cities, jurisdiction remains with the state unless modified by a maintenance agreement. In turnback areas where the turnback agreement has not been completed, the state maintains full jurisdiction (see Chapters 510, 520, and 530).

When project work occurs on a managed access state route inside an incorporated city that has jurisdiction beyond the curbs (RCW 47.24.020), design pedestrian facilities using the city design standards adopted in accordance with RCW 35.78.030 and the most current ADA requirements. Document the coordination with the city in the Design Documentation Package (DDP). Refer to Chapter 300 for information about the DDP.

1510.04(3) Transition Planning

Section 504 of the Rehabilitation Act and the ADA require all public entities to conduct a self-evaluation of their programs and activities, including sidewalks, curb ramps, and other pedestrian facilities and elements within the public right of way, to determine if barriers exist that prevent people with disabilities from being able to access these programs and activities.

If barriers are identified, agencies with 50 or more employees must develop and implement a transition plan that describes the barriers, the modifications needed, and a schedule for when the needed work will be accomplished.

1510.04(4) Maintenance

As noted in 1510.01, Title II of the ADA requires that a public entity maintain in operable working condition those features of facilities and equipment that are required to be readily accessible to and usable by persons with disabilities.

1510.05 ADA Requirements by Project Type

Wherever pedestrian facilities are intended to be a part of the transportation facility, federal regulations (28 CFR Part 35) require that those pedestrian facilities meet ADA guidelines. All new construction or alteration of existing transportation facilities must be designed and constructed to be accessible to and usable by persons with disabilities. FHWA is one of the federal agencies designated by the Department of Justice to ensure compliance with the ADA for transportation projects.

1510.05(1) New Construction Projects

New construction projects address the construction of a new roadway, interchange, or other transportation facility where none existed before. For these projects, pedestrians' needs are assessed and included in the project. All pedestrian facilities included in these projects must fully meet the accessibility criteria when built.

1510.05(2) Alteration Projects

Any project that affects or could affect the usability of a pedestrian facility is classified as an alteration project. Alteration projects include, but are not limited to, renovation; rehabilitation; reconstruction; historic restoration; resurfacing of circulation paths or vehicular ways; and changes or rearrangement of structural parts or elements of a facility. Where existing elements or spaces are altered, each altered element or space within the limits of the project shall comply with the applicable accessibility requirements to the maximum extent feasible.

The following are some examples of project types that are classified as alteration projects and can potentially trigger a variety of ADA requirements:

- HMA overlay or inlay
- Traffic signal installation or retrofit
- Roadway widening
- Realignment of a roadway (vertical or horizontal)
- Sidewalk improvements
- PCCP panel repair/replacement
- Bridge replacement
- Raised channelization

The following are not considered alterations:

- Spot pavement repair
- Liquid-asphalt sealing, chip seal (BST), or crack sealing
- Lane restriping that does not alter the usability of the shoulder

If there is uncertainty as to whether a project meets the definition of an alteration project, consult with the Regional ADA Liaison.

The following apply to alteration projects:

- All new pedestrian facilities included in an alteration project that are put in place within an existing developed right of way must meet applicable accessibility requirements to the maximum extent feasible.
- All existing pedestrian facilities disturbed by construction of an alteration project must be replaced. The replacement facilities must meet applicable accessibility requirements
to the maximum extent feasible.
- An alteration project shall not decrease or have the effect of decreasing the accessibility of a pedestrian facility or an accessible connection to an adjacent building or site below the ADA accessibility requirements in effect at the time of the alteration.
- Within the construction impact zone of an alteration project, any existing connection from a pedestrian access route to a crosswalk (marked or unmarked) that is missing a required curb ramp must have a curb ramp installed that meets applicable accessibility requirements to the maximum extent feasible. (See 1510.09(2) for curb ramp accessibility criteria.)

- A crosswalk served by a curb ramp must also have an existing curb ramp in place on the receiving end unless there is no curb or sidewalk on that end of the crosswalk (RCW 35.68.075). If there is no existing curb ramp in place on the receiving end, an accessible curb ramp must be provided. This requirement must be met regardless of whether the receiving end of the crosswalk is located within the project's limits.
- Within the construction impact zone of an alteration project, evaluate all existing curb ramps to determine whether curb ramp design elements meet the accessibility criteria. (See 1510.09(2) for curb ramp accessibility criteria.) Modify existing curb ramps that do not meet the accessibility criteria to meet applicable accessibility requirements to the maximum extent feasible. This may also trigger modification of other adjacent pedestrian facilities to incorporate transitional segments in order to ensure specific elements of a curb ramp will meet the accessibility criteria.
- Within the construction impact zone of an alteration project that includes hot mix asphalt overlay (or inlay) of an existing roadway and *does not* include reconstruction, realignment, or widening of the roadway, evaluate all existing marked and unmarked crosswalks. (See 1510.10(2) for crosswalk accessibility criteria.) If it is not possible to meet the applicable accessibility requirements for crosswalks, document this in the DDP.
- Within the construction impact zone of an alteration project that includes reconstruction, realignment, or widening of the roadway, evaluate all existing crosswalks (marked or unmarked) to determine whether crosswalk design elements meet the accessibility criteria. (See 1510.10(2) for crosswalk accessibility criteria.) Modify crosswalk slopes to meet the applicable accessibility requirements to the maximum extent feasible.

It may not always be possible to fully meet the applicable accessibility requirements during alterations of existing facilities. If such a situation is encountered, consult with the Regional ADA Liaison to develop a workable solution to meet the accessibility requirements to the maximum extent feasible. Cost is not to be used as a justification for not meeting the accessibility criteria. Physical terrain or site conditions that would require structural impacts, environmental impacts, or unacceptable impacts to the community in order to achieve full compliance with the accessibility criteria are some of the factors that can be used to determine that the maximum extent feasible is achieved. If it is determined to be virtually impossible to meet the accessibility criteria for an element, document the decision in one of the following ways, as applicable:

- Within the construction impact zone of an alteration project that does not include reconstruction, realignment, or widening of the roadway, document the following deficient elements in the DDP:
    - Perpendicular curb ramp or parallel curb ramp landing cross slope that is constrained by the existing roadway gutter profile and exceeds 2%, but is less than or equal to 5%, that cannot be constructed to fully meet applicable accessibility requirements.
    - Flared side of a perpendicular curb ramp that is constrained by the existing roadway gutter profile and has a slope that exceeds 10%, but is less than or equal to 16.7%, that cannot be constructed to fully meet applicable accessibility requirements.

- For any deficient element that does not match the preceding description, document the decision via a stamped and signed Maximum Extent Feasible (MEF) document. The MEF document will be reviewed by the appropriate Assistant State Design Engineer (ASDE) and the Headquarters (HQ) ADA Compliance Manager. If acceptable, the MEF document will be approved and included in the DDP.

1510.05(2)(a) Requirements for Crossings with Pedestrian Pushbuttons

Coordinate sidewalk and curb ramp work with signal system work so that signal poles with pedestrian equipment meet accessibility requirements for APS pushbuttons to the maximum extent feasible. See 1510.12 for additional information on pedestrian pushbutton accessibility.

For existing signal systems only, the work required for each signal system location is determined as follows:

1. If no sidewalk ramp work is being performed at a signal system location, no work is required for that signal system as part of the project.
2. If any ramp is being reconstructed at a signal system location, and the traffic signal system is owned by WSDOT, then all poles with pedestrian equipment shall be made accessible for the entire traffic signal system at that location. This may require new or relocated poles, as well as additional ramp and sidewalk work beyond that previously described in 1510.05(2).
3. If any ramp is being reconstructed at a signal system location, and the traffic signal system is owned by another agency, only poles with pedestrian pushbuttons serving a crossing served by a ramp that is being reconstructed are required to be made accessible as part of the project. This may require reconstruction of the ramps, landings, or sidewalk areas at both ends of the crossing. The remaining crossings and poles may be addressed if the owning agency wishes to provide funding for the additional work.

If APS pushbuttons are not being installed as part of a project, any revised pole locations shall be designed to meet accessibility requirements with a conventional pushbutton installed and with an APS pushbutton installed, so that the pole does not have to be relocated when the conventional pushbutton is replaced with an APS pushbutton. Typically a location that is accessible with an APS pushbutton installed will be accessible with a conventional pushbutton installed, but verification is required.

Locations where these requirements cannot be fully met shall follow the procedures for maximum extent feasible documentation as previously described.

1510.06 Pedestrian Circulation Paths (PCP)

PCP are prepared exterior or interior ways of passage provided for pedestrian travel. They include independent walkways, sidewalks, shared-use paths, and other types of pedestrian facilities. Pedestrian circulation paths can either be immediately adjacent to streets and highways or separated from them by a buffer. Examples of PCP are shown in Exhibit 1510-1.

When the PCP is located behind guardrail, address protruding bolts. Installing a rub rail or a “W-beam” guardrail on the pedestrian side of the posts can mitigate potential snagging and also serve as a guide for sight-impaired pedestrians.

Provide a smooth finish to vertical surfaces adjacent to a PCP to mitigate potential snagging or abrasive injuries from accidental contact with the surface. Where adjacent walkway segments diverge, such as can occur if a parallel curb ramp does not occupy the entire width of a PCP, any resulting drop-offs must be protected to prevent trips or falls.

When relocation of utility poles and other fixtures is necessary for a project, determine the impact of their new location on all PCP. Look for opportunities to relocate obstructions, such as existing utility objects, away from the PCP.

Exhibit 1510-1 Pedestrian Circulation Paths

Highway shoulders are an extension of the roadway and are not typically considered pedestrian facilities. Pedestrians are allowed to use many state highways. Although pedestrians are allowed to travel along the shoulder in these cases, its main purpose is to provide an area for disabled vehicles, a recovery area for errant vehicles, and positive drainage away from the roadway.

Shoulders may serve as a pedestrian facility when sidewalks are not provided. If pedestrian generators, such as bus stops, are present and pedestrian usage is evident, a 4-foot-wide paved shoulder is adequate. Note that detectable warning surfaces should not be installed where a sidewalk ends and pedestrians are routed onto a shoulder since the shoulder is not a vehicular traveled way.

Where pedestrian traffic is evident, consider a separate PCP during the planning and programming of the project. Consult with the State Bicycle and Pedestrian Coordinator.

1510.06(1) Accessibility Criteria for Pedestrian Circulation Paths

The following criteria apply across the entire width of the PCP, not just within the pedestrian access route.

1510.06(1)(a) Vertical Clearance

- The minimum vertical clearance for objects that protrude into or overhang a pedestrian circulation path is 80 inches.
- If the minimum vertical clearance cannot be provided, railings or other barriers shall be provided. The leading bottom edge of the railing or barrier shall be located 27 inches maximum above the finished surface for cane detection.

Note: Per the MUTCD, the vertical clearance to the bottom of signs is 7 feet (84 inches.)

1510.06(1)(b) Horizontal Encroachment

- Protruding objects on PCPs shall not reduce the clear width of the pedestrian access route to less than 4 feet, exclusive of the curb.

Note: If an object must protrude farther than 4 inches into a PCP at a height that is greater than 27 inches and less than 80 inches above the finished surface, then it must be equipped with a warning device that is detectable by a vision-impaired person who navigates with a cane. The minimum clear width of the PAR must still be provided.

1510.06(1)(c) Post-Mounted Objects

- Objects mounted on posts, at a height that is greater than 27 inches and less than 80 inches above the finished surface, shall not protrude more than 4 inches into a pedestrian circulation path.

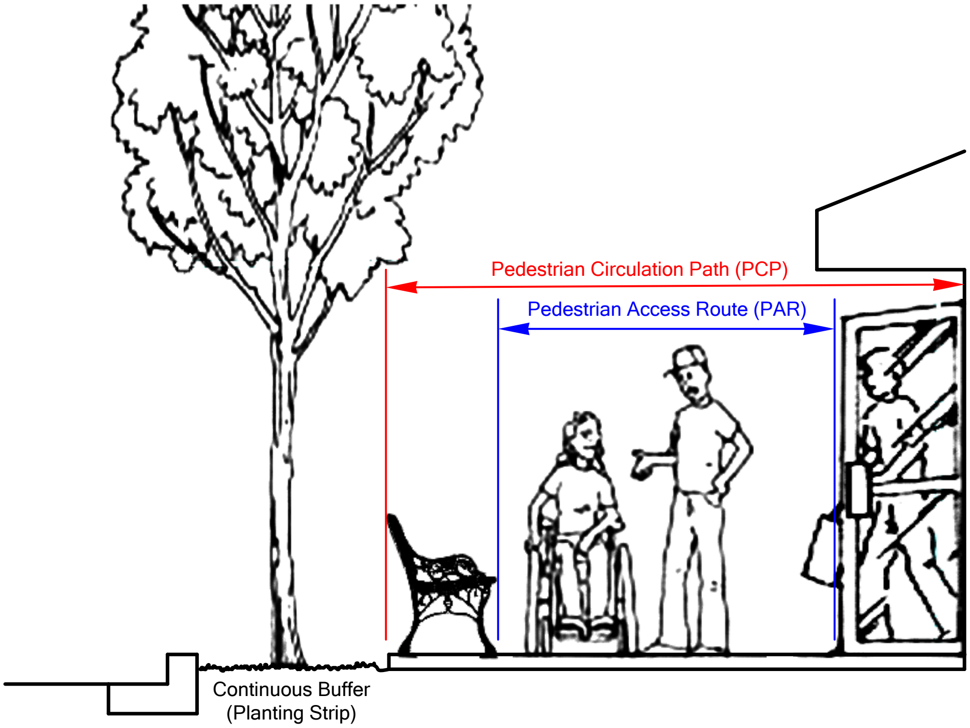
Note: If an object must protrude farther than 4 inches into a pedestrian circulation path at a height that is greater than 27 inches and less than 80 inches above the finished surface, then it must be equipped with a warning device that is detectable by a vision-impaired person who navigates with a cane. The minimum clear width of the pedestrian access route must still be provided.

- Where a sign or other obstruction on a pedestrian circulation path is mounted on multiple posts, and the clear distance between the posts is greater than 12 inches, the lowest edge of the sign or obstruction shall be either 27 inches maximum or 80 inches minimum above the finished surface.

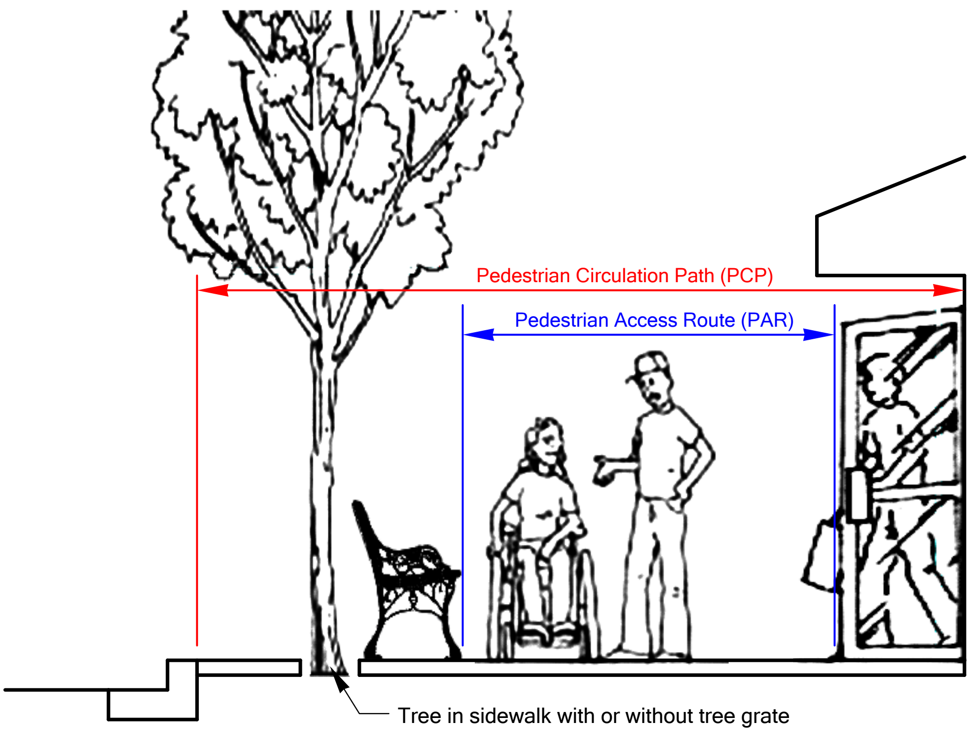
1510.07 Pedestrian Access Routes (PARs)

All PCPs are required to contain a continuous PAR (see Exhibit 1510-2) that connects to all adjacent pedestrian facilities, elements, and spaces that are required to be accessible. PARs consist of one or more of the following pedestrian facilities: walkways/sidewalks, crosswalks, curb ramps (excluding flares), landings, pedestrian overpasses/underpasses, access ramps, elevators, and platform lifts.

Exhibit 1510-2 Relationship Between Pedestrian Circulation Paths and Pedestrian Access Routes



With Continuous Buffer



Without Continuous Buffer

1510.07(1) Accessibility Criteria for Pedestrian Access Routes

1510.07(1)(a) Clear Width

- The minimum continuous and unobstructed clear width of a PAR shall be 4 feet, exclusive of the width of the curb.
- PARs that are less than 5 feet in clear width, exclusive of the width of the curb, shall provide passing spaces at intervals no farther apart than 200 feet. Passing spaces shall be 5 feet wide minimum, for a minimum distance of 5 feet.

Exhibit 1510-3 Obstructed Pedestrian Access Route

Note: Provide wheel stops or a wider sidewalk to remedy the encroachment into the PAR.

1510.07(1)(b) Cross Slope and Grade

- The cross slope of a PAR shall be 2% maximum.

Note: It is recommended that cross slopes be designed to be less than the allowed maximum to allow for some tolerance in construction. For example: design for a maximum 1.5% cross slope (rather than 2% maximum).

Exceptions:

1. Midblock crosswalks – The cross slope of the crosswalk and any connected curb ramp is permitted to match street or highway grade.
2. Crosswalks without stop sign control – The cross slope of the crosswalk can be up to 5% maximum.

- Where a PAR is contained within the highway right of way, its grade shall not exceed the general grade established for the adjacent roadway.
- ***Exception:*** The maximum grade in a crosswalk (marked or unmarked) is 5%, measured parallel to the direction of pedestrian travel in the crosswalk.
- Where a PAR is not contained within the highway right of way, the maximum running slope allowed is 5% unless designed as an access ramp. (See 1510.15(2) for access ramp accessibility criteria.)
- For additional criteria when a PAR is supported by a structure, see 1510.14.

1510.07(1)(c) Surface

- The surface of the PAR shall be firm, stable, and slip resistant. Use hard surfaces like cement or asphalt concrete; crushed gravel is not considered to be a stable, firm surface.
- Vertical alignment shall be planar within curb ramps, landings, and gutter areas within the PAR and within clear spaces for accessible pedestrian signals, street furniture, and operable parts.
- Grade breaks shall be flush.
- Surface discontinuities (see Exhibits 1510-4 and 1510-5) on existing surfaces in the pedestrian access route (such as at the joints of settled or upheaved sidewalk panels) may not exceed ½ inch maximum. Vertical discontinuities between ¼ inch and ½ inch maximum shall be beveled at 2H:1V or flatter. Apply the bevel across the entire level change.

Exception: No surface discontinuity is allowed at the connection between an existing curb ramp or landing and the gutter. This grade break must be flush.

Exhibit 1510-4 Beveling Options

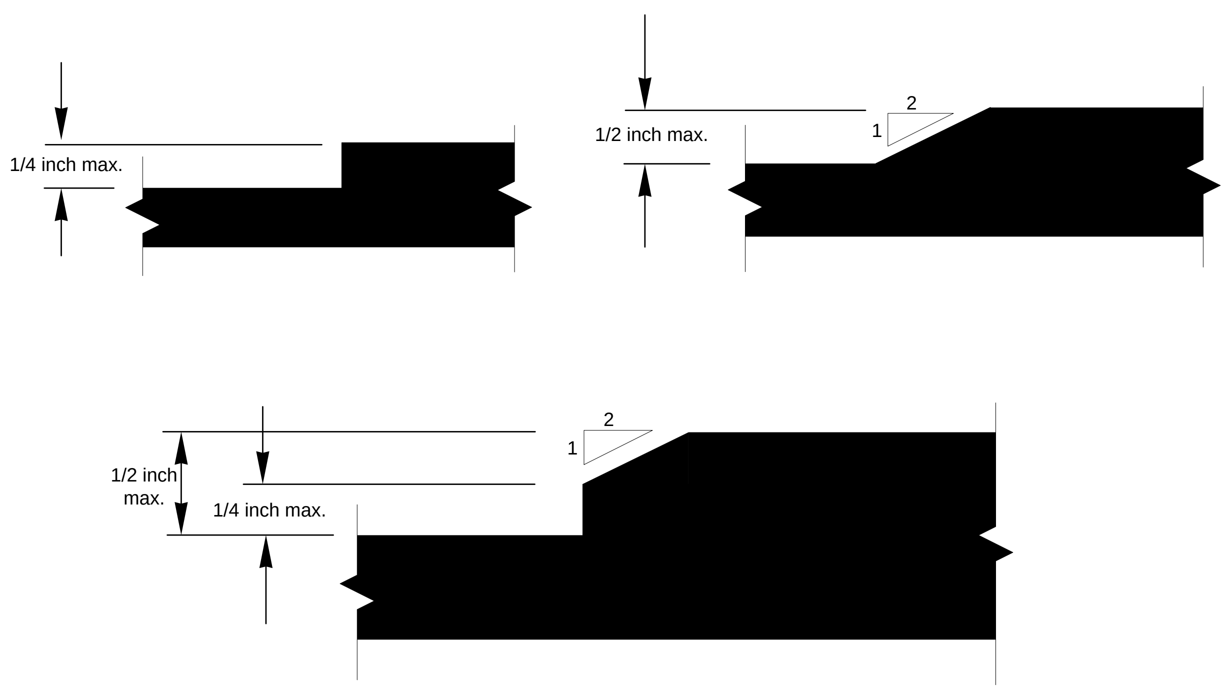
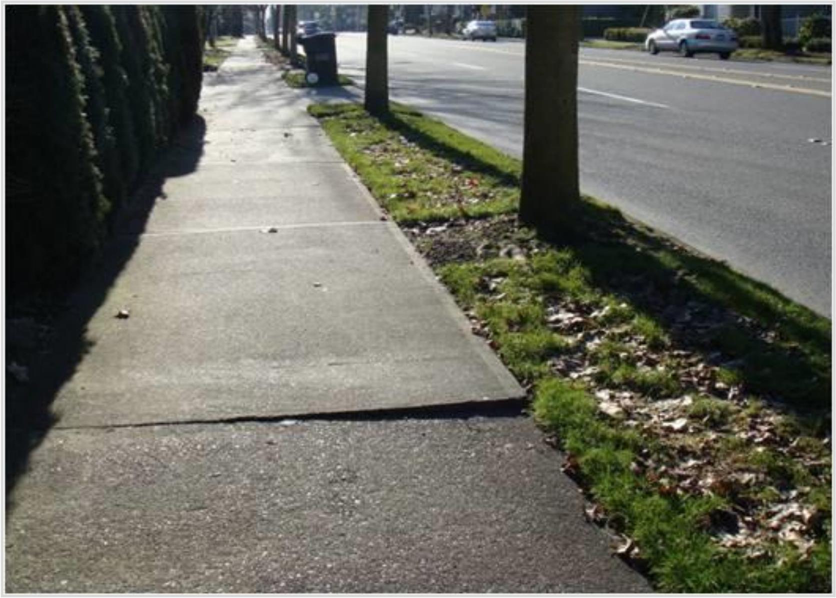


Exhibit 1510-5 Surface Discontinuities (Noncompliant)



- Gratings, access covers, utility objects, and other appurtenances shall not be located on curb ramps, landings, or gutters within the PAR.
- Locate gratings, access covers, utility objects, and other appurtenances outside the PAR on walkways and sidewalks. Where this is not possible, ensure covers, grates, and lids are designed to be slip resistant and are installed flush with the surrounding surface (see the *Standard Plans*).

1510.07(1)(d) Horizontal Openings

- Any sidewalk joints or gratings that are in the PAR shall not permit passage of a sphere more than ½ inch in diameter.
- Elongated openings shall be placed so that the long dimension is perpendicular to the dominant direction of travel.
- Openings for wheel flanges at pedestrian crossings of nonfreight rail track shall be 2½ inches maximum (3 inches maximum for freight rail track).
- For additional requirements when a PAR crosses a railroad, see 1510.13.

1510.08 Sidewalks

Sidewalks are one type of PCP. (See 1510.06 for PCP accessibility criteria.) Plan the design of sidewalks carefully to include a PAR that provides universal access. (See 1510.07 for PAR accessibility criteria.) Sidewalk design elements are found in Exhibit 1510-7 and details for raised sidewalks are shown in the *Standard Plans*. Wherever appropriate, make sidewalks continuous and provide access to side streets. The most pleasing and comfortable installation for the pedestrian is a sidewalk separated from the traveled way by a planted buffer. This provides a greater separation between vehicles and pedestrians than curb alone.

1510.08(1) Sidewalk and Buffer Widths

The WSDOT minimum sidewalk width is 5 feet (excluding the curb), but providing wider sidewalks is encouraged. Wider sidewalks are desirable on major arterials, in central business districts, and along parks, schools, and other major pedestrian generators. When sidewalks abut storefronts, additional width should be provided to accommodate window-shoppers and to avoid conflicts with opening doors and pedestrians entering or leaving the buildings.

When a buffer (vegetated as well as alternate pavement) is provided, the buffer should be at least 3 feet wide (excluding the curb). Document the decision to reduce a buffer width to less than 3 feet in the DDP.

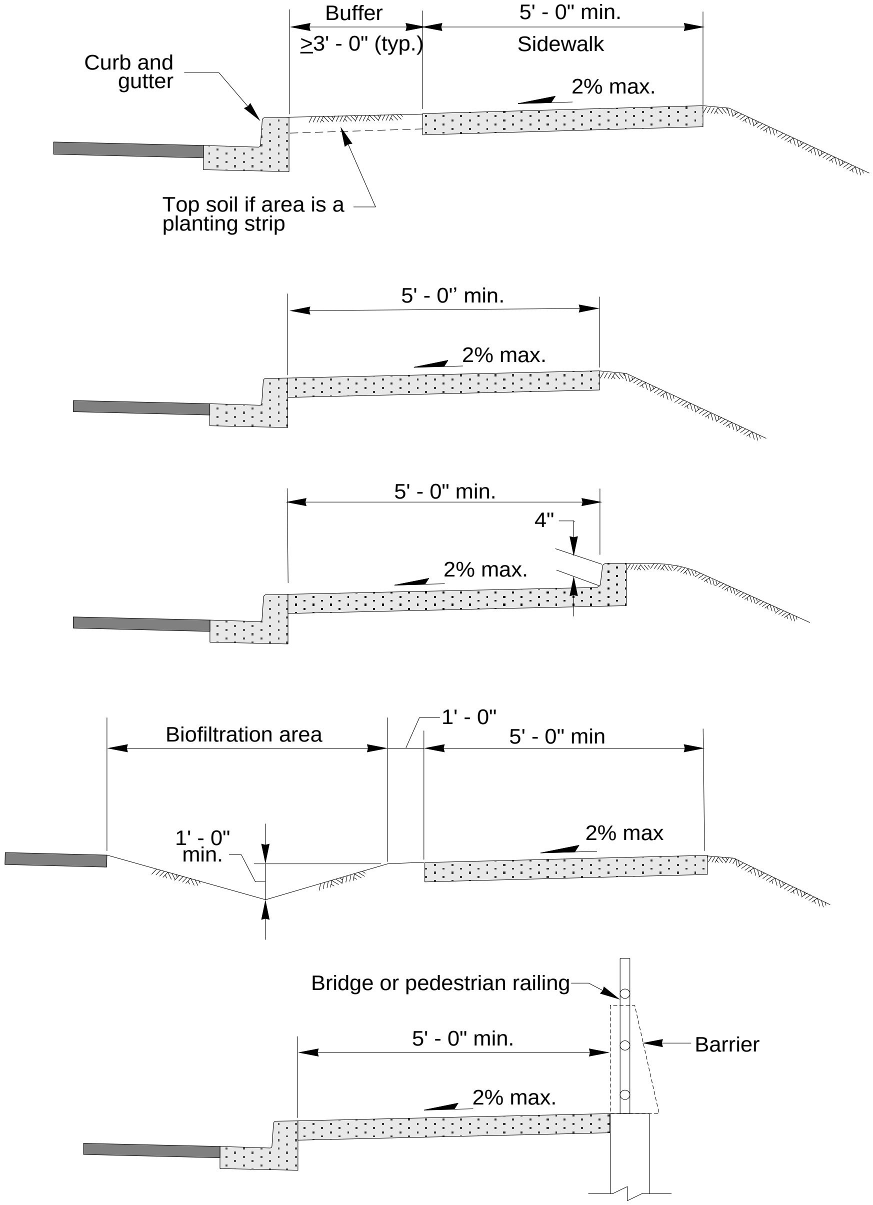
If trees or shrubs are included in a buffer, coordinate with the region or HQ Landscape Architect. Take into account Design Clear Zone guidelines (see Chapter 1600). Design subsurface infrastructure (such as structural soils) and select plants whose root systems do not cause sidewalks to buckle or heave. Coordinate buffer planting with maintenance personnel.

Where possible, strive to accommodate snow storage while keeping the pedestrian route free of snow accumulation. Make sure maintenance access is not obstructed. Shoulders, bike lanes, and on-street parking are not considered buffers, but they do offer the advantage of further separation between vehicles and pedestrians.

Exhibit 1510-6 Sidewalks With Buffers



Exhibit 1510-7 Typical Sidewalk Designs



Notes:

If vertical drop is within the Design Clear Zone and the posted speed is > 35 mph, then barrier may be needed (see Chapter 1600).

If vertical drop is > 2 feet 6 inches and barrier is not needed, then railing is indicated.

If vertical drop is < 2 feet 6 inches and barrier is not needed, then a 4-inch curb at back of sidewalk is adequate.

General:

See the *Standard Plans* for details on slopes at back of sidewalk.

See Chapter 1230 for slope selection criteria.

Sidewalks may be sloped away from the roadway for stormwater treatment (see the *Highway Runoff Manual*).

1510.08(2) Sidewalks at Driveways

Provide a PAR where driveways intersect a PCP (see Exhibit 1510-8). The *Standard Plans* shows details of driveway designs that provide a PAR. (See 1510.06 and 1510.07 for accessibility criteria.) When a driveway is signalized as part of an intersection, contact the Region ADA Liaison for guidance.

Exhibit 1510-8 Typical Driveways

1510.09 Curb Ramps

Curb ramps provide an accessible connection from a raised sidewalk down to the roadway surface. A curb ramp, or combination of curb ramps, is required to connect PAR to crosswalks (marked or unmarked) where curbs and sidewalks are present, except where pedestrian crossing is prohibited. (See 1510.10(2)(c) for guidance on closed crossings and Exhibit 1510-17 for an example.)

For new construction projects, provide a curb ramp oriented in each direction of pedestrian travel within the width of the crosswalk it serves. For alteration projects, a curb ramp oriented in each direction of pedestrian travel within the width of the crosswalk it serves is desirable.

Every curb ramp must have a curb ramp at the other end of the crosswalk it serves unless there is no curb or sidewalk on that side (RCW 35.68.075).

Curb ramps are also required at midblock crossings where curbs and sidewalks are present.

1510.09(1) Types of Curb Ramps

Different types of curb ramps can be used: perpendicular, parallel, and combination. Carefully analyze and take into consideration drainage patterns, especially when designing a parallel or combination curb ramp installation.

1510.09(1)(a) Perpendicular Curb Ramp

Perpendicular curb ramps (see Exhibits 1510-9 and 1510-10) are aligned to cut through the curb and meet the gutter grade break at a right angle. The landing is to be located at the top of the curb ramp.

1. Advantages

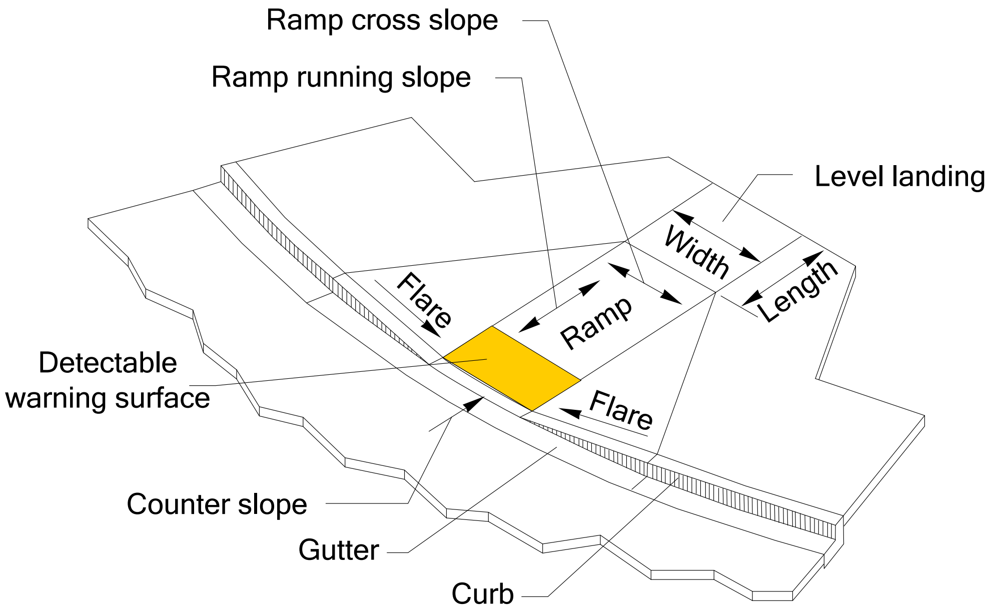
- Having the path of travel aligned to cross the gutter grade break at a right angle facilitates usage by individuals with mobility devices.
- The height of the ramp run relative to the gutter elevation may facilitate drainage.
- The height of the ramp run relative to the gutter elevation discourages vehicular traffic from cutting across the corner.
- On small-radius corners, the ramp alignment may be more closely aligned with the alignment of the crosswalk markings, which facilitates direction finding for the visually impaired.

2. Disadvantages

- The ramp run and landing might not fit within available right of way.
- On small-radius corners, the flares may not fit between closely spaced perpendicular curb ramps.
- On larger-radius corners, there will be less facilitation of direction finding for the visually impaired due to the requirement that the path of travel cross the gutter grade break at a right angle.

Exhibit 1510-9 Perpendicular Curb Ramp

Exhibit 1510-10 Perpendicular Curb Ramp Common Elements



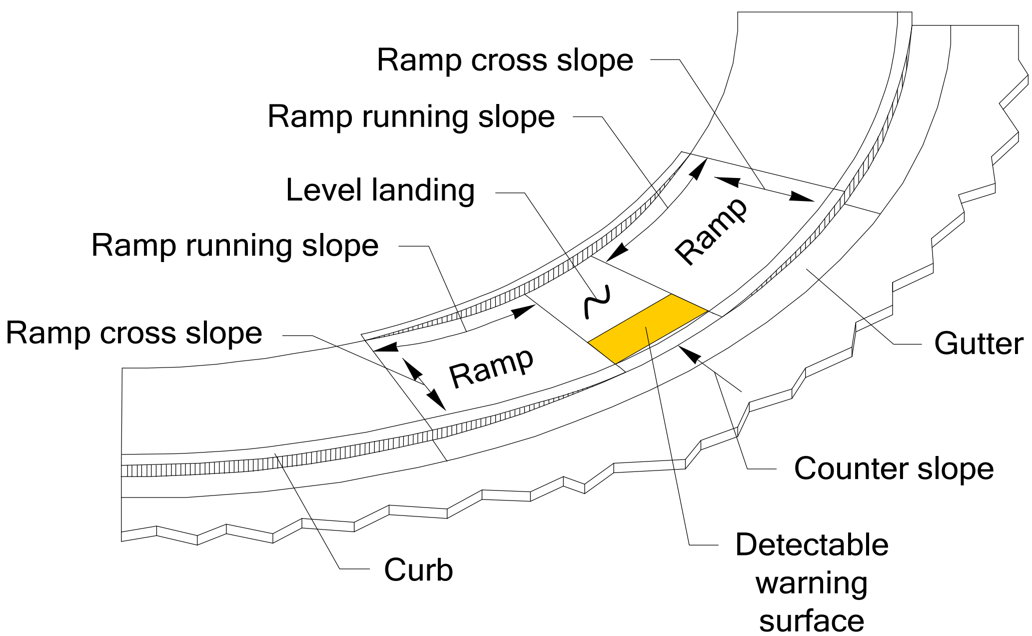
1510.09(1)(b) Parallel Curb Ramp

Parallel curb ramps (see Exhibits 1510-11 and 1510-12) are aligned with their running slope in line with the direction of sidewalk travel, parallel to the curb. The landing is located at the bottom of the curb ramp.

1. **Advantages**
   - Requires minimal right of way.
   - Allows ramps to be extended to reduce ramp grade within available right of way.
   - Provides edges on the side of the ramp that are detectable to vision-impaired pedestrians who navigate with a cane.
2. **Disadvantages**
   - Depending on the style of parallel curb ramp, pedestrian through traffic on the sidewalk may need to negotiate two ramp grades instead of one, possibly making it more difficult to traverse for some.
   - The installation of additional drainage features in the upstream gutter line may be necessary to prevent the accumulation of water or debris in the landing at the bottom of the ramp.

Exhibit 1510-11 Parallel Curb Ramp

Exhibit 1510-12 Parallel Curb Ramp Common Elements



Note: The pedestrian curb shown on the back of the curb ramp is intended to retain material in a cut section and is not required if there is no material to retain due to the nature of the roadside topography.

1510.09(1)(c) Combination Curb Ramp

Combination curb ramps (see Exhibit 1510-13) combine the use of perpendicular and parallel types of curb ramps. Landings may be shared by multiple ramps in this application. Buffer areas and pedestrian curbing that define the pedestrian path of travel are inherent design elements for this type of curb ramp.

1. Advantages

- Allows the elevation difference between the sidewalk and the gutter line to be transitioned with multiple ramps. This can help achieve compliant ramp running slopes.
- Provides additional locations in the gutter line along the radius where drainage structures can be placed outside the pedestrian access route due to the well-defined pedestrian paths of travel.
- Can be constructed within available right of way when the right of way boundary is located at the back of the existing sidewalk, provided sufficient buffer width is available on the roadway side of the sidewalk.
- Provides a way to avoid the relocation of existing features such as utility poles, fire hydrants, and signal poles by incorporating those features into the buffer areas.
- The pedestrian curbing that defines the buffer areas and forms the curb returns for the perpendicular ramp connections facilitates direction finding for a vision-impaired person who navigates with a cane.

2. Disadvantages

- Has a higher construction cost than other curb ramp types due to extensive use of curbing and a larger footprint.
- Due to generally flatter ramp grades and multi-tiered ramp elements, inadequate drainage and accumulation of debris can occur.

Exhibit 1510-13 Combination Curb Ramps

1510.09(2) Accessibility Criteria for Curb Ramps

The accessibility criteria for PCPs and PARs described in 1510.06 and 1510.07 also apply to curb ramps, except where superseded by the following additional accessibility criteria specifically for curb ramps.

1510.09(2)(a) Clear Width

- The clear width of curb ramps and their landings shall be 4 feet minimum, excluding flares.

1510.09(2)(b) Running Slope

- The running slope of curb ramps shall not exceed 8.3% maximum.

Note: It is recommended that running slopes be designed to be less than the allowed maximum to allow for some tolerance in construction. For example, design for a maximum 7.5% curb ramp running slope (rather than the 8.3% maximum).

- The running slope of a perpendicular curb ramp shall intersect the gutter grade break at a right angle at the back of curb.
- If the maximum running slope of 8.3% cannot be achieved due to existing physical constraints, the ramp shall be as flat as possible but the ramp length is not required to exceed 15 feet.

1510.09(2)(c) Cross Slope

- The cross slope of curb ramp shall not be greater than 2%, measured perpendicular to the direction of travel.

Note: It is recommended that cross slopes be designed to be less than the allowed maximum to allow for some tolerance in construction. For example, design for a maximum 1.5% cross slope (rather than the 2% maximum).

Exception: The cross slopes of curb ramps at midblock crossings are permitted to match the street or highway grade.

1510.09(2)(d) Landing

A level landing is required either at the top of a perpendicular ramp or the bottom of a parallel curb ramp, as noted in 1510.09(1)(a) and (b) for the type of curb ramp used.

- Provide a landing that is at least 4 feet minimum length by 4 feet minimum width.
- The running and cross slopes of a curb ramp landing shall be 2% maximum.

Note: It is recommended that cross slopes be designed to be less than the allowed maximum to allow for some tolerance in construction. For example, design for a maximum 1.5% cross slope (rather than 2% maximum).

Exception: The running and cross slopes of landings for curb ramps at midblock crossings are permitted to match the street or highway grade.

1510.09(2)(e) Flares

- Flared sides are to be used only where a PCP crosses the curb ramp from the side.
- Flared sides are to have a slope of 10% maximum, measured parallel to the back of curb.

1510.09(2)(f) Counter Slope

- The counter slope of the gutter or street at the foot of a curb ramp or landing shall be 5% maximum.

1510.09(2)(g) Detectable Warning Surfaces

- Detectable warning surfaces are required where curb ramps or landings connect to a roadway. (See the *Standard Plans* for placement details and other applications.)
- Detectable warning surfaces shall contrast visually (either light-on-dark or dark-on-light) with the adjacent walkway surface, gutter, street, or highway.

Note: Federal yellow is the color used to achieve visual contrast on WSDOT projects. Within cities, other contrasting colors may be used if requested by the city.

1510.09(2)(h) Surfaces

- Surfaces of curb ramps shall be firm, stable, and slip resistant.
- Gratings, access covers, utility objects, and other appurtenances shall not be located on curb ramps, landings, or gutters within the pedestrian access route.

1510.09(2)(i) Grade Breaks

- Vertical alignment shall be planar within curb ramp runs, landings, and gutter areas within the PAR.
- Grade breaks at the top and bottom of curb ramps shall be perpendicular to the direction of travel on the ramp run.
- Surface slopes that meet at grade breaks shall be flush.

1510.09(2)(j) Clear Space

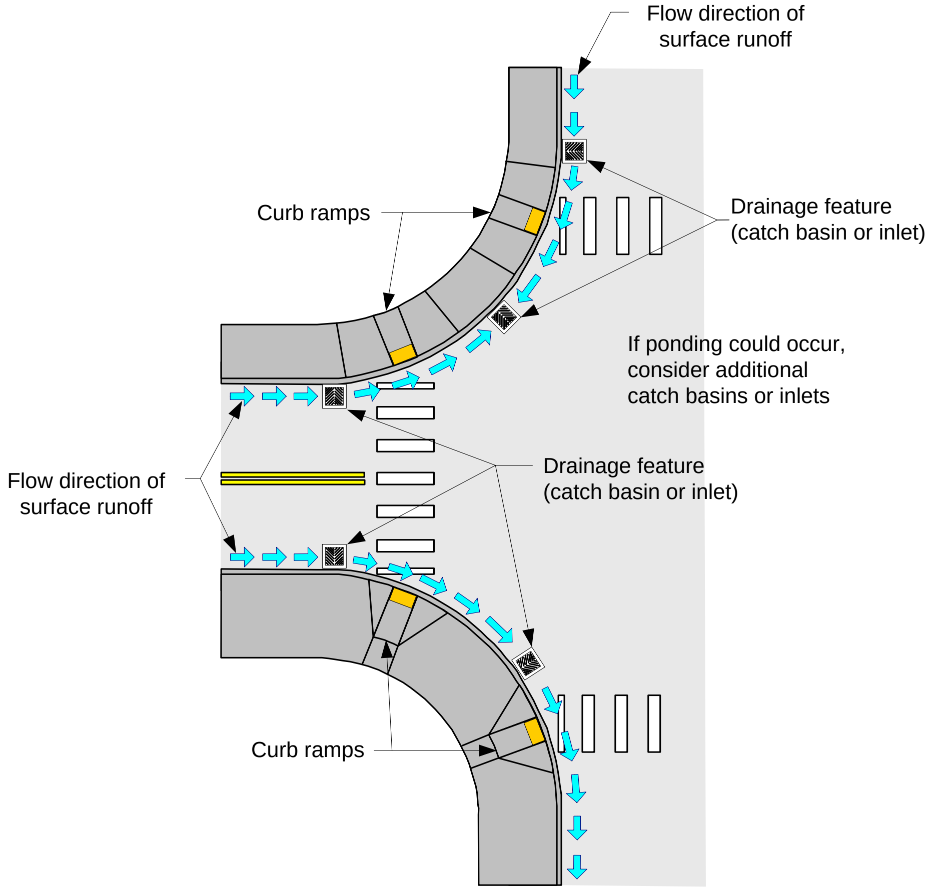
- Beyond the curb face where the bottom of a curb ramp or landing meets the gutter, a clear space of 4 feet minimum by 4 feet minimum shall be provided in the roadway that is contained within the width of the crosswalk and located wholly outside the parallel vehicle travel lane.

Note: Clear space is easily achieved when a separate curb ramp is provided, oriented in each direction of pedestrian travel within the width of the crosswalk it serves.

1510.09(3) Curb Ramp Drainage

Surface water runoff from the roadway can flood the lower end of a curb ramp. Provide catch basins or inlets to prevent ponding at the base of curb ramps and landings. Exhibit 1510-14 shows examples of drainage structure locations. Verify that drainage structures will not be located in the PAR.

Exhibit 1510-14 Typical Curb Ramp Drainage



1510.10 Crosswalks

1510.10(1) Designing Crossing Facilities

Evaluate the following for crossing facilities to address the needs of all user modes:

- Minimize turning radii to keep speeds low. (See Chapter 1300 for design vehicle guidance.)
- Place crosswalks so they are visible and connect to the adjacent pedestrian facilities.
- Provide sight distance (driver to pedestrian; pedestrian to driver).
- Use a separate left-turn phase along with a “WALK/DON’T WALK” signal.
- Restrict or prohibit turns.
- Shorten crossing distance.
- Use a raised median/cut-through island for a pedestrian refuge.
- Use accessible pedestrian signals (APS).
- Use signing and delineation as determined by the region Traffic Engineer.
- Place crosswalks as close as practicable to the intersection traveled way.
- Provide pedestrian-level lighting.
- Consider the crosswalk location in relation to transit stops.
- Provide a PAR that meets the accessibility criteria at all pedestrian crossings.

1510.10(2) Crosswalks at Intersections

Provide a PAR within marked and unmarked pedestrian crossings. (See 1510.07 for accessibility criteria for PAR.)

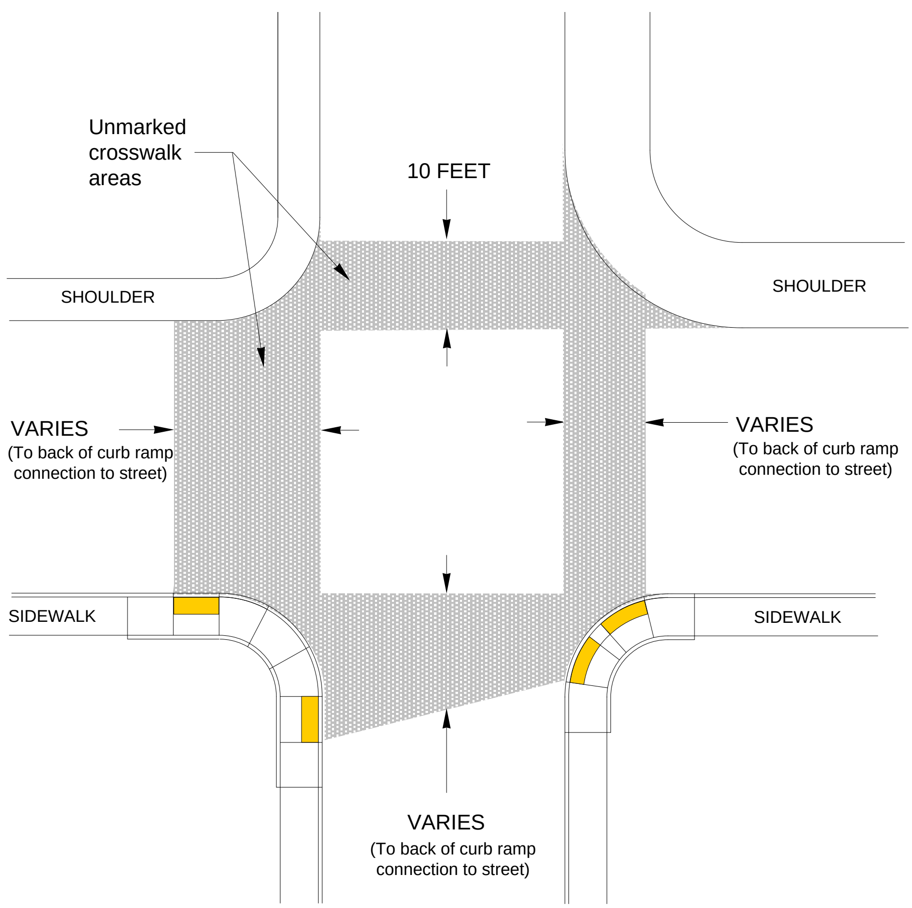
Crosswalks are provided on all legs of an intersection, except in rare cases. There are normally three crosswalks at a “T” intersection and four crosswalks at a “four-leg” intersection. For pedestrian route continuity, the minimum number of crosswalks is two at “T” intersections and three at “four-leg” intersections. One example where crosswalks might not be provided on all interaction legs is a diamond interchange with heavy left-turn movements from the off-ramp approach. (See 1510.10(2)(c) for Closed Crossings policy.)

The *Traffic Manual* provides recommendations for determining pedestrian markings based on lane configuration, vehicular traffic volume, and speed. However, coordinate with the region Traffic Engineer early on with any existing or proposed crosswalks. The Traffic Engineer makes the final determination on appropriate signing and delineation.

1510.10(2)(a) Unmarked Crossings

Legal crosswalks exist at all intersections, whether marked or not, regardless of the number of legs at the intersection. An unmarked crosswalk (see Exhibit 1510-15) is the portion of the roadway behind a prolongation of the curb or edge of the through traffic lane and a prolongation of the farthest sidewalk connection or, in the event there are no sidewalks, between the edge of the through traffic lane and a line 10 feet from there (RCW 46.04.160).

Exhibit 1510-15 Unmarked Crosswalks



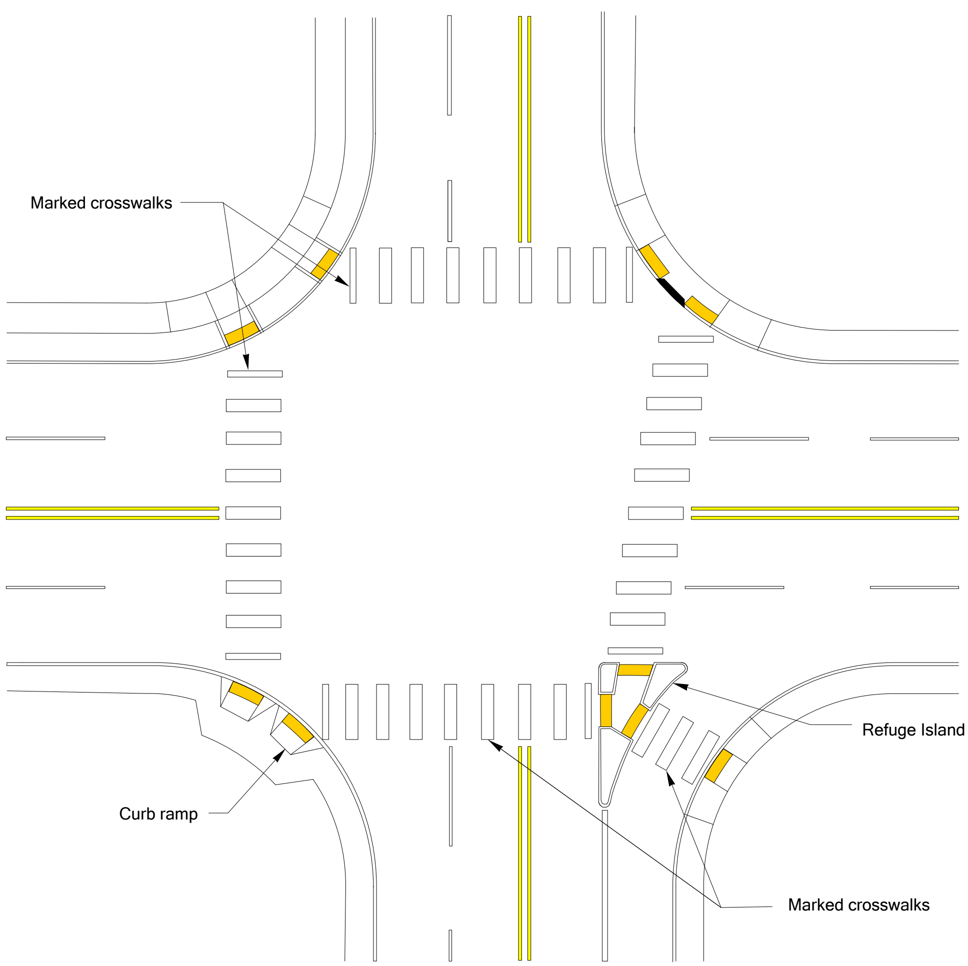
1510.10(2)(b) Marked Crossings

Marked crosswalks are used at intersections or midblock crossings. They should not to be used indiscriminately, but considered based on a thorough evaluation of site conditions. Maintenance agreements and RCW 47.24.020 provide jurisdictional authority for decisions to mark crosswalks based on a population threshold of 27,500 and should be consulted prior to a decision to mark a crosswalk. Consult region Traffic Offices for "best practices" for marking crosswalks based on intersection type. The MUTCD, the AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities, and the NACTO Urban Street Design Guide are all good resources to use when evaluating locations for marked crosswalks.

The desirable width for a marked crosswalk is 10 feet (6 feet minimum, with justification). The preferred type of marked crosswalk is a longitudinal pattern known as a Ladder Bar, which is shown in the *Standard Plans* and Exhibit 1510-16. Stop and yield line dimensions and placement must conform to the MUTCD and are shown in the *Standard Plans*.

Some decorative crosswalk materials (such as colored pavement or bricks) may cause confusion for visually impaired pedestrians and can create discomfort for wheelchair users. Supplement decorative crosswalks with pavement markings to enhance visibility and delineate the crosswalk. Refer to the MUTCD and the Local Agency Crosswalk Options website:
www.wsdot.wa.gov/design/standards/plansheet/pm-2.htm

Exhibit 1510-16 Marked Pedestrian Crossing



1510.10(2)(c) Closed Crossings

Pedestrian crossings shall only be closed for documented potential or observed crash concerns or for essential signal operations. If a crossing has been previously closed as indicated by existing signing and ADA facilities are being evaluated, provide an appropriate treatment that is detectable by people with vision difficulties who navigate with a cane, such as directional pedestrian curbing and removal of ramps at these closed crossing. The region Traffic Engineer is the approval authority for the closing of crossings.

Vacant

Exhibit 1510-17

1510.10(3) Midblock Crosswalks

On roadways with pedestrian crossing traffic caused by nearby pedestrian generators, a midblock crossing may be appropriate. (See 1510.10(2) for crosswalk criteria and the *Traffic Manual* for marked crosswalk recommendations at unsignalized intersections.) The approval authority is the Traffic Engineer.

Engineering judgment of conditions that might increase the value of a midblock crossing includes the following:

- High pedestrian crossing volume present with long block spacing.
- Evidence of pedestrian-vehicular midblock conflicts (site observations, law enforcement reporting, and city traffic engineers).
- Proposed crossing with a realistic opportunity to channel multiple pedestrian crossings to a single location.
- Sight lines that enable sufficient eye contact between motorists and pedestrians.
- Community commitment for a successful outcome.
- Ability to mitigate risks associated with the location using proven countermeasures such as, but not limited to, refuge islands, rectangular rapid flashing beacons, and/or pedestrian hybrid beacons.
- Modal interchange points where high volumes crossing pedestrians occur (e.g., transit stop to apartment complex).

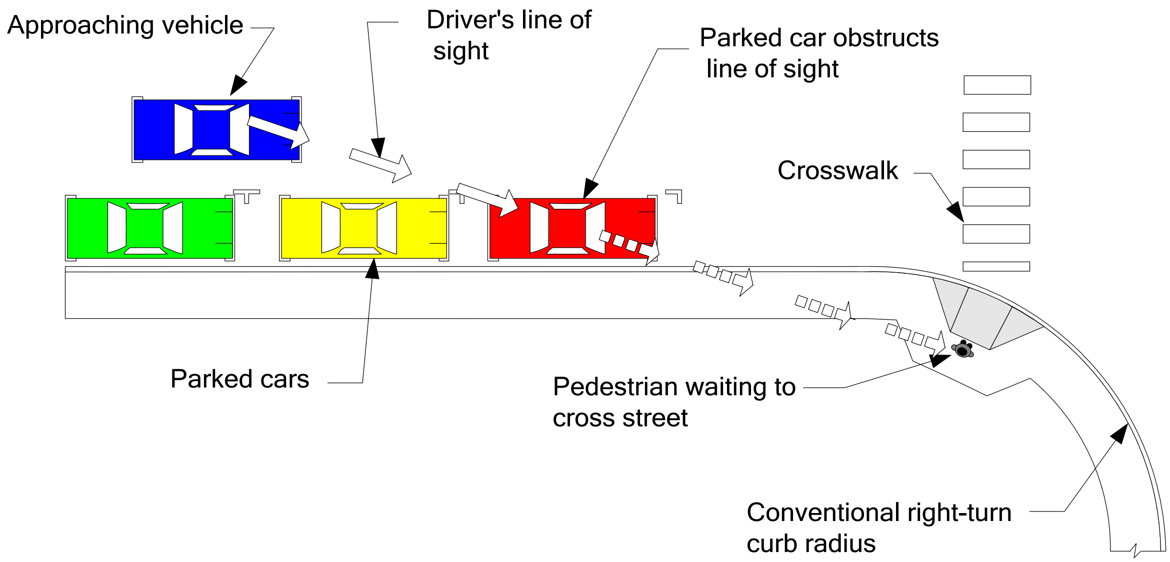
To meet the accessibility criteria, the PAR in the crosswalk may have a cross slope that matches the grade of the roadway. An example of a midblock crossing is shown in Exhibit 1510-18. (See Chapter 530 for further information on pedestrian access and paths on limited access facilities.)

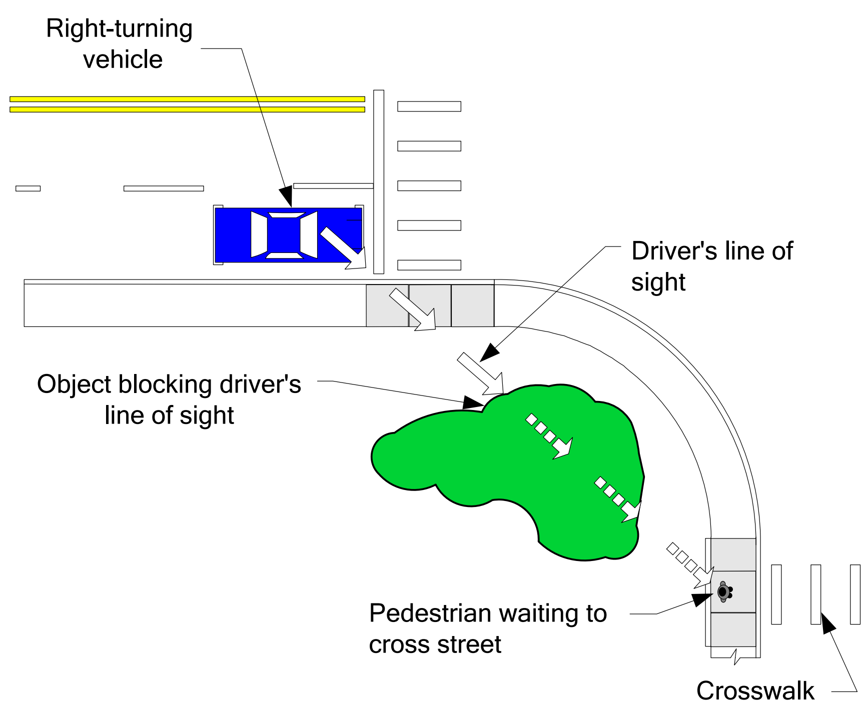
Exhibit 1510-18 Midblock Pedestrian Crossing

1510.10(4) Sight Distance at Crosswalks

When locating crosswalks at intersections, it is important to evaluate the sight lines between pedestrians and motorists. Shrubbery, signs, parked cars, and other roadside elements can block motorists' and pedestrians' views of one another. Exhibit 1510-19 illustrates these sight distance concerns.

Exhibit 1510-19 Obstructed Line of Sight at Intersection





1510.10(5) Curb Extensions

Curb extensions are traffic calming measures that may improve sight distance and reduce pedestrian crossing times, which limits pedestrian exposure. Installing a curb extension can help reduce the sight distance problem with parked cars that limit driver/pedestrian visibility. Curb extensions may allow for better curb ramp design as well as provide more space for pedestrians. *Note:* Curb extensions are not an option on streets with intermediate and high speed traffic or without on-street parking because drivers would be confronted with sudden changes in roadway width. Extend the curb no farther than the width of the parking lane. (See Chapters 1230, and 1520 for shoulder/bike lane width guidance.) Design the approach nose to ensure adequate setback of vehicles to provide visibility of pedestrians. At intersections with traffic signals, the curb extensions can be used to reduce pedestrian signal timing. Examples of sidewalk curb extensions are shown in Exhibits 1510-20 and 1510-21.

Exhibit 1510-20 Improved Line of Sight at Intersection

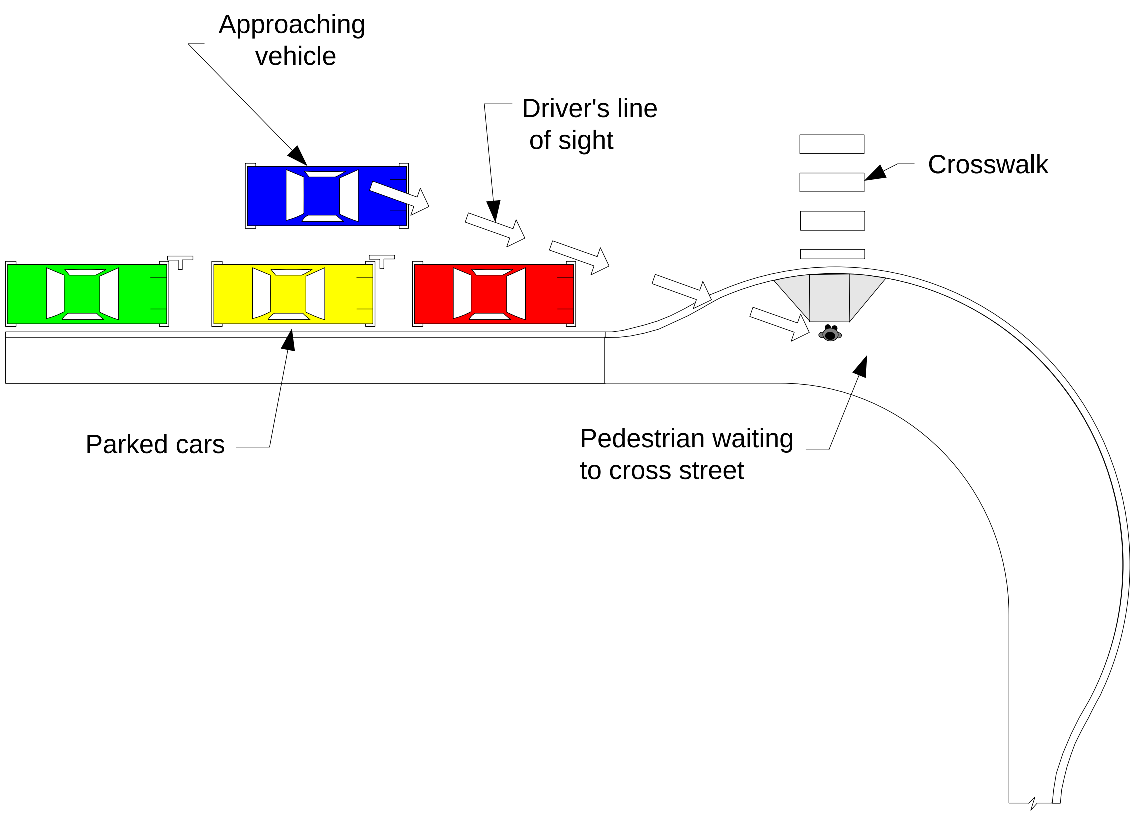


Exhibit 1510-21 Curb Extension Examples

The right-turn path of the design vehicle 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. Ensure the geometry of the curb extension is compatible with the turn path for the design vehicle selected.

Avoid interrupting bicycle traffic with curb extensions.

Do not use curb extensions on state highways when:

- The design vehicle (see Chapter 1300) encroaches on curbs or opposing lanes, and other solutions will not improve the circumstances.
- On-street parking is not provided/allowed.
- The posted speed is above 35 mph.

Site features such as landscaping, cabinets, poles, benches, planters, bollards, newspaper stands, and sandwich boards should be selected and placed so they do not obstruct the vision of pedestrians or drivers within curb extension areas, as shown in Exhibit 1510-21. Take into account motorist and pedestrian visibility and Design Clear Zone guidelines (see Chapter 1600).

1510.11 Raised Medians/Traffic Islands

Wide multilane streets are often difficult for pedestrians to cross, particularly when there are insufficient gaps in vehicular traffic because of heavy volumes. Consider raised medians and traffic islands with a pedestrian refuge area (see Exhibit 1510-22) on roadways with the following conditions:

- Two-way arterial with speeds of greater than 35 mph,
- Moderate to high average daily traffic (ADT),
- High pedestrian volumes.
- Significant pedestrian crash history.
- Near a school or other community center.
- Crossing distance exceeds 30 feet.
- Complex or irregularly shaped intersections.

A traffic island used for channelized right-turn slip lanes can provide a pedestrian refuge, but the slip lane may promote faster turning speeds. Minimize the turning radius of the slip lane to keep speeds as low as feasible. To reduce conflicts, keep the slip lane as narrow as practicable and design a crosswalk alignment that is at a right angle to the face of curb. (See Chapters 1310 for turn lanes, 1360 for interchange ramps, and 1320 for pedestrian accommodations in roundabouts.)

The PAR through a raised median or traffic island can be either raised with curb ramps or a cut-through type (see Exhibit 1510-22). Curb ramps in medians and islands can add difficulty to the crossing for some users. The curbed edges of cut-throughs can be useful cues to the visually impaired in determining the direction of a crossing, especially on an angled route through a median or island.

1510.11(1) Accessibility Criteria for Raised Medians and Traffic Islands

There are many design considerations when deciding whether to ramp up to the median or island grade or create a cut-through median or island matching the roadway grade. These considerations may include the profile grade and cross slope of the road, drainage patterns, and the length or width of the median or island.

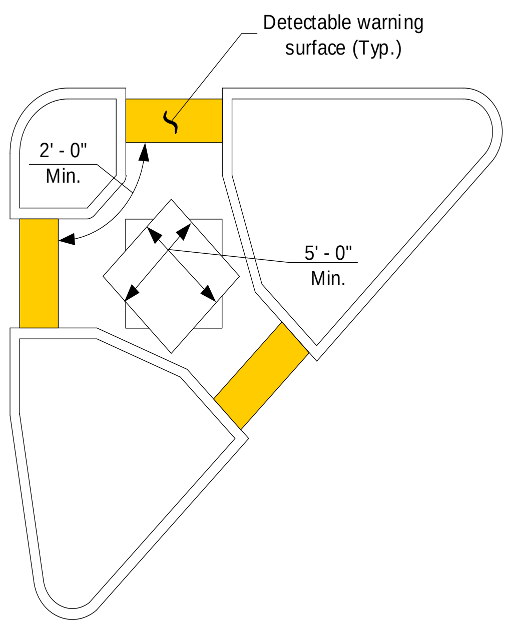
The following accessibility criteria apply:

- Each raised median or traffic island shall contain a PAR connecting to each crosswalk (see 1510.07).
- A passing space shall be provided that is at least 5 feet wide for a distance of at least 5 feet for each PAR in a raised median or on a traffic island (see Exhibit 1510-22).

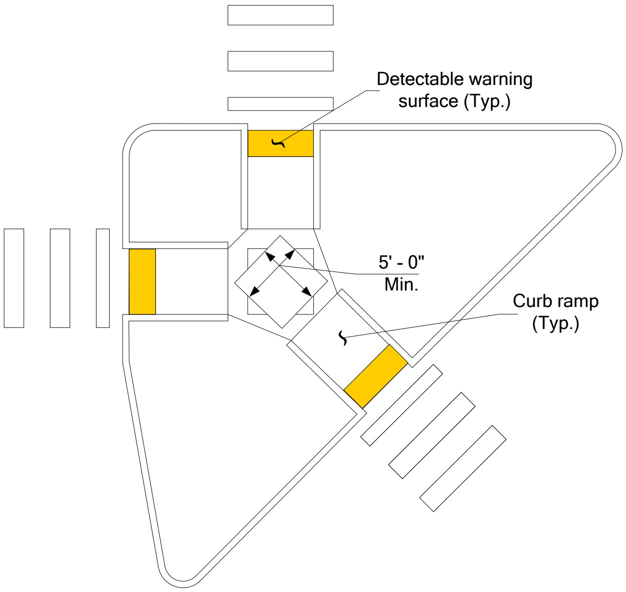
Note: It is recommended that cut-throughs be designed to have a minimum width of 5 feet to ensure a passing space is provided.

- Medians and pedestrian refuge islands shall be 6 feet minimum in length in the direction of pedestrian travel.
- Detectable warning surfaces are to be separated by 2 feet minimum length in the direction of pedestrian travel.
- Detectable warning surfaces are located at each curb ramp or roadway entrance of a PAR through a raised median or traffic island. The detectable warning surface shall be located at the back of the curb (see Exhibit 1510-22).
- PARs of shared-use paths that go through raised medians or traffic islands shall be the same width as the shared-use path (see Chapter 1515).

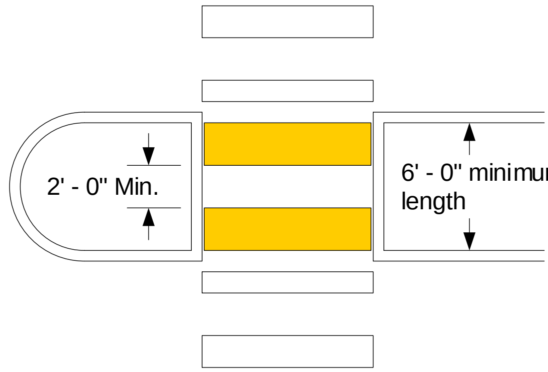
Exhibit 1510-22 Raised Islands With Curb Ramps and Pedestrian Cut-Throughs



Island Cut-Through



Raised Traffic Island With Curb Ramps



Median Island Cut-Through (full width shown)

(See 1510.11(1) for minimum accessibility criteria.)

See the *Standard Plans* for details.

1510.12 Pedestrian Pushbuttons

Pedestrian pushbuttons are an operating control with their own accessibility requirements. All pedestrian pushbuttons, regardless of the type of system they are part of, require a level clear space located so that users of all types can reach the button to actuate the associated system.

1510.12(1) Accessibility Criteria for All Pedestrian Pushbuttons (including APS)

1510.12(1)(a) Location Requirements

See 1330.04(4) for pushbutton location requirements. These location requirements limit the potential locations for the pedestrian pushbutton clear space.

1510.12(1)(b) Clear Space Requirements

- Grade: 2% maximum running and cross slopes.
- Clear space dimensions:
    a. Standard: 48 inches in width by 60 inches in length, with the pushbutton located along one of the long sides of the clear space.
    b. Minimum: 48 inches minimum width by 48 inches minimum length. Although the ADA minimum required clear space for an operational control is 30 inches by 48 inches, the narrow dimension is increased to 48 inches to allow for maneuvering, similar to a curb ramp landing (see Exhibit 1510-23). If the clear space is constrained on three sides, such that the clear space is set back 15 inches or more from the PAR, then the clear space shall be 48 inches minimum width by 60 inches minimum length, to allow for maneuvering within the constrained space. (see Exhibit 1510-23).

- Additional unobstructed or traversable space of 12 inches on either end of the clear space should be provided if possible, to allow for protruding equipment such as foot rests to extend beyond the clear space. This helps mobility assistance device users get their shoulder line closer to the pushbutton (see Exhibit 1510-23).
- Clear space is allowed to overlap other PAR elements (i.e., sidewalk/curb ramp landing) (see Exhibits 1510-24a and 1510-24b).
- Clear space must be connected to the crosswalk served by the pedestrian pushbutton with a PAR.

Exhibit 1510-23 Clear Space for Pedestrian Pushbutton

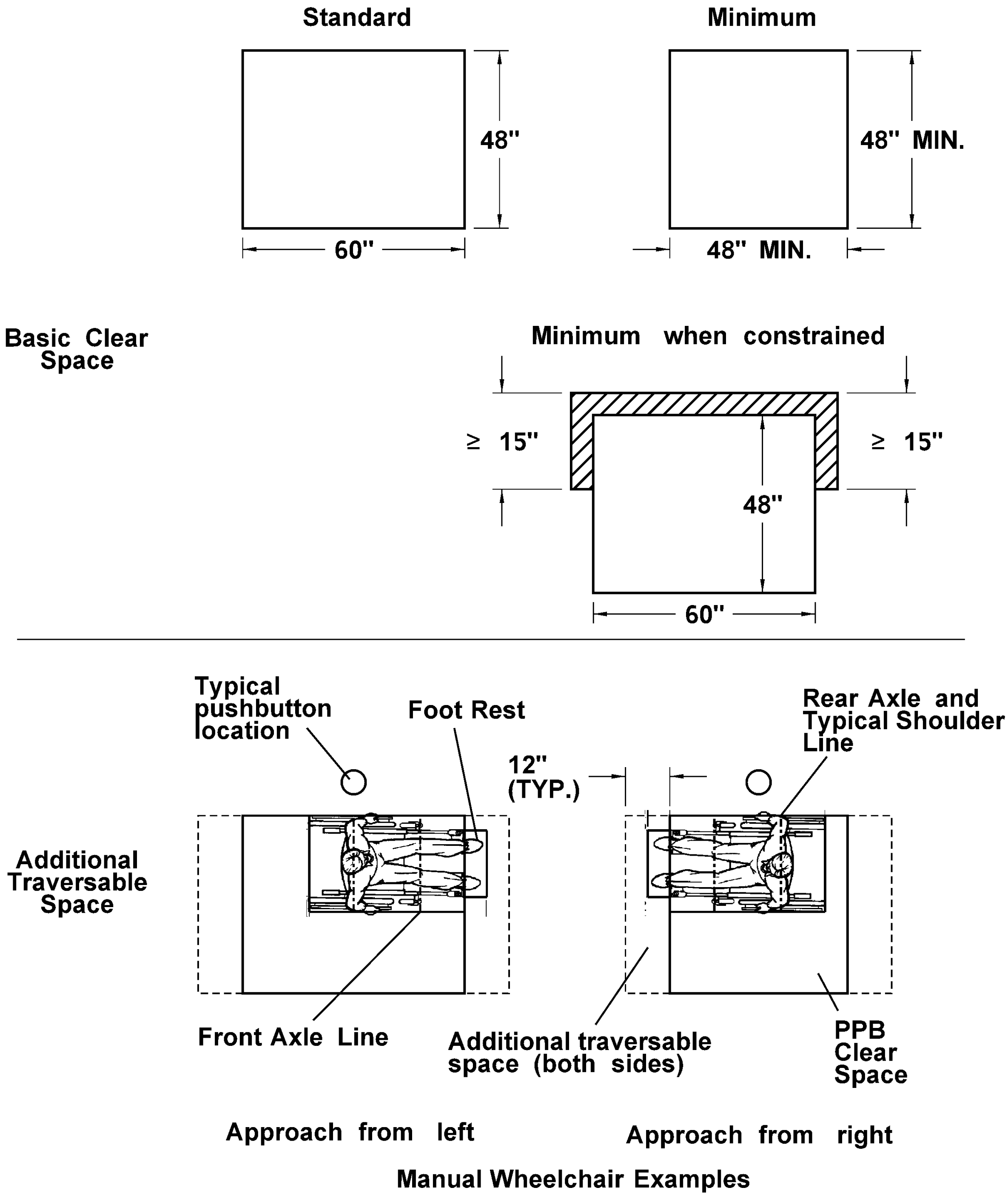
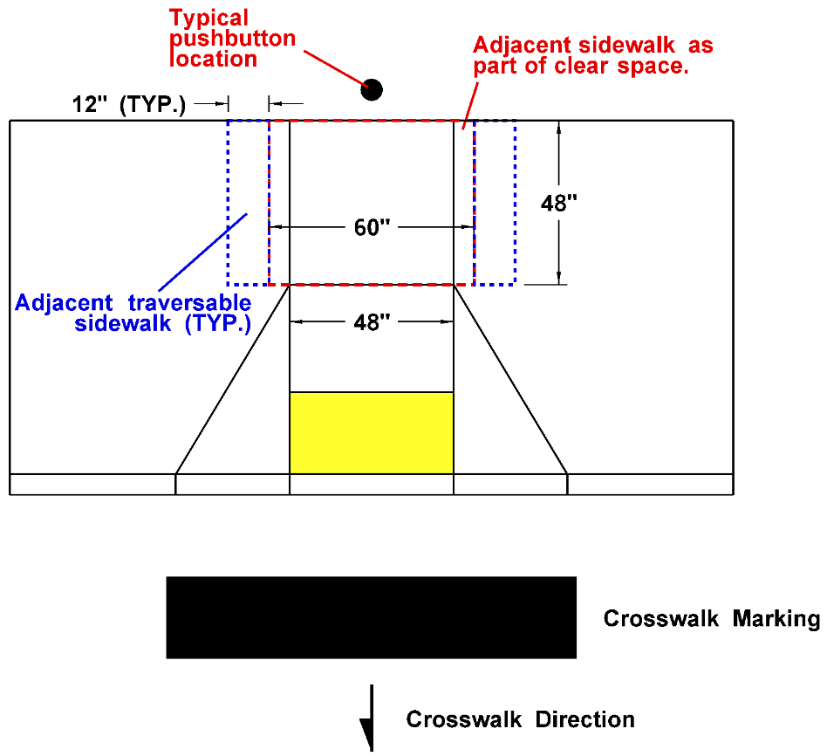


Exhibit 1510-24a Perpendicular Ramp Concurrent Clear Space Examples

Perpendicular Ramp Option:
Use Adjacent Level Sidewalk
(Not to scale)



Perpendicular Ramp Option:
Widen Ramp and Landing
(Not to scale)

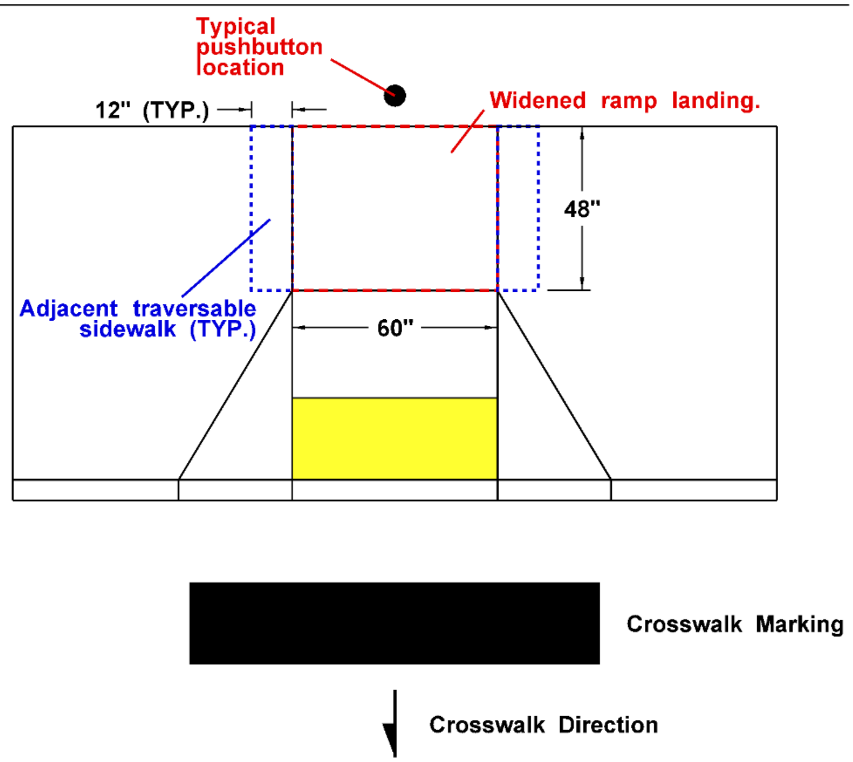
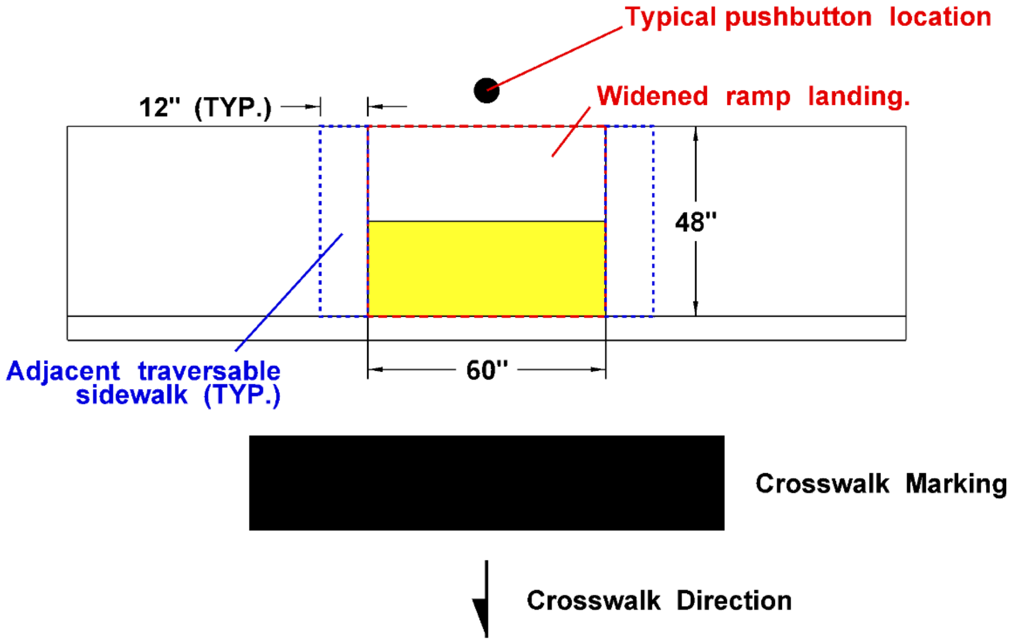
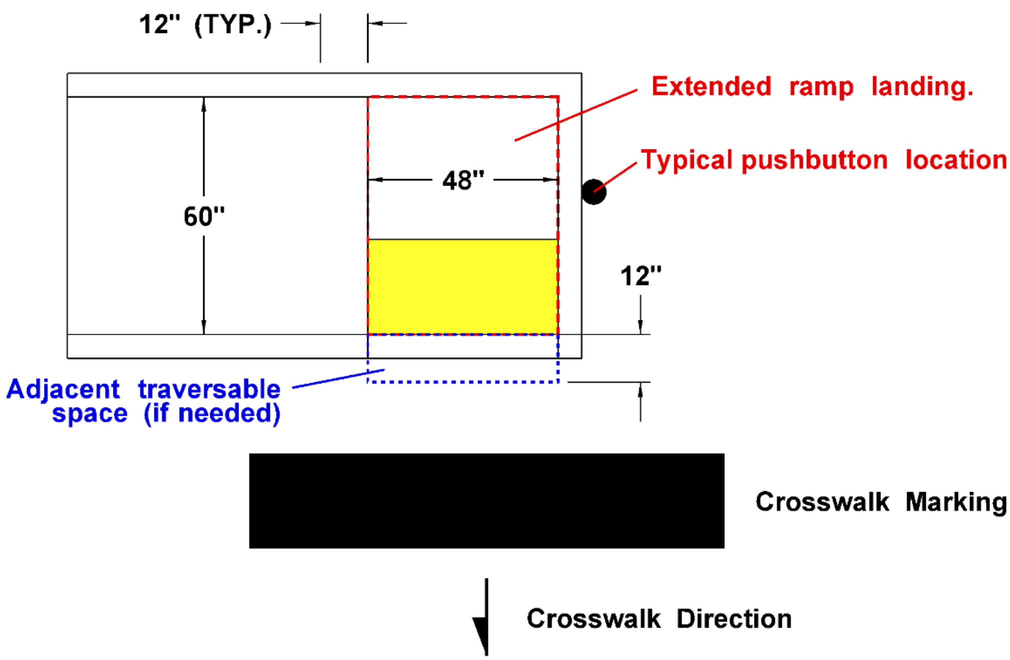


Exhibit 1510-24b Parallel Ramp Concurrent Clear Space Examples



Parallel Ramp Mid-Sidewalk Option: Widen Ramp Landing to 60"



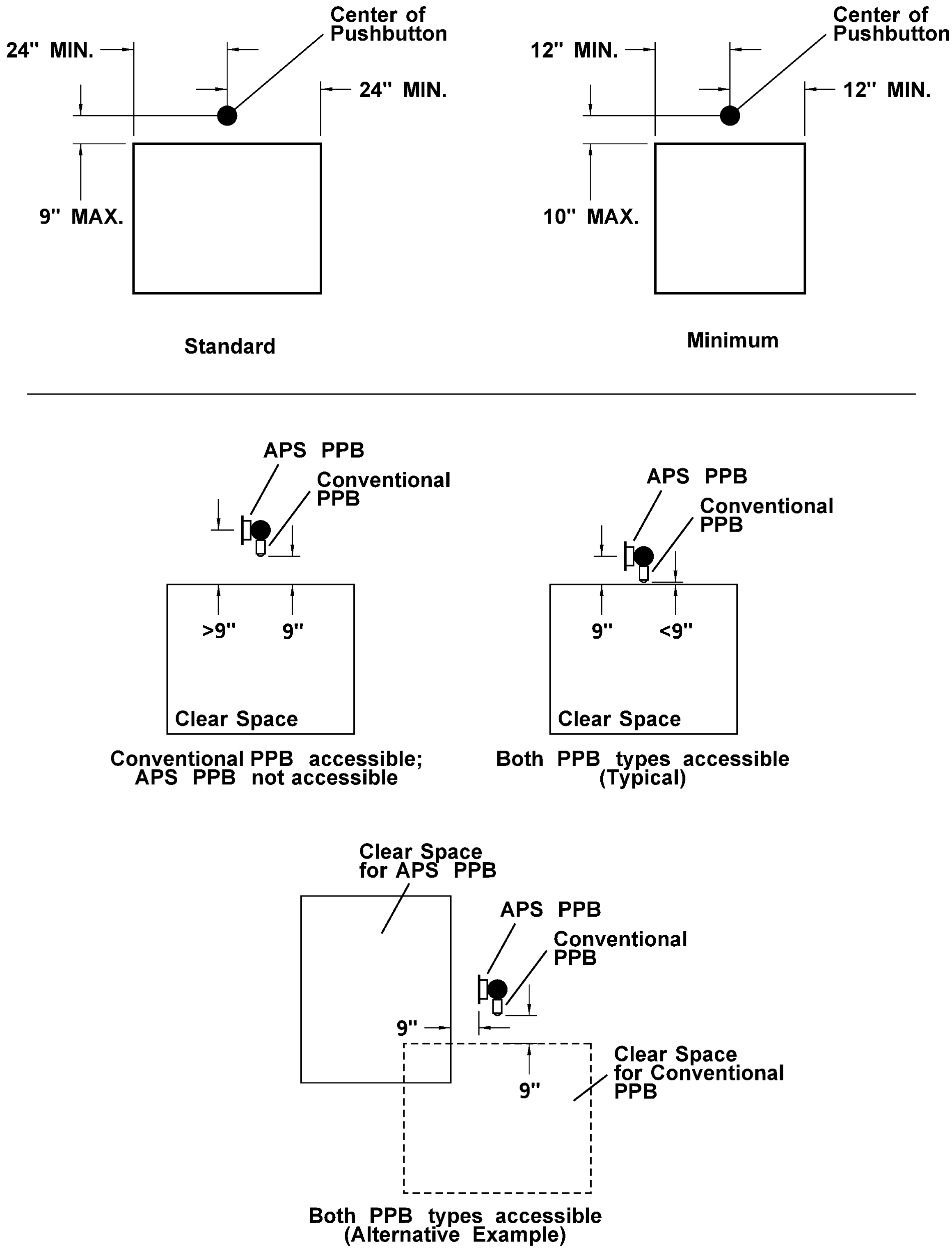
Parallel Ramp End of Sidewalk Option: Extend Ramp Landing to 60"

1510.12(1)(c) Reach Range Requirements

Pushbuttons are in locations considered unobstructed, and follow the allowable unobstructed reach distance requirements of the ADA accessibility requirements. This manual designs clear space for pushbuttons based on a parallel approach, due to difficulties in both accessibility and design when attempting to accommodate a forward reach.

- The provided clear space must be within reach range of the pedestrian pushbutton.
- The reach range is 10 inches maximum, as measured from the edge of the clear space to the center of the physical pushbutton (not just the housing).
- For new construction, the center of the physical pushbutton shall be no more than 9 inches from the edge of the clear space. It is preferable to locate the pushbutton as close to the edge of the clear space as possible.
- Different types of pushbuttons (front mount H-frame type versus side mount Accessible Pedestrian Signal type) will have different reach ranges on the same pole. Generally, designing for a side mount pushbutton will result in a front mount pushbutton also being within the required reach range. This is generally not true the other way around. (see Exhibit 1510-25)
- The center of the physical pushbutton shall be 42 inches above the surface of the clear space. Existing installations may remain if they are within a range of 36 inches minimum to 48 inches maximum above the surface of the clear space.
- The pushbutton shall be a minimum of 12 inches in from both ends of the clear space, and should be at least 24 inches in from both ends of the clear space. Ideally, the pushbutton should be centered along one side of the clear space. If the clear space is rectangular, the pushbutton shall be located along one of the long sides of the clear space.

Exhibit 1510-25 Reach Range for Pedestrian Pushbuttons



NOTE: See Exhibits 1330-14a and 1330-14b for pole setback limits

1510.12(2) Accessible Pedestrian Signals (APS)

APS are only installed where there is a pedestrian traffic signal display (walking person / hand). APS are not installed as part of crosswalk flashing beacon systems. See Chapter 1330 for additional information on APS equipment.

1510.13 At-Grade Railroad Crossings

The design of pedestrian facilities that cross railroad tracks (see Exhibit 1510-26) often presents challenges due to the conflicting needs of pedestrians and trains. In particular, the flangeway gap for trains to traverse a crossing surface may create a significant obstacle for a person who uses a wheelchair, crutches, or walking aids for mobility. Whenever practicable, align pedestrian crossings perpendicular to the tracks in order to minimize potential problems related to flangeway gaps. Crossing surfaces may be constructed of timber planking, rubberized materials, or concrete. Concrete materials generally provide the smoothest and most durable crossing surfaces. When detectable warning surfaces are used at railroad crossings, place them according to the MUTCD stop line placement criteria.

Exhibit 1510-26 Pedestrian Railroad Crossings

Undesirable

Recommended

There are a number of railroad crossing warning devices (see Exhibit 1510-27) intended specifically for pedestrian facilities (see the MUTCD). When selecting warning devices, factors such as train and pedestrian volumes, train speeds, available sight distance, number of tracks, and other site-specific characteristics should be taken into account. Coordinate with the HQ Design Office Railroad Liaison early in the design process so that all relevant factors are considered and an agreement may be reached regarding the design of warning devices and crossing surfaces.

Exhibit 1510-27 Pedestrian Railroad Warning Device

Except for crossings located within the limits of first-class cities,* the Washington Utilities and Transportation Commission (WUTC) approves proposals for any new railroad at-grade crossings or changes to warning devices or geometry at existing crossings. Additionally, any project that requires the railroad to perform work such as installation of warning devices or crossing surfaces must obtain a railroad construction and maintenance agreement. Contact the HQ Design Office Railroad Liaison to coordinate with both the WUTC and the railroad company.

*RCW 35.22.010: A first class city is a city with a population of ten thousand or more at the time of its organization or reorganization that has a charter adopted under Article XI, section 10, of the state Constitution.

Note: There are very few first-class cities in the state of Washington. Verify with the HQ Design Office Railroad Liaison.

1510.14 Pedestrian Grade Separations (Structures)

On the approach to a bridge that has a raised sidewalk, provide a ramp that transitions to the sidewalk from the paved shoulder. A ramp that transitions from a paved shoulder to a sidewalk on a bridge is to have a slope of 5% maximum and be constructed of asphalt or cement concrete. In addition to aiding pedestrian access, the ramp also serves as a roadside safety feature to mitigate the raised blunt end of the concrete sidewalk. If a PCP (such as a raised sidewalk or shared-use path) is located near the bridge, consider eliminating the gap between the bridge sidewalk and the PCP by extending the bridge sidewalk to match into the nearby PCP.

At underpasses where pedestrians are allowed, it is desirable to provide sidewalks and to maintain the full shoulder width. When bridge columns are placed on either side of the roadway, it is preferred to place the walkway between the roadway and the columns for pedestrian visibility and security. Provide adequate illumination and drainage for pedestrian safety and comfort.

In cases where there is a pedestrian crash history, and the roadway cannot be redesigned to accommodate pedestrians at grade, planners should consider providing a grade-separated pedestrian structure (see Exhibits 1510-28 and 1510-29). When considering a grade-separated pedestrian structure, determine whether the conditions that require the crossing are permanent. If there is likelihood that pedestrians will not use a grade separation, 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.

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. ***Note:*** The HQ Bridge and Structures Office is responsible for the design of pedestrian structures.

Consider a grade-separated crossing where:

- There is moderate to high pedestrian demand to cross a freeway or expressway.
- There are large numbers of young children, particularly on school routes, who regularly cross intermediate and high speed or high-volume roadways.
- The traffic conflicts that would be encountered by pedestrians are considered unacceptable (such as on wide streets with high pedestrian volumes combined with intermediate or high speed traffic).
- There are documented crashes or close calls involving pedestrians and vehicles
- One or more of the conditions stated above exists in conjunction with a well-defined pedestrian origin and destination (such as a residential neighborhood across a busy street from a school).

1510.14(1) Pedestrian Bridges

Pedestrian grade-separation bridges (see Exhibit 1510-28) are more effective when the roadway is below the natural ground line, as in a cut section. Elevated grade separations in cut sections, where pedestrians climb stairs or use long approach ramps, tend to be underused. Pedestrian bridges need adequate right of way to accommodate accessible ramp approaches leading up to and off of the structure. The bridge structure must comply with ADA requirements and meet the accessibility criteria for either a pedestrian circulation path (if the grade is 5% or less) or an access ramp (if the grade is greater than 5% but less than or equal to 8.3%), and must include a pedestrian access route. (See 1510.06 and 1510.07 for PCP and PAR accessibility criteria; see 1510.15(2) for access ramp accessibility criteria.)

For the minimum vertical clearance from the bottom of the pedestrian structure to the roadway beneath, see Chapter 720. The height of the structure can affect the length of the pedestrian ramp approaches to the structure. When access ramps are not feasible, provide both elevators and stairways.

Provide railings on pedestrian bridges. Protective screening is sometimes desirable to deter pedestrians from throwing objects from an overhead pedestrian structure (see Chapter 720).

The minimum clear width for pedestrian bridges is 8 feet. Consider a clear width of 14 feet where a pedestrian bridge is enclosed or shared with bicyclists, or equestrians, or if maintenance or emergency vehicles will need to access.

Exhibit 1510-28 Pedestrian Bridges

1510.14(2) Pedestrian Tunnels

Tunnels are an effective method of providing crossings for roadways located in embankment sections. Well-designed tunnels can be a desirable crossing for pedestrians. When feasible, design the tunnel with a nearly level profile to provide an unobstructed line of sight from portal to portal (see Exhibit 1510-29). People may be reluctant to enter a tunnel with a depressed profile because they are unable to see whether the tunnel is occupied. Law enforcement also has difficulty patrolling depressed profile tunnels.

Provide vandal-resistant daytime and nighttime illumination within the pedestrian tunnel. Installing gloss-finished tile walls and ceilings can enhance light levels within the tunnel. The minimum overhead clearance for a pedestrian tunnel is 10 feet. The minimum width for a pedestrian tunnel is 12 feet. Consider a tunnel width between 14 and 18 feet depending on usage and the length of the tunnel.

Exhibit 1510-29 Pedestrian Tunnel

Pedestrian tunnels need adequate right of way to accommodate accessible approaches leading to the tunnel structure. The tunnel structure must comply with ADA requirements and meet the accessibility criteria for either a pedestrian circulation path (if the grade is less than or equal to 5%) or an access ramp (if the grade is greater than 5% and less than or equal to 8.3%), and must include a pedestrian access route. (See 1510.06 and 1510.07 for PCP and PAR accessibility criteria; see 1510.15(2) for access ramp accessibility criteria.)

1510.15 Other Pedestrian Facilities

1510.15(1) Transit Stops and School Bus Stops

The location of transit stops is an important element in providing appropriate pedestrian facilities. (Coordinate with the local transit provider.) Newly constructed transit stops must conform to ADA requirements. Design newly constructed transit stops so that they are 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 a transit stop (see *Traffic Manual* 7.9), consider transit ridership and land use demand for the stop. Also, take into account compatibility with the following roadway/traffic characteristics:

- ADT
- Traffic speed
- Crossing distance
- Crash history
- Sight distance
- Connectivity to a pedestrian access route
- Traffic generator density

If any of these suggests an undesirable location for a pedestrian crossing, consider a controlled crossing or another location for the transit stop. (See Chapter 530 for further information on bus stops on limited access facilities.)

When analyzing a transit stop location with high pedestrian crash frequency, take into account the presence of nearby transit stops and opportunities for pedestrians to cross the street in a reasonably safe manner. At-grade midblock pedestrian crossings may be 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 the *Traffic Manual* for recommendations for marked crosswalks at unsignalized intersections.)

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 for the bus. Coordinate with the local school district. Because of their smaller size, children might be difficult for motorists to see at crossings or stops. Determine whether utility poles, vegetation, and other roadside features interfere with motorists’ ability to see the children. When necessary, remove or relocate the obstructions or move the bus stop. Parked vehicles can also block visibility, and parking prohibitions might be advisable near the bus stop. Coordinate transit and school bus stop locations with the region Traffic Office.

1510.15(2) Access Ramps Serving Transit Stops, Park & Ride Lots, Rest Areas, Buildings, and Other Facilities

An access ramp (see Exhibit 1510-30) provides an accessible pedestrian route from a pedestrian circulation path to a facility such as a transit stop, park & ride lot, rest area, pedestrian overcrossing/undercrossing structure, or building. When the running slope is 5% or less, it can be designed as a pedestrian circulation path that includes a pedestrian access route. When the running slope is greater than 5% to a maximum of 8.3%, it must be designed as an access ramp. (See 1510.06 and 1510.07 for PCP and PAR accessibility criteria; see 1510.15(2)(a) for access ramp accessibility criteria.)

1510.15(2)(a) Accessibility Criteria for Access Ramps

Access ramps are composed of one or more ramp segments interconnected by level landings. Unless superseded by the following specific accessibility requirements for access ramps, the accessibility requirements for pedestrian access routes also apply:

- Ramp segments shall have a maximum running slope of 8.3%.
- The cross slope of ramp segments shall be 2% maximum.
- The minimum clear width of ramps is 4 feet; however, it is desirable to match the width of the connecting pedestrian facility.
- The rise for any ramp segment shall be 30 inches maximum.
- A level landing (2% maximum running and cross slopes) shall be provided at the top and bottom of each access ramp segment.
- An access ramp landing’s clear width shall be at least as wide as the widest ramp segment leading to the landing.
- An access ramp landing’s length shall be 5 feet minimum.
- Access ramps that change direction between ramp segments at landings shall have a level landing 5 feet minimum width by 5 feet minimum length.
- All access ramp segments with a rise greater than 6 inches shall have ADA-compliant handrails (see 1510.15(3) for handrail accessibility criteria).

Provide edge protection complying with one of the two following options on each side of access ramp segments:

- The surface of the ramp segment and landing shall extend 12 inches minimum beyond the inside face of the handrail.
- A curb or barrier shall be provided that does not allow the passage of a 4-inch-diameter sphere, where any portion of the sphere is within 4 inches of the ramp/landing surface.

Exhibit 1510-30 Access Ramp With Accessible Handrails

1510.15(3) Railings and Handrails for Pedestrian Facilities

Accessible handrails are required on stairs and also on access ramps that have a rise greater than 6 inches (see 1510.15(2)(a) for access ramp accessibility criteria). If the height of a drop-off (typically greater than 30 inches) adjacent to a pedestrian facility necessitates the need to protect pedestrians from falls, then a more robust railing system designed for fall protection should be used. If the drop-off is adjacent to either a stairway or an access ramp with a rise greater than 6 inches, then a combined railing system that meets the requirements for both accessibility and fall protection must be used.

1510.15(3)(a) Fall Protection Railing

Railing designed for fall protection alone is typically placed adjacent to pedestrian facilities other than stairs or access ramps to prevent pedestrians or bicyclists from falls. The minimum railing height for pedestrian fall protection is 42 inches. For facilities where bicycle traffic is anticipated, such as on a grade-separation structure on a shared-use facility (see Chapter 1515), the minimum railing height for bicyclist fall protection is 54 inches.

1510.15(3)(b) Accessible Fall Protection Railing

When fall protection is needed adjacent to stairs or an access ramp that has a rise greater than 6 inches, then a combined railing system that meets both the accessibility criteria for handrail outlined in 1510.15(3)(d) and the requirements for fall protection must be used. The minimum railing height for pedestrian fall protection is 42 inches. For facilities where bicycle traffic is anticipated, such as on the approach to a grade-separation structure on a shared-use facility (see Chapter 1515), the minimum railing height for bicyclist fall protection is 54 inches.

1510.15(3)(c) Accessible Handrail

Accessible handrail meeting the accessibility criteria listed in 1510.15(3)(d) that is not designed to provide fall protection is to be used adjacent to stairs or access ramps that have a rise greater than 6 inches at locations where robust fall protection is not needed.

1510.15(3)(d) Accessibility Criteria for Handrail

The following accessibility criteria apply to all handrail installations provided at stairs and access ramps that have a rise greater than 6 inches.

1. **Height**
   - The top of handrail gripping surfaces shall be 34 inches minimum and 38 inches maximum vertically above walking surfaces, stair nosings, and ramp surfaces.
   - The mounting height of the handrail shall also be at a consistent height.
2. **Gripping Surface**
   - Clearance between handrail gripping surfaces and adjacent surfaces shall be 1½ inches minimum.
   - Handrail gripping surfaces shall be continuous along their length and shall not be obstructed along their tops or sides.
   - The bottoms of handrail gripping surfaces shall not be obstructed for more than 20% of their length.
   - Where provided, horizontal projections shall be located 1½ inches minimum below the bottom of the handrail gripping surface.
   - Handrail gripping surfaces with a circular cross section shall have an outside diameter between 1¼ inches minimum and 2 inches maximum.
   - Handrail gripping surfaces with a noncircular cross section shall have a perimeter dimension between 4 inches minimum and 6¼ inches maximum, and a cross section dimension of 2¼ inches maximum.
   - Handrail gripping surfaces and the surfaces adjacent to them shall be free of sharp or abrasive elements and shall have rounded edges.
   - Handrails shall not rotate in their fittings.
3. **Placement and Continuity**
   - Handrails shall be provided on both sides of access ramps and stairs.
   - Handrails shall be continuous within the full length of each access ramp run or stair flight.
   - Inside handrails on switchback or dogleg access ramps and stairs shall be continuous between runs or flights.
4. **Extensions**
   - Access ramp handrails shall extend horizontally above the landing for 12 inches minimum beyond the top and bottom of ramp runs.
   - At the top of a stair flight, handrails shall extend horizontally above the landing for 12 inches minimum beginning directly above the first riser nosing.
   - At the bottom of a stair flight, handrails shall extend at the slope of the stair flight for a horizontal distance at least equal to one tread depth beyond the last riser nosing.
   - Handrail extensions shall return to a wall, guard, or the landing surface, or shall be continuous to the handrail of an adjacent access ramp run or stair flight.
   - ***Exception:*** Handrail extensions shall not be required for continuous handrails at the inside turn of switchback or dogleg access ramps or stairs.

1510.15(4) Other Pedestrian Facilities, Features, and Elements

This chapter covers the accessibility criteria for the most commonly encountered pedestrian design elements in the public right of way. However, there are ADA requirements that apply to any feature or element for pedestrian use, such as doorways, elevators, stairs, call boxes, and drinking fountains. For accessibility criteria for less commonly encountered pedestrian design elements, consult the applicable federal guidance document(s) listed in 1510.02(2).

1510.16 Illumination and Signing

In Washington State, the highest number of crashes between vehicles and pedestrians tends to 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 (mounted at a lower level) lighting for PCPs, 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 crashes. (See Chapter 1040 for design guidance on illumination, and Chapter 1020 and the MUTCD for pedestrian-related signing.)

1510.17 Work Zone Pedestrian Accommodation

While Title II of the ADA requires that a public entity maintain its pedestrian facilities in operable working condition, including maintenance of their accessibility features, construction and maintenance activities often temporarily disrupt these facilities. When this occurs, provide access and mobility for pedestrians through and around work zones (see Exhibit 1510-31). Address this in the temporary traffic control plans if the project occurs in a location accessible to pedestrians. The designer must determine pedestrian needs in the proposed work zone during the public input process and through field visits.

Detailed guidance on work zone pedestrian accommodation can be found in the WSDOT *Field Guide for Accessible Public Rights of Way*, the MUTCD, and Chapter 1010.

Some work zone considerations include:

- Separate pedestrians from conflicts with work zone equipment and operations.
- Separate pedestrians from traffic moving through or around the work zone.
- Provide pedestrians with alternate routes that have accessible and convenient travel paths that duplicate, as closely as feasible, the characteristics of the existing pedestrian facilities.

Provide walkways that are clearly marked and pedestrian barriers that are continuous, rigid, and detectable to vision-impaired persons who navigate with a cane. Also, keep:

- The pedestrian head space clear.
- Walkways free from pedestrian hazards such as holes, debris, and abrupt changes in grade or terrain.
- Access along sidewalks clear of obstructions such as construction traffic control signs.
- A minimum clear width path throughout: 4 feet for pedestrians or 10 feet for pedestrians and bicyclists.

Temporary pedestrian facilities within the work zone must meet accessibility criteria to the maximum extent feasible. (See 1510.06 and 1510.07 for pedestrian circulation path and pedestrian access route accessibility criteria.)

Consider the use of flaggers if pedestrian generators such as schools are in the work zone vicinity. Consider spotters who are prepared to help pedestrians through the work zone.

Provide for advance public notification of sidewalk closures in the contract special provisions and plans.

Where transit stops are affected or relocated because of work activity, provide an accessible route to temporary transit stops.

Exhibit 1510-31 Work Zones and Pedestrian Facilities

Meets ADA requirements

Does not meet ADA requirements

1510.18 Documentation

Refer to Chapter 300 for design documentation requirements.

Chapter 1515 Shared-Use Paths

1515.01 General

Shared-use paths are designed for both transportation and recreation purposes and are used by pedestrians, bicyclists, skaters, equestrians, and other users. Some common locations for shared-use paths 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 as well as within existing roadway corridors. A common application is to use shared-use paths to close gaps in bicycle networks. There might also be situations where such facilities can be provided as part of planned developments. Where a shared-use path is designed to parallel a roadway, provide a separation between the path and the vehicular traveled way in accordance with this chapter.

As with any roadway project, shared-use path projects need to fit into the context of a multimodal community. Exhibits are provided throughout this chapter to illustrate possible design solutions, which should be treated with appropriate flexibility as long as doing so complies with corresponding laws, regulations, standards, and guidance. Engage various discipline experts, including landscape architects, soil and pavement engineers, maintenance staff, traffic control experts, ADA and bicycle coordinators, and others. Additionally, when designing such facilities, consider way-finding.

This chapter includes technical provisions for making shared-use paths accessible to persons with disabilities. Design shared-use paths and roadway crossings in consultation with your region’s ADA Coordinator, Bicycle Coordinator, and State Bicycle and Pedestrian Coordinator. For additional information on pedestrian and bicycle facilities, see Chapters 1510 and 1520, respectively.

1515.02 Shared-Use Path Design

When designing shared-use paths, the bicyclist may not be the critical design user for every element of design. For example, the crossing speeds of most intersections between roads and pathways should be designed for pedestrians, as they are the slowest users. Accommodate all intended users, and minimize conflicts. When designing to serve equestrians, it is desirable to provide a separate bridle trail along the shared-use path to minimize conflicts with horses.

Exhibit 1515 - 1 Shared-Use Path

1515.02(1) Design Speed

The design speed for a shared-use path is based on bicycle use and is dependent on the terrain and the expected conditions of use. Design the shared-use path to encourage bicyclists to operate at speeds compatible with other users. Higher speeds are discouraged in a mixed-use setting. Design shared-use paths to maintain speeds at or below the speeds shown in Exhibit 1515-2 by designing to the horizontal curve radii shown.

Exhibit 1515 - 2 Bicycle Design Speeds

Conditions	Design Speed (mph)	Curve Radius (ft)
Long downgrades (steeper than 4% and longer than 500 ft)	30	166
Open country (level or rolling); shared-use paths in urban areas	20	74
Approaching intersections	12	27

When minimum radius curves cannot be obtained because of right of way, topographical, or other constraints, consider installing the following mitigation measures for traffic calming to slow bicyclists when approaching curves:

- Intermittent curves to slow or maintain desired speeds.
- Standard curve warning signs and supplemental pavement markings in accordance with the MUTCD.
- Perpendicular stripes painted on the pathway in decreasing intervals to provide the perception of increased speed. This has been shown to slow drivers when applied to roadways.
- Changes in pavement texture to encourage reductions in speed at tight curve approaches.

The negative effects of tight radius curves can also be partially offset by widening the pavement through the curves. Steeper vertical grades affect the running speed of bicycles. A shared-use path should be designed not to exceed 5%. Refer to 1515.04(3) for further guidance.

1515.02(2) Widths, Cross Slopes, Side Slopes, and Clearances

1515.02(2)(a) Shared-Use Path Widths

The appropriate paved width for a shared-use path depends on the context, volume, and mix of users. The desirable paved width of a shared-use path, excluding the shoulders on either side, is 12 feet. The minimum paved width, excluding the shoulders on either side, is 10 feet.

A paved width of more than 12 feet, excluding the shoulders on either side, may be appropriate when substantial use by both pedestrians and bicyclists is expected or maintenance vehicles are anticipated.

Shared-use path shoulders are typically unpaved and 2 feet wide on either side. Exhibits 1515-3 through 1515-5 provide additional information and cross-sectional elements.

On bridges or tunnels, it is common to pave the entire shared-use path, including shoulders. This usable width can be advantageous for emergency, patrol, and maintenance vehicles and allows for maneuvering around pedestrians and bicyclists who may have stopped. It also keeps the structure uncluttered of any loose gravel shoulder material.

1515.02(2)(b) Exceptions to Minimum Path Widths

A reduced path width of 8 feet may be designed at locations that present a physical constraint such as an environmental feature or other obstacle. Refer to the MUTCD for signing and pavement markings for such conditions.

In very rare circumstances, a reduced width of 8 feet may be used where the following conditions prevail:

- Bicycle traffic is expected to be low, even on peak days or during peak hours.
- Pedestrian use of the facility is not expected to be more than occasional.
- Horizontal and vertical alignments provide frequent, well-designed passing and resting opportunities.
- The shared-use path will not be regularly subjected to maintenance vehicle loading conditions that would cause pavement edge damage.
- The share-use path is a short distance such as a spur connection to a neighborhood.

1515.02(2)(c) Existing Shared-Use Paths – Considerations

Some existing shared-use paths were constructed with narrower dimensions, generally providing 8 feet of pavement. Evaluate existing older paths for current needs. Consider widening an existing shared-use path to meet current geometric standards.

1515.02(2)(d) Cross Slope

The maximum cross slope on a paved shared-use path is to be 2%. The cross slope of the shoulders can be no steeper than 6H:1V. To accommodate drainage, the entire section, including shoulders, should transition through curves. It is desirable to design the pivot point on the outside edge of one side of the shoulder or the other to avoid a pavement crown (see Exhibits 1515-3 through 1515-5).

It is best practice to design the cross slope to be less steep than the allowed maximum to account for some tolerance in construction. For example, design for a 1.5% cross slope (rather than the 2% maximum).

Sloping the pavement surface to one side is desirable and usually simplifies drainage design and surface construction. Generally, surface drainage from the path is dissipated as it flows down the side slope.

1515.02(2)(e) Side Slopes and Pedestrian Rail

Side slopes along shared-use paths are an important design feature. Embankment side slopes of 6H:1V or flatter provide a gently sloping path border.

For shared-use paths with side slopes steeper than 3H:1V, or where obstacles or waterways may exist, evaluate the potential risk and provide mitigation such as:

- A minimum 5-foot separation from the edge of the pavement to the embankment edge. This can be accomplished by providing a 5-foot shoulder as shown in Exhibit 1515-5, Example 2.
- A natural barrier such as dense shrubbery on the side slopes.
- A physical barrier, such as a pedestrian rail.
- Where a shared-use path is adjacent to a vertical drop of 2 feet 6 inches or more, a pedestrian rail is needed (see Exhibit 1515-5, Example 4).
- If the vertical drop is less than 2 feet 6 inches, a pedestrian rail, chain link fence, or 4-inch curb at the edge of the shared-use path may be installed to delineate the edge.
- Where a shared-use path is constructed on the side of a hill, drainage facilities may need to be considered.

1515.02(2)(f) Clearances

The minimum horizontal clearance from the edge of pavement to an obstruction (such as bridge piers or guardrail) is 2 feet. For vertical clearances see 1515.04 Grade Separation Structures.

Exhibit 1515 - 3 Two-Way Shared-Use Path: Independent Alignment

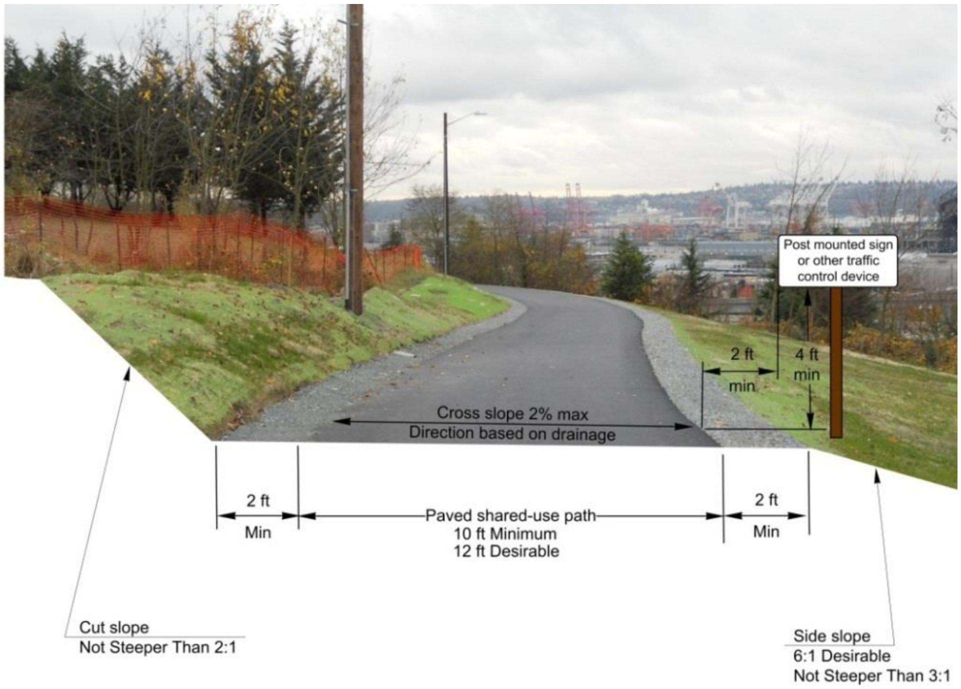
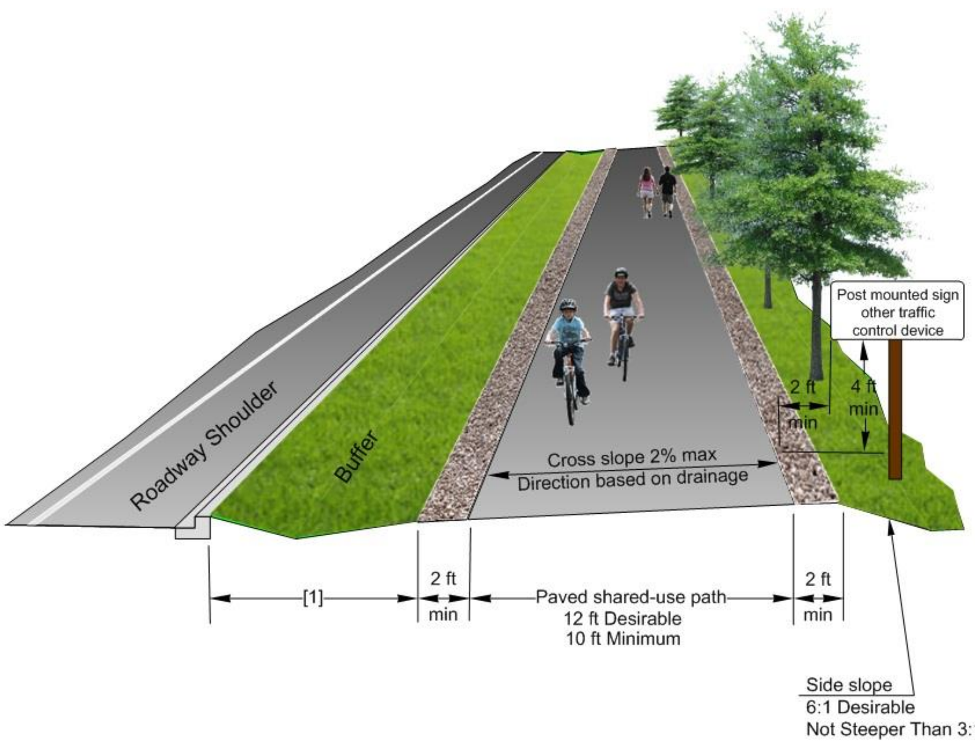


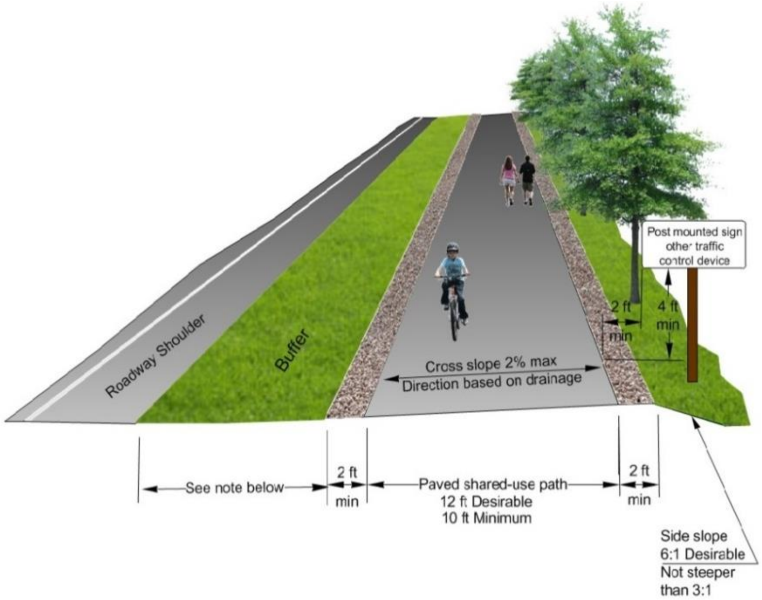
Exhibit 1515 - 4a Two-Way Shared-Use Path: Adjacent to Roadway (≤ 35 mph)



Note:

[1] 3 ft minimum. Provide as much separation from the roadway as practicable.

Exhibit 1515-4b Two-Way Shared-Use Path: Adjacent to Roadway (> 35mph)

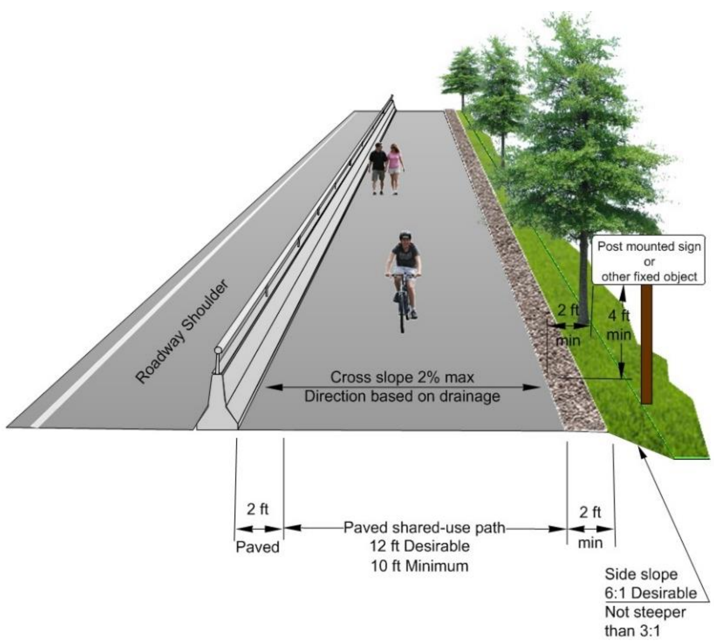


Notes:

A separation greater than 5 feet is required for path user comfort. If separation greater than 5 feet cannot be obtained, provide barrier separation in accordance with Exhibit 1515-4c.

See Chapter 1600 for roadway clear zone design guidance for fixed objects.

Exhibit 1515-4c Two-Way Shared-Use Path: Attached to Roadway (> 35mph)

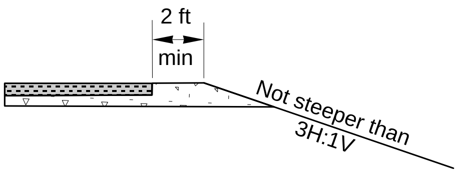


Notes:

It is desirable for the cross slope to slope toward grass areas for drainage.

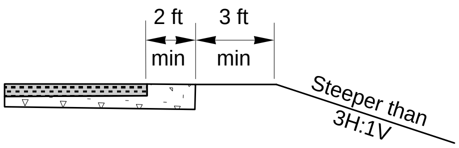
See Chapter 1610 for barrier design. Pedestrian rail height minimum is 42 inches.

Exhibit 1515 - 5 Shared-Use Path Side Slopes and Railing



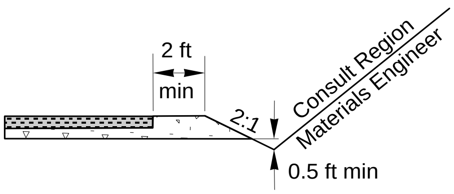
Example 1: Embankment

Based on context, flatter slopes are desirable.



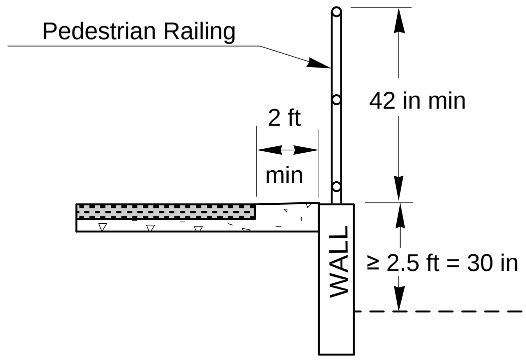
Example 2: Shoulder widening to 5 feet or more

Used with steeper fill slopes to provide clear space between the hinge point and path. Vegetation can also be used as a buffer on slopes. Consider a natural or physical barrier in lieu of 3 ft additional widening.



Example 3: Cut section with ditch

Consult with the Region Materials Engineer to determine for appropriate cut slopes.



Example 4: Railing used at drop off

Apply railing or fencing a minimum of 42 inches high when a drop off is present, such as along a retaining wall. Consult with the Region Materials Engineer to determine if the shoulder along the wall should be paved.

Note: These drawings depict some common applications for various slope alternatives.

1515.02(3) Running Slopes, Landings, and Rest Areas

1515.02(3)(a) Running Slopes

Design running slopes (grades) on shared-use paths less than or equal to 5% to accommodate all user types, including pedestrians with disabilities.

When the path is within the highway right of way, its running slope can match the general grade established for the adjacent roadway.

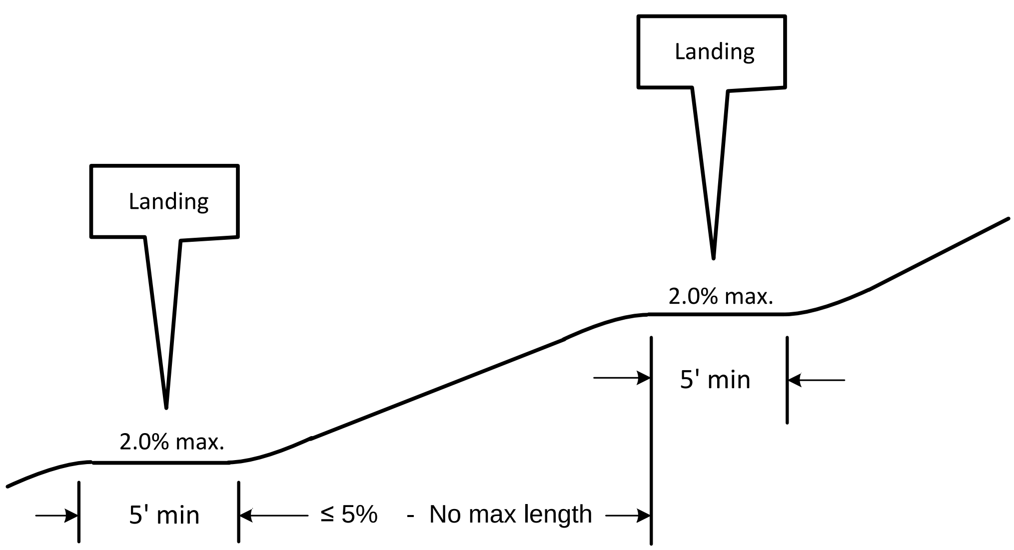
1515.02(3)(b) Landings

Shared-use path landings provide users a level place to rest on extended grades. Exhibits 1515-6 and 1515-7 show these features.

Design landings to:

- Permit users to stop periodically and rest.
- Not exceed maximum running slopes and cross slopes of 2%.
- Be in line and as wide as the shared-use path. Landings are to be at least 5 feet long.
- Avoid abrupt grade changes or angle points. Design transitions to landings using vertical curves.

Exhibit 1515 - 6 Shared-Use Path Landing Profile



Notes:

Landings are desirable on extended grades.

Design vertical curves to transition from the grade to the landing.

Exhibit 1515-7 illustrates a landing and a rest area.

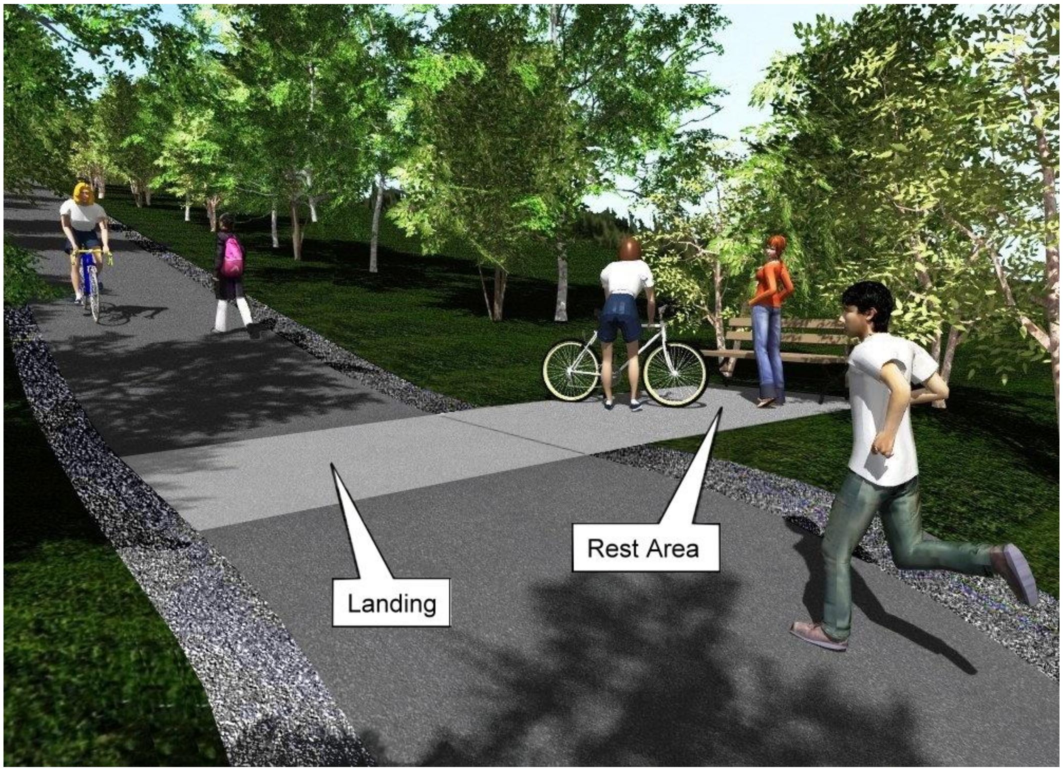
1515.02(3)(c) Rest Areas

Although not required, rest areas may be provided adjacent to the shared-use path outside of the path travelled way as shown in Exhibit 1515-7.

Requirements for rest areas include:

- The maximum running slope and cross slopes are 2%.
- The minimum size is to be 5 feet by 5 feet.
- If features such as benches are provided, they must meet ADA requirements; consult with the region ADA Coordinator for guidance.

Exhibit 1515 - 7 Shared-Use Path Landing and Rest Area



Notes:

Design inline landings at least 5 feet long and as wide as the shared-use path.

Design inline landings with a maximum cross slope and running slope of 2%.

1515.02(4) 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 path. (Design loads are normally maintenance and emergency vehicles.) Provide a firm, stable, slip-resistant pavement surface.

Design the pavement structural section as recommended by the Region Materials Engineer.

Use crushed rock or other suitable material for shoulder graded areas as recommended by the Region Materials Engineer. On bridges or tunnels, it is common to pave the entire shared-use path, including shoulders across the structure.

1515.02(5) Stopping Sight Distance

The distance needed to bring a shared-use path user to a complete stop is a function of the user's perception and braking reaction time, the initial speed, the coefficient of friction between the wheels and the pavement, the braking ability of the user's equipment, and the grade. Exhibits 1515-14a and 14b provide a graph and an equation to obtain minimum stopping sight distances for various design speeds and grades.

1515.02(5)(a) Stopping Sight Distance on Crest Vertical Curves

Exhibit 1515-15 provides a chart or equations to obtain the minimum lengths of crest vertical curves for varying stopping sight distances and algebraic differences in grade. The values are based on a 4.5-foot eye height for the bicyclist and a 0-foot height for the object (path surface).

1515.02(5)(b) Stopping Sight Distance on Horizontal Curves

Exhibit 1515-16 gives the minimum clearances to line-of-sight obstructions for sight distance on horizontal curves. Provide lateral clearance based on the sum of stopping sight distances from Exhibits 1515-14a and 14b 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.

Exhibits 1515-14a, 14b, 15, and 16 are presented at the end of the chapter.

1515.03 Intersections and Crossings Design

This section covers path/roadway intersections and grade-separated crossings. Detectable warning surfaces are required where shared-use paths connect to the roadway.

1515.03(1) Intersections with Roadways

Clearly define who has the right of way and provide sight distance for all users at shared-use path and roadway intersections.

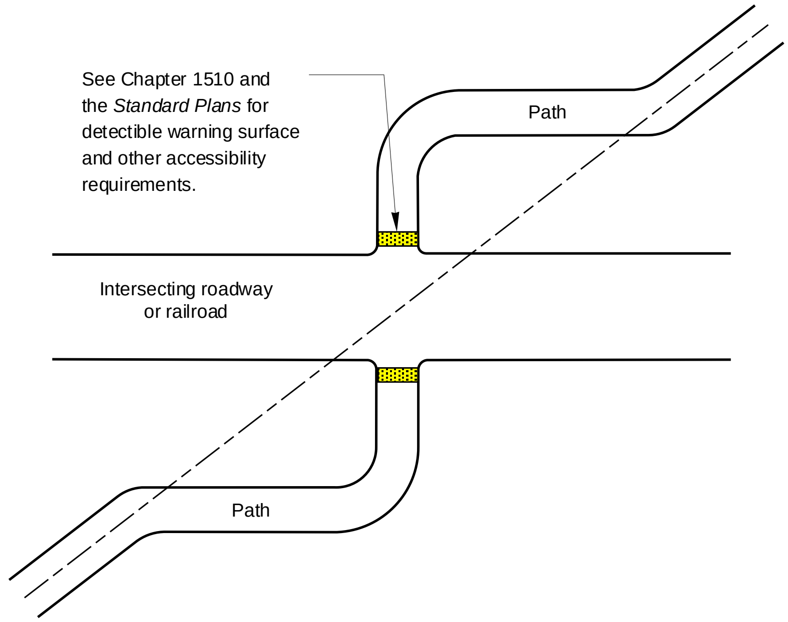
The common types of shared-use path/roadway at-grade intersection crossings are midblock and adjacent.

For roadway intersections with roundabouts, see Chapter 1320.

Midblock crossings are located between roadway intersections. When possible, locate the path crossings far enough away from intersections to minimize conflicts between the path users and motor vehicle traffic. It is preferable for midblock path crossings to intersect the roadway at an angle as close to perpendicular as practicable. A minimum 60-degree crossing angle is acceptable to minimize right of way needs. A diagonal midblock crossing can be altered as shown in Exhibit 1515-8.

There are other considerations when designing midblock crossings. They include 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.

Exhibit 1515 - 8 Typical Redesign of a Diagonal Midblock Crossing



Notes:

For path and highway signing and markings, see the MUTCD and the *Standard Plans*.
http://www.wsdot.wa.gov/publications/fulltext/Standards/english/PDF/m09.60-00_e.pdf

For radii approaching roadway intersections, see Exhibit 1515-2.

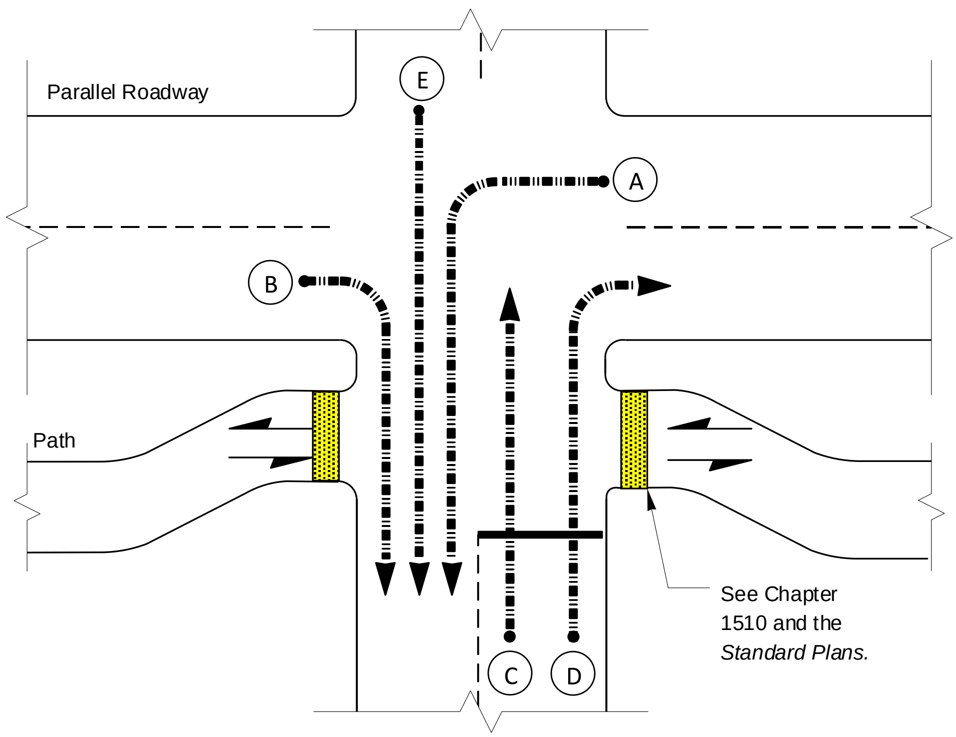
Adjacent path crossings are located at or near public intersection crosswalks and are normally placed with them. These crossings are usually placed with pedestrian crossings, where motorists can be expected to stop. If alternate intersection locations for a shared-use path are available, select the one with the greatest sight distance.

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 Exhibit 1515-9. It is desirable 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).

Consider crossing improvements on a case-by-case basis. Suggested improvements include: move the crossing; evaluate existing or proposed intersection control type; change signalization timing; or provide a refuge island and make a two-step crossing for path users.

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.

Exhibit 1515 - 9 Adjacent Shared-Use Path Intersection



Note:

For signing and pavement markings, see the MUTCD and the *Standard Plans*.

Additional Roadway/Path Intersection Design Considerations

Additional roadway/path intersection design considerations include the following:

Evaluate Intersection Control

Determine the need for traffic control devices at 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. Provide traffic signal timing set for pedestrians.

Signal Actuation Mechanisms

Place the manually operated accessible pedestrian pushbutton in a location that complies with ADA requirements. For additional information, see Chapters 1330 and 1510. A detector loop in the path pavement may be provided in addition to the manually operated accessible pedestrian push button.

Signing

Provide sign type, size, and location in accordance with the MUTCD. Place path STOP signs as close to the intended stopping point as feasible. Do not place the shared-use path signs where they may confuse motorists or place roadway signs where they may confuse shared-use path users. For additional information on signing, see the MUTCD and Chapter 1020.

Approach Treatments

Design shared-use path and roadway intersections with level grades, and provide sight distances. Provide advance warning signs and pavement markings that alert and direct path users that there is a crossing (see the MUTCD). Do not use speed bumps or other similar surface obstructions intended to cause bicyclists to slow down. Consider some slowing features such as horizontal curves (see Exhibits 1515-2 and 1515-8). Avoid locating a crossing where there is a steep downgrade where bike speeds could be high.

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 desirable for the roadway traffic. Refer to Chapter 1260 for stopping sight distance for the roadway and 1515.04(5) for shared-use path stopping sight distance.

Curb Ramp Widths

Design curb ramps with a width equal to the shared-use path. Curb ramps and barrier-free passageways are to provide a smooth transition between the shared-use path and the roadway or sidewalk (for pedestrians). Curb ramps at path/ roadway intersections must meet the requirements for curb ramps at a crosswalk. For design requirements, see Chapter 1510, and for curb ramp treatments at roundabouts, see Chapter 1320.

Refuge Islands

Consider refuge islands where a shared-use path crosses a roadway when one or more of the following applies:

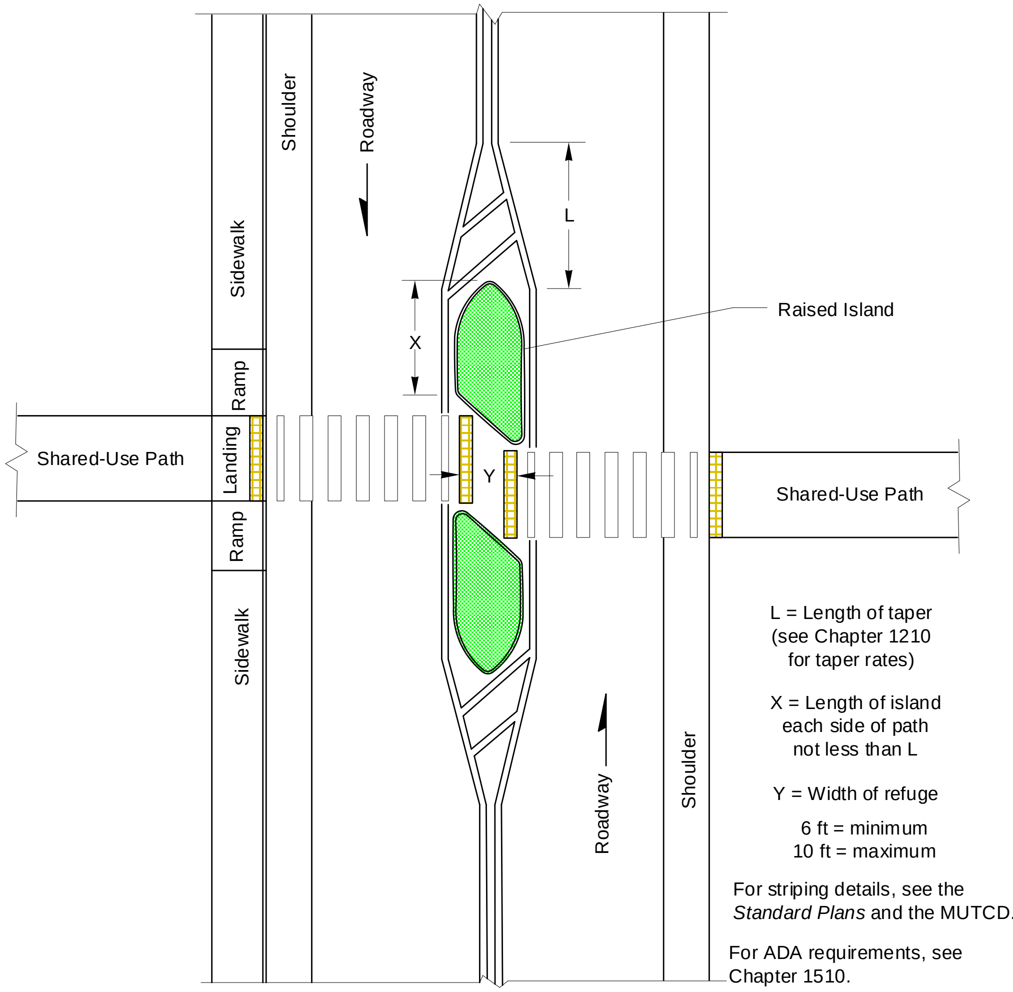
- High motor vehicle traffic volumes and speeds
- Wide roadways
- Use by the elderly, children, the disabled, or other slow-moving users

The refuge area may either be designed with the storage aligned perpendicularly across the island or be aligned diagonal (as shown in Exhibit 1515-10). The diagonal storage area has the added benefit of directing attention toward oncoming traffic since it is angled toward the direction from which traffic is approaching.

1515.03(2) At-Grade Railroad Crossings

Wherever possible, design the crossing at right angles to the rails. For signing and pavement marking for a shared-use path crossing a railroad track, see the MUTCD and the *Standard Plans*. Also, see Chapter 1510 for design of at-grade pedestrian railroad crossings.

Exhibit 1515 - 10 Roadway Crossing Refuge Area



Note:

This exhibit shows a case where a path intersects a roadway framed with both a sidewalk and a paved shoulder, for the purpose of showing detectible warning surface placements.

1515.04 Grade Separation Structures

Provide the same minimum clear width as the approach paved shared-use path plus the graded clear areas.

Carrying full widths across 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.

For undercrossings and tunnels, it is the Designer’s responsibility to determine the correct minimum vertical clearance (shared use path pavement surface to overhead obstruction) of each undercrossing or tunnel based on coordination with maintenance and emergency services.

Many types of maintenance and emergency vehicles need more than the 10 feet of vertical clearance needed for bicyclists and/or equestrians. Engage Region Maintenance, Emergency Services, and others that need to cross under or through the facility to determine an appropriate minimum vertical clearance. Account for existing or proposed overhead obstructions (lighting, signals, sign, etc.) that would reduce the available vertical clearance.

Consult the region Maintenance Office and the HQ Bridge Preservation Office to verify that the planned path width and vertical clearance meets their needs. If not, widen and/or increase vertical clearance to their specifications.

Use expansion joints that accommodate shared-use path users. Expansion joints should be perpendicular to the path and have a maximum gap of ½ inch or be covered with a slip-resistant plate.

The installation of protective screening is analyzed on a case-by-case basis. Refer to Chapter 720 for guidance.

Exhibit 1515 - 11 Shared-Use Path Bridge and Approach Walls

Note:

On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for additional information.

Exhibit 1515 - 12 Bridge and Pedestrian Rail

Notes:

The photo above shows a bridge with a shared-use path separating the users from the roadway. Pedestrian rail is used on the outside edge.

On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for additional information.

1515.05 Signing, Pavement Markings, and Illumination

Generally, WSDOT does not provide continuous centerline striping or channelization for user modes on shared-use paths. However, signing and pavement markings can be beneficial to warn shared-use path users of curves, grades, obstructions, and intersections.

Refer to the MUTCD for guidance and directions regarding signing (regulatory, warning, and way finding) and pavement markings.

The *Standard Plans* shows shared-use path pavement markings at obstructions in accordance with the MUTCD and also shows placement of detectible warning surfaces.

For pavement marking around bollards and other obstructions, see Standard Plan M-9.60:
http://www.wsdot.wa.gov/publications/fulltext/standards/english/pdf/m09.60-00_e.pdf

The level of illumination on a shared-use path is dependent on the amount of nighttime use expected and the nature of the area surrounding the facility. If illumination is used, provide illumination in accordance with Chapter 1040.

1515.06 Restricted Use Controls

This section presents considerations on use of fencing and other treatments to restrict roadway and path users to their domains.

1515.06(1) Fencing

Limited access highways often require fencing or other forms of controlling access. Shared-use paths constructed within these corridors, such as shown in Exhibit 1515-13, likely require fencing. For guidance on fencing, limited access controls, and right of way, refer to Division 5 of the *Design Manual*. Evaluate the impacts of fencing on sight distances.

Exhibit 1515 - 13 Shared-Use Path in Limited Access Corridor

1515.06(2) Restriction of Motor Vehicle Traffic

Shared-use paths often need some form of physical barrier at roadway intersections to prevent unauthorized motor vehicles from entering.

Bollards have been used by many path owners to prevent unauthorized vehicle access. However, bollards should not be applied indiscriminately, and there are other considerations to bollard installation.

1515.06(2)(a) Landscaped Islands

A preferred method of restricting entry of motor vehicles is to split the entry way into two sections separated by low landscaping, thereby splitting a path into two channels at roadway intersections. This method essentially creates an island in the middle of the path rather than installing a bollard. Such an island could be planted with low-growing, hardy vegetation capable of withstanding the occasional authorized vehicle traveling over it. When splitting a path, employ MUTCD pavement markings and signing, such as is used for bollards and obstructions.

1515.06(2)(b) Bollard Considerations

Typically, one bollard located in the center of the path is sufficient to control motor vehicle access to the path. If more than one bollard is needed, the additional bollards should be placed at the edge of the shared-use path.

Install bollards at entrances to shared-use paths to discourage motor vehicles from entering. Do not use bollards to divert or slow path traffic. When locating such installations, stripe an envelope around the bollards and paint and reflectorize them to be visible to path users both day and night. Bollards located on or adjacent to shared-use paths represent an object that needs to be avoided by bicyclists and pedestrians. To increase the potential for appropriate maneuvering to occur, provide designs where the post is clearly visible and recognizable.

When designing bollards, the following apply:

- The desirable design is to provide a single bollard, installed in the middle of the path to reduce confusion.
- When multiple bollard posts are used in wide path sections, use a minimum 5-foot spacing between the edge of concrete footings to permit passage of bicycle-towed trailers, wheelchairs, and adult tricycles, with room for bicycle passage without dismounting.
- Provide 4 feet minimum (5 feet desirable) clear width between the edge of concrete footing and edge of path.
- At a minimum, provide stopping sight distance to bollards. An ideal location for bollard placement is in a relatively straight area of the path where the post placement has the stopping sight distance given in Exhibit 1515-14a and 14b. Do not place bollards in difficult-to-see locations (for example, immediately upon entering a tunnel).
- For cases where multiple posts are used longitudinally along the path, locate them at least 20 feet apart, with the first post in line from each direction having stopping sight distance.
- Use a contrasting striping pattern on the post.
- Use reflective materials on the post, such as a band at the top and at the base.
- Design all bollards along a corridor to be uniform in appearance. Frequent cyclists can become familiar with the posts and recognize them easily.
- Provide pavement markings in accordance with the *Standard Plans* and MUTCD at all bollards on paved paths.
- Use removable bollards (Bollard Type 1) to permit access by emergency and service vehicles.
- Non-removable bollards (Bollard Type 2) may be used where access is not needed.

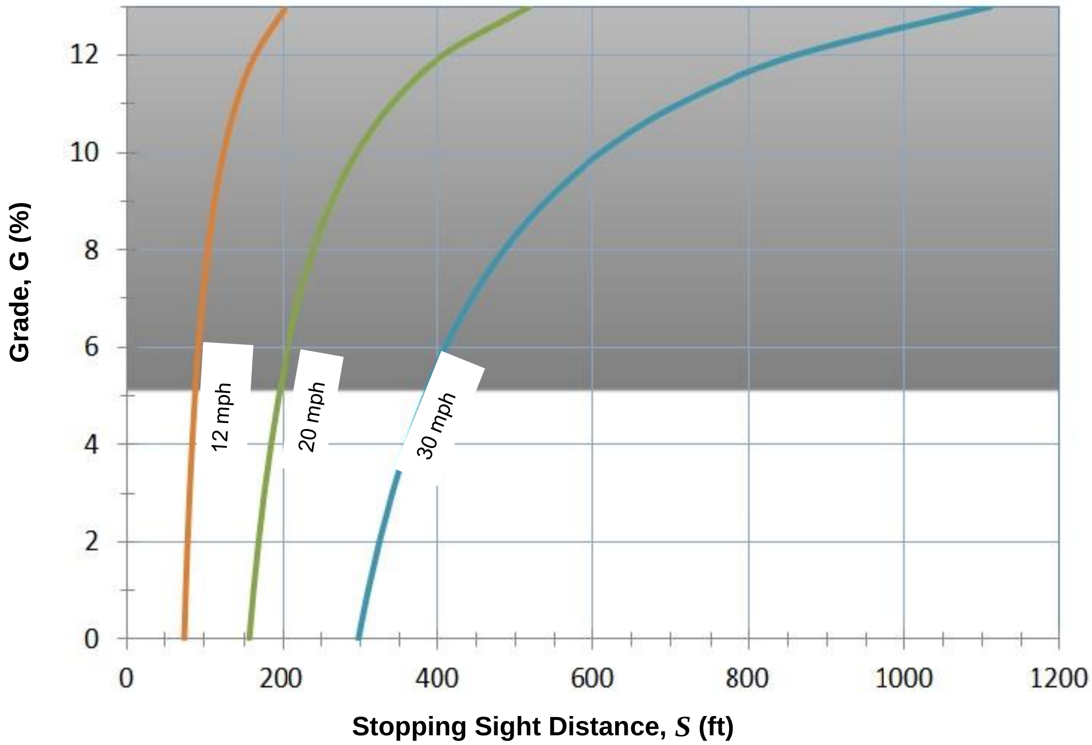
Refer to the *Standard Plans* for bollard designs and the *Standard Plans* and MUTCD for pavement markings at bollards.

When bollards need to be placed near the roadway, see Chapter 1600 for clear zone requirements.

1515.07 Documentation

For the list of documents required to be preserved in the Design Documentation Package and the Project File, see the Design Documentation Checklist:
www.wsdot.wa.gov/design/projectdev/

Exhibit 1515 - 14a Stopping Sight Distance for Downgrades



Note:

Shaded area represents grades greater than 5%.

$$S = \frac{V^2}{0.30(f - G)} + 3.67V$$

Where:

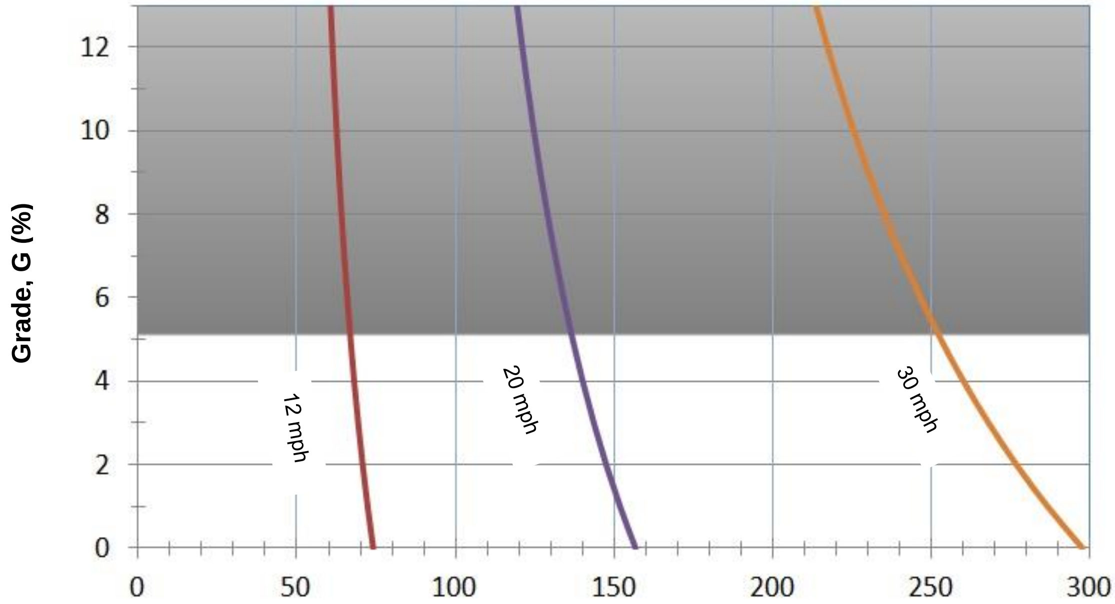
S = Stopping sight distance (ft)

V = Speed (mph)

f = Coefficient of friction (use 16)

G = Grade (%)

Exhibit 1515 – 14b Stopping Sight Distance for Upgrades



Stopping Sight Distance, *S* (ft)
(Based on 2.5 second reaction time)

Note:

Shaded area represents grades greater than 5%.

$$S = \frac{V^2}{0.30(f + G)} + 3.67V$$

Where:

S = Stopping sight distance (ft)

V = Speed (mph)

f = Coefficient of friction (use 16)

G = Grade (%)

Exhibit 1515 - 15 Minimum Lengths for Crest Vertical Curves

A (%)	Stopping Sight Distance, S (ft)													
	40	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	
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	1,000
11	3	38	78	122	176	240	313	396	489	592	704	826	958	1,100
12	5	45	85	133	192	261	341	432	533	645	768	901	1,045	1,200
13	11	51	92	144	208	283	370	468	578	699	832	976	1,132	1,300
14	16	56	100	156	224	305	398	504	622	753	896	1,052	1,220	1,400
15	20	60	107	167	240	327	427	540	667	807	960	1,127	1,307	1,500
16	24	64	114	178	256	348	455	576	711	860	1,024	1,202	1,394	1,600
17	27	68	121	189	272	370	484	612	756	914	1,088	1,277	1,481	1,700
18	30	72	128	200	288	392	512	648	800	968	1,152	1,352	1,568	1,800
19	33	76	135	211	304	414	540	684	844	1,022	1,216	1,427	1,655	1,900
20	35	80	142	222	320	436	569	720	889	1,076	1,280	1,502	1,742	2,000
21	37	84	149	233	336	457	597	756	933	1,129	1,344	1,577	1,829	2,100
22	39	88	156	244	352	479	626	792	978	1,183	1,408	1,652	1,916	2,200
23	41	92	164	256	368	501	654	828	1,022	1,237	1,472	1,728	2,004	2,300
24	43	96	171	267	384	523	683	864	1,067	1,291	1,536	1,803	2,091	2,400
25	44	100	178	278	400	544	711	900	1,111	1,344	1,600	1,878	2,178	2,500

Minimum Length of Vertical Curve, L (ft)

$$L = \frac{AS^2}{900} \quad \text{when } S < L$$

$$L = 2S - \frac{900}{A} \quad \text{when } S > L$$

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.

Note:

Below ▬▬ represents $S \leq L$.

Shaded area represents A>10%.

Exhibit 1515 - 16 Lateral Clearance for Horizontal Curves

Height of eye: 4.50 ft

Height of object: 0.0 ft

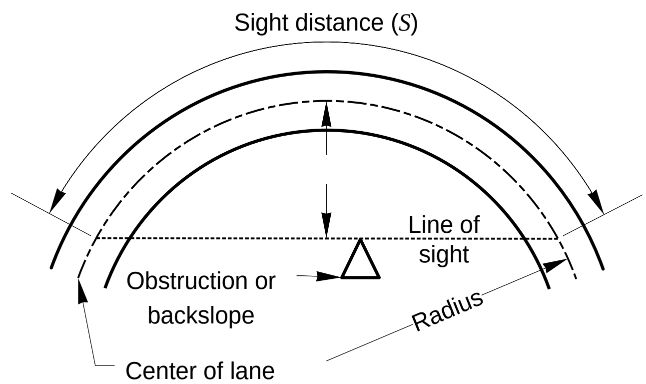
Line of sight at the M distance is normally 2.3 ft above centerline of inside lane at point of obstruction, provided no vertical curve is present in horizontal curve.

$$M = R\left(1 - \cos\frac{S\,28.65}{R}\right)$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R-M}{R}\right)\right]$$

$S \leq$ 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
1,000	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 Exhibits 1515-14a and 14b) for bicyclists traveling
M in both directions.

Chapter 1520 Roadway Bicycle Facilities

1520.01 General

The Washington State Department of Transportation (WSDOT) encourages and relies on bicycle use on and interconnecting with its facilities. Bicycle facilities or improvements for bicycle transportation are included in WSDOT's project development and highway programming processes.

This chapter is a guide for designing bicycle facilities within state highway right of way or between the curb lines on city streets designated as state highways. When designing facilities outside of state highway right of way or beyond the curb on city streets designated as state highways, use the local agency's design guidance. If the bicycle facility will have shared use with pedestrians incorporate ADA requirements in Chapter 1515.

Guidance in this chapter applies to typical situations encountered on state highways, and includes options for intersection and interchange design. Unique design challenges are resolved using expertise and guidance from the regional Bicycle Coordinator or if none exists, the WSDOT headquarters Bicycle Coordinator. Additional concepts to resolve unique bicycle facility design situations can be found in guides referenced (1520.07), but may require additional approvals for signing, pavement markings or bike facility types not presented within this chapter.

The region Traffic Engineer is responsible for determining which sections are inappropriate for bicycle traffic on state highways. 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 Office for further information.

1520.02 Roadway Bicycle Facility Types

WSDOT has adopted the following six types of bicycle facilities, from most protected to least protected:

- Shared-Use Paths (see Chapter 1515 for guidance)
- Raised and Curb-Separated
- Separated Buffered Bike Lanes
- Buffered Bike Lanes
- Conventional Bike Lanes
- Shared Lane Markings

Shared-use paths (see Chapter 1515) are the most protected type of bike facility because the path is physically separated from motor vehicle traffic most commonly by a wide vegetated outer separation or other physical barrier. Roadway bicycle facilities can range from separated from motor vehicle traffic to physically sharing a lane with motor vehicle traffic. The following subsections discuss five types of roadway bicycle facilities adopted for use on state highways.

All roadway bicycle facility types will be designated by striping, signage, and pavement markings to indicate the preferential or exclusive use for bicycle users. See 1520.05(1) for more information.

1520.02(1) Raised and Curb-Separated

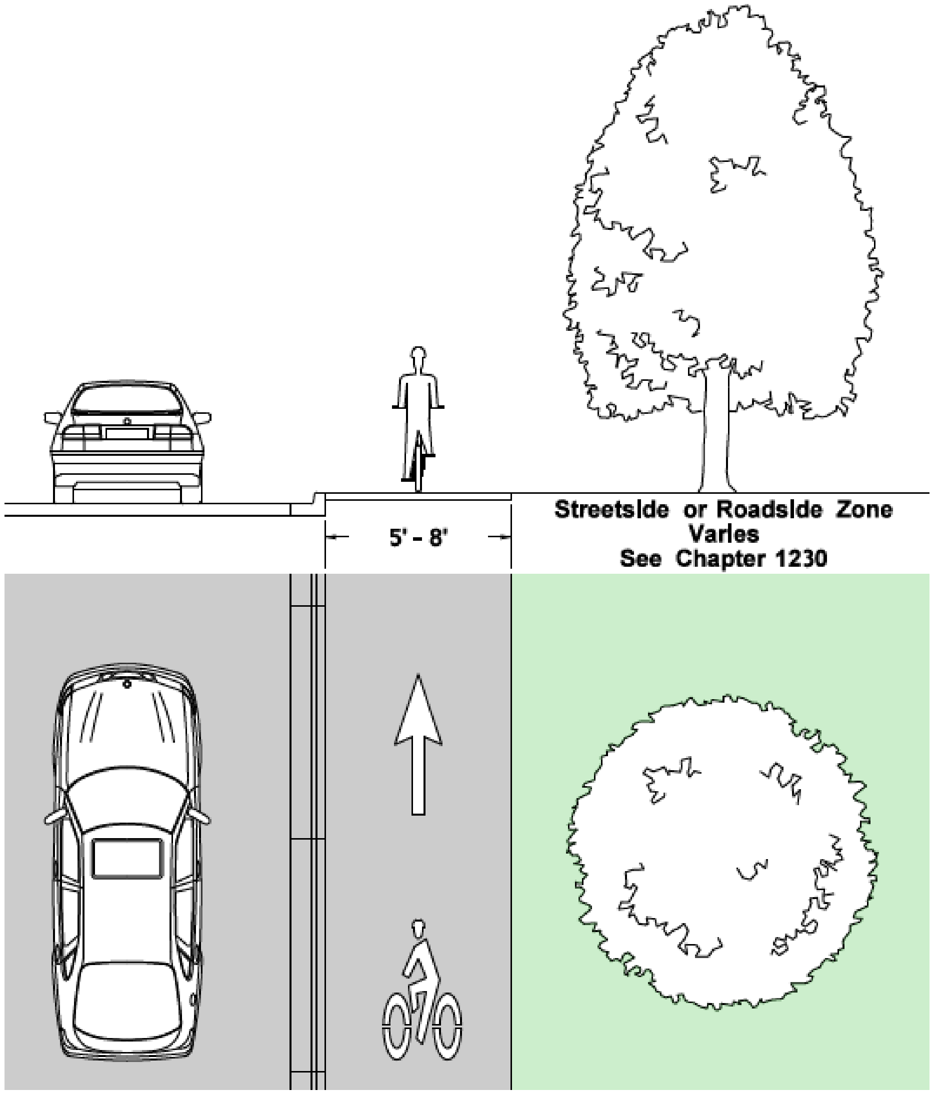
Exhibit 1520-1 shows a raised and curb-separated bicycle facility. These facilities are considered protected because they are vertically separated from motor vehicle traffic. When a raised and curb-separated bicycle facility is applied, it is considered part of the streetside zone (see Chapter 1230); however, it cannot be combined with other zone areas because the intent is also segregation from pedestrians. The raised and curb-separated facility is dedicated for bike users and delineated with pavement markings, signing, and in some cases pavement material.

There are advantages in utilizing streetside zones in conjunction with a raised and curb-separated bike facility. A furnishing zone can be used to help segregate pedestrian and bicycle users or for additional separation between the bike facility and motor vehicle traffic. If a furnishing zone is not used to separate the raised bike facility from the pedestrian zone, consider different pavement types, signs, pavement borders, or striping within the streetside zone to effectively separate pedestrian and bicycle users.

When the raised and curb-separated bike facility is placed adjacent to motor vehicle traffic, consider using a sloped and mountable curb (see Chapter 1230) to enable passing maneuvers between cyclists.

Within incorporated limits, raised and curb-separated bike facilities are located behind the curb and therefore fall under a local agency’s jurisdiction. (See Chapters 1230, and 1600 for additional information on jurisdictional boundaries). In these situations, follow the local agency’s design guidance for this type of bike facility.

Exhibit 1520-1 Raised and Curb-Separated Bike Facility



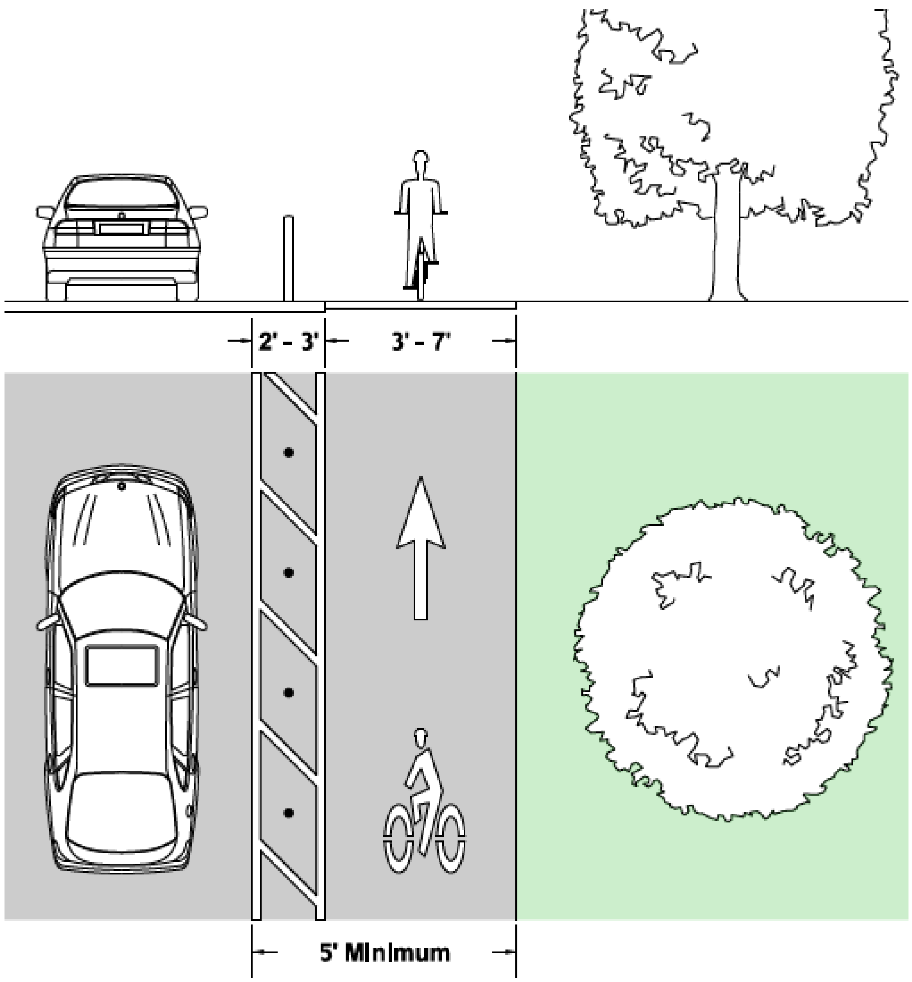
1520.02(2) Separated Buffered Bike Lanes

Separated buffered bike lanes are at grade with the roadway, and they include a bike lane, a buffer area, and some type of vertical feature that reduces the likelihood of encroachment into the bike lane by motor vehicles and increases user comfort. Bike markings (see the *Standard Plans*) in the bike lane and signage are employed. The most common type of vertical separator used within the buffer area is a pavement mounted flexible tubular marker or delineator. Use of dual-faced curbing, raised medians, or the parking zone adjoining the buffer area can also accomplish the same task.

If parked vehicles within the parking zone are used as the vertical separator, the parking zone cannot encroach onto the buffer area. When a separated buffered bike lane is positioned between motor vehicle lanes and a parking zone, consider including an additional buffer area between the parking zone and bike lane. Use of the buffer area described in these two configurations facilitates loading and unloading of the parked vehicles, and reduces the risk of a cyclist being struck when a parked vehicle door opens (aka "dooring"). See NACTO's *Urban Bikeway Design Guide and Urban Street Design Guide* for examples.

Exhibit 1520-2 shows an example of separated buffered bike lane using a flexible tubular marker as the vertical separator. A painted buffer strip with flexible tubular marker helps accentuate the bicycle facility from the motor vehicle lane, when curbing or a raised median (also considered vertical separation) is not used for the buffer strip. Consider a 3-foot-wide buffer strip whenever possible. When utilizing a buffer, the bike lane itself may be 3 feet in width. However, 5 feet is recommended exclusively to the bike lane to enable passing maneuvers between cyclists, and account for the effective width needs of bicyclists when drainage features are present in the bike lane. In space constrained areas where inexperienced bicyclists, such as children, are expected or where there is a steep uphill grade use a 4 foot minimum for the bicycle lane. High bicyclist volume locations should consider more width to facilitate mobility performance for this mode. In constrained spaces where lower volumes of cyclists are anticipated and inexperienced bicyclists are not expected, the minimum total width of both the bike lane and buffer combined is 5 feet.

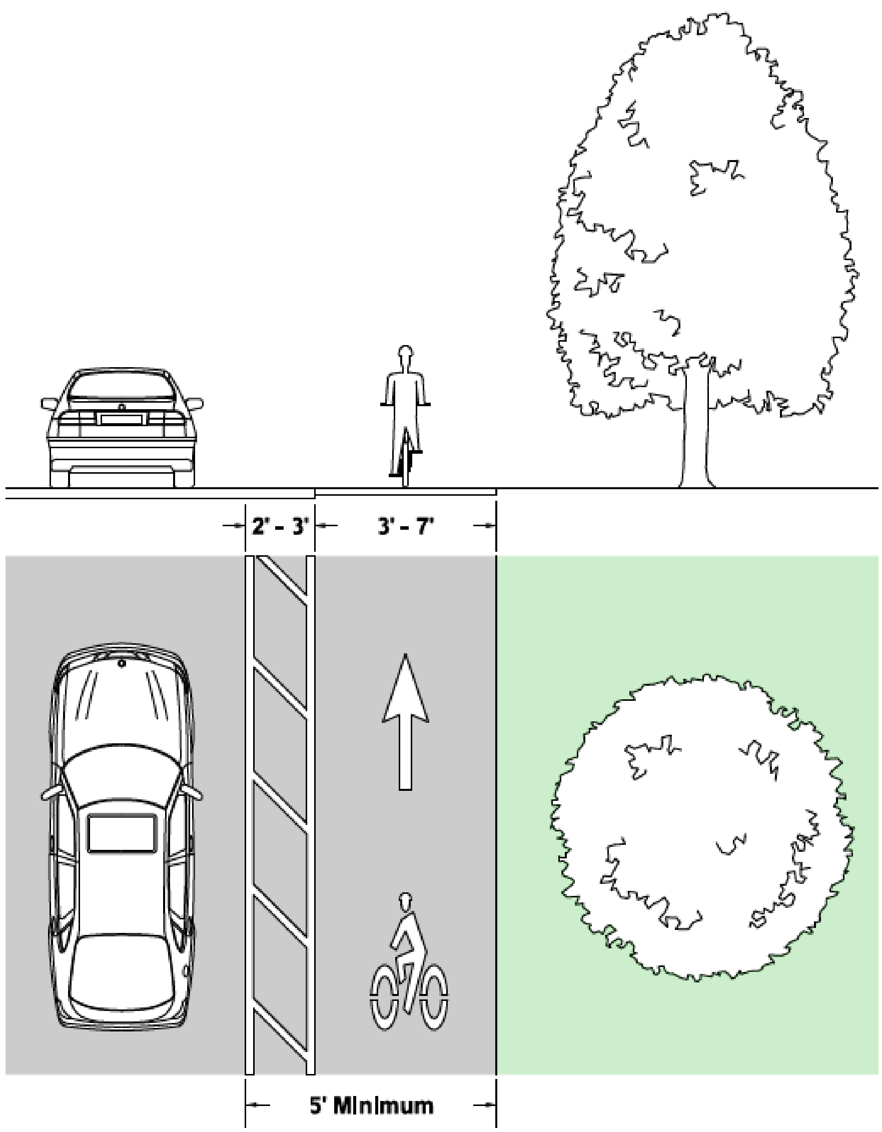
Exhibit 1520-2 Separated Buffered Bike Lane



1520.02(3) Buffered Bike Lane

Exhibit 1520-3 shows a buffered bike lane. The design is effectively the same as a separated buffered bike lane (see 1520.02(2)) without the use of vertical separators. Consider a 3-foot buffer strip whenever possible. When utilizing a buffer, the bike lane itself may be 3 feet in width, but it is recommended that 5 feet be provided exclusively to the bike lane to enable passing maneuvers between cyclists. High cyclist volume locations should consider more width to facilitate mobility performance for this mode. In locations where the posted speed is 30mph or less and lower volumes of cyclists are anticipated, the minimum total width of both the bike lane and buffer combined is 5 feet. In locations where inexperienced bicyclists, such as children, are expected or when there is a steep uphill grade the minimum total width of both the bike lane and the buffer combined is 6 feet.

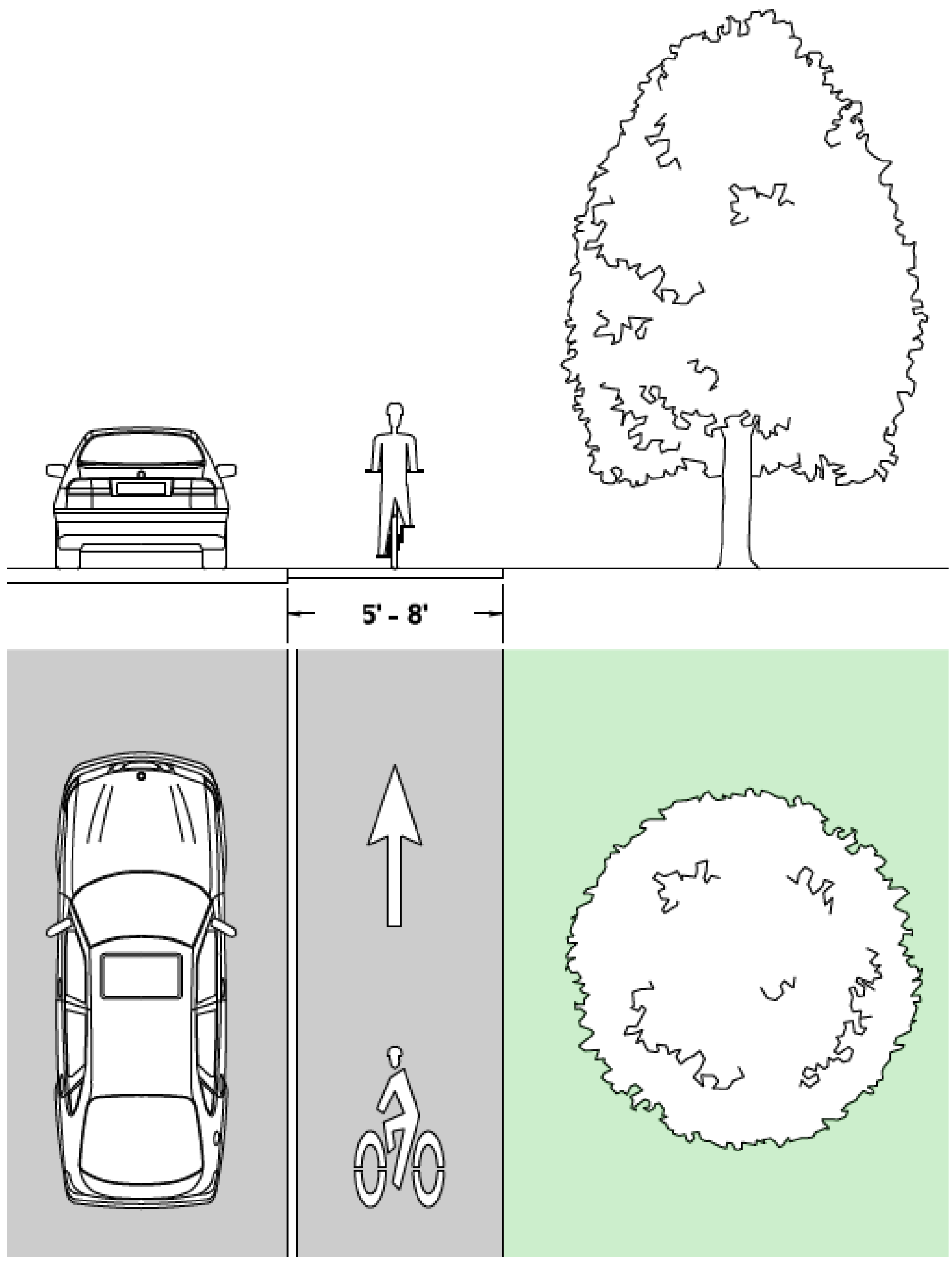
Exhibit 1520-3 Buffered Bike Lane



1520.02(4) Conventional Bike Lane

Conventional bike lanes are at grade and adjacent to motor vehicle traffic lane and are designated by a single solid wide stripe between the motor vehicle lane and bike lane. Additional bike markings (see the *Standard Plans*) in the bike lane and signage are employed. A width of 6 feet is recommended for a conventional bike lane when designing for the "Interested, but Concerned" user type. The minimum width for a conventional bike lane is 5 feet when adjacent to curb, or 4 feet when no curb is present. Additional width is considered when higher volumes of cyclists are anticipated or when adjacent to parallel on-street parking. Exhibit 1520-4 shows a conventional bike lane.

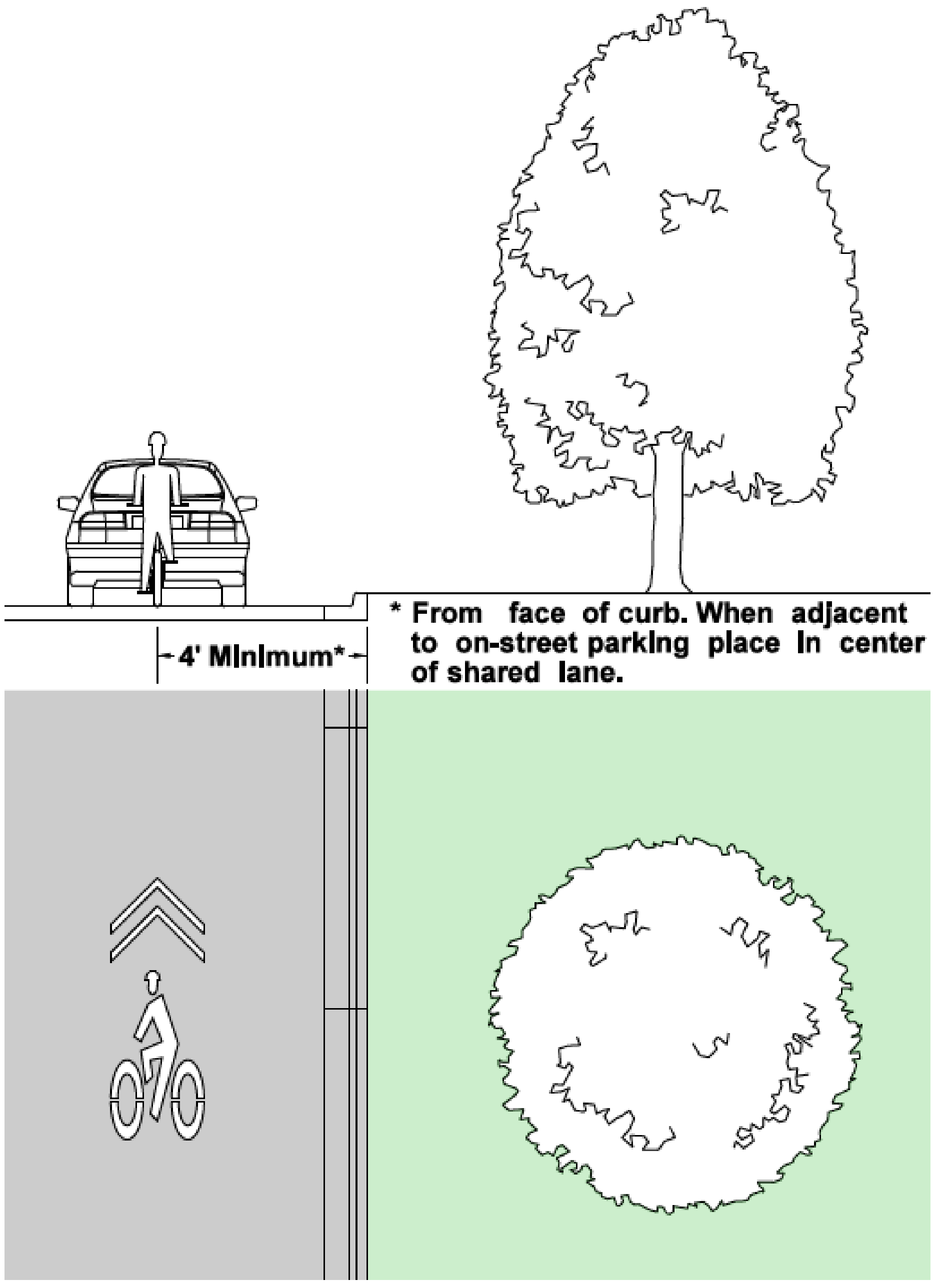
Exhibit 1520-4 Bike Lane



1520.02(5) Shared Lane

A shared lane is a combined motor vehicle and bicycle lane, as shown in Exhibit 1520-5. Shared lanes are appropriate for lower-speed and lower-volume streets. Shared lanes employ pavement markings and signage to indicate the combined use. Shared lanes are more common in bicycle boulevards, establishing a complete network for cyclists within an urban or suburban environment. Shared lanes may be used on state highways within the ranges presented in 1520.03; however, it is more likely that shared lanes will interface with state highways through crossing situations. It is important to consider how to configure an intersection or dedicated bicycle crossing location when intersecting with a bicycle boulevard network (see 1520.04(5)).

Exhibit 1520-5 Shared Lane Markings



Shared lane markings (aka “sharrows”) are pavement markings specifically used to indicate a shared lane or intersection space. The position of the marking can encourage a desired lateral position within the lane for cyclists, as well as alerting motor vehicle users. Consider the shared lane marking placement with respect to on-street parking and the potential for dooring that will lower safety performance for the cyclist. Shared lane markings must be placed at least 4 feet from the face of curb, or in the center of the shared lane (or at least 11 feet from face of curb) when an adjacent parallel parking zone is present.

Conventionally, wide lanes have been encouraged for shared-lane applications, to allow for motor vehicles to pass cyclists, or for cyclists to pass motor vehicles in a queue. However, wider lanes may also encourage motor vehicle drivers to travel at higher speeds and a detriment for a shared lane application. Permitting in-lane passing between motor vehicles and bicyclists can lower safety performance for cyclists.

The speed of cyclists can vary significantly between users, and depends on the experience, fitness level of the user, bike technology, and roadway grade. If a shared lane is proposed on an hill, consider a conventional bike lane in the upgrade direction of travel.

1520.02(5)(a) Accommodating Bikes on Shoulders

Many rural highways are used by bicyclists for commuting between cities or for recreation. Providing and maintaining paved shoulders can significantly improve convenience and safety for both bicyclists and motorists along such routes.

Accommodating bicycle users on the shoulder is common on state highways, particularly on rural high-speed facilities. Shoulder improvements to facilitate bicycle travel include widening the shoulders to a minimum of 4 feet, improving roadside maintenance (including periodic sweeping), and removing surface obstacles such as drain grates that are not compatible with bicycle tires. If shoulder rumble strips are present, provide for at least 4 feet of usable shoulder 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.

Accommodating bicycle use on shoulders is appropriate at many locations. Note, however, that bike on shoulder accommodations are not dedicated bicycle facilities, and bicycle users do not have the same operating privileges as with designated roadway bike facilities. In rural to suburban/urban transition areas consider converting the shoulder to a protected buffered bike lane, both to encourage speed management of motor vehicle users through the transition and to establish a dedicated special-use lane for cyclists to tie into the local network.

1520.03 Bicycle Facility Selection

Bicycle facilities are desirable in order to provide viable travel alternatives, and for bicycle users to have the ability to access land use destinations along state highways.

Understand how the state highway interfaces with routes identified as local, state, or regional bike routes. If the state highway is the bike route, intersects with an existing route, or if bicycle users are an identified modal priority (See Chapter 1103), account for the bike facility needs within the design. Other projects need to consider a design that does not preclude the future vision for a planned bike route, depending on the context identification selection (See Chapter 1102) and design year selection (See Chapter 1103).

The only instance during planning or design when performance effects on existing or planned bike facilities may not be considered is in locations being designed for the existing context, and the location is prohibits bicycle use. State highways that prohibit bike use can be found here: http://www.wsdot.wa.gov/bike/closed.htm

1520.03(1) Types of Cyclists

Recent research indicates that people have different viewpoints and thresholds that dictate their willingness to utilize bike facilities. Three general types of cyclist users exist:

- *Strong and Fearless* – This cyclist type are confident not only in their abilities as a cyclist but also with their ability to operate intermixed with other modal users.
- *Enthused and Confident* – These cyclists prefer utilizing separated facilities, but are comfortable riding intermixed within other modes in some transportation contexts.
- *Interested, but Concerned* – Cyclists who primarily have safety concerns and who are less skilled or less familiar with the rules of the road, but would like to ride more. These cyclists are frequently dissuaded from cycling, even if bike facilities are present, because of the degree of separation between themselves and other traffic. This category includes children and others new to bicycling.

1520.03(1)(a) Designing for the Interested, but Concerned

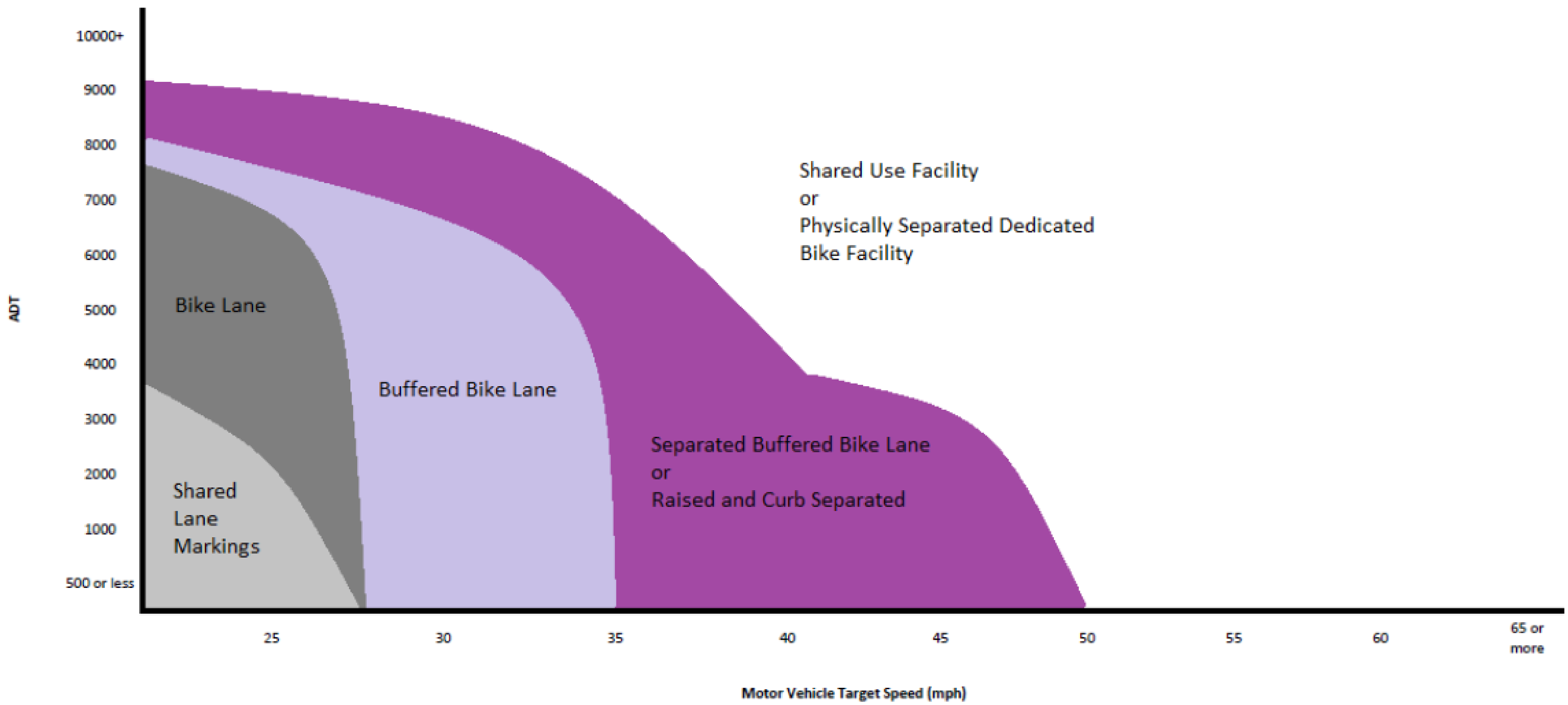
The Interested, but Concerned cyclist constitutes the largest segment of cyclist types within suburban, urban and small town populations. Bike facility selection on state routes is based on designing for the "Interested, but Concerned" user type as a starting point. Exhibit 1520-6a shows ranges of applications for the different types of bicycle facilities related to generally accepted safety and mobility performance for this design user.

Other performance needs may increase or decrease the viability of certain types of bike facilities, such as shared-use paths through aesthetic areas or those planned for a mixture of commute and recreational purposes. Further considerations for cyclist perception of comfort are another factor that can affect use of the facility. Designing for a higher level of separation may be more important at locations that serve community activity centers, schools or popular destinations (such as a retail oriented segment of a route) where additional accommodations are appropriate for either the functional uses or less skilled cyclists (including children). In these situations, separated facilities or wider dimensions may provide the level of comfort needed to satisfy user needs and context considerations. Additionally, some suburban, urban, and small town contexts will have more specific bicycle performance needs that will help identify either spot improvements or alteration of the type of existing facility to enhance a specific performance area. Bike facility selection in 1520.03(1)(b) are provided for these reasons.

1520.03(1)(b) Designing for the Confident

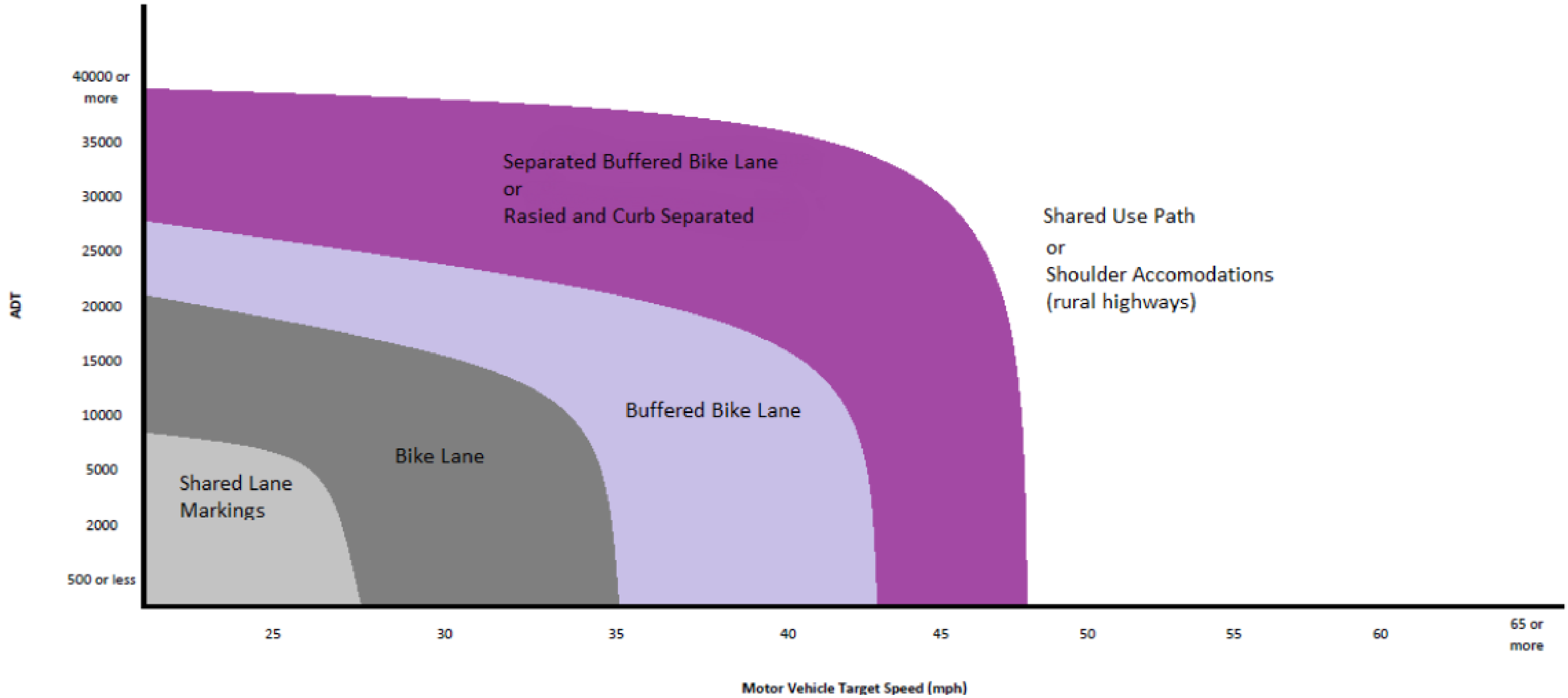
In some contexts, it is appropriate to design for the Strong and Fearless, and Enthused and Confident user types. In cases, where right of way is very constrained or where bicycles are not considered the modal priority (see Chapter 1103), it is appropriate to use Exhibit 1520-6b for determining facility selection after input from community engagement efforts. However, understand that the application of Exhibit 1520-6b may result in less mode shift or use of the capacity provided.

Exhibit 1520-6a Bicycle Facility Selection Chart – Interested, but Concerned Cyclists



Note: Adapted from *Montgomery County Bicycle Planning Guidance*, Montgomery County Department of Transportation, 2014.

Exhibit 1520-6b Bicycle Facility Selection Chart – Confident Cyclists



1520.03(2) Speed Considerations

While Exhibits 1560-6a and 1560-6b provide ranges of speeds in which different types of bike facilities may be appropriate, it is critical to understand that motor vehicle speed plays a significant role in crash severity between motor vehicles and cyclists. When designing multimodal facilities, a target speed selection within the low speed design control is encouraged. Safety performance increases as motor vehicle speeds are decreased. The optimum target speed for safety performance of multimodal designs is the lowest statutory speed allowed on state routes, which is 25 mph. See Chapter 1103 for further discussion on target speed and speed management treatments.

1520.04 Intersection Design Treatments

The principle objective when designing intersections for bicycle mobility and safety performance is to provide a visible, distinct, predictable, and clearly designated path leading to and through the intersection while managing potential conflicts between all other users and cyclists. This chapter covers options for intersection design for bicyclists while chapters in the 1300 series provide guidance for intersection control type selection and design.

Intersection design to meet the bicycle safety and mobility performance of the cyclist is unique to each location. The primary emphasis is to create a visible, distinct, predictable and clear path for the cyclist to reduce conflicts between cyclists and other design users. This is most commonly achieved through clear delineation of the bike facility leading up to and through the intersection, along with segregating or prioritizing movements between design users. Several proven state-of-the-practice intersection treatments are presented within this section. However, pavement marking or aspects about the configuration may not currently be supported by the *Manual on Uniform Traffic Control Devices*.

At the time of publication, bike boxes (1520.04(2)) and two-stage left turn lanes (1520.04(3)) are subject to an experimentation request to FHWA. Obtain Headquarters (HQ) Traffic Office approval and assistance with submitting a request for experimentation. Consult, as appropriate, the Federal Highway Administration's (FHWA) MUTCD website for bicycle facilities for a listing of the current status of bicycle-related pavement markings and treatments:
http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/index.cfm.
See 1520.05(1) for additional information on bicycle pavement markings under MUTCD evaluation.

Note: Exhibits 1520-7 through 1520-9 all show colored pavement markings to increase the safety performance of intersection designs. However, colored pavement markings are not required, and may be added at a later stage if the desired safety performance is not met.

1520.04(1) Approach Through Lanes

The approach to intersections needs to balance the bicycle user's safety needs with the mobility needs of other users. Clear delineation of user lanes and potential conflict areas is currently the treatment most commonly used to manage the approach to intersections. Use dotted lines to identify the conflict area. Colored pavement markings can be used to further enhance and delineate the conflict area. Exhibit 1520-7 shows different applications of the approach through lane most likely to be encountered.

1520.04(2) Bike Boxes and Crossing Pavement Markings

Bike boxes are designated areas for bicyclists positioned across and in front of the bike and motor vehicle lanes as shown in Exhibit 1520-8. Bike boxes are used at signalized intersections and increase both mobility and safety performance for the bicycle mode. Applying a bike box assists mobility performance by prioritizing the bicycle movement at an intersection, and enables a cyclist to position for a left-turn movement. Bike boxes have also been found to prevent cyclist and motor vehicle encroachment into the pedestrian crossing, reducing conflicts with pedestrians at intersections. Bicycle safety performance is improved by increasing the visibility of the cyclist, and by reducing conflicts between motor vehicles making a right turn and the bicycle through movement (also known as “right-hook” conflict).

There are several different ways to delineate bike lanes through the intersection. Dotted lines are the most common, but can be combined with sharrows or green pavement markings (see 1520.05(1)) to further enhance the bike facility’s presence and position within an intersection.

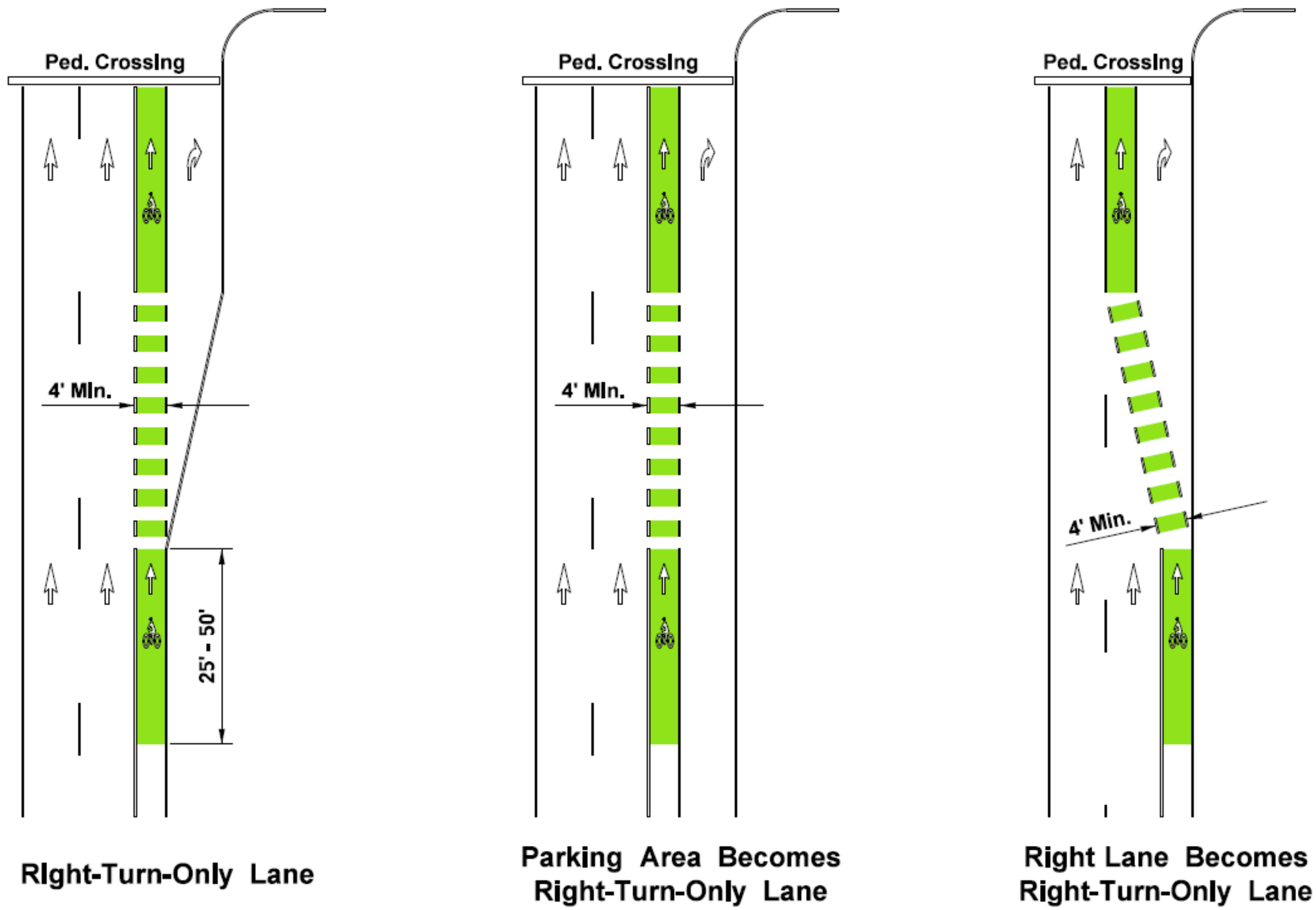
1520.04(3) Two-Stage Left Turns

Exhibit 1520-9 shows an example of a two-stage left-turn design for bicycle users. This design utilizes a rectangular bike box to enable cyclist queueing at the crossroad signal phase. The bicyclist passes partway through the intersection to access the bike box, and then waits for the crossroad next signal phase to eliminate the bicyclist left turn movement. This treatment is has best value at intersections with significant volumes of motor vehicle traffic or large volumes of left-turn cyclists, or when separated or buffered roadway bicycle facilities are used on the segment.

This treatment can increase safety performance by reducing conflicts between cyclists and other users, segregating motor vehicle and bicycle users, and separating turning cyclists from through cyclists.

The position of the queue box is a critical aspect of this intersection design. Depending on the size and configuration of the intersection, it may present a modal performance trade-off between bicycle mobility and safety versus motor vehicle mobility performance. Use turn simulation software to verify the queue box is outside the crossroad left-turn path, or restrict left turns at the crossroad to accommodate the queue box. Similarly, right turns may need to be restricted for motor-vehicles approaching the queue box if motor vehicle right-turn lanes or right-turn pockets are not present.

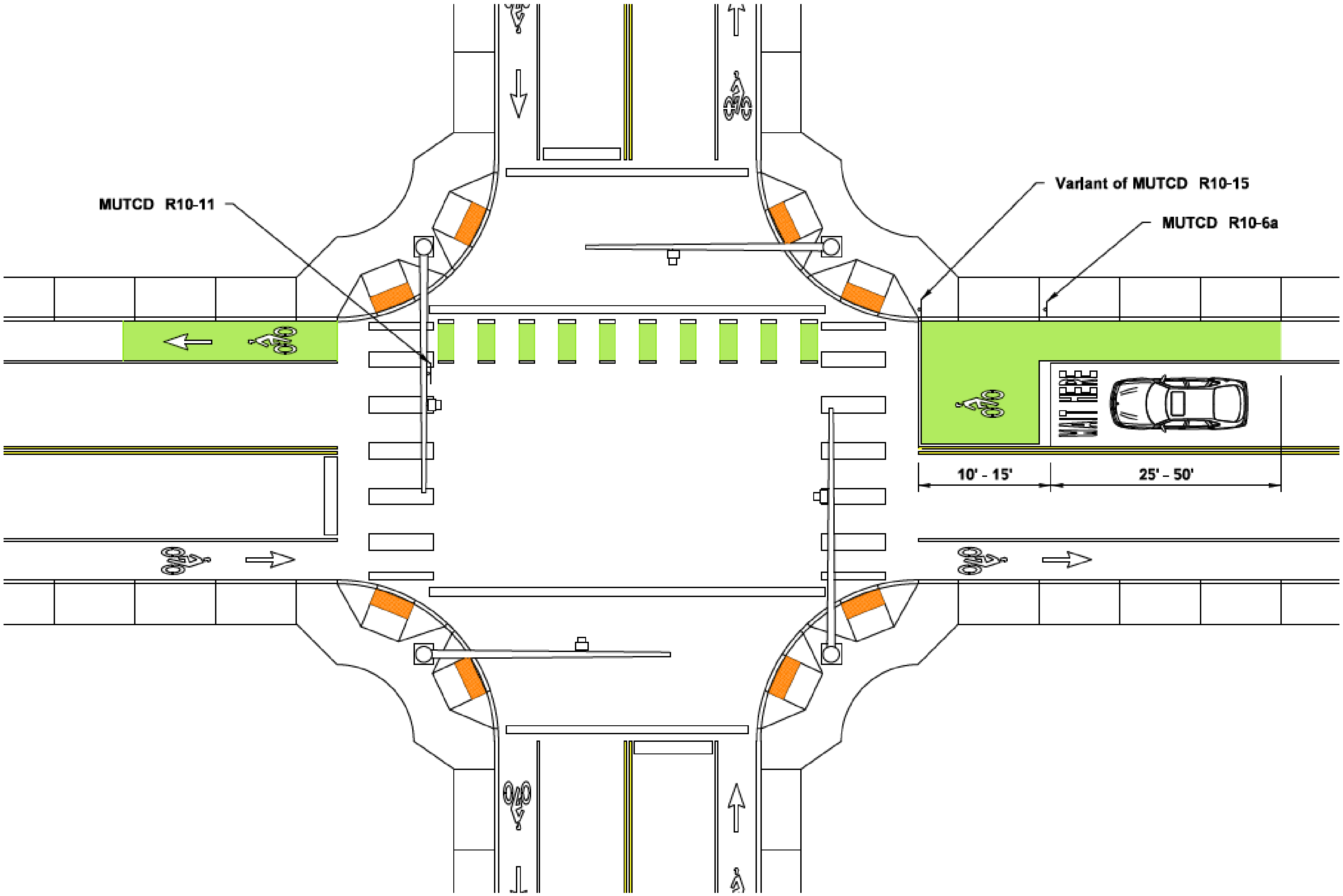
Exhibit 1520-7 Approach Through Lanes



Notes:

- Not to scale and not all dimensions shown.
- See 1520.05(1)(a) for criteria when considering the use of green colored pavement markings.
- Consider both the speed of motorized vehicles and bicyclists when determining the length of weave and degree of taper for the bike lane.

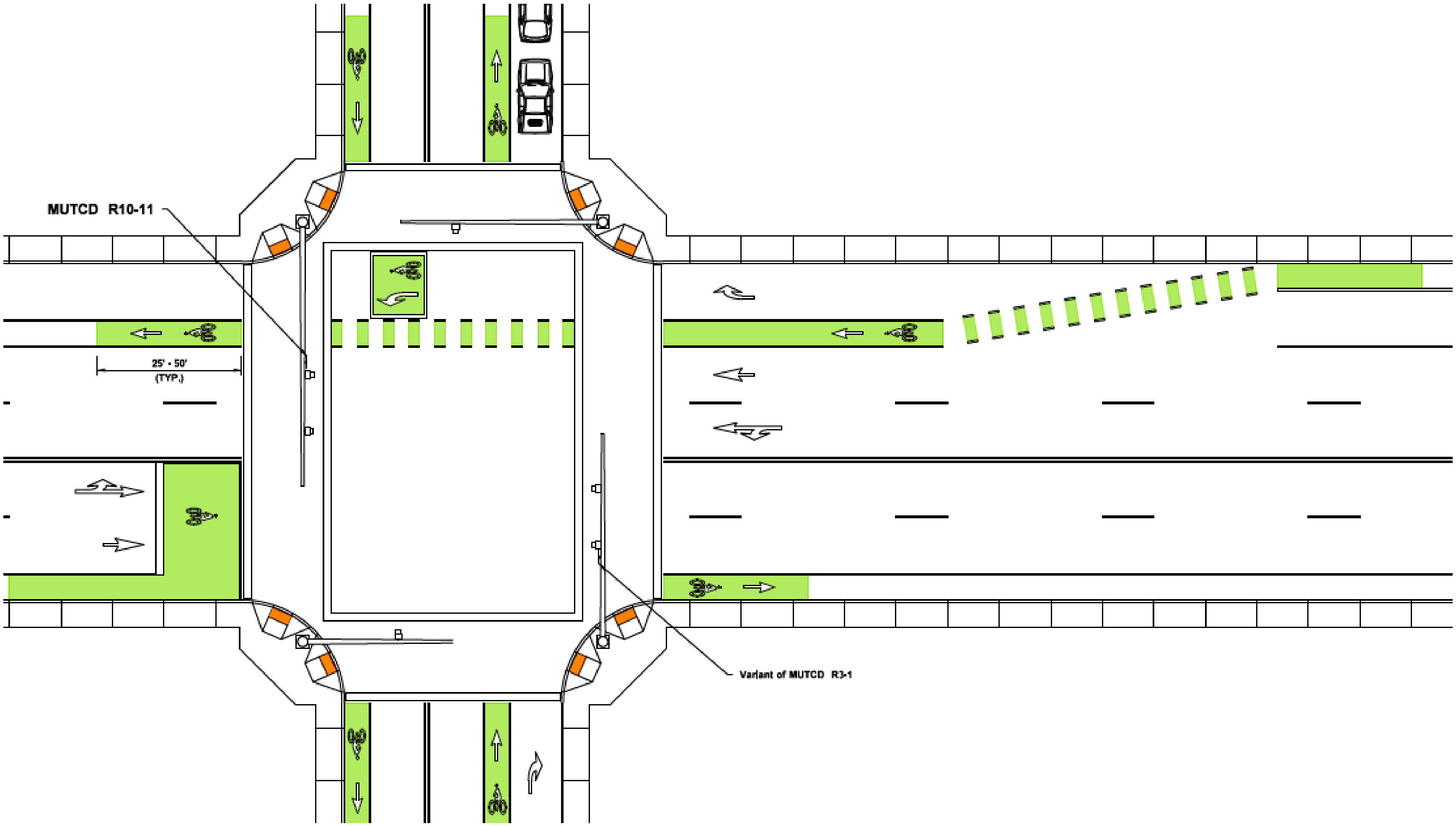
Exhibit 1520-8 Bike Box and Intersection Crossing Markings



Notes:

- This exhibit is intended to illustrate options for bike facilities through interchange areas, and not intended to represent recommended practice for any other features including ADA criteria (See Chapter 1510 for ADA and pedestrian design).
- See 1520.05(1)(a) for criteria when considering the use of green colored pavement markings.

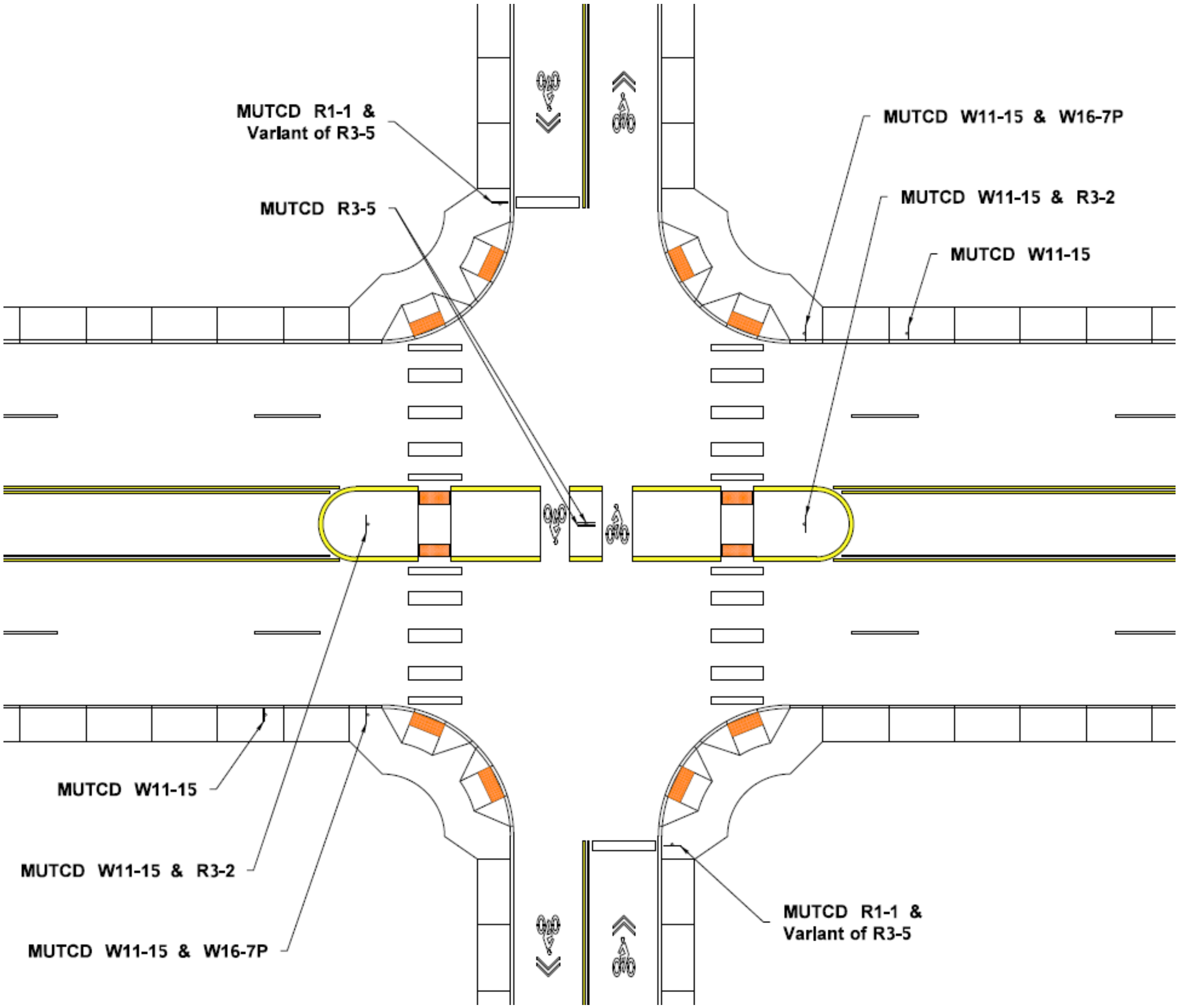
Exhibit 1520-9 Two-Stage Left-Turn Queue Box



Notes:

- This exhibit is intended to illustrate options for bike facilities through interchange areas, and not intended to represent recommended practice for any other features including ADA criteria (See Chapter 1510 for ADA and pedestrian design).
- Consider both the speed of motorized vehicles and bicyclists when determining the length of weave and degree of taper for the bike lane.
- See 1520.05(1)(a) for criteria when considering the use of green colored pavement markings.

Exhibit 1520-10 Median Refuge Island for Cyclists



1520.04(4) Traffic Signals Considerations

Consider bicycle needs and intersection geometry when timing the traffic signal cycle and when selecting the method of detecting the presence of cyclists. Contact the regional Bicycle Coordinator and region Traffic Engineer for assistance in determining the timing criteria. At a minimum consider safety performance needs, projected bicycle volume, motor vehicle volume, traffic delay, roadway grade and the types of bicyclists using the intersection that may require more time to clear the intersection. 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. Select detectors sensitive enough to detect bicycles, and use a bike detector symbol to identify detector presence.

Push button actuators may also be used to facilitate movement of bicyclists through a signalized intersection. However, requiring bicyclists to go out of their way to use push button actuators may create motor vehicle driver confusion of the bicyclists intended path through the intersection, as well as inconveniencing the bicyclist. If pushbutton actuators are used, consider their position relative to the bike facility. Pushbutton actuators are more effective when the bike facility is adjacent to the curb (curb extensions at intersections can create this environment). Consider an additional push button actuator for the exclusive use of cyclists when positioning of the actuator is in conflict with ADA design requirements (see Chapter 1510). For additional guidance on signal design, see Chapter 1330.

1520.04(4)(a) Bike Signals

Intersections with separated bike lanes, other complex multimodal intersection treatments or those with a specific baseline need to increase bicycle user safety performance may incorporate a dedicated bike signal head with detection or actuation systems. Bike signal heads further separate modal user movements at intersections, while also allowing for priority to cyclists at intersections. Contact the region Traffic Engineer for approval for application of this treatment.

At the time of this publication, bike signal faces are subject to requirements of FHWA Interim Approval for this treatment. For current status of the treatment and conditions of the Interim Approval, if still applicable, see
http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/index.cfm

1520.04(5) Median Refuge Islands for Cyclists

Layered networks have the benefit of separating modes onto different facilities to either enhance mobility or safety performance of active transportation modes. However, layered networks do intersect and specific median treatments exist to manage the confluence of these networks.

Median refuge islands provide a refuge for bicyclists to cross one direction of traffic at a time while restricting motor-vehicle through movements on crossroads designated as primary bicycle corridors or bike boulevards. The treatment minimizes impacts for bicyclists on the crossroad while prohibiting motor vehicle left turn movements from the cross street to eliminate conflicts.

Consider median refuge islands when one or more of the following occurs:

- Bike facilities cross a roadway with median restricted left turns.
- Bike facilities cross a moderate to high (motor vehicle) volume roadway, with intermediate motor-vehicle speeds
- Bike facilities cross a 4 lane divided highway.
- Separated or buffered bike facilities used on the cross street.
- There is a performance need to restrict motor vehicle through traffic on a bike route.
- Safety or mobility performance need of mainline cyclists exist for left turning movements onto a bike route or shared use pathway

Exhibit 1520-10 shows an example of a median refuge designed for cyclists. Design refuge areas between 4 and 5 feet wide (longitudinally with respect to the median), additional width may be needed if high volumes of cyclists exist or are anticipated at the crossing. Consider the types of cyclists and destinations when determining the median refuge length (lateral dimension with respect to the median) to adequately store the bicycle. Consider what locations may need to accommodate the length of a bicycle and trailer. The refuge area is to be in alignment with the approach and receiving lanes of the crossroad. In other situations the median refuge island may be designed for both pedestrians and bicycle users. When this is the case, design the median refuge predominately for the pedestrian as with midblock crossings (See Chapter 1510), note that additional lateral and longitudinal dimensions will be necessary.

1520.05 Additional Bicycle Design Requirements and Considerations

1520.05(1) Signing and Pavement Markings

Use the MUTCD and the *Standard Plans* for signing and pavement marking criteria. (See Chapter 1020 for additional information on signing and Chapter 1030 for information on pavement markings). Pavement marking and signing options for bicycle facilities are rapidly changing. Situations may exist where unique project concerns may necessitate innovative pavement markings or signage. Consult, as appropriate, the Federal Highway Administration (FHWA) MUTCD website for bicycle facilities for a listing of the current status of bicycle-related pavement markings and treatments:
http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/index.cfm

HQ Traffic Office approval is necessary for traffic control devices not currently approved for use through the MUTCD.

1520.05(1)(a) Green Pavement Marking – Criteria for Consideration

Green -colored pavement markings are a traffic control device whose need must be demonstrated before use and documented with a design decision. The highest benefit of applying green colored pavement markings occurs where the potential conflicts exist between cyclists and other design users, or when other design users should yield to cyclists. Green colored pavement markings are only intended as a supplemental treatment for standard striping configurations for bicycle facilities.

The below criteria are provided when evaluating the need to apply green colored pavement markings.

1. Existing Bike Facilities – retrofitting an existing facility with green pavement may be considered when two or more of the following apply:
    a. It is the engineering judgment of the Region Traffic Engineer
    b. There is an existing traffic conflict area, such as bike lane crossing a motor vehicle turn lane, and there are one or more observed motor vehicle and bicyclist crashes in the last 5 years.
    c. The bike mode is a modal priority (see Chapter 1103), and there is a baseline or contextual need identified associated with increasing safety performance of the mode.
    d. When a bike route intersects a multilane highway, and the crossing is neither signalized nor a roundabout.
2. Changing of Bike Facility Type –consider green pavement markings when one or more of the following apply:
    a. It is the engineering judgment of the Region Traffic Engineer.
    b. A transition from a separated facility through a functional intersection or interchange area necessitates additional delineation to create a clear, visible, predictable and distinct travel path for bike users, and a bike signal or actuation device is not used.
    c. The facility type change does not substantively alter the configuration of an existing conflict area, and there are one or more observed motor vehicle and bicyclist crashes in the last 5 years at that conflict area.
3. New Bike Facility – Generally, the immediate application of green colored pavement on a new bike facility is discouraged until the need for increased safety performance is demonstrated. This said, consider green colored pavement when two or more of the following conditions exist:
    a. It is the engineering judgment of the Region Traffic Engineer
    b. The bike mode is a modal priority (see Chapter 1103), and there is a baseline or contextual need in which the application of green colored pavement markings is needed to meet the stated modal safety performance target (see Chapter 1101).
    c. The bike facility nodes and/or crossings are within 1 mile of activity centers, such as schools, libraries, colleges, etc.
    d. The bike facility crosses a motor vehicle free right turn to or from an interchange ramp.
    e. The bike facility is a bike route or bike boulevard (for definition, see NACTO's *Urban Bikeway Design Guide*).
    f. The state route is also a city street, and the city policy or municipal code requires green colored pavement markings as their standard.
    g. The bike facility is raised and curb separated, and the city engineer requests green colored pavement markings at either crossings or conflict areas.

1520.05(1)(b) Green Pavement Marking – Configuration

Use green pavement markings to supplement the conventional white bike lane striping as required by the MUTCD. Apply green colored pavement markings in conflict areas, consistent with what is shown in Exhibits 1520-7 through 1520-9. Preceding the conflict area, apply solid green 25-50 feet in length (see Exhibit 1520-11), use green ladder striping between the required white dotted striping through the extent of the conflict area, and apply solid green after the ladder striping for at least 25 ft but no more than 50 ft. If closely spaced conflict areas exist, it may be appropriate to carry solid green into the next conflict area as determined by the Region Traffic Engineer.

1520-11 Length of Solid Green Pavement Marking Preceding Conflict Area

Motor Vehicle Speed	Length of Solid Green Colored Pavement Marking Preceding Conflict Area
25 mph	25 ft
30 mph	30 ft
35 mph or more	35-50 ft
Interchange Ramps	See 1520.05(6)

Additional configurations or styles exist for the application of green colored pavement and can be used with the approval of HQ Traffic Office. Consider specifically when bike route continuity with a local agency's bike facilities is a concern.

1520.05(2) Drainage Grates and Manhole Covers

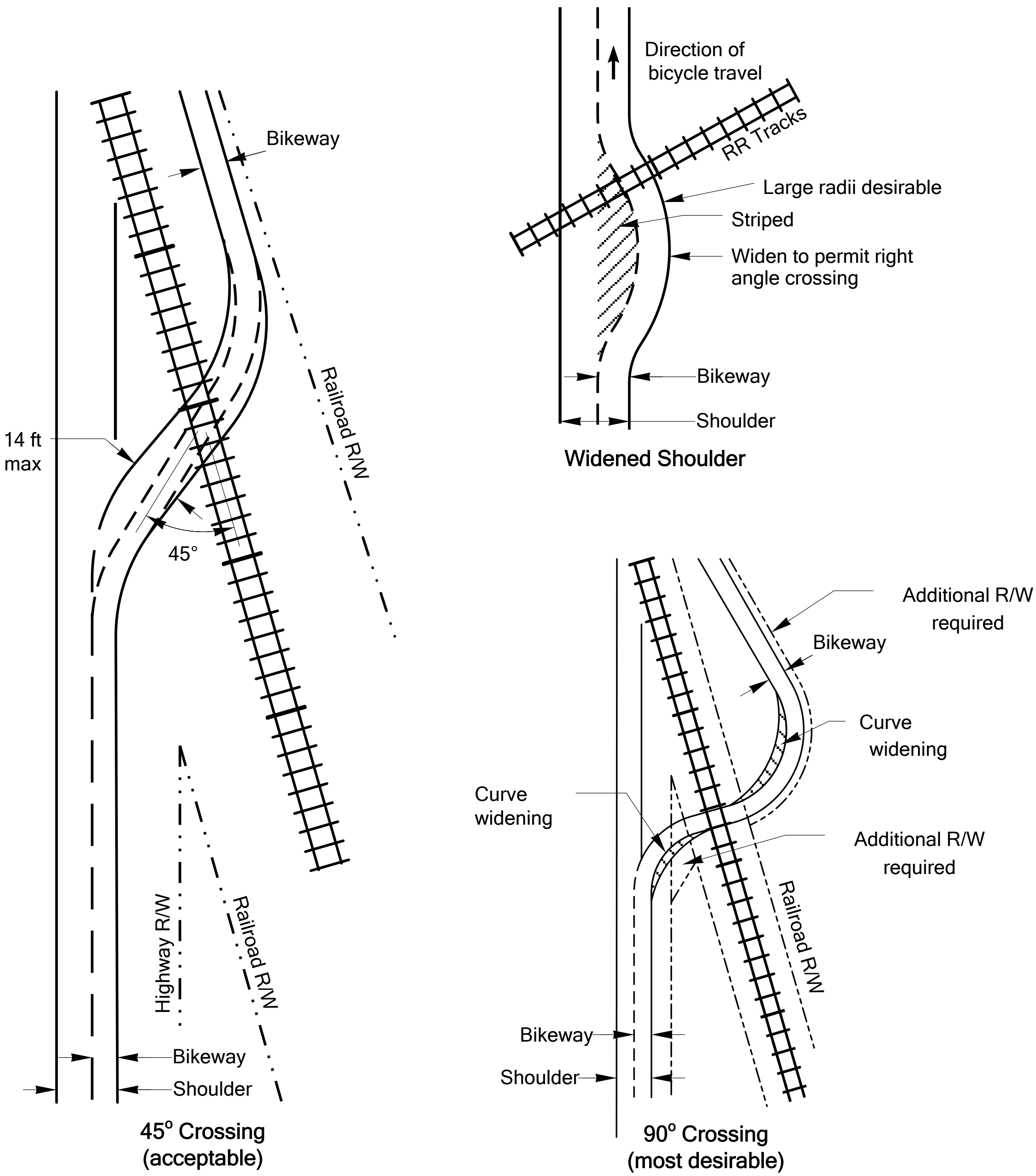
Locate drainage inlet grates and manhole covers to avoid bike lanes. When drainage grates or manhole covers are located in a bike lane, minimize the effect on bicyclists. Consider providing 3 feet of lateral clearance between the edge of a drainage inlet grate and the bike lane stripe, when practicable. Install and maintain grates and manhole covers level with the surface of the bike lane.

Provide drainage inlet grates on bicycle facilities that have openings narrow enough and short enough that bicycle tires will not drop into the grates. Replace existing grates that are not designed for bicycles: a WSDOT vanned grate, herringbone grate, or other grate with an opening 4 inches or less center to center and perpendicular to the direction of travel.

1520.05(3) At-Grade Railroad Crossings

Whenever a bike lane crosses railroad tracks, continue the crossing at least as wide as the bike lane. 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. Where a skew is unavoidable, widen the shoulder or bike lane, to permit bicyclists to cross at right angles. Exhibit 1520-12 shows options and details to consider for at-grade railroad crossings.

Exhibit 1520-12 At-Grade Railroad Crossings



Notes:

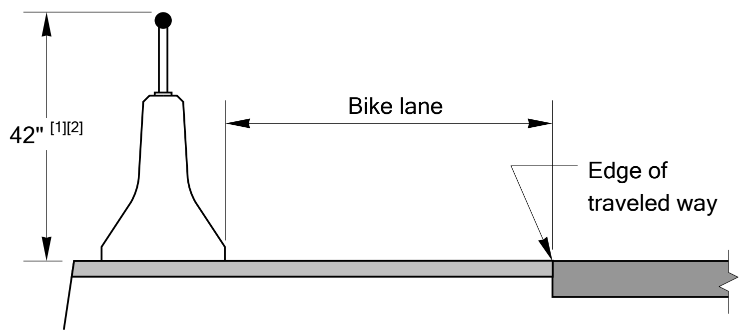
- Provide additional width at railroad crossings to allow bicyclists to choose their own crossing routes.
- When pedestrians are provided for, design as a shared-use path (see Chapters 1510 and 1515).

1520.05(4) Barrier and Railing

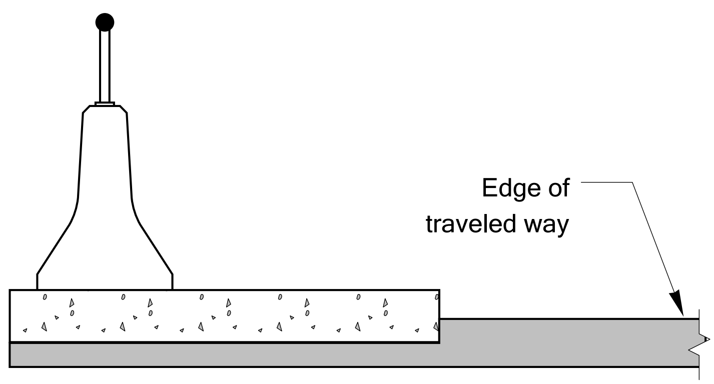
When the edge of the bike lane is within 5 feet of a barrier or railing, provide a barrier height a of 42 inches or more to reduce the potential for bicyclists to fall over the barrier (see Exhibit 1520-13). When the bicycle facility is adjacent to barrier, consider single slope barrier to mitigate for pedal movement conflicts other barrier designs.

On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for additional information. (See Chapter 720 for further considerations.)

Exhibit 1520-13 Barrier Adjacent to Bicycle Facilities



Bike Lane



Bike Lane With Sidewalk or Curb

Bike lane between edge of traveled way and sidewalk

Notes:

[1] Height does not apply to bridge railing. 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] Applies to bike lanes. Additional height is not needed for shared-use roadways.

1520.05(5) Transit Considerations

Transit and bicycle facilities can generate unique conflicts because of their typical position within the geometric cross section of the traveled way zone. Where public transport and cycling facilities meet, an integrated design that does not inconvenience either mode is desirable to meet the performance needs of these modes. Consider the following:

- Route the bike lane behind the transit stop location using a raised bike lane or outer separation for that spot location. Ensure the resulting outer separation provided for the transit stop meets the Americans with Disabilities Act (ADA) requirements (see Chapter 1510). Ensure signing and pavement markings are used to alert cyclists and pedestrians of the conflict area created with this design.
- Provide additional delineation in the bike lane to highlight the pedestrian and cyclist conflict, when separated buffered bike lanes and in-lane transit stops are used. Bus loading and other conflict areas will need to meet ADA requirements (see Chapter 1510) and those of the transit agency.
- Where bus operating speeds are low, consider a bus-bicycle shared lane with the transit agency.

Consider providing bicycle parking facilities near public transportation stops to improve accessibility performance needs.

1520.05(6) Interchange Considerations

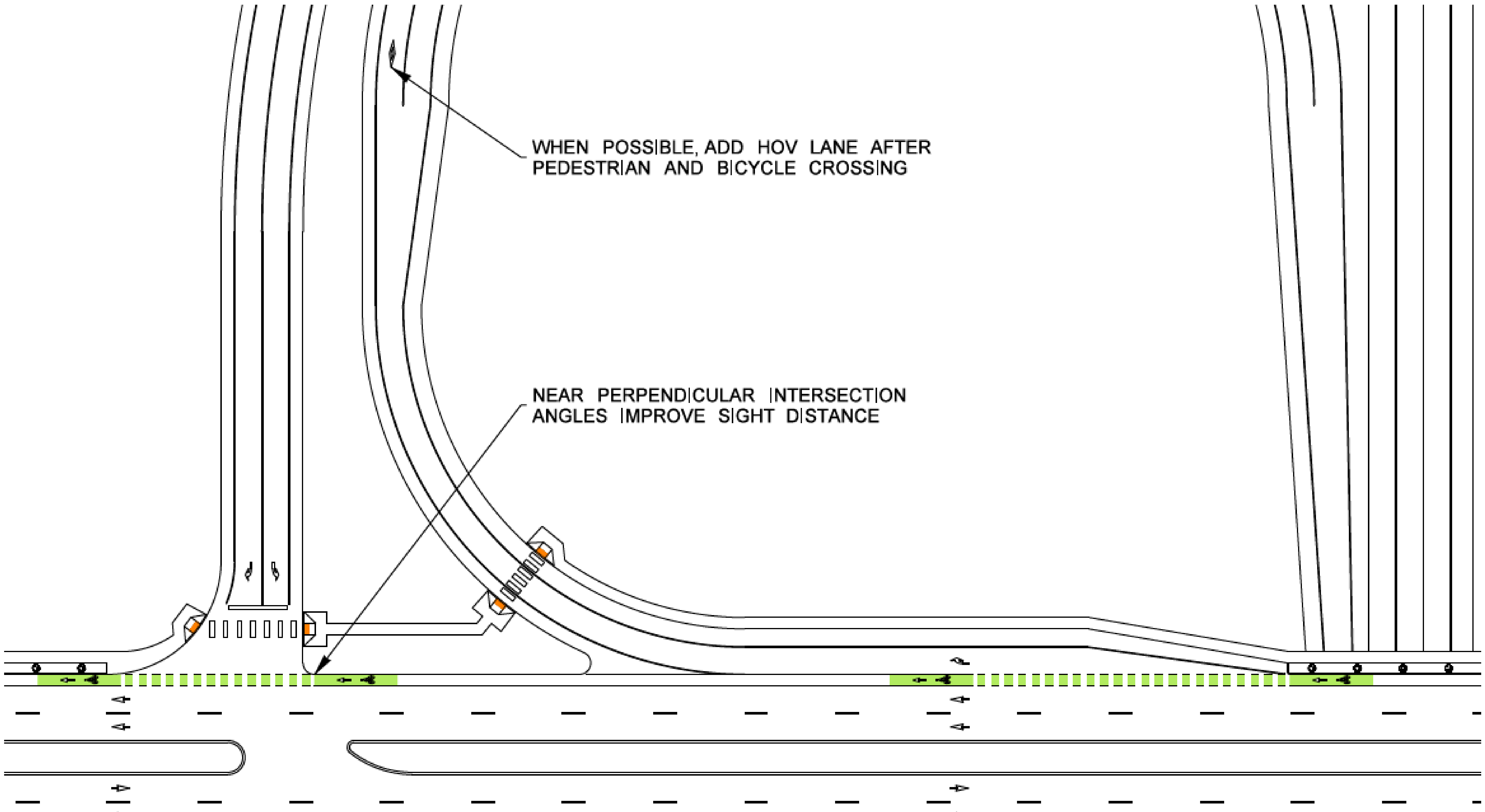
Crossing bicycle facilities through an interchange functional area has a greater potential for conflict because of higher travel speeds and lane configurations. Interchange crossings designed in a manner similar to intersection crossings are more compatible to bicyclists. Exhibits 1520-14a through 1520-14d illustrate design options for bike facilities design through an interchange functional area. Interchanges can be special environments to evaluate the safety and mobility needs of the bike mode. The specific challenge is often the inclusion of motor vehicle free right turns to or from interchange ramps. The preferred configuration for bicycle safety performance at an interchange will not provide the motor vehicle free right turn, and will realign ramps to intersect perpendicular with the crossroad (see off ramp terminal in Exhibit 1520-14a). However, given the modal priorities and operational performance needs of those priorities, this configuration may not always be practicable.

In some cases, it is possible to align the bike facility to cross an off ramp with a more direct path for the bike crossing (see Exhibit 1520-14d). Breaking up the work load for the motor vehicle driver is one advantage of this configuration, similar to pedestrian treatments common in roundabout design. Shortening the crossing distance required for the bicyclist is another advantage with this configuration. Consider the inclusion of Rectangular Rapid Flashing Beacons (RRFB) or a refuge island when there are multiple travel lanes. This configuration may also require additional speed management (see Chapter 1103), signing or striping treatments on the ramp.

Other situations may dictate additional delineation parallel to and matching the length of the auxiliary lane provided at the ramp terminal as shown in Exhibit 1520-14b. This configuration can be coupled with additional signing preceding the motor vehicle merge, and additional separation or a buffer between the ramp’s auxiliary lane and the through bike lane. The length of the motorized auxiliary lane will vary depending on speed and volume, so the length of green markings shown in Exhibit 1520-11 may not adequately satisfy the delineation desired at these locations. Consult with the Region Traffic Engineer for determining the length of green pavement markings at interchange locations, when they are provided according to 1520.05(1)(a).

Exhibit 1520-14c provides a design option in which the bike lane merges with the sidewalk, and requires bicyclists to cross an interchange ramp at the pedestrian crossing. This configuration is ideal when bicycle mode is not identified as a modal priority, there is high motor vehicle ADT, there is a large intersection design vehicle, there is intermediate to high motor vehicle speeds, or when there are identification design users (see Chapter 1103) that suggests low experienced bicyclists will be present. Consider inclusion of an RRFB or a median refuge island when there are multiple lanes. Exhibits 1520-14b and 1520-14d also show the option of providing a bike ramp to the sidewalk. Providing options for cyclists at interchanges is encouraged, since the range of comfort among users is known to be diverse. Consult with the local agency regarding any prohibitions against bicyclists using the sidewalk that may negate the ability to implement this configuration.

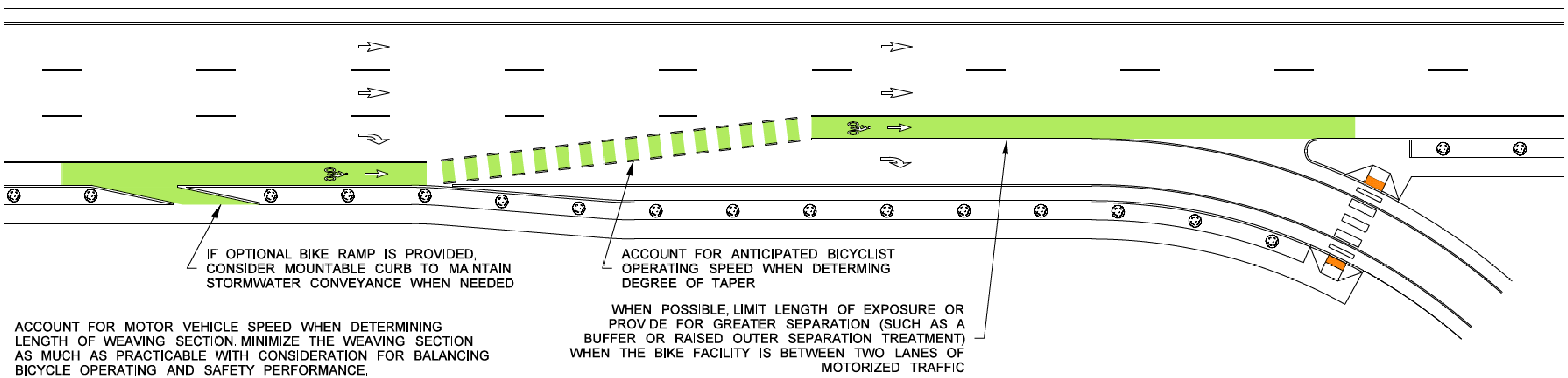
Exhibit 1520-14a – Bike Facility Crossing On- and Off-Ramps



Notes:

- Adapted from the Draft *Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges*, ITE, unpublished.
- This exhibit is intended to illustrate options for bike facilities through interchange areas, and not intended to represent recommended practice for any other features including ADA criteria (See Chapter 1510 for ADA and pedestrian design).

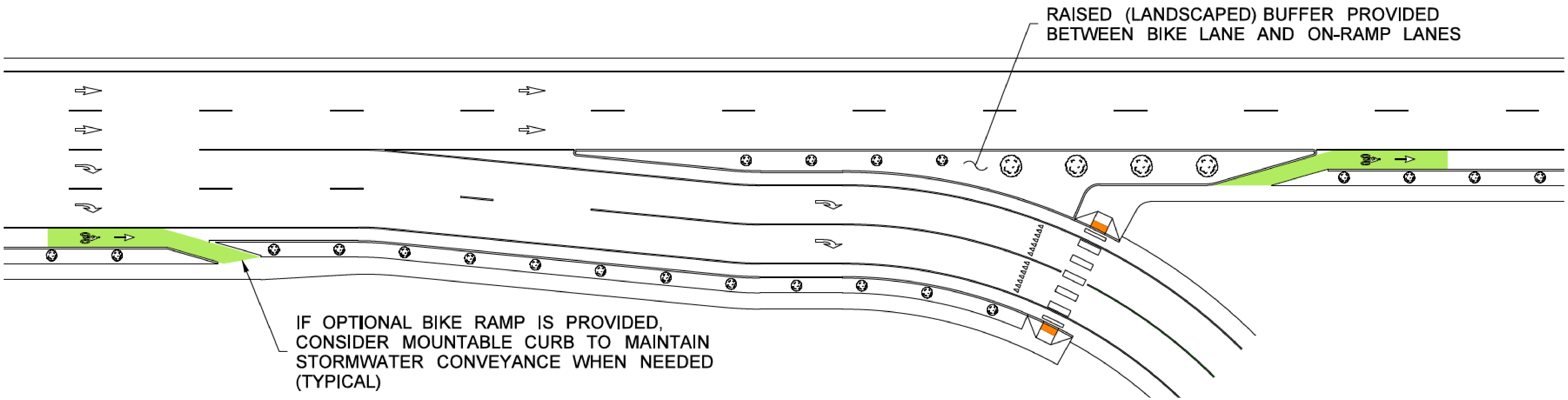
Exhibit 1520-14b – Bicycle Facility Crossing Single-Lane On-Ramp



Notes:

- Adapted from the Draft *Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges*, ITE, unpublished.
- This exhibit is intended to illustrate options for bike facilities through interchange areas, and not intended to represent recommended practice for any other features including ADA criteria (See Chapter 1510 for ADA and pedestrian design).
- Consider both the speed of motorized vehicles and bicyclists when determining the length of weave and degree of taper for the bike lane.

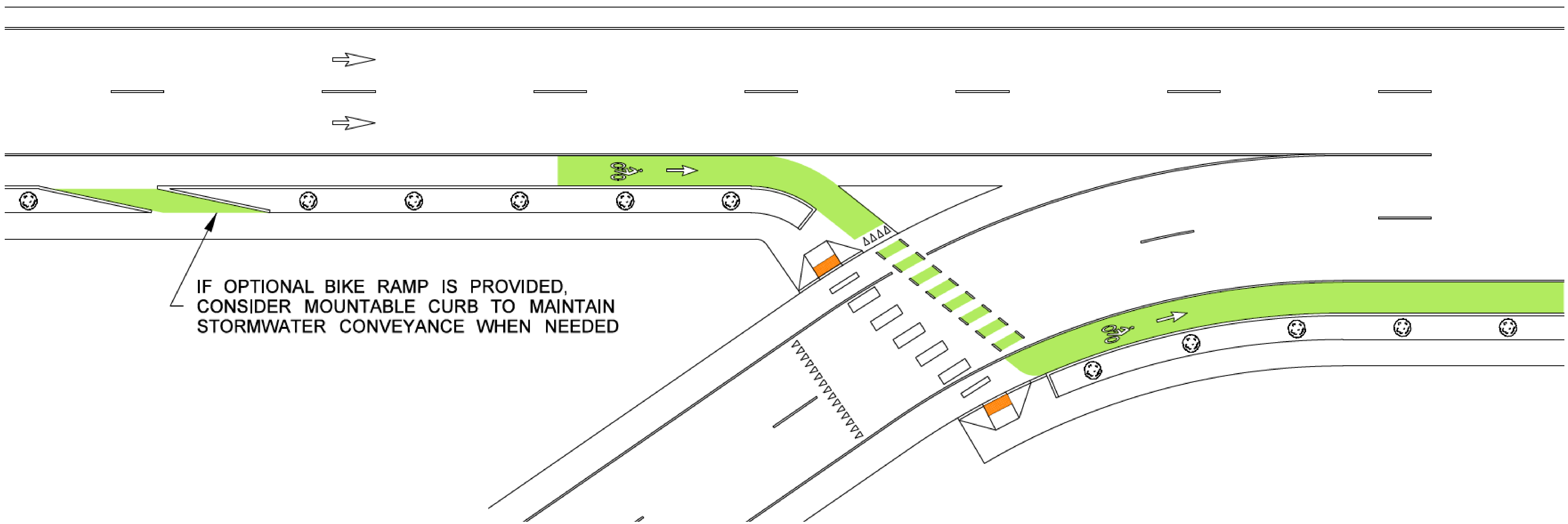
Exhibit 1520-14c – Bicycle Facility Crossing Option for Dual Lane On-Ramp Configuration



Notes:

- Adapted from the Draft *Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges*, ITE, unpublished.
- This exhibit is intended to illustrate options for bike facilities through interchange areas, and not intended to represent recommended practice for any other features including ADA criteria (See Chapter 1510 for ADA and pedestrian design).

Exhibit 1520-14d – Bicycle Facility Crossing Option for Dual Off-Ramp



Notes:

- Adapted from the Draft *Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges*, ITE, unpublished
- This exhibit is intended to illustrate options for bike facilities through interchange areas, and not intended to represent recommended practice for any other features including ADA criteria (See Chapter 1510 for ADA and pedestrian design).

1520.05(7) Sight Triangles at Intersections and Conflict Areas

The visibility of all users is to be evaluated at intersections. Identifying sight triangles can help determine the optimal configuration of bicycle and pedestrian crossings. See Chapter 1310 for determining sight distance at an intersection, and Chapter 1340 for sight distance at road approaches near midblock crossings. Visibility is impacted by both speed and the configuration of the intersection. There are multiple benefits in multimodal intersection configurations to proactively manage motorized vehicle speeds (see Chapter 1103 for speed reducing traffic calming treatments) at intersection locations, rather than widening the intersection and/or removing elements from the roadside or streetside zone to obtain the needed sight distance. The primary objective at intersections and interchanges is to create a clear, distinct, and predictable travel path for all users through the intersection.

1520.05(8) Maintenance Considerations

Consult with all maintenance jurisdictions for partnering opportunities and clearly understand which jurisdiction will be responsible for specific elements of the bike facility maintenance. Some maintenance jurisdictions may be better equipped to maintain the bike facility than others. Certain bike facilities, like the raised and curb separated, clearly fall within the jurisdictional authority of an incorporated city (see chapters 1230 and 1600 for more information). For other facility types it may be more advantageous to discuss the capabilities of each maintenance jurisdiction, and develop a maintenance agreement (see Chapter 301).

It is important to obtain information from maintenance regarding the facility type and dimensioning, and discuss methods for maintaining the facility. The Maintenance Owner's Manual (See Chapter 301) is suggested to contain frequency, equipment needs and material types necessary for the continual maintenance of facility features, including but not limited to:

- Sweeping
- Snow removal
- Striping and pavement markings
- Signing

1520.06 Documentation

Document the type of bike facility employed or changed in section 5 of the Basis of Design. Dimensions chosen for the facility are documented on design parameter sheets.

1520.07 References

1520.07(1) 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
http://apps.leg.wa.gov/rcw/default.aspx?cite=35.75

RCW 46.04, Definitions
http://apps.leg.wa.gov/rcw/default.aspx?cite=46.04

RCW 46.61, Rules of the road
http://apps.leg.wa.gov/rcw/default.aspx?cite=46.61\

RCW 46.61.710, Mopeds, electric-assisted bicycles – General requirements and operation
http://apps.leg.wa.gov/rcw/default.aspx?cite=46.61.710

RCW 47.26.300, Bicycle routes – Legislative declaration
http://apps.leg.wa.gov/rcw/default.aspx?cite=47.26.300

1520.07(2) Supporting Information

Urban Bikeway Design Guide, NACTO, current edition (WSDOT endorsed)
http://nacto.org/publication/urban-bikeway-design-guide/

Guide for the Development of Bicycle Facilities, AASHTO, current edition
https://bookstore.transportation.org/collection_detail.aspx?ID=116

Separated Bike Lane Planning and Design Guide, FHWA, current edition
http://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm

Bicycle Parking Guidelines, Association of Pedestrian and Bicycle Professionals, current edition
http://www.apbp.org/?page=Publications

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC "Manual on uniform traffic control devices for streets and highways" (MUTCD)
www.wsdot.wa.gov/publications/manuals/mutcd.htm

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT
www.wsdot.wa.gov/publications/manuals/m21-01.htm

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005
www.wsdot.wa.gov/research/reports/600/638.1.htm

Selecting Roadway Design Treatments to Accommodate Bicycles, USDOT, Federal Highway Administration (FHWA), 1994

NCHRP Report 766: Recommended Bicycle Lane Widths for Various Roadway Characteristics, Transportation Research Board of the National Academies, 2014
🖱 http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_766.pdf

NCHRP Report 500 Volume 18: A Guide for Reducing Collisions Involving Bicycles, Transportation Research Board of the National Academies, 2006
🖱 http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v18.pdf

Four Types of Cyclists?, Dill, Jennifer, and Nathan McNeil, Transportation Research Record: Journal of the Transportation Research Board 2387.1 (2013): 129-138.

Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges, ITE, unpublished.
🖱 http://ecommerce.ite.org/IMIS/ItemDetail?iProductCode=RP-039

Montgomery County Bicycle Planning Guidance, Montgomery County Department of Transportation, 2014.
🖱 http://www.montgomeryplanning.org/transportation/bikeways/documents/FINALBicyclePlanningGuidance.pdf

Separated Bike Lane Planning and Design Guide, Massachusetts Department of Transportation (MassDOT), 2015
🖱 http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/ManualsPublicationsForms/SeparatedBikeLanePlanningDesignGuide.aspx

Chapter 1600 Roadside Safety

1600.01 General

Roadside safety addresses the area outside the roadway and is an important component of total highway design. There are numerous reasons why a vehicle leaves the roadway, including driver error and behaviors. Regardless of the reason, a roadside design can reduce the severity and subsequent consequences of a roadside encroachment. From a crash reduction and severity perspective, the ideal highway has roadsides and median areas that are relatively flat and unobstructed by objects. It is also recognized that different facilities have different needs and considerations, and these issues are considered in any final design.

It is not possible to provide a clear zone free of objects at all locations and under all circumstances. The engineer faces many tradeoffs in design decision-making, balancing needs of the environment, right of way, and various modes of transportation. The fact that recommended design values related to the installation of barrier and other mitigation countermeasures are presented in this chapter, does not mean that WSDOT is required to modify or upgrade existing locations to meet current criteria.

Roadside safety may be addressed by projects identified through priority programming, during certain preservation project activities (See Chapter 1120), or may be considered by projects as part of a safety analysis (See Chapter 321). Elements such as sideslopes, fixed objects, and water are all features that a vehicle might encounter when it leaves the roadway and become part of such an analysis.

On projects where the need to mitigate objects is determined based on location related to Design Clear Zone, consider the following mitigation measures in this order: (See 1600.02 Clear Zone)

1. Remove
2. Relocate
3. Redesign a fixed object by using breakaway features or making the fixed object traversable (See Section 1600.03)
4. Shield with a traffic barrier
5. Delineate (To only delineate requires a Design Analysis. If this seems to be your only option, consult your Region traffic barrier expert or your Region's ASDE.)

Factors for selecting a mitigation measure include, but may not be limited to:

- Crash severity potential
- Maintenance needs
- Cost (initial and life cycle costs)

Rumble strips can be employed to reduce the potential for lane departure or roadside encroachment in certain contexts (see Section 1600.05(1)). Use traffic barriers when other measures cannot reasonably be accomplished and conditions are appropriate based on an engineering analysis (See Chapter 1610).

1600.02 Clear Zone

A clear roadside border area beginning at the edge of the traveled way is a primary consideration with existing or new roadside and median features (see Section 1600.03). The intent is to provide a clear, traversable area for a vehicle driver or bicyclist to recover when their path is altered due to environmental, human, or vehicle or bicycle factors.

The Design Clear Zone indicates the target value for the clear roadside area (clear zone) and the level of documentation associated with roadside design. Compile an inventory of existing roadside and median features when they are located entirely or partially inside the Design Clear Zone. Document each inventoried feature location, the corrective actions considered, estimated cost to correct, and if the correction is planned or not using the Design Clear Zone Inventory Form (Exhibit 1600-3). In cases where no action is taken, provide the reason(s) on the back of the form.

In situations where the Design Clear Zone is beyond WSDOT right of way, evaluate options on a case-by-case basis. Consider the nature of the objects within the Design Clear Zone, the roadway geometry, traffic volume, and crash history. Coordinate with adjacent property owners when proposed options include any work beyond WSDOT right of way. At a minimum, provide clear zone to the limits of the WSDOT right of way.

Clear zone is measured from the edge of the through traveled way. All projects that alter the relationship between the through lane and the roadside by widening or realignment have altered the existing clear zone, and require an evaluation of objects in the clear zone. Auxiliary lanes longer than 400 feet generally operate the same as a through lane and should be considered through lanes for the purpose of determining Design Clear Zone.

1600.02(1) Design Clear Zone along Limited Access State Highways and Other State Highways Outside Incorporated Cities and Towns

Use the Design Clear Zone Inventory form (Exhibit 1600-3) to identify features to be mitigated and propose actions taken to address those features.

Guidance for establishing the Design Clear Zone for highways outside incorporated cities is provided in Exhibit 1600-2. This guidance also applies to limited access facilities 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 practicable to provide these recommended distances. In these situations, document the decision as a Design Analysis as discussed in Chapter 300.

There is flexibility in establishing the Design Clear Zone in urbanized or urbanizing areas where operating speeds are 35 mph or less. To achieve this flexibility, use a Design Analysis to establish the Design Clear Zone that presents the tradeoffs associated with the decision. Provide information on the benefits and effects of the Design Clear Zone selected in the Design Analysis, including safety, aesthetics, the environment, economics, modal needs, and access control. Although not a WSDOT policy document on clear zone, Chapter 10 of the AASHTO *Roadside Design Guide* provides information to consider when performing a Design Analysis in urbanized areas.

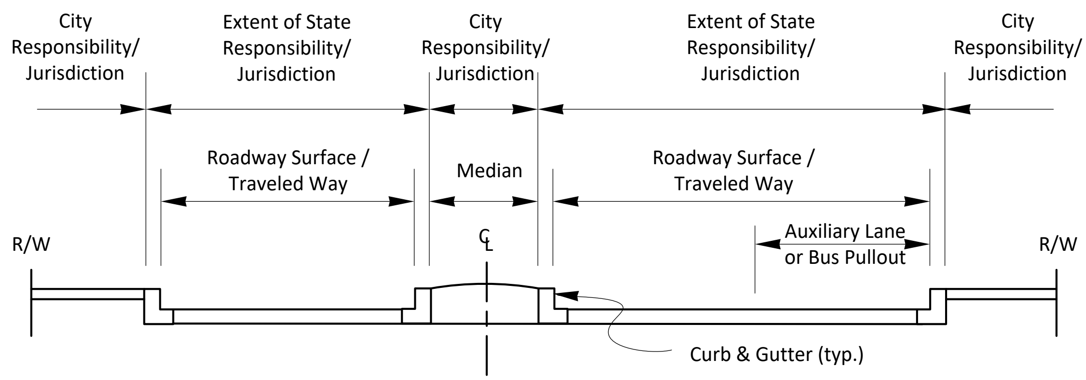
In curbed sections, and where applicable (e.g. parking), provide an 18-inch operational offset beyond the face of curb for lateral clearance to accommodate opening car doors or large side mirrors.

1600.02(2) Design Clear Zone Inside Incorporated Cities and Towns

For managed access state highways within an urban area, it might not be practicable or appropriate to provide the Design Clear Zone distances shown in Exhibit 1600-2. 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.

For projects on city streets as state highways that include work in those areas that are the city's responsibility and jurisdiction (see Exhibit 1600-1), design the project using the city's development/design standards. The standards adopted by the city must meet the requirements set by the City Design Standards Committee for all arterial projects, bike projects, and federal-aid projects. See the *Local Agency Guidelines,* Chapter 42, for more information on this Committee.

Exhibit 1600-1 City and State Responsibilities and Jurisdictions



Roadway with Raised Median (Landscaped)

1600.02(2)(a) Roadside and Median

For managed access state highways inside incorporated cities, 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 (*Local Agency Guidelines*, Chapter 42.) Exhibit 1600-1 shows an example of state and city responsibilities and jurisdictions. Document the Design Clear Zone established by the city in the Design Documentation Package. Have the responsible transportation official from the city (e.g., City Engineer) document the Design Clear Zone, and their acknowledgement and acceptance of the design and maintenance responsibilities for project roadsides and medians, in a letter addressed to WSDOT, and file this letter as part of the local agency coordination in the Design Documentation Package. Respond to the sender acknowledging receipt.

1600.02(3) Design Clear Zone and Calculations

Use Exhibit 1600-2 to determine the Design Clear Zone based on posted speed, sideslopes, and traffic volume at any given location. Note that there are no clear zones 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 likely will not be able 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 Exhibit 1600-4.

For ditch sections, the following criteria determine the Design Clear Zone:

(a) For ditch sections with foreslopes 4H:1V or flatter (see Exhibit 1600-5, 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); or
- 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 Exhibit 1600-5, 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 (see Exhibit 1600-4; also see Exhibit 1600-5, Case 3, for an example).

1600.03 Mitigation Guidance

There are three general categories of features to be mitigated: sideslopes, fixed objects, and water. This section provides guidance for determining when these objects are to be mitigated. For each case, the following conditions need consideration:

- Locations with an expected elevated crash frequency.
- Locations with pedestrian and bicyclist usage (See Chapters 1510, Pedestrian Facilities, 1515, Shared-Use Paths, and 1520, Roadway Bicycle Facilities).
- Locations where speed management measures are present or contemplated (See Chapter 1103).
- Locations with playgrounds, monuments, and other locations with high social value.
- Locations where redirectional landforms, also referred to as earth berms, were installed to mitigate objects 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 landforms has been discontinued as a means for mitigating fixed objects. Where redirectional landforms currently exist as mitigation for a fixed object, provide designs where the landforms, and the feature(s) they were intended to mitigate, are removed, relocated, made crashworthy, or shielded with barrier.

The use of a traffic barrier for mitigation of features other than those described in the section below requires justification.

1600.03(1) Side Slopes

1600.03(1)(a) Fill Slopes

Fill slopes can increase the crash potential for 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 condition. If flattening the slope is not feasible or cost-effective, the installation of a barrier might be appropriate. Exhibit 1600-6 represents a selection procedure used to determine whether a fill sideslope constitutes a condition for which a barrier is a cost-effective mitigation. The curves shown on Exhibit 1600-6 are based on the severity indexes and represent the points where total costs associated with a traffic barrier are equal to the predicted cost of crashes over the service life for 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 Exhibit 1600-6 for slope design. Design slopes consistent with guidance in Chapter 1239, evaluating designs with clear, traversable slopes before pursuing a barrier option. Also, if Exhibit 1600-6 indicates that barrier is not recommended at a slope, that result is not justification for a Design Analysis. For example, if the ADT is 4,000 and the embankment height is 10 feet, barrier might be cost-effective for a 2H:1V slope, but not for a 2.5H:1V slope. This process only addresses the crash potential on the slope. Objects on the slope can compound the condition. Where barrier is not cost-effective, use the recovery area formula to evaluate fixed objects on critical fill slopes less than 10 feet high.

1600.03(1)(b) Cut Slopes

A traversable cut slope reduces crash potential. The exception is a rock cut with a rough face that might cause vehicle snagging rather than providing relatively smooth redirection.

Analyze the location and evaluate the roadside characteristics, crash potential, and other benefits of treatment of rough rock cuts located within the Design Clear Zone. Conduct an individual investigation for each rock cut or group of rock cuts. A cost-effectiveness analysis that considers the consequences of doing nothing, removal, smoothing of the cut slope, grading at the base of the rock cut to provide a smooth surface, and other viable options to reduce the severity of the condition can be used to determine the appropriate treatment. Some potential mitigative options are roadside barrier and rumble strips.

1600.03(2) Fixed Objects

Use engineering judgment when considering the following objects for mitigation:

- Wooden poles or posts with cross-sectional areas greater than 16 square inches that do not have breakaway features.
- Signs, illumination, cameras, weather stations, and other items mounted on non-breakaway poles, cantilevers, or bridges.
- Trees with 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/electrical/ITS cabinets, piers, and retaining walls.
- Drainage elements, such as culvert and pipe ends.

1600.03(2)(a) Trees

When evaluating new plantings or existing trees in the Design Clear Zone, 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.

Removal of trees may reduce the severity of impacts of roadway departure. It is recognized that different facilities have different needs and considerations, and these issues are considered in any design. For instance, removal of trees within the Design Clear Zone may not be desirable in suburban, urban, or urban core areas, or in other land use contexts that provide for non-motorized uses, such as a forest, park, or within a scenic and recreational highway. In these situations, analyze crash reports' contributing factors to determine whether roadside vegetation is contributing to the severity of crashes. If large vegetation is removed, consult guidance contained in established vegetation management plans, corridor plans, or the *WSDOT Roadside Manual*. Additional guidance for maintenance of roadside vegetation can be found for some routes in the Memorandum of Understanding between the US Forest Service and WSDOT, *Highways Over National Forest Lands*, dated July 2002. In incorporated cities, refer to guidance in 1600.02(2).

1600.03(2)(b) Mailboxes

For mailboxes located within the Design Clear Zone, provide 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 specified height in the contract plans. (See Exhibit 1600-7 for installation guidelines.) Coordinate with homeowners when upgrading mailboxes.

Where sidewalks are present, contact the postal service to determine the most appropriate mailbox location. Locate mailboxes on limited access highways in accordance with Chapter 530, Limited Access. A turnout, as shown in Exhibit 1600-7, is not needed on limited access highways with shoulders of 6 feet or more where only one mailbox is to be installed. On managed access highways, mailboxes are to be on the right-hand side of the road in the postal carrier's direction of travel. Avoid placing mailboxes along high-speed, high-volume highways. Locate Neighborhood Delivery and Collection Box Units outside the Design Clear Zone.

1600.03(2)(c) Culvert Ends

Provide a traversable end treatment when the culvert end section or opening is within the Design Clear Zone. No part of the culvert or end treatment should protrude more than 4" above the ground line. Traversable end treatments include:

- **Culverts perpendicular to direction of travel:**
  - Culverts 36" and smaller as measured parallel to the direction of travel (Consider treating these culvert ends even outside Design Clear Zone)
    - For roadway side slopes 4:1 or steeper, see Standard Plan B-70.20
    - For slopes flatter than 4:1 (see Standard Plan B-70.20 and note "treatment for slopes flatter than 4:1")
  - Culverts larger than 36 inches, as measured parallel to the direction of travel, require Type 1 safety bars. (See Standard Plan B-75.50)

- **Culverts parallel to direction of travel require safety bars**:
  - Type 2 safety bars are used for circular culverts up to 36 inches. (See Standard Plan B-75.60)
  - Type 3 safety bars are used for metal end sections of circular culverts between 36 inches and 60 inches and for metal end sections of arched culverts between 30 inches and 72 inches. (See Standard Plan B-80.20)
  - Type 4 safety bars are used for metal end sections of circular culverts between 15 inches and 60 inches and for metal end sections of arched culverts between 18 inches and 72 inches. (See Standard Plan B-80.40)

Bars are permitted where they will not significantly affect the stream hydraulics and where debris drift is minor. Consult the Region Maintenance Office and Region Hydraulics to verify these conditions. If debris drift is a concern, consult Region Hydraulics for options to reduce the amount of debris that can enter the pipe.

1600.03(2)(d) Signposts

Whenever possible, locate signs behind the standard run, but not the end terminals, of existing or planned traffic barrier installations to eliminate the need for breakaway posts, and place them such that the sign face is behind the barrier. (See Chapter 1020 for additional information regarding the placement of signs.) Use the *MUTCD* to guide placement of the warning sign.

Signposts with cross-sectional areas greater than 16 square inches that are within the Design Clear Zone and not located behind a barrier are to have breakaway features as shown in the *Standard Plans*.

Sign bridges and cantilever sign supports are designed for placement outside the Design Clear Zone or must be shielded by barrier.

1600.03(2)(e) Traffic Signal Standards/Posts/Supports

Breakaway signal posts generally are not feasible or desirable, and barrier is not generally an option due to constraints typically found at intersection locations. To reduce potential for drivers making contact with posts, and to avoid impeding the movement of pedestrian or bicyclist traffic in the vicinity, locate posts in accordance with Chapter 1330.

For ramp meter systems, single lane ramp meters use breakaway Type RM signal standards. Multilane ramp meters normally use Type II signal standards, which must either be located outside of clear zone for all adjacent roadways or be protected by some type of barrier.

1600.03(2)(f) Fire Hydrants

Fire hydrants are typically 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 hydrant that will not be breakaway must not extend more than 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. Provide mitigation to address potential vehicle impact with hydrant types not expected to fracture on impact.

1600.03(2)(g) Utility Objects

Because utilities often share the highway right of way, utility objects such as poles, guy wires, and pedestals are often located along the roadside. These features are installed in the right of way under a variety of occupancy rights; including franchises, permits, or easements. The responsibilities and liabilities associated with the presence of these objects is directly related to the documentation authorizing their installation. Importantly, the rights contained within these authorizing documents include cost responsibility for relocation. Contact the region Utility Engineer to determine if action is needed regarding utility objects located within the project limits, and the occupancy rights in effect for the objects.

For policy and guidance on locating new, and mitigating existing, utility objects along state highways, see Chapter 9 of the *Utilities Manual*. Coordinate with the region Utilities Office to obtain guidance on utility object design or to determine mitigation requirements for existing utility objects.

1600.03(2)(h) Light Standards

Provide breakaway light standards unless fixed light standards can be justified, even if outside of the Design Clear Zone. Fixed light standards may be justified if one of the following criteria are met:

- Posted speed is below 35 MPH (See 1600.02(1) for Design Clear Zone in urbanized and urbanizing areas, and 1600.02(2) in cities).
- Mounted on barrier (top or elbow mount).
- Behind traffic barrier, beyond the barrier's deflection design value (see Chapter 1610).
- Within a parking lot.
- Along isolated walkways and shared-use paths that are outside of Design Clear Zone.

Breakaway light standards require additional embankment widening to ensure proper operation, as shown in the *Standard Plans*. If this additional embankment widening cannot be constructed, such as in cases where the toe of slope will extend beyond right of way or into a water body or other sensitive area, fixed bases and traffic barrier may be considered. Document the decision to use fixed bases in the Design Documentation Package.

1600.03(3) Water

Water with a depth of 2 feet or more and located with a likelihood of encroachment by an errant vehicle is to be evaluated for mitigation.

Perform a benefit-cost analysis that considers the consequences of doing nothing versus installing a longitudinal barrier to determine the appropriate treatment (see Chapter 321 for more information). For fencing considerations along water features see Chapter 560.

1600.04 Medians

Median barriers are normally used on limited access, multilane, high-volume highways. These highways generally have posted speeds of 45 mph or higher. Median barrier is normally placed on limited access state highways. Where median barrier is used on managed access highways where bicyclists, pedestrians, and transit users are present, consider providing accessible barrier openings at crossing locations. Install end treatments where median barrier openings are provided.

Provide median barrier on full access control multilane highways with median widths of 50 feet or less and posted speeds of 45 mph or higher. Consider median barrier on highways with wider medians or lower posted speeds when there is a history of cross-median crashes. Contact the HQ Design Office for more information.

Provide a left-side shoulder when installing median barrier using width criteria given in Chapter 1230. Consider a wider shoulder area where the barrier might cast a shadow on the roadway and hinder the melting of ice. (See Chapter 1239 for additional criteria for placement of median barrier, Chapter 1610 for information on the types of barriers that can be used, and Chapter 1260 for lateral clearance on the inside of a curve to provide the needed stopping sight distance.) Consider the need to accommodate drainage as a result of the addition of median barrier treatments.

When median barrier is being placed in an existing median, identify the existing crossovers and enforcement observation points. Provide the needed median crossovers in accordance with Chapter 1370, considering enforcement needs. Chapter 1410 provides guidance on HOV enforcement.

1600.05 Other Roadside Safety Features

1600.05(1) Rumble Strips and Rumble Stripes

Rumble strips are milled grooves or rows of raised pavement markers placed perpendicular to the direction of travel, or a continuous sinusoidal pattern milled longitudinal to the direction of travel, intended to alert inattentive drivers to a potential lane departure. A sinusoidal pattern can be used when a low noise design is desired.

The pavement receiving rumble strips needs to be in good condition and thick enough to support the rumble strips. Certain pavement types, such as open graded pavements, are not suitable for rumble strip installation. Grinding rumble strips into inadequate pavement will lead to premature deterioration of the surrounding pavement. Areas where the pavement is inadequate for rumble strip installation require removal and replacement of the existing pavement at and adjacent to the location of the rumble strip. Consult with the Region Materials Engineer to determine whether the existing pavement is adequate for rumble strip installation. The Region Materials Engineer will provide a pavement design for removing and replacing the existing pavement near the rumble strip if needed. When installing both rumble strips and recessed lane markers, follow the Standard Plan to avoid overlapping the grindings.

Contact HQ Bridge to confirm if rumble strips are appropriate to be installed on bridges included in the project.

Installing rumble strips in bituminous surface treatment (or BST) or other thin surface treatments can expose pavement structure and lead to delamination. In new rumble strip locations where BST will be applied on a Hot Mix Asphalt (HMA) pavement, install the rumble strips in the HMA pavement before placing the BST. In existing rumble strip locations, note that a single application of BST on top of an existing rumble strip installation typically results in satisfactory rumble strip depth. Where rumble strips currently exist and an additional BST application is contemplated, evaluate whether the depth of the grooves following paving will provide their continuing function to alert drivers. If not, or in the case of an HMA overlay, it may be necessary to remove existing rumble strips and install new ones.

Provide an offset to the longitudinal paving joint so that rumble strips are not ground into the joint where practicable. For additional guidance on surface preparation and pavement stability, refer to the *WSDOT Pavement Policy*.

The noise created when vehicle tires contact a rumble strip may adversely impact nearby residences and other land uses. Left-turning or passing vehicles, frequent passing maneuvers on two lane highways, and off-tracking of vehicles or trailers in tight radius curves, are examples of situations where incidental contact can happen. Noise impacts may be anticipated, and a low noise rumble strip design may be warranted, when installing rumble strips in urban growth areas, and/or within 600 feet of a residence, school, church, or campground. In situations where a low noise rumble strip is desired but is not feasible, measures can still be taken to reduce incidental contact, including discontinuing the rumble strip through frequently used road approaches, through passing zones, and in tight radius curves. Contact HQ Design for more information about low noise rumble strip designs, noise mitigation strategies, and the criteria for employing them.

There are three types of rumble strip functions: roadway, shoulder, and centerline, and each are described in the following sections.

1600.05(1)(a) Roadway Rumble Strips

Roadway rumble strips are placed transversely in the traveled way to alert drivers who are approaching a change of roadway condition or object that requires substantial speed reduction or other maneuvering. Some locations where advance roadway rumble strips may be placed include:

- Stop-controlled intersections
- Port of entry/customs stations
- Lane reductions where crash history shows a pattern of driver inattention, and
- Horizontal alignment changes where crash 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 HQ Design Office for additional guidance on the design and placement of roadway rumble strips.

Document decisions to use roadway rumble strips in the Design Documentation Package.

1600.05(1)(b) Shoulder Rumble Strips and Rumble Stripes

Shoulder rumble strips (SRS) are placed parallel to the traveled way just beyond the edge line to warn drivers they are entering a part of the roadway not intended for routine traffic use. Shoulder rumble stripes are rumble strips placed immediately under the shoulder delineation paint, with any excess width milled or placed outward towards the shoulder. Shoulder rumble stripes are only installed where there is insufficient space to install shoulder rumble strips per one of the standard configurations (see Section 1600.05(1)(b)(2), Undivided Highways).

When shoulder rumble strips and shoulder rumble stripes are used, discontinue them where no edge stripe is present, such as at intersections and where curb and gutter are present. Discontinue shoulder rumble strips and rumble stripes where shoulder driving is allowed.

Shoulder rumble strip and rumble stripe patterns vary depending on whether bicyclists are expected to use 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. Rumble strips and rumble stripes installed on undivided highways 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 and four shoulder rumble stripe patterns. Consult the *Standard Plans* (rumble strips) or *Plan Sheet Library* (rumble stripes) for patterns and construction details.

1. Divided Highways

Install shoulder rumble strips 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 or rumble stripe Type 1 pattern on divided highways.

Omit shoulder rumble strips or rumble stripes along highway segments where any of the following conditions occur:

- When another project scheduled within two years of the proposed project will overlay or reconstruct the shoulders or will use the shoulders for detours.
- At locations where the overall shoulder width is:
    - Less than 4-feet wide on the left (median) side of the roadway.
    - Less than 6-feet wide on the right side of the roadway (5-feet wide where rumble stripes are used).
- At locations where it’s been determined that noise is an issue and a low noise design is not appropriate (see Section 1600.05(1)).

2. Undivided Highways

Shoulder rumble strips or rumble stripes are typically considered on undivided highways during centerline rumble strip installation or pavement rehabilitation. A list of prospective locations are provided to regions by HQ Design as a starting point in their development of a final list. The final list is compiled based on a field review of the prospective locations.

Omit shoulder rumble strips or rumble stripes along highway segments where any of the following conditions occur:

- Where usable shoulder for bicycles will be reduced to less than 4-feet (5-feet where barrier is present). Field-verify these dimensions.
- Where downhill grades exceed 4% for more than 500 feet in length along routes where bicyclists are frequently present.
- At locations where it's been determined that noise is an issue and a low noise design is not appropriate (see Section 1600.05(1)).

Document decisions to omit prospective rumble strip or rumble stripe locations in the final list of locations.

When selecting a rumble strip or rumble stripe design, consult the *Standard Plans* and *Plan Sheet Library* for the patterns and construction details, and apply the following criteria:

- Consider using a low noise pattern, or employ measures to reduce incidental contact, in areas where noise impacts are anticipated (apply criteria in Section 1600.05(1)).
- Consider using a rumble stripe in narrower sections where they can help provide the required 4-feet of usable shoulder (5-feet where guardrail is present).
- Use Shoulder Rumble Strip Type 2 or Type 3 pattern on highways with minimal bicycle traffic.
- Use the Shoulder Rumble Strip Type 4 pattern where the bicycle traffic level on the shoulder is determined to be high. Consult the region and Headquarters Bicycle and Pedestrian Coordinators to determine the bicycle traffic level, and engage them in decision-making processes related to the use of rumble strips or rumble stripes on bike touring routes, and/or on other routes where bicycle events are regularly held.

1600.05(1)(c) Centerline Rumble Strips

Centerline rumble strips are installed on the centerline of undivided highways to alert drivers that they are entering the opposing lane. They are installed with no differentiation between passing permitted and no passing areas. Refresh pavement markings when removed by centerline rumble strips.

Centerline rumble strips are typically installed on rural highways where the posted speed is 45 mph or higher. They may also be installed on urban routes with posted speeds as low as 35 mph. A list of prospective centerline rumble strip installation locations are provided to regions by HQ Design as a starting point in their development of a final list. The final list is compiled based on a detailed review of the prospective locations using the following criteria.

- Field verify lane and shoulder widths. See Chapter 1230 for guidance on lane and shoulder widths. Centerline rumble strips are only installed where the combined lane and shoulder width in either direction is greater than 12 feet.

- In locations where the combined lane and shoulder width in either direction is 14 feet or less, consider the level of bicyclist and pedestrian use along the route before installing centerline rumble strips. When drivers shift their lane position away from centerline to avoid the rumble strips, they are moving closer to pedestrians and bicyclists on the shoulder.
- Consider using a low noise rumble strip design in locations where noise is an issue, or employ measures for reducing incidental contact where a low noise design is not feasible (apply criteria in Section 1600.05(1)).
- In urban areas, do not consider installing rumble strips where the need to interrupt the rumble strip pattern to accommodate left-turning vehicles is very frequent, or where the posted speed is 35 mph and below.
- Do not use centerline rumble strips where two way left-turn lanes exist.

Document the decision to omit centerline rumble strips in a Design Analysis, when that decision is outside of the policy provided in this section (see Chapter 300.)

1600.05(2) Headlight Glare Considerations

Headlight glare from opposing traffic is most common between opposing main line traffic. Glare screens can be used to mitigate this condition. Other conditions for which glare screen might be appropriate are:

- Between a highway and an adjacent frontage road, multi-use path, 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.
- 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.

Glare screening is normally not justifiable where the median width exceeds 20 feet, and the ADT is less than 20,000 vehicles per day. Document the decision to use glare screening using the following criteria:

- Higher frequency of night crashes compared to similar locations or based on statewide experience.
- Higher than normal ratio of night-to-day crashes.
- Unusual distribution or concentration of nighttime crashes.
- Over-representation of older drivers in night crashes.
- 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.

There are currently three basic types of glare screening available: chain link (see the *Standard Plans*), vertical blades, and concrete barrier (see Exhibit 1600-8).

When the glare is temporary (due to construction activity), consider traffic volumes, alignment, duration, presence of illumination, and type of construction activity. Glare screening 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.

1600.06 Documentation

Refer to Chapter 300 for design documentation requirements.

1600.07 References

1600.07(1) Federal/State Laws and Codes

Revised Code of Washington (RCW) 47.24.020(2), Jurisdiction, control

RCW 47.32.130, Dangerous objects and structures as nuisances

1600.07(2) Design Guidance

Highway Safety Manual, AASHTO

Local Agency Guidelines (City and County Design Standards), M 36-63, WSDOT

Roadside Design Guide, AASHTO, 2011

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

1600.07(3) Supporting Information

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2011

Understanding Design Clear Zone – This e-learning course for WSDOT employees covers how to determine the appropriate Design Clear Zone for recoverable and nonrecoverable slopes as well as ditches. Request this training via the web-based Learning Management System.

Highways Over National Forest Lands, MOU, 2013, US Forest Service and WSDOT, www.wsdot.wa.gov/publications/manuals/m22-50.htm

Utilities Manual, M 22-87, WSDOT. Chapter 9 provides Control Zone guidance for utilities in the WSDOT right of way.

Exhibit 1600-2 Design Clear Zone Distance Table

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 ft											
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 – 2,000	12	12	12	12	12	12	*	16	15	14	13	12
	2,001 – 6,000	14	14	14	14	14	14	*	17	17	16	15	14
	Over 6,000	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 – 2,000	13	13	14	14	14	14	*	20	17	16	15	14
	2,001 – 6,000	15	15	16	16	16	16	*	22	19	17	17	16
	Over 6,000	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 – 2,000	14	15	16	17	17	17	*	24	20	18	17	17
	2,001 – 6,000	16	17	17	18	18	18	*	27	22	20	18	18
	Over 6,000	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 – 2,000	15	17	19	20	20	21	*	31	26	23	22	21
	2,001 – 6,000	17	19	21	22	22	23	*	34	29	26	24	23
	Over 6,000	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 – 2,000	17	20	22	22	23	24	*	37	31	28	26	25
	2,001 – 6,000	18	22	24	25	26	27	*	41	34	31	29	28
	Over 6,000	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 – 2,000	19	22	24	25	26	27	*	41	34	31	29	28
	2,001 – 6,000	20	25	27	27	29	30	*	46	37	35	32	31
	Over 6,000	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 – 2,000	20	24	26	27	28	29	*	45	37	34	31	30
	2,001 – 6,000	22	27	29	29	31	32	*	50	40	38	34	33
	Over 6,000	24	29	31	32	34	35	*	54	44	41	37	36

Notes:

This exhibit applies to:

- All state highways outside incorporated cities.
- Limited access state highways within cities.

For Roadside and Median areas on managed access state highways within incorporated cities, see 1600.02 for guidance. Curb is not considered adequate to redirect an errant vehicle.

Design Clear Zone distances are given in feet, measured from the edge of traveled way.

*When the fill section slope is steeper than 4H:1V, but not steeper than 3H:1V, the Design Clear Zone distance is modified by the recovery area formula (see Exhibit 1600-4) 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); therefore, the horizontal distance of these slopes is added to the Design Clear Zone distance to form the recovery area. Provide a minimum of 10 feet at the toe of all traversable, non-recoverable fill slopes.

Exhibit 1600-3 Design Clear Zone Inventory Form

See: www.wsdot.wa.gov/design/support.htm for this form template in PDF, Word, or Excel spreadsheet. (PDF Shown Below) Remember, this form has 2 sides when copying.

Front sheet

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

DOT Form 410-026 EF
Revised 4/05

(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 be forwarded to the region Utility Office for coordination per Control Zone Guidelines.

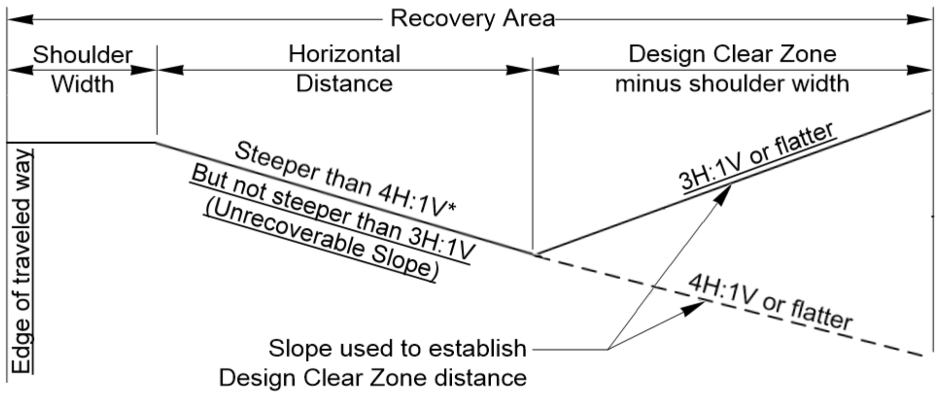
Back sheet

Item Number	Reasons for Not Taking Corrective Action

DOT Form 410-026 EF
Revised 4/05

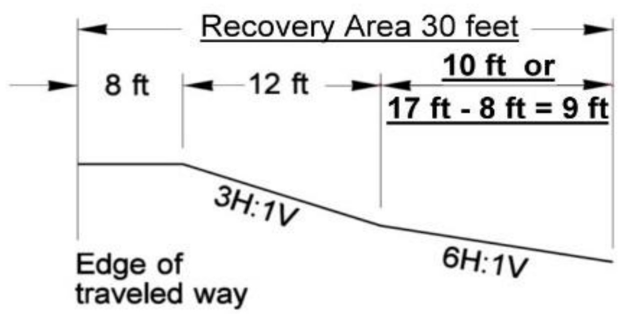
Exhibit 1600-4 Recovery Area

Recovery area formula = (shoulder width) + (nonrecoverable slope distance) + the greater of [10 ft or (Design Clear Zone distance – shoulder width)]



* When the fill section slope is steeper than 4H:1V, but not steeper than 3H:1V, the Design Clear Zone distance is modified by the recovery area formula (see Exhibit 1600-4) and is referred to as the recovery area. The recovery area formula can be used in certain situations with foreslopes steeper than 3H:1V (see 1600.03(1)(a) and Exhibit 1600-5: Case 3 for more information). The basic philosophy behind the recovery area formula is that the vehicle can traverse these slopes but cannot recover and return to the roadway (control steering); therefore, the horizontal distance of these slopes is added to the Design Clear Zone distance to form the recovery area.

Example Recovery Area Calculation: 3H:1V foreslope with 6H:1V fill section used to establish Design Clear Zone distance



Criteria:

Recovery area formula = (shoulder width) + (nonrecoverable slope distance) + the greater of [10 ft or (Design Clear Zone distance – shoulder width)]

Example Conditions:

Shoulder width = 8 ft

Nonrecoverable slope distance = 12 ft

Speed = 45 mph

Traffic = 3,000 ADT

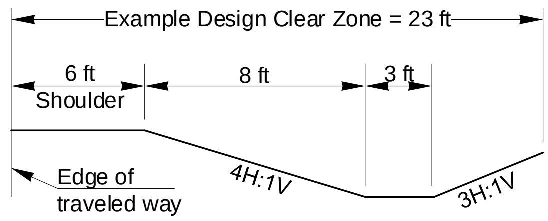
3H:1V Fill Section (Nonrecoverable)

Slope used to establish Design Clear Zone distance 6H:1V Fill Section

Example recovery area = 20 + 10 ft = 30 feet

Exhibit 1600-5 Design Clear Zone Examples for Ditch Sections

Case 1: Cut Section with Ditch (foreslope 4H:1V or flatter)



Criteria:

Greater of:

[1] Design Clear Zone for 10H:1V cut section
[2] 5 feet horizontal beyond beginning of back slope

Example Conditions:

Speed = 55 mph

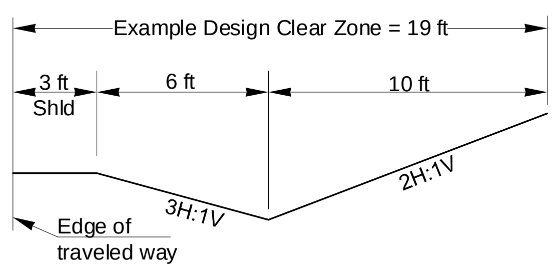
Traffic = 4,200 ADT

Foreslope = 4H:1V

Beginning of backslope = 17 feet

Design Clear Zone = 23 feet

Case 2: Cut section with ditch (foreslope steeper than 4H:1V and backslope steeper than 3H:1V)



Criteria:

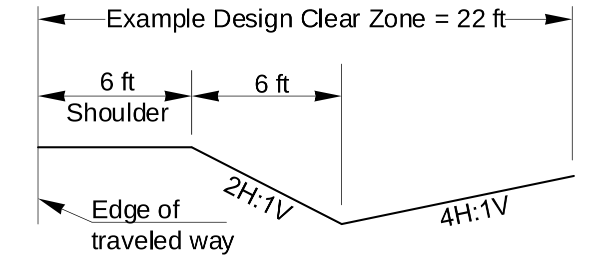
10 feet horizontal beyond beginning of backslope

Example Conditions:

Beginning of backslope = 9 feet

Design Clear Zone = 19 feet

Case 3: Cut section with ditch (foreslope 3H:1V or steeper and backslope not steeper than 3H:1V)



Criteria:

Use recovery area formula

Recovery area formula = (shoulder width) + (nonrecoverable slope distance) + the greater of [10ft or (Design Clear Zone distance – shoulder width)]

Example Conditions:

Speed = 45 mph

Traffic = 3,000 ADT

Foreslope = 2H:1V

Slope used to establish Design Clear Zone distance = 4H:1V Backslope

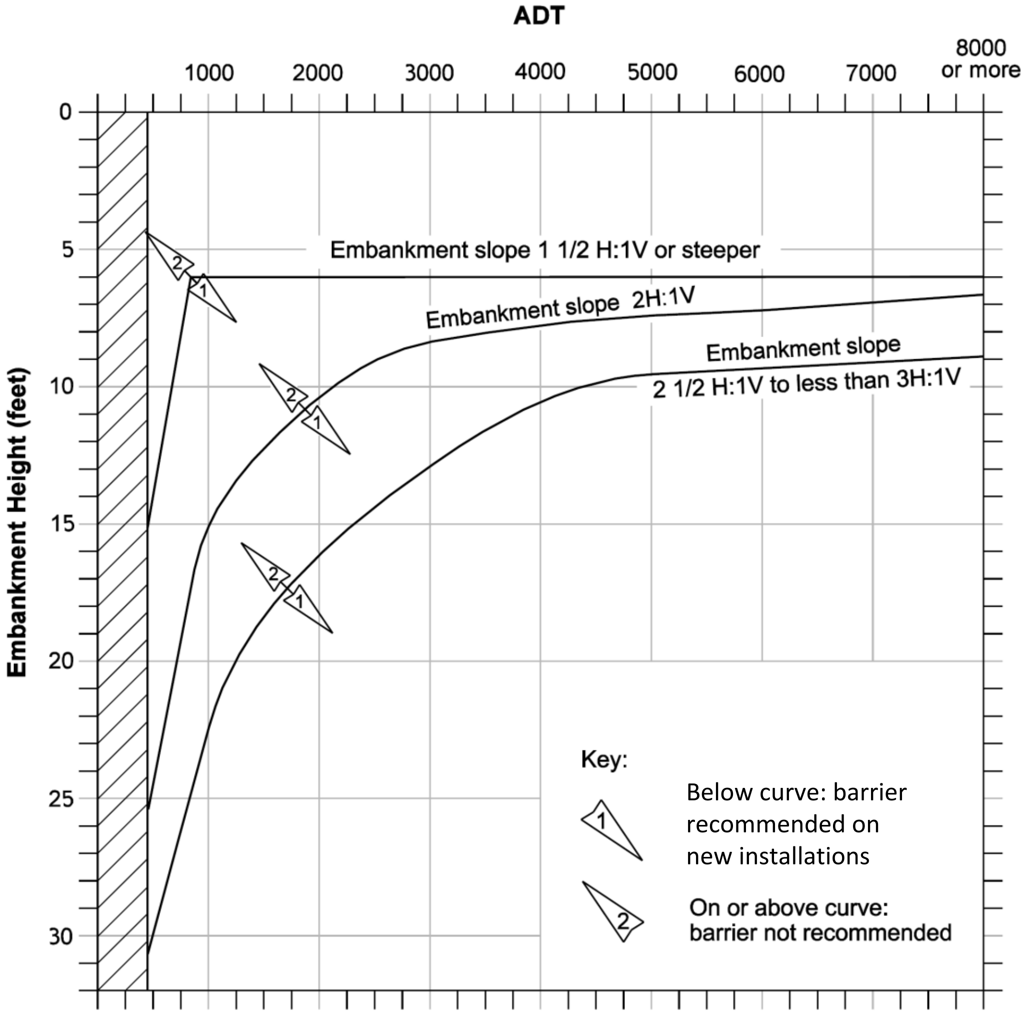
Recovery Area = (shoulder width (6 ft)) + (nonrecoverable slope distance (6 ft)) + greater of [(1) or (2)]:

(1) 10 ft

(2) Design Clear Zone distance for 4H:1V fill section (15 ft) – shoulder width (6 ft)) = 9 ft

Recovery Area = 22 feet

Exhibit 1600-6 Guidelines for Embankment Barrier



Note:

Routes with ADTs under 400 may be evaluated on a case-by-case basis.

Exhibit 1600-7 Mailbox Location and Turnout Design

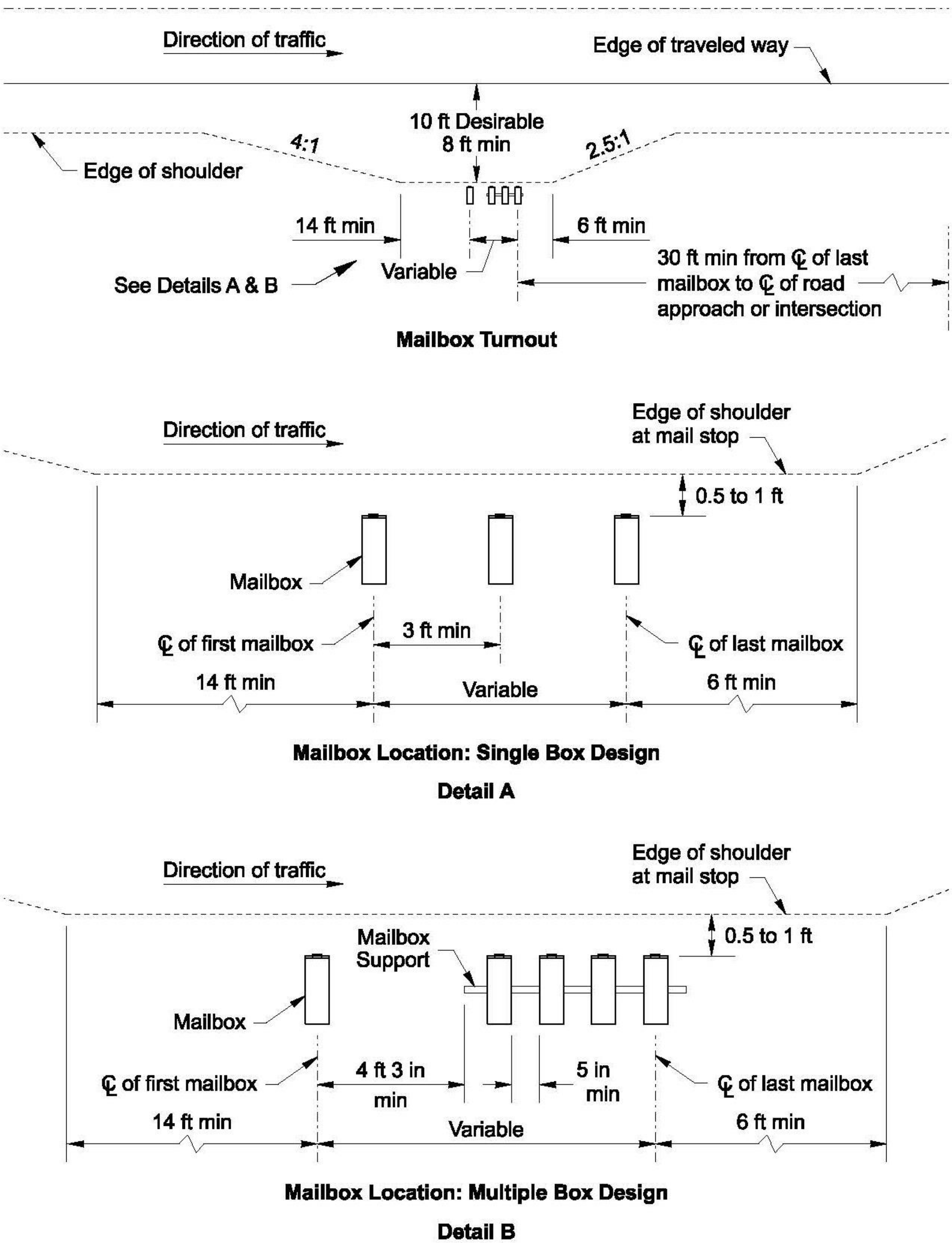
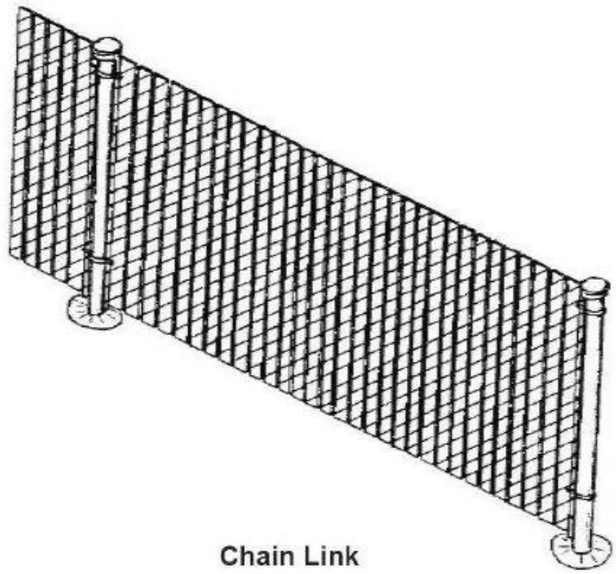
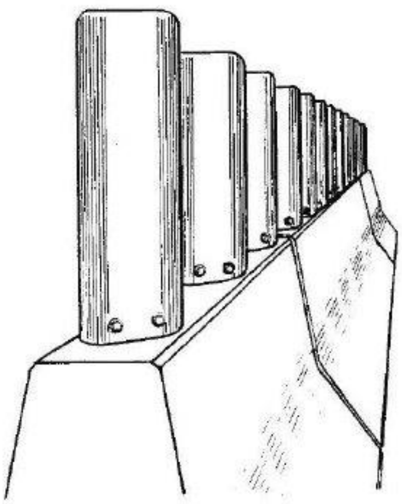


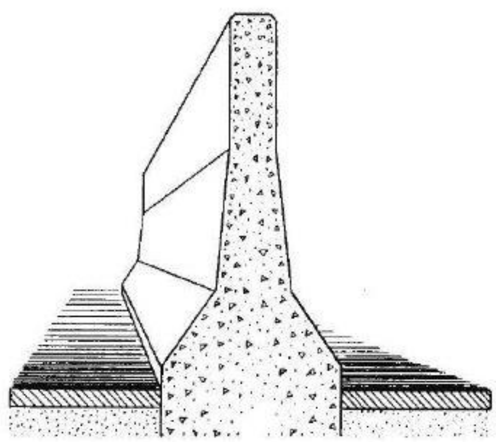
Exhibit 1600-8 Glare Screens



Chain Link



Vertical Blades



Concrete Barrier

Chapter 1610 Traffic Barriers

Chapter Organization: The first sections (Introduction and Barrier Impacts) present information to consider when deciding whether to install a barrier. The next section (General Barrier Design Considerations) contains guidance common to ALL barrier types, such as deflection distance, length of need and sight distance. The remaining sections present design information organized by specific barrier type (beam guardrail, cable barrier, etc.).

Refer to the *Design Manual* Glossary for many of the terms used in this chapter.

Refer to Chapter 300 for design documentation requirements.

1610.01 Introduction

WSDOT uses traffic barriers to reduce the overall severity of crashes. Consideration is given as to whether a barrier is preferable to the recovery area it may replace. In some cases, installation of a traffic barrier may result in more crashes as it presents an object that can be struck. Barriers are designed so that such encounters might be less severe and not lead to secondary or tertiary crashes. However, traffic barriers are not guaranteed to redirect an impacting vehicle without resulting injury to its occupants or triggering additional crashes. Barrier performance is affected by the characteristics of the vehicles that collide with them. Different vehicles will react differently given the characteristics and dynamics of the crash. Therefore, vehicles will be decelerated and redirected differently given the size, weight and direction of force imparted from the vehicle to the barrier.

Barriers are not placed with the assumption that the system will restrain or redirect all vehicles in all conditions. It is recognized that the designer cannot design a system that will address every potential crash situation. Instead, barriers are placed with the assumption that, under typical crash conditions, they might decrease the potential for excessive vehicular deceleration or excessive vehicle redirection when compared to the location without the barrier.

Traffic barriers do not prevent crashes or injuries from occurring. They often lower the potential severity for crash outcomes. Consequently, barriers should not be used unless a reduced crash severity potential is likely. No matter how well a barrier system is designed, optimal performance is dependent on drivers' proper maintenance and operation of their vehicles and the proper use of passenger restraint systems. The ultimate choice of barrier type and placement should be made by gaining an understanding of site and traffic conditions, having a thorough understanding of and applying the criteria presented in Chapters 1600 and 1610, and using engineering judgment.

Barrier systems and vehicle fleets continue to evolve. The choice of a barrier is based on the characteristics of today's vehicle fleet and testing criteria, not on speculative assumptions of future vehicle designs. This continuum of change does not allow engineers to predict the future with any degree of certainty. Consequently, engineering decisions need to be made based on the most reliable and current information.

Engineers are constantly striving to develop more effective design features to improve highway safety. However, economics, asset management and maintenance needs, and feasibility do not permit the deployment of new designs as soon as they become available on the market or are invented by a manufacturer. Further, most new designs only make marginal changes to systems and do not imply that old designs are unsafe or need modification.

Solutions may consider crash frequency and severity. As discussed previously, performance of the system relies on the interaction of the vehicle, driver, and system design at any given location. Additionally, the ability to safely access, maintain and operate over time is incorporated into the final barrier decision.

When barriers are crash-tested, it is impossible to replicate the innumerable variations in highway conditions under which the barrier applications occur. Therefore, barriers are crash-tested under standardized conditions. These standard conditions were previously documented in National Cooperative Highway Research Program (NCHRP) Reports 230 and 350. These guidelines have been updated and are now presented in the AASHTO publication, *Manual for Assessing Safety Hardware* (MASH).

The MASH criteria is implemented by WSDOT product category. Implementation takes place as designs and products are successfully tested or otherwise evaluated, become available and/or can be specified and are accepted by WSDOT for use. Following acceptance, implementation is documented through modifications to the corresponding standard specification(s), standard plan(s), and/or are accepted to the Qualified Products List (in the case of proprietary hardware). When a hardware category is converted to MASH, existing hardware may remain in service and be repaired as needed. However, if a full replacement is needed during the course of repair, a MASH compliant device is used if at least one suitable model or design has been accepted for use. The policy on work zone devices is described in Chapter 1010. To learn more about WSDOT's plan for implementing MASH-compliant hardware see the following website:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.01(1) Site Constraints

Site constraints play a major role in decisions regarding guardrail selection and placement. Depending on the location, these constraints may include (but are not limited to) environmental considerations, topographic challenges, restricted right-of-way, geologic concerns or conflicts with other infrastructure to name just a few. Document barrier location decisions, including any site constraints encountered that influenced those decisions. A decision to install barrier using criteria outside the guidance provided in this chapter requires a Design Analysis (See Chapter 300).

1610.02 Barrier Impacts

Engineering judgment is required in determining the appropriate placement of barrier systems, therefore consider the location of the system and the possible impacts the barrier may have to other highway objectives.

1610.02(1) Assessing Impacts to Stormwater and Wetlands

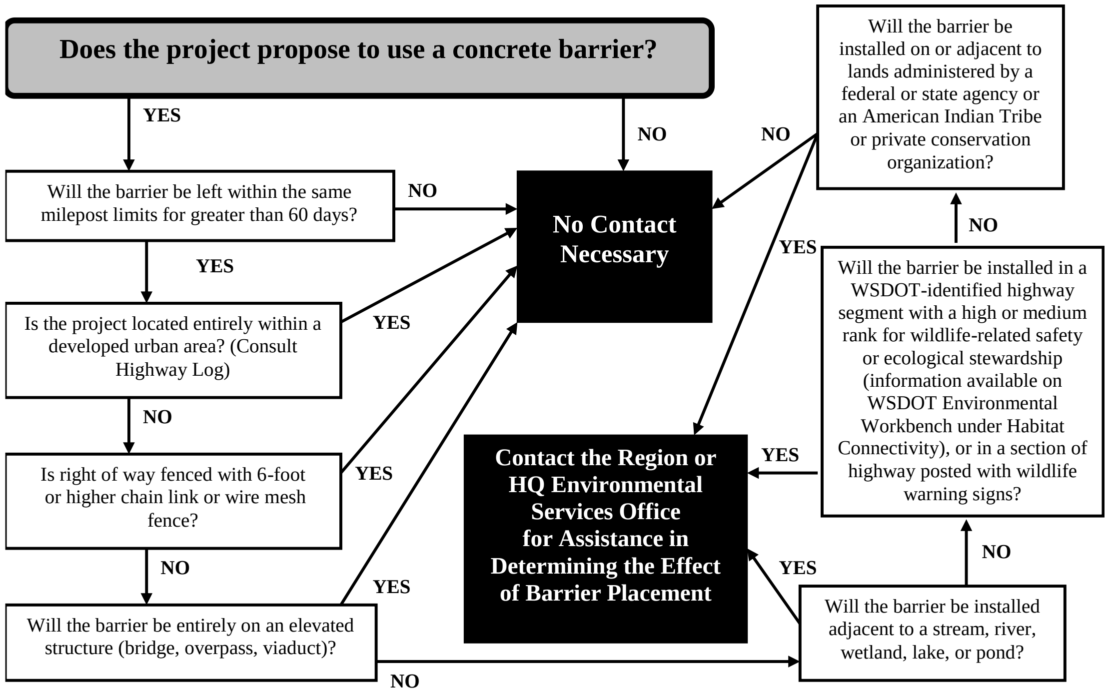
The presence of stormwater facilities or wetlands influence the choice and use of barrier systems. For example, the placement of concrete barrier may increase the amount of impervious surface, which could then result in retrofit or reconstruction of the existing retention/detention systems and environmental impact requirements and studies. Assess whether concrete barrier or beam guardrail placement will cause the need for an evaluation by the HQ Environmental Services Office. Conduct this evaluation early in the project's development process to allow adequate time for discussion of options.

1610.02(2) Assessing Impacts to Wildlife

The placement of concrete barriers in locations where wildlife frequently cross the highway can influence wildlife-vehicle crash potential. When wildlife encounters physical barriers that are difficult to see beyond or cross, such as concrete barriers, they often stop or move parallel to those barriers, increasing their time on the highway and their exposure.

Traffic-related wildlife mortality may play a role in the decline of some species listed under the Endangered Species Act. To address wildlife concerns, see Exhibit 1610-1 to assess whether barrier placement needs to have an evaluation by the HQ Environmental Services Office to determine its effect on wildlife. Conduct this evaluation early in the project development process to allow adequate time for discussion of options.

Exhibit 1610-1 Concrete Barrier Placement Guidance: Assessing Impacts to Wildlife



1610.03 General Barrier Design Considerations

See Chapter 1105 Design Element Selection for guidance regarding required design elements for the various different project types (programs and subprograms).

Chapter 1120 identifies those elements and features to be evaluated and potentially addressed during the course of a Preservation project.

Follow the guidance in this chapter for any project that introduces new barrier onto the roadside (including median section) and follow the guidance in Chapter 1600 for removal of barrier that is not needed. Slope flattening is recommended when the crash reduction benefit justifies the additional cost to eliminate the need for barrier.

When selecting a barrier, consider the barrier system's deflection characteristics, cost, maintainability and impacts to traffic flow during repair. Barriers are categorized as flexible, semi-rigid, or rigid depending on their deflection characteristics (see Exhibit 1610-3). Barrier types include:

- Beam Guardrail
- Cable Barrier
- Concrete Barrier
- Bridge Traffic Barrier
- Other Barriers

Since non-rigid systems typically sustain more damage during an impact, consider the amount of traffic exposure maintenance crews might incur with the more frequent need for repairs.

The costs for procuring and maintaining the barrier system are important factors when considering what system to install. Considerations may include:

- Consultation with the Area Maintenance Superintendent to identify needs or recommendations.
- 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. Cable barrier is not an obstruction to drifting snow.
- Analysis of potential reduction of sight distance due to barrier selection and placement.
- Additional widening and earthwork requirements. With some systems, such as concrete barrier and beam guardrail, the need for additional shoulder widening or slope flattening is common. Selection of these types of barriers may require substantial environmental permitting or roadway reconstruction. Permits issued under the SEPA and NEPA processes may lead to the use of a barrier design, such as cable barrier, which has fewer potential environmental impacts and costs.
- For concrete barrier systems:
    - Lower maintenance costs than for other barrier types.
    - Deterioration due to weather and vehicle impacts is less than most other barrier systems.
    - Unanchored precast concrete barrier can usually be realigned or repaired after a vehicle impact. However, heavy equipment may be necessary 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. See Exhibit 1610-3 for deflection area requirements.

Consider the following for existing barrier systems:

- Install, replace, or modify transitions as discussed in 1610.04(6) Transitions and Connections.
- When installing new terminals, extend the guardrail to meet the length-of-need criteria found in Section 1610.03(5).
- When replacing damaged terminals, consider extending the guardrail to meet the length of need criteria in 1610.03(5)
- When the end of a barrier has been terminated with a small mound of earth, remove and replace with a terminal as described in 1610.06(4).
- Special use or aesthetic barriers may be used on designated Scenic Byway and Heritage Tour routes if funding, permits, and approvals can be arranged (see 1610.08).
- Design Manual Chapter 1120 identifies specific requirements to be addressed for a Preservation project. For other projects, address barrier runs that include:
    - W-beam guardrail with 12-foot 6-inch post spacing, or no blockouts, or both.

- W-beam guardrail on concrete posts.
- Cable barrier on wood or concrete posts.
- Half-moon or C-shaped rail elements.

1610.03(1) Barrier Placement Considerations

Proper installation of a barrier system is required for the system to perform similar to the crash tests that resulted in its acceptance for use on our highways. Maximize the distance between the barrier and the travelled way.

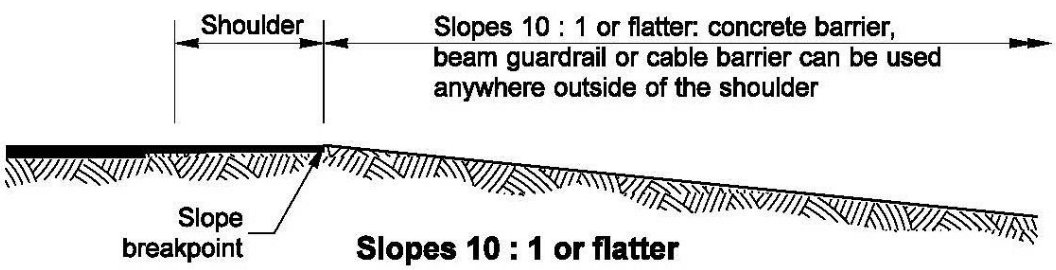
See Chapter 1239 for minimum lateral clearance requirements.

1610.03(1)(a) Placement on a Slope

Slopes may affect barrier placement. Considerations for barrier placement on a slope include:

- For slopes that are 10:1 or flatter, concrete barrier, beam guardrail or cable barrier can be installed anywhere beyond the edge of shoulder. See Exhibit 1610-2.
- For additional placement guidance see 1610.05(1) for cable barrier, see 1610.04(2) for beam guardrail, and see 1610.06 for concrete barrier.

Exhibit 1610-2 Traffic Barrier Locations on Slopes



1610.03(1)(b) Placement in Median Locations

Considerations for barrier placement in a median include:

- The following barrier types may be used in medians in new installations: Cast in place or precast single slope double-sided concrete barrier, F-shape double-sided concrete barrier (either pinned or unpinned), Type 31 w-beam guardrail, double-sided Type 31 w-beam guardrail, and high tension cable barrier.
- Select the appropriate barrier type using the following criteria:
  - Use single slope high performance concrete barrier (HP barrier) on freeways with medians 22-feet wide and less.
  - Any barrier type listed above may be used on freeways with medians greater than 22-feet wide.
  - Contact HQ Design when retrofitting non-freeways with median barrier (regardless of median width).
- Address the design deflection characteristics of the barrier to avoid placement of barrier where the design deflection extends into oncoming traffic.

- Narrow medians provide little space for any maintenance activities, including repair or repositioning of the barrier. Installing barriers in medians that provide less than 8 feet from the edge of the traveled way to the face of the barrier will likely require temporarily closing the adjacent lane during maintenance activities. This will impact the travelling public and impact maintenance staff, and maintenance staff should be consulted. See Chapter 301 Design and Maintenance Coordination.
- 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 needed along the lower roadway except where there are fixed features in the median.
- In wider medians, the selection and placement 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 of the median as possible so that the recovery distance can be maximized for both directions. There may be a need to offset the barrier from the flow line to avoid impacts to the drainage flow.
- In general, cable barrier is recommended with medians that are 30 feet or wider. However, cable barrier may be appropriate for narrower medians if adequate deflection distance exists.
- When W-beam barrier is placed in a median as a countermeasure for cross-median crashes, design the barrier to be struck from either direction of travel. For example, the installation of beam guardrail might be double-sided (Type 31-DS).
- Barrier may be provided under certain conditions as separation between a freeway mainline and collector-distributor road (see Chapter 1360).
- For additional placement guidance see 1610.05(1) for cable barrier, see 1610.04(2) for beam guardrail, and see 1610.06 for concrete barrier.

1610.03(2) Sight Distance

When selecting and placing a barrier system, consider the possible impact the barrier type and height may have on sight distance. In some cases, barriers may restrict the sight distances of road users entering the roadway, such as from road approaches, intersections, and other locations. In these cases, the barrier may need to be adjusted to meet the sight distance requirements at these locations.

1610.03(3) Barrier Deflections

Expect all barriers, except for certain types of rigid barriers (such as concrete bridge rails, barrier integral to retaining walls, or embedded cast-in-place barriers), to deflect when hit by an errant vehicle. The amount of deflection is primarily dependent on the stiffness of the system. However, vehicle speed, angle of impact, and weight of the vehicle also affect the amount of barrier deflection.

For roadside or wide median installations of flexible and semi-rigid roadside barriers (high tension cable barrier and beam guardrail), 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 help prevent the barrier from being knocked over the side of a drop-off or steep fill slope (2H:1V or steeper).

For narrower median installations, design systems so that the anticipated deflection will not enter the lane of opposing traffic. When evaluating new barrier installations, consider whether impacts would require significant traffic closures to accomplish maintenance. Rigid embedded barrier systems are used when no barrier deflection is necessary or desired (areas such as narrow medians, at the edge of bridge decks, or other vertical drop-off areas). Runs of rigid embedded concrete barrier can be precast, cast in place, or extruded with appropriate footings.

In locations where deflection distance is limited, precast concrete barrier can be anchored. Some movement can be expected for rigid anchored barrier systems and repairs may be more expensive (anchoring pins may damage the asphalt or concrete surface that the barrier is placed upon during a vehicle collision).

Use of an anchored precast concrete barrier and other deflecting barrier systems placed on top of a retaining wall at less than the deflection distances provided in Exhibit 1610-3 requires approval from the HQ Design Office. See 1610.06 for more information on concrete barrier.

Exhibit 1610-3 provides barrier deflection design values when selecting standard runs of longitudinal barrier. This exhibit does not provide deflection values for specialty barrier systems or installations (for example long span guardrail systems, box culvert guardrail systems, Type 31 barrier installed on a flare, etc.). Contact HQ Design for specialty barrier systems or installations deflections. The deflection values for cable and beam guardrail are minimum distances measured between the face of the barrier to the fixed feature. The deflection values for concrete barrier are minimum distances measured from the back edge of the barrier to the fixed feature, drop-off, or slope break.

Exhibit 1610-3 Longitudinal Barrier Deflection

Barrier Type	System Type	Deflection Distance
High-tension cable barrier	Flexible	6 ft to 10 ft typical [1] (measured from face of barrier to object)
Beam guardrail, Types 1, 1a, 2, and 10	Semi-rigid	3 ft [3] (measured from face of barrier to object)
Beam guardrail, two-sided Types 3, and 4	Semi-rigid	4 ft (measured from nearest face of barrier to object)
Beam guardrail Type 31 (including two-sided and omitted post)	Semi-rigid	5 ft (measured from face of barrier to object)
Permanent precast concrete barrier, unanchored	Rigid Unrestrained	6 ft (measured from back of barrier to object, slope break point, or drop-off)
Permanent precast concrete barrier, unanchored (When placed in front of a 2:1 or flatter fill slope on right hand shoulders and not shielding any fixed objects. Contact HQ Design before using this deflection condition for barrier placed in medians)	Rigid Unrestrained	3 ft (measured from back of barrier to slope break point)
Permanent precast concrete barrier, anchored	Rigid Anchored	2 ft (measured from back of barrier to object, slope break point, or drop-off)
Temporary precast concrete barrier, unanchored [4]	Rigid Unrestrained	3 ft [2] (measured from back of barrier to object, slope break point, or drop-off)
Temporary precast concrete barrier, anchored [4]	Rigid Anchored	1 ft [2] [5] (measured from back of barrier to object, slope break point, or drop-off)
Cast in place or precast concrete barrier, embedded	Rigid Embedded	No deflection [6]

Notes:

This exhibit provides deflection values for standard runs of barrier. It does not provide deflection values for specialty systems or installations (e.g. long span guardrail systems, box culvert guardrail systems, Type 31 barrier installed on a flare, etc.).

[1] See Section 1610.05(2)

[2] When used as temporary bridge rail, anchor all barrier when the back of barrier is located within 3 feet of a drop-off.

[3] Place any new objects a minimum of 5 feet from the face of existing beam guardrail type 1.

[4] Steel barrier is also available for temporary applications. See Chapter 1010 for more information.

[5] When anchoring temporary precast concrete barrier on bridges or other drop-offs, see applicable Standard Plans for anchorage details, lateral offsets, and deflection distances.

[6] When placed in front of a fill slope or on top of an MSE wall, provide a minimum distance of 2-feet of widening with a 10:1 or flatter slope from the back of barrier to the slope break point.

1610.03(4) Flare Rate

A roadside barrier is considered flared when it is not parallel to the edge of the traveled way.

Flare the ends of longitudinal barriers where site constraints allow (see Section 1610.01(1)). The four functions of a flare are to:

- Maximize the distance between the barrier (and its terminal) and the travelled way.
- Reduce the length of need.
- Redirect an errant vehicle.
- Minimize a driver's reaction to the introduction of an object near the traveled way.

Keeping flare rates as flat as site constraints allow preserves the barrier's redirectional performance and minimizes the angle of impact. It has also 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 the driver does not perceive the barrier as an object to be avoided. The flare rates in Exhibit 1610-4 are intended to satisfy the four functions listed above. Flares that are more gradual may be used. Flare rates are offset parallel to the edge of the traveled way. Transition sections are not flared.

Situations exist where hardware installations may have barrier flare rates different than shown in Exhibit 1610-4. If a *Standard Plan* for a barrier installation shows a different flare rate than is shown in Exhibit 1610-4, the flare rate shown on the *Standard Plan* can be used.

Exhibit 1610-4 Longitudinal Barrier Flare Rates

Posted Speed (mph)	Rigid & Rigid Anchored System	Unrestrained Rigid System	Semi-rigid
65–70	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

1610.03(5) Length of Need

Length of need refers to the total length of longitudinal barrier needed to shield a fixed feature.

In many cases, there may be a portion of the traffic barrier installation that is not redirective in capability. For instance, if a run of concrete barrier is terminated with an impact attenuator, there will likely be a section of the impact attenuator that is not redirective (see Chapter 1620 for more information). Therefore, in most cases, the Length of Need does not equal (i.e., it is shorter than) the actual physical length of the traffic barrier installation required to achieve that length of need.

Length of need is dependent on the location and geometrics of the object, direction(s) of traffic, posted speed, motor vehicle traffic volume, and type and location of traffic barrier.

When designing a barrier for a fill slope (see Chapter 1600), the length of need begins at the point where the need for barrier is recommended. For fixed objects and water, Exhibit 1610-5 shows design parameters for determining the needed length of a barrier for both adjacent and opposing traffic on relatively straight sections of highway.

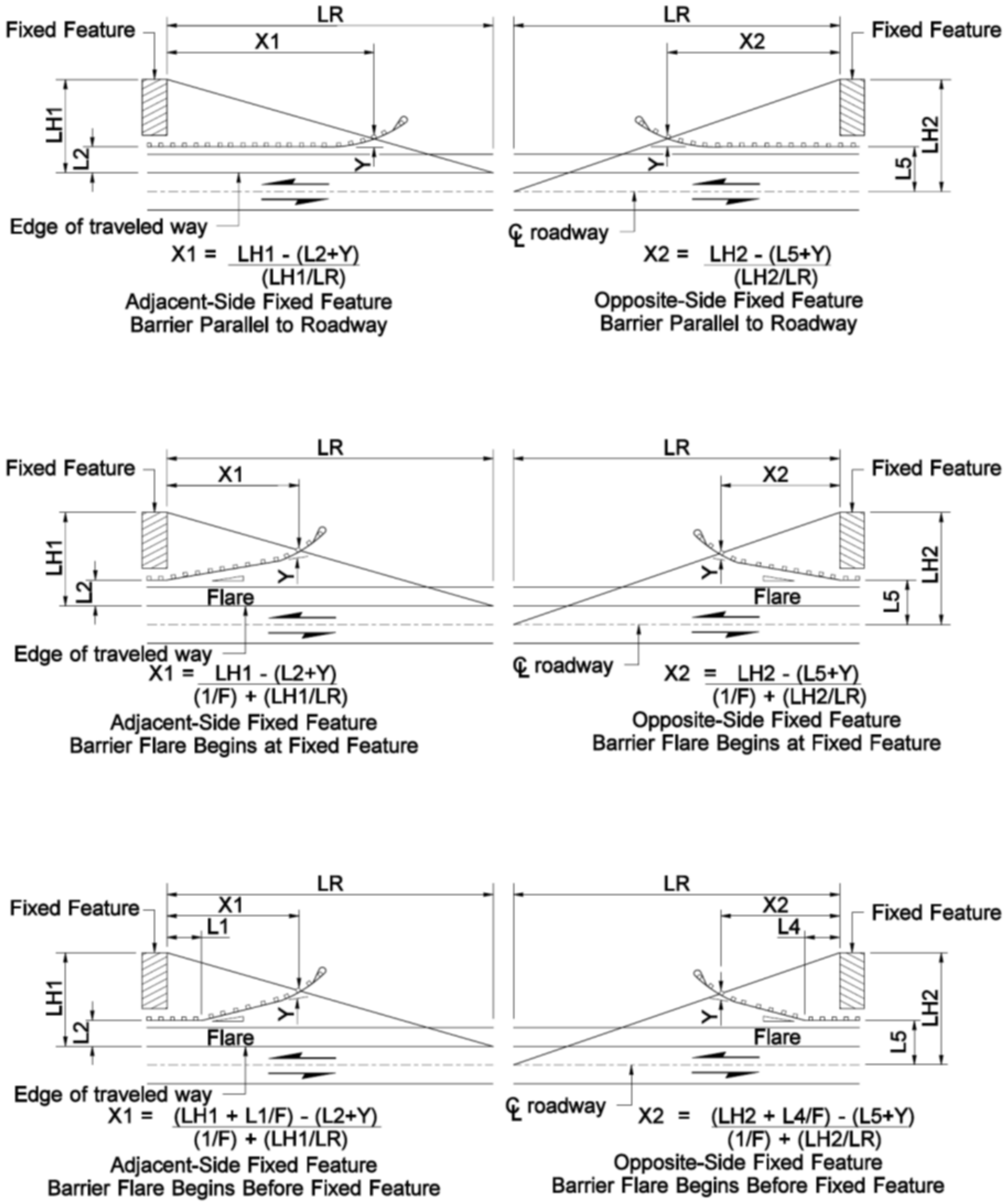
When barrier is to be installed on the outside of a horizontal curve, the length of need can be determined graphically as shown in Exhibit 1610-7. For installations on the inside of a curve, determine the length of need as though it were straight. Also, consider the flare rate, barrier deflection, and barrier end treatment to be used.

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 Design Clear Zone of opposing traffic (see Exhibit 1610-8). This is also a consideration when objects are placed in the outer separations between the main line and collector-distributors.

Before the actual length of need is determined, establish the lateral distance between the proposed barrier installation and the object shielded. Provide a distance that is greater than or equal to the anticipated deflection of the longitudinal barrier. (See Exhibit 1610-3 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 within 300 feet of another barrier run (either existing or proposed), it is recommended that the barriers be connected to form a continuous run except where the gap involves a buried terminal and cut slope. In these cases and where practicable, extend barrier runs beyond the length of need to a backslope and provide a buried terminal (see Section 1610.06(4) for concrete barrier buried terminal, and Section 1610.04(5) and Standard Plan C-22.16 for beam guardrail buried terminal). Where access is needed behind a barrier (e.g. maintenance access, utility objects, road approaches, etc.) and an alternative approach to providing access is not practicable, provide a gap in the barrier that meets the access need using a configuration where the termination of the downstream run is situated behind the upstream run, or is otherwise outside the Design Clear Zone. Where this overlapping configuration is not practicable, provide a minimum size gap in the guardrail run to meet the access need and evaluate for the need of crashworthy terminals on the upstream and downstream runs.

Exhibit 1610-5 Barrier Length of Need on Tangent Sections



Note:

For supporting length of need equation factors, see Exhibit 1610-6

Exhibit 1610-6 Barrier Length of Need

Posted Speed (mph)	Design Parameters						
	ADT				Barrier Type		
	Over 10,000	5,000 to 10,00	1,000 to 4,999	Under 1,000	Rigid & Rigid Anchored Barrier	Rigid Unrestrained Barrier	Semi-rigid Barrier
	LR (ft)	LR (ft)	LR (ft)	LR (ft)	F	F	F
70	360	330	290	250	20	18	15
65	330	290	250	225	20	18	15
60	300	250	210	200	18	16	14
55	265	220	185	175	16	14	12
50	230	190	160	150	14	12	11
45	195	160	135	125	12	11	10
40	160	130	110	100	11	10	9
35	135	110	95	85	11	10	9
30	110	90	80	70	11	10	9
25	110	90	80	70	11	10	9

L1 = Length of barrier parallel to roadway from adjacent-side fixed feature 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 fixed feature to beginning of barrier flare.

L5 = Distance from centerline of roadway to portion of barrier parallel to roadway. ***Note:*** If the fixed feature is outside the Design Clear Zone when measured from the centerline, it may only be necessary to provide a crash-tested end treatment for the barrier.

LH1 = Distance from outside edge of traveled way to back side of adjacent-side fixed feature.

Note*:* If a fixed feature 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 fixed feature. ***Note:*** If a fixed feature 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 fixed feature.

X2 = Length of need for barrier to shield an opposite-side fixed feature.

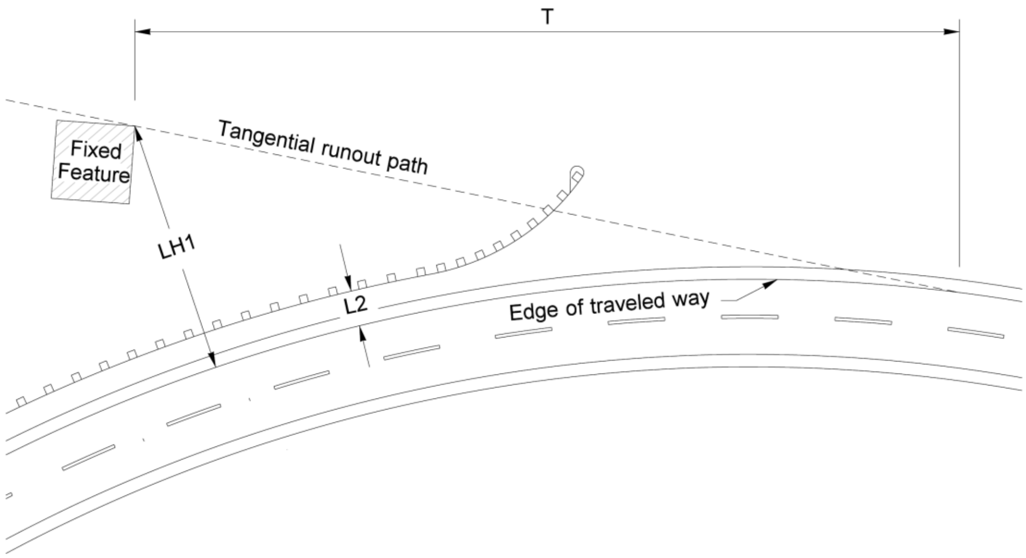
F = Flare rate value.

Y = Offset distance needed at the beginning of the length of need.

Different end treatments need 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 needed for the non-flared terminals or impact attenuator systems. Use Y = 0.

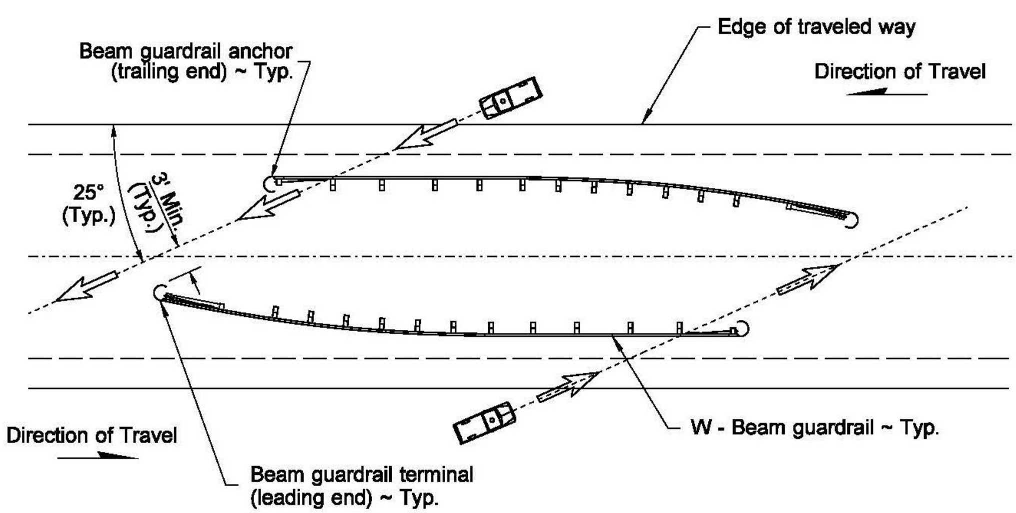
Exhibit 1610-7 Barrier Length of Need on Curves



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 fixed feature. Compare T to LR from Exhibit 1610-6 and use the shorter value.
- If using LR, follow Exhibits 1610-5 and 6.
- If using T, draw the intersecting barrier run to scale and measure the length of need.

Exhibit 1610-8 W-Beam Guardrail Trailing End Placement for Divided Highways



1610.03(6) Barrier Delineation

Refer to Chapter 1030 for barrier delineation requirements.

1610.04 Beam Guardrail

Strong post W-beam guardrail and thrie beam guardrail are semi-rigid barriers used predominantly on roadsides. They have limited application as median barrier. A strong-post W-beam (commonly referred to as W-Beam) guardrail system is the most common type of guardrail system used. The design uses wood or steel posts, rail, and blockouts to support the rail away from the post. The system resists a vehicle impact through a combination of the tensile and flexural stiffness of the rail and the bending or shearing resistance of the post.

Installed incorrectly, strong post W-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 crash-tested end treatments, and by blocking the rail away from the posts.

Beam guardrail systems are shown in the *Standard Plans*.

1610.04(1) Beam Guardrail Systems

1610.04(1)(a) Type 31 Beam Guardrail

Use Type 31 guardrail for new installations. The Type 31 system uses many of the same components as the old WSDOT Type 1 system. The main differences are that the blockouts extend 12 inches from the posts, the rail height is 31 inches from the ground to the top of the rail, the deflection requirements are 2 feet greater, and the rail elements are spliced between posts.

Type 31 guardrail offers tolerance for future HMA overlays. The system allows a 3-inch tolerance from 31 inches to 28 inches without adjustment of the rail element.

Type 31 guardrail is available double-sided, which can be used in medians.

1610.04(1)(b) (Old) Type 1 Beam Guardrail

Previous WSDOT standard practice was to install W-beam guardrail at a rail height of 27 to 28 inches, and is referred to as “Type 1” guardrail. WSDOT is phasing out the use of Type 1 guardrail. Do not use Type 1 guardrail for new installations, except when the Type 1 guardrail weak post system is the best choice at an intersection due to site constraints (see Section 1610.04(7)(a)). Place new objects a minimum of 5 feet behind the face of existing beam guardrail type 1. For more information on (Old) Beam Guardrail Type 1, see:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

Existing runs of Type 1 guardrail are acceptable to leave in place. If an existing run of Type 1 guardrail requires extending, use the Beam Guardrail Type 31 to Beam Guardrail Type 1 Adaptor shown in the *Standard Plans*, and complete the guardrail extension using Type 31 guardrail.

1610.04(1)(c) Other Guardrail Types

W-beam guardrail Type 2 and Type 3 have a height of 30 inches and utilize a rubrail. A rubrail is a structural steel channel added below the W-beam rail and is used in these specific designs to reduce vehicle snagging on the post. Existing runs of Type 2 or Type 3 guardrail are acceptable to leave in place. If the existing run of Type 2 or 3 requires extending contact WSDOT Design Office to identify appropriate extension methods.

Type 4 guardrail is a double-sided version of the Type 1 guardrail system. For new installation, use the Type 31 double-sided w-beam guardrail instead of Type 4 guardrail. Existing runs of Type 4 guardrail are acceptable to leave in place. If the existing run of Type 4 requires extending contact WSDOT Design Office to identify appropriate extension methods to transition to the Type 31 double-sided system.

Type 10 and Type 11 are thrie-beam guardrail systems. Existing runs of Type 10 or 11 guardrail are acceptable to leave in place. If an existing run of Type 10 or Type 11 guardrail requires extending, contact the WSDOT Design Office to discuss options.

Weak post W-beam guardrail (Type 20) and thrie beam guardrail (Type 21) are flexible barrier systems primarily used in conjunction with a Service Level 1 bridge rail system for bridges with timber decks. These systems use weak steel posts. For information on Type 20 and Type 21 guardrail see: 🖰 http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

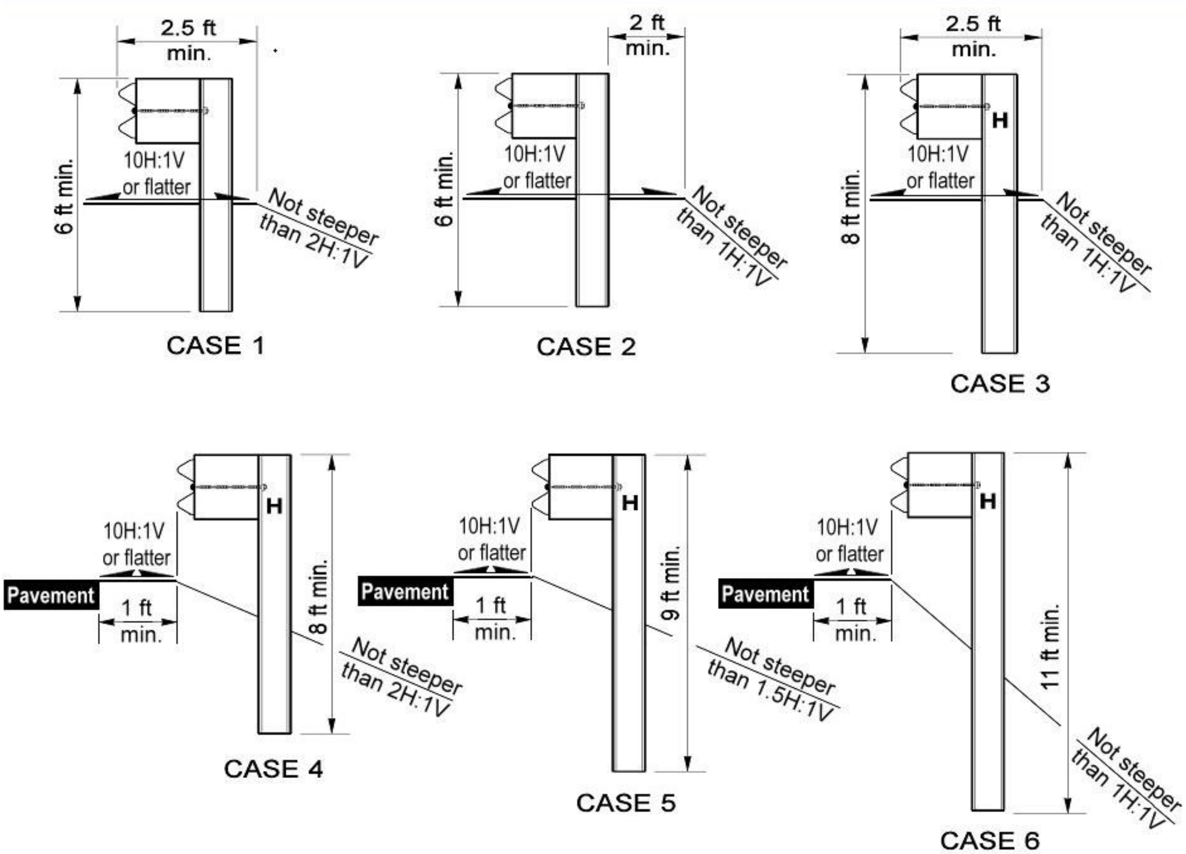
1610.04(2) Beam Guardrail Placement

There a number of considerations regarding guardrail placement. These include:

- During the project development processes, consult with maintenance staff to help identify guardrail runs that may need to be modified.
- When existing Type 1 guardrail is replaced by Type 31 guardrail along existing shoulders with a width greater than 4 feet (5 feet for bicycles), the shoulder width may be reduced by 4 inches to accommodate the 12-inch blockout. A Design Analysis is not required for the reduced shoulder width. If the remaining shoulder width is 4 feet or less, see Chapter 1030 for barrier delineation guidance.
- Keep the slope of the area between the edge of the shoulder and the face of the guardrail 10H:1V or flatter.
- Type 31 or Type 1 beam guardrail can be placed anywhere outside of the shoulder on fill slopes 10:1 or flatter.
- Type 1 beam guardrail can be placed on fill slopes between 6H:1V and 10H:1V at the slope break point of the shoulder or at least 12 feet from the slope breakpoint. This placement case does not apply to Type 31 beam guardrail.
- Do not place Type 31 or Type 1 beam guardrail with standard length posts on a fill slope steeper than 6H:1V. See Exhibit 1610-9 for allowable placement exceptions on fill slopes steeper than 6H:1V using long post beam guardrail.
- On the high side of superelevated sections, place beam guardrail at the edge of shoulder prior to the slope breakpoint.

- For W-beam guardrail installed at or near the shoulder, 2 feet of widening behind the barrier is generally provided from the back of the post to the slope breakpoint of a fill slope (see Exhibit 1610-9, Case 2). If the slope is 2H:1V or flatter, this distance can be 2.5 feet measured from the face of the guardrail rather than the back of the post (see Exhibit 1610-9, Case 1).
- On projects where no roadway widening is proposed and site constraints prevent providing the 2-foot shoulder widening behind the barrier, long post installations are available as shown in Exhibit 1610-9, Cases 3, 4, 5, and 6. When installing guardrail where the roadway is to be widened or along new alignments, the use of Cases 5 and 6 requires a Design Analysis.

Exhibit 1610-9 Beam Guardrail Post Installation



Notes:

- Use Cases 1 and 3 when 2.5-foot or greater shoulder widening exists or will be constructed from face of guardrail to the slope breakpoint.
- Use Case 2 when 4.0-foot or greater shoulder widening exists or will be constructed from face of the guardrail to the slope breakpoint.
- Use Cases 4, 5, and 6 when less than a 2.5-foot shoulder widening exists or will be constructed from face of guardrail to the slope breakpoint (see 1610.04(2)).
- Cases shown do not apply to terminals, transition sections, or anchors. Install terminals, transition sections, and anchors per the *Standard Plans*.
- Cases shown only apply to standard guardrail run installations that are placed parallel to the roadway. Apply Case 2 when installing guardrail on a flare (see Section 1610.03(4)).
- See Exhibit 1239-4 for shoulder widening/grading details associated with guardrail.

1610.04(3) W-Beam Barrier Height

See Chapter 1120 when evaluating guardrail system height on Preservation (P1, P2, P3) projects.

For other projects requiring evaluation of guardrail (see Section 1105.02(1)), evaluate the guardrail system height as follows:

- For existing Type 1 guardrail with heights falling outside the range from 26.5 inches to 31 inches, adjust or replace the rail to a minimum height of 28 inches up to a maximum height of 30 inches, or replace the run with 31-inch-high Type 31 beam guardrail.
- For existing Type 31 guardrail runs with heights falling outside the range of 28 to 32 inches, adjust or replace the rail to a height of 31 inches, or replace the run with a new run of 31-inch-high Type 31 beam guardrail.

For Type 1 and Type 31 standard run W-beam guardrail, the blockout and rail element may be raised up to 4 inches by field drilling a new hole in the guardrail post. Verify that the condition of the posts and blockouts are suitable for raising in this manner. If not, the post or block will need to be replaced. See the *Standard Plans*.

If Type 1 Alternative W-beam guardrail is present, the blockout and rail element may be raised after each overlay by using the pre-drilled holes in the guardrail posts.

See Section 1610.04(5) for information on adjusting the height of guardrail terminals.

1610.04(4) Additional Guidance

Additional guidance related to w-beam guardrail:

- Crossroad and driveway locations cause gaps in the guardrail creating situations requiring special consideration. The preferred solutions are either to eliminate the need for the barrier, or realign the crossroad or driveway to accommodate the necessary guardrail run length. Alternatively, an intersection design guardrail system can be installed at the intersection. See Section 1610.04(7)(a) for more information. At these locations, a barrier flare might be needed to provide sight distance.
- Snowload post and rail washers are not used in new guardrail installations or guardrail terminal installations. Snowload post and rail washers installed on existing guardrail installations may remain in place except when the rail element is removed from post for any reason. If this occurs, remove and discard the snowload post and rail washers before reassembling the guardrail components.
- In most cases, the use of curb in conjunction with beam guardrail is discouraged. When a curb is needed place the curb as follows:
    - For Type 1 W-beam guardrail, a 3-inch high curb is preferred and it is placed flush with the face of rail or placed behind the face of the rail. The 3-inch high curb can be used for any posted speed. If necessary, a 4-inch high extruded curb is placed flush with the face of rail or placed behind the face of the rail and can be used for any posted speed. Finally, a 6-inch high extruded curb is placed flush with the face of rail or placed

    behind the face of the rail and can be used where the posted speed is 50 mph or below. When replacing extruded curb at locations where the posted speed is above 50 mph, use 3-inch high or 4-inch high curb. (See the *Standard Plans* for extruded curb designs.)
  - For Type 31 W-beam guardrail, a 3-inch, 4-inch, or 6-inch curb is placed flush with the face of rail or placed behind the face of the rail and can be used for any posted speed. Use the shortest height curb possible. An acceptable option is to place up to a 6-inch-high extruded curb at a maximum 6 inch offset in front of the rail face at any posted speed. Contact the WSDOT Design Office for more information.
- Guardrail posts should be able to rotate when the rail is impacted. When installing strong post W-beam guardrail posts in a rigid surface such as asphalt or concrete pavement, use leave-outs. Leave-outs are areas around the post that has no rigid material, which allows the post to rotate. Contact the WSDOT Design Office for more information.
- For (Old) Guardrail Types 1, 2, 3, and 4, it is acceptable to use blockouts that extend the rail element from the post for a distance not to exceed 16 inches.
- Where it is not feasible to install a post on a Type 31 system (i.e. utility or drainage conflict), one post may be omitted every 56.25 feet (9^{th} post), except that an omitted post must be a minimum of 75 feet from an anchorage post, a minimum of 35 feet from the beginning of a thrie beam transition, and a minimum of 35 feet from the point where a terminal system joins the standard run.
  - Do not omit posts in guardrail runs with posts placed less than 2 feet from the slope break point. Guardrail runs with omitted posts must have at least 2 feet of 10:1 or flatter embankment behind them as shown in DM Exhibit 1610-10 Case 2.
  - Do not omit posts where curb is in front the guardrail.
  - Consult HQ Design for acceptable conditions to omit single posts in guardrail runs with 12’ – 6”, 18’ – 9”, or 25’ – 0” span systems (see Std. Plan C-20.40) placed within the run.
  - List all the locations of omitted posts in the project plans to ensure that posts are omitted following the conditions described in this section.

- In locations where shallow fill depth prevents the installation of standard length guardrail posts (i.e. box culverts, drainage), guardrail can be spanned over the location or be attached to the top of the structure (see standard plans). When a barrier design requires the guardrail posts to be attached to the top of a structure, either: (1) Notify the structure designer from HQ Bridge about the guardrail post attachment requirement, or (2) Follow the design requirements for a structure with attached guardrail posts provided in Chapter 8 of the Bridge Design Manual. Other shallow fill designs are available. Contact HQ Design for more information about these alternative designs.

1610.04(5) 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 within the Design Clear Zone and subject to head-on impacts, a crash-tested guardrail terminal is required (see the *Standard Plans*).

See Chapter 1120 for guidance regarding the evaluation of terminals on Preservation projects (P1, P2, and P3).

For other projects requiring evaluation of terminals (see Section 1105.02(1)), evaluate the terminals as follows:

Replace guardrail terminals that do not have a crash-tested design with MASH compliant crash-tested guardrail terminals. Common features of systems that do not meet current crash-tested designs include:

- 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 if the terminal is otherwise a crash-tested design —see the *Standard Plans* for end section details.
- Terminals with 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 28 inches (measured in relation to a 10H:1V line extended from the breakpoint at edge of shoulder).

When the height of a terminal or anchor, as measured from the ground to the top of the rail element, will be affected by the project, adjust the terminal or anchor based upon the following criteria:

- If the height of the terminal or anchor adjoining Types 1, 2, 3, or 4 guardrail will be reduced by the project to be less than 26.5 inches or increased to greater than 30 inches, adjust the height of the terminal to a minimum of 28 inches and a maximum of 30 inches. A terminal height of 30 inches is desirable to accommodate future overlays.
- If the height of the terminal or anchor adjoining Type 31 guardrail will be reduced by the project to be less than 28 inches or increased to greater than 32 inches, adjust the height to 31 inches.

- When adjusting terminals that are equipped with CRT posts, the top-drilled holes in the posts need to remain at the surface of the ground.
- When adjusting the height of a terminal or anchor, adjust it by raising the posts of the terminal or anchor and tamping the ground around the posts to prevent settlement of the raised posts. Note: do not raise the blockouts or rail of the terminal or anchor by drilling new holes in the terminal posts.

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 Slotted Rail Terminal (SRT) and a Type 1 anchor (Type 1 anchor posts are wood set in a steel tube or a concrete foundation). For guidance regarding BCT’s and other terminals on Preservation projects see Chapter 1120. For non-Preservation projects, replace BCTs with a currently approved terminal using the following guidance:

- Verify length of need, and adjust the terminal location as required.
- Replace adjacent transition sections that are not compliant with Section 1610.04(6).
- Transition from Type 1 to Type 31 using the adaptor (Standard Plan C-25.80) where required.
- Raise or replace the entire run if engineering judgement indicates that it is prudent for that situation.
- Use the grading criteria shown on the terminal standard plans (C-22.40 or C-22.45). When using existing grading, check to see that it complies with the grading criteria shown on the current terminal standard plans.
- Remove curbs from in front of terminals if hydraulically acceptable.

Information regarding (Old) Type 1 beam guardrail terminals can be found at:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(5)(a) Buried Terminal (BT) for Type 31 Beam Guardrail

A buried terminal 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.

For new BT installations, use the Buried Terminal Type 2. Previously, another BT option (the Buried Terminal Type 1) was an available choice. For existing installations, it is acceptable to leave this option in service as long as height requirements and other design criteria is met. See the plan sheet at: www.wsdot.wa.gov/design/standards/plansheet.

The BT uses a Type 2 anchor to develop the tensile strength in the guardrail. The backslope needed to install a BT is to be 3H:1V or steeper and at least 4 feet in height above the roadway. 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 to the point where the barrier enters the backslope.

For backslopes between 1H:1V and 3H:1V, 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. If the backslope is flatter than 1H:1V, provide a minimum 20-foot-wide by 75-foot-long clear area that is free of fixed features behind the barrier and between the beginning length of need point at the terminal end to the mitigated object to be protected.

Flare the guardrail to the foreslope/backslope intersection using a flare rate that meets the criteria in 1610.03(4). Provide a 4H:1V or flatter foreslope into the face of the guardrail and maintain the full guardrail height to the foreslope/backslope intersection in relation to a 10H:1V line extending from edge of shoulder breakpoint. (See the *Standard Plans* for details.)

1610.04(5)(b) Non-flared Terminals for Type 31 Beam Guardrail

Install a non-flared terminal when a buried terminal cannot be installed as described in Section 1610.04(5)(a). WSDOT does not use flared terminals on Type 31 guardrail systems. Non-flared terminals typically use w-beam guardrail, proprietary hardware, and an impact head mounted at the leading end. These systems also include an anchor to provide tensile strength for the guardrail. Non-flared terminals absorb energy during head-on impacts by processing the rail through the impact head in varying ways depending on the manufacturer's own proprietary approach. Although these terminal systems are called non-flared, all manufacturers allow for an offset to move the impact head away from traffic.

Select non-flared terminals based on the posted speed: those restricted to locations 45 mph or below (TL-2, Standard Plan C-22.45), and those that can be installed at any posted speed (TL-3, Standard Plan C-22.40). Where practicable, provide an offset of up to one-foot over the length of the terminal (TL-2, Standard Plan C-22.45) or up to two feet over the length of the terminal (TL-3, Standard Plan C-22.40) to increase the clearance between the impact head and traffic to reduce the potential of incidental hits.

Include or confirm that embankment widening is provided as part of the terminal design and installation. Where practicable, install non-flared terminals on tangent sections of roadway. Contact HQ Design for options to install non-flared terminals on horizontal curves. Do not install snowload rail or post washers within the limits of the terminals. Do not install terminals behind or coincident with curbs.

Refer to Standard Plans C-22.40 or C-22.45 for additional details about terminal layout and dimensions that are useful in design including:

- Terminal lengths and pay limits
- Embankment widening dimensions
- Location of the Length of Need point on the terminal as it varies by manufacturer

The roadside safety website provides information on availability or acceptance of different terminal systems including approved shop drawings. (see
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm)

1610.04(5)(c) Terminal Evolution Considerations

Some currently 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. Previous designs for these terminals may remain in place.

Note: If questions arise concerning the current approval status of a device, contact the HQ Design Office for clarification when replacement is being considered.

1610.04(5)(d) Anchors

A guardrail anchor is needed at the end of a run of guardrail to develop tensile strength throughout its length.

- Use the Type 10 anchor to develop the tensile strength of the guardrail on the end of Type 31 guardrail runs where a crash-tested terminal is not needed.
- A Type 2 anchor is used with the buried terminal.

For information on anchor types used in runs of (Old) Beam Guardrail Type 1, see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

1610.04(6) 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 may 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 reduce the possibility of pocketing.

When connecting beam guardrail to a more rigid barrier or a structure use the transitions and connections that are shown in Exhibits 1610-10 and 1610-11 and detailed in the *Standard Plans*. Verify the length of need (see Section 1610.03(5)) when designing transitions, particularly transitions between beam guardrail or end terminals to bridge structures.

Type 21 transitions can be used on highways with all posted speeds to connect w-beam guardrail to single slope, safety shape or vertical concrete barriers.

Type 22 and Type 23 transitions are used to connect w-beam guardrail to thrie beam on bridges.

Type 24 transitions can be used on highways with a posted speed of 45 mph or less to connect w-beam guardrail to single slope, safety shape or vertical concrete barriers.

When connecting a Type 21 or Type 24 Transition to an existing vertical faced bridge rail with a low parapet, a special connection plate may be required. Coordinate with the WSDOT Bridge and Structures Office (BSO). The transition pay item includes the connection.

Install transitions on 10:1 or flatter slopes with the 10:1 or flatter slope extending a minimum of 2 feet behind the guardrail transition post similar to what is shown in DM Exhibit 1610-9 Placement Case 2.

For information regarding transitions used with (Old) Type 1 guardrail see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

Exhibit 1610-10 Guardrail Connections

Condition	Connection
Unrestrained precast concrete barrier	A
Rigid, rigid anchored, 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, single slope bridge rail or concrete barrier, or tapered safety shape barrier [1]	D
All bridge rail and concrete barrier types located on trailing ends of one-way roadways	F

Note:

[1] New single slope and 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.

Exhibit 1610-11 Transitions and Connections

Connecting Type 31 W-Beam Guardrail to:			Transition Type*	Connection
Bridge Rail [1]	New Installation		21, 24 [3]	D
	Existing Concrete	Concrete Parapet > (Greater Than) 20 in.	21, 24 [3]	Exh. 1610-10 [2]
		Concrete Parapet < (Less Than) 20 in.	21, 24 [3]	Exh. 1610-10 [2]
	Thrie Beam at Face of Curb	Approach End	23	n/a
		Trailing End (two-way traffic only)	23	n/a
	Thrie Beam at Bridge Rail (curb exposed)	Approach End	22	n/a
		Trailing End (two-way traffic only)	22	n/a
Concrete Barrier	Rigid & Rigid Anchored		21, 24 [3]	Exhibit 1610-10
	Unrestrained		21, 24 [3]	A
Connecting Thrie Beam Guardrail to:			**Transition Type***	**Connection**
Bridge Rail or Concrete Barrier	See the thrie beam transition in the Plan Sheet Library			Exhibit 1610-10

*Consult Section C of the *Standard Plans* for details on transition types.

Notes:

[1] For Service Level 1 bridge rail, see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm., Type 1 Beam Guardrail Placement Cases, Placement Case 14.

[2] When connecting a Type 21 or Type 24 Transition to an existing vertical faced bridge rail with a low parapet, a special connection plate may be required. Contact the WSDOT BSO for details.

[3] Transition Type 21 is acceptable for use on highways with all posted speeds. Transition Type 24 is acceptable for use on highways with posted speeds 45 mph or below.

1610.04(7) Guardrail Placement Cases

The *Standard Plans* and Plan Sheet Library contain placement cases that show beam guardrail elements needed for typical situations. For new installations, use the appropriate Type 31 placement option (except as noted below).

Information regarding placement cases for (Old) Type 1 beam guardrail can be found at 🖰 http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

1610.04(7)(a) Beam Guardrail Placement Cases

- Case 1-31 is used where there is one-way traffic. It uses a crash-tested terminal on the approach end and a Type 10 anchor on the trailing end.
- Case 2-31 is used where there is two-way traffic. A crash-tested terminal is used on both ends.
- Case 3-31 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. If there is a history of crossover collisions, consider additional protection such as an impact attenuator.
- Case 4-31 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 needed at the bridge end. Curves (bends) are shown in the guardrail to shift it to the bridge rail. However, the length of the curves are not critical. The criterion is to provide smooth curves that are not more abrupt than the allowable flare rate (see Exhibit 1610-4).
- Case 5-31 is a typical bridge approach where a terminal and a transition are needed.
- Case 10 (A-31, B-31, and C-31) is used at roadside fixed features (such as bridge piers) when 5 or more feet are available from the face of the guardrail to the feature. The approach end is the same for one-way or two-way traffic. Case 10A-31 is used with two-way traffic; therefore, a terminal is needed on the trailing end. Case 10B-31 is used for one-way traffic when there is no need to extend guardrail past the bridge pier and a Type 10 anchor is used to end the guardrail. Case 10C-31 is used for one-way traffic when the guardrail will extend for a distance past the bridge pier.
- The Beam Guardrail Type 31 Placement 12'-6", 18'-9", or 25'-0" Span design is used when it is necessary to omit one, two, or three posts. This application is typically used when guardrail is installed over a shallow buried obstruction, such as drainage structures. This design may be used in other situations where there are no above ground objects located behind the guardrail and within the lateral deflection distance. Three CRT posts are provided on each end of the omitted post(s). Type 31 guardrail (including terminals and anchors) must extend at least 62.5 feet (10 posts) upstream and downstream from the ends of the outer CRT posts (furthest from obstruction) in order for the guardrail system to function as designed during a vehicle crash. Also, this guardrail design has specific grading requirements, see applicable standard plan. Note: This guardrail design may require fall protection. See Section 730.04(7)(b) for worker fall protection requirements. See Section 1510.15(3) for pedestrian fall protection requirements. When a fall protection system is located within the deflection zone of the barrier system, contact HQ Design for options.

- Guardrail Placement at intersections – Two solutions are currently available for use where bridge ends or similar conditions exist in close proximity to a roadway intersection or driveway. These designs are used at crossroads or road approaches where a barrier is needed and where the length of need cannot be achieved using standard components such as standard longitudinal barrier runs, transitions, and terminals. The “Strong Post Intersection Design” uses Type 31 guardrail and is available for use in new installations. A “Weak Post Intersection Design,” which uses Type 1 guardrail, is available and may also be used in new installations (see 1610.04(1)(b)).
- Type 31 guardrail placement with less than 5-feet from face of guardrail to a fixed or breakaway object – There may be instances where Type 31 beam guardrail cannot be placed at least 5-feet from the face of rail to the front edge of an object which does not meet the minimum deflection distance of the Type 31 guardrail system. Contact HQ Design to discuss barrier placement options when this occurs.

1610.05 High-Tension Cable Barrier

Cable barrier is a flexible barrier system that can be used on a roadside or as a median barrier. Early cable barrier designs centered around low-tension cable systems. With research and crash analysis of these systems, the designs evolved into high-tension cable systems. These high-tension cable systems are primarily used in medians and are preferred for many installations due in part to high benefit-to-cost ratios. Read about advantages for selecting a cable barrier system here:
http://www.wsdot.wa.gov/publications/fulltext/design/Policy/CableBarriers.pdf.

There are a number of manufacturers of high-tension cable barrier systems. These systems have been designed using either three or four-cables fixed to metal posts placed at a fixed spacing. Each cable system has specially designed anchors placed at both ends of the barrier run to provide the proper tensioning in the cables. Currently, both three and four-cable high-tension cable barrier systems are installed along WSDOT state routes. See additional information about these approved cable barrier systems here:
http://www.wsdot.wa.gov/publications/fulltext/design/Policy/CableBarriers.pdf.

Use four-cable high-tension cable barrier systems for all new installations.

1610.05(1) High-Tension Cable Barrier Placement

High-tension cable barrier can be placed in a median or along the roadside.

Note: Additional placement cases are shown in the WSDOT *Standard Plans*. For non-typical installations, such as double runs of cable barrier or median ditch cross sections that differ significantly from those shown, contact the HQ Design Office for guidance.

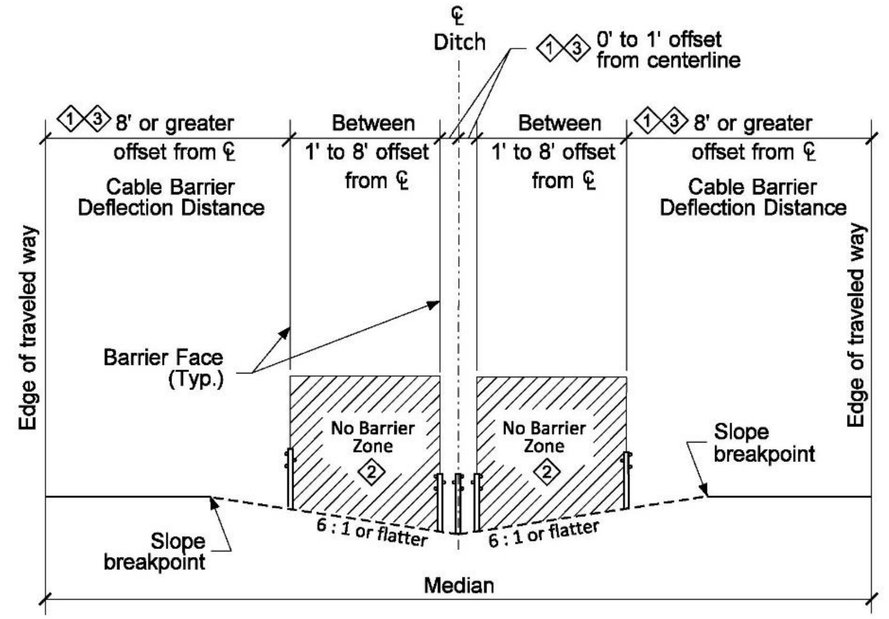
1610.05(1)(a) Median Applications

For typical cable barrier installations in a median, the following apply (see Exhibit 1610-12a):

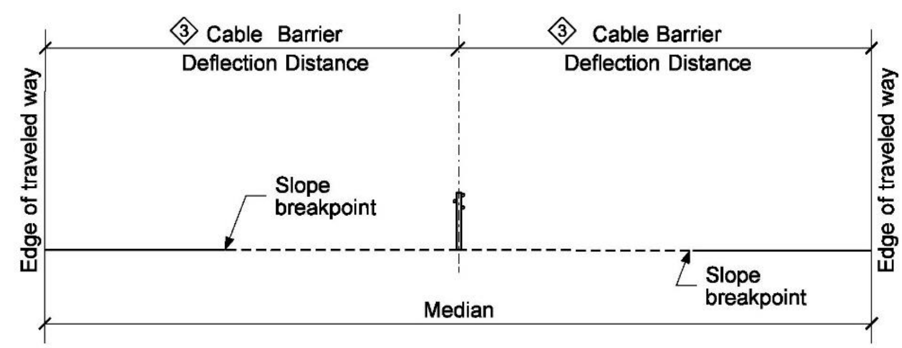
- Install the cable barrier as far from the edge of traveled way as site constraints allow. Consider a minimum placement distance of 8 feet from the edge of traveled way to allow vehicles to use this area for refuge.
- Install cable barrier on slopes 6H:1V or flatter.

- There are approved high-tension cable barrier systems that can be placed on slopes as steep as 4H:1V. The use of these systems requires special placement considerations, contact the HQ Design Office for guidance.
- Provide an obstruction free zone within the cable barrier system's lateral deflection distance (see Section 1610.05(2)).
- On tangent sections of a roadway where no ditch is present, consider installing the cable barrier in the middle of the median. See Exhibit 1610-12a.
- Along horizontal curves, consider installing the cable barrier along the inside of the curve. Reduce the post spacing per manufacturer's recommendations.
- In medians with ditches, install the cable barrier as follows (See Exhibit 1610-12a):
    - The preferred location is to install the cable barrier at an 8-foot or greater offset from the ditch centerline.
    - Alternatively, the cable barrier can be installed at the centerline of the ditch out to a 1-foot offset either side of the ditch centerline. While permissible, this is not the preferred area to install cable barrier due to the potential of post scour, possible interference with drainage structures, and maintenance concerns.
    - Do not install cable barrier in the area between 1-foot to 8-foot offset from the ditch centerline to avoid "under-riding" of vehicles crossing the ditch.
- In some situations, it may be advantageous to terminate a run of cable barrier on one side of the median (to provide maintenance access to a feature, for example) and then begin an adjacent cable barrier run on the opposite side of the median. In this application, it is important to provide adequate cable barrier overlap distance between the two runs. For placement guidance, see Exhibit 1610-13a.
- Narrow medians provide little space for maintenance crews to repair or reposition the barrier. Wherever site conditions permit, provide at least 14 feet of clearance from the adjacent lane edge to the face of the cable barrier.

Exhibit 1610-12a Median Cable Barrier Placement



Median Cable Barrier Placement (Ditch Section with 6 : 1 or Flatter Slopes)



Median Cable Barrier Placement (No Ditch)

Notes:

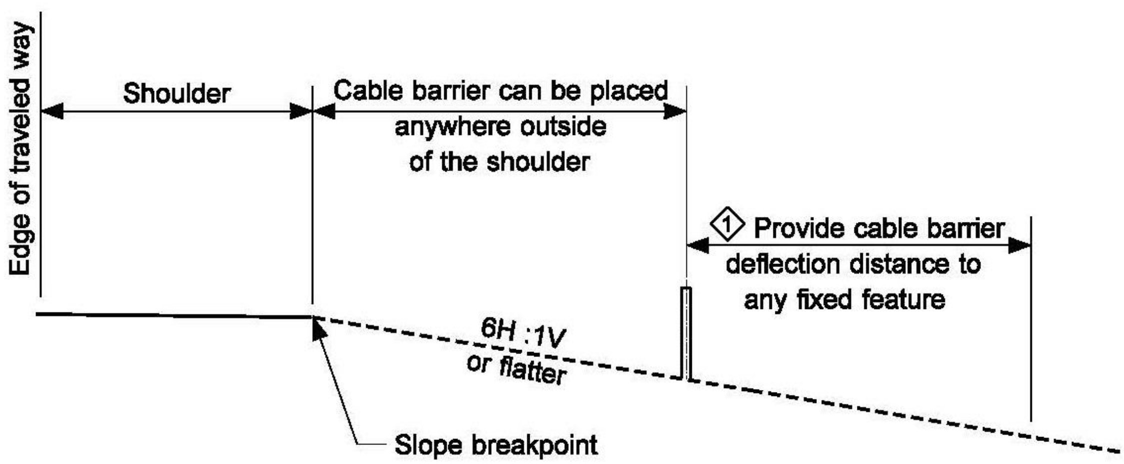
1. Cable barrier may be installed at an 8-foot or greater offset from centerline (preferred placement), or it may be installed in the center of the ditch out to a 1-foot offset from the ditch centerline (left or right).
2. Avoid installing cable barrier in the area between 1-foot to 8-foot offset from the ditch centerline (left or right).
3. Provide an obstruction free zone within the cable barrier's lateral deflection distance, and provide sufficient lateral barrier deflection distance to prevent a vehicle's encroachment into the opposite lane of travel. See Section 1610.05(2) for more information.

1610.05(1)(b) Roadside Applications

For typical non-median roadside applications, the following apply:

- Install the cable barrier as far from the edge of traveled way as site constraints allow.
- Consider a minimum placement distance of 8 feet from the edge of traveled way to allow vehicles to use this area for refuge.
- Install cable barrier on slopes 6H:1V or flatter
- There are approved high-tension cable barrier systems that can be placed on slopes as steep as 4H:1V. The use of these systems requires special placement considerations, contact the HQ Design Office for guidance.
- Along horizontal curves, consider installing along the inside of the curve. Reduce post spacing per manufacturer's recommendations
- Provide an obstruction free zone within the cable barrier system's lateral deflection distance, see Section 1610.05(2).

Exhibit 1610-12b Roadside Cable Barrier Placement



Notes:

1 Provide an obstruction free zone within the cable barrier's lateral deflection distance, see Section 1610.05(2)

1610.05(2) High-Tension Cable Barrier Lateral Deflection Distances

Depending on the high-tension cable barrier system, lateral deflection distances for each barrier system vary based upon the length of the barrier run, the spacing of the end anchors, and post spacing. Provide an obstruction free zone within the system's lateral deflection distance for the following situations:

In the direction of travel (located in the median or along roadside), locate the cable barrier system so that there are no fixed objects within the limits of the cable barrier lateral deflection distance.

For opposing traffic (where present), locate the cable barrier to provide lateral deflection distance to prevent a vehicle's encroachment into the opposite lane of travel.

Low–tension cable barrier systems require 12 feet of lateral deflection. Use high-tension cable barrier systems in new cable barrier installations. High-tension barrier systems have lateral deflection distances between 6 to 10 feet. Specify the maximum allowable lateral deflection distance in the contract documents in order for the contractor to select a cable barrier manufacturer that meets the lateral deflection requirements.

Note: There are new high-tension cable barrier systems under development that may change selection and placement criteria. For example, newer systems may allow placement on steeper slopes or have reduced deflection distances. Contact the HQ Design Office for guidance.

1610.05(3) High-Tension Cable Barrier Termination

Manufacturers of high-tension four-cable barrier systems provide designed anchors for the ends of cable barrier runs. Whenever practicable, locate high-tension cable barrier terminals in areas where they are least likely to be hit by errant vehicles (e.g. located outside clear zone, located behind another barrier system).

Often, high-tension cable barrier systems will overlap/interface with a stiffer barrier system (typically beam guardrail but can be concrete barrier). When terminating a cable barrier run to begin a beam guardrail run, there are essentially four choices for the overlap/interface of the two barrier systems (contact HQ Design when terminating a cable barrier run to begin a concrete barrier run). The four choices are:

Connect Cable Barrier to Beam Guardrail: This placement connects the cable barrier directly onto the beam guardrail runs (such as cable barrier connected to beam guardrail transitions coming off bridge rails) or to a different cable barrier anchorage system.

When connecting cable barrier onto beam guardrail, the guardrail must continue at least 75 feet downstream from the point where the cable barrier attaches to the beam guardrail, or the beam guardrail needs to be connected to a stiffer system (i.e. bridge rail, concrete barrier) to reduce the chance of beam guardrail posts pulling out of the ground from the tension in the cable barrier system. When terminating cable barrier in this manner; review field conditions, check local maintenance personnel needs, and specify the required connection option in the contract documents.

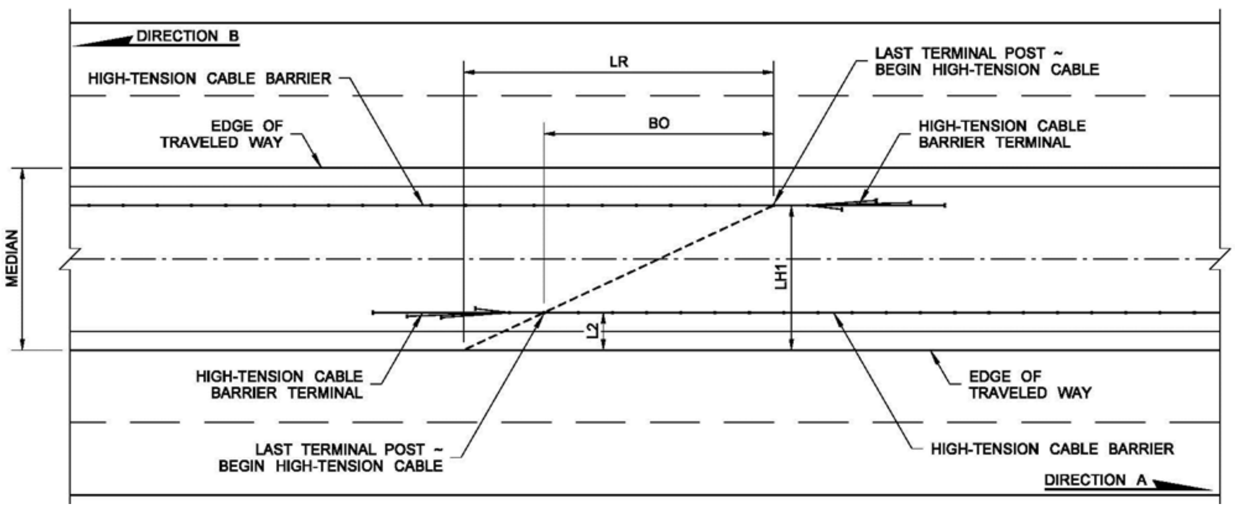
When cable barrier is connected directly to a more rigid barrier, a transition section is typically needed. Contact the HQ Design Office for further details.

Install Cable Barrier Behind Beam Guardrail: This placement terminates the cable barrier behind the beam guardrail system. Ensure the lateral distance between the two barrier systems exceeds the deflection distance of the beam guardrail system placed in front of the cable barrier system. This will reduce the chances of having the two barrier systems interfering with each other during a vehicle impact, or having an errant vehicle rebound off the cable barrier into the back of the beam guardrail during a vehicle impact. Exhibit 1610-13b shows an example of terminating cable barrier behind a beam guardrail system.

Install Cable Barrier in Front of Beam Guardrail: This placement terminates the cable barrier in front of the beam guardrail system. Ensure that the standard run of cable barrier extends to, or past, the Length of Need post of the beam guardrail terminal, and provide a minimum lateral distance of 4-feet between the two barrier systems. This will reduce the chances of having the two barrier systems interfere with each other during a vehicle impact. Exhibit 1610-13b shows an example of terminating cable barrier in front of a beam guardrail system.

Terminate Cable Barrier in Advance of Beam Guardrail: This placement terminates the cable barrier in advance of the beam guardrail system. This placement leaves a gap in guardrail coverage and can be a maintenance concern if both terminals are hit by an errant vehicle. However, this placement can be used when side slope grades become an issue (i.e. slope is too steep to place cable barrier or beam guardrail, slope widening requires large amounts of fill to accommodate barrier systems). Exhibit 1610-13b shows an example of terminating cable barrier in advance of a beam guardrail system.

Exhibit 1610-13a Cable Barrier Placement: Overlap on Divided Highways



Cable Barrier Median Overlap

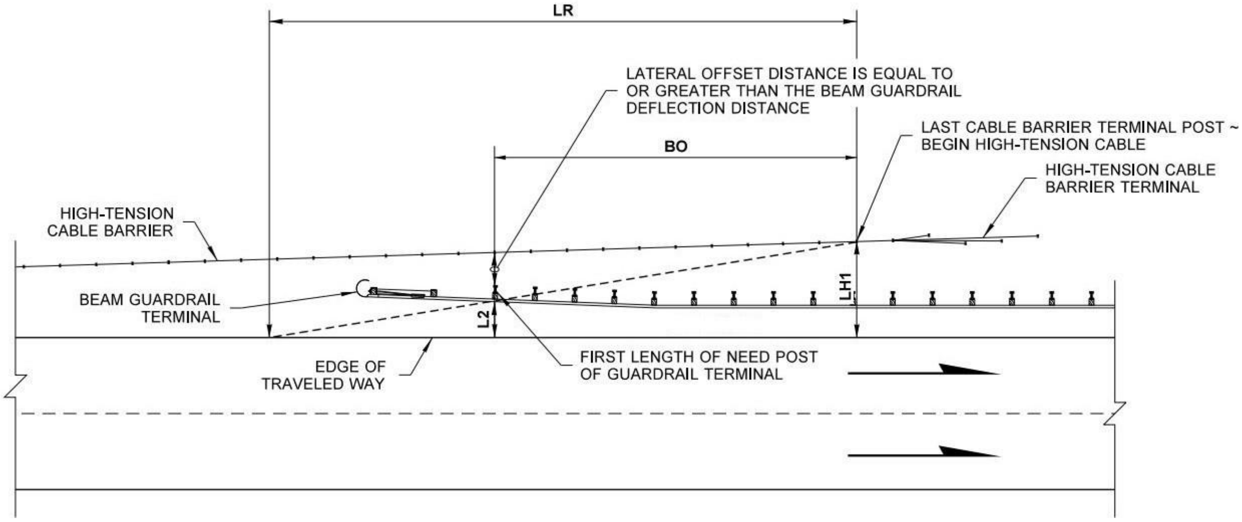
$$BO = \frac{LH1 - L2}{\frac{LH1}{LR}} \text{ (Direction A shown)}$$

Notes:

[1] Calculate barrier overlap (BO) from both directions of travel. Use the greatest value of BO obtained.

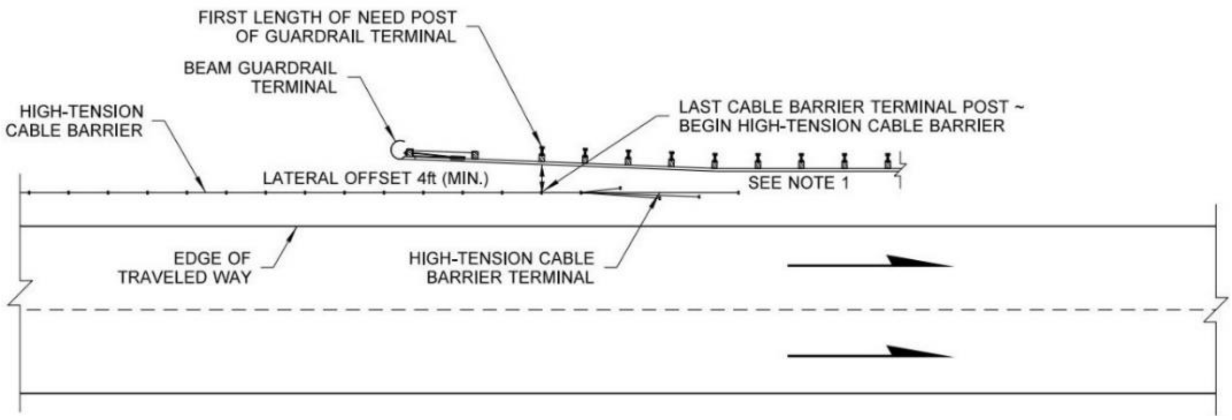
[2] For supporting length of need equation factors, see Exhibit 1610-6.

Exhibit 1610-13b Cable Barrier Placement: Cable Barrier Termination/Overlap with Beam Guardrail



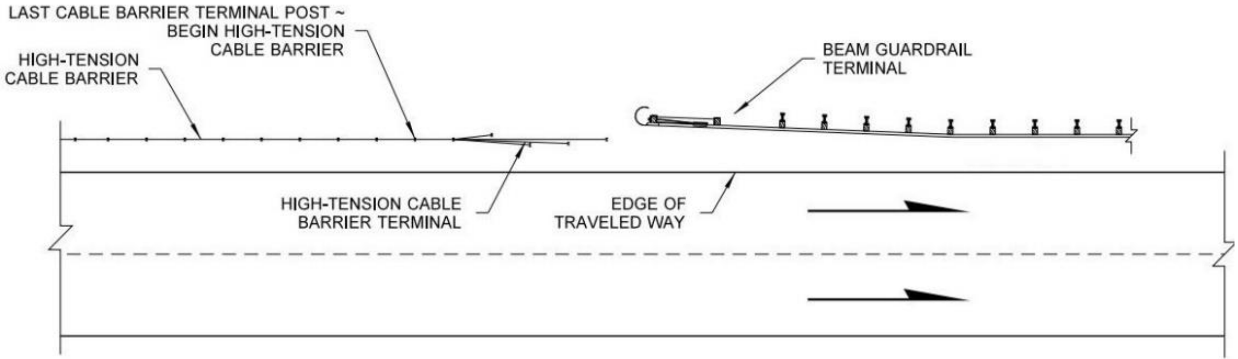
$$\mathrm{BO} = \frac{\mathrm{LH1} - \mathrm{L2}}{\mathrm{LH1/LR}}$$

Cable Barrier Termination: Install Behind Beam Guardrail



Cable Barrier Termination: Install in Front of Beam Guardrail

Exhibit 1610-13b Cable Barrier Placement: Cable Barrier Termination/Overlap with Beam Guardrail (cont)



Cable Barrier Termination: Terminate In Advance of Beam Guardrail

Notes:

These barrier placements can be placed in both roadside and medians.

[1] The beam guardrail may need to be extended and flared in advance of a cable barrier terminal to maintain adequate barrier overlap, lateral offset distance between barrier systems, and shoulder width.

[2] Typical applications may be at either bridge transitions or where high-tension cable and beam guardrail systems end or begin.

[3] For supporting length of need equation factors, see Exhibit 1610-6.

1610.05(4) High-Tension Cable Barrier Curb Placement

Avoid the placement of curb in conjunction with high-tension cable barrier systems. Currently, there are no known acceptable cable barrier systems that have been successfully crash tested with this feature present.

1610.06 Concrete Barrier

Concrete barriers are identified as either rigid, rigid anchored, or unrestrained rigid systems. They are commonly used in medians and as shoulder barriers. These systems are stiffer than beam guardrail or cable barrier, and impacts with these barriers tend to be more severe. Consider the following when installing concrete barriers:

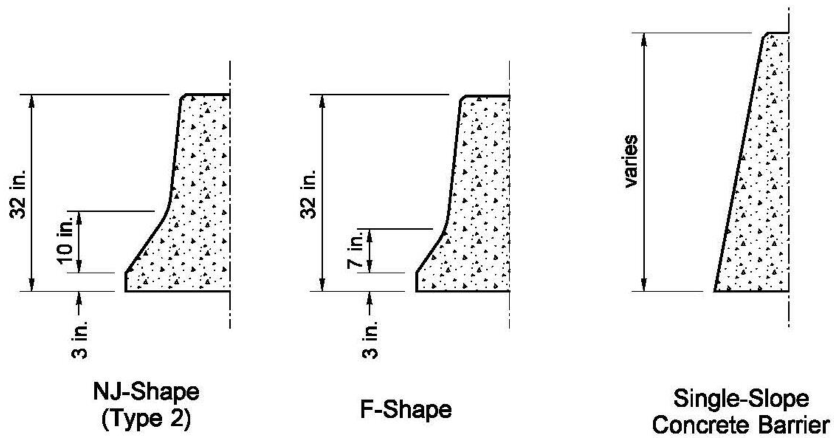
- For slopes 10H:1V or flatter, concrete barrier can be used anywhere outside of the shoulder.
- Do not use concrete barrier at locations where the foreslope into the face of the barrier is steeper than 10H:1V.
- Light standards mounted on top of precast concrete median barrier must not have breakaway features. (See the concrete barrier light standard section in the *Standard Plans*.)
- When considering concrete barrier use in areas where drainage and environmental issues (such as stormwater, wildlife, or endangered species) might be adversely impacted, contact the HQ Hydraulics Office and/or the appropriate environmental offices for guidance. Also, refer to 1610.02.

1610.06(1) Concrete Barrier Shapes

Concrete barriers use a single-slope or safety shape (New Jersey or F-Shape) to redirect vehicles while minimizing vehicle vaulting, rolling, and snagging. A comparison of these barrier shapes is shown in Exhibit 1610-14.

The single-slope barrier face is the recommended option for embedded rigid concrete barrier applications.

Exhibit 1610-14 Concrete Barrier Shapes



Bridge Transitions: When the single-slope or F-Shape face is used on structures and precast barrier is selected for use on the approaches; a transition section is needed to provide gradual stiffening from the less rigid precast barrier system to the more rigid bridge rail system and to ensure that no vertical edges of the barrier are exposed to oncoming traffic due to the difference in shapes and height of the barriers. Note: Precast concrete barrier transitions to bridges are currently under development. Contact HQ Design for more information. For details on bridge rail designs, see the *Bridge Design Manual*.

Roadside/Median Shape Transitions: Use a transition section when it is necessary to change the shape of the barrier within a single run (i.e. Type F to Single Slope, Type 2 to Type F). Transition designs will differ when used on roadside/wide median applications (subject to vehicle impacts on one side only), or narrow median applications (subject to vehicle impacts on both sides). Note: Precast concrete barrier shape transitions for roadside and median applications are currently under development. Contact HQ Design for more information.

Stiffness Transitions: A transition section is also needed when changing the stiffness of the barrier system within a single run but not the barrier shape (i.e. Type F anchored to Type F unanchored). This type of transition requires a change in anchoring pin configuration when moving from an unanchored barrier system to an anchored barrier system. There is no other change to the barrier other than the anchoring pin configuration. Note: Precast concrete barrier transition plans for barrier system stiffness changes are currently under development. Contact HQ Design for more information.

For aesthetic reasons, avoid changes in the shape of the barrier face within a project or corridor.

The New Jersey shape and F-shape barriers are commonly referred to as “safety shapes.” The New Jersey shape and F-shape have an initial overall height of 32 inches. This height includes provision for up to a 3-inch future pavement overlay that can reduce the barrier height to 29 inches minimum.

As part of the implementation of MASH-compliant hardware, WSDOT has transitioned from using New Jersey shape barrier (Type 2 barrier) for precast concrete barrier to using F-shape concrete barrier (Type F barrier) instead. F-Shape (Type F) barrier is used in permanent or temporary installations. New Jersey shape (Type 2) barrier is only allowed to be used in temporary installations. Existing runs of Type 2 barrier permanently installed are allowed to remain in place. When replacing concrete barrier, use Type F. When removing and resetting Type 2 barrier, contact HQ Design for more details.

1610.06(1)(a) Safety Shape Barrier

Concrete Barrier Type F (see the *Standard Plans*) is a freestanding precast barrier that has the F-shape on both sides. The F-Shape barrier can be used in permanent or temporary installations. It can be used for both median and shoulder installations. Unanchored units are connected with steel pins through metal loops. For permanent installations, this barrier is placed on a paved surface and a paved surface is provided beyond the barrier for deflection. For temporary installations, this barrier can be placed on a paved or a compacted unpaved surface with the respective surface provided beyond the barrier for deflection. Do not anchor Type F barrier on a compacted unpaved surface. See Exhibit 1610-3 for deflection requirements.

Concrete Barrier Type 2 (see the *Standard Plans*) is a freestanding precast barrier that has the New Jersey shape on two sides. The Type 2 barrier is only used in temporary installations. It can be used for both median and shoulder installations. Unanchored units are connected with steel pins through wire rope loops. For temporary installations, this barrier can be placed on a paved surface or a compacted unpaved surface with the respective surface provided beyond the barrier for deflection. Do not anchor Type 2 barrier on a compacted unpaved surface. See Exhibit 1610-3 for deflection requirements.

The cost of precast safety shape barrier is significantly less than the cost of the cast-in-place barriers. Therefore, consider the length of the barrier run and the deflection needs to determine whether transitioning to precast barrier is desirable. If precast safety shape barrier is used for the majority of a project, use the single slope barrier for small sections that need cast-in-place barrier (such as for a light standard section). Precast concrete barrier transitions are currently under development. Contact HQ Design for more information.

Type F narrow base is a precast, single-faced F-Shape barrier. These units are not freestanding and are to be placed against a rigid structure (or anchored to the pavement in temporary installations). If Type F narrow base barriers are used back to back, fill any gap between them to prevent tipping.

Type F barrier can be anchored where a more rigid barrier is needed. The barrier can be anchored in permanent or temporary installations on asphalt pavement, concrete pavement, or bridge decks (Anchoring methods are shown in the *Standard Plans*). Consult with the WSDOT BSO for details when anchoring permanent precast concrete barrier to a rigid (Portland cement concrete) pavement or bridge deck.

Precast Type 2 barrier can be anchored where a more rigid barrier is needed. The barrier can be anchored in temporary installations using Type 1 and Type 2 anchors for rigid concrete pavement, and Type 3 anchors for asphalt pavement (Anchoring methods are shown in the *Standard Plans*). Consult with the WSDOT BSO for details when anchoring precast concrete barrier to a bridge deck.

Precast barrier used on the approach to bridge rail is to be connected to the bridge rail by installing loops or a loop bar embedded into the bridge rail with epoxy resin and as detailed in the *Standard Plans*.

Place unrestrained (unanchored) precast concrete barrier on slopes of 5% (20H:1V) or flatter where possible. The maximum slope for placement of concrete barrier is 10% (10H:1V).

1610.06(1)(b) Single-Slope Barrier

Single-slope barrier is available in various heights as shown in the *Standard Plans*. Single-slope concrete barrier can be cast-in-place or precast. Single-slope barrier is considered a rigid system regardless of the construction method used provided that precast barrier is embedded a minimum of 3-inches in the roadway wearing surface (asphalt or concrete) on both sides, precast barrier is embedded a minimum of 10-inches in compacted soil (i.e. CSBC, select borrow, gravel borrow, native soil) on both sides, and cast-in-place barrier is embedded a minimum of 3-inches in the roadway wearing surface (asphalt or concrete) or compacted soil on both sides.

For new installations in asphalt, concrete, or compacted soil; the minimum height of the single-slope barrier above the roadway is 2 feet 10 inches which allows a 2-inch tolerance for future overlays. The minimum total height of the barrier section is 3-feet-6 inches (including embedment). The single-slope barrier can be installed with grade separation between roadways as follows:

- For cast-in-place barrier with a minimum 3-inch embedment, or pre-cast barrier installed in asphalt or concrete with a minimum 3-inch embedment; a grade separation of up to 4-inches is allowed when using a 3-foot-6-inch tall barrier section, a grade separation of up to 7-inches is allowed when using a 4-foot tall barrier section, and a grade separation of up to 10-inches is allowed when using a 4-foot-6-inch tall barrier section as shown in the *Standard Plans*.
- For pre-cast barrier installed in compacted soil with a minimum 10-inch embedment; a grade separation of up to 4-inches is allowed when using a 4-foot tall barrier section, and a grade separation of up to 10-inches is allowed when using a 4-foot-6 inch tall barrier section.
- The barrier is to have a depth of embedment equal to or greater than the grade separation. Contact the WSDOT BSO for grade separations greater than 10-inches.
- Cast-in-place and pre-cast High Performance single-slope barrier can be installed with a grade separation between the roadways as well, see the *Standard Plans*.

1610.06(1)(c) High-Performance Concrete Barrier

High-Performance Concrete Barrier (HP Barrier) is a rigid barrier with a minimum height of 3-foot-6-inch above the roadway surface. This barrier is designed to function more effectively during heavy-vehicle crashes. This taller barrier may also offer the added benefits of reducing headlight glare and reducing noise in surrounding environments. WSDOT HP Barrier utilizes the single-slope shape. (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 crash history suggests a need or where roadway geometrics increase the possibility of larger trucks hitting the barrier at a high angle (for example, on-ramps for freeway-to-freeway connections with sharp curvature in the alignment).

Consider the use of HP Barrier at other locations such as highways with narrow medians, near highly sensitive environmental areas, near densely populated areas, over or near mass transit facilities, or on vertically divided highways.

1610.06(1)(d) Low-Profile Barrier

Low-profile barrier designs are available for median applications where the posted speed is 45 mph or below. 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.

1610.06(2) Concrete Barrier Placement in Front of Bridge Piers

<u>Existing barrier in front of bridge piers may remain in place in preservation (P1, P2, P3) projects. For all other projects, contact the HQ Bridge traffic barrier specialist when an existing or proposed bridge pier is in the Design Clear Zone, regardless of whether a barrier currently exists.</u>

1610.06(3) Concrete Barrier Height

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 necessary.

- Allow no less than 2-foot 5 inches from the pavement to the top of the safety shape barriers. Allow no less than 2-foot 8-inches from the pavement to the top of the single-slope barrier.

1610.06(4) Concrete Barrier Terminals

Whenever possible, bury the blunt end of a concrete barrier run into the backslope of the roadway. If the end of a concrete barrier run cannot be buried in a backslope or terminated as described below, terminate the barrier using a guardrail terminal and transition or an impact attenuator (see Chapter 1620).

To bury the blunt end of the barrier into a backslope, the following conditions must be met:

- The backslope is 3H:1V or steeper
- The backslope extends minimum of 4 feet in height above the edge of shoulder
- Flare the concrete barrier into the backslope using a flare rate that meets the criteria in Section 1610.03(4)
- Provide a 10H:1V or flatter foreslope into the face of the barrier and maintain the full barrier height until the barrier intersects with the backslope. This might create the need to fill ditches and install culverts in front of the barrier face.

The 10- to 12-foot single-slope barrier terminal (precast or cast-in-place) may be used in the following conditions:

- 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 mph or below.

See the *Standard Plans* for barrier terminal details. Note: The Type F concrete barrier terminal standard plans are currently under development. Contact HQ Design for information.

1610.07 Bridge Traffic Barriers

Bridge traffic barriers redirect errant vehicles and help to keep 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).

When considering work on a bridge traffic barrier consult the WSDOT Bridge and Structures Office (BSO).

The standard bridge traffic barrier is a 3 foot 6 inch single slope or F Shape traffic barrier.

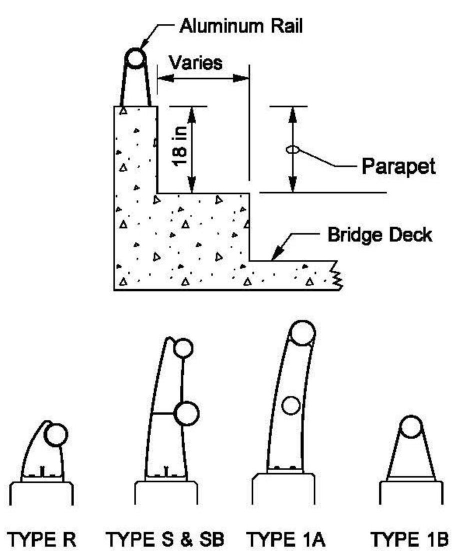
For corridor continuity, a 2 foot 10 inch single slope or 2 foot 8 inch F Shape traffic barrier may be used with a pedestrian railing attached to the top for a total height of 3 foot 6 inch height inches. This also meets requirements for worker fall protection.

Approach barriers, transitions, and connections are usually needed on all four corners of bridges carrying two-way traffic and on both corners of the approach end for one-way traffic. (See 1610.04(6) for guidance on beam guardrail transitions). A concrete barrier transition is being made available to connect the Type F concrete barrier (F-shape) and the bridge barrier (F-Shape or Single Slope) (Note: Transitions are currently under development. Contact HQ Design for further details).

Bridge railing attaches to the top of the bridge barrier. When bridge barrier is included in a project, the bridge rails, including crossroad bridge rail, are to be addressed. Consult the WSDOT BSO regarding bridge rail selection and for design of the connection to an existing bridge. Consider the following:

- Use an approved, NCHRP 350 or MASH crash-tested bridge traffic barrier on new bridges or bridges to be widened. The *Bridge Design Manual* provides examples of typical bridge rails. The BSO's minimum crash test level for all state and interstate bridges is a TL-4.
- An existing bridge rail on a roadway with a posted speed of 30 mph or below 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 mph or below, it may remain in place regardless of the type of metal rail installed. Other bridge rails are to be evaluated for strength and geometrics. (See Section 1610.07(1) for guidance on retrofit techniques.)
- 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 are factors in determining the adequacy of the Type 7 bridge rail, as shown in Exhibit 1610-15. Consult the WSDOT BSO for assistance in evaluating other bridge rails.
- When considering an overlay on a bridge, consult the WSDOT BSO to verify the overlay depth can be placed on the bridge deck based on the type of traffic barrier. There may be instances where the height of the bridge barrier will not allow for the planned overlay depth without removal of existing pavement.

Exhibit 1610-15 Type 7 Bridge Rail Upgrade Criteria



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 WSDOT BSO	

*When the curb width is greater than 9 inches, the aluminum rail must be able to withstand a 5 kip load.

1610.07(1) Bridge Barrier Retrofit

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 needed. Consult the WSDOT BSO to determine which retrofit method described below can be completed.

1610.07(1)(a) Concrete Safety Shape

Consult the WSDOT BSO to determine whether the existing bridge deck and other superstructure elements are of sufficient strength to accommodate this bridge barrier system and provide design details for the retrofit. Retrofitting with a new concrete bridge barrier is costly and requires authorization from Program Management when no widening is proposed.

1610.07(1)(b) Thrie Beam Retrofit

Retrofitting the bridge barrier with thrie beam is an economical way to improve the strength and redirectional performance of a bridge barrier. 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. Exhibit 1610-16 shows typical retrofit criteria.

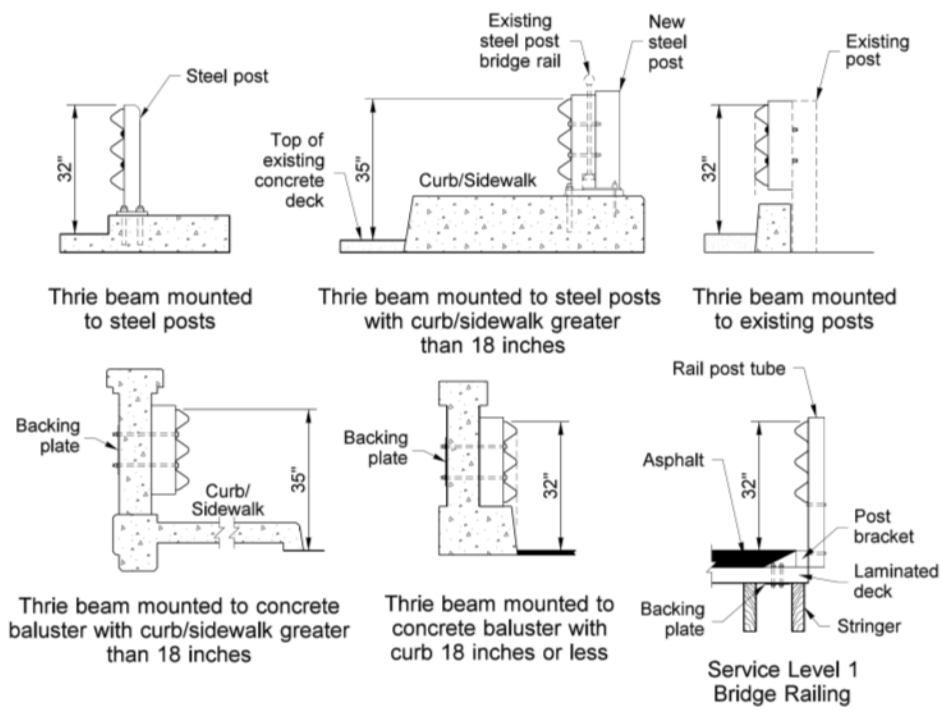
Note that Bridges designated as historical landmarks may not be candidates for thrie beam retrofitting. Contact the Environmental Services Office regarding bridge historical landmark status.

Consider the Service Level 1 (SL-1) system on bridges with wooden decks and for bridges with concrete decks that do not have the needed strength to accommodate the thrie beam system. Contact the WSDOT BSO for information needed for the design of the SL-1 system.

If a thrie beam retrofit results in reduction in sidewalk width ensure ADA compliance is addressed, see Chapter 1510.

Exhibit 1610-16 Thrie Beam Rail Retrofit Criteria

<table>
<tr><th rowspan="2">Curb Width</th><th rowspan="2">Bridge Width</th><th colspan="2">Concrete Bridge Deck</th><th rowspan="2">Wood Bridge Deck or Low- Strength Concrete Deck</th></tr>
<tr><th>Concrete Bridge Rail (existing)</th><th>Steel or Wood Post Bridge Rail (existing)</th></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><td rowspan="3">• Service Level 1 Bridge Rail. [2]
• Height = 32 inches.
• Curb or wheel guard needs to be removed.</td></tr>
<tr><td>>18 inches</td><td>> 28 ft (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 ft (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>



Notes:

[1] To maximize available curb/sidewalk width for pedestrian use, thrie beam may be mounted to the bridge rail at a height of 35 inches.

[2] Contact the WSDOT BSO for design details on bridge rail retrofit projects.

1610.08 Other Barriers

1610.08(1) Redirectional Landform

Redirectional landforms, also referred to as earth berms, were formerly installed to help mitigate crashes with fixed objects 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 landforms has been discontinued. Where redirectional landforms currently exist as mitigation for a fixed object, provide alternative means of mitigating the fixed object, such as removing, relocating, changing the fixed object to a crash-tested breakaway system, or shielding with barrier.

1610.08(2) Aesthetic Barrier Treatment

An aesthetic barrier may be desired on a project, or it may be required by a memorandum of understanding, a Scenic Byway designation, an easement or corridor management plan, or as a result of stakeholder engagement. Contact the region or HQ Landscape Architect Office to confirm this requirement, and to verify any specific conditions with respect to the barrier's appearance in the applicable plan or corridor document. Reactive coloring agents and powder coating are approved treatment options for w-beam guardrail, and may be applicable to other barrier types. Check with the manufacturer and/or the product documentation when specifying aesthetic treatment for proprietary devices, such as guardrail terminals.

One alternative to the use of aesthetic treatments are barriers designed to be aesthetic, such as steel-backed timber guardrail and stone guard walls. These alternative barriers will likely necessitate a partnering effort because of their higher costs, although grants may be available for this purpose if the need is identified early in the project definition phase.

1610.08(3) 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 incorporation of the Ironwood Guardrail will need to be documented. Consult with the Assistant State Design Engineer to determine what justification (proprietary or a public interest finding) will be required.

The most desirable method of terminating the steel-backed timber guardrail is to bury the end in a backslope, as described in 1610.04(5). When this type of terminal is not possible, use of the barrier is limited to highways with a posted speed of 45 mph or below. On these lower-speed highways, the barriers can be flared away from the traveled way as described in Section 1610.03(4) and terminated in a berm outside the Design Clear Zone.

For details on these systems, contact the HQ Design Office.

1610.08(4) Stone Guardwalls

Stone guardwalls function like rigid concrete barriers but have the 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 textured projection of the stones to help aid in 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 Section 1610.06(4). When this type of terminal is not possible, use of the barrier is limited to highways with a posted speed of 45 mph or below. On these lower-speed highways, the barrier can be flared away from the traveled way and terminated in a berm outside the Design Clear Zone.

For details on these systems, contact the HQ Design Office.

1610.08(5) 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 limited 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 1270)
- T-intersections
- Work zones
- Swing span bridges

Coordinate with the HQ Design Office for design details.

1610.09 References

1610.09(1) Design Guidance

WSDOT Roadside Safety site:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

Bridge Design Manual LRFD, M 23-50, WSDOT

Roadside Design Guide, AASHTO, 2011 with Errata (July 2015)

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Traffic Manual, M 51-02, WSDOT

1610.09(2) Supporting Information

Manual for Assessing Safety Hardware (MASH), AASHTO, 2016

Manual for Assessing Safety Hardware (MASH), AASHTO, 2009

NCHRP 350, TRB, 1993

Determining Length of Need. This e-learning course for WSDOT employees covers the "Length of Need," which is a calculation of how much longitudinal barrier is necessary to shield objects on the roadside. Request this training via the web-based Learning Management System.

Glossary

Acronyms

Glossary of Terms

Acronyms

AADT	Annual average daily traffic
ACT	Alternatives Comparison Table
ADA	Americans with Disabilities Act of 1990
ADT	Annual daily traffic
ALJ	Administrative law judge
AOS	Apparent opening size
APS	Accessible pedestrian signal
ARR	Access Revision Report
AWDVTE	Average weekday vehicle trip ends
ATDM	Active Transportation Demand Management
B/C	Benefit / cost
BLM	Bureau of Land Management
BOD	Basis of Design
BRT	Bus rapid transit
BST	Bituminous surface treatment
CAR	Crash Analysis Report
CDA	Conceptual Design Approval
CE	Categorical Exemption (SEPA)
CE	Categorical Exclusion (NEPA)
CFA	Contributing Factors Analysis
CFR	Code of Federal Regulations
CGT	Continuous Green “T” intersection
CIPP	Capital Improvement and Preservation Program
CPMS	Capital Program Management System
CRT	Controlled releasing terminal post
CSS	Context sensitive solutions
CTR	Commute Trip Reduction
CVISN	Commercial Vehicle Inf. System and Networks
DA	Design Approval
DB	Design Build
DBB	Design Bid Build
DDHV	Directional design hour volume
DDI	Diverging Diamond Interchange
DDP	Design Documentation Package
DHV	Design hourly volume
DLT	Displaced Left Turn
DNS	Determination of Nonsignificance (SEPA)
DS	Determination of Significance (SEPA)
E&EP	Environmental & Engineering Programs Division
EA	Environmental Assessment (NEPA)
EIS	Environmental Impact Statement
ERS	Environmental Review Summary
FGTS	Freight and Goods Transportation System
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact (NEPA)
FTA	Federal Transit Administration
GIS	Geographic Information System
GMA	Growth Management Act
HCM	Highway Capacity Manual
HCP	Highway Construction Program
HMA	Hot mix asphalt
HOT	High-occupancy toll
HOV	High-occupancy vehicle
HQ	WSDOT’s Headquarters in Olympia
HSM	Highway Safety Manual
HSP	Highway System Plan
HSS	Highways of Statewide Significance
ICD	Inscribed circle diameter
ICE	Intersection Control Evaluation
ITS	Intelligent transportation systems
L/A	Limited access
LOS	Level of service
MAP-21	Moving Ahead for Progress in the 21st century
MASH	Manual for Assessing Safety Hardware
MEF	Maximum extent feasible
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
NEPA	National Environmental Policy Act
NHS	National Highway System
PAR	Pedestrian access route
PCP	Pedestrian circulation path
PEL	Planning and Environmental Linkage
PDA	Project Development Approval
PF	Project File
PoDI	Project of Division Interest (FHWA)
PS	Project Summary
PSF	Pounds per square foot
PS&E	Plans, Specifications, and Estimates
QOL	Quality of Service
R/W	Right of way
RCUT	Restricted Crossing U Turn
RCW	Revised Code of Washington
RFP	Request for Proposal
ROD	Record of Decision
RTIP	Regional Transportation Improvement Program
RTPO	Regional Transportation Planning Organization
SAFETEA-LU	Safe Accountable Flexible Efficient Transportation Equity Act (A legacy for users)
SEPA	[Washington] State Environmental Policy Act
SHS	Sustainable Highway Safety
SHSP	Strategic Highway Safety Plan
SIMMS	Signal Maintenance Management System
SOV	Single-occupant vehicle
SRA	Safety rest area
SPUI	Single Point Urban Interchange
STIP	Statewide Transportation Improvement Program

STP	Surface Transportation Program
TIA	Traffic Impact Analysis
TIP	Transportation Improvement Program
TMA	Transportation Management Area
TMP	Transportation management plan
TTC	Temporary Traffic Control
TO	Transportation Operations
TWLTL	Two-way left-turn lane
UPO	[Central Puget Sound] Urban Planning Office
USC	United States Code
VE	Value engineering
VECP	Value Engineering Change Proposal
VIC	Visitor Information Center
VPH	Vehicles per hour
WAC	Washington Administrative Code
WIM	Weigh in motion
WSDOT	Washington State Department of Transportation
WSPMS	Washington State Pavement Management System
WTP	Washington Transportation Plan

Glossary of Terms

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	Y	Z

A

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 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.

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 control The limiting and regulating of public and private access to Washington State's highways, as required by state law. A *design control* (see Chapter 1103) – there are two categories of controlling access to state highways *limited access* and *managed access.*

Access Control Tracking System Limited Access and Managed Access Master Plan A database list, related to highway route numbers and mileposts, that identifies either the level of limited access or the class of managed access: www.wsdot.wa.gov/design/accessandhearings

access density The number of access points (driveways) per mile.

access design analysis A design analysis (see Chapter 300) that authorizes deferring or staging acquisition of limited access control, falling short of a 300-foot requirement, or allowing an existing access point to stay within 130 feet of an intersection on a limited access highway. Approval by the Director & State Design Engineer, Development Division, or designee, is required (see Chapter 530).

access hearing plan A limited access plan prepared for presentation at an access hearing.

access management The programmatic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street connections to a roadway.

access point Any point that allows private or public entrance to or exit from the traveled way of a state highway, including "locked gate" access and maintenance access points.

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.

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 access point to the next (see also corner clearance).

access revision report (ARR) A technical report which documents specific analyses in order to approve or reject a proposed revision to freeway access. See Chapter 550.

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.

accessible Usable by persons with disabilities (ADA compliant). (ADA term)

accessible pedestrian signal (APS) A device that communicates information about the "WALK" phase in audible and vibrotactile (vibrating surface that communicates information through touch, located on the accessible pedestrian signal button) formats. (ADA term)

accessible route See *pedestrian access route*. (ADA term)

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. Title II of the ADA requires public entities to design new pedestrian facilities or alter existing pedestrian facilities to be accessible to and usable by people with disabilities. (ADA term)

adaptive lighting system A lighting system with a control system connected, allowing for dimming, on/off operation by time of night, and independent scheduling of individual lights for select hours of operation during nighttime hours.

affidavit of publication A notarized written declaration stating that a notice of hearing (or notice of opportunity for a hearing) was published in the legally prescribed manner.

affidavit of service by mailing A notarized written declaration stating that the limited access hearing packet was mailed at least 15 days prior to the hearing and entered into the record at the hearing.

alteration A change to a facility in the public right of way that affects or could affect access, circulation, or use. Alterations include, but are not limited to: renovation; rehabilitation; reconstruction; historic restoration; resurfacing of circulation paths or vehicular ways; or changes or rearrangement of structural parts or elements of a facility. Alterations *do not* include: Spot pavement repair; liquid-asphalt sealing, chip seal (bituminous surface treatment), or crack sealing; or lane restriping that does not alter the usability of the shoulder. (ADA term)

alternative(s) Possible solutions to accomplish a defined purpose and need. These include local and state transportation system mode and 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.

Alternatives Comparison Table (ACT) A table that documents and presents the tradeoffs among those performance metrics identified for each alternative under consideration on a project. The ACT is used to assist in analyzing the baseline and contextual performance tradeoffs and ultimately to select an alternative. It is a supplemental document to the “Alternatives Analysis” section of the *Basis of Design*.

ancillary services Those secondary services, also considered amenities, provided at safety rest areas that include, but are not limited to, vending machines, picnic areas, interpretive signing, telephones, recreational vehicle (RV) sanitary disposal facilities, trails, scenic viewpoints, commercial and public information displays, and visitor information centers.

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. Normally, periodic daily traffic volumes are adjusted for hours of the day counted, days of the week, and seasons of the year to arrive at average annual daily traffic.

annual daily traffic (ADT) The average 24 hour volume, being the total volume during a stated period divided by the number of days in that period. Normally, this would be periodic daily traffic volumes over several days, not adjusted for days of the week or seasons of the year.

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.

approach and access connection These terms are listed under the specific access section to which they apply. 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 right of way other than at an intersection with another road or street.

(a) ***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*** An off and on approach in a 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*** 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 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. This approach type may be used for wind farms when use of the

approach is limited to those vehicles necessary to construct and maintain the farm for use in harvesting wind energy.

- ***Type C*** An off and on approach in a legal manner, for a 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 and on full control limited access highways where no other reasonable means of access exists, as solely determined by the department.
- ***Type D*** 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 allowed only on modified control limited access highways.
- ***Type E*** 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*** 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 allowed only on partial control limited access highways. (See WAC 468 58 080(vi) for further restrictions.)

(b) ***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.
- ***grandfathered 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.

(c) ***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 540).

area of influence The area that will be directly impacted by the proposed action: freeway main line, ramps, crossroads, immediate off-system intersections, and state and local roadway systems.

articulated bus A two-section bus that is permanently connected at a joint.

auxiliary aids and services (1) Qualified interpreters, notetakers, transcription services, written materials, telephone handset amplifiers, assistive listening devices, assistive listening systems, telephones compatible with hearing aids, open and closed captioning, telecommunications devices for persons with hearing or speech difficulties (TDDs), videotext displays, or other effective methods for making aurally delivered materials available to individuals with hearing limitations; (2) Qualified readers, taped texts, audio recordings, Brailled materials, large print materials, or other effective methods for making visually delivered materials available to individuals with visual impairments; (3) Acquisition or modification of equipment or devices; (4) Other similar services and actions; and (5) Providing and disseminating information, written materials, and notices in languages other than English, where appropriate.

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.

average light level The average of all light intensities within the design area.

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.

B

backslope A sideslope that goes up as the distance increases from the roadway (cut slopes).

barrier terminal A crash-tested 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.

baseline The approved time phased plan (for a project, a work breakdown structure component, a work package, or a schedule activity), plus or minus approved project scope, cost, schedule, and technical changes. Generally refers to the current baseline, but may refer to the original or some other baseline. Usually used with a modifier (e.g., cost baseline, schedule baseline, performance measurement baseline, technical baseline).

baseline performance metric A description of need in terms that can be measured or assessed in both the existing and proposed (future) state.

baseline performance need The primary reason a project has been proposed. It refers to the threshold determination at the project location resulting from a statewide biennial prioritization and funding process. It may also be the specific issue to be addressed by the project described by a partnering agency that is providing the funding.

basic number of lanes The minimum number of general purpose lanes designated and maintained over a significant length of highway.

Basis of Design (BOD) A document and template used to record information, decisions, and analysis needed in the development of a project design, including all factors leading to the development and selection of a project alternative, and the selection of design elements associated with that alternative.

benefit/cost analysis A method of valuing a proposition by first monetizing all current expenditures to execute—cost—as well as the expected yields into the future—benefit, then dividing the total benefit by the total cost, thus providing a ratio. Alternatives may be rendered and compared in this fashion where, typically, a higher ratio is preferable, indicating a better return on investment.

bicycle Any 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 is used or has a high potential for use by bicyclists or that is 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.

buffer A space measured from the back of the curb to the edge of the sidewalk that could be treated with plantings or alternate pavement, or be used for needs such as drainage treatment or utility placement. (ADA term)

buffer-separated HOV lane An HOV lane that is separated from the adjacent same direction general-purpose freeway lanes by a designated buffer.

bus A rubber-tired motor vehicle used for transportation, designed to carry more than ten passengers.

business access transit (BAT) lanes A transit lane that allows use by other vehicles to access abutting businesses.

bus pullout A bus stop with parking area designed to allow transit vehicles to stop wholly off the roadway.

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).

bus shelter A facility that provides seating and protection from the weather for passengers waiting for a bus.

bus stop A place designated for transit vehicles to stop and load or unload passengers.

C

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).

Capital Improvement and Preservation Program (CIPP) WSDOT's program of projects developed each biennium that delivers capital investments in highway, marine, and rail facilities that have been funded in part or in whole by the state Legislature. The CIPP is submitted to the Governor and, ultimately, by the Governor to the Legislature.

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

central island The area of the roundabout, including the truck apron, surrounded by the circulating roadway.

central island diameter The diameter of the central island, including the truck apron (see Chapter 1320).

circulating lane A lane used by vehicles circulating in the roundabout.

circulating roadway The traveled lane(s) adjacent to the central island and outside the truck apron, including the entire 360° circumference of the circle.

circulating roadway width The total width of the circulating lane(s) measured from inscribed circle to the central island (see Chapter 1320).

clear run-out area The area beyond the toe of a nonrecoverable slope available for use by an errant vehicle.

clear width The unobstructed width within a pedestrian circulation path. The clear width within a pedestrian circulation path must meet the accessibility criteria for a pedestrian access route. (ADA term)

clear zone The total roadside border area, available for use by errant vehicles, starting at the edge of the traveled way and oriented from the outside or inside shoulder (in median applications) as applicable. 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, fixed objects, or water deeper than 2 feet.

climate change vulnerability The risk a transportation facility will be impacted by the effects of climate change.

climbing lane An auxiliary lane used for the diversion of slow traffic from the through lane.

collector A context description of a roadway intended to provide a mix of access and mobility performance. Typically low speed, collecting traffic from local roads and connecting them with destination points or arterials. This term is used in multiple classification systems, but is most commonly associated with the *Functional Classification* System.

collector-distributor road (C-D road) A parallel roadway designed to remove weaving from the main line and reduce the number of main line entrances and exits.

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).

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.

complex ramp alignment and grade As related to Chapter 1040 Illumination. The exit advisory speed is 35 mph 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.

Conceptual Design Approval Documented approval of the Conceptual Design Approval for design-build projects locks in design policy for three years. Conceptual Design Approval becomes part of the Design Documentation Package (see Chapter 300).

conflict point A point where road user paths cross, merge, or diverge.

consider To think carefully about, especially in order to make a decision. The decision to document a consideration is left to the discretion of the engineer (See Section 300.03(2)).

construction impact zone The area in which an alteration to an existing facility takes place (also known as the project footprint). If a crosswalk (marked or unmarked) will be reconstructed, paved (overlay or inlay), or otherwise altered as part of a project, then the curb ramps that serve that crosswalk are within the construction impact zone. (ADA term)

context Refers to the environmental, economic, and social features that influence livability and travel characteristics. Context characteristics provide insight into the activities, functions, and performance that can be influenced by the roadway design. Context also informs roadway design, including the selection of design controls, such as target speed and modal priority, and other design decisions. See Chapter 1102.

context categories The naming convention used to describe either a land use or transportation context (see Chapter 1102).

context characteristic A distinguishing trait within a context, either land use or transportation. Chapter 1102 lists several common characteristics that help distinguish between one type of context versus another. There may be additional traits not covered in the chapter.

contextual performance metric A restatement of a contextual performance need in terms that can be measured or assessed in both the existing and proposed (future) state.

contextual performance need A statement of need that applies to a project location which has not been identified as a baseline need.

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.

continuous load The electrical load on a circuit that lasts for a duration of three or more hours on any day.

contributing factors Those operational conditions, human factors, context conditions, design elements, design controls, or actions identified by data, engineering judgment, or the community that contribute to a performance need under evaluation.

controlled releasing terminal (CRT) post A standard-length guardrail post that has two holes drilled through it so it might break away when struck.

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.

corner clearance On a managed access highway, the distance from an intersection of a public road or street to the nearest access connection along the same side of the highway. The minimum corner clearance distance (see Chapter 540) 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*).

corridor sketch An information source that describes the attributes of a state highway corridor, its current and future function, as well as its performance expectations. It will ultimately identify cost-effective strategies for future consideration. A completed corridor sketch may have information that is valuable at the project level in determining contextual performance needs, and project alternatives. A corridor sketch is not a substitute for detailed planning and analysis, nor is it a list of investments or projects.

corridor vision The future transportation context from a regional perspective. Practical Design considers and accounts for the contextual needs of the longer section of highway in the development and evaluation of alternatives to ensure a favorable outcome for the greater system.

counter slope The slope of the gutter or roadway at the foot of a curb ramp or landing where it connects to the roadway, measured along the axis of the running slope extended. (ADA term)

countermeasure An action taken to counteract an existing or anticipated condition.

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

Crash Analysis Report (CAR) A template that is used for documenting required analysis for I-2 CAL/CAC/IAL projects, as described in Chapter 321.

critical fill slope A slope on which a vehicle is likely to overturn. Slopes steeper than 3H:1V are considered critical fill slopes.

cross slope The slope measured perpendicular to the direction of travel. (ADA term)

crossroad The minor roadway at an intersection. At a stop-controlled intersection, the crossroad has the stop.

crosswalk A marked or unmarked pedestrian crossing, typically at an intersection, that connects the pedestrian access routes on opposite sides of a roadway. A crosswalk must meet accessibility criteria. A crosswalk is also defined as:

- "…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).
- "(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 might be supplemented by contrasting pavement texture, style, or color" (MUTCD, 2003*; Guide for the Planning, Design, and Operation of Pedestrian Facilities*, AASHTO, 2004). (ADA term)

curb extension A curb and sidewalk bulge or extension out into the parking lane used to decrease the length of a pedestrian crossing and increase visibility for the pedestrian and driver. (ADA term)

curb ramp A combined ramp and landing to accomplish a change in level at a curb. This element provides street and sidewalk access to pedestrians with mobility impairments. (ADA term)

- ***parallel curb ramp*** A curb ramp design where the sidewalk slopes down to a landing at road level with the running slope of the ramp in line with the direction of sidewalk travel
- ***perpendicular curb ramp*** A curb ramp design where the ramp path is perpendicular to the curb and meets the gutter grade break at a right angle.

curb section A roadway cross section with curb and sidewalk.

D

decision sight distance The distance needed for a driver to detect an unexpected or difficult-to-perceive condition, recognize the condition, select an appropriate maneuver, and complete the maneuver based on design conditions and design speed.

deflection (in respect to roundabouts) The change in the path of a vehicle imposed by the geometric features of a roundabout resulting in a slowing of vehicles.

delineation Any method of defining the roadway operating area for the driver.

deliverable Any unique and verifiable product, result or capability to perform a service that must be produced to complete a process, phase, or project.

design analysis A process and tool to record design element changes where the dimensions chosen do not meet the value, or lie within the range of values, provided for that element in the *Design Manual*. (See Sections 300.03(2) and 1106.07).

Design Approval (DA) Documented approval of the design at this early milestone locks in design policy for three years. Design approval becomes part of the Design Documentation Package (see Chapter 300.)

design-bid-build The project delivery method where design and construction are sequential steps in the project development process (23 CFR 636.103).

design-build contract An agreement that provides for design and construction of improvements by a consultant/contractor team. The term encompasses design-build-maintain, design-build-operate, design-build-finance, and other contracts that include services in addition to design and construction. Franchise and concession agreements are included in the term if they provide for the franchisee or concessionaire to develop the project that is the subject of the agreement (23 CFR 636.103).

design-builder The firm, partnership, joint venture, or organization that contracts with WSDOT to perform the work.

design controls Key parameters that critically shape design decisions and effect calculated dimensions for some design elements. Design controls are conscientiously selected and work together with the context characteristics to achieve a particular outcome (see Chapter 1103)

Design Clear Zone The minimum clear zone target value used in highway design.

Design Documentation Package (DDP) See *Project File*.

design element Any component or feature associated with roadway design that becomes part of the final product. Examples include lane width, shoulder width, alignment, and clear zone (see Chapter 1105.)

designer This term applies to WSDOT design personnel. Wherever "designer" appears in this manual, design-build personnel shall deem it to mean: Engineer of Record, Design Quality Assurance Manager, design-builder, or any other term used in the design-build contract to indicate design-build personnel responsible for the design elements of a design-build project, depending on the context of information being conveyed.

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*), 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.

design speed A design control; the speed used to determine the various geometric design features of the roadway.

design up An approach to developing project alternatives utilizing the smallest dimensions that meet the need by providing the desired performance.

design users A broad term intended to capture all modal users that currently utilize or are legally permitted on a roadway segment or node.

design variance Same as Design Analysis.

design vehicle See *intersection design vehicle*.

design year The forecast year used for design as described in Chapter 1103. See also *horizon year*.

desirable Design criteria that are recommended for inclusion in the design.

detectable warning surface A tactile surface feature of truncated dome material built into or applied to the walking surface to alert persons with visual impairments of vehicular ways. Federal yellow is the color used on WSDOT projects to achieve visual contrast. Colors other than federal yellow that meet the light-on-dark/dark-on-light requirement may be used on projects where cities have jurisdiction. (Detectable warning surfaces are detailed in the *Standard Plans*.) (ADA term)

Determination of Nonsignificance (DNS) (SEPA) The written decision by the Regional 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 Regional Administrator that a proposal could have a significant adverse impact and an EIS is required.

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.

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.

document (verb) The act of including a short note to the Design Documentation Package that explains a design decision (See Section 300.03(2)).

dooring Describes a conflict with a parked vehicle door opening into a roadway bike facility.

driveway A vehicular access point that provides access to or from a public roadway.

E

easement A documented right, as a right of way, to use the property of another for designated purposes.

element An architectural or mechanical component or design feature of a space, site, or public right of way.

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.

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 ensures 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, which is allowed at non-intersection locations only. At least two identical displays are required per approach.

enforcement observation point A place where a law enforcement officer may park and observe traffic.

entry angle The angle between the entry roadway and the circulating roadway measured at the yield point (see Chapter 1320).

entry curve The curve of the left edge of the roadway that leads into the circulating roadway (see Chapter 1320).

entry width The width of an entrance leg at the inscribed circle measured perpendicular to travel (see Chapter 1320).

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 whether an EIS or a FONSI should be prepared.

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

Environmental Review Summary (ERS) (see *Project Summary*) Part of the Project Summary document, the ERS identifies environmental permits and approvals. It is prepared in the region and is required for Design Approval.

expressway A divided highway that has a minimum of two lanes in each direction for the exclusive use of traffic and that may or may not have grade separations at intersections. A transportation context characteristic that is designated for a divided highway with limited access that provides regional mobility.

extrude A procedure for applying marking material to a surface by forcing the material through a die to give it a certain shape.

F

facility All or any portion of buildings, structures, improvements, elements, and pedestrian or vehicular routes located in a public right of way.

feature A component of a pedestrian access route, such as a curb ramp, driveway, crosswalk, or sidewalk.

Federal Highway Administration (FHWA) The division of the U.S. 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 division of the U.S. 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.

final design Any design activities following preliminary design; expressly includes the preparation of final construction plans and detailed specifications for the performance of construction work (23 CFR 636.103). Final design is also defined by the fact that it occurs after NEPA/SEPA approval has been obtained.

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

findings and order A document containing the findings and conclusions of a limited access hearing approved by the Assistant Secretary, Engineering & Regional Operations (see Chapter 210).

findings and order plan A limited access plan, prepared after a limited access hearing, which is based on the hearing record.

fixed feature (object to be mitigated) A fixed object, a side slope, or water that, when struck, can result in impact forces on a vehicle's occupants that may result in injury or place the occupants in a situation that has a high likelihood of injury. A fixed feature can be either constructed or natural.

flangeway gap The gap for the train wheel at a railroad crossing. The space between the inner edge of a rail and the pedestrian crossing surface. (ADA term)

flare The widening of the approach to the roundabout to increase capacity and facilitate natural vehicle paths.

flyer stop A transit stop inside the limited access boundaries.

footcandle (fc) The illumination of a surface one square foot in area on which a flux of one lumen is uniformly distributed. One footcandle equals one lumen per square foot.

foreslope A sideslope that goes down as the distance increases from the roadway (fill slopes and ditch inslopes).

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 beside 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.

G

geocomposites Prefabricated edge drains, wall drains, and sheet drains that typically consist 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, which 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.

Geographic Information System (GIS) A computerized geographic information system used to store, analyze, and map data. Data may be used with GIS if the data includes the Accumulated Route Mile (ARM) or State Route Milepost (SRMP) programs. 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. GIS is used to gather and analyze data to support the purpose and need as described in the Project Summary (http://wwwi.wsdot.wa.gov/gis/supportteam/default.asp).

geogrids A polymer grid mat constructed either of coated yarns or a punched and stretched polymer sheet. Geogrids usually have high strength and stiffness and are used primarily for soil reinforcement.

geomembranes Impervious polymer sheets that are typically used to line ponds or landfills. In some cases, geomembranes are placed over moisture-sensitive swelling clays to control moisture.

geonets Similar to geogrids, but typically lighter weight and weaker, with smaller mesh openings. Geonets are used in light reinforcement applications or are combined with drainage geotextiles to form a drainage structure.

geosynthetic erosion control 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 Chapter 630 are only used where more natural means (like 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 filtration 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.

geosynthetic survivability 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.

geotextiles (nonwoven) A sheet of continuous or staple fibers entangled randomly into a felt for needle-punched nonwovens and pressed and melted together at the fiber contact points for 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.

geotextiles (woven) 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.

gore The area downstream from the intersection of the shoulders of the main line and exit ramp. Although generally referring to 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.

gore nose At an exit ramp, the point at the end of the gore area where the paved shoulders of the main line and the ramp separate (see Chapter 1360) or the beginning of traffic barrier, not including any impact attenuator. Also, the similar point at an entrance ramp.

grade break The intersection of two adjacent surface planes of different grade. (ADA term)

H

hearing An assembly to which the public is invited and at which participation is encouraged. Types of hearings include:

- ***administrative appeal hearing*** A formal process whereby a property owner may appeal WSDOT's implementation of access management legislation. The appeal is heard by an administrative law judge (ALJ), who renders a decision. (See Chapter 540 for administrative appeal hearing procedures.)
- ***combined hearing*** A hearing held when there are public benefits to be gained by combining environmental, corridor, design, and/or limited access subjects.
- ***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. This type of hearing is beneficial for existing corridors with multiple Improvement projects programmed over a long duration.
- ***design hearing*** A formal or informal hearing that presents the design alternatives to the public for review and comment before the selection of a preferred alternative.
- ***environmental hearing*** A formal or informal hearing documenting that social, economic, and environmental impacts have been considered and that public opinion has been solicited.
- ***formal hearing format*** A hearing conducted by a moderator using a formal agenda, overseen by a hearing examiner, and recorded by a court reporter, as required by law. Limited access hearings require the use of the formal hearing format (see Chapter 210).
- ***informal hearing format*** A hearing where oral comments are recorded by a court reporter, as required by law. An informal hearing often uses the "open house" format (see Chapter 210). A formal agenda and participation by a hearing examiner are optional.
- ***limited access hearing*** A formal hearing that gives local public officials, owners of abutting properties, and other interested persons an opportunity to be heard about the limitation of access to the highway system.

hearing agenda An outline of the actual public hearing elements, used with formal hearings. (See Chapter 210 for contents.)

Hearing Coordinator The HQ Access and Hearings Section Manager: (360) 705-7266.

hearing examiner An administrative law judge from the Office of Administrative Hearings, or a WSDOT designee, appointed to moderate a hearing.

hearing script A written document of text to be presented orally by department representatives at a hearing.

hearing summary Documentation prepared by the region and approved by Headquarters that summarizes environmental, corridor, and design hearings. (See Chapter 210 for content requirements.)

hearing transcript A document prepared by the court reporter that transcribes verbatim all oral statements made during the hearing, including public comments. This document becomes part of the official hearing record.

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 meets the occupancy requirements of the facility as authorized by WAC 468-510-010.

high pavement type Portland cement concrete pavement or hot mix asphalt (HMA) pavement on a treated base.

highway A general term denoting a street, road, or public way for the purpose of vehicular travel, including the entire area within the right of way.

Highway Construction Program (HCP) A comprehensive multiyear program of highway Improvement and Preservation projects selected by the Legislature.

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, action strategies, and costs to maintain, operate, preserve, and improve the state highway system for 20 years. The HSP is the starting point for the state highway element of the CIPP and the 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 "constrained" costs of the highway programs, and provides details of conceptual solutions and performance in the improvement program.

Highways of Statewide Significance (HSS) Include interstate highways and other principal arterials that are needed to connect major communities in the state. The designation helps assist with the allocation and direction of funding. (http://www.wsdot.wa.gov/planning/HSS)

Horizon year Typically considered to be 20 years from the year construction is scheduled to begin, as described in Chapter 1103. See also design year.

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.

I

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 fixed feature.

incorporated city or town A city or town operating under RCW 35 or 35A.

inscribed circle The outer edge of the circulating roadway.

inscribed circle diameter (ICD) The diameter of the inscribed circle (see Chapter 1320).

inner corridor access a means of entering or leaving a roadside area inside of the state limited access right of way without crossing over, under, or physically through the plane of limited access.

intelligent transportation systems (ITS) An integrated system of advanced sensor, computer, electronics, and communication technologies and management strategies, used to increase the safety and efficiency of the surface transportation system.

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.

intermediate pavement type Hot mix asphalt pavement on an untreated base.

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.

intersection angle The angle between any two intersecting legs at the point the centerlines 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 farthest point: (a) the end of the corner radii, (b) through any marked crosswalks adjacent to the intersection, (c) to the stop bar, or (d) 10 feet from the edge of shoulder of the intersecting roadway (see Chapter 1310).

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.

- ***four-leg intersection*** An intersection formed by two crossing roadways.
- ***split tee*** A four-leg intersection with the crossroad intersecting the through roadway at two tee intersections offset by at least the width of the roadway.
- ***tee (T) intersection*** An intersection formed by two roadways where one roadway terminates at the point it meets a through roadway.
- ***wye (Y) intersection*** An intersection formed by three legs in the general form of a “Y” where the angle between two legs is less than 60°.

intersection control beacon (also *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; however, two displays per approach are desirable. Intersection control beacons are installed only at intersections that control two or more directions of travel.

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.

Note: 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 density The ratio of intersections per mile.

intersection design vehicle A specific selection of the vehicle to be used to dimension intersection design elements at an individual intersection.

intersection sight distance The length of roadway visible to the driver of a vehicle entering an intersection.

Interstate System A network of routes designated by the state and the Federal Highway Administration (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.

island A defined area within an intersection, between traffic lanes, for the separation of vehicle movements or for pedestrian refuge.

J

justify Preparing a memo to the DDP identifying the reasons for the decision: a comparison of advantages and disadvantages of all options considered <u>(See Section 300.03(2))</u>.

K

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, GIS & Modeling Office’s Annual Peak Hour Report.

L

lamp lumens The total light output from a lamp, measured in lumens.

lane A strip of roadway used for a single line of vehicles.

lane control signal (reversible lanes) A special overhead signal that permits, prohibits, or warns of impending prohibition of lane use.

lane width The lateral <u>dimension of a lane measured between the centers of lane lines to adjacent lane lines, edge lines, the faces of curbs, or gutters. Note, gutters are not part of a lane when the gutter is a different color than the lane. See Design Manual Exhibit 1230-1 Geometric Cross Section - Guide to Chapters for more detail.</u>

landing A level paved area, within or at the top and bottom of a stair or ramp, designed to provide turning and maneuvering space for wheelchair users and as a resting place for pedestrians. (ADA term)

lateral clearance The distance from the edge of traveled way to a roadside object.

layered networks Roadway network arrangement where the objective is to separate modes onto different facilities with planned interconnection locations.

lead agency The public agency that has the principal responsibility for carrying out or approving a project.

left-cross Describes the intersection conflict between a motor vehicle left-turn and bicycle through movement in the opposing direction.

legal road approach A road approach that complies with the requirements of Chapter 530 for limited access facilities and Chapter 540 for managed access facilities.

length of need The length of a traffic barrier used to shield a fixed feature.

level of service (LOS) LOS is based on peak hour, except where noted. LOS assigns a rank (A – F) to facility sections based on traffic flow concepts like density, delay, and/or corresponding safety performance conditions. (See the Highway Capacity Manual and AASHTO's Geometric Design of Highways and Streets ["Green Book"] for further details.)

life cycle cost The total cost of a project or item over its useful life. This includes all of the relevant costs that occur throughout the life of a project or item, including initial acquisition costs (such as right of way, planning, design, and construction), operation, maintenance, modification, replacement, demolition, financing, taxes, disposal, and salvage value as applicable.

light emitting diode (LED) A two-lead semiconductor light source.

limited access (L/A) 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 (see Chapter 520).

- ***acquired limited access control*** Access rights have been purchased.
- ***established limited access control*** An access hearing has been held and the Assistant Secretary, Engineering & Regional Operations, has adopted the findings and order, which establishes the limits and level of control.
- ***planned limited access control*** Limited access control is planned for some time in the future; however, no access hearing has been held.

Limited Access and Managed Access Master Plan A map of Washington State that shows established and planned limited access highways: www.wsdot.wa.gov/design/accessandhearings

limited access highway All highways listed as "Established L/A" on the Limited Access and Managed Access Master Plan and 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.

local roads Non-state highways that are publicly owned.

long tunnel A tunnel, lid, or underpass that is greater than 80’ in length and has a length to vertical clearance ratio greater than 10:1.

low pavement type Bituminous surface treatment (BST).

lumen The unit used to measure luminous flux.

luminaire A complete lighting unit comprised of a light bulb or light emitting Diode (LED) module, 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.

M

M2D2 Multimodal Development and Delivery

managed access highway Highways where the rights of direct access to or from abutting lands have not been acquired from the abutting landowners.

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.

managing project delivery A WSDOT management process for project delivery from team initiation through project closing.

maximum extent feasible (MEF) From the U.S. Department of Justice, 28 CFR Part 36.402, Alterations. The phrase “to the maximum extent feasible” applies to “the occasional case where the nature of an existing facility makes it virtually impossible to comply fully with applicable accessibility standards through a planned alteration.” This phrase also refers to a stand-alone piece of design documentation that WSDOT uses to record its reasons for not being able to achieve full ADA compliance in alteration projects (called a Maximum Extent Feasible document). (ADA term)

maximum uniformity ratio The average light level within the design area divided by the minimum light level within the design area (see Chapter 1040).

maximum veiling luminance ratio The maximum veiling luminance divided by the average luminance over a given design area for an observer traveling parallel to the roadway centerline (see Chapter 1040).

mcd/m2/lux Pavement marking retroreflectivity is represented by the coefficient of retroreflected luminance (R_L) measured in millicandelas per square meter.

Measures of Effectiveness (MOEs) In the context of Chapter 320, examples are: speed, delay, density, LOS, QOS, person or vehicle throughput, cost vs. benefit, and queue. (See FHWA's MOE List.)

median The portion of a divided highway , from edge of traveled way to edge of traveled way, that separates vehicular traffic traveling in opposite directions.

median functions one or more reason(s) for a median as described in Chapter 1239.

median opening An opening in a continuous median for the specific purpose of allowing vehicle movement.

Memorandum of Understanding (MOU) for a road approach permit There is a MOU (Highways Over National Forest Lands) between the United States Forest Service (USFS) and WSDOT that requires the USFS to obtain a road approach permit for new access to a state highway that is crossing Forest Service land.

metering signal A signal used to control the predominant flow rate of traffic at an at-grade facility.

Methods and Assumptions Document A mandatory document developed at the beginning of the ARR phase to record ARR assumptions, methodologies, criteria, and decisions (see Chapter 550).

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 Program (TIP).

midblock pedestrian crossing A marked pedestrian crossing located between intersections. (ADA term)

minimum average light level The average of all light intensities within the design area, measured just prior to relamping the system (see Chapter 1040).

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 Chapter 1040).

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).

minor operational enhancement projects These projects usually originate from the Q2 component of the Q Program and are quick responses to implement low-cost improvements. They 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.

modal compatibility An assessment to determine which mode(s) need to be considered strictly based on the context characteristics present or planned. The assessment is independent of whether any particular mode is present on the segment, and intended to guide strategic investment opportunities on a segment.

modal priority Mode(s) that will be prioritized when making design decisions for the project, guided by the outcome of the modal compatibility assessment.

mode A specific type or form of transportation. Typically for roadway design the modes are: automobiles, transit, truck freight, pedestrians, skateboards, and bicycles.

monument As defined in Chapter 410, a monument is any physical object or structure that 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.

monument removal or destruction The physical disturbance or covering of a monument such that the survey point is no longer visible or readily accessible.

mountable curb A sloped curb with a height 6 inches or less. When the slope is steeper than 1H:1V, the height is limited to 4 inches or less.

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.

movable bridge signal (also drawbridge signal) A signal installed to notify traffic to stop when the bridge is opened for waterborne traffic. Movable bridge signals display continuous green when the roadway is open to vehicular traffic.

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).

N

National Highway System (NHS) The NHS was developed by the U.S. Department of Transportation (DOT) in cooperation with the states, local officials, and metropolitan planning organizations (MPOs).

The NHS includes the following subsystems of roadways (note that a specific highway route may be on more than one subsystem):

- ***Interstate*** The Eisenhower Interstate System of highways retains its separate identity within the NHS.
- ***Other Principal Arterials*** These are highways in rural and urban areas that provide access between an arterial and a major port, airport, public transportation facility, or other intermodal transportation facility.
- ***Strategic Highway Network (STRAHNET)*** This is a network of highways that are important to the United States' strategic defense policy and that provide defense access, continuity, and emergency capabilities for defense purposes.

- ***Major Strategic Highway Network Connectors*** These are highways that provide access between major military installations and highways that are part of the Strategic Highway Network.
- ***Intermodal Connectors*** These highways provide access between major intermodal facilities and the other four subsystems making up the National Highway System.

natural vehicle path The natural path that a driver navigates a vehicle given the layout of the intersection and the ultimate destination.

need A statement that identifies the transportation problem(s) or other performance gap

negative illumination Lighting the background and leaving the object dark to contrast with the light behind it as the driver views it.

network connectivity How the various roadways and other transportation facilities within a network interconnect in a defined geographic area.

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 discernible at a distance of 500 feet (RCW 46.04.200).

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.

nonconforming road approach A road approach that does not meet current requirements for location, quantity, spacing, sight distance, or geometric elements.

nonrecoverable slope A slope on which an errant vehicle might continue until it reaches the bottom, without having the ability to recover control. Fill slopes steeper than 4H:1V, but not steeper than 3H:1V, are considered nonrecoverable.

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.

notice of appearance A form provided by WSDOT for anyone wanting to receive a copy of the findings and order and the adopted limited access plan (see Chapter 210).

notice of hearing (or hearing notice) A published advertisement that a public hearing will be held.

notice of opportunity for a hearing An advertised offer to hold a public hearing.

O

occupancy designation The minimum number of occupants required for a vehicle to use the HOV facility.

operating speed The speed at which drivers are observed operating their vehicles during free flow conditions.

order of hearing The official establishment of a hearing date by the Director & State Design Engineer, Development Division.

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 (C-D) road.

overall project cost The total cost of Preliminary Engineering, Right of Way, and Construction Costs.

overlapped displays Overlapped displays allow a traffic movement to operate with one or more nonconflicting phases. 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 (the main phase the overlap is associated with) terminates. An overlapped display programmed for two or more parent phases continues to display until all of the parent phases have terminated. An overlap is made up of two or more phases—not one phase controlling two movements.

P

painted nose The point where the main line and ramp lanes separate.

passenger loading zone An area provided for pedestrians to board/disembark a vehicle. (ADA term)

passing lane An auxiliary lane on a two-lane highway used to provide the desired frequency of passing zones.

passing sight distance The distance (on a two-lane highway) needed for a vehicle driver to execute a normal passing maneuver based on design conditions and design speed.

pavement marking A colored marking applied to the pavement by spray, extrusion, adhesives, or glue to provide drivers with guidance and other information.

pavement marking beads ***Glass:*** Small glass spheres used in highway pavement markings to provide retroreflectivity. ***Composite:*** any non-glass bead intended to provide wet weather retroreflectivity.

pavement marking durability A measure of a pavement marking's resistance to wear and deterioration.

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. The 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.

pedestrian Any person afoot or using a wheelchair (manual or motorized) or means of conveyance (other than a bicycle) propelled by human power, such as skates or a skateboard. (ADA term)

pedestrian access route (PAR) (synonymous with accessible route) A continuous, unobstructed walkway within a pedestrian circulation path that provides accessibility. Pedestrian access routes consist of one or more of the following pedestrian facilities: walkways/sidewalks, curb ramps (excluding flares), landings, crosswalks, pedestrian overpasses/underpasses, access ramps, elevators, and platform lifts.

Note: Not all transportation facilities need to accommodate pedestrians. However, those that do accommodate pedestrians need to have an accessible route. (ADA term)

pedestrian circulation path A prepared exterior or interior way of passage provided for pedestrian travel. Includes independent walkways, shared-use paths, sidewalks, and other types of pedestrian facilities. All pedestrian circulation paths are required to contain a continuous pedestrian access route that connects to all adjacent pedestrian facilities, elements, and spaces that are required to be accessible. (ADA term)

pedestrian facilities Walkways such as sidewalks, 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. (ADA term)

pedestrian overpass or underpass A grade-separated pedestrian facility, typically a bridge or tunnel structure over or under a major highway or railroad that allows pedestrians to cross. (ADA term)

pedestrian refuge island An island in the roadway that physically separates the directional flow of traffic, provides pedestrians with a place of refuge, and reduces the crossing distance. Note: Islands with cut-through paths are more accessible to persons with disabilities than are raised islands with curb ramps. (ADA term)

pedestrian signal An adaptation of a conventional traffic signal installed at established pedestrian crossings. It is used to provide a protected phase for pedestrians by terminating the conflicting vehicular movements to allow for pedestrian crossings. (ADA term)

performance-based decisions Decisions that are made based on performance, performance metrics, performance targets, and performance gaps. Also, decisions made using performance evaluation tools, such as the Highway Safety Manual predictive methods for evaluating safety performance.

performance category Any broad area of performance important to an organization, project, or place. WSDOT's six performance categories: Economic Vitality, Preservation, Safety, Mobility, Environment, and Stewardship are the result of legislative policy per RCW 47.04.280.

performance evaluation tools Quantitative tools used to measure performance. Examples of these tools currently being used by WSDOT are *Highway Safety Manual* methodology (for safety performance) and *Highway Capacity Manual* (for mobility performance).

performance gap The difference between the measured and targeted performance unit for a performance metric. This gap is another way of describing the performance need(s) at a location.

performance metric Any measurable indicator used to assess the achievement of outcomes.

performance need See *baseline performance need* and *contextual performance need*

performance target(s) An outcome or desired state intended for a project. Performance targets are identified as either baseline or contextual (see Chapter 1101).

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 that has legal authority to issue managed access connection permits. For access connections in unincorporated areas, the permitting authority is WSDOT; for access connections within corporate limits, the permitting authority is a city or town.

person with a disability Per the U.S. Department of Justice: An individual with a disability is defined by the ADA as a person who has a physical or mental impairment that substantially limits one or more major life activities, a person who has a history or record of such an impairment, or a person who is perceived by others as having such an impairment. It is defined by law through the American with Disabilities Act. (ADA term)

physical nose The point, upstream of the gore, with a separation between the roadways of 16 to 22 feet (see Chapter 1360).

planning Transportation planning is a decision-making process required by federal and state law used to solve complex, interrelated transportation and land use problems.

Planning and Environmental Linkage (PEL) A collaborative and integrated approach to transportation decision-making that (1) considers environmental, community, and economic goals early in the planning process, and (2) uses the information, analysis, and products developed during planning to inform the environmental review process.

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.

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.

portable traffic signal A type of conventional traffic signal used in work zones to control traffic. This signal is most commonly used on two-way two-lane highways where one lane has been closed for roadwork. This signal is most commonly operated in pairs, with one signal at each end of the work zone. This eliminates the need for 24-hour flagger control. 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.

positive illumination Lighting the surface of the object as the driver views it.

posted speed The maximum legal speed as posted on a section of highway using regulatory signs.

Practical Design/Practical Solutions An approach to making project decisions that focuses on the specific problem the project is intended to address. This performance-based approach looks for lower cost solutions that meet outcomes that WSDOT, partnering agencies, communities and stakeholders have identified. Practical design is a fundamental component to the vision, mission, values, goals, and reforms identified in Results WSDOT- WSDOT's Strategic Plan. With practical solutions, decision-making focuses on maximum benefit to the system, rather than maximum benefit to the project. Focusing on the specific project need minimizes the scope of work for each project so that system-wide needs can be optimized.

prehearing packet A concise, organized collection of all necessary prehearing data, prepared by the region and approved by the HQ Access and Hearings Section Manager prior to the hearing (see Chapter 210).

preliminary engineering (PE) A term used to describe the Project Delivery process from project scoping through PS&E review.

principal arterial system A connected network of rural arterial routes with appropriate extensions into and through urban areas, including routes designated as part of the Interstate System, that serves corridor movements with travel characteristics indicative of substantial statewide and interstate travel (RCW 47.05.021).

Priority Programming Process The rational selection of projects and services according to factual need and an evaluation of life cycle costs and benefits.

project The Project Management Institute defines a project to be "a temporary endeavor undertaken to create a unique product or service."

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 Chapter 300).

Project Engineer This term applies to WSDOT personnel. Wherever "Project Engineer" appears in this manual, the design-builder shall deem it to mean "Engineer of Record."

Project File (PF) A file containing all documentation and data for all activities related to a project (see Chapter 300).

- ***Design Documentation Package (DDP)*** The portion of the Project File, including Design Approval and 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 Chapter 300. Technical reports and calculations are part of the Project File, but they are not designated as components of the DDP. Include estimates and justifications for decisions made in the DDP (see Chapter 300). The DDP explains how and why the design was chosen and documents approvals.

project management plan A formal, approved document that defines how the project is executed, monitored, and controlled. It may be in summary or detailed form and may be composed of one or more subsidiary management plans and other work planning documents. For further information, see the Project Management Guide:
http://www.wsdot.wa.gov/Projects/ProjectMgmt/OnlineGuide/ProjectManagementOnlineGuide.htm

project need statement A statement identifying the baseline performance need for the project. For each identified project need, there may be one or more performance metrics, targets, and gaps.

Project Scoping See *scoping phase*.

Project Summary A set of documents consisting of the, Environmental Review Summary (ERS), and 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 Chapter 300).

- ***Environmental Review Summary (ERS)*** A document that records the environmental classification (class of action) and considerations (consequences of action) for a specific project.
- ***Project Definition (PD)*** A document that records the purpose and need of the project, along with program level and design constraints.

Projects of Division Interest (PoDIs) A primary set of projects for which FHWA determines the need to exercise oversight and approval authority, as described in Chapter 300.

proposal The combination of projects/actions selected through the study process to meet a specific transportation system need.

public art An enhancement to a functional element, feature, or place within a transportation facility to provide visual interest. The enhancement could be an addition to a functional element, integrated into a design, or for purely aesthetic purposes. An element is considered "public art" if it is beyond WSDOT standard practice for architectural treatment.

public involvement plan A plan to collaboratively involve the public in decision making, tailored to the specific needs and conditions of a project and the people and communities it serves. It is often part of a broader communications plan.

public transportation Passenger transportation services available to the public, including buses, ferries, rideshare, and rail transit.

purpose General project goals such as improve safety, enhance mobility, or enhance economic development.

Q

Quality of Service (QOS) Defined by the *Highway Capacity Manual* or by agreement. Intended to describe how well a facility or service operates or functions from the perspective of the user.

quantitative safety analysis An analysis of quantitative safety performance based on data-driven science based tools and techniques that model modal crash potential.

quantitative tools Analytical tools used to measure performance. Examples of tools currently being used by WSDOT are:

- *Highway Safety Manual* predictive methods (for safety performance)
    - AASHTOWare *SafetyAnalyst*

  - ISATe (spreadsheet tool for implementing the HSM predictive methods for freeways and interchanges)
  - IHSDM (FHWA software tool for implementing the HSM predictive methods)
  - HSM Enhanced Spread Sheets (spreadsheet tools for implementing the HSM predictive methods for rural two lane two way roadways, rural multilane roads, and urban and suburban arterials)
  - See also http://wwwi.wsdot.wa.gov/highwaysafety
- *Highway Capacity Manual* (for mobility performance)

queue cutter traffic signal A traffic signal used at highway-rail grade crossings where the queue from a downstream traffic signal is expected to extend within the Minimum Track Clearance Distance. It is used to keep vehicles from an adjacent signalized intersection from queuing on the railroad tracks.

R

raised median A raised island in the center of a road used to restrict vehicle left turns and side street access. Note: Islands with cut-through paths are more accessible to persons with disabilities than are raised islands with curb ramps. (ADA term)

ramp A walking surface with a running slope steeper than 20H:1V (5%). (ADA term)

ramp (in relation to a *Roadway*) 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 roadway.

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 An intersection at the end of a ramp.

Record of Decision (ROD) Under the National Environmental Policy Act, the Record of Decision 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.

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.

Recreational Vehicle Account In 1980 the RV account was established for use by the department of transportation for the construction, maintenance, and operation of recreational vehicle sanitary disposal systems at safety rest areas (RCW 46.68.170). A recreational vehicle sanitary disposal fee is required for registration of a recreational vehicle (RCW 46.17.375). Adjustments to the recreational vehicle fee by the department of transportation may be implemented after consultation with the citizens' representatives of the recreational vehicle user community (RCW 47.01.460).

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 that are responsible for coordinating transportation planning activities within a region.

relocation assistance program A program that establishes uniform procedures for relocation assistance that will ensure legal entitlements and provide fair, equitable, and consistent treatment to persons displaced by WSDOT-administered projects, as defined in the *Right of Way Manual*.

Request for Proposal (RFP) The document package issued by WSDOT requesting submittal of proposals for the project and providing information relevant to the preparation and submittal of proposals, including the instructions to proposers, contract documents, bidding procedures, and reference documents.

résumé An official notification of action taken by WSDOT following adoption of a findings and order (see Chapter 210).

retroreflection The phenomenon of light rays striking a surface and being returned directly back to the source of light.

Retroreflection, coefficient of (R_L) A measure of retroreflection.

retroreflectometer An instrument used to measure retroreflectivity.

right-hook Potential intersection conflicts between motor vehicles making a right turn and the bicycle through movement.

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 An access point, other than a public road/street, that allows access to or from a limited access highway on the state highway system.

roadside park A roadside user facility for safe vehicular parking off the traveled way and separated from the highway by some form of buffer. These sites might be equipped with features or elements such as points of interest, picnic tables, and/or vault toilet buildings. Unlike a safety rest area, a roadside park does not always provide a permanent restroom building.

roadway The portion of a highway, including shoulders.

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.

roundabout A circular intersection at grade with yield control of all entering traffic, channelized approaches with raised splitter islands, counter-clockwise circulation, and appropriate geometric curvature to force travel speeds on the circulating roadway generally to less than 25 mph.

rumble strips Rumble strips are grooves or rows of raised pavement markers placed perpendicular to the direction of travel, or ground in a continuous longitudinal sinusoidal pattern. They are used to alert inattentive drivers.

running slope A slope measured in the direction of travel, normally expressed as a percent. (ADA term)

S

Safety Analyst A program developed to implement the *Highway Safety Manual* methodology

safety rest area (SRA) A roadside facility equipped with permanent restroom building(s), a parking area, picnic tables, refuse receptacles, illumination, and other ancillary services. SRAs typically include potable water and might include traveler information and telephones.

Safety Rest Area Strategic Plan Developed in 2008 under a stakeholder-coordinated effort of executive and advisory team members, this plan provides guidance for current and future management of the SRA program.

sawtooth berth A series of bays that are offset from one another by connecting curb lines, constructed at an angle from the bus bays. This configuration minimizes the amount of space needed for vehicle pull in and pull out.

scoping phase An initial phase of project development for a specific project. The scoping phase precedes the design and/or preliminary engineering phase and is intended to support priority programing and budget building scenarios. The *Project Summary* is the documentation developed during this phase.

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.

separated HOV facility An HOV roadway that is physically separated from adjacent general-purpose lanes by a barrier or median, or is on a separate right of way.

shared-use 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. Shared-use paths are primarily used by bicyclists and pedestrians, including joggers, skaters, and pedestrians with disabilities, including those who use nonmotorized or motorized wheeled mobility devices. With appropriate design considerations, equestrians may also be accommodated by a shared-use path facility.

short tunnel A tunnel, lid, or underpass that is shorter than 80’ in length and has a length to vertical clearance ratio of 10:1 or less.

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 allowed, use by pedestrians and bicycles.

shoulder width The lateral dimension of the shoulder, measured from the edge of traveled way to the edge of roadway or the face of curb. See Exhibit 1230-1 Geometric Cross Section - Guide to Chapters for a list of shoulder width chapters.

sidewalk A walkway along a highway, road, or street intended for use by pedestrians. (ADA term)

sight distance The length of highway visible to a driver.

Signal Maintenance Management System (SIMMS) A database used for traffic signals, illumination, and Intelligent Transportation Systems (ITS). SIMMS is used to establish an inventory base, enter work reports, print timesheets, and store maintenance records for electrical/electronic systems within WSDOT right of way.

single-lane roundabout A roundabout having single-lane entries at all legs and one circulating lane.

single-occupant vehicle (SOV) Any motor vehicle other than a motorcycle carrying one occupant.

site Parcel(s) of land bounded by a property line or a designated portion of a public right of way. (ADA term)

site design Style and configuration of the built environment or parcel(s).

slip base A mechanical base designed to allow the light standard to break away from the fixed foundation when hit by a vehicle traveling at the design speed and traveling at a departure angle less than or equal to the design departure angle.

slip lane A lane that separates heavy right-turn movements from the roundabout circulating traffic (see Chapter 1320).

slip ramp A connection between legs of an intersection that allows right-turning vehicles to bypass the intersection or a connection between an expressway and a parallel frontage road. These are often separated by an island.

slow-moving vehicle turnout A shoulder area widened to provide room for a slow-moving vehicle to pull out of the through traffic, allow vehicles to pass, and then return to the through lane.

special-use lanes Lanes that are designed for a specific purpose such as:

Bicycle lanes	Left-turn lanes	Transit lanes
Collector-Distributor (CD) lanes	Reversible lanes	Truck climbing lanes
Ferry holding lanes	Right-turn lanes	Two-way left-turn lanes
High Occupancy Vehicle (HOV) lanes	Slow vehicle lanes	Weaving/speed change lanes

speed The operations or target or posted speed of a roadway. There are three classifications of speed established:

- ***Low speed*** is considered 35 mph and below.
- ***Intermediate speed*** is considered 40-45 mph.
- ***High speed*** is considered 50 mph and above.

speed limit sign beacon A beacon installed with a fixed or variable speed limit sign. The preferred display is two flashing yellow indications.

speed management An engineered effort to achieve a targeted speed.

speed transition segment An engineered segment of road intended to lower the operating speed between contexts with different target speeds.

splitter island The raised island at each two-way leg between entering and exiting vehicles, designed primarily to control the entry and exit speeds by providing deflection. They also discourage wrong-way movements, and provide pedestrian refuge.

state highway system All roads, streets, and highways designated as state routes in compliance with RCW 47.17.

static scale A scale that requires a vehicle to stop for weighing.

stopping sight distance The distance needed for a driver to stop a vehicle traveling at design speed based on design conditions.

stop sign beacon A beacon installed above a stop sign. The display is a flashing red indication.

street furniture Sidewalk equipment or furnishings, including garbage cans, benches, parking meters, and telephone booths. (ADA term)

streetside The portion of the public right of way dedicated to the pedestrian thoroughfare and supporting the accessibility, activities and functions of the local land use. The streetside is comprised of a frontage zone, pedestrian zone and furnishing zone (see Chapter 1238). Note some local agencies may divide the streetside zone.

study area The transportation system area to study in the study process and for an ARR. The study area is a minimum of one interchange upstream and downstream from the proposal. The study area shall also include the intersecting roadway in the area to the extent necessary to ensure its ability to collect and distribute traffic to and from the interchange. The study area should be expanded as necessary to capture operational impacts of adjacent interchanges in the vicinity that are, or will be, bottlenecks or chokepoints that influence the operations of the study interchange.

study plan A term associated with environmental procedures, this plan proposes an outline or "road map" of the environmental process to be followed during the development of a project that requires complex NEPA documentation (see Chapter 210 and the *Environmental Manual*).

subgrade The compacted soil that supports the roadway pavement courses.

subject matter expert A person who is an authority in a particular area or topic, and understands the data and the limitations on the use and application of the data.

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.

support team An integral part of the ARR process consisting of an assemblage of people from the regions, FHWA (for Interstates), WSDOT HQ Access and Hearings, and other representatives organized to develop and analyze alternatives to meet the need of a proposal, including approval authorities.

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

T

tangent runout The length of highway needed to change the cross slope from normal crown to a section with adverse crown removed (level).

target speed A proactive approach to establishing a speed consistent with the context characteristics. Target speed is the design operating speed, which aligns design, posted and operating speed as the same value.

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.

tradeoffs analysis An analysis method for balancing factors, performance or outcomes, which are not attainable at the same time.

traffic barrier A longitudinal barrier, including bridge rail or an impact attenuator, used to redirect vehicles from fixed features located within an established Design Clear Zone, help mitigate median crossovers, reduce the potential for errant vehicles to travel over the side of a bridge structure, or (occasionally) protect workers, pedestrians, or bicyclists from vehicular traffic.

traffic barrier/longitudinal barrier A device oriented parallel or nearly parallel to the roadway whose primary function is to contain or safely redirect errant vehicles away from fixed features or to (occasionally) protect workers, pedestrians, or bicyclists from vehicular traffic. Beam guardrail, cable barrier, bridge rail, concrete barrier, and impact attenuators are barriers, and they are categorized as rigid, rigid anchored, unrestrained rigid, semirigid, and flexible. They can be installed as roadside or median barriers.

traffic calming Design techniques that have been shown to reduce traffic speeds and unsafe maneuvers. These techniques can be stand-alone or used in combination, and they include lane narrowing, curb extensions, surface variations, and visual clues in the vertical plane. (ADA term)

traffic calming treatments Treatments along the roadway that can be used to reduce speeds through a section of roadway (see Chapter 1103).

Traffic Impact Analysis (TIA) (sometimes called *Traffic Impact Study (TIS)*) If a traffic analysis is not an ARR it is a TIA. TIAs are used for environmental reviews and developer projects (see Chapter 320).

transit A general term applied to passenger rail and bus service used by the public.

transit facility A capital facility that improves the efficiency of public transportation or encourages the use of public transportation.

transit flyer stop A multimodal connection located within the boundaries of a limited access facility.

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.

transitional segments Segments of a pedestrian circulation path that blend between existing undisturbed pedestrian facilities and newly altered pedestrian facilities. Use of transitional segments may permit the work of the alteration to more nearly meet the new construction standards. At a later time, when other segments of the pedestrian circulation path are altered, the noncomplying transitional segments can be removed and replaced with pedestrian facilities that meet the accessibility criteria. (ADA term)

transit lane A lane for the exclusive use of transit vehicles.

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).

Transportation Management Area (TMA) Urbanized areas with populations of 200,000 or greater are federally designated as Transportation Management Areas.

transportation management plan (TMP) A set of traffic control plans, transportation operations plans, and public information strategies for managing the work zone impacts of a project. A TMP is required for all projects to address work zone safety and mobility impacts.

travel demand The demand travelers will make on the system based on the number and types of trips they will take and the mode and routes they will use. Local travel demand represents short trips that should be made on the local transportation system, such as intracity roads and streets. Regional travel demand represents 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.

traveler information Commercial and noncommercial information that informs and orients the traveling public. This includes access information for food, gas, lodging, local attractions, regional tourist attractions, roadway conditions, and construction schedules.

traveling public Motorists, motorcyclists, bicyclists, pedestrians, and pedestrians with disabilities.

trips Short trips are normally local. Long trips are normally interstate, regional, or interregional.

truck apron The optional mountable portion of the central island of a roundabout between the raised nontraversable area of the central island and the circulating roadway (see Chapter 1320).

turning radius The radius that the front wheel of the intersection design vehicle on the outside of the curve travels while making a turn (see Chapter 1320).

turning roadway A curve on an open highway, a ramp, or the connecting portion of the roadway between two intersecting legs of an intersection.

two-way left-turn lane (TWLTL) A lane, located between opposing lanes of traffic, to be used by vehicles making left turns from either direction, from or onto the roadway.

U

undivided multilane A roadway with two or more through lanes in each direction on which left turns are not controlled.

uniformity ratio The ratio of the minimum average light level on the design area to the minimum light level of the same area (see Chapter 1040).

universal access Access for all persons regardless of ability or stature. (ADA term)

urban area An area designated by the Washington State Department of Transportation (WSDOT) in cooperation with the Transportation Improvement Board (TIB) and Regional Transportation Planning Organizations (RTPO), subject to the approval of the Federal Highway Administration (FHWA).

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.

V

validation A process to confirm the reasonableness, accuracy and completeness of estimated costs and quantities.

Value Engineering (VE) Analysis A systematic approach to identifying and removing unnecessary costs which do not contribute to a desired result by analyzing cost versus function.

Value Engineering Change Proposal (VECP) A construction contract change proposal submitted by the construction contractor based on a VECP provision in the contract. The intent of these types of proposals is to (1) improve the project's performance, value, and/or quality, (2) lower construction costs, or (3) shorten the delivery time, while considering their impacts on the project's overall life-cycle cost and other applicable factors.

Value Engineering (VE) Job Plan A systematic and structured action plan (see Chapter 310) for conducting and documenting the results of the VE analysis. While each VE analysis shall address each phase in the VE Job Plan, the level of analysis conducted and effort expended for each phase should be scaled to meet the needs of each individual project. The WSDOT VE analysis uses the Seven-Phase Job Plan shown in Exhibit 310-1.

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.

viewpoint A roadside stopping opportunity with a view of some point of interest or area scenery. This area is not typically separated from the traveled way by some form of highway buffer.

violation rate The total number of violators divided by the total number of vehicles on an HOV facility.

visioning exercises a process of determining the goals for a facility or place.

Visitor Information Center (VIC) A staffed or nonstaffed booth or separate building that displays and dispenses free tourist travel maps and brochures. These are typically located at border-entry SRAs to provide travel information to highway users as they enter the state.

W

walk interval That phase of a traffic signal cycle during which the pedestrian is to begin crossing, typically indicated by a WALK message or the walking person symbol and its audible equivalent. (ADA term)

walkway The continuous portion of the pedestrian access route that is connected to street crossings by curb ramps. (ADA term)

warning 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 or at intersections that control two or more lanes of travel. A warning identification beacon is energized only during those times when the warning or regulation is in effect.

warrant A minimum condition for which an action is authorized. Meeting a warrant does not attest to the existence of a condition that needs attention. Further justification is required.

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

weaving section A length of highway over which one-way traffic streams cross by merging and diverging maneuvers.

weigh in motion (WIM) A scale facility capable of weighing a vehicle without the vehicle stopping.

wet film thickness Thickness of a pavement marking at the time of application without beads.

work zone An area of a highway with construction, maintenance, or utility work activities. A work zone is identified by the placement of temporary traffic control devices that may include signs, channelizing devices, barriers, pavement markings, and/or work vehicles with warning lights. 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 impact Highway construction, maintenance, or utility work operations in the traveled way, adjacent to the traveled way, or within the highway's right of way that creates safety and mobility concerns for workers or the traveling public.

work zone traffic control The planning, design, and preparation of contract documents for the modification of traffic patterns due to work zone impacts.

wye (Y) connection An intersecting one-way roadway, intersecting at an angle less than 60°, in the general form of a "Y."

Y

yield-at-entry The requirement that vehicles on all entry lanes yield to vehicles within the circulating roadway.

yield point The point at which entering traffic must yield to circulating traffic before entering the circulating roadway (see Chapter 1320).

Z