Washington State Department of Transportation

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Remarks and Instructions

What's Changed in the Design Manual?

For a summary of the December 2009 changes, see page 3.

General

Download the current electronic WSDOT *Design Manual,* the latest revision package, or separate chapters at: http://www.wsdot.wa.gov/Publications/Manuals/M22-01.htm. You can also sign up here for e-mail alerts for other WSDOT manuals and receive notifications regarding manual updates.

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Revision Marks

- A new date appears on the footer of each page that has changes.
- Revision marks (underlines/sidebars) are used as a convenience to show designers what has changed.
- When a chapter is completely rewritten (such as Chapters 1010 and 1330), no revision marks are applied.

Summary of Design Manual Changes – December 2009
(Revisions merit careful study beyond this summary)

Chapter 100 – Manual Description

- Changed Chapter 1510 title from “Pedestrian Design Considerations” to “Pedestrian Facilities” on page 100-8.

Chapter 120 – Planning

- Added descriptions of the route classes in the FGTS system.

Chapter 230 – Environmental Permits and Approvals

- Removed Exhibit 230-1, Permits and Approvals. This information is officially maintained in the Environmental Procedures Manual; a link has been provided to Chapter 500 in the EPM.

Chapter 300 – Design Documentation, Approval, and Process Review

- Revised to indicate that the Design Approval milestone is a scalable effort and in some cases might be combined with the Project Development milestone in a single approval memo.
- Added reference to the Emergency Procedures Manual.
- Exhibit 300-3, first page: Removed the row related to roundabout approvals, coinciding with the revisions in Chapter 1320.

Chapter 550 – Interchange Justification Report

- Identified that the efforts to produce an IJR on a non-Interstate highway are scalable to the project.
- Required an IJR process team to be established to decide the level of documentation appropriate for the project and future steps (if any).

Chapter 620 – Design of Pavement Structure

- Revised to notify procedure for pavement design reporting on Design-Build projects.
- Changed "Shoulder Ballast" to "Permeable Ballast," coinciding with 2010 Standard Specs.

Chapter 630 – Geosynthetics

- Changed "Shoulder Ballast" to "Permeable Ballast," coinciding with 2010 Standard Specs.

Chapter 710 – Site Data for Structures

- Added procedural guidance to alert designers that they must investigate scour depth for walls and reinforced slopes that might be within flood plains or near water.

Chapter 720 – Bridges

- Corrected chapter references in 720.04(7).

Chapter 730 – Retaining Walls and Steep Reinforced Slopes

- Added procedural guidance to alert designers that they must investigate scour depth for walls and reinforced slopes that might be within flood plains or near water.

Chapter 1010 – Work Zone Safety and Mobility

- Chapter reorganized; reading volume reduced.

Chapter 1020 – Signing

- Replaced omitted statement regarding vertical clearance in 1020.04(2).

Chapter 1100 – Design Matrix Procedures

- No policy changes.
- Incorporated errata in Matrix Notes [2], [3], [4], and [21], correcting a chapter section reference.
- Replaced “accidents” with “crash history” in note [17].
- Added Design Matrix Notes, Exhibit 1100-9, which combines all matrix notes to one page.

Chapter 1130 – Modified Design Level

- Clarified the design vehicle on which Exhibit 1130-12 is based (no policy changes).

Chapter 1140 – Full Design Level

- Added new Note [1] to Exhibit 1140-2, Minimum Shoulder Width, related to truck parking.
- Revised Exhibits 1140-6, 7, & 8. Changed the 40-foot minimum bridge width value to 36 feet for two-lane route types shown to have 6-foot shoulders, to equate to the summation of the lane and shoulder dimensions shown for these specific two-lane highway design class routes.
- Made changes to Exhibit 1140-9 for clarity.

Chapter 1240 – Turning Roadways

- Revised to clarify design vehicle basis in exhibits that present turning roadway widths.

Chapter 1270 – Auxiliary Lanes

- Expanded guidance on passing lanes in 1270.05. Other minor revisions.

Chapter 1310 – Intersections at Grade

- Revised to make WB-67 design vehicle desirable for state route and ramp terminal intersections.
- Removed requirement in 1310.12(1) for HQ Design Office approval for intersections with roundabouts. Other changes for clarity.

Chapter 1320 – Roundabouts

- Reduced PE efforts related to roundabout analyses, documentation, and approvals. Additional changes call for using the WB-67 design vehicle for roundabout design on state routes, an update to the capacity software statements, and a few changes to the sign plan.

Chapter 1330 – Traffic Control Signals

- Rewritten to correspond with the MUTCD, railroad signal requirements, and other changes.

Chapter 1340 – Road Approaches

- Modified Exhibit 1340-4 to show that the 50' radius is tangential to the edge of traveled way.

Chapter 1360 – Interchanges

- Revised Exhibit 1360-14d to correctly show the extent of the 92°, 17' diverge angle.
- Revised Exhibit 1360-14e to show the 90° angle is taken from the edge of thru-lane.

Chapter 1410 – High-Occupancy Vehicle Facilities

- Corrected Note [1] in Exhibit 1410-4a to refer to Chapter 1360.

Chapter 1510 – Pedestrian Design Considerations

- Clarified policy requirements. Chapter rewritten.

Chapter 1520 – Bicycle Facilities

- Corrected chapter reference on page 1520-9.

Chapter 1610 – Traffic Barriers

- Revised to direct use of steel posts for new beam guardrail runs. (Note: For projects with Design Approval prior to December 2009, wood posts may remain as an option for new installations.)
- Revised selection/placement of 4-cable high-tension cable barrier systems for new installations. (This policy change is an update to high-tension cable systems to further enhance performance of high-tension cable systems.)
- Revised 1610.06(4), Terminals and Anchors. Buried Terminal Type 1 was removed. (This change is meant to reflect FHWA acceptance criteria and to help with placement.)
- Updated 1610.06(6), Guardrail Placement Cases. (This change reflects recent Standard Plan developments.)
- Updated exhibits to reflect policy changes.

Chapter 1620 – Impact Attenuators

- Added instruction on WSDOT's products acceptance policy for low-maintenance safety devices.

Index

- The index for the paper manual will no longer be maintained. The electronic manual is searchable in its entirety or by individual chapters at the Design Manual Abstract website:

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

Washington State Department of Transportation

TECHNICAL MANUAL

Design Manual

Volume 1 – Procedures

M 22-01.06

December 2009

Division 1 – General Information
Division 2 – Hearings, Environmental, and Permits
Division 3 – Project Documentation
Division 4 – Surveying
Division 5 – Right of Way and Access Control
Division 6 – Soils and Paving
Division 7 – Structures
Division 8 – Hydraulics
Division 9 – Roadside Development
Division 10 – Traffic Safety Elements

Environmental and Engineering Programs
Design Office

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Division 1 – General Information

Division 2 – Hearings, Environmental, and Permits

Division 4 – Surveying

Division 5 – Right of Way and Access Control

Division 7 – Structures

Division 8 – Hydraulics

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Division 11 – Project Design Criteria

Division 12 – Geometrics

Division 13 – Intersections and Interchanges

Division 14 – HOV and Transit

Division 15 – Pedestrian and Bicycle Facilities

Division 16 – Roadside Safety Elements

Division 17 – Roadside Facilities

Division 12 – Geometrics: Covers geometric plan elements; horizontal alignment; lane configurations and pavement transitions; geometric profile elements; vertical alignment; geometric cross sections; and sight distance.

- **Chapter 1210 – Geometric Plan Elements:** The design of horizontal alignment, lane configuration, and pavement transitions.
- **Chapter 1220 – Geometric Profile Elements:** The design of vertical alignment.
- **Chapter 1230 – Geometric Cross Section:** Roadway width and roadside slope design.
- **Chapter 1240 – Turning Roadways:** Widening curves to make the operating conditions comparable to those on tangent sections.
- **Chapter 1250 – Superelevation:** Superelevating curves and ramps so design speeds can be maintained.
- **Chapter 1260 – Sight Distance:** Stopping, passing, and decision sight distance design elements.
- **Chapter 1270 – Auxiliary Lanes:** Auxiliary facilities such as climbing lanes, passing lanes, slow-vehicle turnouts, shoulder driving for slow vehicles, emergency escape ramps, and chain-up areas.

Division 13 – Intersections and Interchanges: Addresses the design considerations of at-grade intersections, roundabouts, road approaches, railroad grade crossings, and traffic interchanges.

- **Chapter 1310 – Intersections at Grade:** Designing intersections at grade, including at-grade ramp terminals.
- **Chapter 1320 – Roundabouts:** Guidance on the design of roundabouts.
- **Chapter 1330 – Traffic Control Signals:** The use of power-operated traffic control devices that warn or direct traffic.
- **Chapter 1340 – Road Approaches:** The application and design of road approaches on state highways.
- **Chapter 1350 – Railroad Grade Crossings:** The requirements for highways that cross railroads.
- **Chapter 1360 – Traffic Interchanges:** The design of interchanges on interstate highways, freeways, and other multilane divided routes.
- **Chapter 1370 – Median Crossovers:** Guidance on locating and designing median crossovers for use by maintenance, traffic service, emergency, and law enforcement vehicles.

Division 14 – HOV and Transit: Provides design guidance on HOV lanes and transit facilities.

- **Chapter 1410 – High-Occupancy Vehicle Facilities:** Evaluating and designing high-occupancy vehicle (HOV) facilities.
- **Chapter 1420 – HOV Direct Access:** Design guidance on left-side direct access to HOV lanes and transit facilities.
- **Chapter 1430 – Transit Benefit Facilities:** Operational guidance and information for designing transit facilities such as park & ride lots, transfer/transit centers, and bus stops and pullouts.

Division 15 – Pedestrian and Bicycle Facilities: Provides guidance on pedestrian and bicycle facility design.

- **Chapter 1510 – Pedestrian Facilities:** Designing facilities that encourage efficient pedestrian access that meets ADA.
- **Chapter 1520 – Bicycle Facilities:** Selecting and designing useful and cost-effective bicycle facilities.

Division 16 – Roadside Safety Elements: Addresses design considerations for the area outside the roadway, and includes clear zone, roadside hazards, safety mitigation, traffic barriers, and impact attenuator systems.

- **Chapter 1600 – Roadside Safety:** Clear zone design, roadside hazards to consider for mitigation, and some roadside safety features.
- **Chapter 1610 – Traffic Barriers:** Design of traffic barriers based on the design levels identified in the design matrices.
- **Chapter 1620 – Impact Attenuator Systems:** Permanent and work zone impact attenuator systems.

Division 17 – Roadside Facilities: Provides design guidance for the area outside the roadway, including rest areas and truck weigh sites.

- **Chapter 1710 – Safety Rest Areas and Traveler Services:** Typical layouts for safety rest areas.
- **Chapter 1720 – Weigh Sites:** Guidance on designing permanent, portable, and shoulder-sited weigh sites.

(f) **Freight and Goods Transportation System (FGTS)**

The FGTS is established to develop the most effective and efficient system for moving freight from suppliers to destinations. The FGTS is required by RCW 47.05.021(4).

The FGTS ranks state highways, county roads, and city streets based on annual tonnage carried. Freight corridors with statewide significance, usually designated as Strategic Freight Corridors, are those routes that carry an average of four million or more gross tons by truck annually.

The tonnage classifications used for designating the FGTS are as follows:

- T-1 = more than 10 million tons per year
- T-2 = 4 million to 10 million tons per year
- T-3 = 300,000 to 4 million tons per year
- T-4 = 100,000 to 300,000 tons per year
- T-5 = at least 20,000 tons in 60 days

The FGTS is primarily used to establish funding eligibility for Freight Mobility Strategic Investment Board (FMSIB) grants, support highways of statewide significance designation, fulfill federal reporting requirements, and plan for pavement needs and upgrades. At a minimum, WSDOT updates the list of T-1 and T-2 roadways every two years to assist in FMSIB strategic freight corridor designation.

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

Further information on the FGTS can be accessed here:
www.wsdot.wa.gov/Freight/FGTS/default.htm

(g) **Access Control (RCW 47.50, WAC 468-51, and WAC 468-52)**

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

There are two types of access control on state highways: limited access control and managed access control (see Chapters 520, 530, and 540). For limited access control, WSDOT purchases the right to limit access to a highway. Managed access control is a regulatory program established by state law that requires access to state highways in unincorporated areas be managed by WSDOT to protect the public and preserve highway functionality. Cities also have authority to grant access to state highways with managed access within incorporated areas. WSDOT retains authority on state highways with limited access.

WSDOT has established the Limited Access and Managed Access Master Plan for access control, which is consulted when transportation improvement strategies are planned.

120.05 Planning at WSDOT

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

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

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

(1) Transportation Planning Office

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

(a) **Systems Analysis and Program Development Branch**

The major responsibilities of the Systems Analysis and Program Development Branch are to:

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

(b) **Policy Development and Regional Coordination Branch**

Policy Development and Regional Coordination Branch responsibilities include:

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

The responsibilities of the Central Puget Sound UPO are discussed in 120.05(4).

(2) Public Transportation Division

The Public Transportation Division works to enhance mobility options by managing, coordinating, and advocating for rail, commuting options, and public transportation programs throughout the state. The division's mission is to:

- Improve transportation choices, connections, coordination, and efficiency.
- Provide planning, project oversight, financial, and technical assistance to public transportation providers.

The division also oversees the state Commute Trip Reduction Program and provides technical assistance and grants to help reduce vehicle miles traveled by commuters in urban regions of the state.

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

(a) **Public Transportation and Commute Options Office**

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

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

(b) **Transportation Demand Management Office (TDM)**

The TDM Office advocates for, creates, and develops effective solutions to capacity constraints within the state transportation system. The TDM Office provides financial and technical support within WSDOT and external transportation organizations to help ensure demand management can be implemented whenever such programs are appropriate and cost-effective.

Program support is provided in areas such as land use planning, TDM research, parking management, high-capacity transportation planning, and policy development for the state's freeway high-occupancy vehicle system.

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

The TDM Office provides leadership through developing policies and guidelines that help direct public and private investment in the state's transportation system. An essential function of the TDM Office is to develop and maintain a TDM Strategic Plan for WSDOT. This plan helps ensure the Washington Transportation Plan and all other internal planning processes incorporate TDM activities.

Regional and local TDM activities and planning functions are further supported by the TDM Office through coordinating and implementing statewide TDM programs and providing public information, marketing tools, and training opportunities. The office also administers local TDM grant programs and planning grants that generate commute efficiencies in certain urban areas of the state.

(c) **Freight Systems Division**

The movement of truck freight is the focus of the Freight Systems Division's Truck Office. The Truck Office is working to develop a strategic freight investment plan to increase our state's economic vitality, improve marketplace competitiveness, and ensure resiliency. It is also working to integrate truck freight requirements into WSDOT's highway design, planning, operations, and project prioritization. The office works with planners and designers; MPO's; RTPO's; local jurisdictions; other WSDOT offices (HQ and region); ports; railroads; trucking companies and associations; and other stakeholders.

(3) Rail Office

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

The Intercity Rail Passenger Plan for Washington State defines a passenger rail system that links major population centers throughout the state and provides the blueprint for needed improvements to these intercity rail systems. The plan emphasizes incrementally upgrading the Amtrak passenger rail system along the Pacific Northwest Rail Corridor in western Washington. The vision is to reduce travel times and provide better passenger rail service in the Pacific Northwest. A number of activities unrelated to passenger rail are continually underway in the corridor, requiring extensive coordination among various agencies and private organizations. The corridor also serves some of the world's busiest ports. WSDOT is working with the Puget Sound Regional Council and other area agencies through the

Freight Action Strategy for the Everett-Seattle-Tacoma Corridor (FAST Corridor) project to plan for the elimination of at-grade highway/railroad crossing conflicts and to improve port access.

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

(4) Highways and Local Programs Division (H&LP)

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

(5) WSDOT Regions and the Central Puget Sound Urban Planning Office (UPO)

The planning roles at the WSDOT regions and the Central Puget Sound UPO are similar in many ways. Following are descriptions of the different region and UPO planning roles:

(a) **WSDOT Region Planning**

Each WSDOT region has a Planning Office that has several roles, including:

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

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

Each region Planning Office conducts long-range planning studies such as route development plans, corridor master plans, and site-specific transportation alternatives and studies. These studies evaluate alternative solutions for both existing and projected transportation needs, initiate the long-range public involvement process, and ultimately provide the foundation for inclusion of identified improvement strategies into the Washington Transportation Plan (WTP) and the State Highway System Plan (HSP).

Region Planning offices coordinate with and assist the local Metropolitan Planning Organizations (MPOs) and Regional Transportation Planning Organizations (RTPOs). In some cases, the region Planning Office provides staff support for the local RTPO.

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

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

The region Planning Office also reviews and provides comments on local comprehensive plans so development regulations, local transportation elements, and WSDOT goals and interests are consistent.

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

(b) **The Central Puget Sound Urban Planning Office (UPO)**

The Central Puget Sound UPO is based in Seattle and is part of the Strategic Planning and Programming Division. It has a similar role to a region Planning Office, yet the UPO role is more specialized. The UPO oversees WSDOT's long-range planning efforts in the four-county Central Puget Sound area of King, Pierce, Snohomish, and Kitsap counties. This is the same area covered by the MPO called the Puget Sound Regional Council (PSRC), located in Seattle. The four-county region is geographically split between WSDOT's Olympic and Northwest regions.

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

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

The UPO also has the responsibility of coordinating plans developed by Washington State Ferries with the strategies contained in the State Highway System Plan.

(6) Washington State Ferries Division

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

(7) Aviation Division

The WSDOT Aviation Division:

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

This division is responsible for development of the Washington State Airport System Plan. The division also operates 17 state airports strategically placed throughout the state.

120.06 Linking Transportation Plans

A major WSDOT objective is that our transportation system allows the public to travel on the state's highways quickly, safely, and with the least possible inconvenience and expense. To fulfill WSDOT's and the public's desire for a seamless transportation system, coordination of transportation planning efforts is essential.

(1) Coordination of Planning Efforts

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

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

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

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

(2) Transportation Improvement Programs

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

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

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

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

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

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

(3) Development of the STIP

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

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

The Governor's approval of the MTIPs, plus the FHWA's and the FTA's approval of the STIP, are required prior to expenditure of federal funds.

120.07 Linking WSDOT Planning to Programming

Exhibit 120-3 is a flowchart describing the process conceptual solutions must go through to receive funding. This chart also describes the link between planning and program development. (For more information, see Chapter 300 for project definition, Chapter 1100 for design matrices, and Chapter 220 for environmental documentation.)

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

The WSDOT planning process determines *what* facilities or services will be provided *where*. The role of WSDOT Systems Analysis and Program Development Branch is to determine *when* the improvements will be implemented. The WSDOT Systems Analysis and Program Development Branch prioritizes the projects that are selected from the State Highway System Plan component of the Washington Transportation Plan (see 120.04(2)(a)1.).

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

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

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

(2) Subprogram Categories

Subprogram categories for the service objectives and action strategies have been established within WSDOT's budget to allow decision makers to determine timing and the amount of money to invest in meeting transportation needs. (See the HSP for the service objectives and action strategies.)

The order of needs within each subprogram category is usually prioritized based on benefit/cost methodology; however, some subprograms do not have a prioritization methodology attached to them (such as Economic Initiatives).

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

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

(3) WSDOT Budgets

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

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

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

(4) Key Points of Planning and Programming at WSDOT

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

- Executive policy sets the direction for the WTP.
- Federal transportation laws and state transportation and land use laws guide solutions to address the needs for transportation facilities and services.
- The WTP is developed in partnership with MPOs and RTPOs and is tied to the land use plans of towns, cities, and counties.
- Region Planning offices are responsible for meeting many of the state and federal planning requirements.
- The SHSP is a component of the WTP.
- The SHSP sets forth service objectives and action strategies.
- Conceptual solutions are prioritized within most budget categories based on benefit/cost analyses to obtain the greatest benefit at the least cost.
- Tradeoffs between project categories are made by policy choice through a multitiered process.
- An improvement strategy must be listed in the HSP to be considered for project funding.

Chapter 230 Environmental Permits and Approvals

230.01 General

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

230.02 Permits and Approvals

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

Table 500-1 of the *Environmental Procedures Manual* provides a comprehensive list of the environmental permits and approvals that may be required for WSDOT projects. For each permit or approval, the responsible agency is identified, the conditions that trigger the permit are listed, and the statutory authority is cited:
www.wsdot.wa.gov/publications/manuals/fulltext/M31-11/500.pdf

The conditions that trigger a permit or approval are discussed in detail in Part 5 of the *Environmental Procedures Manual*. The permit triggers are subject to interpretation and change as new regulations are developed or court decisions are rendered that alter their applicability. Determining which permits and approvals apply and how they apply is dependent on the facts of each project. Consult the region or HQ Environmental Office at each stage of the project design to review the permits and approvals that might be required based on the project design.

230.03 Project Types and Permits

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

(1) Project Types

To make the evaluation familiar, this chapter uses the design matrices developed in Chapter 1100 as a template. The project types and definitions are found in Chapter 1100, with the exception of some additional project types for bridge work. These additional bridge projects are defined below. Rather than identify levels of design for each project type, the matrices identify permits and approvals. While every project is unique to some degree, there are common facts associated with project types that allow for a level of predictability. As the project type gets more complex, the predictability of which environmental permits and approvals may be triggered decreases.

Exhibits 230-1 through 230-6 present certain project types combined with assumptions on environmental conditions to generate probabilities about required permits and approvals. The probabilities cannot be substituted for a fact-based analysis of the project and the applicability of any particular environmental permit or approval. Contact the region and/or HQ Environmental offices before decisions are made about whether a permit or approval applies. Coordination with the HQ Bridge and Structures Office and the HQ Environmental Services Office is recommended for bridge projects.

(2) Permit Probability

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

The assumptions underlying the project types and probabilities are shown as endnotes following the matrices (see Exhibit 230-6). Some general assumptions were made regarding the project types: for main line projects on the Interstate, National Highway System main line (except Interstate), or non-National Highway System, all bridgework is assumed to be over water. For interchange projects on the Interstate and non-Interstate, all bridgework is assumed to be over roads (see Chapter 1100).

The environmental permits and approvals selected for inclusion in the matrices represent the ones that are most frequently triggered. The other permits and approvals listed in Table 500-1 of the *Environmental Procedures Manual* are more limited in their application and often require very specific fact situations. They are discussed in more detail in the *Environmental Procedures Manual.*

(3) Additional Bridge Projects

The additional bridge projects are as follows:

(a) **Bridge Replacement (Obsolete, Structural)**

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

(b) **Existing Bridge Widening**

This is widening an existing bridge for an existing highway.

(c) **Bridge Deck Rehabilitation**

These are structures Preservation projects that repair delaminated concrete bridge deck and add a protective overlay that will provide a sound, smooth surface; prevent further corrosion of the reinforcing steel; and preserve operational and structural capacity. The goal is to ensure safe, long-lasting riding surfaces on all reinforced concrete bridges.

(d) **Bridge Scour Countermeasures**

These are measures undertaken to reduce the risk of bridge foundation scour damage and streambank erosive forces that increase the potential of bridge collapse due to flooding and long-term waterway changes. The goal is to maintain the structural integrity of the roadway prism and highway structures. Bridge scour repair can include repair to the streambed around a bridge column or repairs to streambanks near a bridge. This category typically involves an in-depth engineering and environmental review for site and reach processes. Extensive documentation and permitting are typically needed. Early and close coordination with the permit agency representatives through the region Environmental Office is essential. Close coordination with the HQ Bridge Preservation Office, HQ Hydraulics Section, and HQ Environmental Services Office (watershed and permit programs) are useful to ensure a one-WSDOT project approach is established early in the design phase.

(e) **Steel Bridge Painting**

This includes measures undertaken to preserve the load-carrying capacity of steel bridges by maintaining properly functioning paint systems to provide protection against corrosion. These measures include high-pressure washing and spot abrasive blasting to prepare steel surfaces for painting. This category typically involves discharge of wastewater into waters of the state and the decisions surrounding the need for full or partial containment of the wash water and blast media used for preparing the steel surfaces. Early and close coordination with the Bridge Management Engineer is necessary. A thorough review of the *Standard Specifications'* current Water Quality Implementing Agreement (WQIA) and available Programmatic Permits, such as the General Hydraulic Project Approval (GHPA) and National Pollution Discharge Elimination System (NPDES) permits, is also recommended. Early project scoping for determination of wildlife usage is another factor for early coordination with all departments.

(f) **Bridge Seismic Retrofit**

This is seismic retrofit of a bridge element (typically bridge columns). For example, measures undertaken to reduce the vulnerability of existing state-owned bridges in the high to moderate seismic risk areas to earthquake damage that could cause collapse, excessive repair costs, or lengthy closures to traffic. This includes Phase 1 repairs (prevent span separation), Phase 2 repairs (retrofit single-column supports), and Final Phase repairs (retrofit multiple-column supports).

(g) **Special Bridge Repair (Electrical/Mechanical Retrofit)**

This covers rehabilitating a major portion of an existing bridge to include electrical and mechanical repairs, such as for a movable bridge, a bridge over navigable water, or sign support structures.

(h) **Other Bridge Structures**

This includes major repair or replacement of Sign Bridges, Cantilever Sign Supports, Bridge-Mounted Sign Supports, Tunnels, and High Mast Light Standards.

(i) **New Special Structures**

These are measures taken to build a new floating, movable, suspension, or cable stayed bridge for new or existing roadway.

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

Note: For an explanation of the matrices, see Exhibit 230-6.

Project Environmental Matrix 1:
Permit Probabilities for Interstate Routes (Main Line)
Exhibit 230-1

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

Note: For an explanation of the matrices, see Exhibit 230-6.

Project Environmental Matrix 2:
Permit Probabilities for Interstate Interchange Areas
Exhibit 230-2

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

Note: For an explanation of the matrices, see Exhibit 230-6.

Project Environmental Matrix 3:
Permit Probabilities for NHS Routes, Non-Interstate (Main Line)
Exhibit 230-3

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

Note: For an explanation of the matrices, see Exhibit 230-6.

Project Environmental Matrix 4:
Permit Probabilities for Interchange Areas, NHS (Except Interstate), and Non-NHS
Exhibit 230-4

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

Note: For an explanation of the matrices, see Exhibit 230-6.

Project Environmental Matrix 5:
Non-NHS Routes (Main Line)
Exhibit 230-5

NOTES

For Exhibits 230-1 through 230-5

For main line projects on the Interstate, National Highway System main line (except Interstate), or non-National Highway System, all bridgework is assumed to be over water. For interchange projects on the Interstate and non-Interstate, all bridgework is assumed to be over roads (see Chapter 1100).

NEPA/SEPA Endnotes

(*) Programmatic permits may apply

(**) Night work may require noise variance

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

Section 404 IP Endnotes

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

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

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

Section 404 NWP Endnotes

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

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

H = High probability assumes likelihood for work and/or fill in waters of the U.S. below the OHWM or wetland fills below 25 cy or 1/10 acres.

Section 401 Endnotes

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

CZM Endnotes

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

ESA Endnotes

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

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

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

HPA Endnotes

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

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

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

Shoreline Endnotes

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

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

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

Endnotes for Project Environmental Matrices

Exhibit 230-6

Floodplain Endnotes

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

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

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

Aquatic Resource Use Authorization Endnotes (DNR)

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

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

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

Section 402 NPDES Municipal Stormwater General Permit Endnotes

[3] Applies to construction, operation, and maintenance activities in areas governed by Phase I and Phase II of the Municipal Stormwater Permit Program.

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

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

Section 402 NPDES Stormwater Construction General Permit Endnotes

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

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

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

Section 402 NPDES Industrial Discharge General Permit Endnotes

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

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

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

State Waste Discharge Permit Endnotes

[4] Applies to discharges of commercial or industrial wastewater into waters of the state; does not cover stormwater discharges under NPDES program.

L = Low probability assumes SWD permit does not apply.

M = Medium probability assumes potential for SWD permit.

Section 9 Bridge Permit Endnotes

[5] Applies to work on bridges across navigable waters of the U.S.

L = Low probability assumes no bridgework.

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

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

Section 10 Permit Endnotes

[6] Applies to obstruction, alteration, or improvement of navigable waters of the U.S.

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

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

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

Endnotes for Project Environmental Matrices

Exhibit 230-6 (continued)

Section 106 Endnotes

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

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

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

Section 4(f)/6(f) Endnotes

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

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

H = High probability assumes likelihood for use of or acquiring of new right of way. Review triggers: www.wsdot.wa.gov/Environment/Compliance/Section4Fguidance.htm

Critical/Sensitive Areas Endnotes

[7] The mechanism for critical/sensitive areas review varies by jurisdiction.

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

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

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

Noise Variance Endnotes

L = Low probability assumes no night work.

M = Medium probability assumes potential for night work.

H = High probability assumes likelihood for night work.

Endnotes for Project Environmental Matrices

Exhibit 230-6 (continued)

230.04 Design Process and Permit Interaction

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

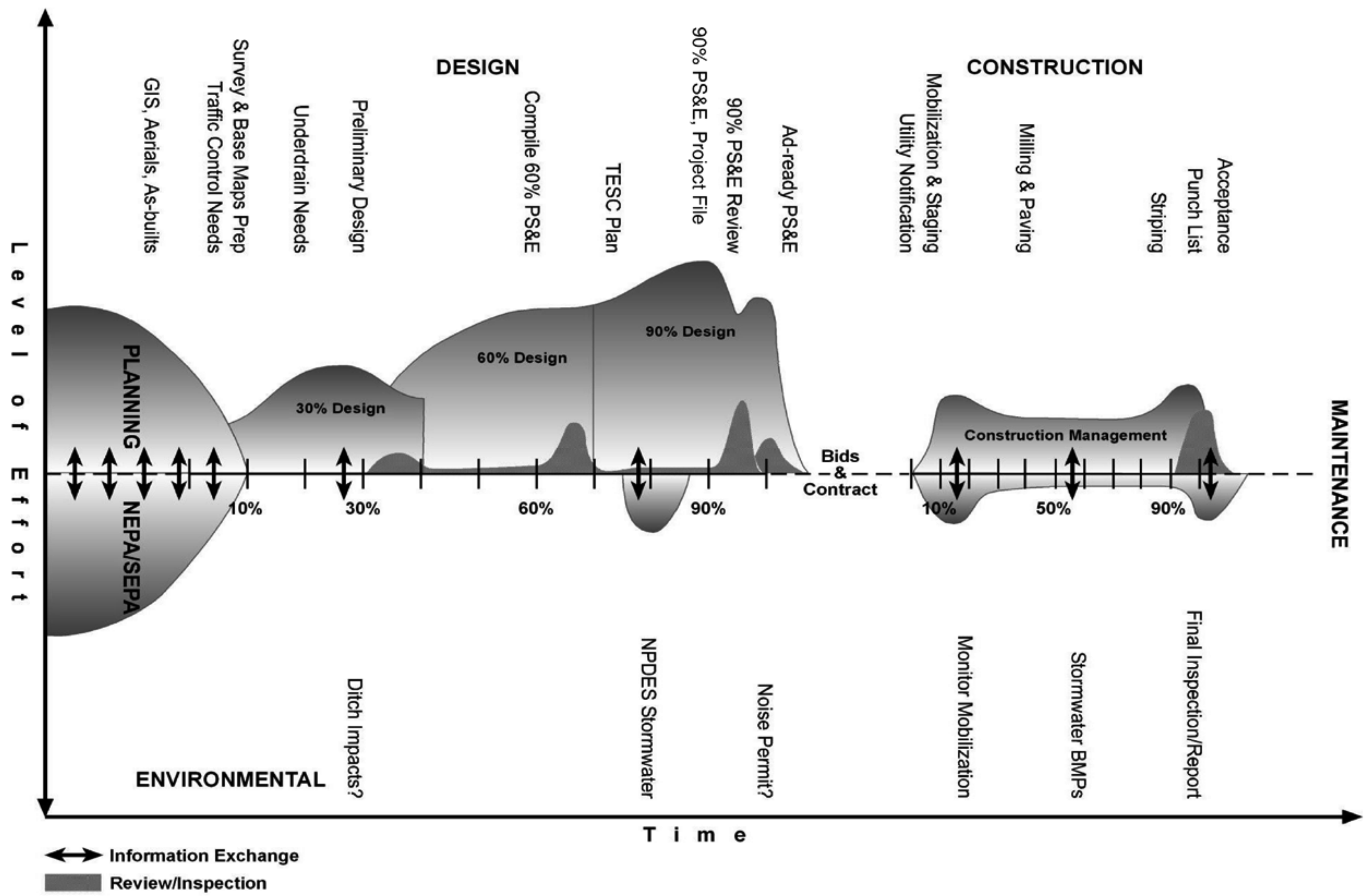
The permit process begins well in advance of the actual permit application. For some permits, WSDOT has already negotiated permit conditions through the use of programmatic and general permits. These permits typically apply to repetitive, relatively simple projects, and the permit conditions apply regardless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

For many project types, the permit process begins during the design phase. This section illustrates the interaction between design and permitting for two relatively uncomplicated projects. Exhibits 230-7 and 230-8 illustrate project timelines for two project types and the interaction of typical permits for those project types. The project types are an overlay project and a channelization project. The exhibits illustrate the level of effort over time for both design components and environmental permits.

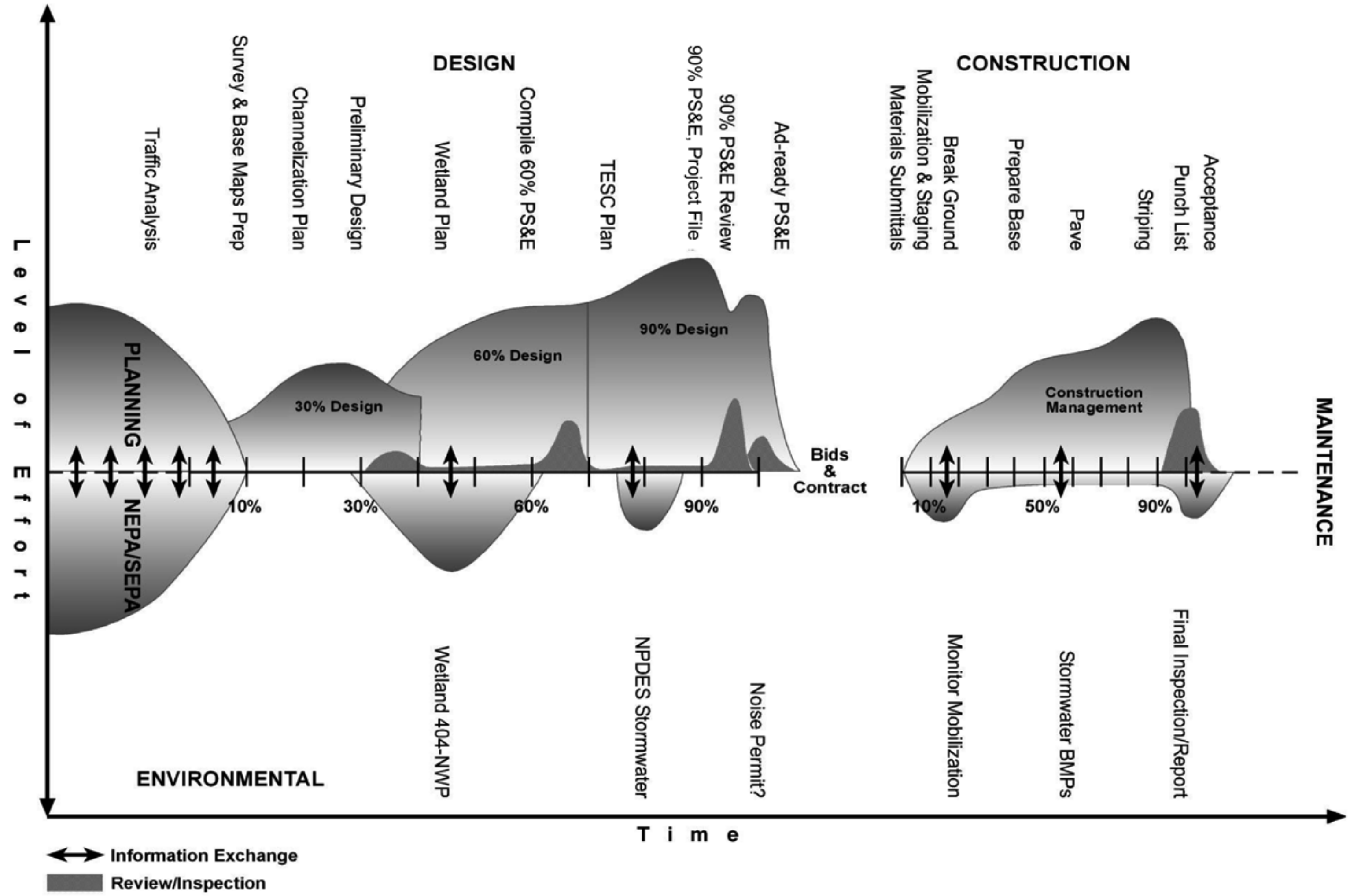
The overlay project assumes that only an NPDES Municipal Stormwater General Permit is required. Compliance with this permit is through application of the *Highway Runoff Manual* and the implementation of WSDOT's 1997 Stormwater Management Plan. The possibility for a noise variance exists because of the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

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

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



Environmental Interrelationship: HMA/PCCP/BST Main Line Overlay
Exhibit 230-7



Environmental Interrelationship: Safety Corridor Channelization Main Line

Exhibit 230-8

Chapter 300 Design Documentation, Approval, and Process Review

300.01 General

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

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

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

For emergency projects, also refer to the *Emergency Relief Procedures 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 References

(1) Federal/State Laws and Codes

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

23 CFR 635.411, Material or product selection

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

RCW 47.28.035, Cost of project, defined

"Washington Federal-Aid Stewardship Agreement," as implemented in the design matrices (see Chapter 1100)

(2) Design Guidance

WSDOT Directional Documents Index, including the one listed below:
http://wwwi.wsdot.wa.gov/docs/

- 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
- *Emergency Relief Procedures Manual*, M 3014, WSDOT
- *Hydraulics Manual*, M 23-03, WSDOT
- *Plans Preparation Manual*, M 22-31, WSDOT
- *Project Control and Reporting Manual*, M 30-26, WSDOT
- *Roadside Classification Plan*, M 25-31, WSDOT

Limited Access and Managed Access Master Plan, WSDOT
www.wsdot.wa.gov/Design/accessandhearings/tracking.htm

Washington State Highway System Plan, WSDOT
www.wsdot.wa.gov/planning/HSP

(3) Supporting Information

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

300.03 Definitions

corridor analysis Documentation that justifies a change in design level and/or decisions to include, exclude, or modify design elements. A corridor analysis addresses needs and design solutions within a substantial segment of roadway. A corridor analysis is useful beyond a specific project contained within it, and is an appropriate document to address design speed.

Design Approval Documented approval of the design criteria, which becomes part of the Design Documentation Package. This approval is an endorsement of the design criteria by the designated representative of the approving organization as shown in Exhibit 300-2.

design exception (DE) A method to document a geometric feature that has been preauthorized to exclude improvement of an existing design element for various types of projects, as designated in the design matrices (see Chapter 1100). A DE designation indicates that the design element is normally outside the scope of the project type (see Exhibit 300-1).

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

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

Design Variance Inventory System (DVIS) A database application developed to generate the DVI form. The DVIS also provides query functions, giving designers an opportunity to search for previously granted variances. The DVIS was started in the early 2000s and does not identify prior variances. The *Design Manual* is constantly being refined and guidelines change over time. What may have been a design variance previously may not be a deviation today. The DVIS database is intended for internal WSDOT use only, and WSDOT staff access it from:
www.wsdot.wa.gov/design/projectdev

deviation A documented decision granting approval at project-specific locations to differ from the design level specified in the *Design Manual* (see Chapter 1100 and Exhibit 300-1).

environmental acronyms (see Chapter 220 for definitions)

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

evaluate upgrade (EU) A decision-making process to determine whether or not to upgrade an existing design element as designated in the design matrices. Documentation is required (see Exhibit 300-1).

FHWA Federal Highway Administration.

HQ Washington State Department of Transportation Headquarters organization.

Project Analysis Documentation that justifies a change in design level and/or decisions to include, exclude, or modify design elements specific to a project only (also see Chapter 1100).

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

Project Development Approval Final approval of all project development documents by the designated representative of the approving organization prior to the advertisement of a capital transportation project (see Exhibit 300-2).

Project File (PF) A file containing all documentation and data for all activities related to a project (see 300.01 and 300.04).

- ***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 this chapter. Common components are listed in Exhibit 300-5. Technical reports and calculations are part of the Project File, but are not designated as components of the DDP. Include estimates and justifications for decisions made in the DDP (see 300.04(2)). The DDP explains how and why the design was chosen, and documents approvals (see 300.01).

Project Summary A set of electronic documents consisting of the Design Decisions (DD), the Environmental Review Summary (ERS), and the Project Definition (PD). The Project Summary is part of the design documentation required to obtain Design Approval and is ultimately part of the design documentation required for Project Development Approval (see 300.06).

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

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

300.04 Design Documentation

(1) Purpose

Design documentation records the evaluations and decisions by the various disciplines that result in design recommendations. Design assumptions and decisions made prior to and during the scoping phase are included. Changes that occur throughout project development are documented. Required justifications and approvals are also included.

The “Design Documentation Checklist” has been developed as a tool (optional) to assist in generating the contents of the DDP and the PF:
www.wsdot.wa.gov/design/projectdev/

(2) Design Documents

The DDP portion of the PF preserves the decision documents generated during the design process. In each package, a summary (list) of the documents is recommended.

The design documents commonly included in the PF and DDP for all but the simplest projects are listed in Exhibit 300-5.

Documentation is not required for components not related to the project as dictated by the design matrices.

The DVI is needed for all projects that have design variances. The DVI lists all EUs not upgraded to the applicable design level, DEs, and deviations as indicated by the design matrices. Record variances resulting from a project or corridor analysis in the DVI. Use the DVIS database to record and manage:

- Individual design variances identified during project development.
- Variances resulting from a project or corridor analysis.

The DVIS database is found at the Project Development website:
www.wsdot.wa.gov/design/projectdev

The ERS and the PD are required for most projects. Exceptions will be identified by the HQ Project Control and Reporting Office.

The DD is not required for the following project types unless they involve reconstructing the lanes, shoulders, or fill slopes. Since these and some other project types are not included in the design matrices, evaluate them with respect to modified design level (M) for non-NHS routes and full design level (F) for NHS routes. Include in the evaluation only those design elements specifically impacted by the project. Although the following list illustrates some of the project types that do not require a DD, the list is not intended to be a complete accounting of all such projects. Consult with the HQ System Analysis and Program Development Office for projects not included on the list.

- Bridge painting
- Crushing and stockpiling
- Pit site reclamation
- Lane marker replacement
- Guidepost replacement
- Signal rephasing
- Signal upgrade
- Seismic retrofit
- Bridge joint repair
- Navigation light replacement
- Signing upgrade
- Illumination upgrade
- Rumble strips
- Electrical upgrades
- Major drainage
- Bridge scour
- Fish passage
- Other projects approved by the HQ Design Office

(3) Certification of Documents by Licensed Professionals

All original technical documents must bear the certification of the responsible licensee (see Executive Order E 1010).

(4) Design Exception (DE), Evaluate Upgrade (EU), and Deviation Documentation

In special cases, projects may need to address design elements, which are shown as blank cells in a design matrix (see Exhibit 300-1). These special cases must be coordinated with the appropriate Assistant State Design Engineer (ASDE) and the HQ Project Control and Reporting Office. When this is necessary, document the reasons for inclusion of that work in your project.

Matrix Cell Contents	Design Element Meets Specified Design Level	Document to File[1]	Record in DVIS[2]
Blank cell in design matrix		No[3]	No
Cell Entry			
Full (F), Modified (M), or Basic (B) (with no DE or EU qualifiers)	Yes	No	No
	No[4]	Yes[5]	Yes
Design Exception (DE)	Yes[3]	DDP	No
	No	DDP	Yes
Evaluate Upgrade (EU)[5]	Yes	DDP	No
	No	DDP	Yes

DDP = Design Documentation Package

Notes:

[1] See 300.04(3).

[2] See 300.04(2).

[3] Document to the DDP if the element is included in the project as identified in the Project Summary or Project Change Request Form.

[4] Nonconformance with specified design level (see Chapter 1100) requires an approved deviation.

[5] Requires supporting justification (see 300.04(4)).

Design Matrix Documentation Requirements
Exhibit 300-1

When the design matrices specify a DE for a design element, the DE documentation specifies the matrix and row, the design element, and the limits of the exception. Some DEs require justification. Include this in the DVIS. When a DVI is required for the project, the DE locations are recorded in the inventory.

The EU process determines whether an item of work will or will not be done, through analysis of factors such as benefit/cost, route continuity, accident reduction potential, environmental impact, and economic development. Document all EU decisions to the DDP using the list in Exhibit 300-6 as a guide for the content. The cost of the improvement must always be considered when making EU decisions. EU examples on the Internet can serve as models for development of EU documentation. The appropriate approval authority for EUs is designated in Exhibit 300-2.

Deviation requests are stand-alone documents that require enough information and project description for an approving authority to make an informed decision of approval or denial. Documentation of a deviation contains justification and is approved at the appropriate administrative level, as shown in Exhibit 300-2. Submit the request as early as possible because known deviations are to be approved prior to Design Approval.

(5) Deviation Approval

Deviation approval is at the appropriate administrative level, as shown in Exhibit 300-2.

If the element meets current AASHTO guidance adopted by FHWA, such as *A Policy on Geometric Design of Highways and Streets*, but not *Design Manual* criteria, it is a deviation from the *Design Manual* that does not require approval by FHWA or the HQ Design Office. The following documentation is required:

- Identify the design element.
- Explain why the design level specified in the design matrices was not used.
- Explain which AASHTO guidance was used, including the title of the AASHTO guidance, the publication date, and the chapter and page number of the guidance.

When applying for deviation approval, it is necessary to provide two explanations. The first identifies the design element and explains why the design level specified in the design matrices was not or cannot be used. The second provides the justification for the proposed design. Justification for a deviation is to be supported by at least two explanations, which may include the following:

- Accident history and accident analysis
- Benefit/cost analysis
- Engineering judgment*
- Environmental issues
- Route continuity

*Engineering judgment may include a reference to another publication, with an explanation of why that reference is applicable to the situation encountered on the project.

Reference a corridor or project analysis, if one exists, as supporting justification for design deviations dealing with route continuity issues (see Chapter 1100).

Once a deviation is approved, it applies to that project only. When a new project is programmed at the same location, the subject design element is to be reevaluated and either the subject design element is rebuilt to conform to the applicable design level or a new deviation is developed, approved, and preserved in the DDP for the new project. Check the DVIS for help in identifying previously granted deviations.

A change in a design level resulting from an approved corridor planning study, or a corridor or project analysis as specified in design matrix notes, is documented similar to a deviation. Use Exhibit 300-7 as a guide to the outline and contents of your project analysis. Design elements that do not comply with the design level specified in an approved corridor or project analysis are documented as deviations.

To prepare a deviation request, use the list in Exhibit 300-7 as a general guide for the sequence of the content. The list is not all-inclusive of potential content and it might include suggested topics that do not apply to a particular project.

For design deviation examples, see: www.wsdot.wa.gov/design/projectdev

300.05 Project Development

In general, the region initiates the development of a specific project by preparing the Project Summary. Some project types may be initiated by other WSDOT groups such as the HQ Bridge and Structures Office or the HQ Traffic Office, rather than the region. The project coordination with other disciplines (such as Real Estate Services, Roadside and Site Development, Utilities, and Environmental) is started in the project scoping phase and continues throughout the project's development. The region coordinates with state and federal resource agencies and local governments to provide and obtain information to assist in developing the project.

The project is developed in accordance with all applicable Directives, Instructional Letters, Supplements, and manuals; the Limited Access and Managed Access Master Plan; the Washington State Highway System Plan; approved corridor planning studies; the Washington Federal-Aid Stewardship Agreement as implemented in the design matrices (see Chapter 1100); and the Project Summary.

The region develops and maintains documentation for each project. The Project File includes documentation of project work, including planning; scoping; public involvement; environmental action; design decisions; right of way acquisition; Plans, Specifications, and Estimates (PS&E) development; project advertisement; and construction. Refer to the *Plans Preparation Manual* for PS&E documentation. Exhibit 300-8 is an example checklist of recommended items to be turned over to the construction office at the time of project transition. An expanded version is available here: www.wsdot.wa.gov/Design/ProjectDev/

All projects involving FHWA action require NEPA clearance. Environmental action is determined through the ECS form. The environmental approval levels are shown in Exhibit 300-3.

Upon receipt of the ECS approval for projects requiring an EA or EIS under NEPA, the region proceeds with environmental documentation, including public involvement, appropriate for the magnitude and type of the project (see Chapter 210).

Design Approval and approval of right of way plans are required prior to acquiring property. If federal funds are used to purchase the property, then NEPA clearance is also required.

The ASDEs work with the regions on project development and conduct process reviews on projects as described in 300.09.

(1) Scoping Phase

Development of the project scope is the initial phase of project development. This effort is prompted by the Washington State Highway System Plan. The project scoping phase consists of determining a project's description, schedule, and cost estimate. The intent is to make design decisions early in the project development process that focus the scope of the project. During the project scoping phase, the Project Summary documents are produced.

(2) Project Summary

The Project Summary provides information on the results of the scoping phase; links the project to the Washington State Highway System Plan and the Capital Improvement and Preservation Program (CIPP); and documents the design decisions, the environmental classification, and agency coordination. The Project Summary is developed and approved before the project is funded for design and construction, and it consists of ERS, DD, and PD documents. The Project Summary database contains specific online instructions for completing the documents.

(a) **Environmental Review Summary (ERS)**

The ERS lists the required environmental permits and approvals, environmental classifications, and environmental considerations. This form also lists the requirements by environmental and permitting agencies. If there is a change in the PD or DD, the information in the ERS must be reviewed and revised to match the rest of the Project Summary. The ERS is prepared during the scoping phase and is approved by the region. During final design and permitting, revisions may need to be made to the ERS and be reapproved by the region.

(b) **Design Decisions (DD)**

The DD generally provides the design matrix used to develop the project, as well as the roadway geometrics, design deviations, EUs, other roadway features, roadside restoration, and any design decisions made during the scoping of a project. The information contained in this form is compiled from various databases of departmental information, field data collection, and evaluations made in development of the PD and the ERS. Design decisions may be revised throughout the project development process based on continuing evaluations.

The appropriate ASDE concurs with the Design Decisions for all projects requiring one. The region design authority approves the DD when confident there will be no significant change in the PD or estimated cost. Schedule, scope, or cost changes require a Project Change Request Form to be submitted and approved by the appropriate designee, in accordance with the *Project Control and Reporting Manual*.

(c) **Project Definition (PD)**

The PD identifies the various disciplines and design elements that will be encountered in project development. It also states the purpose and need for the project, the program categories, and the recommendations for project phasing. The PD is completed early in the scoping phase to provide a basis for full development of the ERS, DD, schedule, and estimate. If circumstances necessitate a change to an approved PD, process a Project Change Request Form for approval by the appropriate designee.

300.06 FHWA Approval

For all NHS projects, the level of FHWA oversight varies according to the type of project, the agency doing the work, and the funding source as shown in Exhibit 300-2. Oversight and funding do not affect the level of design documentation required for a project.

FHWA approval is required for any new or revised access point (including interchanges, temporary access breaks, and locked gate access points) on the Interstate System, regardless of funding (see Chapter 550).

Documents for projects requiring FHWA review, Design Approval, and Project Development Approval are submitted through the HQ Design Office. Include applicable project documents as specified in Exhibit 300-5.

300.07 Design Approval

When the Project Summary documents are complete, and the region is confident that the proposed design adequately addresses the purpose and need for the project, a Design Approval may be pursued and granted at this early stage. Early approval is an option at this point in the design phase and is likely most relevant to larger projects with longer PE phases because it provides early, approved documentation that locks in design policy for three years. This is a benefit for longer PE phases in that it avoids design changes due to policy updates during that time and provides consistency when purchasing right of way or publishing environmental documentation. If early Design Approval is not beneficial for a subject project, the typical items (below) that are part of this package become required in the combined Design Approval/Project Development Approval Package. Design Approval may occur prior to NEPA approval. Approval levels for design and PS&E documents are presented in Exhibits 300-2, 3, and 4.

The following items are typically provided for Design Approval:

- Stamped cover sheet (project description).
- One- or two-page reader-friendly memo that describes the project.
- Project Summary documents.
- Corridor or project analysis.
- Known variances.
- Design Criteria worksheets or equivalent: www.wsdot.wa.gov/design/projectdev
- Design Variances Inventory (for known variances at this stage).
- Channelization plans, intersection plans, or interchange plans (if applicable).
- Alignment plans and profiles (if project significantly modifies either the existing vertical or horizontal alignment).
- Current cost estimate with a confidence level.

Design Approval is entered into the Design Documentation Package and remains valid for three years or as approved by the HQ Design Office. Evaluate policy changes or revised design criteria that are adopted by the department during this time to determine whether these changes would have a significant impact on the scope or schedule of the project. If it is determined that these changes will not be incorporated into the project, document this decision with a memo from the region Project Development Engineer that is included in the DDP. For an overview of design policy changes, consult the Detailed Chronology of Design Policy Changes Affecting Shelved Projects: www.wsdot.wa.gov/design/policy/designpolicy

(1) Alternative Project Delivery Methods

Design Approval applies to projects delivered using alternative means, including design-build projects. Design documentation begins in the project scoping phase and continues through the life of the design-build project. This documentation is thus started by WSDOT and is completed by the design-builder. Since Design Approval is related to project scoping, this milestone may very well be accomplished prior to issuing a Design-Build Request for Proposal (see Exhibit 110-1). However, the design-builder shall refer to the RFP for direction on approval milestones.

300.08 Project Development Approval

When all project development documents are completed and approved, Project Development Approval is granted by the approval authority designated in Exhibit 300-2. The Project Development Approval becomes part of the DDP. (See 300.04 and Exhibit 300-5 for design documents that may lead to Project Development Approval.) Exhibits 300-2 through 300-4 provide approval levels for project design and PS&E documents.

The following items must be approved prior to Project Development Approval:

- Required environmental documents
- Design Approval documents (and any supplements)
- Updated Design Variance Inventory (all project variances)
- Cost estimate
- Stamped cover sheet (project description)

Project Development Approval remains valid for three years. Evaluate policy changes or revised design criteria that are adopted by the department during this time to determine whether these changes would have a significant impact on the scope or schedule of the project. If it is determined that these changes will not be incorporated into the project, document this decision with a memo from the region Project Development Engineer that is included in the DDP. For an overview of design policy changes, consult the Detailed Chronology of Design Policy Changes Affecting Shelved Projects at: www.wsdot.wa.gov/design/policy/designpolicy

(1) Alternative Project Delivery Methods

For projects delivered using alternative methods, such as design-build, the design-builder shall refer to the project RFP for specification on final and intermediate deliverables and final records for the project. Project Development Approval is *required* prior to project completion.

It is a prudent practice to start the compilation of design documentation early in a project and to acquire Project Development Approval 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 design-build project delivery process.

300.09 Process Review

The process review is done to provide reasonable assurance that projects are prepared in compliance with established policies and procedures and that adequate records exist to show compliance with state and federal requirements. Process reviews are conducted by WSDOT, FHWA, or a combination of both.

The design and PS&E process review is performed in each region at least once each year by the HQ Design Office. The documents used in the review process are the Design Documentation Checklist, the PS&E Review Checklist, and the PS&E Review Summary. These are generic forms used for all project reviews. Copies of these working documents are available for reference when assembling project documentation. The HQ Design Office maintains current copies at:
www.wsdot.wa.gov/design/projectdev

Each project selected for review is examined completely and systematically beginning with the scoping phase (including planning documents) and continuing through contract plans and, when available, construction records and change orders. Projects are normally selected after contract award. For projects having major traffic design elements, the HQ Maintenance and Operations Programs' Traffic Operations Office is involved in the review. The WSDOT process reviews may be held in conjunction with FHWA process reviews.

The HQ Design Office schedules the process review and coordinates it with the region and FHWA.

(a) **Process Review Agenda**

A process review follows this general agenda:

1. Review team meets with region personnel to discuss the object of the review.
2. Review team reviews the design and PS&E documents, construction documents, and change orders (if available) using the checklists.
3. Review team meets with region personnel to ask questions and clarify issues of concern.
4. Review team meets with region personnel to discuss findings.
5. Review team submits a draft report to the region for comments and input.
6. If the review of a project shows a serious discrepancy, the region design authority is asked to report the steps that will be taken to correct the deficiency.
7. Process review summary forms are completed.
8. Summary forms and checklists are evaluated by the State Design Engineer.
9. Findings and recommendations of the State Design Engineer are forwarded to the region design authority for action and/or information within 30 days of the review.

Project Design	FHWA Oversight Level	Deviation and Corridor/Project Approval[1][2]	EU Approval[2]	Design and Project Development Approvals
Interstate				
New/Reconstruction[3] Federal funds No federal funds	 [4] [5]	FHWA	Region	FHWA[10]
Intelligent Transportation Systems (ITS) over $1 million	[6]	HQ Design	Region	HQ Design
All other[7] Federal funds State funds Local agency funds	 [6] [6] [5]	HQ Design	Region	Region
National Highway System (NHS)				
Managed access highway outside incorporated cities and towns or inside unincorporated cities and towns, or limited access highway	[6]	HQ Design	Region	Region
Managed access highway within incorporated cities and towns[8] Inside curb or EPS[9] Outside curb or EPS	 [6] [6]	 HQ Design HQ H&LP	 Region N/A	 Region City/Town
Non-National Highway System (Non-NHS)				
Improvement project on managed access highway outside incorporated cities and towns or within unincorporated cities and towns, or on limited access highway (Matrix lines 5-8 through 5-27)	N/A	HQ Design	Region	Region
Improvement project on managed access highway within incorporated cities/towns[8] Inside curb or EPS[9] Outside curb or EPS (Matrix lines 5-8 through 5-27)	 N/A N/A	 HQ Design HQ H&LP	 Region N/A	 Region City/Town
Preservation project on managed access highway outside incorporated cities and towns or within unincorporated cities and towns, or on limited access highway[11] (Matrix lines 5-1 through 5-7)	N/A	Region[12]	Region	Region
Preservation project on managed access highway within incorporated cities and towns[8][11] Inside curb or EPS[9] Outside curb or EPS (Matrix lines 5-1 through 5-7)	 N/A N/A	 Region HQ H&LP	 Region N/A	 Region City/Town

For table notes, see the following page.

Design Approval Level
Exhibit 300-2

FHWA = Federal Highway Administration
HQ = WSDOT Headquarters
H&LP = WSDOT Highways & Local Programs Office
EPS = Edge of paved shoulder where curbs do not exist

Notes:

[1] These approval levels also apply to deviation processing for local agency work on a state highway.

[2] See 300.04(4).

[3] For definition, see Chapter 1100.

[4] Requires FHWA review and approval (full oversight) of design and PS&E submitted by HQ Design Office.

[5] To determine the appropriate oversight level, FHWA reviews the Project Summary (or other programming document) submitted by the HQ Design Office or by WSDOT Highways & Local Programs through the HQ Design Office.

[6] FHWA oversight is accomplished by process review (see 300.09).

[7] Reduction of through lane or shoulder widths (regardless of funding) requires FHWA review and approval of the proposal, except shoulder reductions as allowed by 1140.09 for seismic retrofit projects.

[8] Applies to the area within the incorporated limits of cities and towns.

[9] Includes raised medians.

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

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

[12] For guidance on access deviations, see Chapters 530 and 540.

Design Approval Level
Exhibit 300-2 (continued)

Item	Approval Authority		
	Region	HQ	FHWA
Program Development			
Work Order Authorization		X	X[1]
Public Hearings			
Corridor Hearing Summary		X[2]	
Design Summary		X[3]	
Access Hearing Plan		X[4]	
Access Findings and Order		X[5]	
Environmental by Classification			
Environmental Classification Summary (ECS) NEPA			X
Class I NEPA (EIS)		[7]	X
Class I SEPA (EIS)		X	
Class II NEPA – Categorical Exclusion (CE)* (Per MOU)	X		
Class II NEPA – Documented Categorical Exclusion (DCE)	[6]		X
Class II SEPA – Categorical Exemption (CE)	X		
Class III NEPA – Environmental Assessment (EA)		[7]	X
SEPA Checklist	X		
Design			
Experimental Features		X	X[9]
Environmental Review Summary	X		
Final Design Decisions	X	X[3]	
Final Project Definition		X[10]	
Interstate Interchange Justification Report		[7]	X
Non-Interstate Interchange Justification Report		X	
Break in Partial or Modified Limited Access		X	
Intersection Plans	X[11]		
Right of Way Plans	[12]	X	
Monumentation Map	X		
Materials Source Report		X[13]	
Pavement Determination Report		X[13]	
Roundabout Geometric Design (see Chapter 1320 for guidance)	X		

For table notes, see the following page.

Approvals
Exhibit 300-3

Item	Approval Authority		
	Region	HQ	FHWA
Design (continued)			
Resurfacing Report		X[13]	
Signal Permits	X[14]		
Geotechnical Report		X[13]	
Tied Bids	X[15]		X[9][15]
Bridge Design Plans (Bridge Layout)	X	X	
Hydraulic Report	X[16]	X[16]	
Preliminary Signalization Plans		X[6]	
Rest Area Plans		X	
Roadside Restoration Plans	X[18]	X[19]	
Structures Requiring TS&Ls		X	X
Planting Plans	X[18]	X[19]	
Grading Plans	X[18]	X[19]	
Continuous Illumination – Main Line		X[20]	
Project Change Request Form	X[21]	X[21]	
Work Zone Transportation Management Plan/Traffic Control Plan	X[22]		
Public Art Plan – Interstate (see Chapter 950)	X[18][23]	X[19][23]	X[9][19][23]
Public Art Plan – Non-Interstate (see Chapter 950)	X[18][23]	X[19][23]	
ADA Maximum Extent Feasible Document (see Chapter 1510)	X	X	

X Normal procedure * If on the preapproved list

Notes:

[1] Federal-aid projects only.
[2] Approved by Environmental and Engineering Programs Director.
[3] Approved by State Design Engineer.
[4] Approved by Right of Way Plans Manager.
[5] Refer to Chapter 210 for approval requirements.
[6] Final review & concurrence required at the region level prior to submittal to approving authority.
[7] Final review & concurrence required at HQ prior to submittal to approving authority.
[9] Applies to new/reconstruction projects on Interstate routes.
[10] Approved by HQ Project Control & Reporting.
[11] Include channelization details.
[12] Certified by the responsible professional licensee.
[13] Submit to HQ Materials Laboratory for review and approval.
[14] Approved by Regional Administrator or designee.
[15] See 23 CFR 635.111.
[16] See the *Hydraulics Manual* for approvals levels.
[18] Applies only to regions with a Landscape Architect.
[19] Applies only to regions without a Landscape Architect.
[20] Approved by State Traffic Engineer.
[21] Consult HQ Project Control & Reporting for clarification on approval authority.
[22] Region Traffic Engineer.
[23] The State Bridge and Structures Architect reviews and approves the public art plan (see Chapter 950 for further details on approvals).

Approvals
Exhibit 300-3 (continued)

Item	New/Reconstruction (Interstate only)	NHS and Non-NHS
DBE/training goals* **	(a)	(a)
Right of way certification for federal-aid projects	FHWA(b)	FHWA(b)
Right of way certification for state-funded projects	Region(b)	Region(b)
Railroad agreements	(c)	(c)
Work performed for public or private entities*	[1][2]	Region[1][2]
State force work*	FHWA[3](d)	Region[3](d)
Use of state-furnished stockpiled materials*	FHWA[4]	FHWA[4]
Stockpiling materials for future projects*	FHWA[4]	FHWA[4]
Work order authorization	[5](d)	[5](d)
Ultimate reclamation plan approval through DNR	Region	Region
Proprietary item use*	FHWA[4]	[4](c)
Mandatory material sources and/or waste sites*	FHWA[4]	Region[4]
Nonstandard bid item use*	Region	Region
Incentive provisions	FHWA	(e)
Nonstandard time for completion liquidated damages*	FHWA(e)	(e)
Interim liquidated damages*	(f)	(f)

Notes:

[1] This work requires a written agreement.
[2] Region approval subject to $250,000 limitation.
[3] Use of state forces is subject to $60,000 limitation and $100,000 in an emergency situation, as stipulated in RCWs 47.28.030 and 47.28.035.
[4] Applies only to federal-aid projects; however, document for all projects.
[5] Prior FHWA funding approval required for federal-aid projects.

Region or Headquarters Approval Authority:

(a) Office of Equal Opportunity
(b) HQ Real Estate Services Office
(c) HQ Design Office
(d) Project Control & Reporting Office
(e) HQ Construction Office
(f) Transportation Data Office

References:

**Plans Preparation Manual*
***Advertisement and Award Manual*

PS&E Process Approvals
Exhibit 300-4

Document[1]	Required for FHWA Oversight
Project Definition	X
Design Decisions Summary	X
Environmental Review Summary	X
Design Variance Inventory (and supporting information for DEs, EUs not upgraded, and deviations)[2]	X
Cost estimate	X
SEPA & NEPA documentation	X
Design Clear Zone Inventory (see Chapter 1600)	X
Interchange plans, profiles, roadway sections	X
Interchange justification report (if requesting new or revised access points)	X
Corridor or project analysis (see Chapter 1100)	X
Traffic projections and analysis	
Collision analysis	
Right of way plans	
Work zone traffic control strategy	
Record of Survey or Monumentation Map	
Documentation of decisions to differ from WSDOT design guidance	
Documentation of decisions for project components for which there is no WSDOT design guidance	
Paths and Trails Calculations[3]	

Notes:

[1] For a complete list, see the Design Documentation Checklist.

[2] Required for all highways.

[3] See the *Plans Preparation Manual*.

Common Components of Design Documentation Package
Exhibit 300-5

1. **Design Element Upgraded to the Level Indicated in the Matrix**
   (a) Design element information
   - Design element
   - Location
   - Matrix number and row

   (b) Cost estimate[1]
   (c) B/C ratio[2]
   (d) Summary of the justification for the upgrade[3]

2. **Design Element Not Upgraded to the Level Indicated in the Matrix**
   (a) Design element information
   - Design element
   - Location
   - Matrix number and row

   (b) Existing conditions
   - Description
   - Accident Summary
   - Advantages and disadvantages of leaving the existing condition unchanged

   (c) Design using the *Design Manual* criteria
   - Description
   - Cost estimate[1]
   - B/C ratio[2]
   - Advantages and disadvantages of upgrading to the level indicated in the matrix

   (d) Selected design, if different from existing but less than the level indicated in the matrix
   - Description
   - Cost estimate[1]
   - B/C ratio[2]
   - Advantages and disadvantages of the selected design

   (e) Summary of the justification for the selected design[3]

Notes:

[1] An estimate of the approximate total additional cost for the proposed design. Estimate may be based on experience and engineering judgment.

[2] Include only when B/C is part of the justification. An approximate value based on engineering judgment may be used.

[3] A brief (one or two sentence) explanation of why the proposed design was selected.

Evaluate Upgrade (EU) Documentation Contents List
Exhibit 300-6

1. **Overview**
   - (a) The safety or improvement need that the project is to meet
   - (b) Description of the project as a whole
   - (c) Highway classification and applicable design matrix number and row
   - (d) Funding sources
   - (e) Evidence of deviations approved for previous projects (same location)

2. **Design Alternatives in Question**
   - (a) Existing conditions and design data
     - Location in question
     - Rural, urban, or developing
     - Approved corridor study
     - Environmental issues
     - Right of way issues
     - Number of lanes and existing geometrics
     - Present and 20-year projected ADT
     - Design speed, posted speed, and operating speed
     - Percentage of trucks
     - Terrain Designation
     - Managed access or limited access
   - (b) Collision Summary and Analysis
   - (c) Design using the *Design Manual* criteria
     - Description
     - Cost estimate
     - B/C ratio
     - Advantages and disadvantages
     - Reasons for considering other designs
   - (d) Other alternatives (may include “No-build” alternative)
     - Description
     - Cost estimate
     - B/C ratio
     - Advantages and disadvantages
     - Reasons for rejection
   - (e) Selected design requiring justification or documentation to file
     - Description
     - Cost estimate
     - B/C ratio
     - Advantages and disadvantages

3. **Concurrences, Approvals, and Professional Seals**

Deviation Request and Project Analysis Contents List
Exhibit 300-7

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
   - ❑ Design decisions and constraints
   - ❑ Approved deviations & project/corridor analysis
   - ❑ 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

Design to Construction Transition Project Turnover Checklist Example

Exhibit 300-8

Chapter 550 Interchange Justification Report

550.01 General

An Interchange Justification Report (IJR) is the document used to justify a new access point or access point revision on limited access freeways and highways in Washington State. This chapter provides policy and guidance on developing the required documentation for an IJR, and the sequence of an IJR presentation, for both Interstate and non-Interstate limited access routes.

Federal law requires Federal Highway Administration (FHWA) approval of all revisions to the Interstate system, including changes to limited access. Both FHWA and Washington State Department of Transportation (WSDOT) policy require the formal submission of a request to either break or revise the existing limited access on Interstate routes. Breaking or revising existing limited access on state routes must be approved by an Assistant State Design Engineer. An IJR is a stand-alone document that includes the necessary supporting information needed for a request. It documents the IJR team's assumptions and the design of the preferred alternative, the planning process, the evaluation of the alternatives considered, and the coordination that supports and justifies the request for an access revision.

Engineers at the WSDOT Headquarters (HQ) Design Office Access and Hearings Section specialize in providing support for meeting the guidance provided in this chapter. To ensure project success, consult with them before any of the IJR work is started. They can help you during the development of the study, Methods and Assumptions Document, and the Interchange Justification Report.

Establish an IJR support team to help integrate the planning, programming, environmental, traffic, safety, and design efforts that lead to development of a proposal. The team includes representatives from the HQ Access and Hearings Section and FHWA (for Interstate routes) to help determine the priority and level of detail needed to address each policy point and the scale of the required documentation.

The scale and complexity of the report varies considerably with the scope of the proposed access point revision. (See Exhibits 550-1 and 550-2 for an idea of what an IJR will include.) The support team, including HQ Access and Hearings, decides what an IJR will include. IJRs on the Interstate require that all eight policy points be addressed. The level of effort necessary to address each policy point is scalable and should vary depending on the complexity of the proposal. The level of effort is set by the support team and documented in the Methods and Assumptions Document. For non-Interstate IJRs, the support team will establish which policy points are needed and the level of analysis necessary based on the complexity of the project.

The support team reviews regional and state transportation plans to determine whether the need and proposed solution are already identified. Proposals to request new or reconstructed interchanges must be consistent with those plans.

When a local agency or developer is proposing an access point revision, WSDOT requires that a study team be formed.

The IJR will contain a cover sheet that will be stamped by the Engineer of Record responsible for the report's preparation and the Traffic Analysis Engineer responsible for the traffic analysis included in Policy Point 3. (See Exhibit 550-5 for an example.)

550.02 References

(1) Federal/State Laws and Codes

23 Code of Federal Regulations (CFR) Part 450 (implementing 23 United States Code [USC] Section 135)

40 CFR Parts 51 and 93 (regarding federal conformity with state and federal air quality implementation plans)

23 USC Sections 111 (requires the U.S. Secretary of Transportation to approve access revisions to the Interstate System), 134 (metropolitan transportation planning), and 135 (statewide transportation planning)

Revised Code of Washington (RCW) 36.70A, Growth management – Planning by selected counties and cities

(2) Design Guidance

Highway Capacity Manual, Special Report No 209 (HCM), Transportation Research Council

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

Traffic Analysis Toolbox (tools used in support of traffic operations analyses)
www.ops.fhwa.dot.gov/trafficanalysistools/index.htm

WSDOT HQ Access and Hearings web page (provides guidance and timelines for preparing IJRs and example Methods and Assumptions Documents):
www.wsdot.wa.gov/design/accessandhearings

(3) Supporting Information

Notice of policy statement: "Additional Interchanges to the Interstate System," FHWA notice published in the Federal Register, October 22, 1990 (Vol. 55, No. 204)

Notice of policy statement: "Additional Interchanges to the Interstate System," FHWA notice published in the Federal Register, February 11, 1998 (Vol. 63, No. 28)
www.access.gpo.gov/su_docs/fedreg/a980211c.html

State Highway System Plan
www.wsdot.wa.gov/planning/HSP

550.03 Definitions

access A means of entering or leaving a public road, street, or highway with respect to abutting property or another public road, street, or highway.

access break Any point from inside or outside the state limited access right of way limited access hachures that crosses over, under, or physically through the plane of the limited access, is an access break or "break in access," including, but not limited to, locked gates and temporary construction access breaks.

access point Any point from inside or outside the limited access hachures that allows entrance to or exit from the traveled way of a limited access freeway, including "locked gate" access and temporary construction access.

access point revision A new access point or a revision of an existing interchange/intersection configuration. Locked gates and temporary construction breaks are also access point revisions.

alternatives 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.

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.

baseline The existing transportation system configuration and traffic volumes for a specific year against which to compare possible alternative solutions.

break See ***access break***.

collision rate Collisions per one million vehicle miles traveled and fatal rates per one hundred million vehicle miles.

design year 20 years from the beginning of construction.

ECS See Chapter 220.

FONSI See Chapter 220.

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.

Interchange Justification Report (IJR) The document used to propose a revision to limited access freeways.

limited access Full, partial, or modified access control is planned and established for a corridor and then acquired as the right to limit access to each individual parcel.

Methods and Assumptions Document A mandatory document developed at the beginning of the IJR phase to record IJR assumptions, methodologies, criteria, and decisions (see 550.04(1)(c)).

need A statement that identifies the transportation problem(s) that the proposal is designed to address and explains how the problem will be resolved. An existing or anticipated travel demand that has been documented through a study process to require a change in access to the state's limited access freeway system.

no-build condition The baseline, plus state transportation plan and comprehensive plan improvements, expected to exist, as applied to the year of opening or the design year.

policy point There are eight policy points addressed in the IJR:

- Need for the Access Point Revision
- Reasonable Alternatives
- Operational & Collision Analyses
- Access Connections & Design
- Land Use & Transportation Plans
- Future Interchanges
- Coordination
- Environmental

proposal The combination of projects/actions selected through the study process to meet a specific transportation system need.

purpose General project goals such as improve safety, enhance mobility, or enhance economic development.

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.

study area The transportation system area to study in the study process and for an IJR. 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.

support team An integral part of the IJR 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.

Transportation Management Area (TMA) Urbanized areas with populations of 200,000 or greater are federally designated as Transportation Management Areas.

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.

trips Short trips are normally local. Long trips are normally interstate, regional, or interregional.

550.04 Procedures

Gaining concurrence and approval for an access point revision is a multistep process. It begins with assembling a support team to conduct a feasibility or planning-level study. The purpose of this study is to determine whether there are improvements that can be made to the local roadway network to meet the purpose and need of the proposed access modification. If the study shows that the purpose and need of the proposal cannot be achieved with the local infrastructure only, the next step would normally be to prepare an IJR (see the Interstate IJR Process Flow Chart, Exhibit 550-3).

Steps in the IJR process include:

- Assemble the support team to engage subject experts and decision makers.
- Determine whether a feasibility study needs to be conducted or already exists.
- Prepare Methods and Assumptions Document to lay the groundwork for the IJR—this is required.
- Support team endorses Methods and Assumptions Document to prepare the IJR.
- Prepare IJR.
- IJR Review and Approval.

Exhibits 550-1 and 550-2 list the project types most likely to affect freeway safety and operations, requiring the submission of an IJR. Consult the HQ Access and Hearings Section early for specific direction.

Guidance and examples on assumptions documents are provided here:
www.wsdot.wa.gov/design/accessandhearings

(1) Organize Support Team and Conduct Study

(a) Support Team

Establish a support team before beginning the feasibility study. This same support team would also be involved with the IJR process if the study shows that either a revision or a new access point is needed to meet the proposal purpose and need.

The support team normally consists of the following:

- FHWA Area Engineer and Mobility and ITS Engineer (for Interstate projects)
- Region Planning, Design, or Project Development Engineer (or designee)
- HQ Assistant State Design Engineer
- HQ Access and Hearings Engineer
- HQ Traffic Office Representative
- Representative from local agencies (city, county, port, or tribal government)
- Recorder
- IJR writer

A support team comprised of subject experts and approval authorities will ensure your IJR the highest possible level of success.

The support team enlists specialists, including:

- Metropolitan Planning Organization (MPO)
- Regional Transportation Planning Organization (RTPO)

- WSDOT region (planning, design, environmental, maintenance, and traffic)
- WSDOT Headquarters (design, bridge, traffic, and geotechnical)
- Project proponent specialists (region, local agency, developer)
- Transit agencies

The support team works together, from the corridor study through preparation of the assumptions document and completion of the IJR.

The support team's role is to:

- Review regional and state transportation plans to see if the request is consistent with the needs and solutions shown in those plans.
- Develop a charter that includes the processes for reaching agreement, resolving disputes, and assigning responsibility for final decisions.
- Develop purpose, need, and vision statements for the study. They should be consistent with the project environmental document.
- Expedite the study steps (and, if needed, the IJR development and review process) through early communication and agreement.
- Establish the agreed-upon study area (including baseline transportation improvements) and future travel demand forecasts for each of the alternatives being considered.
- Develop and endorse the Methods and Assumptions Document.
- Provide guidance and support.
- Evaluate data and identify possible alternatives for the proposal during the study and, if needed, for an IJR.
- Contribute material for the report that documents the discussions and decisions.
- Review results and determine whether an IJR is warranted.
- Ensure the compatibility of data used in various studies.
- Ensure integration of the Project Definition process, value engineering studies, public involvement efforts, environmental analyses, operational analyses, safety analyses, other analyses for the study (and, if needed, to prepare an IJR). This encourages the use of consistent data.
- Address design elements. Status of known deviations must be noted in Policy Point 4. Deviations are discouraged on new accesses.

(b) **Feasibility Study**

Study the transportation network in the area. This study will identify the segments of both the local and regional network that are currently experiencing congestion or safety deficiencies, or where planned land use changes will prompt the need to evaluate the demands on and the capacity of the transportation system. The study area includes the affected existing and proposed interchanges/intersections upstream and downstream from the proposed access point revision. Extend the study far enough that the proposal creates no significant impacts to the adjacent interchanges/intersections, then analyze only through the area of influence. When the area of influence extends beyond the one interchange/intersection upstream and downstream, extend the analysis far enough to include the extent of the traffic impacts.

Segments of the local and regional network within the study area will be evaluated for system improvements. Part of the study process is to identify local infrastructure needs and develop a proposal. The study must investigate investments in local infrastructure improvements to meet the purpose and need of the proposal. It must be shown that the local infrastructure alone cannot be improved to address the purpose and need.

During the study process and while developing a proposal, it is important to use the data and analysis methods required for an IJR. If the study indicates that an IJR is warranted, the study data can be utilized in the IJR.

(c) **Methods and Assumptions Document**

This document is developed to record assumptions used in the IJR, along with methodologies, criteria, and support team decisions. The document presents the proposed traffic analysis tool and approach, study area, peak hour(s) for analysis, traffic data, design year, opening year, travel demand forecasts, baseline conditions, and design year conditions. It also documents the team's decisions on how much detail will be included in each policy point. The signed Methods and Assumptions Document represents endorsement by the support team on the IJR approach, tools, data, and criteria used throughout the IJR process.

The Methods and Assumptions Document is dynamic, and is updated and re-endorsed when changed conditions warrant. The document also serves as a historical record of the processes, dates, and decisions made by the team. WSDOT and FHWA require the development and acceptance of the document, because early agreement on details results in the highest level of success for the IJR process.

Example Methods and Assumptions Documents and an outline of this process are provided online at: www.wsdot.wa.gov/design/accessandhearings

(2) Conduct Analysis and Prepare IJR

Prepare a detailed IJR using the guidance in 550.05, Interchange Justification Report and Supporting Analyses, and Exhibit 550-3.

(a) **Policy Topics**

The IJR addresses the following eight specific policy topics (see Exhibits 550-1 and 550-2 for exceptions):

1. Need for the Access Point Revision
2. Reasonable Alternatives
3. Operational and Collision Analyses
4. Access Connections and Design
5. Land Use and Transportation Plans
6. Future Interchanges
7. Coordination
8. Environmental Processes

(b) **Early Initiation**

The IJR is initiated early in the environmental process. Traffic analyses help define the area of impact and the range of alternatives. Since the traffic data required for the National Environmental Policy Act (NEPA) or the State Environmental Policy Act (SEPA) and the operational/safety analyses of the IJR are similar. It is recommended that these documents be developed together, whenever feasible, using the same data sources and procedures. This can result in a benefit to the IJR process with concurrent data.

(3) IJR Review and Approval

Concurrence and approval of a new or revised access point is based on the IJR. The IJR contains sufficient information about and evaluation/analysis of the proposal to provide assurance that the safety and operations of the freeway and local systems are not significantly impacted.

The region, or proponents, with the help of the support team, prepares the IJR and submits four draft copies, including backup traffic data, to the HQ Access and Hearings Section for review.

For a final IJR submittal, contact the HQ Access and Hearing Section for the necessary number of copies.

An IJR is formally approved concurrently with the approval of the project environmental document.

(a) **Interstate IJR**

On Interstate projects, a submittal letter is sent by the region through the HQ Access and Hearings Section, requesting final FHWA approval of the IJR. Interstate IJRs are submitted by Headquarters to FHWA for concurrence and approval.

Interstate access point revisions are reviewed by both WSDOT Headquarters and FHWA. This can be a two-step process:

- If environmental documentation is not completed, a finding of engineering and operational acceptability is given.
- If the environmental documentation is complete, final approval can be given.

Some Interstate IJRs are reviewed and approved by the local FHWA Division Office. Other Interstate IJRs are reviewed and approved by the FHWA Headquarters Office in Washington DC. Additional review time is necessary for reports that have to be submitted to Washington DC (see Exhibit 550-1.)

Final IJR approval by FHWA is provided when the appropriate final environmental decision is complete: ECS, FONSI, or ROD (see definitions).

(b) **Non-Interstate IJR**

On non-Interstate projects, a different scaled process is followed based on the type of project being contemplated. The Methods and Assumptions Document development determines the scope and complexity of what is to be prepared. The project proponent, using the process in Exhibit 550-4, advances the Methods and Assumptions documentation to determine what will ultimately be prepared and approved. The range of outcomes could be that an IJR is not required (documented by the endorsed Methods and Assumptions Document), only selected policy points are required, or all eight are required to be prepared. In some cases, a support team is not required to create the Methods and Assumptions Document to make this determination (see Exhibit 550-2). In any scenario, for a project proposed on non-Interstate routes, concurrence from the study team is required on the Methods and Assumptions to document the acceptance of the scope and complexity of the IJR or the acceptance of the decision that an IJR is not required. If an IJR is prepared, the appropriate WSDOT Assistant State Design Engineer grants the final approval, not the FHWA (see Exhibit 550-4). Send a submittal letter to the HQ Access and Hearings Section requesting final approval of the non-Interstate project IJR.

550.05 Interchange Justification Report and Supporting Analyses

The eight policy points are presented below. Consult with the HQ Access and Hearings Section for guidance. Factors that affect the scope include location (rural or urban), access points (new or revised), ramps (new or existing), and ramp terminals (freeway or local road).

(1) Policy Point 1: Need for the Access Point Revision

What are the current and projected needs? Why are the existing access points and the existing or improved local system unable to meet the proposal needs? Is the anticipated demand short or long trip?

Describe the need for the access point revision and why the existing access points and the existing or improved local system do not address the need. How does the proposal meet the design year travel demand? Provide the analysis and data to support the need for the access request.

(a) **Project Description**

Describe the needs being addressed and the proposal. Demonstrate that improvements to the local transportation system and the existing interchanges cannot be improved to satisfactorily accommodate the design year travel demands. Describe traffic mitigation measures considered at locations where the level of service (LOS) is (or will be) below agreed-upon service standards in the design year. (See the State Highway System Plan for further information on LOS standards.) Additional measures of effectiveness (such as density, speed changes, delay, and travel times) should be discussed and documented in the Methods and Assumptions Document.

The access point revision is primarily to meet regional, not local, travel demands. Describe the local and regional traffic (trip link and/or route choice) benefiting from the proposal.

(b) **Analysis and Data**

The proposal analysis tools, data, and study area must be agreed upon by the support team. Use the Methods and Assumptions Document to detail the specific items and record the team's agreement to them. Establishing assumptions upfront ensures the project will have the highest rate of success. For further guidance and examples on assumptions documents, see:
www.wsdot.wa.gov/design/accessandhearings

Show that a preliminary (planning level) analysis, comparing build to no-build data, was conducted for the current year, year of opening, and design year, comparing baseline, no-build condition, and build alternatives. Include the following steps:

1. Define the study area. The study area is a minimum of one interchange upstream and downstream from the proposal. 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.
2. Establish baseline transportation networks and future land use projections for the study area. The baseline transportation network typically includes local, regional, and state transportation improvement projects that are funded. The land use projection includes population and employment forecasts consistent with the regional (MPO or RTPO) and local jurisdiction forecasts.
3. Collect and analyze current traffic volumes to develop current year, year of opening, and design year peak hour traffic estimates for the regional and local systems in the area of the proposal. Use regional transportation planning organization-based forecasts, refined by accepted travel demand estimating procedures. Forecasts for specific ramp traffic may require other methods of estimation procedures and must be consistent with the projections of the travel demand models. Modeling must include increased demand caused by anticipated development.
4. Identify the origins and destinations of trips on the local systems, the existing interchange/intersections, and the proposed access using existing information.
5. Develop travel demand forecasts corresponding to assumed improvements that might be made to the following:
   - The local system: widen, add new surface routes, coordinate the signal system, control access, improve local circulation, or improve parallel roads or streets.
   - The existing interchanges: lengthen or widen ramps, add park & ride lots, or add frontage roads.
   - The freeway lanes: add collector-distributor roads or auxiliary lanes.
   - Transportation system management and travel demand management measures.
6. Describe the current year, year of opening, and design year level of service at all affected locations within the study area, including local systems, existing ramps, and freeway lanes.

(2) Policy Point 2: Reasonable Alternatives

Describe the reasonable alternatives that have been evaluated.

Describe all reasonable alternatives that have been considered. These include the design options, locations, and transportation system management-type improvements such as ramp metering, mass transit, and HOV facilities that have been assessed and that meet the proposal design year needs.

After describing each of the alternatives that were proposed, explain why reasonable alternatives were omitted or dismissed from further consideration.

Future projects must be coordinated as described in Policy Point 7, Coordination.

(3) Policy Point 3: Operational and Collision Analyses

How will the proposal affect safety and traffic operations at year of opening and design year?

Policy Point 3 documents the procedures used to conduct the operational and collision analyses and the results that support the proposal.

The preferred operational alternative is selected, in part, by showing that it will meet the access needs without causing a significant adverse impact on the operation and safety of the freeway and the affected local network, or that the proposal impacts will be mitigated.

Document the results of the following analyses in the report:

- Operational Analysis – "No-Build" Alternative: An operational analysis of the current year, year of opening, and design year for the existing limited access freeway and the affected local roadway system. This is the baseline plus state transportation plan and comprehensive plan improvements expected to exist at the year of opening or design year. All of the alternatives will be compared to the no-build condition. The report should document the calibration process and results that show the current year operations match actual field conditions.
- Operational Analysis – "Build" Alternative: An operational analysis of the year of opening and design year for the proposed future freeway and the affected local roadway system.
- Collision Analysis: A collision analysis for the most current data year, year of opening, and design year of the existing limited access freeway and the affected local roadway system for the "no-build." A collision analysis should also be performed for the "build" as well.

The data used must be consistent with the data used in the environmental documentation. If not, provide justification for the discrepancies.

(a) Operational Analyses

Demonstrate that the proposal does not have a significant adverse impact on the operation of the freeway and the affected local roadway system. If there are proposal impacts, explain how the impacts will be mitigated.

To understand the proposal's positive and negative impacts to main line, crossroad, and local system operations, the selection of the appropriate analysis tool(s) is critical. This is a major piece of the assumptions process. Record the support team's tool selection agreement in the Methods and Assumptions

Document. FHWA's Traffic Analysis Toolbox provides an overview and details for making the best tool category selection.

Document the selected operational analysis procedures. For complex urban projects, a refined model might be necessary. WSDOT supports the traffic analysis and traffic simulation software listed on the HQ Traffic Operations website: 🖰 www.wsdot.wa.gov/Design/Traffic/Analysis/

All operational analyses shall be of sufficient detail, and include sufficient data and procedure documentation, to allow independent analysis during FHWA and Headquarters evaluation of the proposal. For Interstate proposals, Headquarters must provide concurrence before it transmits the proposal to FHWA with its recommendation.

Prepare a layout displaying adjacent interchanges/intersections and the data noted below, based on support team determination, which should show:

- Distances between intersections or ramps of a proposed interchange, and those of adjacent existing and known proposed interchanges.
- Design speeds.
- Grades.
- Truck volume percentages on the freeway, ramps, and affected roadways.
- Adjustment factors (such as peak hour factors).
- Affected freeway, ramp, and local roadway system traffic volumes for the "no-build" and each "build" option. This will include: a.m. and p.m. peaks (noon peaks, if applicable); turning volumes; average daily traffic (ADT) for the current year; and forecast ADT for year of opening and design year.
- Affected main line, ramp, and local roadway system lane configurations.

The study area of the operational analysis on the local roadway system includes documenting that the local network is able to safely and adequately collect and distribute any new traffic loads resulting from the access point revision. Expand the limits of the study area, if necessary, to analyze the coordination required with an in-place or proposed traffic signal system. Record the limits of the analysis as well as how the limits were established in the project Methods and Assumptions Document.

Document the results of analyzing the existing access and the proposed access point revision at all affected locations within the limits of the study area, such as weave, merge, diverge, ramp terminals, collision sites, and HOV lanes; along the affected section of freeway main line and ramps; and on the affected local roadway system. In the report, highlight the following:

- Any location for which there is a significant adverse impact on the operation or safety of the freeway facility, such as causing a reduction of the operational efficiency of a merge condition at an existing ramp; introducing a weave; or significantly reducing the level of service on the main line due to additional travel demand. Note what will be done to mitigate this adverse impact.
- Any location where a congestion point will be improved or eliminated by the proposal, such as proposed auxiliary lanes or collector-distributor roads for weave sections.

- Any local roadway network conditions that will affect traffic entering or exiting the freeway. If entering traffic is to be metered, explain the effect on the connecting local system (for example, vehicle storage).
- When the existing local and freeway network does not meet agreed-upon level of service standards, show how the proposal will improve the level of service or keep it from becoming worse than the no-build condition in the year of opening and the design year. Level of service should not be the only performance measure evaluated. There are other measures of effectiveness that can be used to illustrate a broader traffic operation perspective.

(b) **Collision Analysis**

This analysis identifies areas where there may be a safety concern. The study limits are the same as for operational analyses.

Identify and document all safety program (I2) locations. Identify and document collision histories, rates, and types for the freeway section and the adjacent affected local surface system. Project the rates that will result from traffic flow and geometric conditions imposed by the proposed access point revision. Document the basis for all assumptions.

Demonstrate that (1) the proposal does not have a significant adverse impact on the safety of the freeway or the adjacent affected local surface system, or (2) the impacts will be mitigated. The safety analysis for both existing and proposed conditions should include the following:

1. **Type of Collisions**
   - What types of collisions are occurring (overturns, rear-ends, enter-at-angle, hitting fixed object)?
   - What types of collision s are most prevalent?
   - Are there any patterns of collision type or cause?
2. **Severity of Collisions**
   - Fatalities, serious injuries, evident injuries, property damage
3. **Collision Rates and Numbers**
   - Document the number and rate of collisions within the study limits for existing and proposed conditions.
   - What are the existing and anticipated crash/serious injury/fatality rates and numbers by proximity to the interchange exit and entrance ramps?
   - How do these rates compare to similar corridors or interchanges?
   - How do these rates compare to the future rates and numbers?
   - What are the existing and anticipated crash/serious injury/fatality rates and numbers for the impacted adjacent and parallel road system (with and without the access revision)?
4. **Contributing Factors and Conclusions**
   - Document contributing causes of collisions and conclusions. What are the most prevalent causes?

- Evaluate and document the existing and proposed roadway conditions for geometric design standards, stopping sight distance, and other possible contributing factors. Would the proposal reduce the frequency and severity of collisions?

(4) Policy Point 4: Access Connections and Design

Will the proposal provide fully directional interchanges connected to public streets or roads, spaced appropriately, and designed to full design level geometric control criteria?

Provide for all directions of traffic movement on Interstate system-to-system type interchanges, unless justified. The intent is to provide full movement at all interchanges, whenever feasible. Partial interchanges are discouraged. Less than fully directional interchanges for special-purpose access for transit vehicles, for HOVs, or to or from park & ride lots will be considered on a case-by-case basis.

A proposed new or revised interchange access must connect to a public freeway, road, or street and be endorsed by the local governmental agency or tribal government having jurisdiction over said public freeway, road, or street.

Explain how the proposed access point relates to present and future proposed interchange configurations and the *Design Manual* spacing criteria. Note that urban and rural interchange spacing for crossroads also includes additional spacing requirements between adjacent ramps, as noted in Chapter 940.

Develop the proposal in sufficient detail to conduct a design and operational analysis. Include the number of lanes, horizontal and vertical curvature, lateral clearance, lane width, shoulder width, weaving distance, ramp taper, interchange spacing, and all traffic movements. This information is presented as a sketch or a more complex layout, depending on the complexity of the proposal.

The status of all known or anticipated project deviations must be noted in this policy point, as described in Chapter 330.

(5) Policy Point 5: Land Use and Transportation Plans

Is the proposed access point revision compatible with all land use and transportation plans for the area?

Show that the proposal is consistent with local and regional land use and transportation plans. Before final approval, all requests for access point revisions must be consistent with the regional or statewide transportation plan, as appropriate (see Chapter 120). The proposed access point revision may affect adjacent land use and, conversely, land use may affect the travel demand generated. Therefore, reference and show compatibility with the land use plans, zoning controls, and transportation ordinances in the affected area.

Explain the consistency of the proposed access point revision with the plans and studies, the applicable provisions of 23 CFR Part 450, the applicable transportation conformity requirements of 40 CFR Parts 51 and 93, and Chapter 36.70A RCW.

If the proposed access is not specifically referenced in the transportation plans, define its consistency with the plans and indicate the process for the responsible planning agency to incorporate the project. In urbanized areas, the plan refinement must be adopted by the metropolitan planning organization (MPO) before the project is designed. The action must also be consistent with the multimodal State Transportation Plan.

(6) Policy Point 6: Future Interchanges

Is the proposed access point revision compatible with a comprehensive network plan? Is the proposal compatible with other known new access points and known revisions to existing points?

The report must demonstrate that the proposed access point revision is compatible with other planned access points and revisions to existing points.

Reference and summarize any comprehensive freeway network study, plan refinement study, or traffic circulation study.

Explain the consistency of the proposed access point revision with those studies.

(7) Policy Point 7: Coordination

Are all coordinating projects and actions programmed and funded?

When the request for an access point revision is generated by new or expanded development, demonstrate appropriate coordination between the development and the changes to the transportation system.

Show that the proposal includes a commitment to complete the other noninterchange/nonintersection improvements that are necessary for the interchange/intersection to function as proposed. For example, if improvements to the local circulation system are necessary for the proposal to operate, they must be in place before new ramps are opened to traffic. If future reconstruction is part of the mitigation for design year level of service, the reconstruction projects must be in the State Highway System Plan and Regional Transportation Plan.

All elements for improvements are encouraged to include known fiscal commitments and an anticipated time for completion. If the project is to be constructed in phases, it must be demonstrated in Policy Point 3 that each phase can function independently and does not affect the safety and operational efficiency of the freeway. Identify the funding sources, both existing and projected, and the estimated time of completion for each project phase.

(8) Policy Point 8: Environmental Processes

What is the status of the proposal's environmental processes? This section should be something more than just a status report of the environmental process; it should be a brief summary of the environmental process.

All requests for access point revisions on freeways must contain information on the status of the environmental approval and permitting processes.

The following are just a few examples of environmental status information that may apply:

- Have the environmental documents been approved? If not, when is the anticipated approval date?
- What applicable permits and approvals have been obtained and/or are pending?
- Are there hearings still to be held?
- Is the environmental process waiting for an engineering and operational acceptability decision?
- Does the environmental document include a traffic analysis that can be used in the IJR analysis?

550.06 Report Organization and Appendices

Begin the IJR with an executive summary. Briefly describe the access point revision being submitted for a decision and why the revision is needed. Include a brief summary of the proposal.

The IJR must be assembled in the policy point order noted in 550.04(2).

Formatting for the IJR includes providing numbered tabs in the report for each policy point section and each appendix and numbering all pages, including references and appendices. A suggestion for page numbering is to number each individual section, such as “Policy Point 3, PP3–4” and “Appendix 2, A2–25.” This allows for changes without renumbering the entire report.

On the bottom of each page, place the revision date for each version of the IJR. As an individual page is updated, this revision date will help track the most current version of that page. Also, include the title of the report on the bottom of each page.

Use a three-ring binder for ease of page replacement. Do not use comb or spiral binding.

Appendix A is reserved for the Methods and Assumptions Document. Include meeting notes where subsequent decisions are made as additional appendices to the original signed document.

Additional appendices may include documents such as technical memorandums, memos, and traffic analysis operations output.

550.07 Updating an IJR

Recognizing that the time period between the approval of the IJR, the environmental documentation, and the construction contract commonly spans several years, the approved IJR will be reviewed and updated to identify changes that may have occurred during this time period. Submit a summary assessment to the HQ Design Office for evaluation to determine whether the IJR needs to be updated. The HQ Design Office will forward the assessment to FHWA if necessary. The assessment is a document summarizing the significant changes since it was approved. Contact the HQ Access and Hearings Section to coordinate this summary assessment.

550.08 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/

Project Type	Support Team	Policy Point								Concurrence	Approval
		1	2	3	4	5	6	7	8		
Interstate Routes											
New freeway-to-crossroad interchange in a Transportation Management Area[1]	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA DC
New partial interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA DC
New HOV direct access	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA DC
New freeway-to-freeway interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA DC
Revision to freeway-to-freeway interchange in a Transportation Management Area[1][2]	Yes	✓	✓	✓	✓	✓	✓	✓	✓	FHWA and HQ	FHWA
New freeway-to-crossroad interchange not in a Transportation Management Area[1]	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Revision to freeway-to-freeway interchange not in a Transportation Management Area[1][2]	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Revision to interchange[2][3]	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Transit flyer stop on main line	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Transit flyer stop on an on-ramp	No	✓		✓	✓					HQ	FHWA
Addition of entrance or exit ramps that complete basic movements at an existing interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Abandonment of a ramp[4]	Yes	✓	✓	✓	✓	✓	✓	✓	✓	HQ	FHWA
Locked gate	No	✓			[5]					HQ	FHWA
Access breaks that do not allow any type of access to main line or ramps	No	✓	✓		[5]					HQ	FHWA
Pedestrian structure	No	✓			[5]					HQ	FHWA
Construction/emergency access break	No	✓	✓	✓	✓					Region	FHWA

Notes:

All policy points must be addressed on all studies. The scale and scope of the project dictate the level of effort needed to address each policy point. Blank cells in the table above indicate that the policy point will need to be addressed briefly in the IJR. Consult the HQ Access and Hearings Section for direction.

[1] In Washington, designated Transportation Management Areas include Clark, King, Kitsap, Pierce, Snohomish, and Spokane counties.

[2] “Revision” includes changes in interchange configuration, even though the number of access points does not change. Changing from a cloverleaf to a directional interchange is an example of a “revision.”

[3] Revisions that might adversely affect the level of service of the through lanes. Examples include: doubling lanes for an on-ramp with double entry to the freeway; adding a loop ramp to an existing diamond interchange; and replacing a diamond ramp with a loop ramp. Revisions to the ramp terminal intersections may not require an IJR unless the traffic analysis shows an impact to the main line traffic.

[4] Unless it is a condition of the original approval.

[5] Update the right of way/limited access plan as necessary.

[6] As part of Policy Point 1, include a narrative stating that all other alternatives are not feasible.

Interstate Routes: IJR Content and Review Levels

Exhibit 550-1

Project Type	Support Team	Policy Point								Concurrence	Approval
		1	2	3	4	5	6	7	8		
Non-Interstate Routes											
New freeway-to-crossroad interchange on a predominately grade-separated corridor	Yes	✓	✓	✓	✓	✓	✓	✓	✓	Region	HQ
New freeway-to-freeway interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	Region	HQ
Revision to freeway-to-freeway interchange	Yes	✓	✓	✓	✓	✓	✓	✓	✓	Region	HQ
New freeway-to-crossroad interchange on a predominately at-grade corridor[5]	No	✓		✓	✓					Region	HQ
Revision to interchange[1]	No	✓		✓	✓					Region	HQ
Addition of entrance or exit ramps that complete basic movements at an existing interchange	No	✓		✓	✓					Region	HQ
Abandonment of a ramp[2]	No	✓		✓						Region	HQ
Transit flyer stop on main line	Yes	✓	✓	✓	✓	✓	✓	✓	✓	Region	HQ
Transit flyer stop on an on-ramp	No	✓		✓	✓					Region	HQ
Locked gate[4]	No	✓			[3]					Region	HQ
Pedestrian structure	No	✓			[3]					Region	HQ
Construction/emergency access break	No	✓	✓	✓						Region	HQ

Notes:

Policy points to be addressed will be determined by the IJR support team. The scale and scope of the project dictate the level of effort needed to address each policy point. Blank cells in the table above indicate that the policy point will need to be addressed briefly in the IJR as determined by the support team. Consult the HQ Access and Hearings Section for direction.

[1] Revisions that might adversely affect the level of service of the through lanes. Examples include: doubling lanes for an on-ramp with double entry to the freeway; adding a loop ramp to an existing diamond interchange; and replacing a diamond ramp with a loop ramp.

[2] Unless it is a condition of the original approval.

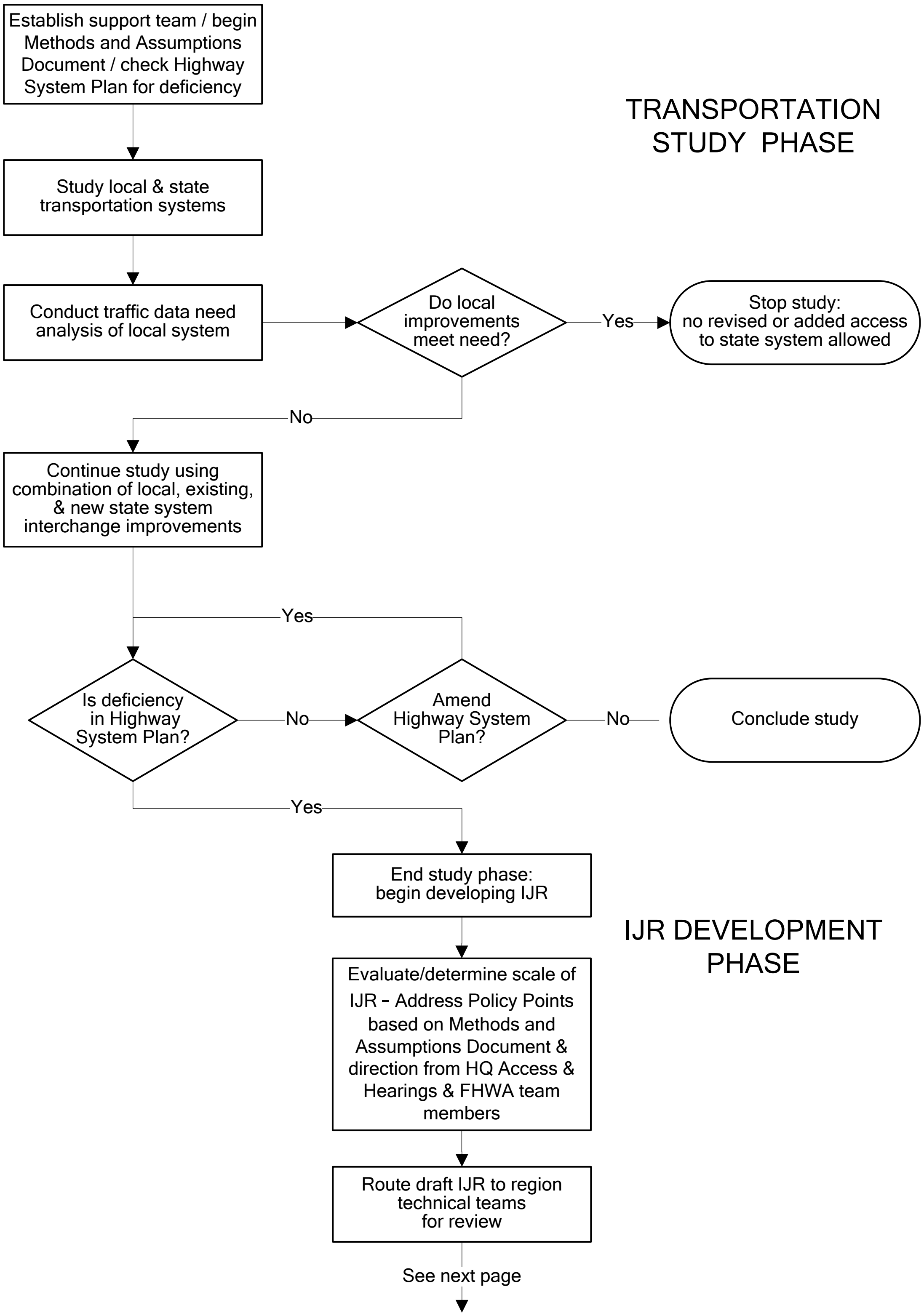
[3] Update the right of way/limited access plan as necessary.

[4] As part of Policy Point 1, include a narrative stating that all other alternatives are not feasible.

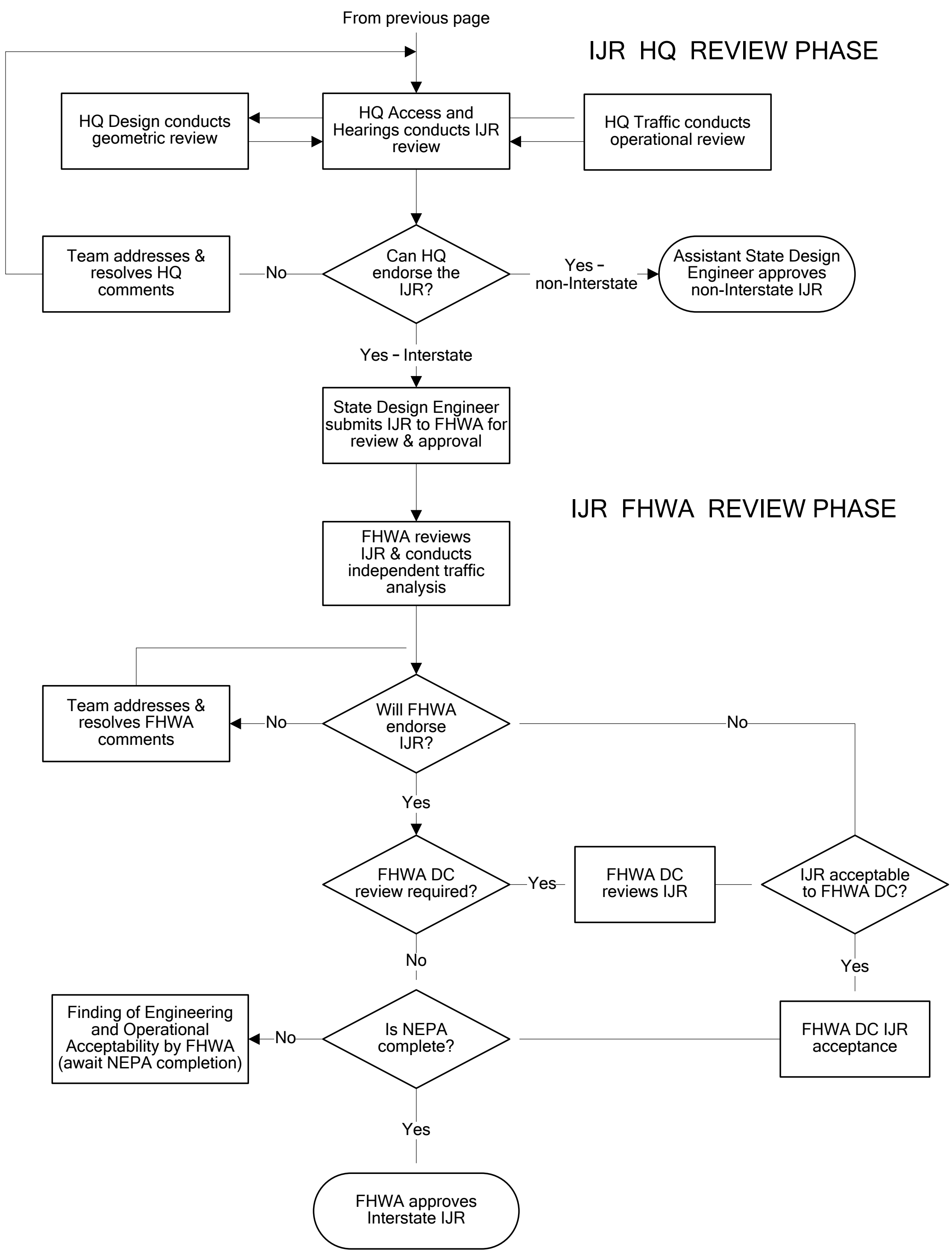
(5) Example: Revising an existing at-grade intersection into an access controlled grade-separated interchange.

Non-Interstate Routes: IJR Content and Review Levels

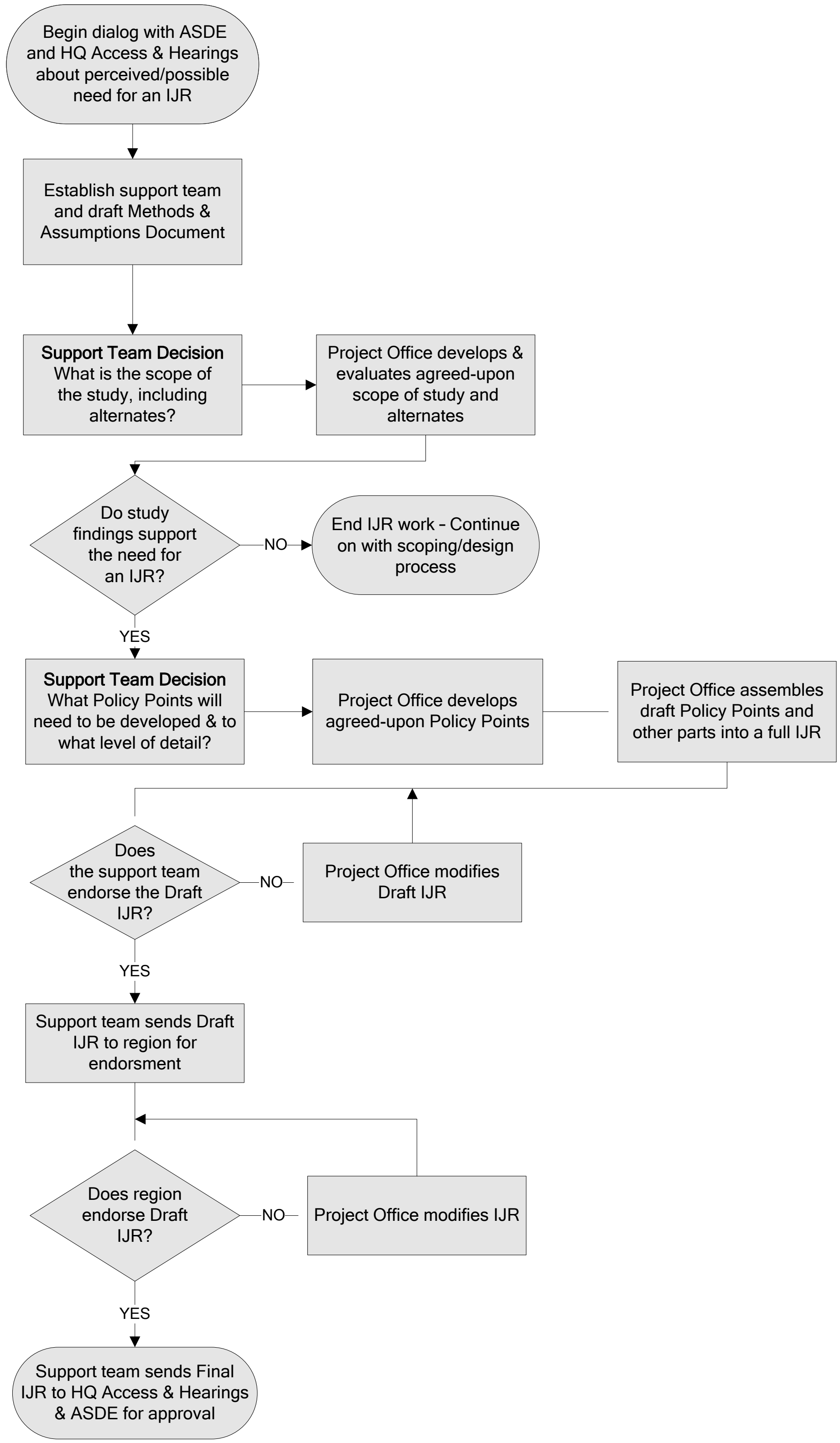
Exhibit 550-2



Interstate IJR: Process Flow Chart
Exhibit 550-3



Interstate IJR: Process Flow Chart
Exhibit 550-3 (continued)



Non-Interstate IJR: Process Flow Chart
Exhibit 550-4

Interchange Justification Report

"Project Title"
"MP to MP"

This ***Interchange Justification Report*** has been prepared under my direct supervision, in accordance with Chapter 18.43 RCW and appropriate Washington State Department of Transportation manuals.

☐ **IJR Engineer of Record**	**By:**______________________ **P.E.** Project Engineer **Date:**______________________**2010**
☐ **Traffic Analysis Engineer**	**By:**______________________ **P.E.** Traffic Analysis Engineer **Date:**______________________**2010**
☐ **Concurrence** **Region Traffic Engineer**	**By:**______________________ **P.E.** **Date:**______________________**2010**
☐ **Concurrence** **Project Development Engineer**	**By:**______________________ **P.E.** **Date:**______________________**2010**
☐ **WSDOT Approval** **Assistant State Design Engineer**	**By:**______________________ **P.E.** **Date:**______________________**2010**
☐ **FHWA Approval** **FHWA Safety and Design Engineer**	**By:**______________________ **P.E.** **Date:**______________________**2010**

IJR: Stamped Cover Sheet Example
Exhibit 550-5

620.01 General

Detailed criteria and methods that govern pavement design are in the Washington State Department of Transportation (WSDOT) *Pavement Policy*:
www.wsdot.wa.gov/biz/mats/pavement/WSDOT_Pavement_Policy.pdf

<u>The pavement design for all Design-Build project RFPs will be conducted by the State Materials Lab, Pavement Division.</u>

620.02 Estimating Tables

Exhibits 620-1 through 620-5h are to be used when detailed estimates are required. They are for pavement sections, shoulder sections, stockpiles, and asphalt distribution. Prime coats and fog seal are in Exhibit 620-2a.

Type of Material	Unit Dry Weight: Truck Measure lb/cy	Truck Measure T/cy	Compacted on Roadway lb/cy	Compacted on Roadway T/cy
Ballast	3,100	1.55	3,900	1.95
Crushed Surfacing Top Course	2,850	1.43	3,700	1.85
Crushed Surfacing Base Course	2,950	1.48	3,700	1.85
Screened Gravel Surfacing			3,700	1.85
**Gravel Base			3,400 – 3,800	1.70 – 1.90
Permeable Ballast			2,800	1.40
Maintenance Sand ⅜" – 0	2,900	1.45		
Mineral Aggregate 2" – 1"	2,600	1.30		
Mineral Aggregate 1¾" – ¾"	2,600	1.30		
Mineral Aggregate 1½" – ¾"	2,550	1.28		
Mineral Aggregate 1" – ¾"	2,500	1.25		
Mineral Aggregate ¾" – ½"	2,400	1.20		
Mineral Aggregate 1¼" – ¼'"	2,600	1.30		
Mineral Aggregate 1" – ¼"	2,600	1.30		
Mineral Aggregate ⅞" – ¼"	2,550	1.28		
Mineral Aggregate ¾" – ¼"	2,500	1.25		
Mineral Aggregate ⅝" – ¼"	2,650	1.33		
Mineral Aggregate ½" – ¼" or #4	2,600	1.30		
Mineral Aggregate ¼" or #4 – 0	2,900	1.45		
Concrete Aggr. No. 2 (1 ¼" - #4)	3,000	1.50		
Concrete Sand (Fine Aggregate)	2,900	1.45		
Crushed Cover Stone	2,850	1.43		
** 3,700 lb/cy (1.85 tons/cy) is recommended as the most suitable factor; however, if the grading approaches the coarseness of ballast, the factor would approach 3,800 lb/cy (1.90 tons/cy), and if the grading contains more than 45% sand, the factor would decrease, approaching 3,400 lb/cy (1.70 tons/cy) for material that is essentially all sand.				

Notes:

- Weights shown are dry weights and corrections are required for water contents.
- The tabulated weights for the materials are reasonably close; however, apply corrections in the following order:

For specific gravity: $\text{Wt.} = \dfrac{\text{tabular wt. x specific gravity on surface report}}{2.65}$

For water content: Wt. = tabular wt. x (1 + free water % in decimals)

- If material is to be stockpiled, increase required quantities by 10% to allow for waste.
- Direct attention to the inclusion of crushed surfacing top course material that may be required for keystone when estimating quantities for projects having ballast course.

Estimating: Miscellaneous Tables

Exhibit 620-1

(d) **Temporary Silt Fence**

Temporary silt fences may also be used in ditch or swale applications. If the area contributing runoff to the fence exceeds the value determined from Exhibit 630-3, hydraulic overload will occur. The ditch or swale storage length and width are defined in Exhibit 630-9. The assumptions used in the development of Exhibit 630-3 are the same as those used for Exhibit 630-2 in terms of the design storm and ground conditions.

As an example, if a site has a 13-foot-wide ditch with an average slope of 2%, the fence can be located such that 7800 ft^2 of area drain to it. If it appears that the area draining to the fence will be larger than the allowable, it may be possible to divide the contributing area into smaller areas and add a silt fence for each smaller area as shown in Exhibit 630-10.

The minimum storage length for the ditch behind each silt fence must be maintained. If this is not possible, it may be necessary to use an alternate erosion control structure, as described in the *Highway Runoff Manual,* or develop a special silt fence design.

Exhibit 630-3 was developed with the assumption that water will be able to pond to a depth of at least 2 feet behind the fence. If this is not the case (the ditch or swale depth is less than 2 feet), the table cannot be used. Furthermore, the ditch depth must be greater than the height of the silt fence at its lowest point within the ditch. Otherwise, there will not be enough storage available behind the fence and water will circumvent the fence by flowing around it.

(e) **Locating a Silt Fence**

Locate silt fences on contour as much as possible. At the ends of the fence, turn it up hill such that it captures the runoff water and prevents water from flowing around the end of the fence. This is illustrated in Exhibit 630-11.

Silt fences are designed to capture up to a 2-foot depth of water behind the fence. Therefore, the ground line at the ends of the fence must be at least 2 feet above the ground line at the lowest part of the fence. This 2-foot requirement applies to ditches as well as to general slope erosion control.

If the fence must cross contours (except for the ends of the fence), use gravel check dams placed perpendicular to the back of the fence to minimize concentrated flow and erosion along the back of the fence (see Exhibit 630-12).

- The gravel check dams are approximately 1 foot high at the back of the fence and are continued perpendicular to the fence at the same elevation until the top of the dam intercepts the ground surface behind the fence.
- Locate the gravel check dams every 10 feet along the fence.
- In general, the slope of the fence line is not to be steeper than 3H:1V.
- For the gravel check dams, use Crushed Surfacing Base Course, Gravel Backfill for Walls, or Permeable Ballast (see the *Standard Specifications*).

If the silt fence application is considered critical (such as when the fence is placed immediately adjacent to environmentally sensitive areas like streams, lakes, or wetlands), place a second silt fence below the first silt fence to capture any silt that passes through the first fence and/or place straw bales behind the silt fence. Locate silt fences at least 7 feet from an environmentally sensitive area.

Where this is impossible, and a silt fence must be used, a special design may be necessary.

Temporary silt fences are sometimes used to completely encircle underground drainage inlets or other similar features to prevent silt from entering the drainage system. This is acceptable, but the silt fence functions primarily as a barrier, and not as a ponding or filtering mechanism, unless the drainage inlet is in a depression that is large enough to allow water to pond behind the silt fence.

- If the drainage inlet and silt fence are not in a large enough depression, silt-laden water will simply be directed around the fence and must be captured by another fence or sedimentation pond downslope.
- If the depression is deep, locate the silt fence no more than 2 feet below the top of the depression to prevent overtopping. A site-specific design may be needed if the silt fence is located deeper than 2 feet within the depression.

It may be necessary to relocate silt fences during the course of a construction project as cuts and fills are built or as disturbed areas change. An erosion control/silt fence plan that accounts for the anticipated construction stages (and eventual removal) should be developed. Do not assume that one silt fence location can routinely be used for the entire life of the contract. Periodically check the locations in the field during the construction project, and field-adjust the silt fence locations as necessary to ensure the silt fences function as intended.

(7) Standard Specification Geotextile Application Identification in the Contract Plans

Identify the geotextile in the contract plan detail in a way that ties it to the appropriate application in the *Standard Specifications*. For example:

- If a geotextile is to be used to line an underground trench drain 3 feet deep and the native soil has less than 15% passing the #200 sieve, identify the geotextile on the plan sheet as “Construction Geotextile for Underground Drainage, Low Survivability, Class A.”
- If the geotextile is to be placed beneath riprap on a slope without a cushion layer between the geotextile and the riprap, and the native soil contains 35% passing the #200 sieve, identify the geotextile on the plan sheet as “Construction Geotextile for Permanent Erosion Control, High Survivability, Class B.”
- If the geotextile is to be placed between the roadway base course and a moist silt subgrade with a resilient modulus of 6,500 psi, and the roadway is planned to be constructed during the dry summer and early fall months, identify the geotextile on the plan sheet as “Construction Geotextile for Separation.”

(8) Site-Specific Designs (All Applications)

A site-specific design is required:

- For all reinforcement applications.
- For applications not covered by the *Standard Specifications.*

Consider a site-specific design for:

- High-risk applications.
- Exceptionally large geotextile projects: if the geotextile quantity in a single application is over 35,000 yd^2 or over 85,000 yd^2 for the separation application.
- Severe or unusual soil or groundwater conditions.

Chapter 710 Site Data for Structures

710.01 General

The Washington State Department of Transportation (WSDOT) Headquarters (HQ) Bridge and Structures Office provides structural design services to the regions. This chapter describes the information required by the HQ Bridge and Structures Office to perform this function.

710.02 References

Bridge Design Manual, M 23-50, WSDOT

Plans Preparation Manual, M 22-31, WSDOT

710.03 Required Data for All Structures

Bridge site data provides information about the type of crossing, topography, type of structure, and potential future construction. Submit bridge site data to the HQ Bridge and Structures Office. Provide a cover memo that gives general information on the project, describes the attachments, and transmits the forms and data included in the submittal. Submit site data as a CAD file, supplemental drawings, and a report. (See Exhibit 710-2 for items to include in a bridge site data submittal). Direct any questions relating to the preparation of bridge site data to the HQ Bridge and Structures Office. The *Bridge Design Manual* shows examples of required WSDOT forms.

(1) 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 must be analyzed. Contact the HQ Geotechnical Services Division and the HQ Hydraulics Office to determine whether a scour analysis is required.

(2) CAD Files and Supplemental Drawings

The HQ Bridge and Structures Office uses the microGDS Computer-Aided Drafting (CAD) system. CAD files prepared for use as bridge site data will be accepted in standard DGN, DXF, or DWG format.

Prepare plan, profile, and section drawings for all structures. Include copies of the CAD site data and supplemental drawings in the reduced plan sheet format with the submittal.

Use a complete and separate CAD file for each structure. (See the *Plans Preparation Manual* for information regarding drawing levels and use of the Bridge and Structures format.) The *Bridge Design Manual* contains examples of completed bridge preliminary plans. These plans show examples of the line styles and drawing format for site data in CAD.

Bridge site data is used to prepare the bridge layout plan, which is to be used in the contract plans. Include the following information in the CAD files or in the supplemental drawings:

(a) **Plan**

- The drawing scales shown are for the full-sized contract plan format and are a guide only. Consider the width and general alignment of the structure when selecting the scale. For structures on curved alignments or where the bridge width is nearly equal to or greater than the bridge length, consult the HQ Bridge and Structures Office for an appropriate plan scale.

Length of Structure	Scale
20 ft to 100 ft	1″=10′
100 ft to 500 ft	1″=20′
500 ft to 800 ft	1″=30′
800 ft to 1,100 ft	1″=40′
More than 1,100 ft	1″=50′

Bridge Site Plan Scales

Exhibit 710-1

- Vertical and horizontal datum control (see Chapters 400 and 410).
- Contours of the existing ground surface. Use intervals of 1, 2, 5, or 10 feet, depending on terrain and plan scale. The typical contour interval is 2 feet. Use 1-foot intervals for flat terrain. Use 5-foot or 10-foot intervals for steep terrain or small scales. Show contours beneath an existing or proposed structure and beneath the water surface of any waterway.
- Alignment of the proposed highway and traffic channelization in the vicinity.
- Location by section, township, and range.
- Type, size, and location of all existing or proposed sewers, telephone and power lines, water lines, gas lines, traffic barriers, culverts, bridges, buildings, and walls.
- Location of right of way lines and easement lines.
- Distance and direction to nearest towns or interchanges along the main alignment in each direction.
- Location of all roads, streets, and detours.
- Stage construction plan and alignment.
- Type, size, and location of all existing and proposed sign structures, light standards, and associated conduits and junction boxes. Provide proposed signing and lighting items when the information becomes available.
- Location of existing and proposed drainage.
- Horizontal curve data. Include coordinates for all control points.

(b) **Profile**

- Profile view showing the grade line of the proposed or existing alignment and the existing ground line along the alignment line.

- Vertical curve data.
- Superelevation transition diagram.

(c) **Section**

- Roadway sections on the bridge and at bridge approaches. Indicate the lane and shoulder widths, cross slopes and side slopes, ditch dimensions, and traffic barrier requirements.

- Stage construction roadway geometrics with the minimum lane and roadway widths specified.

(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

(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.

710.04 Additional Data for Waterway Crossings

Coordinate with the HQ Hydraulics Section and supplement the bridge site data for all waterway crossings with the DOT Form 235-001, Bridge Site Data for Stream Crossings, and the following:

- Show riprap or other slope protection requirements at the bridge site (type, plan limits, and cross section) as determined by the HQ Hydraulics Section.
- Show a profile of the waterway. The extent will be determined by the HQ Hydraulics Section.
- Show cross sections of the waterway. 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 Chapter 240). Generally, ocean tide-influenced waterways and waterways used for commercial navigation require a Coast Guard permit. These structures require the following additional information:

- Names and addresses of the landowners adjacent to the bridge site.
- Quantity of new embankment material within the floodway. This quantity denotes, in cubic yards, the material below and the material above normal high water.

Some waterways may qualify for an exemption from Coast Guard permit requirements if certain conditions are met (see the *Bridge Design Manual*). If the waterway crossing appears to satisfy these conditions, then submit a statement explaining why this project is exempt from a Coast Guard permit. Attach this exemption statement to the Environmental Classification Summary prepared for the project and submit it to the HQ Design Office for processing to the Federal Highway Administration (FHWA).

The region is responsible for coordination with the HQ Bridge and Structures Office, U.S. Army Corps of Engineers, and U.S. Coast Guard for waterways that may qualify for a permit exemption. The HQ Bridge and Structures Office is responsible for coordination with the U.S. Coast Guard for waterways that require a permit.

710.05 Additional Data for Grade Separations

(1) Highway-Railroad Separation

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

(a) **Plan**

- Alignment of all existing and proposed railroad tracks.
- Center-to-center spacing of all tracks.
- Angle, station, and coordinates of all intersections between the highway alignment and each track.
- Location of railroad right of way lines.
- Horizontal curve data. Include coordinates for all circular and spiral curve control points.

(b) **Profile**

- For proposed railroad tracks: profile, vertical curve, and superelevation data for each track.
- For existing railroad tracks: elevations accurate to 0.1 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.

(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.

(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.

(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 Services Division 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 Services Division, evaluates bridge-widening projects involving liquefiable soils and recommends appropriate liquefaction mitigation. The following guidance is intended to assist designers in making project decisions that balance project risks with project and program budget realities.

(a) **Design Decision Considerations**

The following design decision guidance is generally in order of the complexity of project decision making, starting with the most straightforward through the most complex.

1. New bridges will be designed to current seismic and liquefaction standards.
2. Bridge widening that does not require new substructure (a new column) does not require consideration of liquefaction mitigation.

3. Widening that involves any new substructure will require a settlement and lateral loading analysis by the HQ Bridge and Structures Office in collaboration with the HQ Geotechnical Services Division. Each analysis will be unique to the conditions at that particular bridge site.

   a. If a bridge has less than 15 years of its service life remaining, no liquefaction mitigation is necessary according to FHWA guidelines.

   b. If the HQ Geotechnical Services Division analysis demonstrates that the differential settlement induced by liquefaction between the existing bridge and the widened portion will not create forces great enough to cause collapse of the existing bridge, and if lateral loading and movement caused by the liquefaction is minimal, liquefaction mitigation may not be necessary. The decision must be endorsed by the State Geotechnical Engineer, the State Bridge Engineer and the Regional Administrator. The decision and rationale are to be included in the Design Documentation Package.

   c. If the HQ Geotechnical Services Division analysis demonstrates that the differential settlement induced by liquefaction or the lateral loading and movement will be substantial and these movements will result in the collapse of the existing and widened portion of the bridge, additional analysis and documentation are necessary for the project to proceed. A preliminary design and estimate of the mitigation necessary to prevent collapse needs to be performed. Consider alternative designs that eliminate or reduce the need for the widening.

(b) **Deferring Liquefaction Mitigation**

1. **Consideration of Deferment**

   If an alternative design concept is not feasible given the constraints of the project or program, consideration may be given to defer the liquefaction mitigation. Project-related structural retrofits that are deferred because of scope-related issues are to be considered for implementation through the WSDOT seismic retrofit program. The operating characteristics of the roadway and overall estimated cost of the liquefaction mitigation is typically considered in making that decision.

2. **Deferment Requires Approval**

   A decision to defer the mitigation to the seismic retrofit program is made by the WSDOT Chief Engineer after reviewing and considering the alternatives. The decision is to be included in the Design Documentation Package. A memo from the Chief Engineer will be provided to the structural designer of record documenting the agency's decision to defer the mitigation work to the WSDOT seismic retrofit program. A copy of the memo is to be included in the Design Documentation Package (DDP) and the contract general notes.

(7) Pedestrian and Bicycle Facilities

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

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

(1) Federal/State Laws and Codes

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

(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

(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 areas.

For 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. Deviations may be considered, but they require approval as prescribed in Chapter 300. For deviations from the above, deviation approval is not required where sidewalk exists in front of the wall or in other situations where the wall face is otherwise inaccessible to traffic.

(2) Investigation of Soils

All retaining wall and reinforced slope structures require an investigation of the underlying soil/rock that supports the structure. Chapter 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.

(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.

(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 Services Division and HQ Hydraulics Office to determine whether a scour analysis is required.

(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 Services Division 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 Services Division.

(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).

(6) Constructibility

Consider the potential effect that site constraints might have on the constructibility of the specific wall/slope. Constraints to be considered include but are not limited to site geometry, access, time required to construct the wall, environmental issues, and impact on traffic flow and other construction activities.

(7) Coordination With Other Design Elements

(a) Other Design Elements

Retaining wall and slope designs 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 Services Division for geosynthetic walls/slopes and soil nail walls) for assistance regarding this issue.

(b) **Fall Protection**

Department of Labor and Industries regulations require that, when employees are exposed to the possibility of falling from a location 10 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 296-155-24510 for walls that create a potential for a fall of 10 feet or more. During construction or other temporary or emergency condition, fall protection will follow WAC 296-155-505. 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 Chapters 560, Fencing, and 1510, Pedestrian Design Considerations.

For maintenance of a tall wall's surface, consider harness tie-offs if other protective means are not provided.

For maintenance of the area at the top of a tall wall, a fall restraint system is required when all of the following conditions will exist:

- The wall is on a cut slope.
- A possible fall will be of 10 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 of ½-inch-diameter steel wire rope.
- Brown vinyl-coated chain link fencing.
- Steel pipe railing with 1½-inch nominal outside diameter pipe as posts and top and intermediate rails.
- Concrete as an extension of the height of the retaining wall.

A fall restraint system 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 9 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.)

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.

(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.

(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.

Chapter 1010 Work Zone Safety and Mobility

1010.01 General

Addressing work zone impacts 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 are identified and addressed during the project design and environmental review. The cost to address work zone impacts can account for up to 30% of project costs. It is not acceptable to the Washington State Department of Transportation (WSDOT) to allow a project to move forward to advertisement without appropriately addressing these impacts. Planners, designers, construction engineers, maintenance personnel, and others all play a role in developing a comprehensive work zone design.

This chapter provides the designer with guidance to develop comprehensive work zone strategies and plans to address a project's safety, mobility, and constructibility issues, which must be accomplished before the contract is advertised. (See the WSDOT *Environmental Procedures Manual* for guidance on addressing work zone impacts in environmental documents.) Increased traffic volumes on the highways and the need for more work zones increases the need for a more comprehensive design of the work zone for highway workers and road users. A systematic process for addressing work zone impacts is required by state and federal law.

1010.02 References

(1) Federal/State Laws and Codes

23 CFR 630 Subpart J

Americans with Disabilities Act of 1990 (ADA) (28 Code of Federal Regulations [CFR] Part 36, Appendix A, as revised July 1, 1994)

"Final Rule on Work Zone Safety and Mobility," Federal Highway Administration (FHWA), Effective Date October 12, 2007
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)

(2) Design Guidance

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

Accessible Rights-of-Way: A Design Guide, U.S. Access Board, Washington DC
www.access-board.gov/prowac/alterations/guide.htm

Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines (ADAAG), July 23, 2004, U.S. Access Board
www.wbdg.org/ccb/ASTAND/ada_aba.pdf

Executive Order E 1001, Work Zone Safety and Mobility
http://wwwi.wsdot.wa.gov/docs/OperatingRulesProcedures/1001.pdf

Executive Order E 1033, WSDOT Employee Safety
http://wwwi.wsdot.wa.gov/docs/OperatingRulesProcedures/1033.pdf

Plans Preparation Manual, M 22-31, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-10, WSDOT

Traffic Manual, M 51-02, WSDOT

Work Zone Traffic Control Guidelines, M 54-44, WSDOT

(3) Supporting Information

Construction Manual, M 41-01, WSDOT

"Crashworthy Work Zone Traffic Control Devices," Report 553, NCHRP, 2006

Environmental Procedures Manual, M 31-11, WSDOT

Highway Capacity Manual, 2000, 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, 2006

Work Zone & Traffic Analysis, FHWA
www.ops.fhwa.dot.gov/wz/traffic_analysis.htm

Work Zone Operations Best Practices Guidebook, FHWA, 2000
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/

1010.03 Definitions

channelizing devices Traffic safety cones, drums, tubular markers, vertical panels, and barricades used to gradually guide traffic through a work zone of separate traffic from a work area.

Positive Protection Device A crashworthy device that, depending on vehicle dynamics, may prevent intrusion into or redirect a vehicle away from a work area.

traffic control devices Signs, signals, channelizing devices, pavement markings, and other devices placed on, over, or adjacent to a street or highway to regulate, warn, or guide traffic.

transportation management plan (TMP) A set of ,traffic control plans, public information strategies, and transportation operation plans for managing the work zone impacts of a project. A TMP is required for all projects to address work zone safety and mobility impacts.

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 in the traveled way, adjacent to the traveled way, or within the highway's right of way that creates safety and mobility concerns.

work zone traffic control The planning, design, and preparation of contract documents for the modification of traffic patterns during construction.

traveling public Motorists, motorcyclists, bicyclists, pedestrians, and pedestrians with disabilities.

1010.04 Work Zone Safety and Mobility

In September 2004, the Federal Highway Administration (FHWA) published updates to the work zone regulations in 23 CFR 630 Subpart J, Work Zone Safety and Mobility. The updated regulation is referred to as "the Final Rule" on work zone safety and mobility and applies to all state and local governments that receive federal-aid highway funding. At the heart of the Rule is a requirement for agencies to develop an agency-level work zone safety and mobility policy. The policy is intended to support systematic consideration and management of work zone impacts across all stages of project development. Also required by the Rule is the development of processes and procedures to sustain the policy and transportation management plans (TMPs) for project-level procedures to manage work zone impacts.

WSDOT policy and the guidance to carry out the policy are outlined in Executive Order E 1001, Work Zone Safety and Mobility. 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 need to be familiar with this document. The policy defines how WSDOT programs address work zone safety and mobility issues during project planning, design, and construction, and during highway maintenance.

1010.05 Transportation Management Plans and Significant Projects

(1) Transportation Management Plan (TMP)

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 a key element in addressing all work zone safety and mobility impacts. The TMP development begins in the scoping phase of a project by gathering project information, traffic data, impacts assessments, strategies, and mitigation and design solutions.

The three major components of a TMP are described below.

(a) **Temporary Traffic Control (TTC)**

- Control Strategies: Could include staged construction, full road closures, lane shifts or closures, night work, or one-lane two-way operations (flagging and or pilot car).
- Traffic Control Devices: Temporary signing, channelizing devices (cones, drums), changeable message signs, arrow panels, temporary signals, and temporary pavement markings.
- Project Coordination, Contracting Strategies, and Innovative Construction Strategies: A+B bidding, incentives/disincentives, and precast members or rapid cure materials.

These strategies are to be included in the Plans, Specifications, and Estimates (PS&E) as traffic control plans (TCPs) and contract provisions.

(b) **Transportation Operations (TO)**

- Demand Management Strategies: Transit service improvements, transit incentives, and park & ride promotion.
- Corridor/Network Management (traffic operations) Strategies: Signal timing/coordination improvements, temporary signals, bus pullouts, reversible lanes, and truck/heavy-vehicle restrictions.
- Work Zone Safety Management Strategies: Speed limit reductions, barrier and attenuators, and automated flagger assistance devices.
- Traffic/Incident Management and Enforcement Strategies: Work Zone Intelligent Transportation Systems (ITS), Washington State Patrol, tow service, WSDOT Incident Management vehicle(s), and traffic screens.

Some of these strategies may be included in the PS&E, but could also be WSDOT-managed elements outside the contract.

(c) **Public Information (PI)**

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

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.

(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 significant projects.

It is possible to request an exception from FHWA for Interstate projects if sufficient justification is present to demonstrate that a project will not have sustained work zone impacts.

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. Projects with significant work zone impacts that do not meet the federal definition of a significant project still need to be addressed using the same impacts assessment, strategy, and mitigation techniques. A full or formal TMP would not be required, but the same process would be followed to properly address the impacts as discussed below.

Project work zone-related impacts must be addressed and mitigated to an acceptable level. An acceptable level will be defined by the region based on an impact assessment and the adverse effects on safety and mobility. Examples of this may be:

- Traffic delay beyond a local accepted level—possibly in the range of 15 to 20 minutes, but could vary based on local expectations. (Traffic impacts that extend beyond the local/project area also need to be addressed.)
- Safety or access impacts to a school, hospital, emergency services, or community that exceed local expectations based on public input.
- Economic impacts due to traffic delay or restricted access beyond normal local expectations.
- Seasonal impacts that affect recreation or business due to work zone impacts.

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

Significant projects often 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/

Note: Significant projects require a complete TMP to fully address safety and mobility impacts.

Significant TMP project components are:

- **Traffic Control Plans** (TCPs): Required (includes appropriate contract specifications)
- **Transportation Operations Plans** (TOPs): Required
- **Public Information Plans** (PIPs): Required

If a project is not identified as significant, the TMP requirement and level of development is determined by the project safety and mobility impacts assessment. While TCPs are always required for all projects, TO and PI strategies should be considered and developed as needed to address project impacts. Region construction web pages provide a basic level of PI for every project.

TO and PI components are often needed to fully implement the TCPs or contract provisions due to work zone safety and mobility impacts not otherwise resolved through design strategies incorporated in the contract plans.

Non-Significant Project Components are:

- TCPs: Required (includes appropriate contract specifications)
- TOPs: Recommended as needed to address impacts
- PIPs: Recommended as needed to address impacts

(3) TMP Process

It is very important to continue the development of the TMP throughout the project development process. Not all work zone impacts will be addressed within the specific work zone elements of the contract plans. This is why it is critical to consider work zone impacts during the ongoing design of the actual project features, materials selection, working day considerations, overbuilding, temporary widening, phasing, structures, and so on. Many work zone impacts will need to be addressed by design solutions that resolve the impacts within staging plans, structure plans, and various construction plans and details. Some work zone impacts, especially those that are related to time duration may be resolved through innovative bidding and contract administration. Ongoing communication with the designer(s) of project features that will have work zone impacts is critical to ensure design solutions and mitigation measures are included within the project and TMP.

Use the TMP Checklist in Exhibit 1010-3 to help identify issues and strategies for the above-three TMP components. Include the completed checklist in the Project File. For significant projects, develop this checklist and the supporting plans, data, impacts assessments, strategies, and endorsements into a formal TMP document that will become part of the project management plan. The project management plan becomes part of the Project File.

1010.06 Work Zone TMP Strategy Development

(1) Work Zone Key Considerations

The following list provides a quick review of the elements contained within or related to this chapter. These elements are part of WSDOT's work zone policy and are required or are key to the successful development of work zone design decisions. Federal and state regulations set the level of compliance for work zones. This list is intended to alert the designer that these items are not optional and must be addressed. The elements summarized below have more detailed information within this chapter or are contained within related manuals and documents such as the MUTCD, Revised Codes of Washington, and Washington Administrative Codes.

- 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.
- Utilize the Work Zone TMP Checklist/TMP document required for significant projects.
- Hold a Work Zone Design Strategy Conference early in the design process.
- Emphasize flagger safety.
- Address work zone mobility through a capacity analysis.
- Determine work zone impacts through an impact assessment process.
- Integrate project constructibility into the work zone design strategy.
- Attend required work zone training.
- Address state of Washington 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 (including ADA requirements) and bicycle traffic.
- Consider maintenance of existing transit stops.
- Consider school zone impacts.
- Consider risk management and tort liability exposure.
- Consider work efficiency and cost containment.
- Approach the work zone design from the road user's perspective.
- Incorporate worker and other roadway user needs in your work zone designs.
- Account for all needed work areas and operations.
- Address work vehicle ingress and egress to each work area.

(2) Impacts Assessment

One of the most important tasks in developing TMP strategies is assessing all project impacts to mobility and safety. Impacts that are not identified and addressed in the TMP during design will undoubtedly become issues during the construction phase of the project. Addressing these impacts later during construction can significantly affect a project's costs and schedule, as well as increase traffic delays and safety concerns. The construction project may be well underway by the time these unidentified impacts are discovered, and the options to address them may be limited. A complete impacts assessment allows the project designer to develop more effective TMPs that should only need minor modifications to address construction issues.

An impacts assessment allows you to:

- Manage identified impacts within the structure of the TMP, even though the project may not be identified as significant.
- Develop TTC, TO, and PI strategies to address identified impacts as needed to effectively manage the project.
- Resolve potential work zone impacts within the project design features as design decisions are made. Informed decisions that consider work zone impacts during bridge type selection, materials selection, advertisement dates, and more have the potential to resolve work zone impacts before they happen.
- Engage construction PEs at the design level for input and decisions on the management of impact issues. The TMP needs to reflect those decisions.
- Consider innovative mitigation strategies such as staged closures or ITS solutions to solve an otherwise difficult impact that would be hard to manage during construction.

Impacts assessment starts in the scoping phase of a project and is an ongoing process through construction completion. During the design process, design details can produce a need for traffic control strategy revisions. Changes in design, such as types of materials (HMA vs. PCCP) or bridge footings types (shafts vs. spread) can have a big effect on the traffic control strategy. A designer needs to possess a clear understanding of all the features and how they will be constructed to determine the impact. Work closely with the roadway and bridge designers and construction personnel when assessing the impacts.

Once the designer knows what will be constructed and how, including the required work methods, equipment, materials, and duration to complete the work, an accurate assessment can be made. With this information, work areas can be determined. The work area and the duration of time it will be needed define the impact. If the work area requires a lane closure during actual work operations only on a low-volume highway, the impacts are minor. The strategy may be a typical single-lane closure during nonpeak traffic hours to perform the work. If the work area requires a lane closure until the work is completed over several weeks on a high-volume highway, the impact can be significant. The strategy may be to reduce the lane widths to maintain the same number of lanes and provide barrier to protect the work area. If traffic will be shifted onto the shoulder, the pavement depth on the shoulder needs to be determined. This strategy is much more complex and requires project-specific traffic control plans with temporary channelization and possible pavement reconstruction. If a project has many work areas, consider combining the work areas, if possible, or constructing the project in stages.

Not all impacts need to be addressed with traffic restrictions, closures, or other traffic control methods. Design changes, materials selection, construction methods, or construction sequence may reduce or eliminate some impacts. This is why the traffic control designer needs to understand design and construction issues and work closely with project designers and the Construction Office to develop the best overall traffic control strategy.

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

(a) **Impacts to Manage During Design**

The following impacts should be managed during the design of a project:

1. Bridge construction sequence or falsework openings need to match the TCP staging or temporary channelization plans. The bridge falsework opening detail shown in the plans must be consistent with how the traffic will be maintained through the opening. Coordination with the HQ Bridge and Structures Office is essential. Maintain the legal height of 16 feet 6 inches as the minimum falsework opening whenever possible; anything less than this must consider overheight vehicle impacts and possible additional signing needs. Refer to Chapter 720 for additional requirements.
2. Can the existing signals and lighting be maintained during the construction phases or do temporary connections need to be considered or temporary systems installed? Existing lighting at the exit and entrance ramps must be maintained at all times during construction and are often one of the first items of work that the contractor disables.
3. Permanent traffic loop installation (such as advance loops, turn pockets, and stop bars): Consider access to these locations and what types of traffic control will be needed.
4. Temporary traffic loops and signal detection: Consider the detection needs in relation to the work operation and duration (such as temporary loops, video, radar, and timed system).
5. Pavement marking installations (crosswalks, arrows, and so on).
6. Temporary pavement marking needs: What type of marking is most appropriate for the work operation and the pavement surface? When removed, how are existing markings going to impact the roadway surface? Consider how to best minimize for "ghost stripe" potential.
7. Utility relocation needs: How will existing utilities conflict with temporary needs?
8. Temporary impact attenuator installation needs: Determine the appropriate type for the location proposed and the specific needs or materials for the installation pad.
9. Lane shifts onto existing shoulders:
    - Is the depth of the existing shoulder adequate to carry the extra traffic?
    - Are there any existing catch basins or junction boxes located in the shoulder that cannot accept traffic loads over them? Are there existing shoulder rumble strips? Existing rumble strips must be addressed.
    - What is the existing sideslope rate? If steeper than 4H:1V, does it need mitigation? Are there existing roadside objects that, when the roadway is shifted, are now within the clear zone limits?

- Shifting of more than one lane in a direction is only allowed with temporary pavement markings. Shifting lanes by using channelizing devices is not allowed due to the high probability that devices used to separate the traffic will be displaced.
- Existing drainage features: Will they be adversely impacted by temporary lane shifts or by anticipated work operations?
- Signal head alignment: When the lane is shifted approaching the intersection, is the signal head alignment within appropriate limits?

10. Roundabout construction at an existing intersection requires site-specific staging plans. Roundabouts create many unique construction challenges and each roundabout usually has very specific design features. There are no established national standards or guidelines for the construction of roundabouts. Each roundabout must be approached individually for the location and the traffic operational movements that exist.

(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. Refer to the MUTCD for additional information regarding work duration.

(a) **Long-Term Stationary Work Zone**

This is work that occupies a location continuously for more than three days. There is ample time to install and realize benefits from the full range of traffic control procedures and devices. 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.

(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.

(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.

(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.)

(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.

(4) TMP Strategies

When the list of project impacts is complete, the designer can begin to develop strategies for addressing them. There are often several strategies that can be employed to manage traffic through a work zone. The designer will need to analyze the traffic capacity, consider the cost/benefit of the strategy, and consider constructibility issues. Constructibility is a key element in a successful work zone strategy. Safety and mobility are the main concerns, but if the proposed strategy has constructibility issues, the construction costs can escalate, and safety and mobility impacts may not be addressed. Selecting a strategy is often a compromise and involves many engineering and nonengineering factors. Continue to work closely with roadway and bridge designers and construction and maintenance personnel when selecting strategies. The selected strategies are developed into the traffic control PS&E or included in the TMP document to be performed outside the contract.

Do not assume that strategies chosen for past projects will adequately address the impacts for similar projects in the future. 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.

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

(5) Temporary Traffic Control (TTC) Strategies

(a) **Lane Closure**

One or more of the traffic lanes are closed in this work zone type. A capacity analysis is necessary to determine the extent of congestion that might result. This may require night work or peak hour restriction. Consider traffic safety drums and truck-mounted attenuators for freeway or expressway lane closures.

(b) **Shoulder Closure**

A shoulder closure is used for work areas at the edge of the paved shoulder or off the pavement edge. On high-volume freeways or expressways, they should not be in place during peak traffic hours.

(c) **Alternating One-Lane Two-Way Traffic**

This strategy involves using one lane for both directions of traffic. Flaggers are normally used to alternate the traffic movements. Do not include alternating traffic with flaggers as a traffic control strategy until all other reasonable means of traffic control have been considered. Options to remove flaggers during alternating traffic operations are temporary portable traffic signals or automated flagging assistance devices (AFAD).

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. When multiple lanes are present at an intersection, close the lanes so only one lane of traffic approaches the flagger location. When an existing signal is present at the intersection, the signal is to either be turned off or set to flash mode when flagging.

Flagger safety is a high emphasis area. 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. The WSDOT publication, *Work Zone Traffic Control Guidelines*, and the *Standard Specifications* have more information on flaggers, including the Washington State Department of Labor and Industries safety regulations for flaggers.

Using flaggers solely to instruct motorists to proceed slowly is ineffective and is an unacceptable practice. A spotter (not to be confused with a flagger) is used solely to alert workers of an errant vehicle. A spotter does not use a flagging paddle, but instead uses a warning device like an air horn. Intended spotter locations are to be shown on traffic control plans. Additional information on the use of spotters is available in the *Standard Specifications*.

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.

(d) **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.

(e) **Intermittent Closure**

This work zone type involves stopping all traffic in both directions for a relatively short time to allow the work to proceed. After a certain amount of time, based on traffic volume, the roadway is reopened. An example of this type of closure would be a girder-setting operation for a bridge project: typically, the closure would be limited to a ten-minute maximum and would occur in early morning hours when traffic volumes are at a minimum. A traffic control plan is required for this operation detailing the method that will be used to stop traffic. Typically, this will be done by closing the lanes of a multilane roadway to a single lane and using either a flagger or law enforcement at the point of closure. These closure points must be shown on a plan.

(f) **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 is required to show pavement markings, barrier and attenuators, and sign and device placement.

(g) **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. Median paving may be required to create crossover locations. For long-duration crossovers, temporary channelization plans are required, with barrier to separate the two directions of traffic and temporary illumination required at the crossover locations.

(h) **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 devices to separate traffic is not allowed. Use a warning sign to show the changed alignment when the lateral shifting distance is greater than one-half of a lane width.

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

Temporary channelization plans are required when routing traffic onto the shoulder.

(i) **Total Closures**

Total closures may be for the project duration or for a critical work operation that has major constructibility or safety issues. The main requirement for total closures is the availability of a detour route and whether or not the route can accommodate the increased traffic volumes. 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, local businesses, local agencies, transit agencies, 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 duration.
- 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 constructibility as a component of an effective work zone strategy.
- 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.
- Document road closure decisions and agreements in the Project File.

(j) **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 semipermanent 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.

Implementation of the staged temporary alignment and channelization or transitioning from one stage to the next can be a safety and mobility impact. Production rates for removing and replacing pavement markings, temporary barrier, or pavement work at the tie-in locations can create lane and duration impacts that need to be considered. Strategies and plans to implement or change stages must be considered.

(k) **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 signs), portable Highway Advisory Radio (HAR), and other dynamic devices.
- Consider how the operation will impact truck traffic. If the truck volumes are high, additional consideration may be prudent to control in which lane the trucks drive. If the trucks are controlled, 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.

- Consider the use of solid lane line markings to delineate the traffic split or island. There are two striping options to consider during the design of a traffic split: when lane changes are DISCOURAGED, a single solid lane line is used, and when lane changes are PROHIBITED, two solid lane lines are used. Refer to the MUTCD for additional details.
- Supplement the existing roadway lighting with additional temporary lighting to improve the visibility of the island work area.
- Consider the use of STAY IN LANE (black on white) signs, or set up a "no pass" zone approaching the lane split and coordinate with the Washington State Patrol (WSP).

(l) **A+B Bidding**

Use A+B bidding to reduce the contract time by requiring bidders to determine the working days as part of their bid. For more information, see:
www.wsdot.wa.gov/Projects/delivery/alternative/ABBidding

(m) **Incentive/Disincentive Clauses**

These are contract provisions that place financial consequences, good or bad, to ensure high-impact work or projects are finished as soon as possible. These provisions could also include accelerated work schedules for high-impact work operations.

(n) **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.
- Design bridges using super girders, falsework restrictions, or temporary structures.
- Bring adjacent lifts of hot mix asphalt (HMA) to match the latest lifts (lag up), to minimize abrupt lane edges to improve motorist safety.
- Require a tapered wedge joint on HMA lifts to eliminate an abrupt drop-off.

(6) Transportation Operations (TO) Strategies

(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.

(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 narrow shoulders.
- Use heavy-vehicle restrictions and provide alternate routes or lane use restrictions.

(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.

(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.

(7) Public Information (PI) Strategies

(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.

(b) **Driver Information**

In addition to work zone signs, provide driver information using highway advisory radio (HAR) and changeable message signs (existing or portable). Provide additional work zone ITS features that could include traffic cameras or queue detection along with changeable message signs to provide drivers with real time information on delays and traffic incidents. Involve the region TMC in the development and implementation of these strategies. Coordinate freight travel information and restrictions through the Freight Systems Office. Additional information on work zone ITS can be found on the Work Zone Safety web page:
www.wsdot.wa.gov/safety/workzones/

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.

(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.

1010.07 Capacity Analysis

Work zone congestion and delay is a significant issue for many highway projects. High-volume locations with existing capacity problems will certainly be candidates for further capacity problems when a work zone is in place. Work zones can create many types of roadway restrictions, such as lane closures, shoulder closures, narrowed lanes, closures and detours, and diversions, which all reduce capacity. Even when the construction work does not affect adjacent traffic lanes, slowdowns in the traffic flow are common because these activities can distract a motorist.

All work zone restrictions need to be analyzed to determine the level of impacts. Short-term impacts may only require work hour restrictions; long-term impacts require a detailed capacity analysis of the proposed mitigation strategies to select the best method of maintaining mobility. Include the *Work Zone & Traffic Analysis* in the Project File.

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.
- **Constructibility:** 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 constructibility.
- **Local Road Impacts:** Projects with capacity deficiencies can sometimes cause traffic to divert to local roadways, which may impact the surrounding local roadway system and community. Local roads may have lower geometric 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.
- **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:** Congestion and delay, as well as associated collisions and other impacts, can create significant economic impacts to road users and the surrounding community. Calculate user costs as part of a work zone capacity analysis; the costs may be used to justify liquidated damages.

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 a plan to notify road users and mitigate and manage the congestion as much as possible. Traffic capacity mitigation measures are important since many projects cannot effectively design out all the work zone impacts.

A 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.

(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 Office can assist with collecting traffic volume data. Coordination with local agencies may be needed to obtain data on affected local roads.

(2) Short-Term Lane Closure Work Zone Capacity

For short-term lane closures on multilane highways or alternating one-way traffic on two-lane highways, see Exhibit 1010-1, General Lane Closure Work Zone Capacity. It provides information for a quick analysis when compared to current hourly volumes on the highway. The basic traffic analysis programs QUEWZ 98 and QuickZone, 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.

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*.	

General Lane Closure Work Zone Capacity
Exhibit 1010-1

(3) Long-Term Work Zone Capacity

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.

The following resources are also available to assist with the actual analysis and mitigation strategy development upon request:

- HQ Transportation Data 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).

1010.08 Work Zone Design Standards

Work zone design must be consistent with permanent design. When temporary alignment and channelization plans are required, meet the minimum geometric design and roadside safety criteria found in Divisions 12 and 16. Other chapters also apply to work zone design. The following information provides some basic guidance and considerations for temporary channelization designs.

(1) Lane Widths

Maintain existing lane widths during work zone operations whenever possible. For projects that require lane shifts or narrowed lanes due to work area limits and staging, consider the following before determining the final lane width to be implemented:

- Overall roadway width available
- Posted speed limit
- Traffic volumes through the project limits
- Number of lanes
- Existing lane and shoulder widths
- Length of project
- Duration of lane width reduction (if in place)
- Roadway geometry (cross slope, vertical and horizontal curves)
- Truck percentage

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.

The minimum allowable lane width for low-speed low-volume roadways is 10 feet, with 1 foot of shy distance. However, this requires prior approval from the region Traffic Engineer before being accepted. For all other roadways, the minimum allowable striped lane width is 11 feet, with a 2-foot shy distance to a traffic control device or shoulder width. The maximum allowable lane width is 14 feet when the radius is greater than 500 feet. Follow existing lane widths when delineating temporary lanes with channelizing devices.

When determining lane widths, the objective is to use lane geometrics that will be clear to the driver and keep the vehicle in the intended lane. Lane lines and construction joints are treated to provide a smooth flow through the transition area. In order to maintain the minimum lane widths and shy distances, temporary widening may need to be considered.

(2) Buffer Space and Shy Distance

Buffer space is a lateral and/or longitudinal area that separates road user flow from the work space or other areas off limits to motorists, and it might provide some recovery space for an errant vehicle.

- Lateral buffer space provides space between the driver and the active work space, traffic control device, or a condition such as an abrupt lane edge or drop-off. As a minimum, a 2-foot lateral buffer space is recommended.
- Shy distance is the distance from the edge of the traveled way beyond which a roadside object will not be perceived as an immediate concern by the typical driver to the extent that the driver will change the vehicle's placement or speed.
- A longitudinal buffer is the space between the protective vehicle and the work activity.

Devices used to separate the driver from the work space should not encroach into adjacent lanes. If encroachment is necessary, it is recommended to close the adjacent lane to maintain the lateral buffer space. Refer to Chapter 1610 and the MUTCD to determine the appropriate buffer space and shy distance values.

In order to achieve the minimum lateral clearances, there may be instances where temporary pavement widening or a revision to a stage may be necessary. In the case of short-term lane closure operations, the adjacent lane may need to be closed or traffic may need to be temporarily shifted onto a shoulder to maintain a lateral buffer space. During the design of the traffic control plan, the lateral clearance needs to be identified on the plan to ensure additional width is available; use temporary roadway cross sections to show the space in relation to the traffic and work area.

(3) Work Zone Clear Zone

The contractor's operations present opportunities for errant vehicles to impact the clear area adjacent to the traveled way. A work zone clear zone (WZCZ) is established for each project to ensure the contractor's operations provide an appropriate clear area. The WZCZ addresses items such as storage of the contractor's equipment 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 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.)

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

Minimum Work Zone Clear Zone Distance
Exhibit 1010-2

(4) Abrupt Lane Edges and Drop-offs

Minimize, mitigate, or eliminate abrupt lane edges adjacent to the traveled lane whenever possible. There are work operations where drop-offs are unavoidable in order to perform the work, but in these instances, the drop-off can generally be anticipated and addressed in the work zone traffic control plan design. Contract provisions should be included limiting the duration of edges from planing and paving operations and requiring a step wedge on new pavement edges or a lag up requirement to minimize the instances of abrupt lane edges. Use the following guidance examples for drop-off protection measures. Note: These are general guidance examples only. Refer to Exhibit 1010-4, and for a complete discussion of abrupt lanes edges and drop-offs, see Standard Specification 1-07.23(1):
www.wsdot.wa.gov/publications/manuals/fulltext/M41-10/D1.pdf

- Drop-offs up to 0.20 foot may remain exposed with appropriate warning signs alerting motorists of the condition.
- Drop-offs more than 0.20 foot are not allowed in the traveled way or auxiliary lane unless protected with appropriate warning signs, channelization devices, or barrier.
- Drop-offs more than 0.20 foot, but no more than 0.50 foot, that will not be within the traveled way shall be protected with appropriate warning signs, a wedge of compacted stable material at a slope of 4:1 or flatter, channelization devices, or barrier.
- Drop-offs more than 0.50 foot, but less than 2 feet, not within the traveled way or auxiliary lane shall be protected with appropriate warning signs, wedge of compacted stable material at a slope of 4:1 or flatter, channelization devices, or barrier. This drop-off is allowed only if it is less than 1 mile in length, does not remain for more than three working days, and is only on one side of the roadway.

- Drop-offs more than 0.50 foot that will not be within the traveled way or auxiliary lane and are not otherwise covered by No. 4 above shall be protected with appropriate warning signs and wedge of compacted stable material at a slope of 4:1 or flatter and barrier.
- 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 require additional warning and considerations for motorcyclists, bicyclists, and pedestrians, including pedestrians with disabilities. Adequate signing to warn the motorcycle rider of these conditions is required. (See RCW 47.36.200, WAC 468-95-305, and Work Zone Traffic Control (WZ) for signing details.)

(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 included in the temporary traffic control plans. Maintain legal height on temporary falsework for bridge construction projects. Anything less than this must consider overheight vehicle impacts and possible additional signing needs. Widening of existing structures can prove challenging when the existing height is at or less than legal height, so extra care is required in the consideration of overheight 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.

(6) Temporary Median Crossover Requirements

When two-way traffic is placed on one side of a multilane divided highway, consider the following guidelines when designing the crossover:

- Separate opposing traffic with either temporary traffic barriers (on high-speed roadways) or with channelizing devices throughout the length of the two-way operation. Temporary pavement markings, removal of conflicting existing markings, and construction signs are also required.
- The crossover locations are to be paved, and temporary pavement markings are required. Temporary illumination is required to improve the visibility of the crossover location. Temporary drainage may be necessary under the median fill when applicable.
- Geometrics design for temporary crossovers needs to follow the same guidance as permanent construction and have horizontal curves calculated to fit the location.
- Design crossovers for operating speeds not less than 10 mph below the posted speed limit unless unusual site conditions require a lower design speed.
- Straight line crossover tapers work best for highways with narrow paved medians.

- Provide a buffer space between the lane closures and crossover locations.
- Design crossovers to accommodate all roadway traffic, including trucks, buses, motor homes, and bicycles.
- 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.
- A site-specific traffic control plan is required.

(7) Temporary Alignment and Channelization

Temporary alignment and channelization plans may be necessary for some long-term work zones.

The following are guiding principles for the design of temporary alignment and channelization plans:

- Use site-specific base data.
- 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 superelevation transitions that may affect a driver’s ability to maintain control of a vehicle through a work zone.
- 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 constraints for the removal of existing markings and the time required to install new markings, especially if the work is for multilane staged construction. In urban areas where work hour restrictions for lane closures are limited, special consideration may be necessary to allow for time to address pavement markings, or interim stages may be necessary. Reopened temporary traffic lanes are to be marked and in compliance with criteria established in this chapter.
- When showing a run of temporary concrete barrier and the temporary impact attenuator location on a channelization plan, the shoulder approaching the attenuator location also is to be closed using shoulder closure signing and a channelizing device taper consistent with the MUTCD. (See the MUTCD for example details.)
- Existing signing may need to be covered or revised, and additional construction warning signs may be needed for the new alignment.

(8) Reduced Speeds in Work Zones

As part of the design process for construction projects, speed reductions are an option requiring thorough traffic analysis prior to accepting this option. Traffic control design assumes that drivers will reduce their speed only if they clearly perceive a need to do so. Reduced speed limits are used only where roadway and roadside conditions or restrictive features are present, such as narrow, barrier-protected work areas with major shifts in roadway alignment and where a reduced speed is truly needed to address the appropriate speed limit of the roadway. Speed reductions are not applied as a means for selecting lower work zone design criteria (tapers, temporary alignment, device spacing, and so on). Avoid frequent changes in the speed limit.

Speed limit reductions are categorized as follows:

- Continuous Regulatory Speed Limit Reduction: A speed reduction in place 24 hours a day during the number of days that construction is present.
- Variable Regulatory Speed Limit Reduction: A speed reduction in place, usually during an active work shift.
- Advisory Speed Reduction: A specific signed warning message with an advised safe speed for that given work zone condition.

Proposed speed limit reductions of more than 10 mph on any route or less than 60 mph on freeways require HQ Traffic Office approval. The Regional Administrator is authorized to approve regulatory speed limit reductions in work zones as provided for in RCW 47.48. The region Traffic Engineer is responsible for recommending or denying a speed limit reduction request to the Regional Administrator. (See the *Traffic Manual* for additional guidance on speed limit reductions.) Include speed limit reduction approvals in the Project File.

Do not use the advisory speed plaque alone or in conjunction with any sign other than a warning sign. In combination with a warning sign, an advisory speed plaque may be used to indicate a recommended safe speed through a work zone. Refer to the MUTCD for additional guidance.

(9) Accommodation for Pedestrians and Bicyclists

Most public highways and streets accommodate pedestrians and bicyclists. In work zones, they must have adequate facilities to travel through or around the work zone. The construction of temporary pathways that route the pedestrian around a work zone needs to meet ADA standards. Covered walkways are to be provided where there is a potential for falling objects. In work areas where the speeds are low (25 to 30 mph), 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. 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 GSP 072302.GR1 for pedestrian work zone design requirements.)

(10) Motorcycles

The same road surfaces that are a concern for bicyclists are also a concern for motorcyclists. Stability at high speed is a far greater concern for motorcycles than cars on grooved pavement, milled asphalt, and transitions from existing pavement to milled surfaces. Contractors must provide adequate warning signs for these conditions to alert the motorcycle rider. The WSDOT publication, *Work Zone Traffic Control Guidelines* (www.wsdot.wa.gov/publications/manuals/fulltext/M54-44/Workzone.pdf) has more information on regulations for providing warnings to motorcyclists (RCW 47.26.200).

(11) 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. Document communication with these offices and any other stakeholders in the Project File.

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.

1010.09 Temporary Traffic Control Devices

FHWA regulations require that all roadside appurtenances such as portable sign stands, barricades, traffic barriers, barrier terminals, crash cushions, and work zone hardware be compliant with the National Cooperative Highway Research Program (NCHRP) 350 crash test requirements. For additional information on the NCHRP 350 requirements and for additional descriptions of devices, refer to the MUTCD. For additional information and use guidelines for the following work zone devices, refer to *Work Zone Traffic Control Guidelines*.

(1) Channelizing Devices

Channelizing devices are used to alert and guide road users through the work zone. They are a supplement to signing, pavement markings, and other work zone devices. Typical channelizing devices include the following:

(a) **Cones**

Traffic safety cones are the most commonly used devices for traffic control and are very effective in providing delineation to the work zone. Cones are orange in color and are constructed of a material that will not cause injury to the occupants of a vehicle when impacted. For daytime operations on lower-speed (40 mph or lower) roadways, 18-inch-high cones can be used. For nighttime operations and high-speed roadways, reflectorized 28-inch-high cones are necessary. Traffic cones are used to channelize traffic, divide opposing traffic lanes, and delineate short-duration work zones.

(b) **Traffic Safety Drums**

Drums are fluorescent orange in color, constructed of lightweight, flexible materials, and are a minimum of 3 feet in height and 18 inches in diameter. They are highly visible and appear to be formidable obstacles. They are also less likely to be displaced by the wind generated by moving traffic. For these reasons, drums are preferred on high-speed roadways. Type-C steady-burn warning lights may be installed atop drums to improve visibility.

(c) **Tall Channelizing Devices**

Tall channelizing devices are 42 inches tall, fluorescent orange in color, and are constructed of lightweight, flexible material that may be less likely to cause injury in an impact. Tall channelizing devices are used to channelize traffic, divide opposing traffic lanes, and delineate short-duration work zones. These devices provide a larger target value in terms of retroreflectivity than cones, but less than that of drums. They do have a smaller footprint than drums, so they are a good alternative in narrow shoulder conditions.

(d) **Tubular Markers**

Tubular markers are not a recommended device unless they are being used to separate traffic on low-volume low-speed roadways. For descriptions and restrictions on use, refer to the MUTCD and the Channelization Device Application Matrix in the *Work Zone Traffic Control Guidelines*.

(e) **Barricades**

The barricades used in work zone applications are portable devices. They are used to control traffic by closing, restricting, or delineating all or a portion of the roadway. There are four barricade types:

1. **Type 1 Barricade:** Used on lower-speed roads and streets to mark a specific object.
2. **Type 2 Barricade:** Used on higher-speed roadways; it has more reflective area for nighttime use to mark a specific object.

3. **Type 3 Barricade:** Used for lane and road closures.
4. **Directional Indicator Barricade:** A special-use device not commonly used. The device is used to define the route of travel on low-speed streets or in urban areas where tight turns are required. In lane reductions, the directional arrow on this barrier can be used in the transition taper to indicate the direction of the merge.

(f) Longitudinal Channelizing Devices

Longitudinal channelizing devices such as lightweight water-filled barriers are an improvement over the traffic cones and drums used to channelize traffic through a work zone. These types of barriers are **not intended** as a replacement for concrete barrier.

(g) Barrier Drums

Barrier drums are low-density polyethylene fabricated devices placed on and along temporary concrete barriers. They are fluorescent orange with retro-reflective bands and are designed to straddle a concrete barrier. They can be used in place of barrier reflectors for barrier delineation.

(2) Portable and Temporary Signing

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. They 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.

(3) Fixed Signing

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. Ground-mounted sign supports are usually wood; 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.

(4) Warning Lights

Warning lights are either flashing or steady burn (Types A, B, or C) and are mounted on channelizing devices, barriers, and signs. Secure warning lights to the channelizing device or sign so they will not come loose and become a flying object if impacted by a vehicle. (See the MUTCD for additional information.)

- **Type A:** Low-intensity flashing warning light used to warn road users during nighttime hours that they are approaching a work zone.
- **Type B:** High-intensity flashing warning light used 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.

(5) Arrow Panel

The arrow panel (Sequential Arrow Sign) displays either an arrow or a chevron pointing in the direction of the intended route of travel. Arrow panel displays are required for lane closures on multilane roadways. When closing more than one lane, use an arrow panel display for each lane reduction. Place the arrow panel at the beginning of the transition taper and out of the traveled way. The caution display (four corner lights) is only used for shoulder work. Arrow panels are not used on two-lane two-way roadways. (See the MUTCD for additional information.)

(6) Portable Changeable Message Signs (PCMS)

PCMS displays have electronic displays that can be modified and programmed with specific messages, and they are supplemental to other warning signs. These signs are usually mounted on trailers and use solar power and batteries to energize the electronic displays. The maximum number of message panels is two per location. If additional information is necessary, consider using a second sign. Place the PCMS far enough in advance of the roadway condition to allow the approaching driver adequate time to read the sign's message twice. PCMS systems are typically used where:

- Traffic speed is expected to drop substantially.
- Significant queuing and delays are expected.
- There are extreme changes in alignment or surface conditions.
- Advance notice of ramp, lane, or roadway closures is necessary.
- Incident management teams are used.

(7) Truck-Mounted Attenuators

A truck-mounted attenuator (TMA) is a portable impact attenuator attached to the rear of a large truck. Ballast is added to the truck to minimize the roll-ahead distance when impacted by a vehicle. The TMA is used as a shield to prevent errant vehicles from entering the work zone. TMAs should be used on all high-speed roadways. If a TMA is not available, the use of a protective or shadow vehicle is still highly recommended.

(8) Portable Temporary Traffic Control Signals

Portable temporary traffic signals are trailer-mounted and used in work zones to control traffic. These versatile portable units allow for alternative power sources such as solar power, generators, and deep-cycle marine batteries, in addition to AC power. (See the MUTCD for additional information). Portable traffic signals are typically used on two-lane two-way highways where one lane is closed for an extended duration and alternating traffic movements need to be maintained. Contact the region Traffic Office and Signal Superintendent for specific guidance and advice on the use of these systems; a traffic control plan is required.

(9) Portable Highway Advisory Radio (HAR)

A HAR is a roadside radio system that provides traffic and travel-related information (typically affecting the roadway being traveled) via AM radio. The system may be a permanently located transmitter or a portable trailer-mounted system that can be moved from location to location as necessary. Contact the region Traffic Office for specific guidance and advice on the use of these systems.

(10) Automated Flagger Assistance Device (AFAD)

The AFAD is an automated flagging machine that is operated remotely by a flagger located off the roadway and away from traffic. The device is a safety enhancement for projects that use alternating traffic control by physically placing the human flagger off the roadway while maintaining control of the traffic movements approaching the work zone. Contact the region Traffic Office for specific guidance and advice on the use of these systems. A traffic control plan is required for use of the AFAD.

1010.10 Other Traffic Control Devices or Features

(1) Barriers (Positive Protection)

Barriers are used in work zones to separate traffic moving in opposing directions and to separate road users from the work area. Temporary concrete barrier is the most common type of positive protection. (See Chapter 1610 for guidance on barriers.)

Providing positive barrier protection may become the key component of the work zone strategy. Barrier use usually requires long-term stationary work zones and pavement marking revisions, and it can increase the traffic control costs. 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.

Traditional lane closures using channelizing devices may not provide adequate worker and road user protection for some types of construction. Use barriers for the following conditions:

- To separate opposing high-speed traffic 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.
- 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.
- Where drums, cones, or barricades do not provide adequate protection for the motorist or worker.

(a) Temporary Concrete Barriers

These are the safety-shape barriers shown in the *Standard Plans*. Lateral displacement from impacts is usually in the range of 2 to 4 feet. When any barrier displacement is unacceptable, these barriers are anchored to the roadway or bridge deck. Anchoring systems are also shown in the *Standard Plans*.

(b) **Movable Barriers**

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.

(c) **Portable Steel Barriers**

Portable steel barriers have a lightweight stackable design. They have options for gate-type openings and relocation without heavy equipment. Lateral displacement from impacts is in the range of 6 to 8 feet. Steel barriers can be anchored according to the manufacturer's specifications.

(d) **Water-Filled Barriers**

Water-filled barriers will deflect much more than concrete barrier. Therefore, they should only be considered when a work area will not be within the deflection area.

(2) Impact Attenuators

Within the Design Clear Zone, the approach ends of temporary concrete barriers are fitted with impact attenuators to reduce the potential for occupant injury during a vehicle collision with the barrier. Impact attenuators are addressed in Chapter 1620.

The selection and location of impact attenuators in work zones can present situations that do not exist on a fully operational highway. Consider all work zone and traffic protection needs. The information in Chapter 1620 provides all the needed impact attenuator performance information, but the actual work zone location may require careful consideration by the designer to ensure the correct application is used. Consider the dynamic nature of work operations where work zone ingress and egress, work area protection, worker protection, and traffic protection all factor into the final selection. Redirective and nonredirective devices can both be used as long as the aforementioned issues are resolved and the devices also meet the Chapter 1620 criteria when applied to a given work zone location. Also, impact attenuators used in work zones are much more likely to be impacted, which again requires careful consideration of those devices that are durable and easy to repair. Some common impact attenuator work zone issues are:

- Nonredirective device is improperly located. This is usually associated with an inadequate length of need calculation (see Chapter 1610) or protection issues not fully considered.
- Narrow temporary medians, narrow work zones, narrow or no shoulders, temporary median openings, and inadequate installation area (width, cross and approach slope, or base material).
- Temporary or short-term protection issues associated with the removal or relocation of existing or temporary barriers and impact attenuators.

Designers need to ensure the approved list of temporary impact attenuators is appropriate for the individual work zone plan locations. The designer may remove from the list those devices that are not appropriate for a given location.

(3) Delineation

Pavement markings provide motorists with clear guidance through the work zone and are necessary in all long-term work zones. Temporary pavement markings can be made using painted preformed tape or raised pavement markers. Existing contradictory pavement markings must be removed. Other delineation devices are guideposts, concrete barrier delineators, and lateral clearance markers. Show these features on the traffic control plans. These devices have retroreflective properties and are used as a supplement in delineating the traveled way during the nighttime. (See Chapter 1030 for delineation requirements.)

Removal of existing or temporary pavement markings can leave a scar, creating a “ghost stripe” effect on the pavement. Under certain conditions, this scar can appear as a valid marking, which could cause driver confusion. Destructive removal such as intensive grinding can actually leave a groove in the pavement that can hold rainwater and leave the appearance of a stripe, especially at night when headlight reflections intensify the effect.

Consider the types of removal for markings and their potential for ghost stripes and other distracting or conflicting leftover markings. Less destructive types of removal, such as hydroblasting and the use of removable temporary markings, can significantly improve pavement marking performance through the work zone. Continuous positive guidance through high-quality temporary pavement markings, alone or in combination with existing markings, is a substantial benefit to drivers in work zones. Contact the region or HQ Traffic Office for further information on this subject.

Lateral clearance markers are used at the angle points of barriers where they encroach on or otherwise restrict the adjacent shoulder. Concrete barrier delineation is necessary where the barrier is less than 4 feet from the edge of traveled way. This delineation can either be barrier reflectors attached to the face of the barrier or saddle drum delineators that sit on the barrier.

(4) Screening

Screening is used to block the motorist’s view of construction activities adjacent to the roadway. Construction activities can be a distraction, and motorist reactions might cause unsafe vehicle operation and undesirable speed reductions. Consider screening the work area when the traffic volume approaches the roadway’s capacity. Screening can either be vertically supported plywood/plastic panels or chain link fencing with vertical slats. These types of screening are positioned behind traffic barriers to prevent impacts by errant vehicles. The screening is anchored or braced to resist overturning when buffeted by wind. Commercially available screening or contractor-built screening can be used, provided the device meets crashworthy criteria and is approved by the Engineer prior to installation.

Glare screening is another type of screening used on concrete barriers separating two-way traffic to reduce headlight glare from oncoming traffic. Woven wire and vertical blade-type screens are commonly used in this installation. This screening also reduces the potential for motorist confusion at nighttime by shielding 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.

(5) 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.
- Where disruption of an existing illumination system is necessary.
- Projects with lane shifts and restricted geometrics.
- Projects with existing illumination that needs to be removed as part of the construction process.
- Traffic flow is split around or near an obstruction; illumination is required for this type of operation.

For information on light levels and other electrical design requirements, see Chapter 1040.

When flaggers are necessary for nighttime construction activities, supplemental lighting of the flagger stations by use of portable light plants or other approved methods is required.

(6) 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).

(7) Work Zone Intelligent Transportation Systems (ITS)

Intelligent Transportation Systems apply advanced technologies to optimize the safety and efficiency of the existing transportation network. Many permanent systems already exist throughout Washington State and provide the opportunity to greatly enhance construction projects that fall within the limits of the ITS network. ITS applications in work zones can be used to provide traffic monitoring and management, data collection, and traveler information.

ITS can provide real-time work zone information and associated traffic conditions such as slowed or stopped traffic ahead, or they can advise of alternate routes. This gives motorists more information as they make decisions about travel plans.

Work zone ITS technology is an emerging area that can provide the means to better monitor and manage traffic flow through and around work zones. Equipment used in work zones, such as portable camera systems, highway advisory radios, variable speed limits, ramp metering systems, and queue detection sensors, helps ensure a more efficient traffic flow with a positive impact on safety, mobility, access, and productivity.

Identify work zone ITS elements early in the strategy development process and include them in the preliminary estimate so they can be designed along with the other traffic control elements. For large mobility projects that have existing freeway cameras already in place, temporary ITS features (such as temporary poles and portable systems) may be necessary to ensure the network can be maintained during construction, especially if existing camera locations are in conflict with construction activities. In locations that do not have existing camera locations, but have significant construction projects planned, work zone ITS may be a good opportunity to bring ITS technology to the route.

Refer to Chapter 1050 and the work zone safety web page for additional ITS information and guidance.

1010.11 Traffic Control Plan Development and PS&E

WSDOT is obligated to provide a proposal in the PS&E for controlling traffic that is consistent with the project construction requirements. Even though there may be more than one workable solution, a thorough analysis of all the variables will help produce a TMP that addresses all impacts and establishes the appropriate levels of safety, mobility, and constructibility.

The preparation of traffic control plans (TCPs) requires the designer to not only have a thorough knowledge of highway construction activities, but also traffic engineering knowledge and an understanding of the unique traffic flow patterns within the specific project. Road users have little or no understanding of the construction occurring in the work zone and require far greater guidance than the contractor or agency personnel who are familiar with the project.

Traffic control plans can generally be broken down into three specific categories: typical, project-specific, and site-specific. The work zone location, ramps, intersections, access, and other site information will determine the level of detail necessary. Consider these categories for each work zone when developing TCPs.

TCPs are designed from the perspective of drivers, pedestrians, and bicyclists to provide the necessary information to assist them in navigating a work zone. Unexpected roadway conditions, changes in alignment, and temporary roadside obstacles relating to the work activity should be defined adequately to eliminate users' uncertainty. Keep in mind the construction workers' exposure to traffic as the traffic control plans are being developed.

It is recommended that multiple work operations be combined under a single traffic control plan to minimize the impacts to traffic and encourage the efficiency of the contractor. The intention is not to direct the contractor in how to pursue or perform the work, but to provide the most efficient approach to protect the work area and to establish the level of safety and traffic control while maintaining traffic mobility. A constructible and biddable set of traffic control plans is the goal. The contractor has the option of adopting the contract plans or proposing an alternative method.

(1) Traffic Control Plan Types

"Typical" traffic control plans are generic in nature and are not intended to satisfy all conditions for all work zones. They are adaptable to many roadway conditions and work operations. Use this type of plan if it can be applied with little or no field modification. Typical plans may be included in every project. The majority of the time, they will be used to supplement project- or site-specific plans, especially for a complex project. For projects with routine day-to-day operations, such as paving projects on a two-lane roadway, typical plans work well. Even "routine" projects may have some unique work that needs more specific plan development. As a starting point, use the typical plans located at:
www.wsdot.wa.gov/Design/Standards/PlanSheet/WZ-1.htm

A "project-specific" traffic control plan can be a typical plan that has been modified to include project-specific details such as side roads, business approaches, horizontal curves, and so on. A project-specific plan may also be drawn using existing base data, but may not necessarily be a scaled drawing. Project-specific plans are a good compromise between a typical plan with no specific detail and a scaled base data-developed plan, especially when base data may not be available.

"Site-specific" traffic control plans are drawn using scaled base data with scaled traffic control device placements to provide the highest level of accuracy. They ensure that the proposed work operation will actually fit the location and that a workable method to maintain traffic flow can be achieved. If properly designed, site-specific plans need very little field modification. The use of site-specific plans is the best approach to satisfy the intent of a TMP by addressing impacts clearly and completely with detailed plans. For complex work zones, draw the traffic control plans with site-specific base data.

Do not place typical plan-type details on scaled site-specific plans. An example of this would be to use a scaled site-specific base plan and draw typical plan generic "L" distance to represent the lane closure taper distance, with the distance to come from a data box based on the highway speed. Another example is construction signs at specific locations on the scaled plan with a typical "X" distance dimension representing sign spacing. These examples misrepresent where the tapers begin or end and the actual locations where signs will be placed in the field. Inspectors or contractors then have to make field decisions and revisions to the plans that should have been addressed during the design.

The following are types of TCPs and details to consider in addressing TMP strategies in the PS&E.

(a) **Temporary Channelization Plans**

Temporary channelization plans are site-specific TCPs for long-term work zones or staged traffic control. They show the station limits for the beginning and ending locations of the temporary markings and taper rates when applicable. These plans also show the type of markings (such as lane line or edge line) on the plan with enough detail to assist the field inspector with field layout. When applicable, these plans also include temporary concrete barrier locations, flare rates, beginning and ending stations, and attenuator information (among others).

(b) **Temporary Median Crossovers**

These are another type of temporary channelization plan. Geometrics for the crossovers need to follow the same guidance as permanent alignments, and they have horizontal curves calculated to fit the location. Paved roadway surfaces and temporary pavement markings are required. Consider temporary illumination to improve the visibility of the operation. Temporary drainage may be necessary under the median fill, when applicable.

(c) **Temporary Roadway Cross Sections**

These plan details can be invaluable in providing additional details not easily visible when looking at the plan view of a TCP, especially when the roadway is in a temporary shift or configuration. This is also an excellent way to identify roadway drop-off conditions and vertical clearance issues.

(d) **Temporary Pavement Marking Details**

Detail sheets can be helpful in providing the specific details necessary to explain marking installation needs to supplement temporary pavement marking special provisions.

(e) **Temporary Portable Signal Plan**

For projects that include temporary portable signal systems, a traffic control plan is required. Example projects would be alternating one-lane traffic operations on a two-way facility (such as two-lane bridge widening), replacement projects, or emergency slide repair. The plan must include the entire advance signing for the system, temporary markings, location in relation to work operation, temporary lighting at stop bars, and so on. Use a portable signal unit only for projects where the length between signal heads is 1,500 feet maximum and no other accesses lie in between the temporary signals. There are specific temporary signal requirements that go into a project; therefore, for assistance, contact the region Traffic Office.

(f) **Detour and Alternate Route Plan**

For projects that anticipate the need for a detour or alternate route, ensure that sign placement will fit the locations shown along the route and that the signs will not conflict with existing signs, driveways, or pedestrian movements. Depending on the duration, the detour that will be in place, and the anticipated amount of traffic that will use the route, consider upgrades to the route (such as signal timing, intersection turning radius for large vehicle, structural pavement enhancements, or shoulder widening). Note: A signed detour agreement with the appropriate local agency is required for detour routes using local roadways and must be completed prior to project advertisement.

(g) **Pedestrian and Bike Detour Route**

When existing pedestrian and signed 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 the 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.)

(h) **Advance Warning Sign Plan**

May be combined with the vicinity map or shown on a separate plan. Show Class A Construction Signs that will remain in place for the duration of the project. Locate the signs 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.

(i) **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.

(j) **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.

(k) **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.

(2) Plans to Address TMP Strategies

The following are plans that often must be considered when addressing TMP strategies in the PS&E.

(a) **Construction Sequence Plans**

These 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.

(b) **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.

(c) **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.

(3) 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.

(4) 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

Work zone-related training is an important component in an effective work zone safety and mobility program. Federal regulations require that those involved with work zone design and implementation be trained at a level consistent with their responsibilities. It is valuable to know what training classes are available and how those classes relate to the project design and construction programs.

(1) Training Courses

There are many work zone-related courses available, and the HQ Staff Development Office and HQ Traffic Office's Traffic Training Program Manager can assist with the availability and scheduling of classes. Consider the following training courses to develop an overall proficiency in work zone safety and mobility design:

- **Work Zone Traffic Control Design Course:** This course, taught by the HQ Traffic Office, focuses on work zone safety and mobility through transportation management plan development and WZTC PS&E.
- **QuickZone Course:** This course, taught by McTrans, explores the QuickZone work zone traffic capacity analysis program. QuickZone is a useful tool for determining capacity needs, and it allows comparison of alternative strategies.
- **MUTCD Course:** This course, taught by Transpeed, focuses on the content and use of the MUTCD, including Part 6, Temporary Traffic Control.
- **Traffic Control Supervisor (TCS) Course:** This course, taught by the Evergreen Safety Council, NW Laborers Union, and ATSSA, is primarily for those students who intend to become a TCS or those who have TCS-related responsibilities. TCS training offers value to designers regarding how implementation issues interact with design issues. Designer attendance may be restricted to "space available" status.
- **Certified Flagger Training Course:** This course is directed at students who will become certified flaggers in Washington State and is not intended for designers. Designers may want to use the *Flagger Handbook* as a resource to learn about flagger-controlled traffic control and flagging techniques and issues. This class may be valuable for increasing the safety of designers anticipating extensive field surveying and data gathering work during the project development phase.

Other courses on work zone safety, mobility, and related subjects may be available on a limited basis. Some of these courses would fall into the categories of traffic analysis and traffic engineering and may be appropriate, depending on individual designer needs and responsibilities.

(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.

(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 Work Zone Specialist
- Region Construction and Design Offices

(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 Work Zone Safety & Mobility Manager
- State Work Zone Engineer
- State Work Zone Training Specialist
- WSDOT Work Zone Web Page

(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

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/

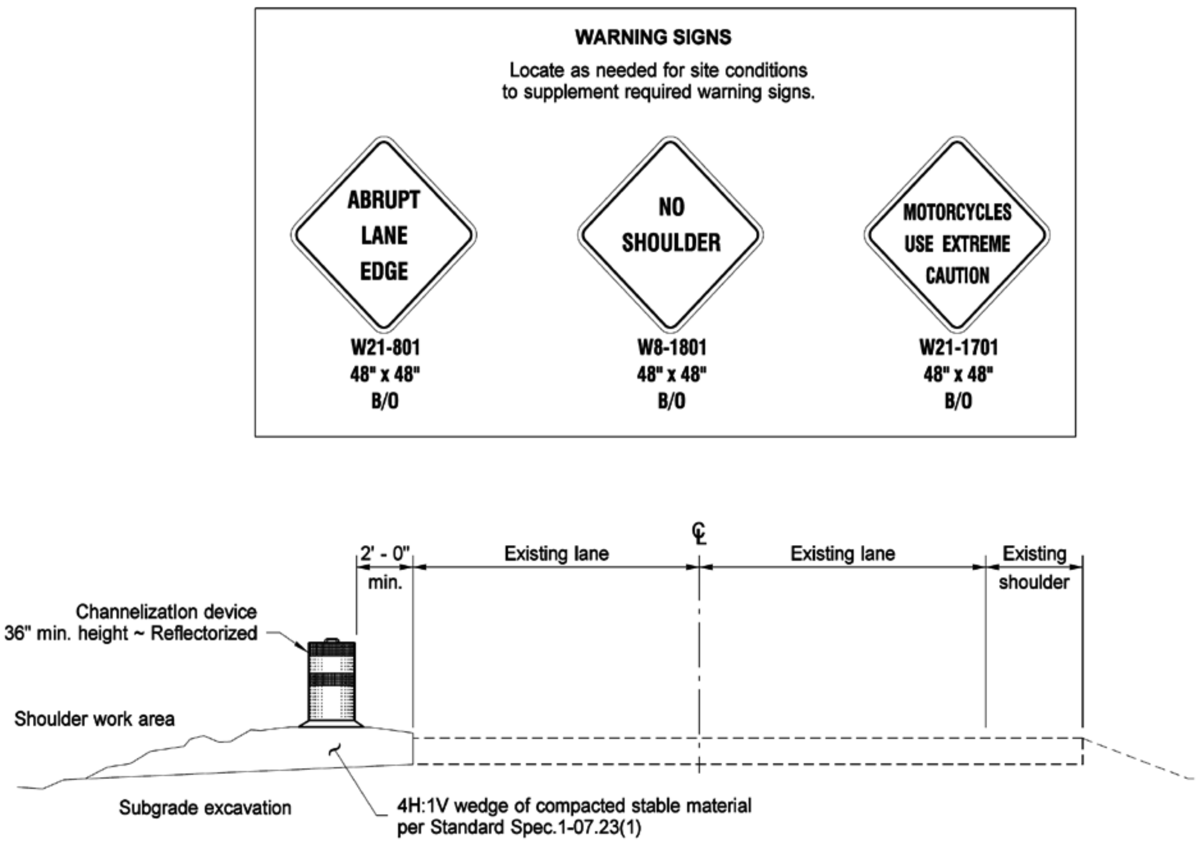
Use the following checklist to develop a formal TMP document on significant projects.

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	

Transportation Management Plan Components Checklist
Exhibit 1010-3

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	
• 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)	

Transportation Management Plan Components Checklist
Exhibit 1010-3 (continued)



Abrupt Edge Pavement Drop-Off Protection

Exhibit 1010-4

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.

(1) Illumination

The retroreflectivity of currently approved sign sheeting removes the need to provide illumination for most sign installations. Ground-mounted signing, regardless of sign type or message content, does not require sign lighting for nighttime legibility. Only overhead-mounted signs with “EXIT ONLY” panels in noncontinuous illumination areas or overhead-mounted guide signs for left side exits in all areas are illuminated.

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. 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.

Overhead Sign Type	Continuous or Noncontinuous Illumination	Sign Lighting Required	Sheeting Type (Background)	Sheeting Type (Legend & Border)
EXIT ONLY guide sign	Continuous	No	IV*	VIII or IX
EXIT ONLY guide sign	Noncontinuous	Yes	II	III or IV
Guide signs for left side exits	Both	Yes	II	III or IV
Other guide signs	Both	No	III or IV	VIII or IX
Regulatory signs	Both	No	IV	n/a
Warning signs	Both	No	VIII or IX	n/a

*For Yellow Background Sheeting, use Type VIII or IX Fluorescent Sheeting.

Note:
Continuous (Full) Illumination is when light standards (luminaires) exist between interchanges.

Reflective Sheeting Requirements for Overhead Signs
Exhibit 1020-1

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.

(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. Contact the HQ Traffic Office regarding signs under bridges and in tunnels.

(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 and 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.

(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 and 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.

1020.05 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.

1020.06 Mileposts

Milepost markers are a part of a statewide system for all state highways and are installed in accordance with Directive D 32-20, "State Route Mileposts."

Washington State Department of Transportation

TECHNICAL MANUAL

Design Manual

Volume 2 – Design Criteria

M 22-01.06

December 2009

Division 11 – Project Design Criteria
Division 12 – Geometrics
Division 13 – Intersections and Interchanges
Division 14 – HOV and Transit
Division 15 – Pedestrian and Bicycle Facilities
Division 16 – Roadside Safety Elements
Division 17 – Roadside Facilities

Environmental and Engineering Programs

Design Office

Americans with Disabilities Act (ADA) Information

Materials can be provided in alternative formats for persons with disabilities by contacting the ADA Compliance Officer via telephone at 360-705-7097 or by e-mail to Shawn Murinko at murinks@wsdot.wa.gov.

Title VI Notice to Public

It is Washington State Department of Transportation (WSDOT) policy to ensure no person shall, on the grounds of race, color, national origin, or sex, as provided by Title VI of the Civil Rights Act of 1964, be excluded from participation in, be denied the benefits of, or be otherwise discriminated against under any of its federally funded programs and activities. Any person who believes his/her Title VI protection has been violated may file a complaint with WSDOT's Office of Equal Opportunity (OEO). For Title VI complaint forms and advice, please contact OEO's Title VI Coordinator at 360-705-7098.

To get the latest information on WSDOT administrative and engineering manuals, sign up for e-mail updates for individual manuals at:
www.wsdot.wa.gov/publications/manuals/

Washington State Department of Transportation
Administrative and Engineering Publications
PO Box 47304
Olympia, WA 98504-7304

Phone: 360-705-7430
Fax: 360-705-6861
E-mail: engrpubs@wsdot.wa.gov
Internet: www.wsdot.wa.gov/publications/manuals/

State Route	NHS Route Description	Begin SR MP	Begin ARM	End SR MP	End ARM
SR 166	SR 16 to Bay St	0.02	0.00	3.40	3.38
SR 167	I-5 to SR 900 / S 2nd St	0.00	0.00	27.28	28.60
I-182	I-82 to US 395	0.00	0.00	15.19	15.19
US 195	Idaho State Line to I-90	0.00B	0.00	95.99	93.37
US 195 Spur	US 195 to Idaho State Line	0.06	0.00	0.60	0.54
I-205	Oregon State Line to I-5	26.59	0.00	37.16	10.57
SR 240	I-182 to Coast St / Bypass Hwy – Hanford Access	30.63	28.86	34.87	33.10
SR 270	US 195 to Idaho State Line	0.00	0.00	9.89	9.89
SR 270	Pullman Couplet	2.67	0.00	2.90	0.23
SR 281	I-90 to SR 28	0.00	0.00	10.55	10.55
SR 281 Spur	SR 281 to I-90	2.65	0.00	4.34	1.69
SR 303	SR 304 to SR 3	0.00B	0.00	9.16	9.32
SR 304	SR 3 to Bremerton Ferry	0.00	0.00	3.51	3.24
SR 305	Winslow Ferry to SR 3	0.02	0.00	13.52	13.50
SR 307	SR 305 to SR 104	0.00	0.00	5.25	5.25
SR 310	SR 3 to SR 304	0.00	0.00	1.84	1.84
US 395	Congressional High-Priority Route / I-82 to Canadian Border	13.05	19.81	270.26	275.09
SR 401	US 101 to SR 4	0.00	0.00	12.13	12.13
I-405	I-5 to I-5	0.00	0.00	30.32	30.30
SR 432	SR 4 to I-5	0.00	0.00	10.33	10.32
SR 433	Oregon State Line to SR 432	0.00	0.00	0.94	0.94
SR 500	I-5 to SR 503	0.00	0.00	5.96	5.96
SR 501	I-5 to Port of Vancouver	0.00	0.00	3.83	3.42
SR 502	I-5 to SR 503	0.00B	0.00	7.56	7.58
SR 503	SR 500 to SR 502	0.00	0.00	8.09	8.09
SR 509	12th Place S to SR 99	24.35B	26.13	29.83	33.11
SR 509	Pacific Ave to Marine View Drive	0.22	1.44	3.20	4.42
SR 512	I-5 to SR 167	0.00	0.00	12.06	12.06
SR 513	Sandpoint Naval Air Station	0.00	0.00	3.35	3.35
SR 516	I-5 to SR 167	2.03	2.02	4.72	4.99
SR 518	I-5 to SR 509	0.00	0.00	3.81	3.42
SR 519	I-90 to Seattle Ferry Terminal	0.00	0.00	1.14	1.14
SR 520	I-5 to SR 202	0.00	0.00	12.83	12.82
SR 522	I-5 to US 2	0.00	0.00	24.68	24.68
SR 524	Cedar Way Spur to I-5	4.64	4.76	5.32	5.44
SR 524 Spur	Cedar Way Spur – Lynnwood Park & Ride to SR 524	4.64	0.00	5.14	0.50
SR 525	I-5 to SR 20	0.00	0.00	30.49	30.72
SR 526	SR 525 to I-5	0.00	0.00	4.52	4.52
SR 529	I-5 to Everett Homeport	0.00	0.00	2.72	2.72
SR 539	I-5 to Canadian Border	0.00	0.00	15.16	15.16
SR 543	I-5 to Canadian Border	0.00	0.00	1.09	1.09
SR 546	SR 539 to SR 9	0.00	0.00	8.02	8.02
I-705	I-5 to Schuster Parkway	0.00	0.00	1.50	1.50
SR 970	I-90 to US 97	0.00	0.00	10.31	10.31

NHS Highways in Washington
Exhibit 1100-3 (continued)

See the following pages for Design Matrices 1–5

See the following pages for Design Matrices 1–5

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⇩ Project Type	Main Line															Bridges			Barriers		
Design Elements ⇨	Horizontal Alignment	Vertical Alignment	Lane Width	Shoulder Width [13]	On / Off Connection	Median Width	Cross Slope Lane	Cross Slope Shoulder	Fill / Ditch Slopes	Clear Zone	Signing [10]	Delineation [9]	Illumination	Vertical Clear. [11]	Bike and Pedestrian	Lane Width	Shoulder Width	Structural Capacity	Term. & Trans. Section [12]	Standard Run	Bridge Rail [14] [19]
(1-1) Preventative Maintenance																					
Pavement Restoration																					
(1-2) Diamond Grinding										EU	EU	F		DE					F	EU	F
(1-3) Milling with HMA Inlays									EU	F	EU	F		DE					F	EU	F
(1-4) Nonstructural Overlay				DE			EU	EU	EU	F	EU	F		EU					F	F	F
Pavement Rehab. / Resurf.																					
(1-5) HMA Structural Overlays	EU	DE	F	F	F[17]	DE	F	EU	F	F	EU	F	F	F		F	DE		F	F	F
(1-6) PCCP Overlays	EU	DE	F	F	F[17]	DE	F	EU	F	F	EU	F	F	F		F	DE		F	F	F
(1-7) Dowel Bar Retrofit	EU	DE	F	F	F[17]	DE	DE		F	F	EU	F	F	DE			DE		F	F	F
Bridge Rehabilitation																					
(1-8) Bridge Deck Rehabilitation												F		F		F	DE	[11]	F[6]	F[22]	F
Safety																					
(1-9) Median Barrier				DE															F[20]	F[20]	
(1-10) Guardrail Upgrades				DE						F									F	F[23]	
(1-11) Bridge Rail Upgrades																			F	F[22]	F
(1-12) Collision Analysis Locations	Design Elements determined based on a project analysis[27]																				
Reconstruction[16]																					
(1-13) New / Reconstruction	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

Design Matrix 1: Interstate Routes (Main Line)
Exhibit 1100-4

⇩ Project Type	Ramps and Collector Distributors																				Crossroad										
															Ramp Terminals			Barriers											Barriers		
Design Elements ⇨	Horizontal Alignment	Vertical Alignment	Lane Width	Shoulder Width	Lane Transition	On / Off Connection	Cross Slope Lane	Cross Slope Shoulder	Fill / Ditch Slopes	Limited Access	Clear Zone	Sign., Delin., Illum. [9] [10]	Vertical Clear. [11]	Bike and Pedestrian	Turn Radii	Angle	I/S Sight Distance	Term. & Trans. Section [12]	Standard Run	Bridge Rail [14] [19]	Lane Width	Shoulder Width	Fill / Ditch Slopes	Limited Access	Clear Zone	Sign., Delin., Illum. [10]	Vertical Clear. [11]	Bike and Pedestrian	Term. & Trans. Section [12]	Standard Run	Bridge Rail [14] [19]
(2-1) Preventative Maintenance																															
Pavement Restoration																															
(2-2) Diamond Grinding											EU	F[15]						F	EU	F					EU	F[15]			F	EU	F
(2-3) Milling With HMA Inlays									EU		F	F[15]	F	M				F	F	F			EU		F	F[15]		M	F	F	F
(2-4) Nonstructural Overlay							EU	EU	EU		F	F[15]	F	M				F	F	F			EU		F	F[15]		M	F	F	F
Pavement Rehab. / Resurf.																															
(2-5) HMA Structural Overlays	EU	DE	F	F	F	F[17]	F	EU	F	F	F	F[15]	F	M	F	F	F	F	F	F	DE	DE	DE	F	F	F[15]	F	M	F	F	F
(2-6) PCCP Overlays	EU	DE	F	F	F	F[17]	F	EU	F	F	F	F[15]	F	M	F	F	F	F	F	F	DE	DE	DE	F	F	F[15]	F	M	F	F	F
(2-7) Dowel Bar Retrofit	DE		DE	DE	F	F[17]	DE		F	F	F	F[15]	DE		F	F	F	F	F	F				F		F[15]			F	F	F
Bridge Rehabilitation																															
(2-8) Bridge Deck Rehabilitation													F	M				F[6]	F[22]	F							F	M	F[6]	F[22]	F
Safety																															
(2-9) Intersection			F	F	F				F	F	F	F		M	F	F	F	F	F	F			F	F	F	F	F	M	F	F	F
(2-10) Guardrail Upgrades				DE							F							F	F[23]										F	F[23]	
(2-11) Bridge Rail Upgrades																		F	F[22]	F									F	F[22]	F
(2-12) Collision Analysis Locations	Design Elements determined based on a Project Analysis[27]																														
Reconstruction[16]																															
(2-13) New / Reconstruction	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

Design Matrix 2: Interstate Interchange Areas
Exhibit 1100-5

⇩ Project Type		Main Line															Bridges[11]				Intersections			Barriers		
Design Elements ⇨		Horizontal Alignment	Vertical Alignment	Lane Width	Shoulder Width	Lane Transition	On / Off Connection	Median Width	Cross Slope Lane	Cross Slope Shoulder	Fill / Ditch Slopes	Access [3]	Clear Zone [18]	Sign., Del., Illum.	Basic Safety	Bike & Ped.	Lane Width	Shoulder Width	Vertical Clearance	Structural Capacity	Turn Radii	Angle	I/S Sight Distance	Term. & Trans. Section [12]	Standard Run	Bridge Rail [14] [19]
Preservation																										
Roadway																										
(3-1)	Non-Interstate Freeway	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F		B	B		DE/F	DE/F	F					F	B	F
(3-2)	HMA/PCCP/BST Overlays	DE/M	DE/M	DE/M	DE/M	DE/F	DE/F	DE/M	DE/M	DE/M	DE/M			B	B	M	DE/M	DE/M	F				B	F	B	F
(3-3)	Replace HMA w/PCCP at I/S	DE/M	DE/M	EU/M	EU/M	DE/F		DE/M	EU/M	DE/M	DE/M			B	B	M	DE/M	DE/M	F				B	F	B	F
Structures																										
(3-4)	Bridge Replacement	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F[2]		F	F		F	F[2]	F[2]	F	F	F[2]	F[2]	F	F	F	F
(3-5)	Bridge Deck Rehab.													B	B	M			F					F[6]	F[22]	F
Improvements[16]																										
Mobility																										
(3-6)	Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	F	F
(3-7)	Urban	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F	F	F[2]	F[2]	F	F	F	F
(3-8)	Rural	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F	F	F[2]	F[2]	F	F	F	F
(3-9)	HOV	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F	F	F[2]	F[2]	F	F	F	F
(3-10)	Bike/Ped. Connectivity	[5]	[5]	[5]	[5]	[5]			[5]	[5]	[5]	[5]	[5]	[5]		F	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]
Safety																										
(3-11)	Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F		F	F	F	F	F	F
(3-12)	Intersection[1]			F[2]	F[2]	F					F[2]	F	F	F		M					F	F	F	F	F	F
(3-13)	Corridor[1][24]	M[4]	M[4]	M[4]	M[4]	F	F[17]	M[4]	M[4]	M[4]	M[4]	F	F	F		F	M[4]	M[4]	F		M[4]	M[4]	F	F	F	F
(3-14)	Median Barrier				DE/F																			F[20]	F[20]	
(3-15)	Guardrail Upgrades				DE/F																			F	F[23]	
(3-16)	Bridge Rail Upgrades																							F	F[22]	F
(3-17)	Risk: Roadside										F	EU/F	F	F										F	F	F
(3-18)	Risk: Sight Distance	F/M[21]	F/M[21]	F/M[21]	F/M[21]						F/M[21]	F[21]	F[21]	F		F	F[21]	F[21]	F[21]		F/M[21]	F/M[21]	F[21]	F	F	F
(3-19)	Risk: Roadway Width			F/M[21]	F/M[21]	F[21]	F[21]	F/M[21]	F/M[21]	F/M[21]	F/M[21]	F	F	F		F	F[21]	F[21]	F[21]		F/M[21]	F/M[21]	F[21]	F	F	F
(3-20)	Risk: Realignment	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F		F[2]	F[2]	F[2]	F	F	F
(3-21)	Collision Analysis Locations	Design Elements determined based on a Project Analysis[27]																								
Economic Development																										
(3-22)	Freight & Goods (Frost Free)[8]	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F[2]	EU/F	F	B		EU/F[26]	DE/F	DE/F	F	F	EU/F	EU/F	EU/F	F	F	F
(3-23)	Four-Lane Trunk System	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	F	F
(3-24)	Rest Areas (New)	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F		F	F	F	F	F	F
(3-25)	Bridge Restrictions	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F[2]		F	F		EU/F[26]	F[2]	F[2]	F	F	F[2]	F[2]	F	F	F	F
(3-26)	Bike Routes (Shldrs)			EU/M	[7]	EU/F				EU/M	EU/M			B	B	F	EU/M	EU/M	F				B	F	B	EU/F

Design Matrix 3: Main Line NHS Routes (Except Interstate)
Exhibit 1100-6

⇩ Project Type	Ramps and Collector-Distributors																				Crossroad											
															Ramp Terminals			Barriers												Barriers		
Design Elements ⇨	Horizontal Alignment	Vertical Alignment	Lane Width	Shoulder Width	Lane Transition	On / Off Connection	Cross Slope Lane	Cross Slope Shoulder	Fill / Ditch Slopes	Access [3]	Clear Zone	Sign., Del., Illum.	Basic Safety	Bike & Ped	Turn Radii	Angle	I/S Sight Distance	Term. & Trans. Section [12]	Standard Run	Bridge Rail [14] [19]	Lane Width	Shoulder Width	Fill / Ditch Slopes	Access [3]	Clear Zone	Sign., Del., Illum.	Basic Safety	Vertical Clearance [11]	Ped. & Bike	Term. & Trans. Section [12]	Standard Run	Bridge Rail [14] [19]
Preservation																																
Roadway																																
(4-1) Non-Interstate Freeway	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F	DE/F		B	B	M	DE/F	DE/F	DE/F	F	B	F	DE/F	DE/F	DE/F			B	B	F	M	F	B	F
(4-2) HMA/PCCP/BST Overlay Ramps												B	B	M			B	F	B	F						B	B	F	M	F	B	F
Structures																																
(4-3) Bridge Replacement	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F	F	F	F	F	F	F[2]	F[2]	F[2]	F	F	F		F	F	F	F	F
(4-4) Bridge Deck Rehab.												B	B	M				F[6]	F[22]	F						B	B	F	M	F[6]	F[22]	F
Improvements[16]																																
Mobility																																
(4-5) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F
(4-6) Urban	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F	F	F	F	F[2]	F[2]	F[2]	F	F	F		F	F	F	F	F
(4-7) Rural	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F	F	F	F	F[2]	F[2]	F[2]	F	F	F		F	F	F	F	F
(4-8) HOV Bypass	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F	F	F	F	F[2]	F[2]	F[2]	F	F	F		F	F	F	F	F
(4-9) Bike/Ped. Connectivity	[5]	[5]	[5]	[5]	[5]		[5]	[5]	[5]	[5]	[5]	[5]		F	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]			[5]		[5]	F	[5]	[5]	[5]
Safety																																
(4-10) Non-Interstate Freeway	F	F	F	F	F	F	F	F	F	F	F	F		M	F	F	F	F	F	F	F	F	F	F	F	F		F	M	F	F	F
(4-11) At Grade[1][25]	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F	F	F	F	F[2]	F[2]	F[2]	F	F	F		F	F	F	F	F
(4-12) Intersection[1]			F[2]	F[2]	F				F[2]	F	F	F		M	F	F	F	F	F]	F			F[2]	F	F	F		F	M	F	F	F
(4-13) Guardrail Upgrades				DE/F														F	F[23]											F	F[23]	
(4-14) Bridge Rail Upgrades																														F	F[22]	F
(4-15) Risk: Roadside									F	EU/F	F	F											F	EU/F	F	F				F	F	F
(4-16) Risk: Sight Distance	F/M[21]	F/M[21]	F/M[21]	F/M[21]					F/M[21]	F[21]	F[21]	F		F	F/M[21]	F/M[21]	F	F	F	F			F/M[21]	F[21]	F[21]			F[21]	F			
(4-17) Risk: Roadway Width			F/M[21]	F/M[21]	F	F[21]	F/M[21]	F/M[21]	F/M[21]	F	F	F		F	F/M[21]	F/M[21]	F	F	F	F	F/M[21]	F/M[21]	F/M[21]	F	F			F[21]	F	F	F	F
(4-18) Risk: Realignment	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F/M[21]	F/M[21]	F	F	F	F	F[2]	F[2]	F[2]	F	F			F[21]	F	F	F	F
(4-19) Collision Analysis Locations	Design Elements determined based on a Project Analysis[27]																															
Economic Development																																
(4-20) Four-Lane Trunk System	F	F	F	F	F	F	F	F	F	F	F	F			F		F	F	F	F	F	F	F	F	F	F		F		F	F	F

Design Matrix 4: Interchange Areas, NHS (Except Interstate), and Non-NHS
Exhibit 1100-7

⇩ Project Type / Design Elements ⇨	Main Line: Horizontal Alignment	Vertical Alignment	Lane Width	Shoulder Width	Lane Transition	Median Width	Cross Slope Lane	Cross Slope Shoulder	Fill / Ditch Slopes	Access [3]	Clear Zone [18]	Sign., Del., Illum.	Basic Safety	Bike & Ped.	Bridges[11]: Lane Width	Shoulder Width	Vertical Clearance	Structural Capacity	Intersections: Turn Radii	Angle	I/S Sight Distance	Barriers: Term. & Trans. Section [12]	Standard Run	Bridge Rail [19]
Preservation																								
Roadway																								
(5-1) HMA/PCCP												B	B	M			F				B	F	B	F
(5-2) BST																								
(5-3) BST Routes/Basic Safety												B	B								B	F	B	F
(5-4) Replace HMA w/PCCP at I/S			EU/M	EU/M		DE/M	EU/M					B	B	M			F					F	B	F
Structures																								
(5-5) Bridge Replacement	M	F	M	M	F		M	M	M		F	F		F	F[2]	F[2]	F	F	M	M	F	F	F	F
(5-6) Bridge Repl. (Multilane)	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]		F	F		F	F[2]	F[2]	F	F	F[2]	F[2]	F	F	F	F
(5-7) Bridge Deck Rehab.												B	B	M								F[6]	F[22]	F
Improvements[16]																								
Mobility																								
(5-8) Urban (Multilane)	F[2]	F[2]	F[2]	F[2]	F	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F	F	EU/F	EU/F	F	F	F	F
(5-9) Urban	M	M	M	M	F		M	M	M	F	F	F		F	M	M	F	F	EU/M	EU/M	F	F	F	F
(5-10) Rural	M	M	M	M	F	M	M	M	M	F	F	F		F	M	M	F	F	EU/M	EU/M	F	F	F	F
(5-11) HOV	M	M	M	M	F	M	M	M	M	F	F	F		F	M	M	F	F	EU/M	EU/M	F	F	F	F
(5-12) Bike/Ped. Connectivity	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]		F	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]
Safety																								
(5-13) Non-Interstate Freeway	F[2]	F[2]	F[2]	F[2]	F[2]	F[2]	F[2]	F[2]	F[2]	F	F	F		F	F[2]	F[2]	F		F[2]	F[2]	F	F	F	F
(5-14) Intersection[1]			M[4]	M[4]	F				M[4]	F	F	F		M					M[4]	M[4]	F	F	F	F
(5-15) Corridor[1][24]	M[4]	M[4]	M[4]	M[4]	F	M[4]	M[4]	M[4]	M[4]	F	F	F		M	M[4]	M[4]	F		M[4]	M[4]	F	F	F	F
(5-16) Median Barrier				DE/F																		F[20]	F[20]	
(5-17) Guardrail Upgrades				DE/F																		F	F[23]	
(5-18) Bridge Rail Upgrades																						F	F[22]	F
(5-19) Risk: Roadside									M[4]	EU/F	F	F										F	F	F
(5-20) Risk: Sight Distance	F/M[21]	F/M[21]	F/M[21]	F/M[21]					F/M[21]	F[21]	F[21]	F		F	F[21]	F[21]	F[21]		F/M[21]	F/M[21]	F[21]	F	F	F
(5-21) Risk: Roadway Width			F/M[21]	F/M[21]	F	F/M[21]	F/M[21]	F/M[21]	F/M[21]	F	F	F		F	F[21]	F[21]	F[21]		F/M[21]	F/M[21]	F[21]	F	F	F
(5-22) Risk: Realignment	F/M	F/M	F/M	F/M	F	F/M	F[2]	F[2]	F/M	F	F	F		F	F[21]	F[21]	F[21]		F/M[21]	F/M[21]	F[21]	F	F	F
(5-23) Collision Analysis Locations	Design Elements determined based on a Project Analysis[27]																							
Economic Development																								
(5-24) Freight & Goods (Frost Free)[8]	EU/M	EU/M	EU/M	EU/M	EU/M	EU/M	M	M	EU/M		F	B	B	EU/F[26]	DE/M	DE/M	F		EU/M	EU/M	EU/F	F	B	F
(5-25) Rest Areas (New)	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F			F	F	F	F	F	F
(5-26) Bridge Restrictions	M	F	M	M	F	M	M	M	M		F	F		EU/F[26]	M	M	F	F	M	M	F	F	F	F
(5-27) Bike Routes (Shldrs)			EU/M	[7]	EU/F			EU/M	EU/M			B	B	F	EU/M	EU/M					B	F	B	EU/F

Design Matrix 5: Main Line Non-NHS Routes
Exhibit 1100-8

Design Matrix Notes:

- ▢ A blank cell indicates that the element is not applicable.
- **F** Full design level (see Chapter 1140).
- **M** Modified design level (see Chapter 1130).
- **DE** Design Exception to full design level.
- **EU** Evaluate Upgrade to full design level.

[1] Collision Reduction or Collision Prevention (At-Grade Removal, Signalization & Channelization). Specific deficiencies that created the project must be upgraded to design level as stated in the matrix.

[2] Modified design level may apply based on a corridor or project analysis (see 1100.03(6)).

[3] If designated as L/A acquired in the Access Control Tracking System, limited access requirements apply. If not, managed access applies (see 1100.03(6)).

[4] Full design level may apply based on a corridor or project analysis (see 1100.03(6)).

[5] For bike/pedestrian design, see Chapters 1520 and 1510.

[6] Applies only to bridge end terminals and transition sections.

[7] 4-ft minimum shoulders.

[8] If all-weather structure can be achieved with spot digouts and overlay, modified design level applies to NHS highways and basic design level applies to non-NHS highways.

[9] Continuous shoulder rumble strips required in rural areas (see Chapter 1600).

[10] See Chapter 1020.

[11] See Chapter 720.

[12] Impact attenuators are considered as terminals.

[13] See Chapters 1140 and 1230.

[14] Includes crossroad bridge rail (see Chapter 1610).

[15] EU for signing and illumination.

[16] For design elements not in the matrix headings, apply full design level as found in the applicable chapters and see 1100.03(2).

[17] DE for existing acceleration/deceleration lanes when length meets posted freeway speed and no significant crash history (see Chapter 1360).

[18] On managed access highways within the limits of incorporated cities and towns, city and county design standards apply to areas outside the curb or outside the paved shoulder where no curb exists.

[19] The funding sources for bridge rail are a function of the length of the bridge. Consult programming personnel.

[20] Applies to median elements only.

[21] Analyses required (see 1100.03(6) for details).

[22] Upgrade barrier, if necessary, within 200 ft of the end of the bridge.

[23] See description of Guardrail Upgrades Project Type, 1100.03(1), regarding length of need.

[24] Apply full design level to projects that realign or reconstruct significant portions of the alignment.

[25] For main line, use the Project Type row for Safety, Non-Interstate Freeway on Matrix 3 for NHS and on Matrix 5 for non-NHS.

[26] Sidewalk ramps must be addressed for ADA compliance (see Chapter 1510).

[27] Collision Analysis Locations (CALs) require a project analysis to document the needs at a location and determine the appropriate design elements to address.

Design Matrix Notes

Exhibit 1100-9

Radius of Centerline, R (ft)	Minimum Total Roadway Width[1], W (ft)	Minimum Lane Width, L (ft)
Tangent	26	11
900	26	11
800	27	12
700	27	12
600	28	12
500	28	12
400	29	12
350	30	12
300	31	12
250	33	13
200	35	13
150	39	13

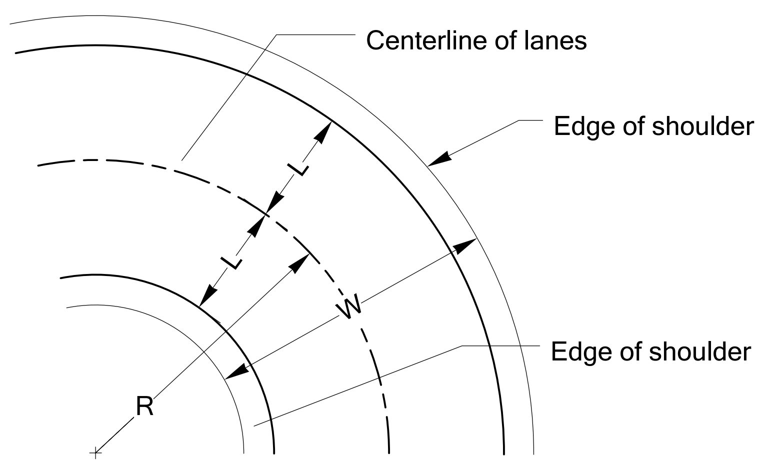
Notes:

Also see minimums from Exhibit 1130-11. If the minimum total roadway width is greater than the sum of the shoulders and lane widths, apply the extra width to the inside of the curve.

[1] Total width may include the shoulders.

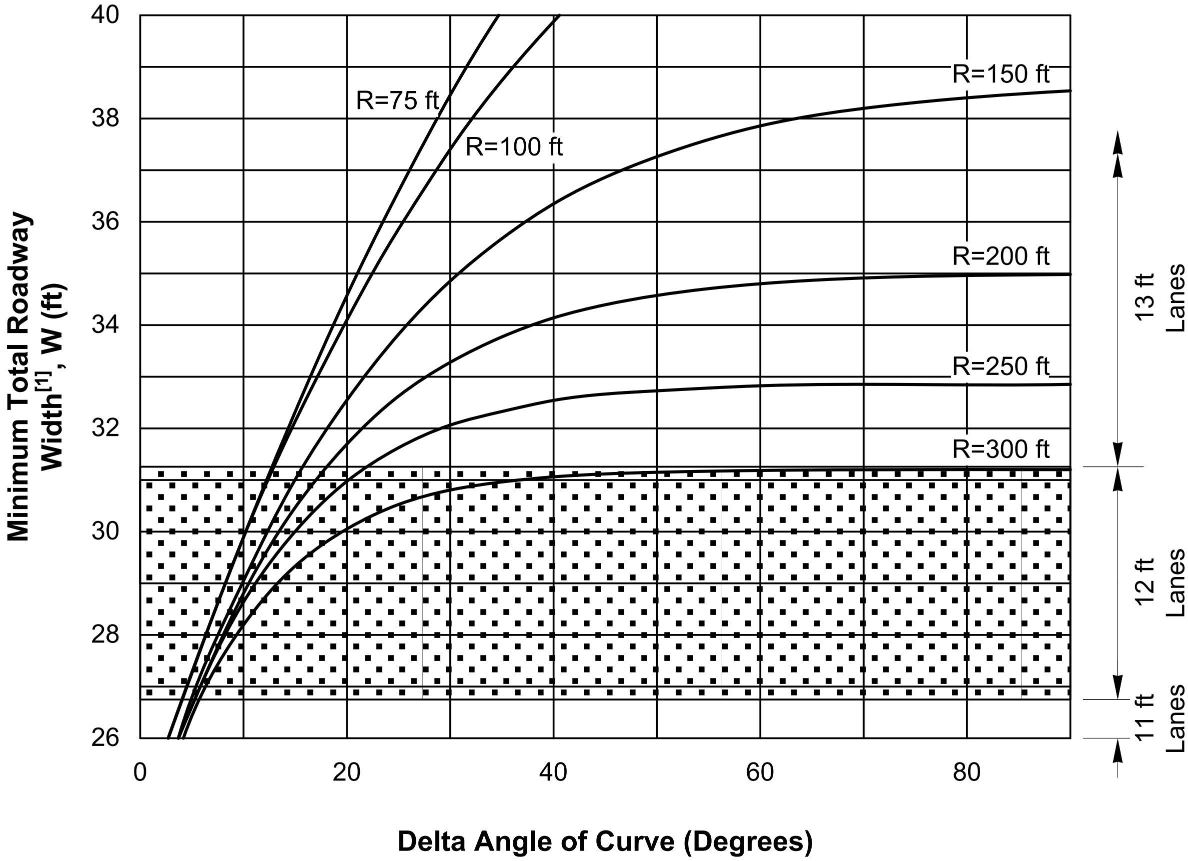
Roadway width is based on:

- WB-63 design vehicle (the WB-63 was used as the design vehicle with 48-ft trailer adopted in the 1982 Surface Transportation Assistance Act).
- 2.5-ft clearance per lane.



Minimum Total Roadway Widths for Two-Lane Two-Way Highway Curves: Modified Design Level

Exhibit 1130-12a



Notes:

May be used when the internal angle (delta) is less than 90°.

If result is less than the total roadway width from Exhibit 1130-11, use the greater.

[1] Total width may include the shoulders.

Roadway width is based on:

- WB-63 design vehicle (the WB-63 was used as the design vehicle with 48-ft trailer adopted in the 1982 Surface Transportation Assistance Act).
- 2.5-ft clearance per lane.

Minimum Total Roadway Widths for Two-Lane Two-Way Highway Curves: Modified Design Level, Based on the Delta Angle

Exhibit 1130-12b

1140.09 Shoulders

Shoulder width is controlled by the functional classification of the roadway, the traffic volume, and the shoulder function.

The more important shoulder functions and the associated minimum widths are given in Exhibit 1140-2. In addition to the functions in Exhibit 1140-2, shoulders also:

- Provide space to escape potential accidents or reduce their severity.
- Provide a sense of openness, contributing to driver ease and freedom from strain.
- Reduce seepage adjacent to the traveled way by discharging stormwater farther away.

Shoulder Function	Minimum Shoulder Width
Stopping out of the traffic lanes	8 ft[1]
Minimum lateral clearance	2 ft[2]
Pedestrian or bicycle use	4 ft[3]
Large-vehicle off-tracking on curves	See Chapters 1130, 1240 & 1310
Maintenance operations	Varies[4]
Law enforcement	8 ft[5]
Bus stops	See Chapter 1430
Slow-vehicle turnouts and shoulder driving	See Chapter 1270
Ferry holding	8 ft[6]
For use as a lane during reconstruction of the through lanes	8 ft[6]
Structural support of pavement	2 ft
Improve sight distance in cut sections	See Chapter 1260
Improve capacity	See Chapter 320

Notes:

[1] 10-ft minimum for trucks; 12-ft preferred.

[2] See Chapters 1600 and 1610.

[3] Minimum usable shoulder width for bicycles. For guidance, see Chapter 1520 for accommodating bicycles and Chapter 1510 for accommodating pedestrians.

[4] 10-ft usable width to park a maintenance truck out of the through lane; 12-ft clearance (14-ft preferred) for equipment with outriggers to work out of traffic.

[5] For additional information, see Chapters 1410 and 1720.

[6] Minimum usable shoulder width (10-ft preferred).

Minimum Shoulder Width
Exhibit 1140-2

Contact the region Maintenance Office to determine the shoulder width for maintenance operations. When shoulder widths wider than called for in Exhibits 1140-5 through 1140-9 are requested, compare the added cost of the wider shoulders to the added benefits to maintenance operations as well as other benefits that may be derived. When the region Maintenance Office requests a shoulder width different than the design class, provide justification for the width selected.

Minimum shoulder widths for use on all rural highways and limited access highways in urban design areas are based on functional classification and traffic volume (see Exhibits 1140-5 through 1140-8). Exhibit 1140-9 gives the minimum shoulder widths for urban managed access highways without curb. (See Chapter 1310 for guidance on shoulder widths at intersections.)

When curb with a height less than 24 inches is present on urban managed access highways, provide the minimum shoulder widths shown in Exhibit 1140-3. For information on curbs, see 1140.11.

When traffic barrier with a height of 2 feet or greater is used adjacent to the roadway, the minimum shoulder width from the edge of traveled way to the face of the traffic barrier is 4 feet. Additional width for traffic barrier shy distance (see Chapter 1610) is normally not provided on urban managed access highways.

Where there are no sidewalks, the minimum shoulder width is 4 feet. Shoulder widths less than 4 feet will require that wheelchairs using the roadway encroach on the through lane. For additional information and guidance regarding pedestrians and accessible routes, see Chapter 1510.

Lane Width	Posted Speed			
	>45 mph	≤45 mph	>45 mph	≤45 mph
	On Left		On Right[3]	
12 ft or wider	4 ft	[1][2]	4 ft	2 ft
11 ft	4 ft	[1][2]	4 ft	3 ft[4]

Notes:

[1] When mountable curb is used on routes with a posted speed of 35 mph or lower, shoulder width is desirable; however, with justification, curb may be placed at the edge of traveled way.

[2] 1 ft for curbs with a height of 8 inches or less. 2 ft for curbs or barriers with a height between 8 and 24 inches.

[3] When the route has been identified as a local, state, or regional significant bike route, the minimum shoulder width is 4 ft. Where signed bike lanes are present, see Chapter 1520 for guidance.

[4] When bikes are not a consideration, width may be reduced to 2 ft with justification.

[5] Measured from the edge of traveled way to the face of curb.

Shoulder Width for Curbed Sections[5] in Urban Areas
Exhibit 1140-3

1140.12 Parking

In urban design areas and rural communities, land use might make parking along the highway desirable. In general, on-street parking decreases capacity, increases accidents, and impedes traffic flow; therefore, it is desirable to prohibit parking.

Although design data for parking lanes are included in Exhibits 1140-6 through 1140-9, consider them only in cooperation with the municipality involved. The lane widths given are the minimum for parking; provide wider widths when feasible.

Angle parking is not permitted on any state route without WSDOT approval (RCW 46.61.575). This approval is delegated to the State Traffic Engineer. Angle parking approval is to be requested through the Headquarters (HQ) Design Office. Provide an engineering study, approved by the region Traffic Engineer, with the request documenting that the parking will not unduly reduce safety and that the roadway is of sufficient width that parking will not interfere with the normal movement of traffic.

1140.13 Pavement Type

The pavement types given in Exhibits 1140-5 through 1140-8 are those recommended for each design class. (See Chapter 620 for information on pavement type selection.) When a roadway is to be widened and the existing pavement will remain, the new pavement type may be the same as the existing without a pavement type determination.

1140.14 Structure Width

Provide a clear width between curbs <u>or barrier</u> on a structure not less than the approach roadway width (lanes plus shoulders). The structure widths given in Exhibits 1140-5 through 1140-9 are the minimum structure widths for each design class.

Additional width for <u>shy to</u> barriers is not normally added to the roadway width on structures. When a structure is in a run of roadside barrier with the added width, consider adding the width on shorter structures to keep a constant roadway width.

1140.15 Right of Way Width

Provide right of way width sufficient to accommodate roadway elements and appurtenances for the current design and known future improvements. To allow for construction and maintenance activities, provide 10 feet desirable, 5 feet minimum, wider than the slope stake for fill and slope treatment for cut. For slope treatment information, see Chapter 1230 and the *Standard Plans*.

The right of way widths given in Exhibits 1140-5 through 1140-8 are desirable minimums for new alignment requiring purchase of new right of way. For additional information on right of way acquisition, see Chapter 510.

1140.16 Grades

Grades can have a pronounced effect on the operating characteristics of the vehicles negotiating them. Generally, passenger cars can readily negotiate grades as steep as 5% without appreciable loss of speed from that maintained on level highways. Trucks, however, travel at the average speed of passenger cars on the level roadway, but they display up to a 5% increase in speed on downgrades and a 7% or greater decrease in speed on upgrades (depending on length and steepness of grade as well as weight-to-horsepower ratio).

The maximum grades for the various functional classes and terrain conditions are shown in Exhibits 1140-5 through 1140-8. For the effects of these grades on the design of a roadway, see Chapters 1220, 1260, 1270, 1310, and 1360.

1140.17 Fencing

Remove rigid top rails and brace rails from existing fencing and retrofit with a tension wire design. For information on fencing, see Chapter 560.

1140.18 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/

Divided Multilane		
Design Class	I-1	
Design Year	[1]	
Access Control[2]	Full	
Separate Cross Traffic		
Highways	All	
Railroads	All	
Design Speed (mph)[3]		
Rural	80[4]	
Urbanized	70[5]	
Traffic Lanes		
Number	4 or more divided	
Width (ft)	12	
Median Width (ft)[6]	Minimum width is as required for shoulders and barrier (including shy distance) or ditch (see 1140.10).	
Shoulder Width (ft)[7]	4 lanes	6 or more lanes
Right of Traffic	10[8]	10[8]
Left of Traffic	4	10[8][9]
Pavement Type[10]	High	
Right of Way Width (ft)[11]		
Rural	63 from edge of traveled way	
Urban	As required[12]	
Structures Width (ft)[13]	Full roadway width each direction[14]	

Type of Terrain	Design Speed (mph)						
	50	55	60	65	70	75	80
Level	4	4	3	3	3	3	3
Rolling	5	5	4	4	4	4	4
Mountainous	6	6	6	6	5	5	5

Grades (%)[15]

Interstate Notes:

[1] The design year is 20 years after the year the construction is scheduled to begin.

[2] For access control, see Chapter 530.

[3] For existing roadways, see 1140.07.

[4] 80 mph is the desirable design speed; with a corridor analysis, the design speed may be reduced to 60 mph in mountainous terrain and 70 mph in rolling terrain. Do not select a design speed that is less than the posted speed.

[5] 70 mph is the desirable design speed; with a corridor analysis, the design speed may be reduced to 50 mph. Do not select a design speed that is less than the posted speed.

[6] Independent alignment and grade are desirable in rural areas and where terrain and development permit in urban areas.

[7] When guardrail is installed along existing shoulders with a width greater than 4 ft, the shoulder width may be reduced by up to 4 inches.

[8] 12-ft shoulders are desirable when the truck DDHV is 250 or greater.

[9] For existing 6-lane roadways, an existing 6-ft left shoulder is a design exception when the shoulder is not being reconstructed and no other widening will be provided.

[10] For pavement type determination, see Chapter 620.

[11] Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut (see 1140.15).

[12] In urban areas, make right of way widths not less than those for cross section elements.

[13] For minimum vertical clearance, see Chapter 720.

[14] For median widths 26 ft or less, address bridge(s) in accordance with Chapter 720.

[15] Grades 1% steeper may be provided in urban areas and mountainous terrain with critical right of way controls.

Geometric Design Data: Interstate
Exhibit 1140-5

Design Class	Divided Multilane				Two-Lane						Undivided Multilane	
	P-1		P-2		P-3		P-4		P-5		P-6[1]	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
DHV in Design Year[2] NHS Non-NHS	Over 1,500		Over 700[3]		Over 201[4] Over 301		61–200 101–300		60 and Under 100 and Under		Over 700[3]	
Access Control[5]	Full		Partial[6]									
Separate Cross Traffic Highways Railroads[7]	 All All		 Where Justified All		 Where Justified All[8]		 Where Justified Where Justified[9]		 Where Justified Where Justified[9]		 Where Justified Where Justified[9]	
Design Speed (mph)[10] Desirable[11] Minimum[12]	 80 60[13]		 70 50[14]		 70 50	 60 40[14]	 70 50	 60 40[14]	 60 40	 60 30[14]	 70 40	 60 30[14]
Traffic Lanes Number Width (ft)	 4 or more divided 12		 4 or 6 divided 12		 2 12		 2 12		 2 12		 4 12	 4 or 6 11[15]
Shoulder Width (ft)[16] Right of Traffic Left of Traffic	 10[17] Variable[19][20]		 10 Variable[19][20]		8[31]		6		4		8[32]	8[18]
Median Width (ft)	Minimum width is as required for shoulders and barrier (including shy distance) or ditch (see 1140.10)										(See 1140.10)	
Parking Lanes Width (ft) – Minimum	None		None		None		None	10	None	10	None	10[21]
Pavement Type[22]	High				High or Intermediate							
Right of Way Width (ft)[23]	[24]	[25]	[24]	[25]	120	80	120	80	100	80	150	80
Structures Width (ft)[26]	Full Roadway Width[27]				40		36[33]		32		Full Rdwy Width	
Other Design Considerations–Urban					[28]		[28]		[28]		[28]	

Type of Terrain	Rural Design Speed (mph)									Urban Design Speed (mph)						
	40	45	50	55	60	65	70	75	80	30	35	40	45	50	55	60[29]
Level	5	5	4	4	3	3	3	3	3	8	7	7	6	6	5	5
Rolling	6	6	5	5	4	4	4	4	4	9	8	8	7	7	6	6
Mountainous	8	7	7	6	6	5	5	5	5	11	10	10	9	9	8	8

Grades (%)[30]

Geometric Design Data: Principal Arterial
Exhibit 1140-6

Principal Arterial Notes:

[1] Justify the selection of a P-6 design class on limited access highways.

[2] The design year is 20 years after the year the construction is scheduled to begin.

[3] When considering a multilane highway, perform an investigation to determine whether a truck-climbing lane or passing lane will satisfy the need (see Chapter 1270).

[4] Where DHV exceeds 700, consider 4 lanes. When the volume/capacity ratio is equal to or exceeds 0.75, consider the needs for a future 4-lane facility. When considering truck-climbing lanes on a P-3 design class highway, perform an investigation to determine whether a P-2 design class highway is justified.

[5] For access control, see Chapters 530 and 540 and the Limited Access and Managed Access Master Plan. Contact the HQ Design Office Access & Hearings Unit for additional information.

[6] Full or modified access control may also be used.

[7] Contact the Rail Office of the Public Transportation and Rail Division for input on railroad needs.

[8] Separate main line and major spur railroad tracks. Consider allowing at-grade crossings at minor spur railroad tracks.

[9] Criteria for railroad grade separations are not clearly definable. Evaluate each site regarding the risk. Provide justification for railroad grade separations.

[10] For existing roadways, see 1140.07.

[11] These are the design speeds for level and rolling terrain in rural design areas. They are the desirable design speeds for mountainous terrain and urban design areas. Higher design speeds may be selected, with justification.

[12] These design speeds may be selected in mountainous terrain, with a corridor analysis. Do not select a design speed that is less than the posted speed.

[13] In urbanized areas, with a corridor analysis, 50 mph may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

[14] In urban design areas, with a corridor analysis, these values may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

[15] Provide 12-ft lanes when the truck DDHV is 150 or greater.

[16] When guardrail is installed along existing shoulders with a width greater than 4 ft, the shoulder width may be reduced by 4 inches.

[17] 12-ft shoulders are desirable when the truck DDHV is 250 or greater.

[18] When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft.

[19] Minimum left shoulder width is to be as follows: 4 lanes – 4 ft; 6 or more lanes – 10 ft. Consider 12-ft shoulders on facilities with 6 or more lanes and a truck DDHV of 250 or greater.

[20] For existing 6-lane roadways, an existing 6-ft left shoulder is a design exception when the shoulder is not being reconstructed and no other widening will be provided.

[21] Restrict parking when DHV is over 1500.

[22] For pavement type determination, see Chapter 620.

[23] Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut (see 1140.15).

[24] 63 ft from edge of traveled way.

[25] Make right of way widths not less than those for cross section elements.

[26] For the minimum vertical clearance, see Chapter 720.

[27] For median widths 26 ft or less, address bridges in accordance with Chapter 720.

[28] For bicycle guidelines, see Chapter 1510. For pedestrian and sidewalk guidelines, see Chapter 1520. Curb guidelines are in 1140.11. Lateral clearances from the face of curb to obstruction are in Chapter 1600.

[29] For grades at design speeds greater than 60 mph in urban design areas, use rural criteria.

[30] Grades 1% steeper may be used in urban design areas and mountainous terrain with critical right of way controls.

[31] Consider 10-ft shoulders when truck DHV is 250 or greater.

[32] Consider 10-ft shoulders when truck DDHV is 250 or greater.

[33] Consider 40 ft for shorter structures.

Geometric Design Data: Principal Arterial
Exhibit 1140-6 (continued)

Design Class	Divided Multilane		Two-Lane						Undivided Multilane	
	M-1		**M-2**		**M-3**		**M-4**		**M-5**[1]	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
DHV in Design Year[2] NHS	Over 700[3]		Over 201[4]		61–200		60 and Under		Over 700[3]	
Non-NHS			Over 401		201–400		200 and Under			
Access Control[5]	Partial[6]									
Separate Cross Traffic										
Highways	Where Justified		Where Justified		Where Justified		Where Justified		Where Justified	
Railroads[7]	All		All[8]		Where Justified[9]		Where Justified[9]		Where Justified[9]	
Design Speed (mph)[10]										
Desirable[11]	70		70	60	70	60	60	60	70	60
Minimum[12][13]	50		50	40	50	40	40	30	40	30
Traffic Lanes										
Number	4 or 6 divided		2		2		2		4	4 or 6
Width (ft)	12		12		12		12		12	11[14]
Shoulder Width (ft)[15]										
Right of Traffic	10		8[30]		6		4		8[31]	8[16]
Left of Traffic	Variable[17][18]									
Median Width (ft)	[19]								[19]	
Parking Lanes Width (ft) – Minimum	None		None		None	10	None	10	None	10[20]
Pavement Type[21]	High								High or Intermediate	
Right of Way Width (ft)[22]	[23]	[24]	120	80	120	80	100	80	150	80
Structures Width (ft)[25]	Full Rdwy Width[26]		40		36[32]		32		Full Rdwy Width	
Other Design Considerations–Urban			[27]		[27]		[27]		[27]	

Type of Terrain	Rural Design Speed (mph)									Urban Design Speed (mph)					
	40	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**30**	**35**	**40**	**45**	**50**	**55**	**60**[28]
Level	5	5	4	4	3	3	3	3	3	8	7	7	6	6	5	5
Rolling	6	6	5	5	4	4	4	4	4	9	8	8	7	7	6	6
Mountainous	8	7	7	6	6	5	5	5	5	11	10	10	9	9	8	8

Grades (%)[29]

Geometric Design Data: Minor Arterial
Exhibit 1140-7

Minor Arterial Notes:

[1] Justify the selection of an M-5 design class on limited access highways.

[2] The design year is 20 years after the year the construction is scheduled to begin.

[3] When considering a multilane highway, perform an investigation to determine whether a truck-climbing lane or passing lane will satisfy the need (see Chapter 1270).

[4] Where DHV exceeds 700, consider 4 lanes. When the volume/capacity ratio is equal to or exceeds 0.75, consider the needs for a future 4-lane facility. When considering truck-climbing lanes on an M-2 design class highway, perform an investigation to determine whether an M-1 design class highway is justified.

[5] For access control, see Chapters 530 and 540 and the Limited Access and Managed Access Master Plan. Contact the Access & Hearings Section of the HQ Design Office for additional information.

[6] Full or modified access control may also be used.

[7] Contact the Rail Office of the Public Transportation and Rail Division for input on railroad needs.

[8] Separate main line and major spur railroad tracks. Consider allowing at-grade crossings at minor spur railroad tracks.

[9] Criteria for railroad grade separations are not clearly definable. Evaluate each site regarding the risk. Provide justification for railroad grade separations.

[10] For existing roadways, see 1140.07.

[11] These are the design speeds for level and rolling terrain in rural design areas. They are the desirable design speeds for mountainous terrain and urban design areas. Higher design speeds may be selected, with justification.

[12] In urban design areas, with a corridor analysis, these values may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

[13] These design speeds may be selected in mountainous terrain, with a corridor analysis. Do not select a design speed that is less than the posted speed.

[14] When the truck DDHV is 150 or greater, consider 12-ft lanes.

[15] When guardrail is installed along existing shoulders with a width greater than 4 ft, the shoulder width may be reduced by 4 inches.

[16] When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft.

[17] The minimum left shoulder width is 4 ft for 4 lanes and 10 ft for 6 or more lanes.

[18] For existing 6-lane roadways, an existing 6-ft left shoulder is a design exception when the shoulder is not being reconstructed and no other widening will be provided.

[19] Minimum median width is as required for shoulders and barrier (including shy distance) or ditch (see 1140.10).

[20] Restrict parking when DHV is over 1500.

[21] For pavement type determination, see Chapter 620.

[22] Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut (see 1140.15).

[23] 63 ft from edge of traveled way.

[24] Make right of way widths not less than those for cross section elements.

[25] For the minimum vertical clearance, see Chapter 720.

[26] For median widths 26 ft or less, address bridges in accordance with Chapter 720.

[27] For bicycle guidelines, see Chapter 1520. For pedestrian and sidewalk guidelines, see Chapter 1510. Curb guidelines are in 1140.11. Lateral clearances from the face of curb to obstruction are in Chapter 1600.

[28] For grades at design speeds greater than 60 mph in urban design areas, use rural criteria.

[29] Grades 1% steeper may be used in urban design areas and mountainous terrain with critical right of way controls.

[30] Consider 10-ft shoulders when truck DHV is 250 or greater.

[31] Consider 10-ft shoulders when truck DDHV is 250 or greater.

[32] Consider 40 ft for shorter structures.

Geometric Design Data: Minor Arterial

Exhibit 1140-7 (continued)

Design Class	Undivided Multilane		Two-Lane					
	C-1		C-2		C-3		C-4	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
DHV in Design Year[1] NHS Non-NHS	Over 900[2]		Over 301[3] Over 501		201–300 301–500		200 and Under 300 and Under	
Access Control	[4]		[4]		[4]		[4]	
Separate Cross Traffic Highways Railroads[5]	Where Justified Where Justified[6]		Where Justified All[6]		Where Justified Where Justified[6]		Where Justified Where Justified[6]	
Design Speed (mph)[7] Desirable[8] Minimum[9][10]	70 40	60 30	70 50	60 40	70 50	60 40	60 40	60 30
Traffic Lanes Number Width (ft)	4 12	4 or 6 11[11]	2 12		2 12		2 12	
Shoulder Width (ft)[12]	8[21]	8[13]	8[22]		6		4	
Median Width (ft)	[14]							
Parking Lane Width (ft) – Minimum	None	10	None		None	10	None	10
Pavement Type[15]	High or Intermediate							
Right of Way (ft)[16]	150	80	120	80	120	80	100	80
Structures Width (ft)[17]	Full Roadway Width		40		36[23]		32	
Other Design Considerations – Urban	[18]		[18]		[18]		[18]	

Type of Terrain	Rural Design Speed (mph)										Urban Design Speed (mph)								
	25	30	35	40	45	50	55	60	65	70	20	25	30	35	40	45	50	55	60[19]
Level	7	7	7	7	7	6	6	5	5	4	9	9	9	9	9	8	7	7	6
Rolling	10	9	9	8	8	7	7	6	6	5	12	12	11	10	10	9	8	8	7
Mountainous	11	10	10	10	10	9	9	8	8	6	14	13	12	12	12	11	10	10	9

Grades (%)[20]

Geometric Design Data: Collector
Exhibit 1140-8

Collector Notes:

[1] The design year is 20 years after the year the construction is scheduled to begin.

[2] When considering a multilane highway, perform an investigation to determine whether a truck-climbing lane or passing lane will satisfy the need (see Chapter 1270).

[3] Where DHV exceeds 900, consider 4 lanes. When the volume/capacity ratio is equal to or exceeds 0.85, consider the needs for a future 4-lane facility. When considering truck-climbing lanes on a C-2 design class highway, perform an investigation to determine whether a C-1 design class highway is justified.

[4] For access control, see Chapters 530 and 540 and the Limited Access and Managed Access Master Plan. Contact the Access & Hearings Section in the HQ Design Office for additional information.

[5] Contact the Rail Office of the Public Transportation and Rail Division for input on railroad needs.

[6] Criteria for railroad grade separations are not clearly definable. Evaluate each site regarding the risk. Provide justification for railroad grade separations.

[7] For existing roadways, see 1140.07.

[8] These are the design speeds for level and rolling terrain in rural design areas. They are the desirable design speeds for mountainous terrain and urban design areas. Higher design speeds may be selected, with justification. Do not select a design speed that is less than the posted speed.

[9] In urban design areas, with a corridor analysis, these values may be used as the minimum design speed. Do not select a design speed that is less than the posted speed.

[10] These design speeds may be selected in mountainous terrain, with a corridor analysis. Do not select a design speed that is less than the posted speed.

[11] Consider 12-ft lanes when the truck DDHV is 200 or greater.

[12] When guardrail is installed along existing shoulders with a width greater than 4 ft, the shoulder width may be reduced by 4 inches.

[13] When curb section is used, the minimum shoulder width from the edge of traveled way to the face of curb is 4 ft.

[14] Minimum median width is as required for shoulders and barrier (including shy distance) or ditch (see 1140.10).

[15] For pavement type determination, see Chapter 620.

[16] Desirable width. Provide right of way width 10 ft desirable, 5 ft minimum, wider than the slope stake for fill and slope treatment for cut (see 1140.15).

[17] For the minimum vertical clearance, see Chapter 720.

[18] For bicycle guidelines, see Chapter 1520. For pedestrian and sidewalk guidelines, see Chapter 1510. Curb guidelines are in 1140.11. Lateral clearances from the face of curb to obstruction are in Chapter 1600.

[19] For grades at design speeds greater than 60 mph in urban design areas, use rural criteria.

[20] Grades 1% steeper may be used in urban design areas and mountainous terrain with critical right of way controls.

[21] Consider 10-ft shoulders when truck DDHV is 250 or greater.

[22] Consider 10-ft shoulders when truck DHV is 250 or greater.

[23] Consider 40 ft for shorter structures.

Geometric Design Data: Collector

Exhibit 1140-8 (continued)

Design Class	Divided Multilane		Undivided Multilane		Two-Lane	
	$U_{M/A}$-1	$U_{M/A}$-2	$U_{M/A}$-3	$U_{M/A}$-4	$U_{M/A}$-5	$U_{M/A}$-6
DHV in Design Year[1]	Over 700	Over 700	700–2,500	Over 700	All	All
Design Speed (mph)	Greater than 45	45 or less	35 to 45	30 or less	Greater than 45	45 or less
Access	[2]	[2]	[2]	[2]	[2]	[2]
Traffic Lanes						
Number	4 or more	4 or more	4 or more	4 or more	2	2
Width (ft) NHS	12[4]	12[3]	12[3]	12[3]	12[6]	12[3]
Non-NHS	12[4]	11[5]	11[5]	11[5]	12[6]	11[7]
Shoulder Width (ft)[8]						
Right of Traffic[9]	10	10	8	8	8[10]	4
Left of Traffic	4	4				
Median Width (ft)[11]			[12]	[12]		
Parking Lane Width (ft)	None	10[13]	10[13]	8[14]	10[15]	8[14]
Structures Width (ft)[16]	Full Roadway Width[17]		Full Roadway Width		32	30
Other Design Considerations	[18]	[18]	[18]	[18]	[18]	[18]

Urban Managed Access Highways Notes:

[1] The design year is 20 years after the year the construction is scheduled to begin.

[2] The urban managed access highway design is used on managed access highways (see Chapter 540).

[3] May be reduced to 11 ft, with justification.

[4] May be reduced to 11 ft, with justification, when truck DDHV is less than 200.

[5] Consider 12-ft lanes when truck DDHV is 200 or greater.

[6] May be reduced to 11 ft, with justification, when truck DHV is less than 100.

[7] Consider 12-ft lanes when truck DHV is 100 or greater.

[8] When curb section is used, see Exhibit 1140-3.

[9] When guardrail is installed along existing shoulders with a width greater than 4 ft, the shoulder width may be reduced by 4 inches.

[10] When DHV is 200 or less, may be reduced to 4 ft.

[11] Minimum width is as required for shoulders and barrier or ditch (see 1140.10).

[12] 2 ft desirable. When a TWLTL is present, 13 ft is desirable, 11 ft is minimum.

[13] Prohibit parking when DHV is over 1500.

[14] 10 ft is desirable.

[15] Prohibit parking when DHV is over 500.

[16] For minimum vertical clearance, see Chapter 720.

[17] For median guidelines, see Chapter 720.

[18] For bicycle guidelines, see Chapter 1520. For pedestrian and sidewalk guidelines, see Chapter 1510. Lateral clearances from face of curb to obstruction are in Chapter 1600. For railroad and other roadway grade separation, maximum grade, and pavement type for the functional class, see Exhibits 1140-6 through 1140-8. Make right of way widths not less than for cross section elements.

Geometric Design Data: Urban Managed Access Highways
Exhibit 1140-9

(3) One-Lane Roadways

Exhibit 1240-3a shows the traveled way width (W) for one-lane turning roadways, including one-lane ramps. For values of R between those given, interpolate W and round up to the next foot.

Minimum width (W), based on the delta angle of the curve for one-lane roadways, may be used. Exhibit 1240-3b gives W using the radius to the outer edge of the traveled way. Exhibit 1240-3c gives W using the radius on the inner edge of the traveled way. Document the reasons for using the minimum width. Round W to the nearest foot.

Build shoulder pavements at full depth for one-lane roadways. To keep widths to a minimum, traveled way widths were calculated using the WB-40 design vehicle, which may force larger vehicles to encroach on the shoulders. This also helps to maintain the integrity of the roadway structure during partial roadway closures.

(4) Other Roadways

For roadways where the traveled way is more than two lanes in any direction, for each lane in addition to two, add the lane width for the highway functional class from Chapter 1140 to the width from 1240.04(2).

For three-lane ramps with HOV lanes, see Chapter 1410.

(5) Total Roadway Width

Full design shoulder widths for the highway functional class or ramp are added to the traveled way width to determine the total roadway width.

Small amounts of widening add to the cost with little added benefit. When the traveled way width for turning roadways results in widening less than 0.5 foot per lane or a total widening of less than 2 feet on existing roadways that are to remain in place, it may be disregarded.

When widening the traveled way:

- Widening may be constructed on the inside of the traveled way or divided equally between the inside and outside. Do not construct widening only on the outside of a curve.
- Place final marked lane lines, and any longitudinal joints, at equal spacing between the edges of the widened traveled way.
- Provide widening throughout the curve length.
- For widening on the inside, make transitions on a tangent where possible.
- For widening on the outside, develop the widening by extending the tangent. This avoids the appearance of a reverse curve that a taper would create.
- For widening of 6 feet or less, use a 1:25 taper. For widths greater than 6 feet, use a 1:15 taper.

1240.05 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/

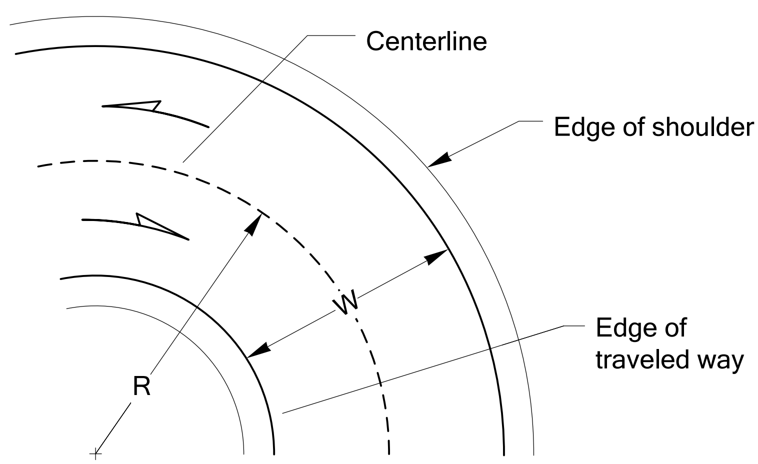
Radius on Centerline of Traveled Way, R (ft)	Design Traveled Way Width, W (ft)[1]
3,000 to tangent	24
2,999	25
2,000	26
1,000	27
800	28
600	29
500	30
400	31
350	32
300	33
250	35
200	37
150	41

Note:

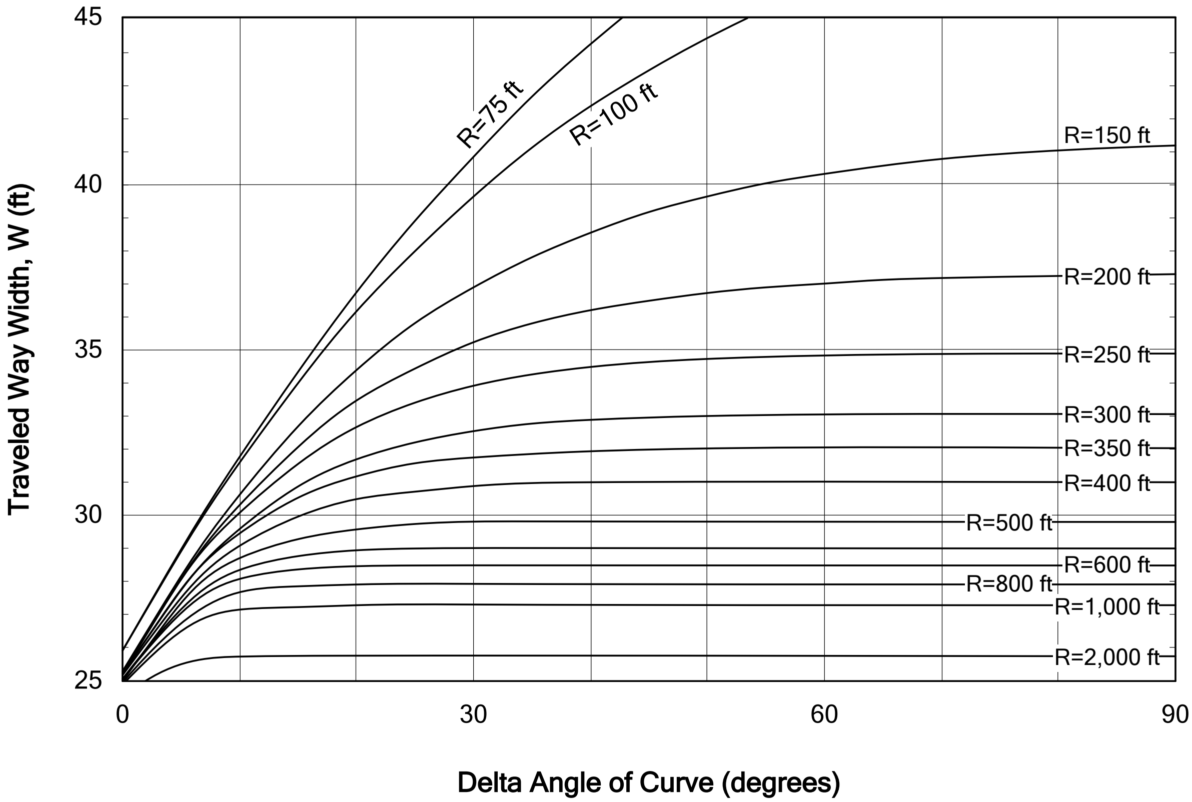
[1] Width (W) is based on:

- WB-67 design vehicle.
- 3-ft clearance per lane (12-ft lanes).

When 11-ft lanes are called for, width may be reduced by 2 ft.



Traveled Way Width for Two-Lane Two-Way Turning Roadways
Exhibit 1240-1a



Note:

Width (W) is based on:

- WB-67 design vehicle.
- 3-ft clearance per lane (12-ft lanes).

When 11-ft lanes are called for, width may be reduced by 2 ft.

Traveled Way Width for Two-Lane Two-Way Turning Roadways: Based on the Delta Angle
Exhibit 1240-1b

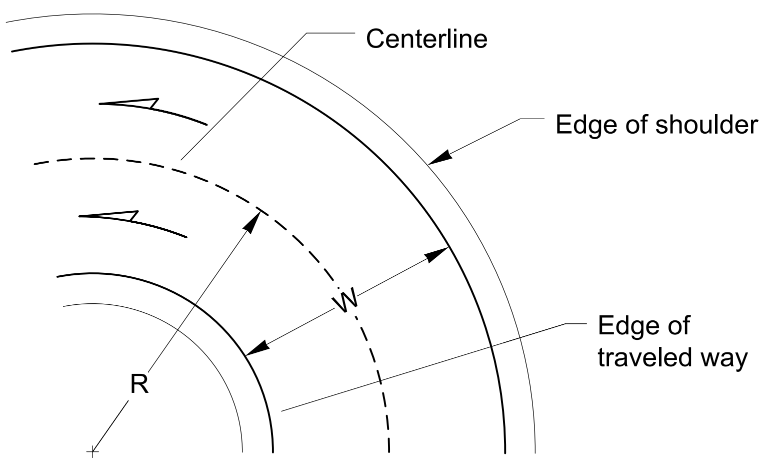
Radius on Centerline of Traveled Way, R (ft)	Design Traveled Way Width, W (ft)[1]
3,000 to tangent	24
1,000 to 2,999	25
999	26
600	26
500	27
400	27
300	28
250	29
200	29
150	31
100	34

Note:

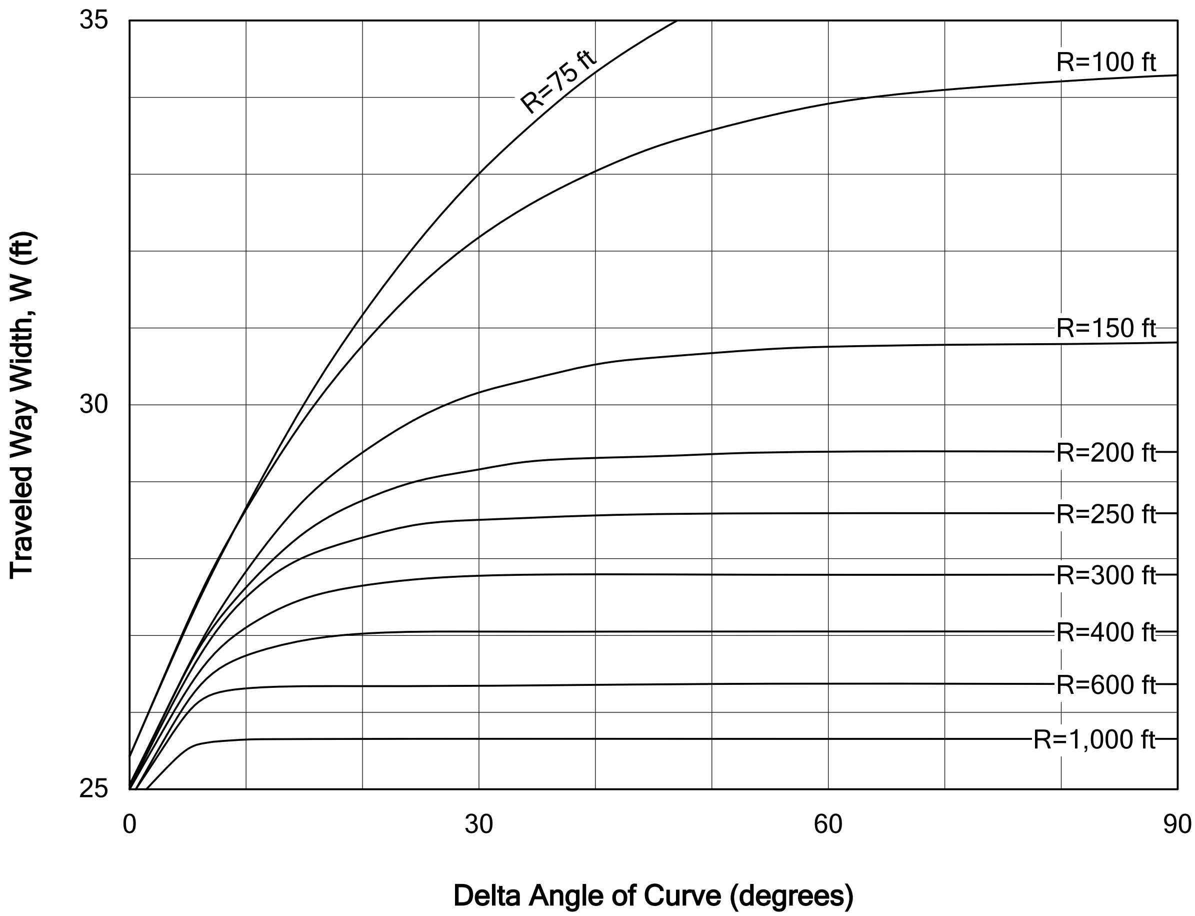
[1] Width (W) is based on:

- WB-40 design vehicle.
- 3-ft clearance per lane (12-ft lanes).

When 11-ft lanes are called for, width may be reduced by 2 ft.



Traveled Way Width for Two-Lane One-Way Turning Roadways
Exhibit 1240-2a



Note:

Width (W) is based on:

- WB-40 design vehicle.
- 3-ft clearance per lane (12-ft lanes).

When 11-ft lanes are called for, width may be reduced by 2 ft.

Traveled Way Width for Two-Lane One-Way Turning Roadways: Based on the Delta Angle
Exhibit 1240-2b

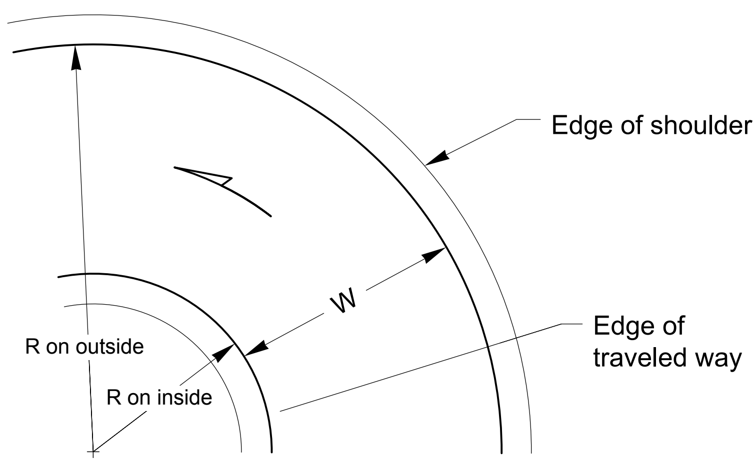
Radius, R (ft)	Design Traveled Way Width, W (ft)	
	Radius on Outside Edge of Traveled Way	Radius on Inside Edge of Traveled Way
7,500 to tangent	13[1]	13[1]
1,600	14	14
300	15	15
250	16	16
200	17	17
150	17	17
100	19	18
75	21	19
50	26	22

Note:

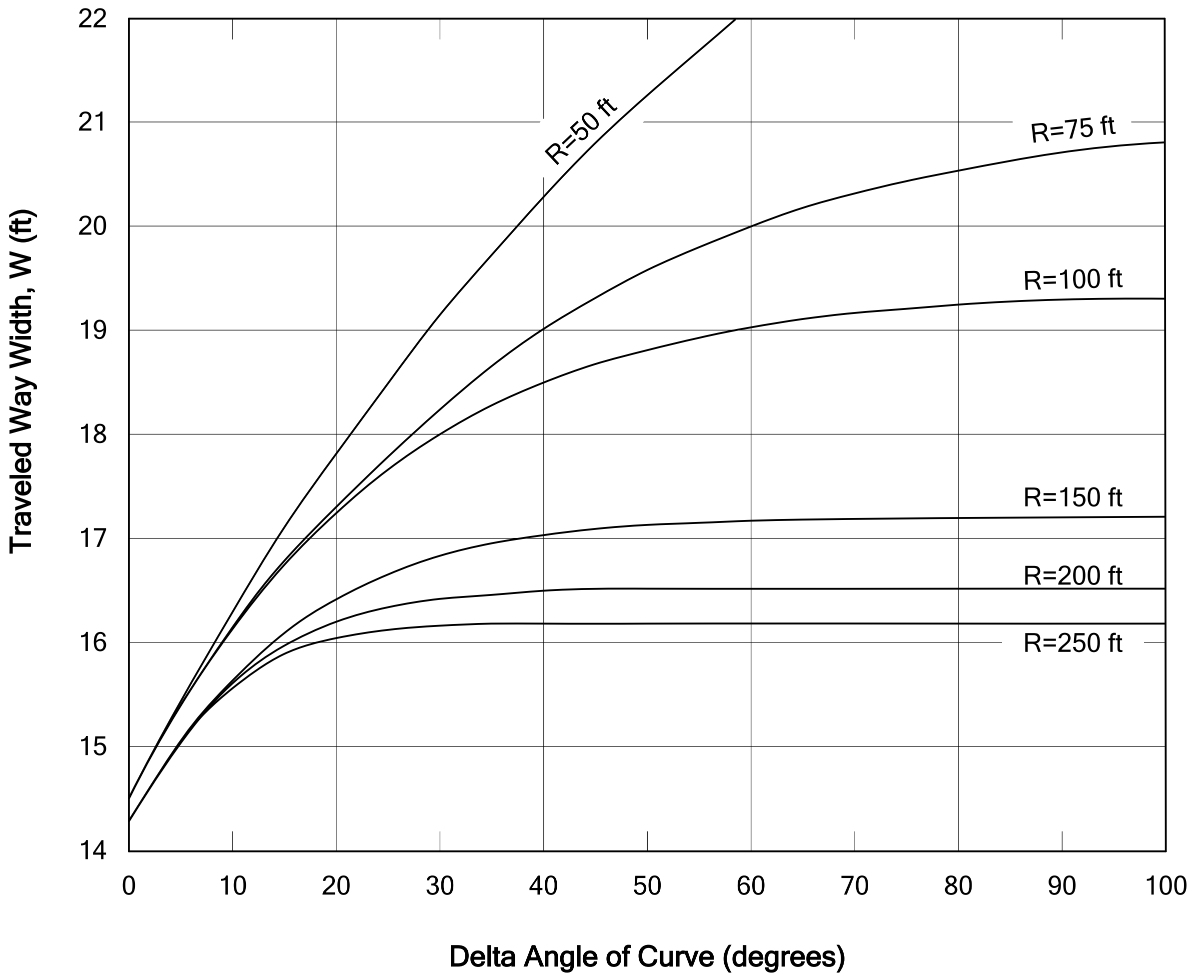
[1] On tangents, the minimum lane width may be reduced to 12 ft.

Width (W) is based on:

- WB-40 design vehicle.
- 4-ft clearance.



Traveled Way Width for One-Lane Turning Roadways
Exhibit 1240-3a



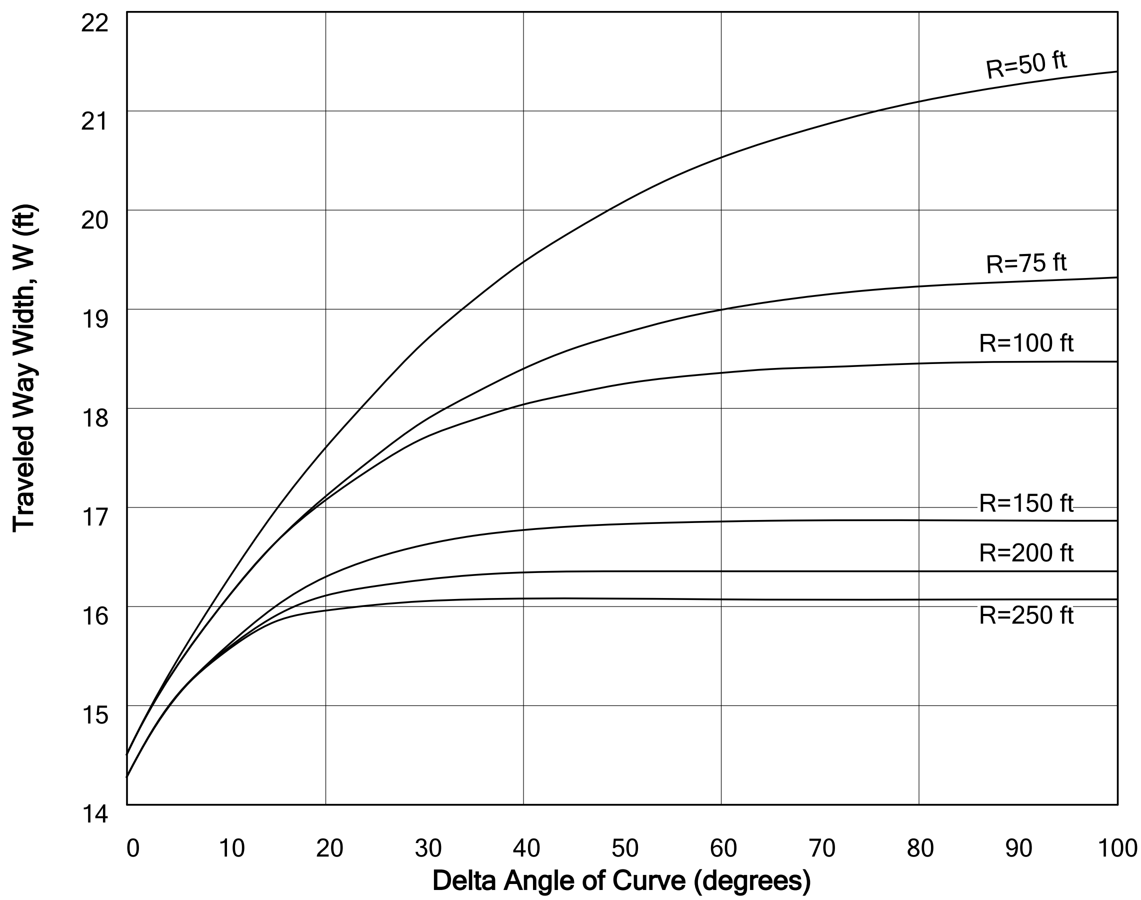
Note:

All radii are to the outside edge of traveled way.

Width (W) is based on:

- WB-40 design vehicle.
- 4-ft clearance.

Traveled Way Width for One-Lane Turning Roadways:
Based on the Delta Angle, Radius on Outside Edge of Traveled Way
Exhibit 1240-3b



Note:

All radii are to the inside edge of traveled way.

Width (W) is based on:

- WB-40 design vehicle.
- 4-ft clearance.

Traveled Way Width for One-Lane Turning Roadways:
Based on the Delta Angle, Radius on Inside Edge of Traveled Way
Exhibit 1240-3c

Chapter 1270 Auxiliary Lanes

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-vehicle turnouts, shoulder driving for slow vehicles, and chain-up areas are not auxiliary lanes, they are covered in this chapter because they perform a similar function.

For additional information, see the following chapters:

Chapter	**Subject**
1310	Turn lanes
1310	Speed change lanes at intersections
1360	Speed change lanes at interchanges
1360	Collector-distributor roads
1360	Weaving lanes
1410	High-occupancy vehicle lanes

1270.02 References

(1) Federal/State Laws and Codes

Revised Code of Washington (RCW) 46.61, Rules of the road

(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

(3) Supporting Information

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

Emergency Escape Ramps for Runaway Heavy Vehicles, FHWA-T5-79-201, March 1978

Highway Capacity Manual, Special Report 209, Transportation Research Board

Truck Escape Ramps, NCHRP Synthesis 178, Transportation Research Board

1270.03 Definitions

Note: For definitions of ***design speed***, ***lane***, ***operating speed***, ***posted speed***, ***roadway***, ***shoulder***, and ***traveled way,*** see Chapter 1140.

auxiliary lane The portion of the roadway adjoining the through lanes for parking, speed change, turning, storage for turning, weaving, truck climbing, passing, and other purposes supplementary to through-traffic movement.

climbing lane An auxiliary lane used for the diversion of slow traffic from the through lane.

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.

lateral clearance The distance from the edge of traveled way to a roadside object.

passing lane An auxiliary lane on a two-lane highway used to provide the desired frequency of passing zones.

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.

warrant A minimum condition for which an action is authorized. Meeting a warrant does not attest to the existence of an unsafe or undesirable condition. Further justification is required.

1270.04 Climbing Lanes

Climbing Lane Example
Exhibit 1270-1

(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.

(2) Climbing Lane Warrants

Generally, climbing lanes are provided when two warrants—speed reduction and level of service—are exceeded. 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 satisfied.

(a) **Warrant No. 1: Speed Reduction**

Exhibit 1270-2a shows how the percent and length of grade affect vehicle speeds. The data are based on a typical 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 satisfied (see Exhibit 1270-2b).

(b) **Warrant No. 2: Level of Service (LOS)**

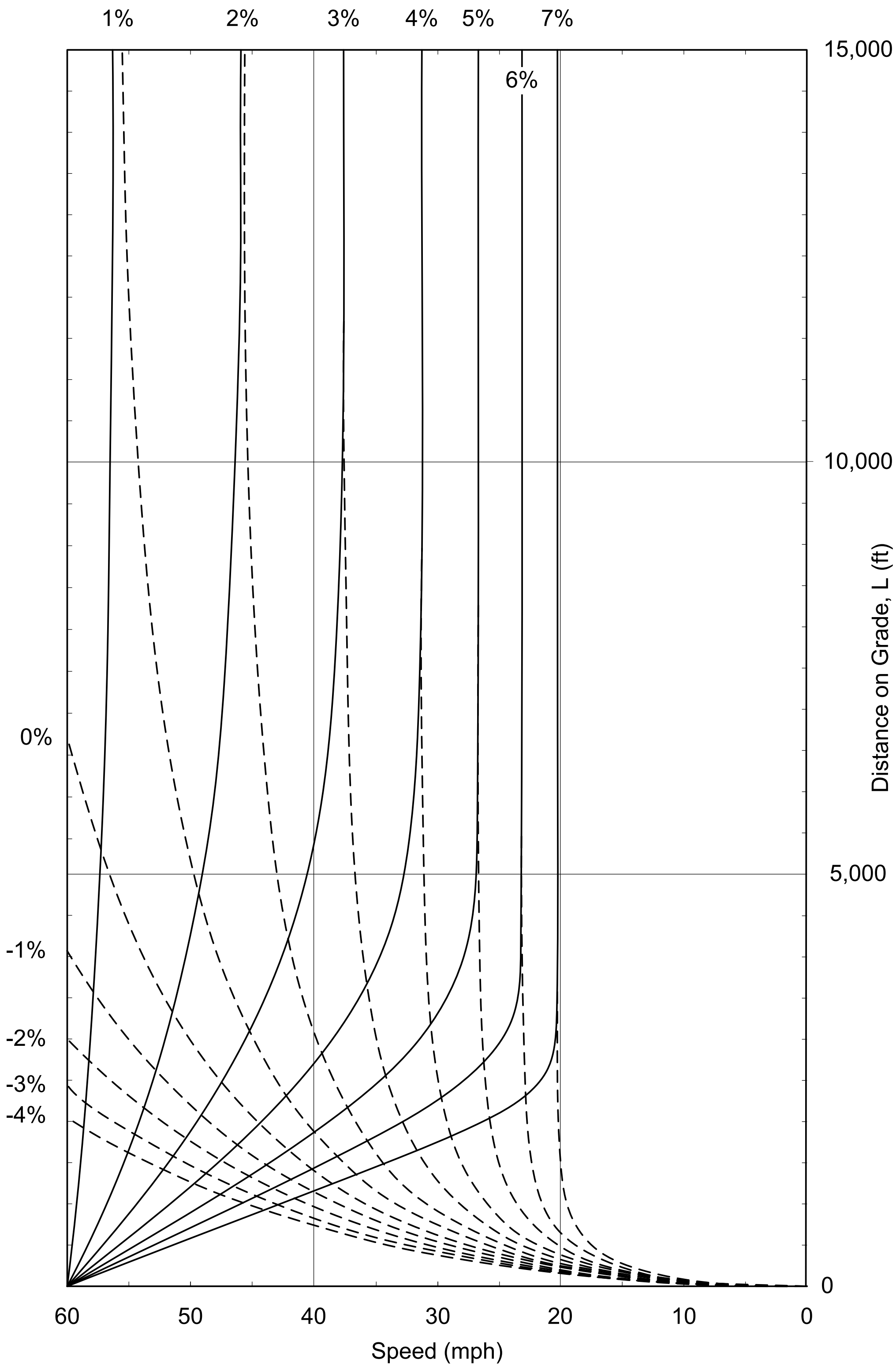
The level of service warrant for two-lane highways is fulfilled when the upgrade traffic volume exceeds 200 vehicles per hour and the upgrade truck volume exceeds 20 vehicles per hour. On multilane highways, a climbing lane is warranted when a capacity analysis shows the need for more lanes on an upgrade than on a downgrade carrying the same traffic volume.

(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.

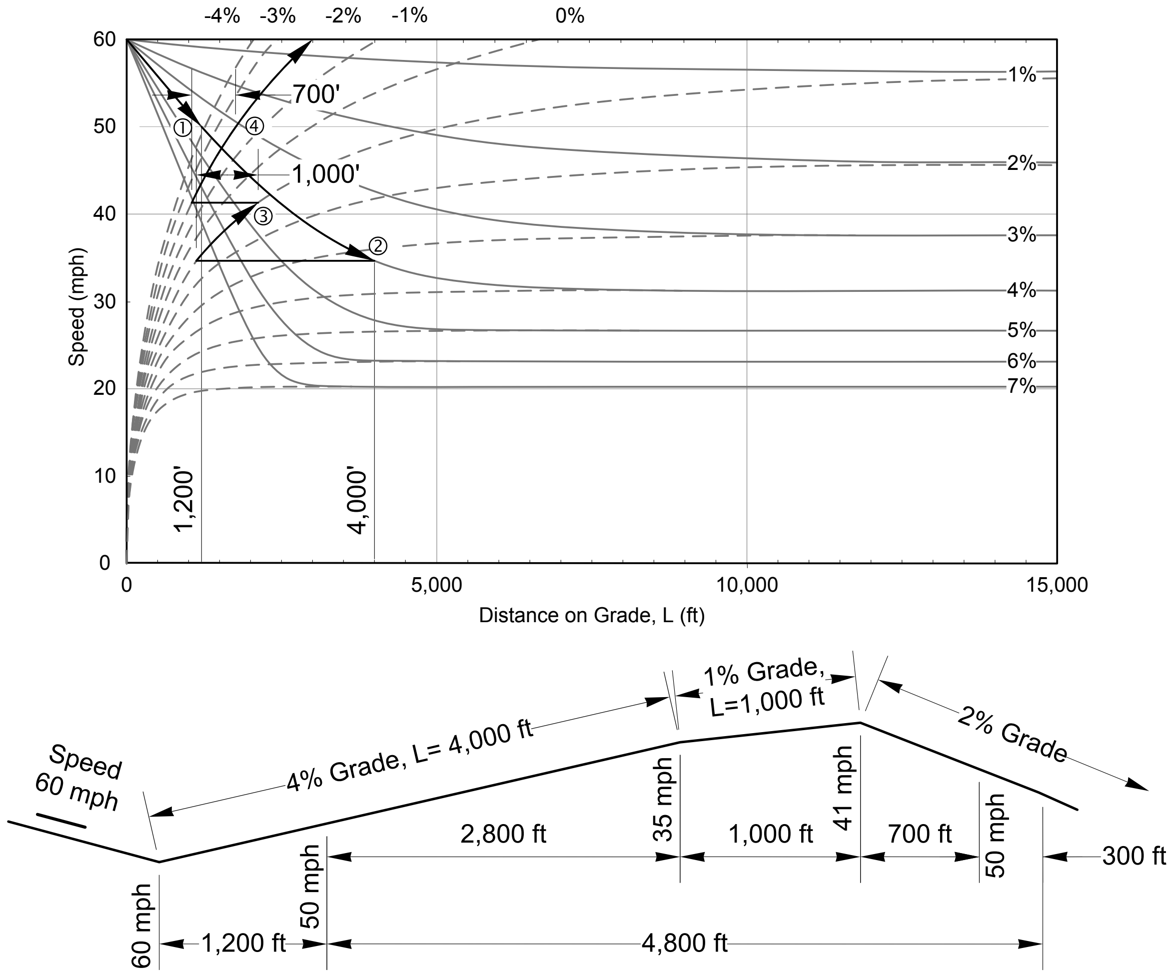
Design climbing lane width equal to that of the adjoining through lane and at the same cross slope as the adjoining lanes. Whenever possible, maintain the shoulder width for the class of highway. However, on two-way two-lane highways, the shoulder may be reduced to 4 feet, with justification.

For signing of climbing lanes, see the *Standard Plans*, the *Traffic Manual,* and the MUTCD.



Speed Reduction Warrant: Performance for Trucks

Exhibit 1270-2a



Given:

A two-lane highway meeting the level of service warrant, with the above profile, and a 60 mph posted speed.

Determine:

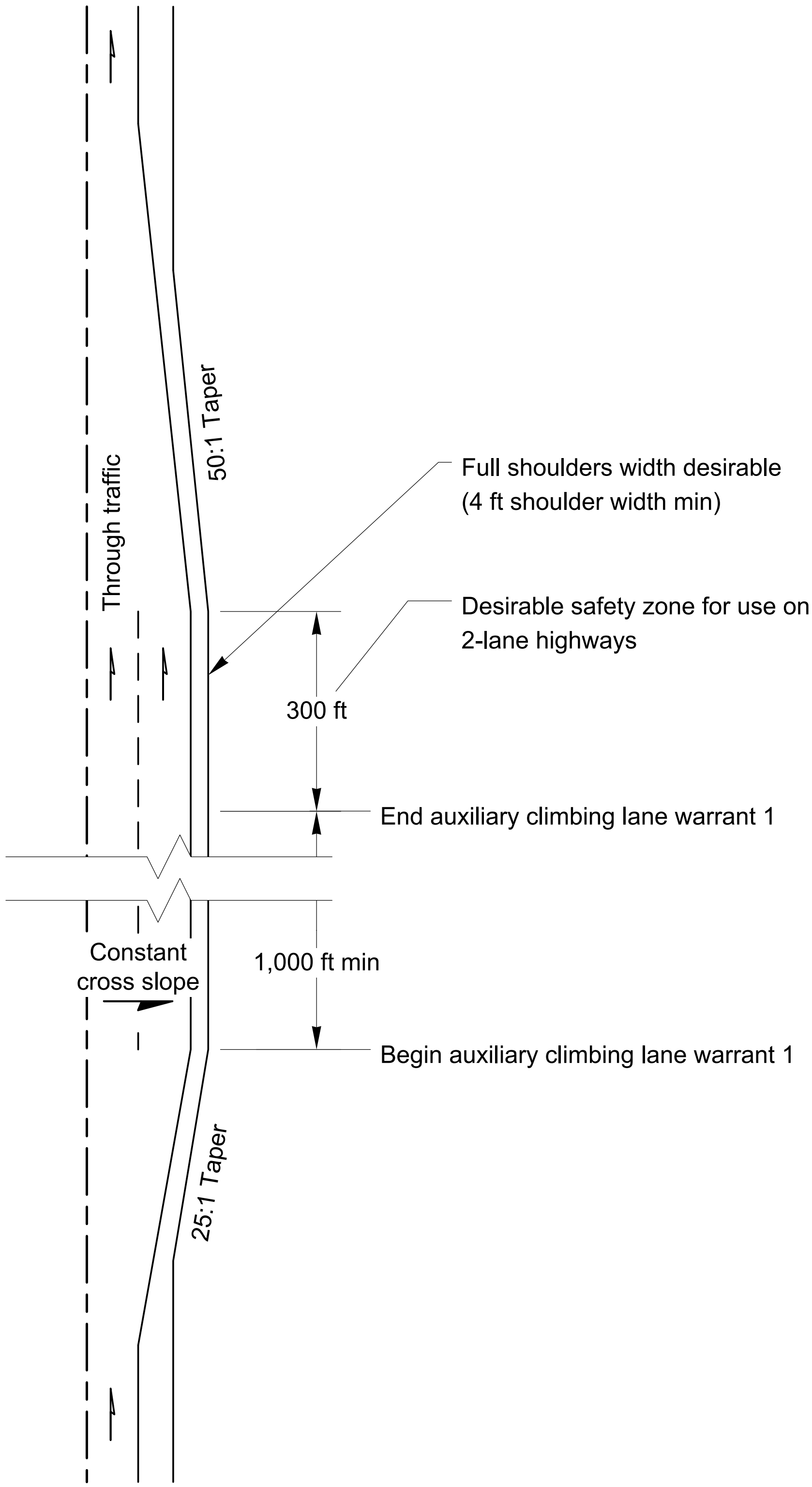
Is the climbing lane warranted? If so, what is its length?

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 1270.04(3) and Exhibit 1270-3).

Speed Reduction Warrant Example

Exhibit 1270-2b



Auxiliary Climbing Lane
Exhibit 1270-3

1270.05 Passing Lanes

Passing Lane Example
Exhibit 1270-4

(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.

  Passing lanes have been found to increase average travel speed within the passing lane itself, and 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.

(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 a desirable 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 with justification. Lengths shown do not include passing lane tapers at the beginning or end of the passing lane.

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	

Length of Passing Lanes
Exhibit 1270-5

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 (HQ) Design Office for assistance (🖰 www.wsdot.wa.gov/Design/Policy/default.htm).

(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 approach to lane increase and lane decrease tapers can be provided.
- 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.
- Carefully consider highway sections with low-speed curves (curves with superelevation less than required for the design speed) before installing a passing lane, since they may not be 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.

(a) **Traffic Operational Considerations**

When passing lanes are provided at an isolated location, their objective is typically to reduce delays at a specific bottleneck; for example, climbing lanes (see 1270.04). 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.

(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.

(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.

(4) Passing Lane Design

Where a passing lane is planned, evaluate several possible configurations (see 1270.05(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).

Lane and shoulder widths for passing lanes are to be consistent with adjacent sections of two-lane highway unless reduced widths are justified. For projects on new or reconstructed alignment (vertical or horizontal) or full width pavement reconstruction, provide the lane and shoulder widths for the design class of the facility (see Chapters 1130 and 1140).

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.

For signing and striping of passing lanes, contact the region Traffic Engineer.

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.

(a) **Alternative Configurations**

Where a passing lane will be provided, evaluate the configurations shown in Exhibit 1270-6. General passing lane configurations and their typical applications are described in the following:

1. **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 1270.04).
2. **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 1270.05(3)).
3. **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 justification. (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.

4. **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.

5. **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.

(b) **Geometric Aspects**

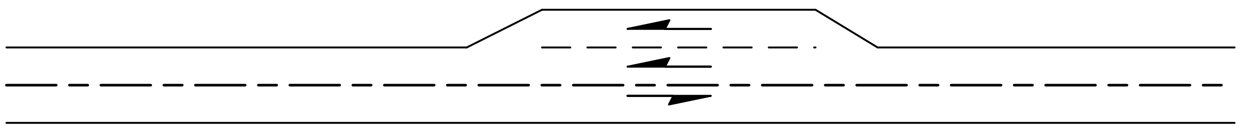
Carefully design transitions between passing lanes in opposing directions. Intersections, bridges, other structures, two-way left-turn lanes, painted medians, or similar elements can be used to provide a buffer area between opposing passing lanes. The length of the buffer area between adjoining passing lanes depends on the configuration (see Exhibit 1270-7).

Exhibit 1270-6 (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.

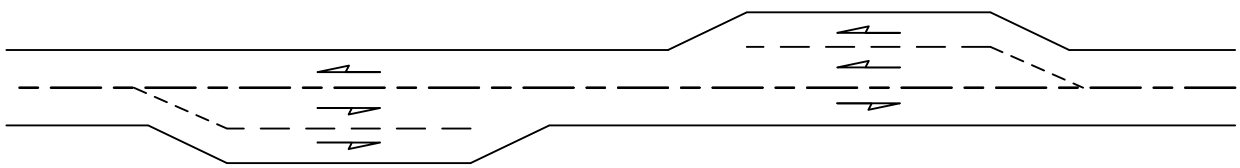
Provide shoulder width in a passing lane section equal to the shoulder width on the adjacent sections of a two-lane highway. However, with justification, the shoulder may be reduced to 4 feet, or 6 feet when shoulder rumble strips are present. Lane widths of 12 feet are preferable throughout the length of the passing lane. The minimum lane width is to be the same as the lane width on the adjacent sections of 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 lane transitions in Chapter 1210 for additional information on taper rates.) A wide shoulder is desirable at the lane drop taper to provide a recovery area for drivers who encounter a merging conflict. Provide decision sight distance (see Chapter 1260) at the approach to lane increase and lane decrease tapers.

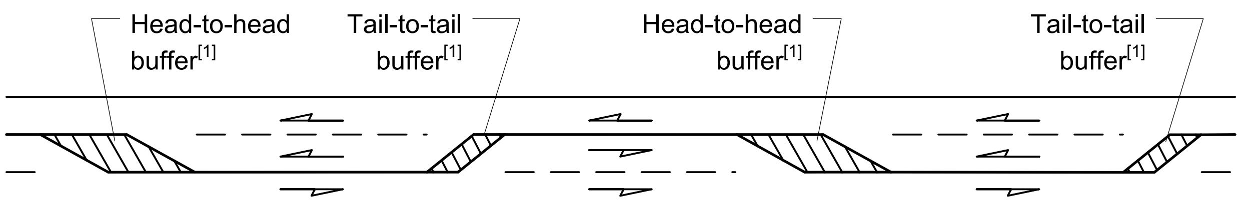
Provide signing and delineation to identify the presence of an auxiliary passing lane. Refer to the *Standard Plans*, the *Traffic Manual,* and the MUTCD for passing lane signing and marking guidance.



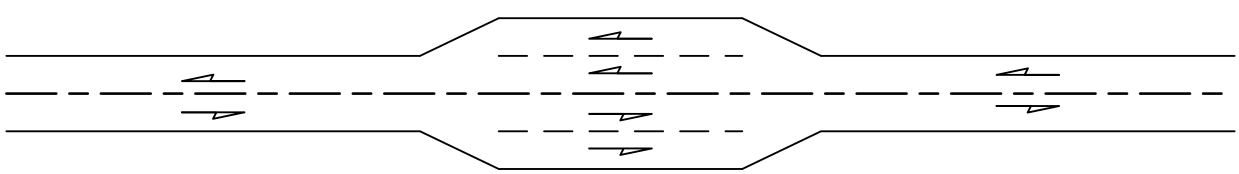
(a) Isolated Passing Lane



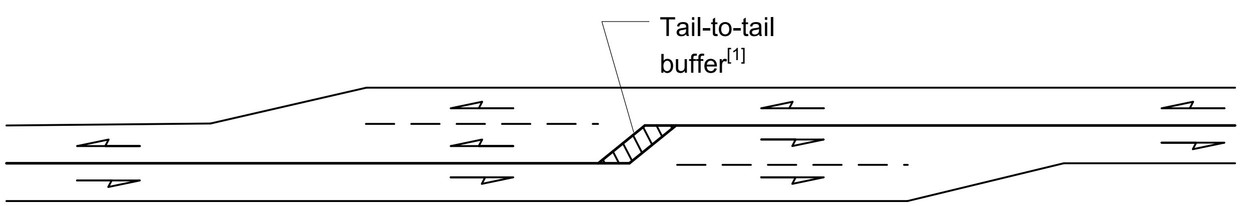
(b) Intermittent Passing Lane



(c) Continuous Three-Lane Section



(d) Short Four-Lane Section

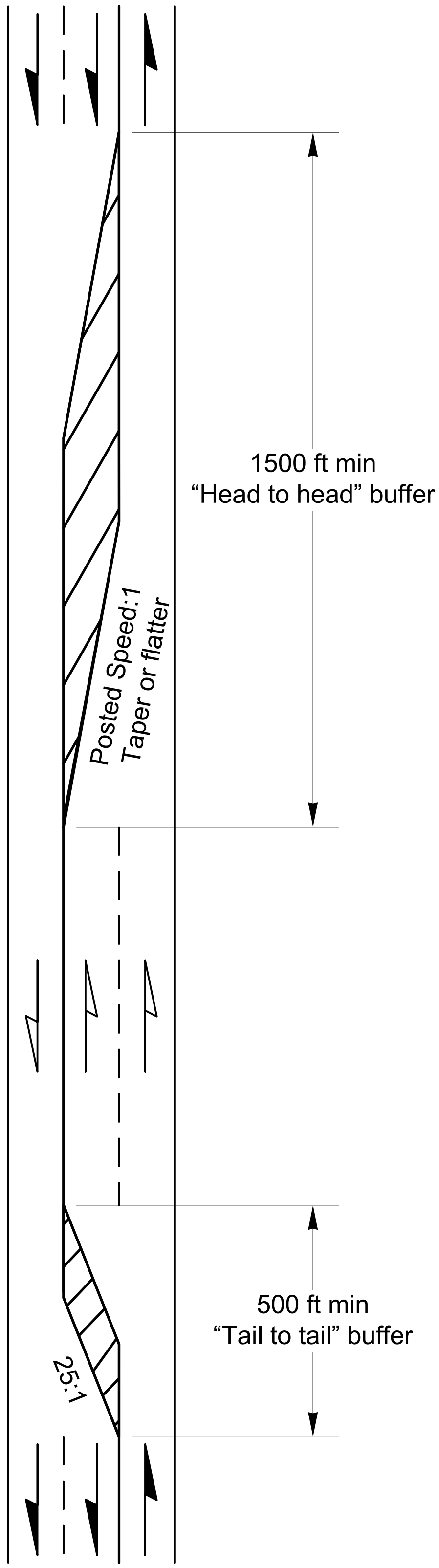


(e) Intermittent Three-Lane Passing Lanes

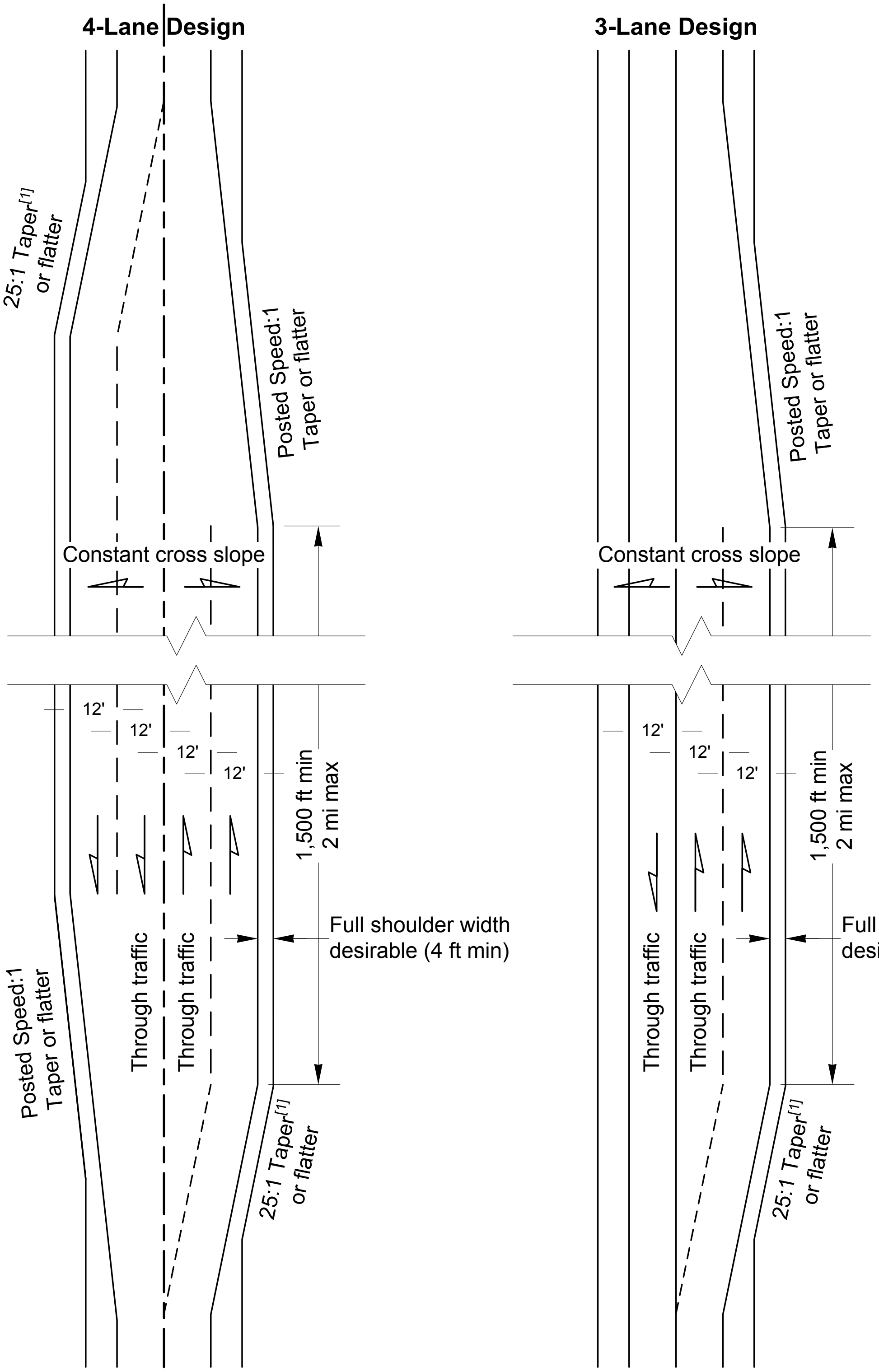
Notes:

[1] See Exhibit 1270-7 for buffer design.

Passing Lane Configurations
Exhibit 1270-6



Buffer Between Opposing Passing Lanes
Exhibit 1270-7



Note:

[1] Provide a posted speed:1 taper when all traffic is directed to the right lane at the beginning of the passing lane.

Auxiliary Passing Lane
Exhibit 1270-8

1270.06 Slow-Moving Vehicle Turnouts

(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.

(2) Design

Base the design of a slow-moving vehicle turnout primarily on sound engineering judgment and Exhibit 1270-9. Designs may vary from one location to another. Provide a *minimum* length of 100 feet. The *maximum* length is ¼ mile, including tapers. Surface 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 decision sight distance (see Chapter 1260) is available. With justification, slow-vehicle turnouts may be located where at least design stopping sight distance is available.

Sign slow-moving vehicle turnouts to identify their presence. For guidance, see the *Standard Plans*, the *Traffic Manual,* and the MUTCD.

When a slow-moving vehicle turnout is to be built, document the need for the turnout, the location of the turnout, and why it was selected over a passing or climbing lane.

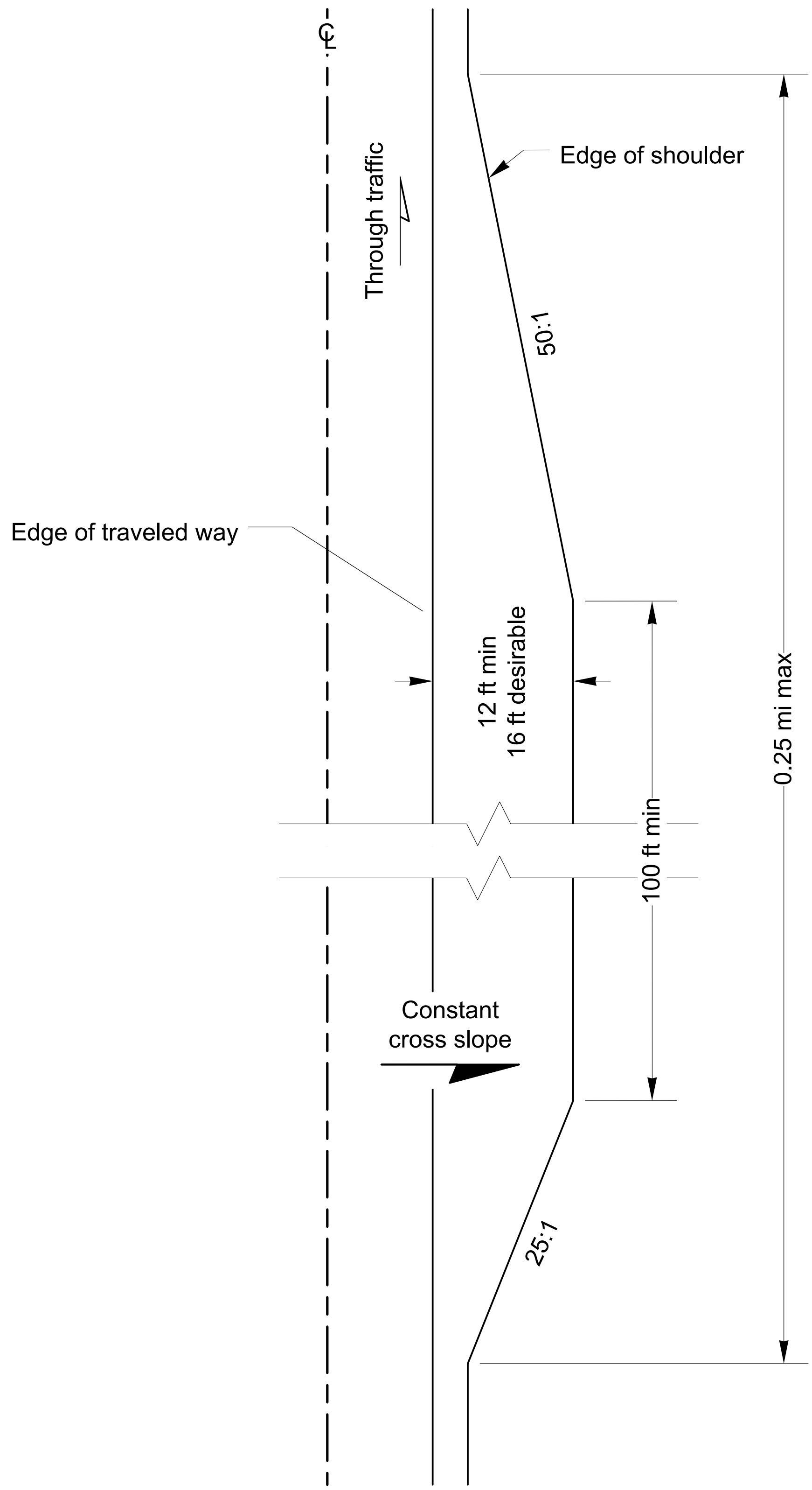
1270.07 Shoulder Driving for Slow Vehicles

(1) General

For projects where climbing or passing lanes are justified, but are not within the scope of the project, or where meeting the warrants for these lanes is borderline, the use of a shoulder driving section is an alternative.

Review the following when considering a shoulder driving section:

- Horizontal and vertical alignment
- Character of traffic
- Presence of bicycles
- Road approaches and intersections
- Clear zone (see Chapter 1600)



Slow-Moving Vehicle Turnout
Exhibit 1270-9

(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 sideslope meets the criteria of Chapter 1230 for new construction and Chapter 1130 for existing roadways. 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.

Document the need for shoulder driving and why a lane is not being built.

1270.08 Emergency Escape Ramps

Emergency Escape Ramp Example
Exhibit 1270-10

(1) General

Consider an emergency escape ramp (see Exhibit 1270-10) 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 traffic accident records to determine whether or not an escape ramp is justified.

(2) Design

(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. (See Chapter 1610 for additional information.)

(b) **Locations**

The location of an escape ramp depends on terrain, length of grade, 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.

(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 1270-11.

$$L = \frac{V^2}{0.3(R \pm G)}$$

Where:
L = Stopping distance (ft)
V = Entering speed (mph)
R = Rolling resistance (see Exhibit 1270-12)
G = Grade of the escape ramp (%)

Emergency Escape Ramp Length
Exhibit 1270-11

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.

Material	*R*
Roadway	1
Loose crushed aggregate	5
Loose noncrushed gravel	10
Sand	15
Pea gravel	25

Rolling Resistance *(R)*
Exhibit 1270-12

(d) **Widths**

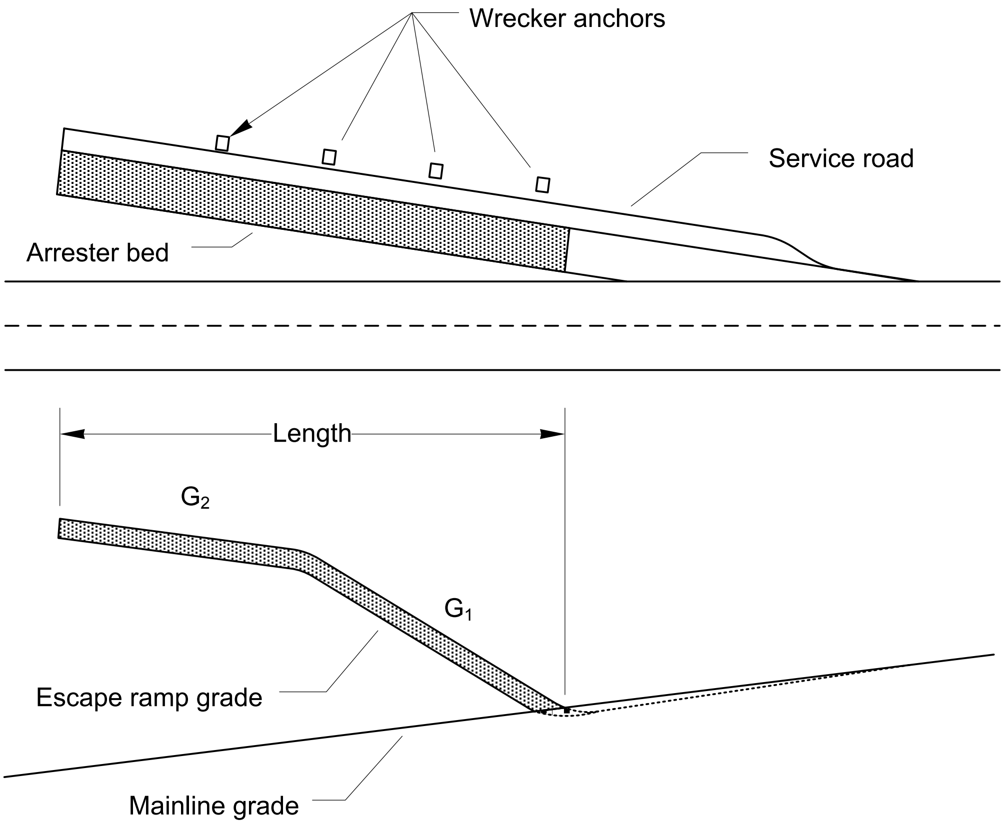
The width of each escape ramp depends on the needs of the individual situation. It is desirable for the ramp to be wide enough to accommodate more than one vehicle. The *desirable* width of an escape ramp to accommodate two out-of-control vehicles is 40 feet and the *minimum* width is 26 feet.

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, noncrushed 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 1270-10 and 1270-13.

Include justification, all calculations, and any other design considerations in the emergency escape ramp documentation.



Typical Emergency Escape Ramp
Exhibit 1270-13

1270.09 Chain-Up and Chain-Off Areas

Provide chain-up areas to allow chains to be put on vehicles out of the through lanes at locations where traffic enters chain enforcement areas. Provide chain-off areas to remove chains out of the through lanes for traffic leaving chain enforcement areas.

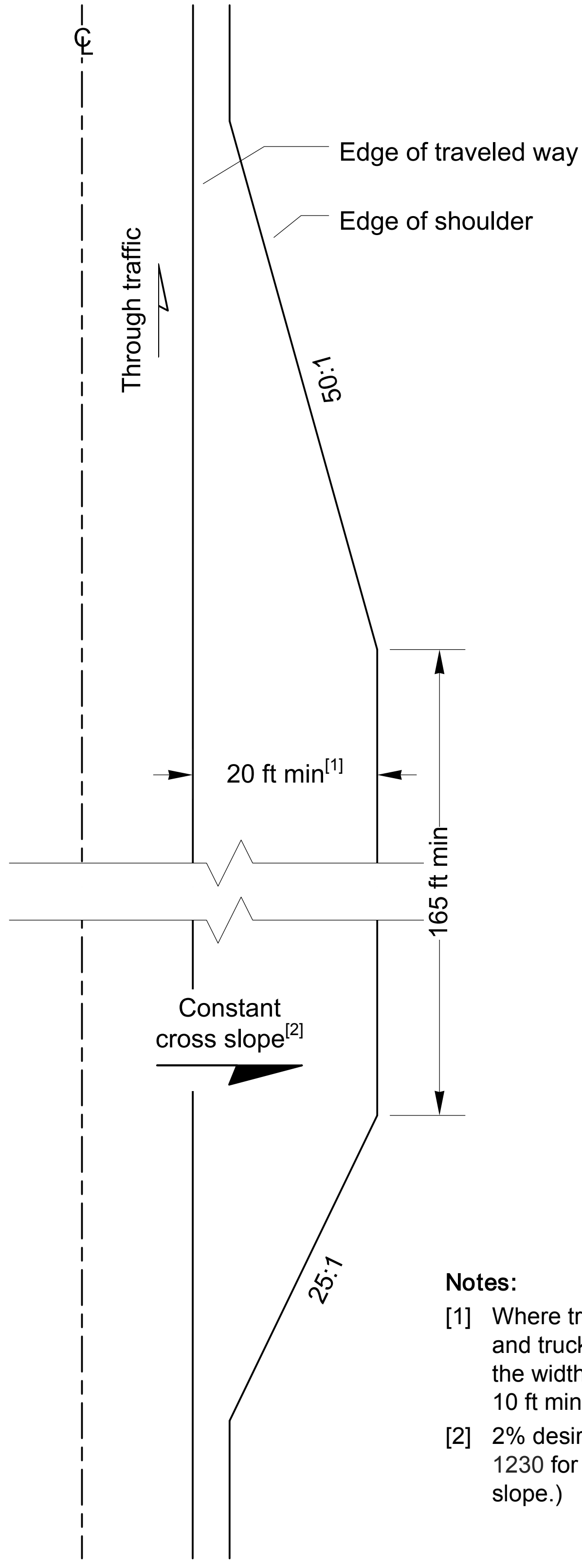
Chain-up or chain-off areas are widened shoulders, designed as shown in Exhibit 1270-14. Locate chain-up and chain-off areas where the grade is 6% or less and desirably on a tangent section.

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.

The wide shoulders at chain-up and chain-off areas may encourage parking. When parking is undesirable, consider parking restrictions.

1270.10 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/



Notes:

[1] Where traffic volumes are low and trucks are not a concern, the width may be reduced to 10 ft min, with 15 ft desirable.

[2] 2% desirable. (See Chapter 1230 for traveled way cross slope.)

Chain Up/Chain Off Area
Exhibit 1270-14

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 believed to be imminent. This allows for future left-turn channelization. Use median channelization when justified by capacity determination and analysis or by the need to provide a smooth traffic flow.

Adjust the alignment of the intersection legs to fit the traffic movements and to discourage wrong-way movements. Use the allowed intersecting angles of 75° to 105° (60° to 120° for modified design level) to avoid broken back or reverse curves in the ramp alignment.

1310.06 Design Vehicle Selection

When selecting a design vehicle for an intersection, consider the needs of all users and the costs. The primary use of the design vehicle is to determine radii for each leg of the intersection. It is possible for each leg to have a different design vehicle. Exhibit 1310-5 shows commonly used design vehicle types.

Evaluate the existing and anticipated future traffic to select a design vehicle that is the largest vehicle that normally uses the intersection. Exhibit 1310-6 shows the minimum design vehicles. Provide justification to use a smaller vehicle; include a traffic analysis showing that the proposed vehicle is appropriate.

To minimize the disruption to other traffic, design the intersection to allow the design vehicles to make each turning movement without encroaching on curbs, opposing lanes, or same-direction lanes at the entrance leg. Use turning path templates (Exhibits 1310-20a through 20c, other published templates, or computer-generated templates) to verify that the design vehicle can make the turning movements.

Encroachment on the same-direction lanes of the exit leg and the shoulder might be necessary to minimize crosswalk distances; however, this might negatively impact vehicular operations. Document and justify the operational tradeoffs associated with this encroachment. When encroachment on the shoulder is required, increase the pavement structure to support the anticipated traffic.

Vehicle Type	Design Symbol
Passenger car, including light delivery trucks	P
Single-unit bus	BUS
Articulated bus	A-BUS
Single-unit truck	SU
Semitrailer truck, overall wheelbase of 40 ft	WB-40
Semitrailer truck, overall wheelbase of 50 ft	WB-50
Semitrailer truck, overall wheelbase of 67 ft	WB-67
Motor home	MH
Passenger car pulling a camper trailer	P/T
Motor home pulling a boat trailer	MH/B

Design Vehicle Types
Exhibit 1310-5

Intersection Type	Minimum Design Vehicle
Junction of Major Truck Routes	WB-67
Junction of State Routes	WB-50[1]
Ramp Terminals	WB-50[1]
Other Rural	WB-50
Industrial	WB-40
Commercial	SU[2][3]
Residential	SU[2][3]

Notes:

[1] WB-67 is desirable.

[2] To accommodate pedestrians, the P vehicle may be used as the design vehicle if justification, with a traffic analysis, is documented.

[3] When the intersection is on a transit or school bus route, use the BUS design vehicle as a minimum. (See Chapter 1430 for additional guidance on transit facilities.)

Minimum Intersection Design Vehicle
Exhibit 1310-6

In addition to the design vehicle, design intersections to accommodate the occasional larger vehicle. When vehicles larger than the design vehicle are allowed and are anticipated to occasionally use the intersection, make certain they can make the turn without leaving the paved shoulders or encroaching on a sidewalk. The amount of encroachment allowed is dependent on the frequency of vehicle usage and the resulting disruption to other traffic. Use the WB-67 as the largest vehicle at state route-to-state route junctions. Document and justify any required encroachment into other lanes and any degradation of intersection operation.

1310.07 Design Elements

When designing an intersection, identify and address the needs of all intersection users.

When pedestrian issues are a primary concern, 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. This normally leads to right-corner designs with smaller turning radii. The negative impacts include possible capacity reductions and greater speed differences between turning vehicles and through vehicles.

Pedestrian refuge islands can also improve pedestrian safety. Pedestrian refuge islands minimize the crossing distance, reduce the conflict area, and minimize the impacts on vehicular traffic. When designing islands, speeds can be reduced by designing the turning roadway with a taper or large radius curve at the beginning of the turn and a small radius curve at the end. This allows larger islands while forcing the turning traffic to slow down.

Channelization, the separation or regulation of traffic movements into delineated paths of travel, can facilitate the orderly movement of vehicles, bicycles, and pedestrians. Channelization includes left-turn lanes, right-turn lanes, speed change lanes (both acceleration and deceleration lanes), and islands.

(1) Right-Turn Corners

Exhibit 1310-11 shows right-turn corner designs for the design vehicles. These are considered the minimum pavement area to accommodate the design vehicles without encroachment on the adjacent lane at either leg of the curve.

With an evaluate upgrade, the right-turn corner designs given in Exhibit 1310-11 may be modified. Document the benefits and impacts of the modified design, including changes to vehicle-pedestrian conflicts; vehicle encroachment on the shoulder or adjacent same-direction lane at the exit leg; capacity restrictions for right-turning vehicles or other degradation of intersection operations; and the effects on other traffic movements. To verify that the design vehicle can make the turn, include a plot of the design showing the design vehicle turning path template.

(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 1310.07(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.

(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 greater than the 100-foot minimum (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 1310-12a, 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 1310-12b 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 the traffic approach a stopped left-turning vehicle at the intersection.

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.

Determine the storage length on two-lane highways by using Exhibits 1310-13a through 13c. On four-lane highways, use Exhibit 1310-12b. These lengths do not consider trucks. Use Exhibit 1310-7 for storage length when trucks are present.

Storage Length* (ft)	% Trucks in Left-Turn Movement				
	10	20	30	40	50
100	125	125	150	150	150
150	175	200	200	200	200
200	225	250	275	300	300
250	275	300	325	350	375
300	350	375	400	400	400
*Length from Exhibits 1310-12b and 1310-13a, 13b, or 13c.					

Left-Turn Storage With Trucks (ft)
Exhibit 1310-7

Use turning templates 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.

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 turning path templates to verify that the design vehicle can complete the turn. Where the design vehicle is a WB-40 or larger, it is desirable to provide for the design vehicle in the outside lane and an SU vehicle turning abreast rather than two design vehicles turning abreast.

Exhibits 1310-14a through 14f show left-turn lane geometrics, which are described as follows:

1. **Widening**

   It is desirable that offsets and pavement widening (see Exhibit 1310-14a) 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.

2. **Divided Highways**

   Widening is not needed for left-turn lane channelization where medians are 11 feet wide or wider (see Exhibits 1310-14b through 14d). 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 1310-14b) to improve sight distance and increase opposing left-turn clearances.

A median acceleration lane (see Exhibits 1310-14c and 14d) 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 1310.07(4), Speed Change Lanes. Where medians have sufficient width, provide a 2-foot shoulder adjacent to a left-turn lane.

3. **Minimum Protected Left Turn With a Median**

At intersections on divided highways where channelized left-turn lanes are not provided, provide the minimum protected storage area (see Exhibit 1310-14e).

4. **Modifications to Left-Turn Designs**

With an evaluate upgrade, the left-turn lane designs discussed above and given in Exhibits 1310-14a through 14e may be modified. Document the benefits and impacts of the modified design, including changes to vehicle-pedestrian conflicts; vehicle encroachment; deceleration length; capacity restrictions for turning vehicles or other degradation of intersection operations; and the effects on other traffic movements. Provide a modified design that is able to accommodate the design vehicle, and provide for the striping (see the *Standard Plans* and the MUTCD). To verify that the design vehicle can make the turn, include a plot of the design showing the design vehicle turning path template.

(b) **Two-Way Left-Turn Lanes (TWLTL)**

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:

- An accident 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.

A TWLTL can reduce delays to through traffic, reduce rear-end accidents, and provide separation between opposing lanes of traffic. However, they do not provide a safe refuge for pedestrians and can encourage strip development with additional closely spaced access points. Evaluate other alternatives (such as prohibiting midblock left turns and providing for U-turns) before using a TWLTL. (See Chapters 1140 and 540 for additional restrictions on the use of TWLTLs.)

The basic design for a TWLTL is illustrated in Exhibit 1310-14f. 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.

(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 guidelines to determine when to provide right-turn lanes at unsignalized intersections:

- The recommendation from Exhibit 1310-15 for multilane roadways with a posted speed 45 mph or above and for all two-lane roadways.
- An accident study indicates an overall accident reduction with a right-turn lane.
- The presence of pedestrians who require right-turning vehicles to stop.
- Restrictive geometrics that require right-turning vehicles to slow greatly below the speed of the through traffic.
- Less than decision sight distance at the approach to the intersection.

For unsignalized intersections, see 1310.07(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 the needed length (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 1310-16) 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 1310-16 shows taper lengths for various posted speeds.

(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 accident history.

A dedicated deceleration lane (see Exhibit 1310-17) is advantageous because it removes slowing vehicles from the through lane.

An acceleration lane (see Exhibit 1310-18) 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.

When either deceleration or acceleration lanes are to be used, design them in accordance with Exhibits 1310-17 and 1310-18. 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.

1310.11 Signing and Pavement Marking

Use the MUTCD and the *Standard Plans* for signing and pavement marking 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.

1310.12 Procedures

Document design decisions and conclusions in accordance with Chapter 300. For highways with limited access control, see Chapter 530.

(1) Approval

An intersection is approved in accordance with Chapter 300. Complete the following items, as needed, before intersection approval:

- Traffic analysis
- Deviations approved in accordance with Chapter 300
- Approved Traffic Signal Permit (DOT Form 242-014 EF) (see Chapter 1330)

(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; and so forth.

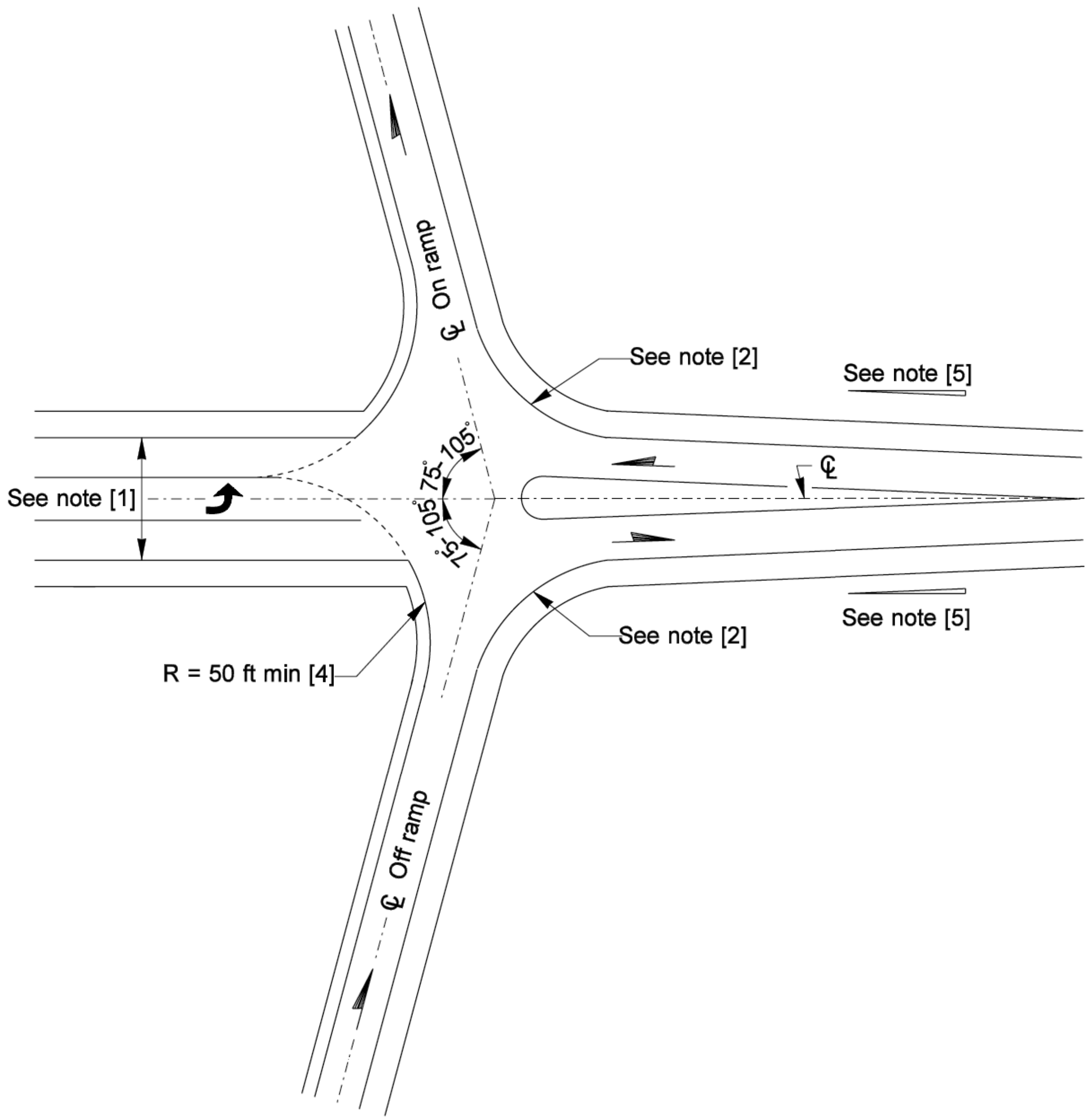
For information to be included on the intersection plan for approval, see the Intersection/Channelization Plan for Approval Checklist on the following website:
www.wsdot.wa.gov/design/projectdev/

(3) Local Agency or Developer-Initiated Intersections

There is a separate procedure for local agency or developer-initiated projects at intersections with state routes. The project initiator submits an intersection plan and the documentation of design decisions that led to the plan to the region for approval. For those plans requiring a design variance, the deviation or evaluate upgrade 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*).

1310.13 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/



Notes:

[1] 12-ft through lanes and 13-ft left-turn lane desirable.
[2] For right-turn corner design, see Exhibit 1310-11.
[3] Intersections may be designed individually.
[4] Use templates to verify that the design vehicle can make the turn.
[5] For taper rates, see Exhibit 1310-14a, Table 1.

Interchange Ramp Terminal Details
Exhibit 1310-10

1320.01 General

Modern roundabouts are 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 conventional intersections. 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. For additional information and details on roundabouts, see *Roundabouts: An Informational Guide*.

Selection of a roundabout is based on an engineering analysis that examines traffic volumes, traffic patterns, space needs, and right of way availability.

Modern roundabouts differ from older circular intersections in three ways: they have splitter islands that provide entry deflection to slow down entering vehicles; they have yield-at-entry, which requires entering vehicles to yield to vehicles in the roundabout to allow free flow of circulating traffic; and they have a smaller diameter that constrains circulating speeds.

1320.02 References

(1) Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA)

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

(2) Design Guidance

ADA Accessibility Guidelines for Buildings and Facilities (ADAAG), U.S. Access Board
www.access-board.gov/adaag/html/adaag.htm

ADA Standards for Accessible Design, U.S. Department of Justice
www.usdoj.gov/crt/ada/adahom1.htm

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

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT

(3) Supporting Information

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

"Crash Reductions Following Installation of Roundabouts in the United States," Insurance Institute for Highway Safety, March 2000
www.nysdot.gov/portal/page/portal/main/roundabouts/files/insurance_report.pdf

Guide to Traffic Engineering Practice, Part 6 – Roundabouts (Austroad Guide), Sydney, Australia: Austroad, 1993

Highway Capacity Manual (HCM), Special Report 209, Transportation Research Board, National Research Council

Modern Roundabout Practice in the United States, NCHRP Synthesis 264, Transportation Research Board, 1998
onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_264.pdf

Roundabouts: An Informational Guide, FHWA-RD-00-067, USDOT, FHWA
www.tfhrc.gov/safety/00068.htm

Roundabout Design Guidelines, Ourston & Doctors, Santa Barbara, California, 1995

The Traffic Capacity of Roundabouts, TRRL Laboratory Report 942, Kimber, R.M., Crowthorne, England: Transport and Road Research Laboratory, 1980

"Use of Roundabouts," ITE Technical Council Committee 5B-17, Feb. 1992
www.ite.org/traffic/documents/JBA92A42.pdf

The Design of Roundabouts: State of the Art Review, Brown, Mike, Transportation Research Laboratory, Department of Transport. London, HMSO, 1995

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005
www.wsdot.wa.gov/eesc/design/Urban/

1320.11 Access, Parking, and Transit Facilities

No road approach connections to the circulating roadway are allowed at roundabouts unless they are designed as legs 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 (see Chapter 550). If minimum corner clearance cannot be met, provide justification. (For additional information on limited access highways, see Chapter 530.)

If the 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 (see Exhibit 1320-33a).

Roadways between roundabouts may have restrictive medians with left-turn access provided with U-turns at the roundabouts (see Exhibit 1320-33b).

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 within the length of the splitter island, 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.

1320.12 Design Procedures

Document roundabout design considerations and conclusions in accordance with Chapter 300.

(1) Conceptual Design

Early coordination between the design team, region Traffic and Project Development offices, and HQ Traffic and Design offices is essential for a roundabout design layout.

(a) **Conceptual Meeting**

Conduct a Conceptual Meeting with the region Traffic Office, the region Project Development Engineer or Engineering Manager, and the HQ Traffic and Design offices after the traffic analysis has been completed. The intent of this meeting is to review, discuss, and evaluate alternative layouts for a roundabout before too much time and resources have been expended. The outcome of the meeting will provide sufficient information that a designer can proceed with finalizing the geometric design.

As a minimum, consider, discuss, and document the following items for the Conceptual Meeting:

1. **Project Overview**
2. **Traffic Analysis Recommendations and Conclusions**

   In addition to Chapter 320, Traffic Analysis, the following items need to be documented:

   - Use 20 years after the year construction is scheduled to begin as the design year of the analysis.
   - Identify the approximate year a single-lane roundabout intersection level of service (LOS) will operate below the selected design LOS or require expansion.
   - Identify and justify growth rate(s) used for the design year analysis.
   - Provide peak hour (both a.m. and p.m.) turning movement volumes for each leg for the existing and design year.
   - Input an environmental factor of 1.1 if required by the analysis software.
   - Provide pertinent reports generated (such as level of service, queue length, delay, percent stopped, and degree of saturation) from the analysis software used. (Contact the region or HQ Traffic Office for currently approved capacity analysis software. Using older software versions is not acceptable).
   - Provide explanation of the impacts to traffic operations upstream and downstream of the intersection in situations where V/C exceeds 0.92.

3. **Preliminary Layout**

   Provide an existing plan sheet, base map, or aerial photo (non-CADD-generated is encouraged) with the preliminary roundabout sketched at the intersection for use in evaluating current or new concepts to the roundabout layout. The intent is for the designer to quickly develop the roundabout footprint for the intersection without expending a lot of time or resources drafting PS&E-quality plans to show the design of the roundabout. Typically, revisions are needed based upon the feedback received at the Conceptual Meeting.

   Use an existing plan sheet, base map, or aerial photo of sufficient scale to show existing roadway alignment and features, surrounding topographic information (may include aboveground and belowground utility elements), rights of way (existing), surrounding buildings, environmental constraints (such as wetlands), drainage, and other constraints that may impact the design of the roundabout.

4. **Design Vehicle**

   Identify the design vehicle for each leg of the intersection. Include the truck types and sizes (oversized vehicles) that travel through the area (currently and in the future) and whether the roundabout is on an existing or planned truck route.

5. **Other Topics for Discussion**

   Additional items that need to be discussed and considered in the design of the roundabout may include:

   - Vehicle turning path templates: Use approved software to validate the roundabout.
   - Fastest path speeds.
   - Splitter island design: Provide a smooth entry alignment into the roundabout.
   - Other roundabout shapes.
   - Bike and pedestrian design, including ADA requirements.
   - Central island design.
   - Curbing details.
   - Signing, illumination, and delineation considerations.
   - Vertical grade.
   - Adjacent posted speeds.
   - Existing and future corridor congestion.

(2) Geometric Design

The Design Documentation Package (DDP) is the documentation of the final roundabout design and the decisions that resulted in the design. Complete the DDP before intersection plan approval.

As a minimum, include the following items in the geometric Design Documentation Package:

(a) Intersection plan showing the roundabout channelization.

(b) A summary of the design decisions and deviations that pertain to the roundabout.

(c) Roundabout geometric data, including the following:

- Identify approach design speeds for all approach legs.
- Identify the design vehicle.
- Provide a table summarizing the roundabout design details, including inscribed diameter, central island diameter, truck apron width, fastest path (radius and speed) for each approach, and superelevation of the circulating roadway.
- Provide detailed drawings showing the fastest paths for each movement.
- Provide a table summarizing stopping and intersection sight distance on each leg.
- Provide auto turn paths showing design vehicle, WB-67, and largest oversize vehicle movements.

(d) Detailed drawings of the splitter islands on each leg.

(e) Preliminary signing, delineation, and illumination plans.

(f) Curb types used.

(g) Central island design.

(h) Bike and pedestrian design, including ADA requirements.

A roundabout review checklist and example package is located on the Project Development web page:
www.wsdot.wa.gov/Design/ProjectDev

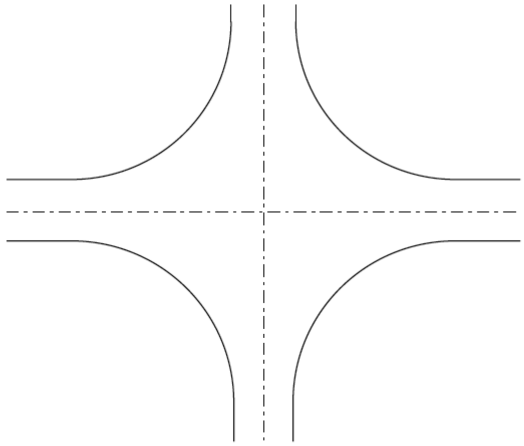
(3) Approvals

A roundabout is approved as an intersection in accordance with Chapter 1310. Document all design decisions as part of the Design Documentation Package (DDP).

If there are numerous design variances for a roundabout design, coordinate with the region Traffic Office, region Project Development Engineer or Engineering Manager, and Assistant State Design Engineer to determine whether a project analysis is needed.

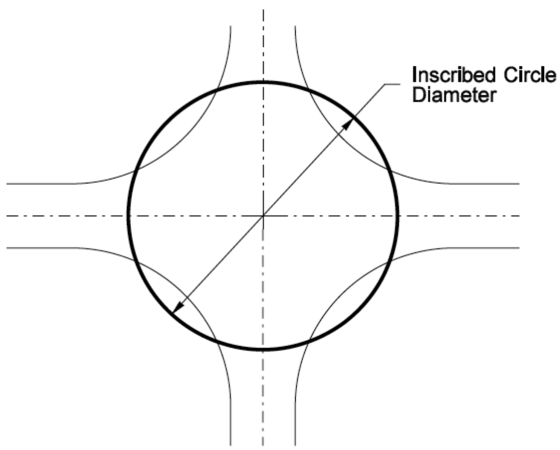
1320.13 Documentation

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/



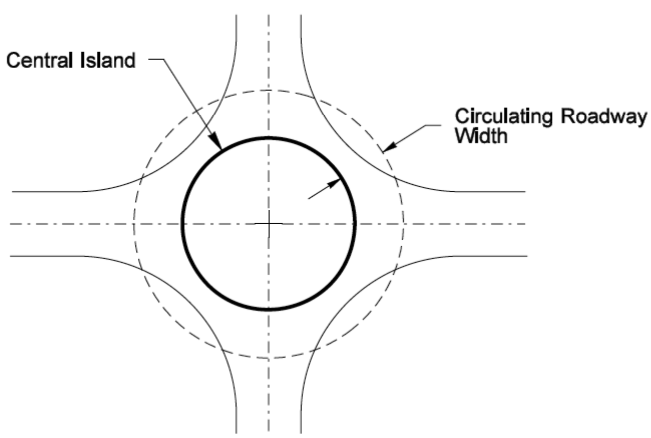
Step 1

Step 1
Start with a scale drawing of the intersection.



Step 2

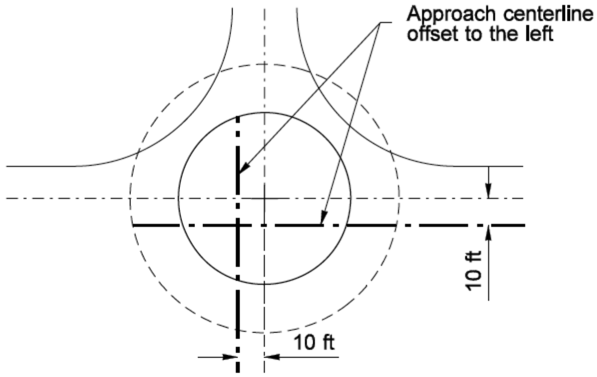
Step 2
Select a trial inscribed circle diameter based on the capacity analysis and Exhibit 1320-8 and place this at the intersection.



Step 3

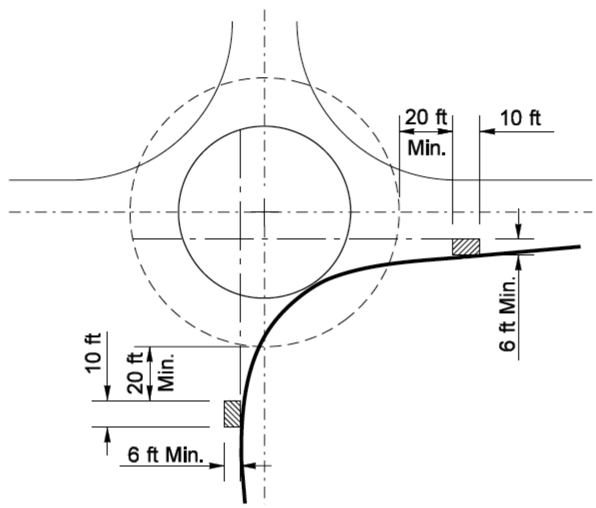
Step 3
Establish the central island and circulating roadway width.

Design Iteration Steps
Exhibit 1320-13a



Step 4

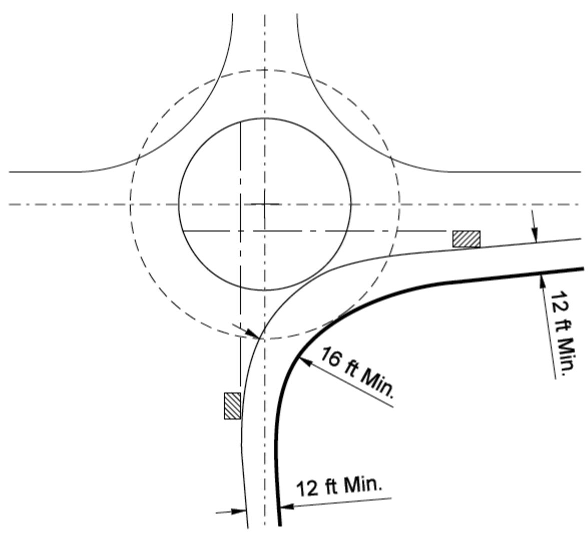
Step 4
Draw each approach's centerline 10 feet to the left of the center of the circle.



Step 5

Step 5
Draw a 10-foot x 6-foot-wide pedestrian refuge 20 feet from the inscribed circle centered on the leg's centerline.

Draw the design elements of the entry curve and the next exit curve to the right. Start with the entry and exit that are closest together and continue around the circle until completing the exit curve on the initial approach.



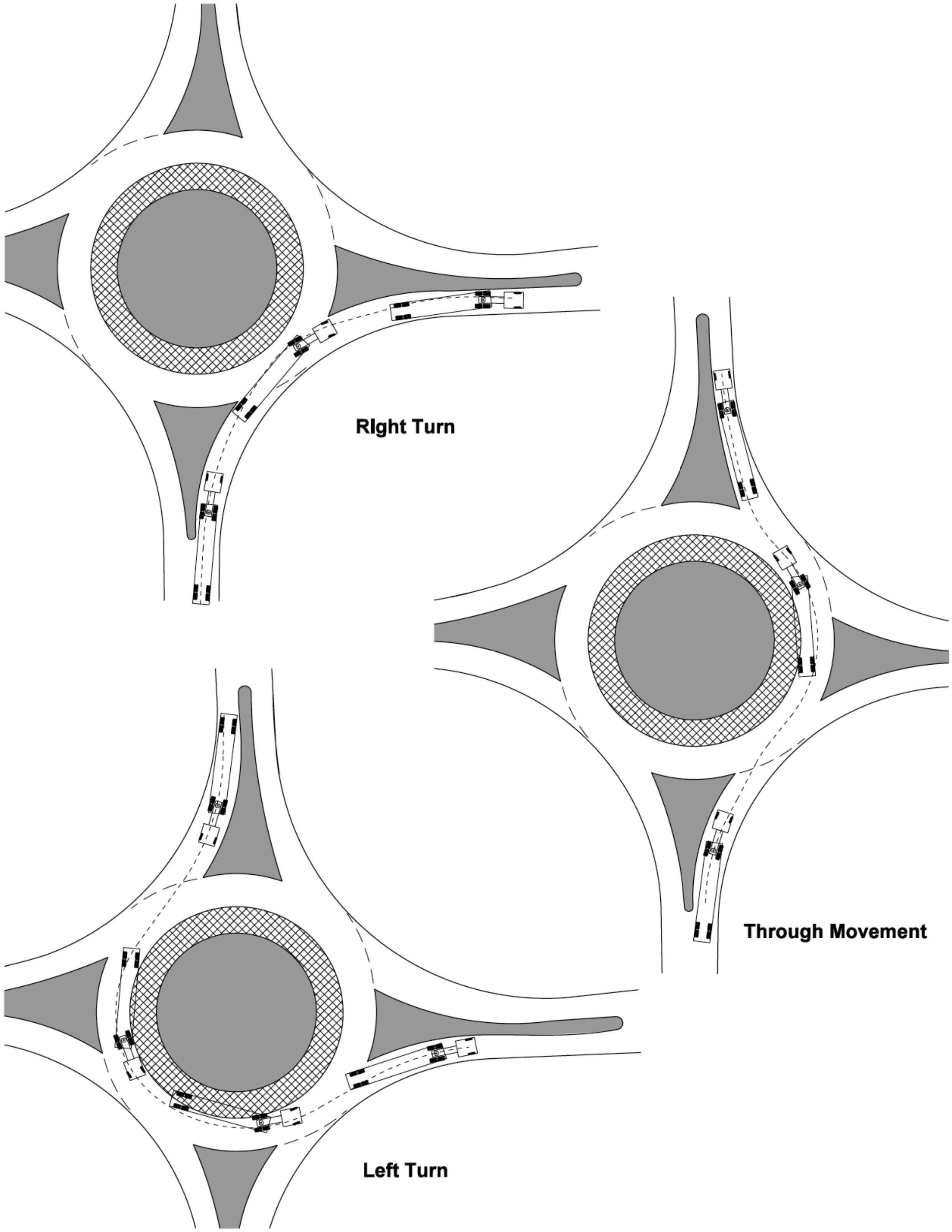
Step 6

Pedestrian Refuge Area

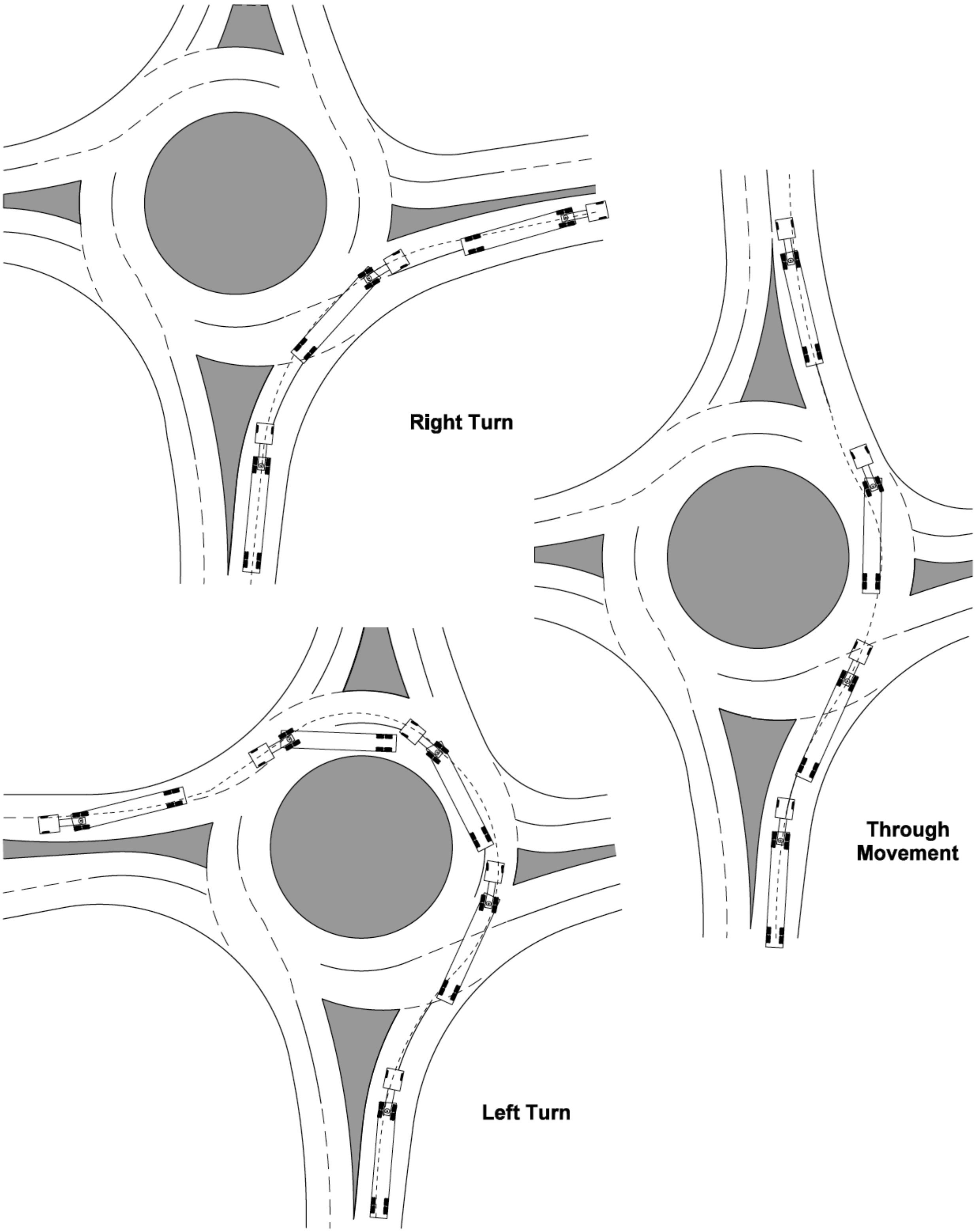
Step 6
Evaluate the adequacy of the roundabout design (check vehicle turning path templates, entry angle, fastest paths, and natural vehicle paths).

Revise deficient design element(s), repeating the design steps above until design performance objectives are met.

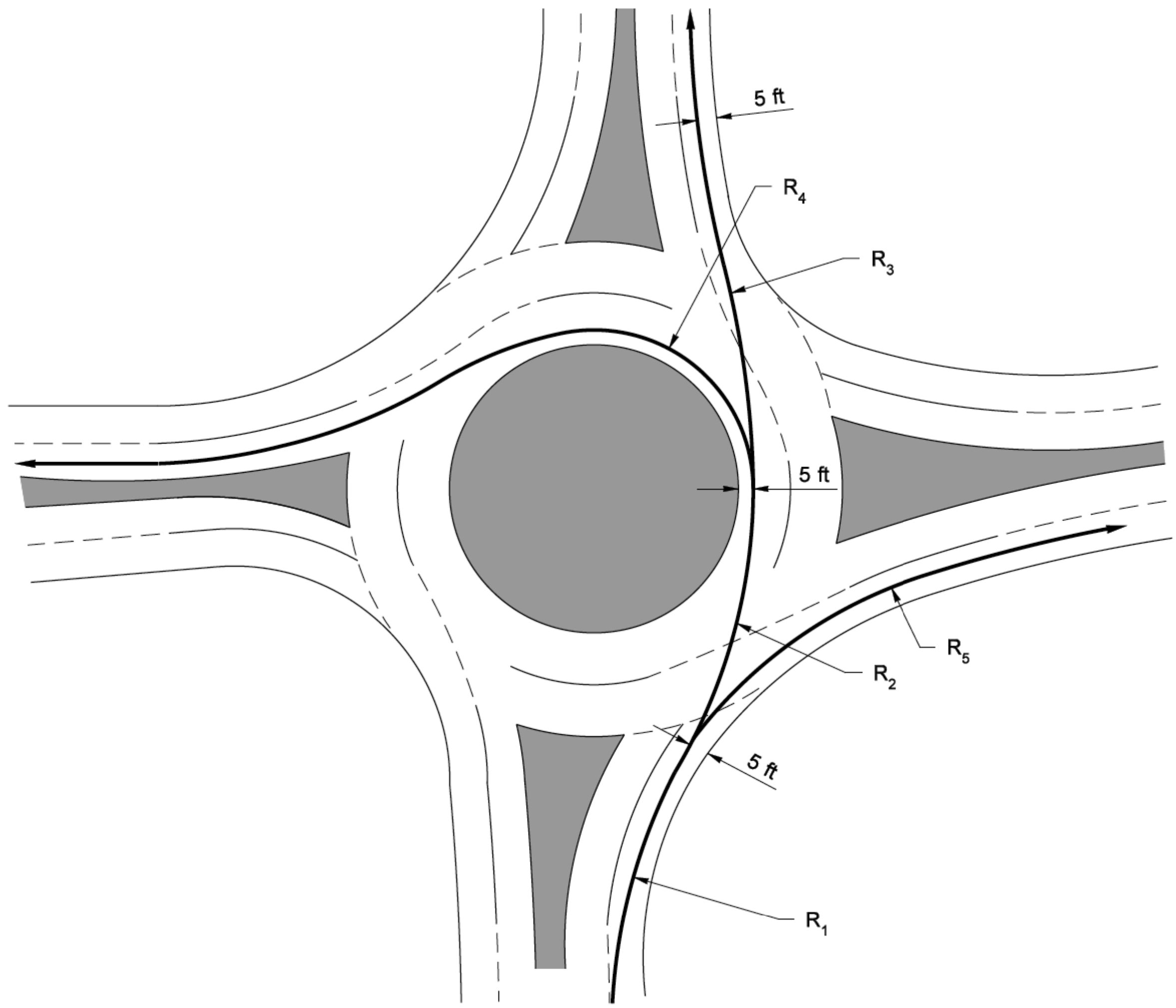
Design Iteration Steps
Exhibit 1320-13b



Truck Turning Paths
Exhibit 1320-14a



Truck Turning Paths
Exhibit 1320-14b



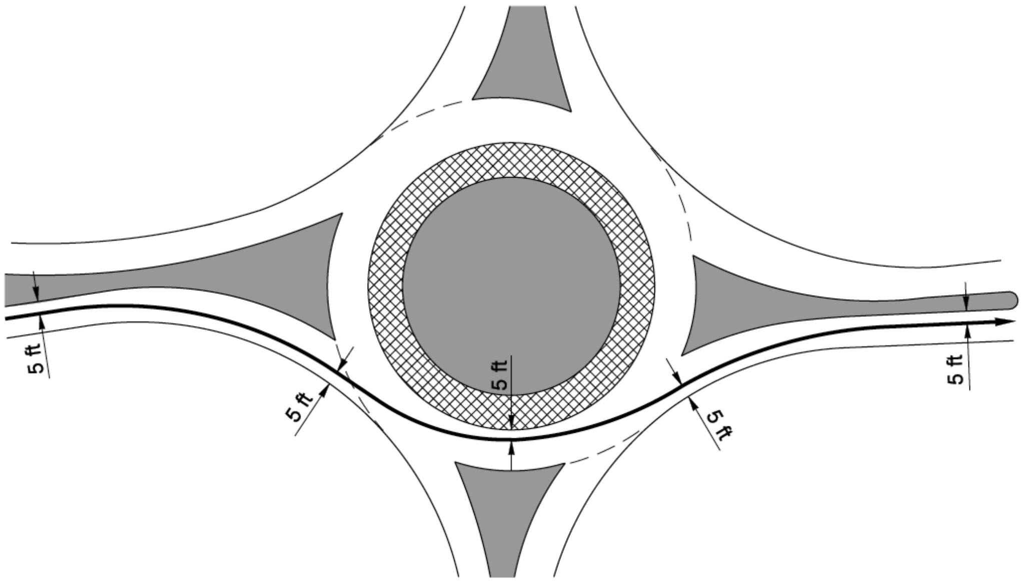
Where:

R_1 = Entry path radius
R_2 = Circulating path radius
R_3 = Exit path radius
R_4 = Left-turn path radius
R_5 = Right-turn path radius

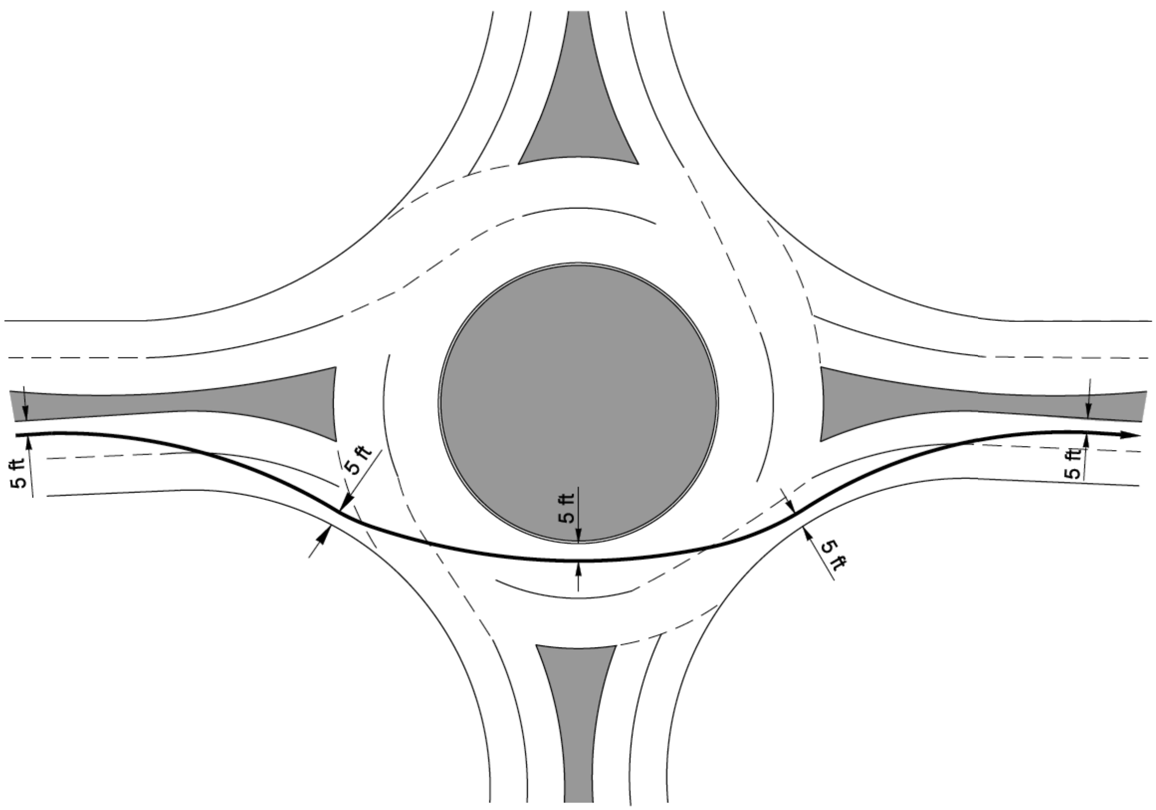
Notes:

- The 5-ft clearance is from raised curbing.
- Edge striping next to a curb is discouraged.

Fastest Path Radii
Exhibit 1320-15a

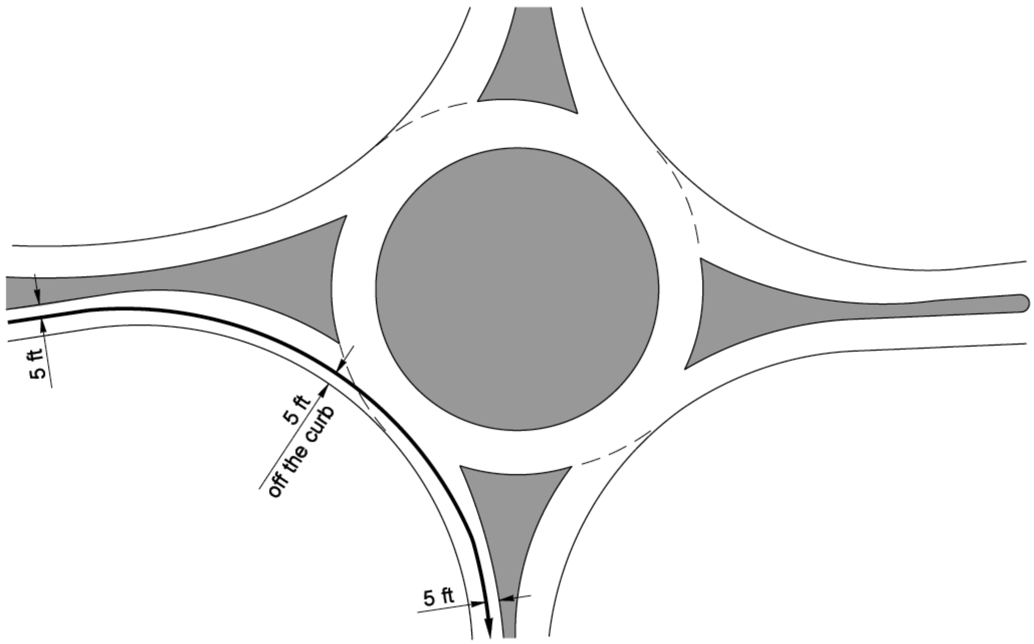


Single-Lane Roundabout

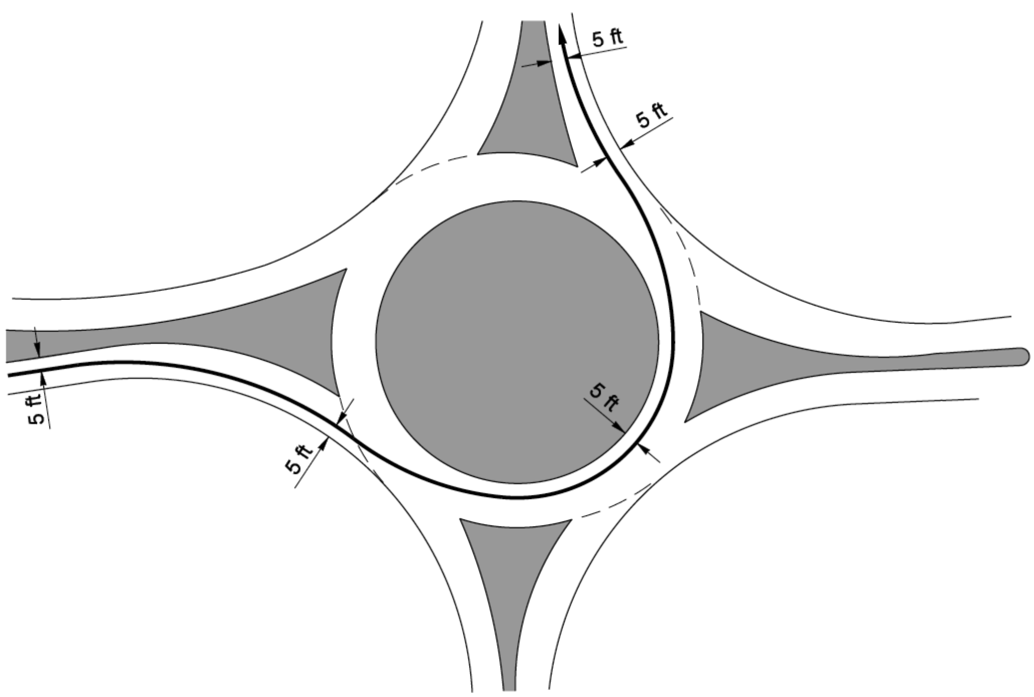


Multilane Roundabout

Fastest Path Radii
Exhibit 1320-15b

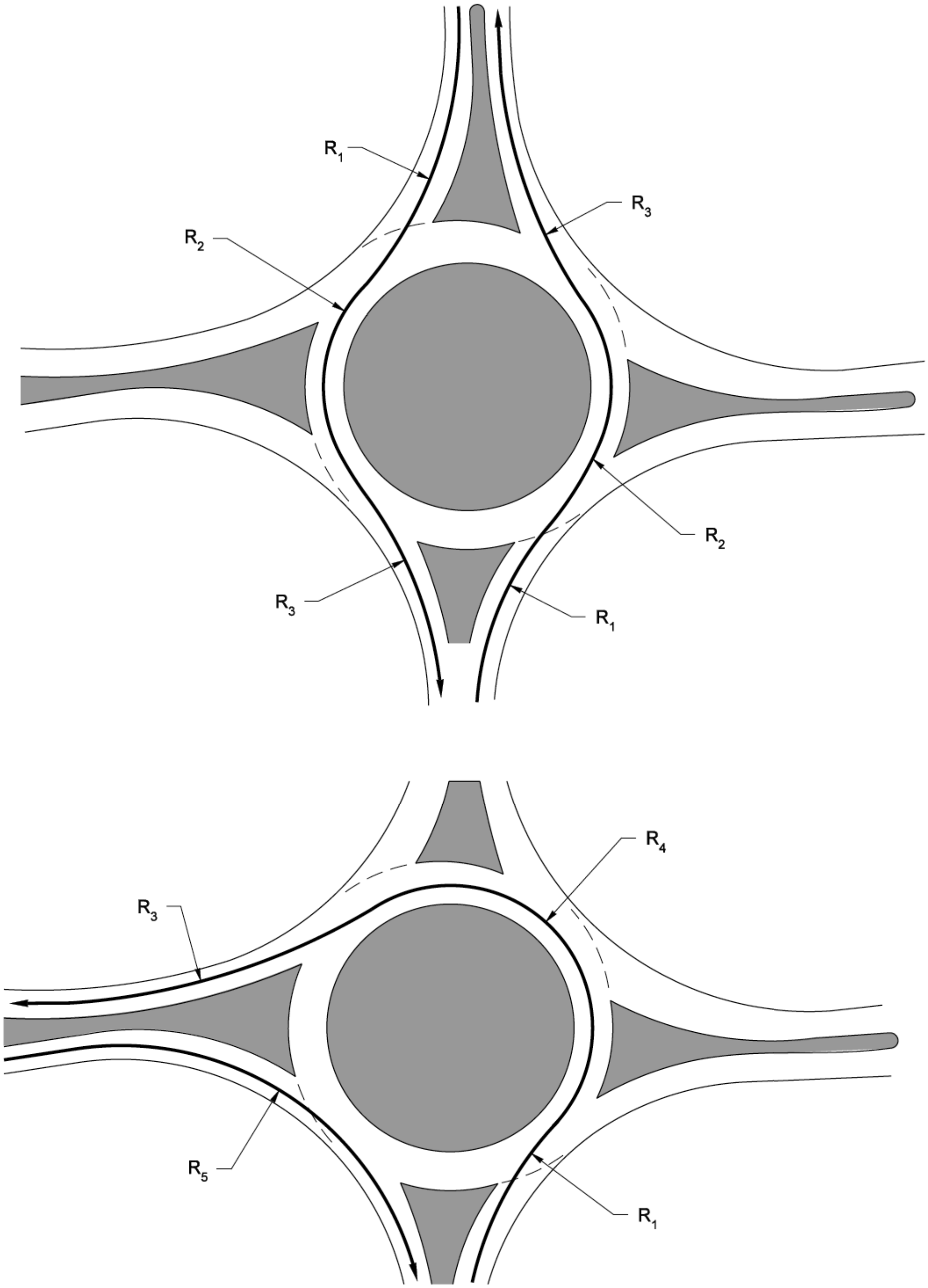


Right-Turn Movement

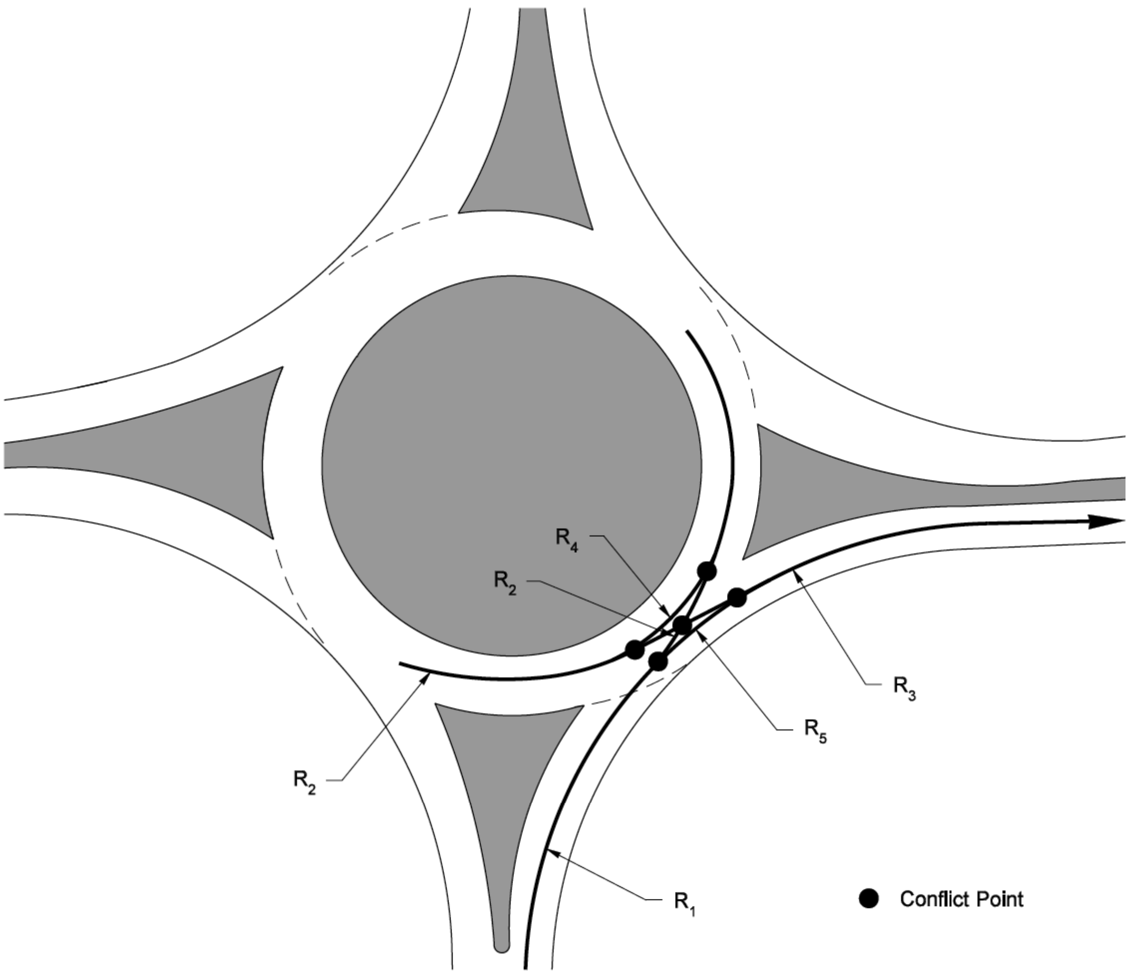


Left-Turn Movement

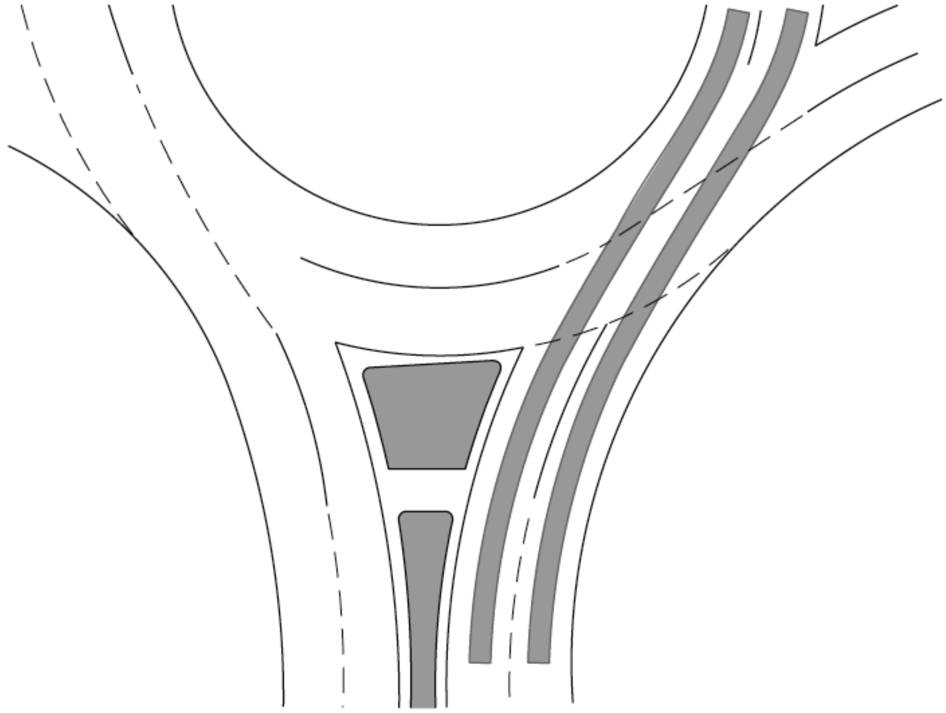
Fastest Path Radii
Exhibit 1320-15c



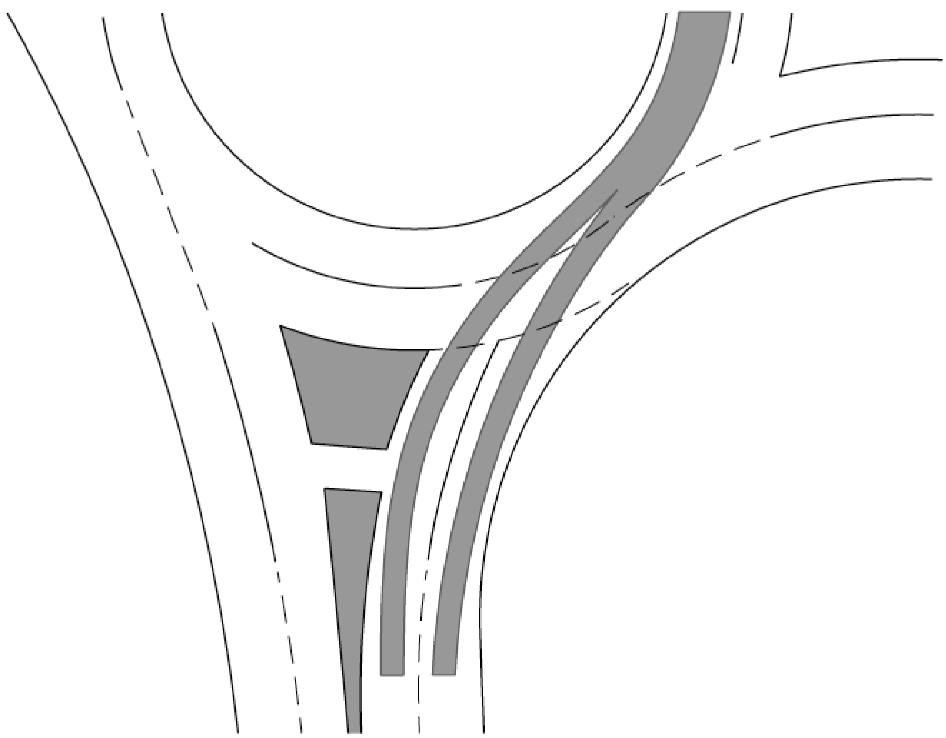
Consecutive Radii
Exhibit 1320-16



Coinciding Radii and Conflict Points
Exhibit 1320-17

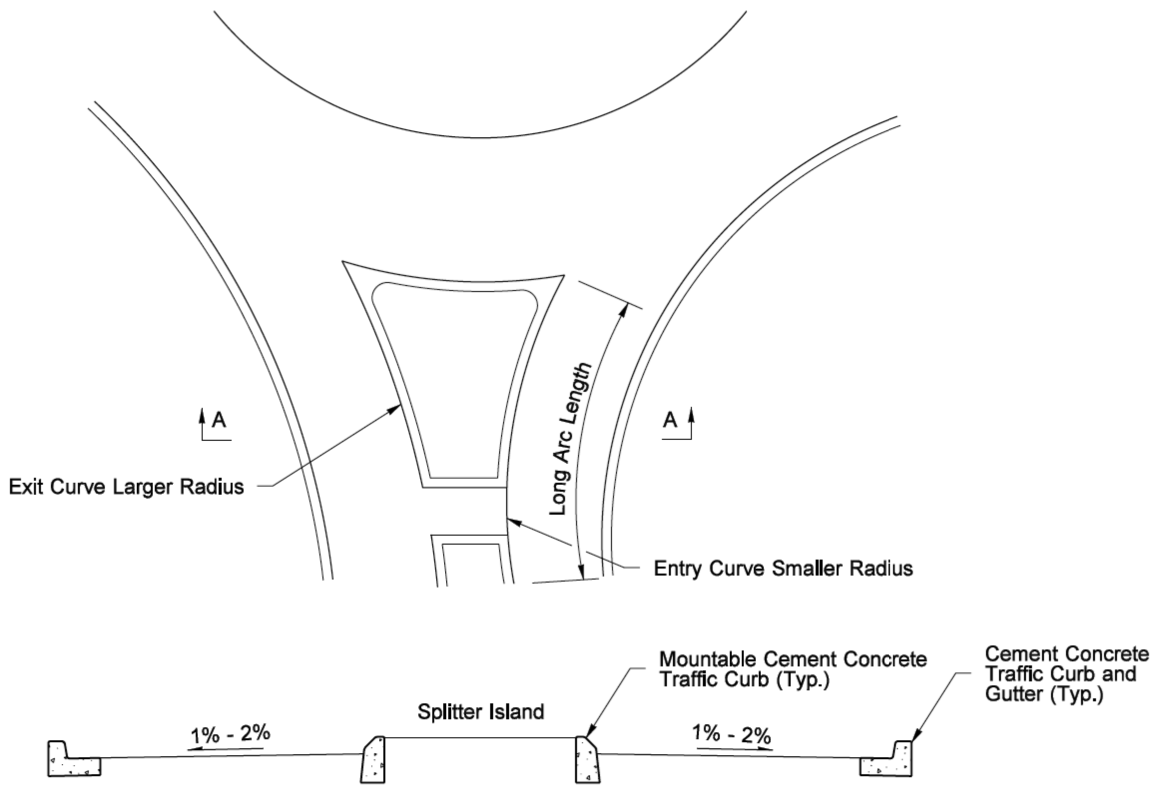


Entry Design Without Path Overlap (Desirable)



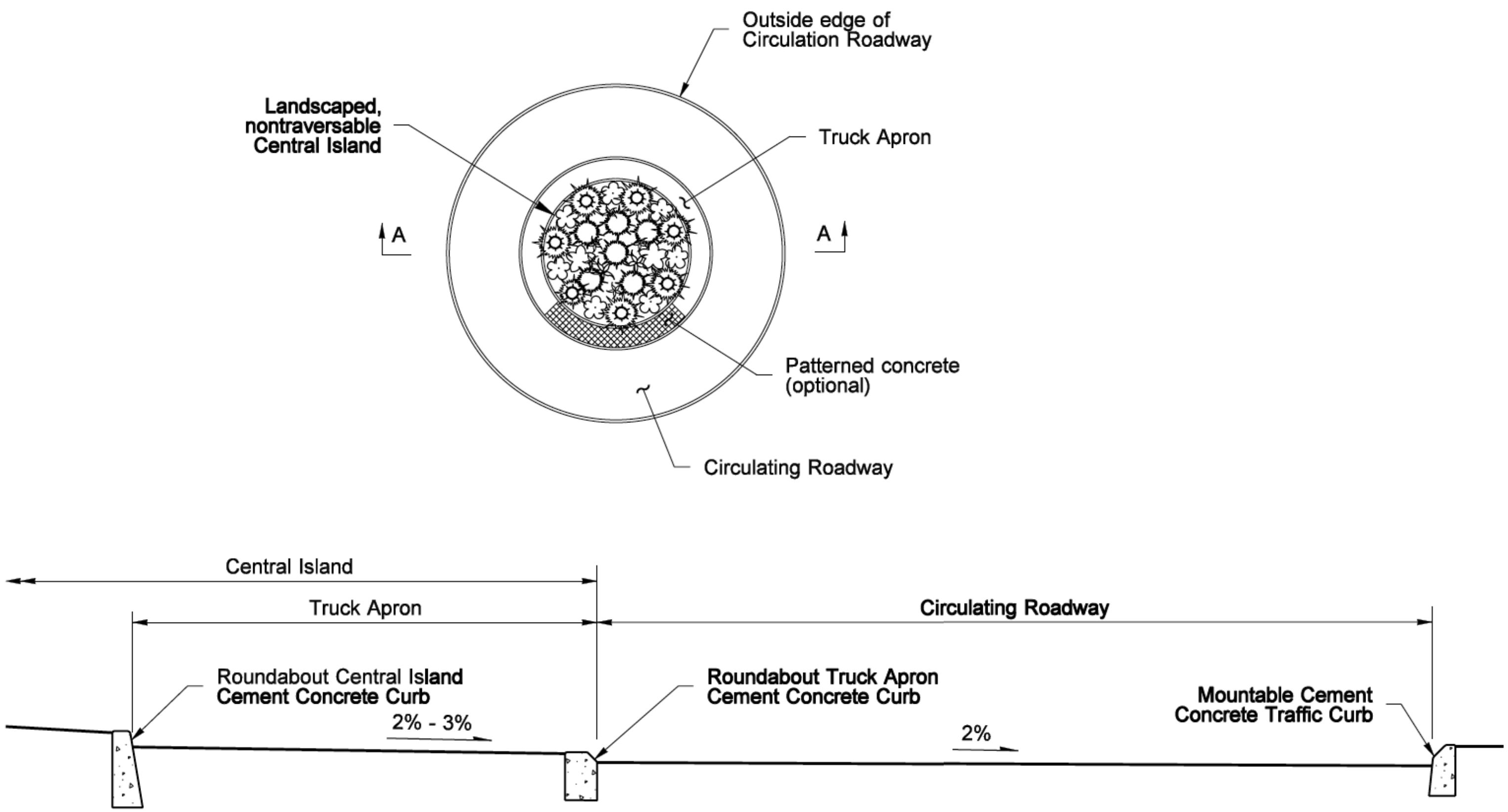
Entry Design With Path Overlap (Undesirable)

Entry Design Path
Exhibit 1320-18



Section A-A
(not to scale)

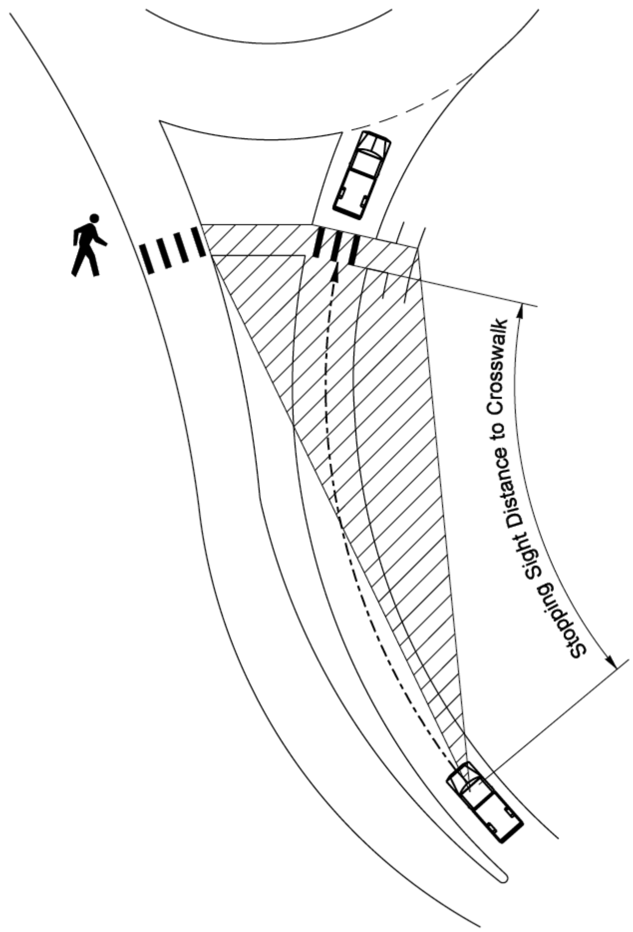
Entry and Exit Curves
Exhibit 1320-19



Section A-A
(not to scale)

Note: For roundabout curb details, see Cement Concrete Curbs in the *Standard Plans*.

Central Island and Cross Section
Exhibit 1320-20

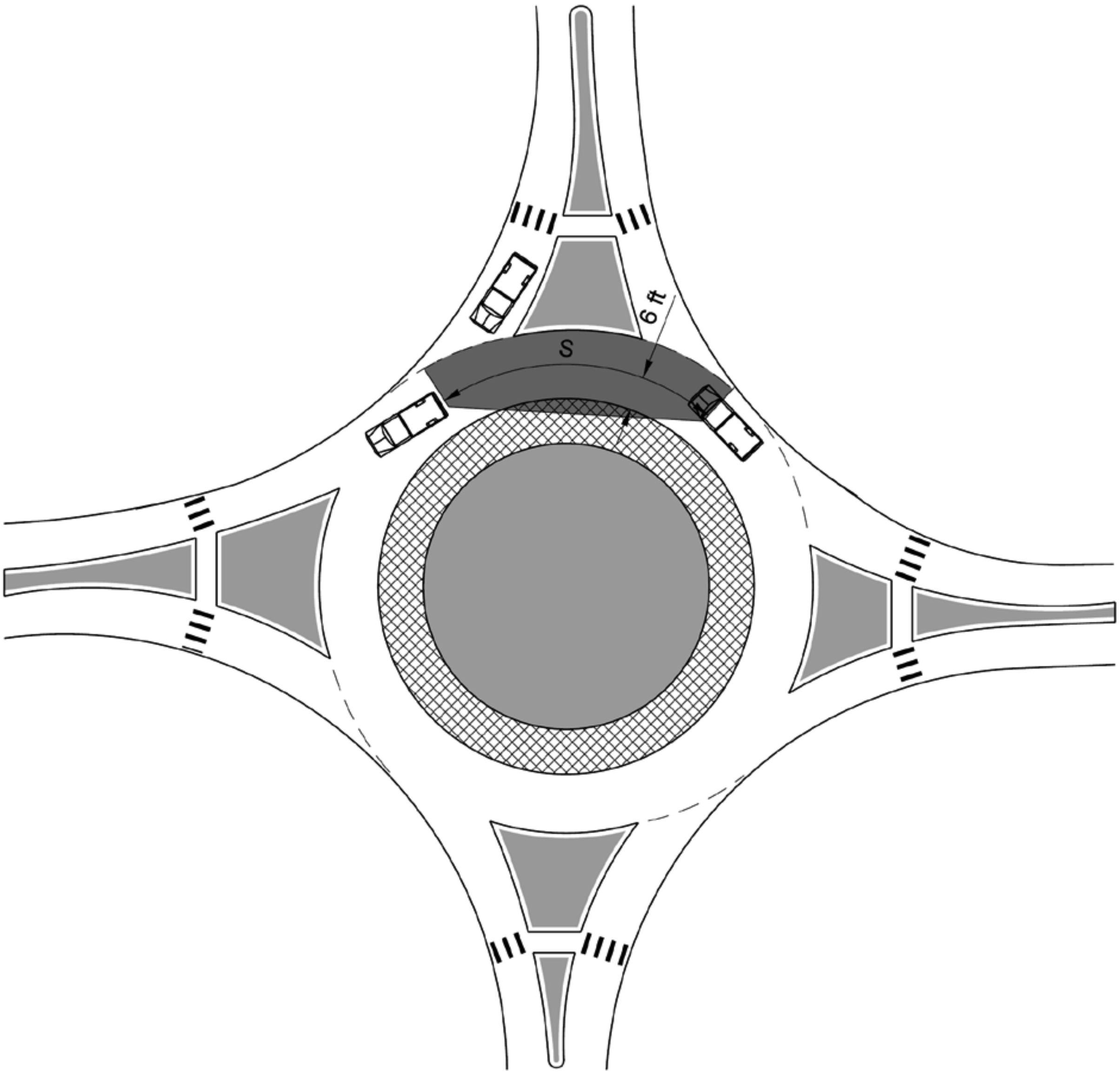


Note:

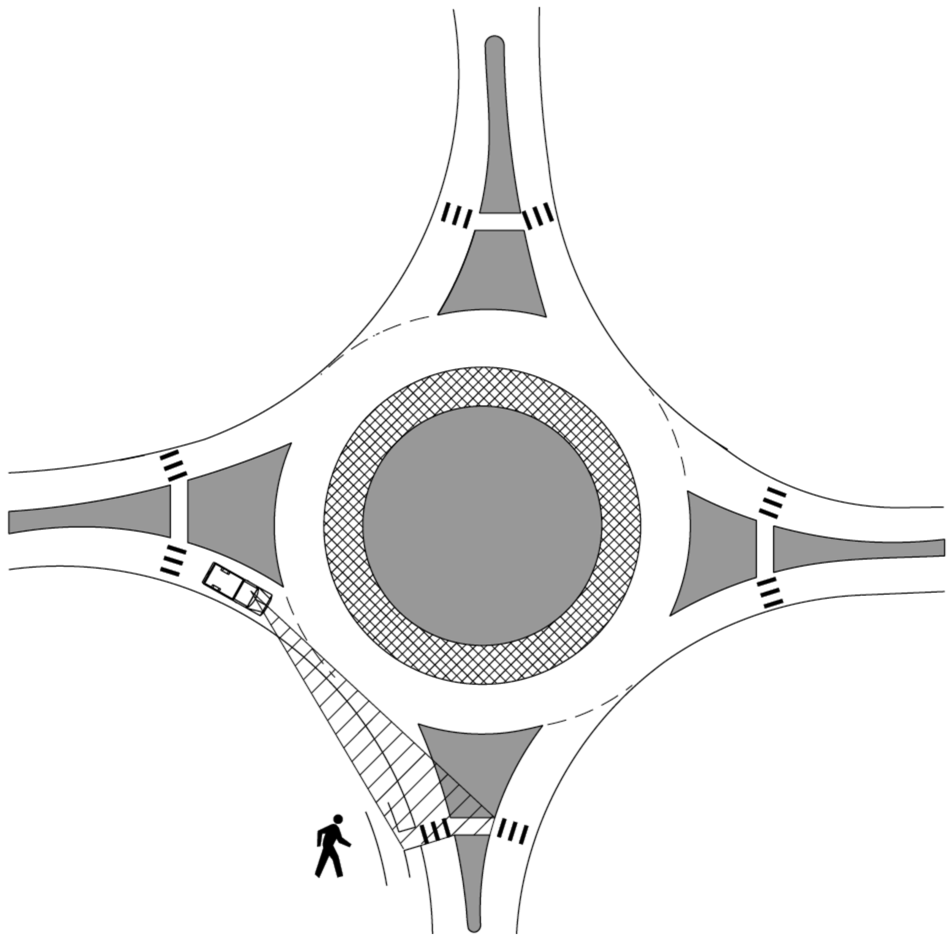
Position the crosswalk one car length (approximately 20 feet) in advance of the yield point.

Approach Stopping Sight Distance to Crosswalk

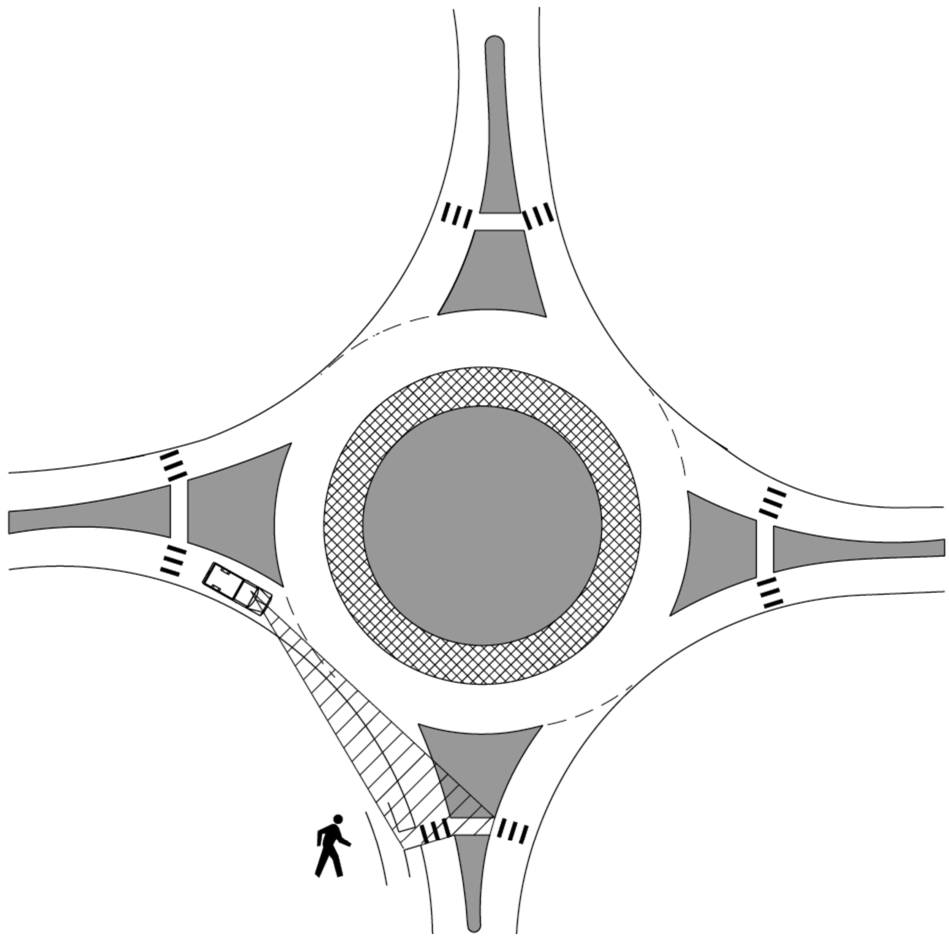
Exhibit 1320-21



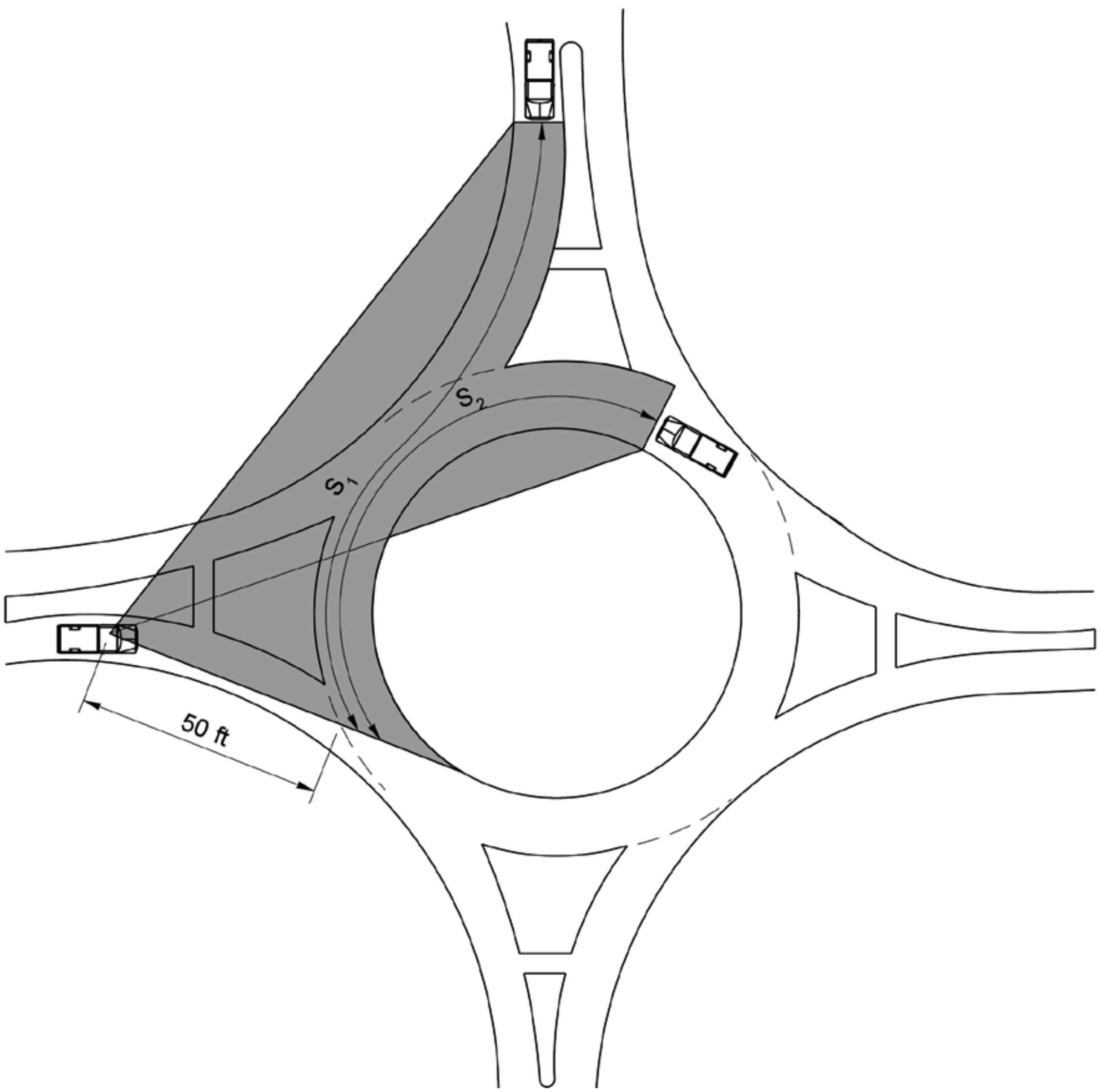
Stopping Sight Distance on Circulatory Roadway
Exhibit 1320-22



Exit Stopping Sight Distance to Crosswalk
Exhibit 1320-23



Exit Stopping Sight Distance to Crosswalk
Exhibit 1320-23

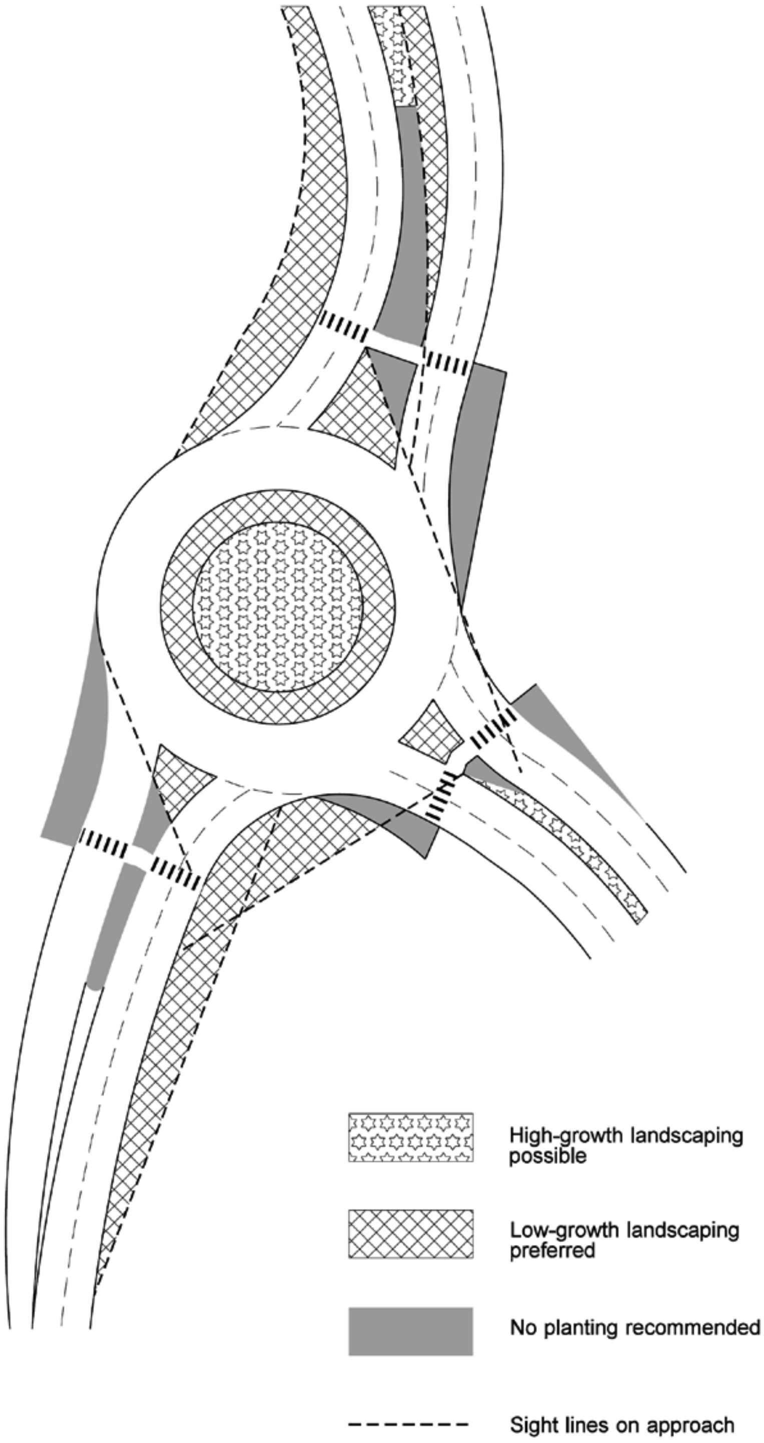


S_1 = Entering stream sight distance

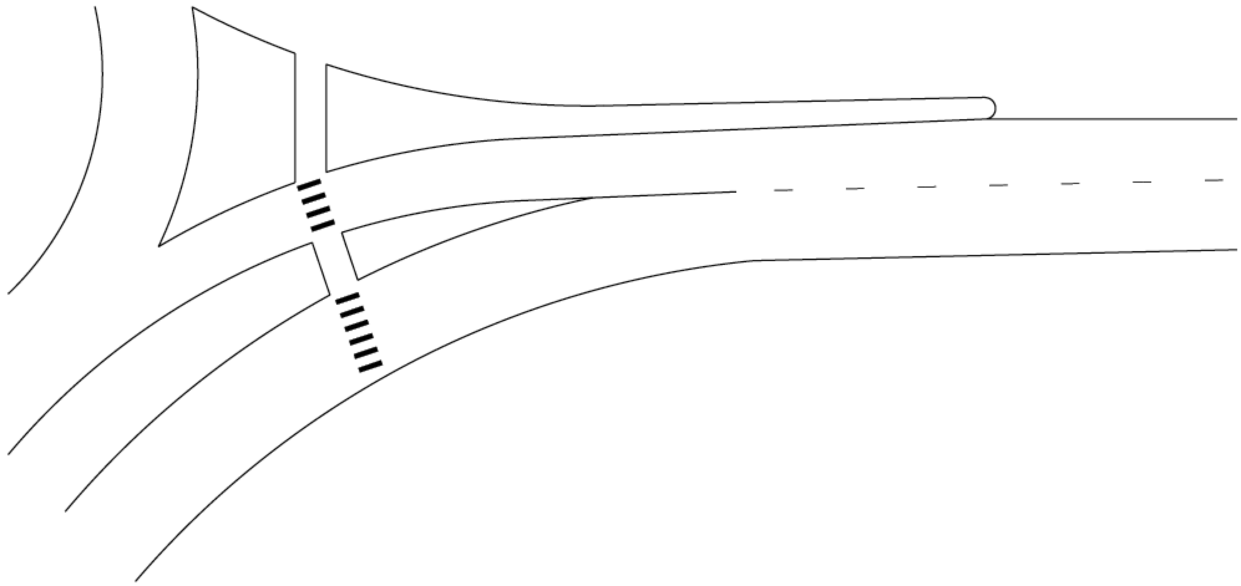
S_2 = Circulating stream sight distance

Intersection Sight Distance

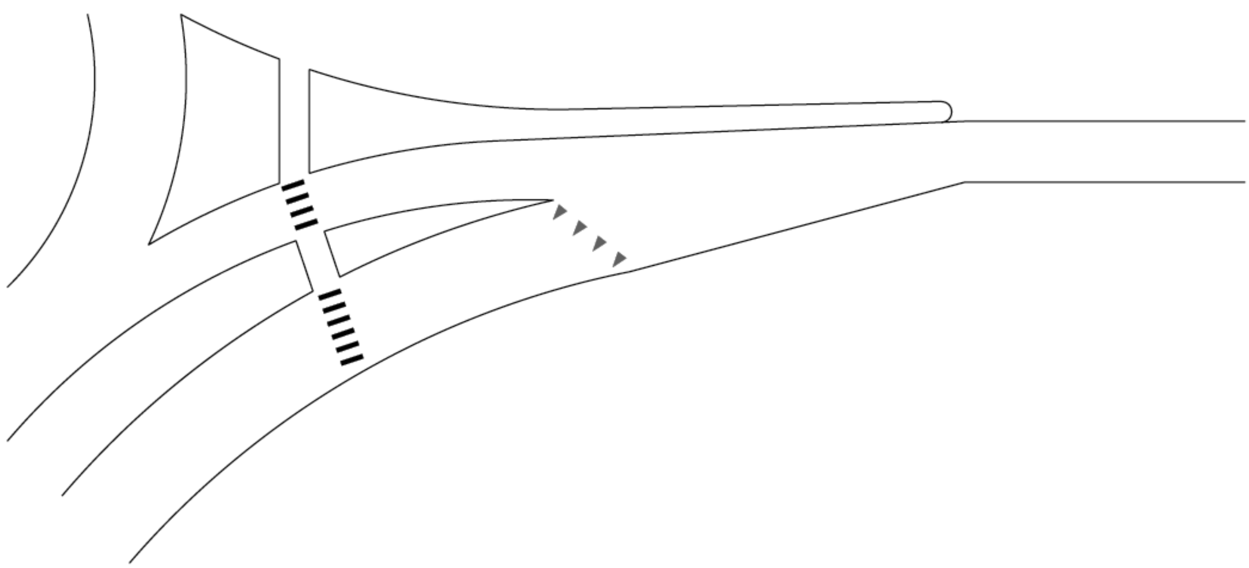
Exhibit 1320-24



Landscaping Height Restrictions for Intersection Sight Distance
Exhibit 1320-25

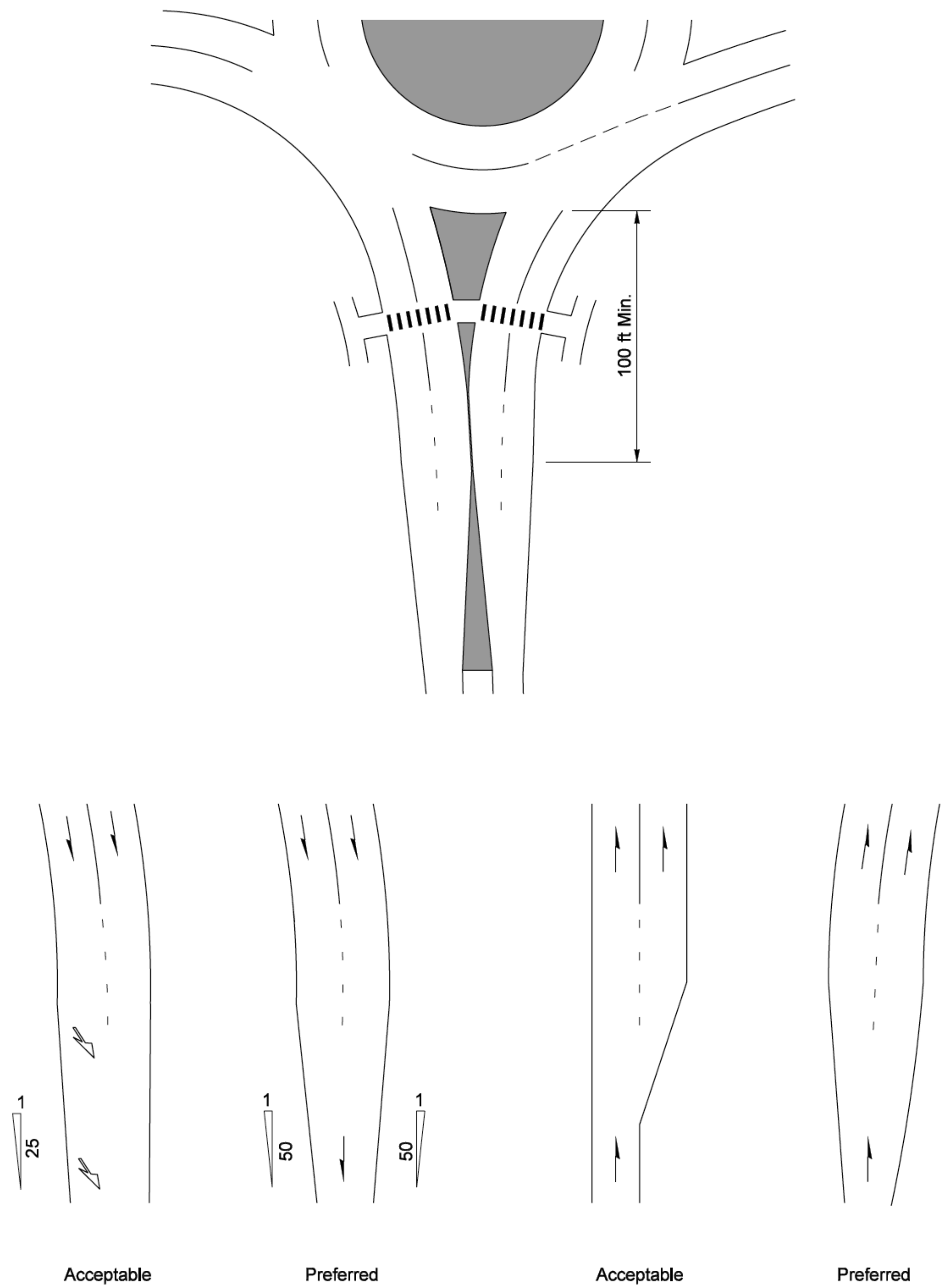


Merge Termination

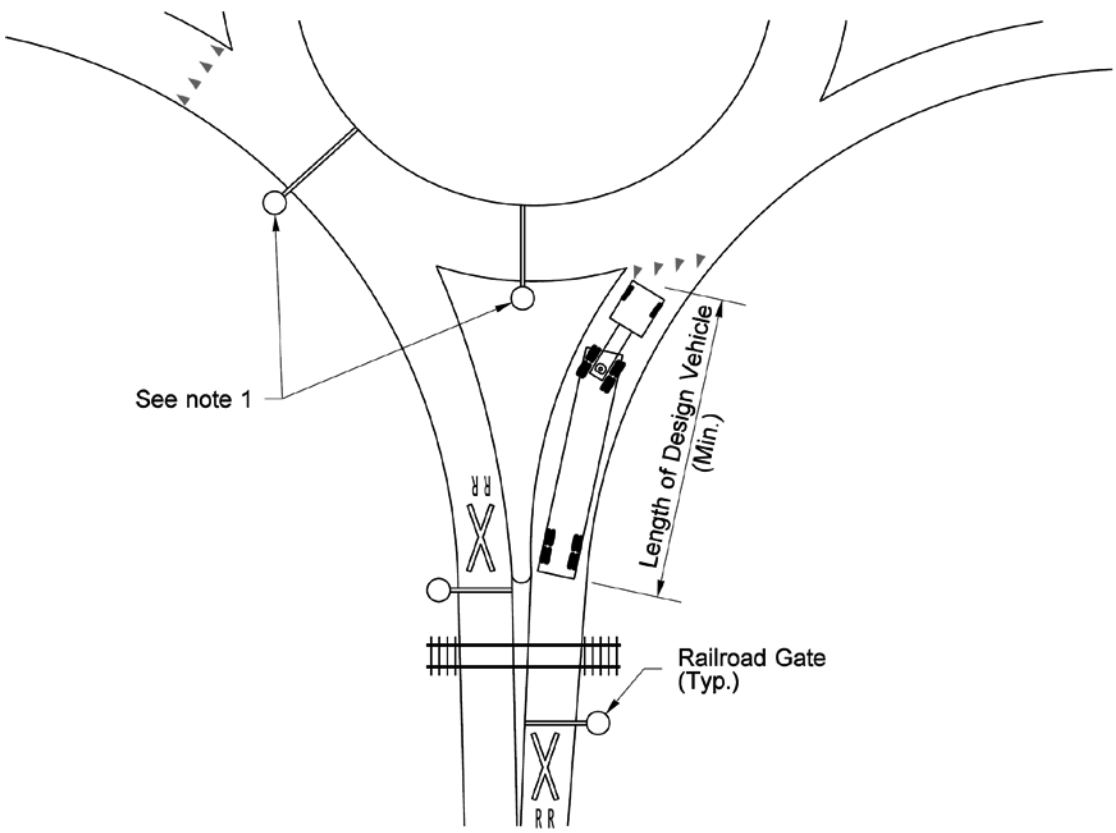


Yield Termination

Right-Turn Slip Lane Termination
Exhibit 1320-26



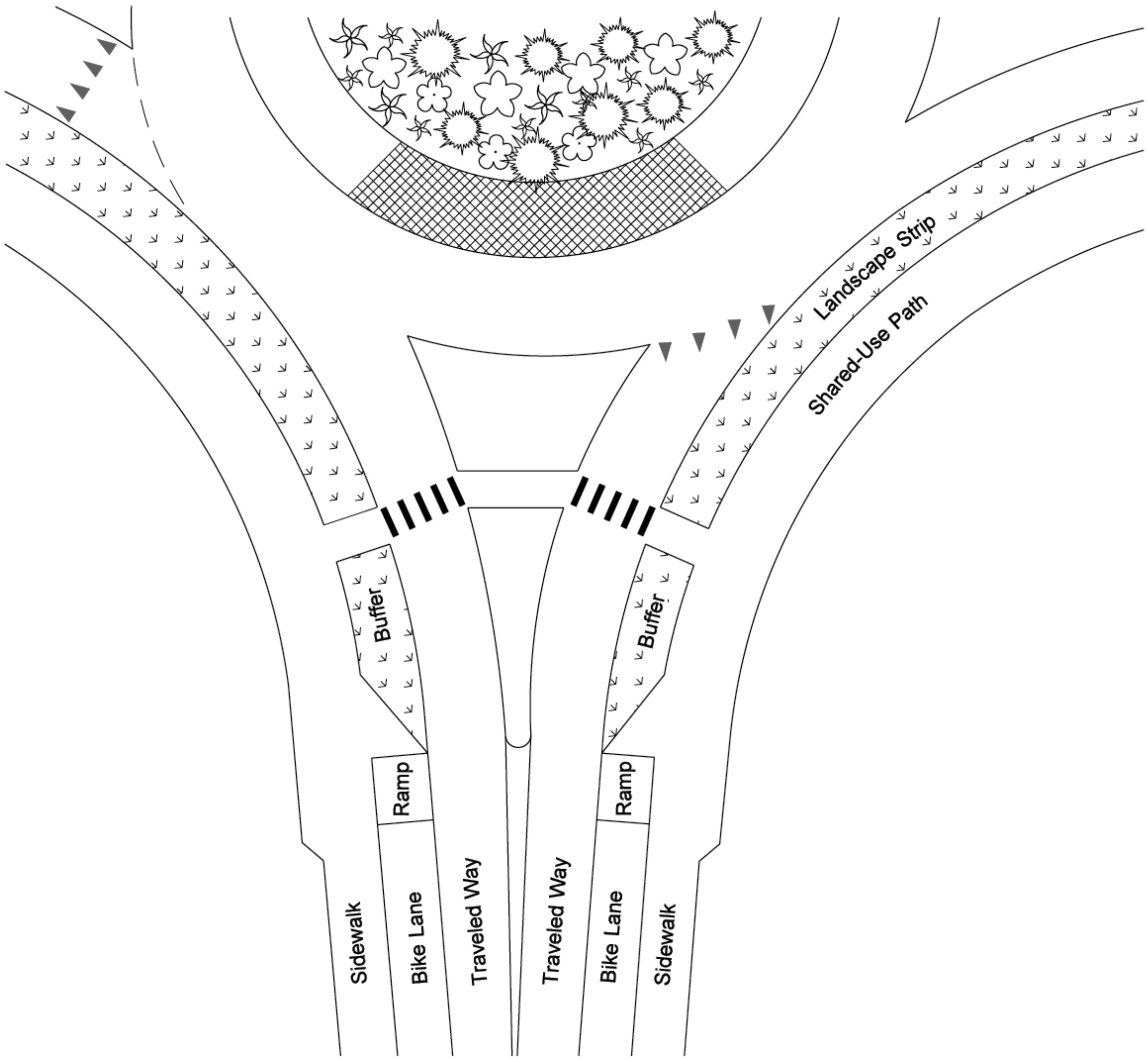
Add and Drop Lanes
Exhibit 1320-27



Note:

[1] Use the intersection analysis and site-specific conditions to help determine the need for, and optimum placement of, a gate on the circulating roadway (see 1320.06(3)(k))

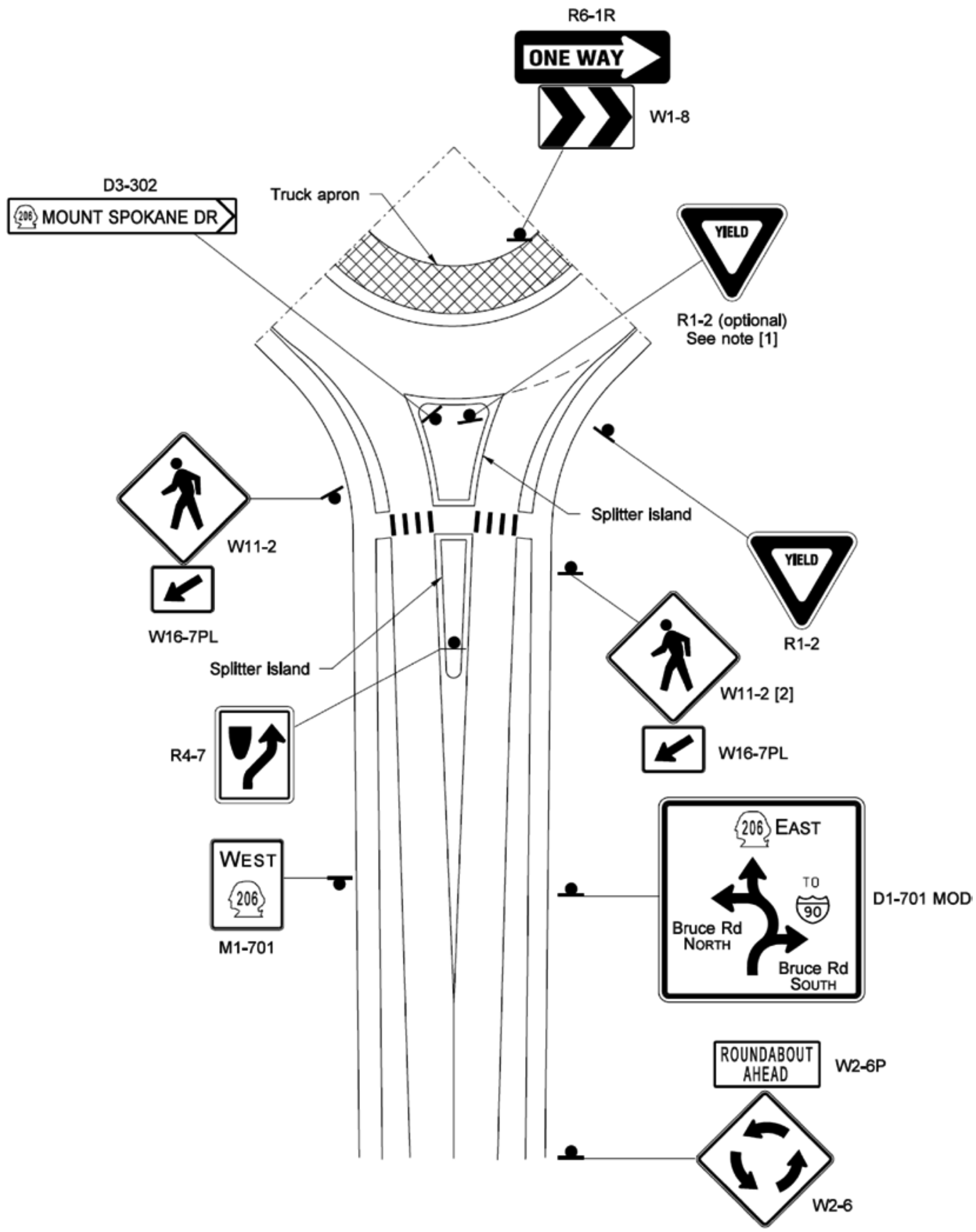
Railroad Gate Configuration
Exhibit 1320-28



Note:

For pedestrian and bicycle design guidance, see Chapters 1510 and 1520.

Bicycle Lanes
Exhibit 1320-29



Notes:

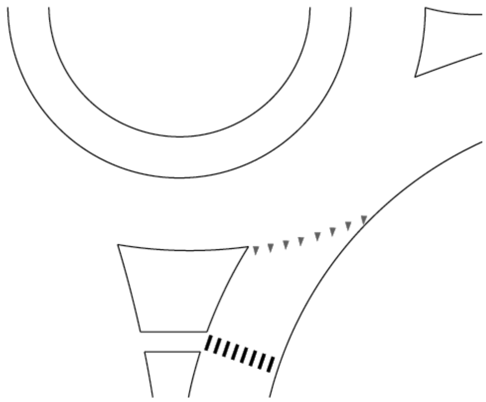
[1] Provide on two-lane entries; consider when view of right-side sign might become obstructed.

[2] Locate in such a way as to not obstruct view of yield sign.

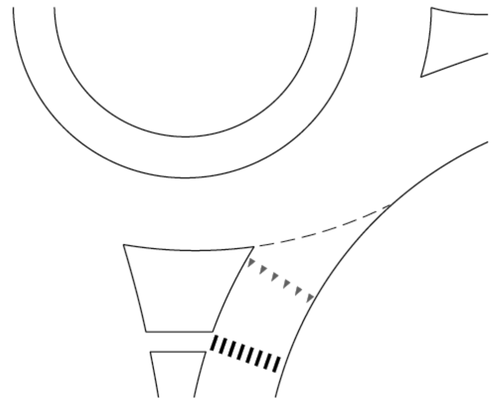
General:

For additional information on sign installation, see Chapter 1020.

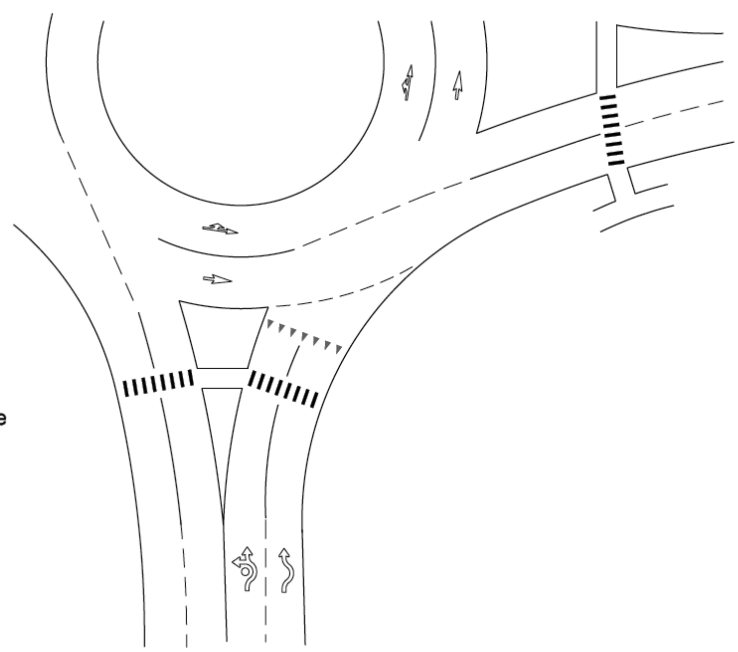
Roundabout Signing
Exhibit 1320-30



Single-Lane Striping
Option 1



Single-Lane Striping
Option 2

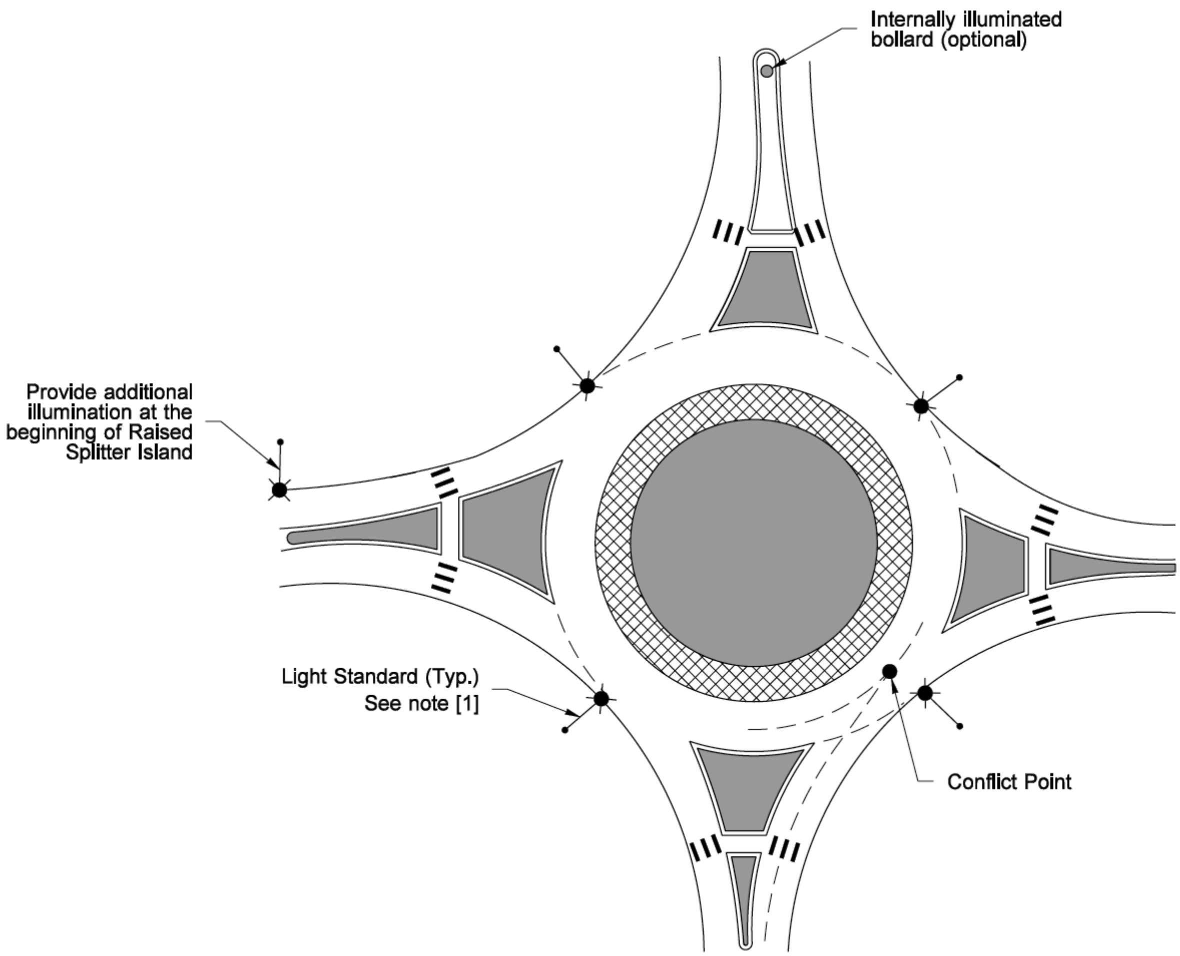


Multilane Striping

Note:

For Single and Multilane Roundabouts use Option 1 or Option 2 for placement of "yield symbols" at or near entry line.

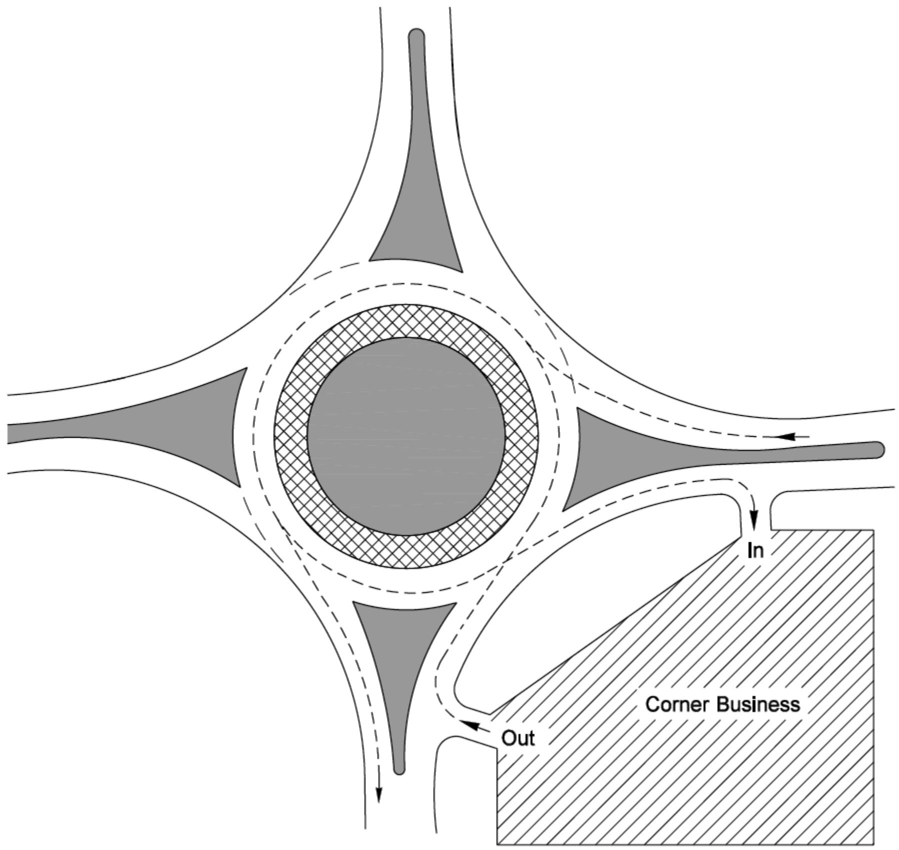
Roundabout Striping and Pavement Marking
Exhibit 1320-31



Note:

[1] Consider additional lighting for walkways and crosswalks to provide visibility for pedestrians. Also use to provide illumination of the roadway behind the pedestrian from the driver's perspective.

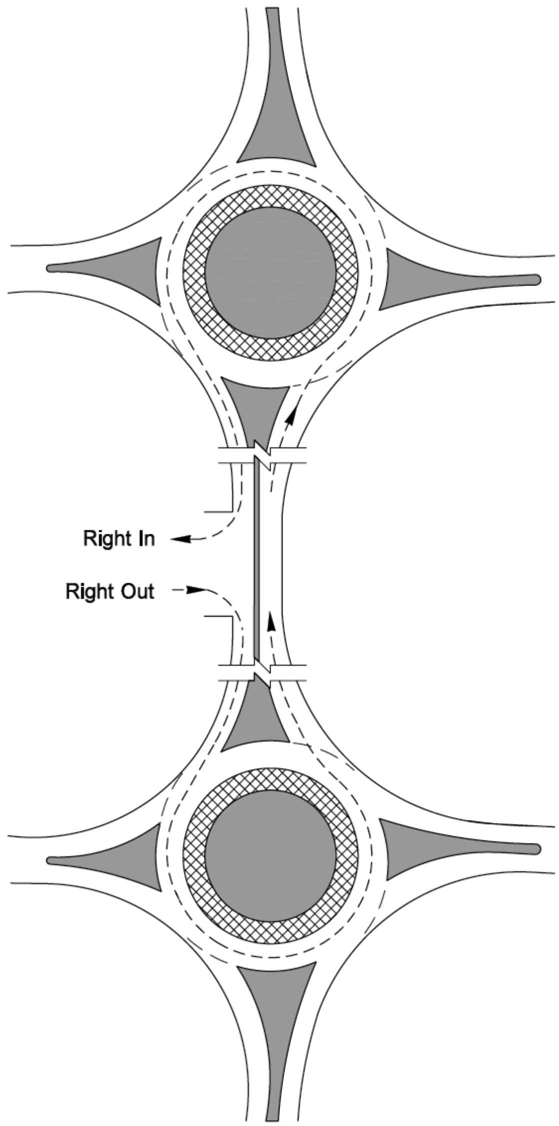
Roundabout Illumination
Exhibit 1320-32



Notes:

- For additional restrictions on limited access highways, see Chapter 530.
- For corner clearance criteria on managed access highways, see Chapter 540.

Multiple Access Circulation
Exhibit 1320-33a



Left-turn access between roundabouts using U-turns at the roundabouts.

Multiple Access Circulation
Exhibit 1320-33b

1330.01 General

Traffic control signals are power-operated traffic control devices that warn or direct motorists to take a specific action. They 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 analysis of alternatives that is approved by the region Traffic Engineer or other designated authority.

1330.02 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.

(1) Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA) (23 CFR Part 36, Appendix A)

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 47.36.060, 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.

(2) Design Guidance

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

Directive D 55-03, "Responsibility for Traffic Control Devices, Pavement Widening, and Channelization at Existing Intersections and Two-Way Left Turn Lanes in Cities"

Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings, MNDOT, 2006

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, U.S. Access Board, Nov. 2005

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/

1330.03 Definitions

The various types of traffic control signals are defined below. Warning beacons, pedestrian flashing beacons, emergency signals, and ramp meter signals are energized only at specific times of the day or upon detecting a user. All other signals remain in operation at all times.

conventional traffic signal A permanent or temporary installation providing alternating right of way assignments for conflicting traffic movements. At least two identical displays are required for the predominant movement on each approach.

emergency vehicle signal A special adaptation of a conventional traffic signal installed to allow for the safe movement of authorized emergency vehicles. Usually, this type of signal is installed on the highway at the entrance into a fire station or other emergency facility. The signal 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 nonintersection locations only. At least two identical displays are required per approach.

flasher warning assembly Flashing beacons that are used only to supplement an appropriate warning or regulatory sign or marker. The displays consist of two alternating flashing yellow indications.

high-speed roadway A roadway with a posted speed of 45 mph or higher.

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.

lane control signal (reversible lanes) A special overhead signal that permits, prohibits, or warns of impending prohibition of lane use.

low-speed roadway A roadway with a posted speed of lower than 45 mph.

metering signal A signal used to control the predominant flow rate of traffic at an at-grade facility.

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.

multilane approach An approach that has two or more lanes, regardless of the lane use designation.

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.

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.

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.

ramp meter signal A signal used to control the flow rate of traffic entering a freeway or similar facility. A minimum of two displays is required for each approach. On single-lane ramps, a Type RM signal pole with two three-section signal heads is normally installed. On double-lane ramps, a Type II signal pole with two three-section signal heads is normally installed. When not in use, ramp meter signals are not energized.

speed limit sign beacon A beacon installed with a fixed or variable speed limit sign. The preferred display is two flashing yellow indications.

stop sign beacon A beacon installed above a stop sign. The display is a flashing red indication.

temporary traffic signal A conventional traffic signal used during construction to control traffic at an intersection while a permanent signal system is being constructed. A temporary traffic signal is typically an inexpensive span-wire installation using timber strain poles.

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.

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.

1330.04 Procedures

(1) Permit

State statutes (RCWs) require Washington State Department of Transportation (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 department's approval of the installation and type of signal and must be included in the DDP. The permit is completed by the responsible agency and submitted, complete with supporting data, to the Regional Administrator for approval. The Regional Administrator approves or denies the application and sends it to the region Traffic Office. The region Traffic Office retains a record of the approved permit and supporting data and forwards a copy to the State Traffic Engineer at WSDOT Headquarters (HQ). 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
- Temporary traffic signals
- Queue-cutter traffic signals

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.

When it is necessary to increase the level of control, such as changing from an intersection control beacon to a conventional traffic signal, a new permit application is required. If the change results in a reduction in the level of control, as in the case of converting a conventional signal to a flashing intersection beacon, or if the change is the removal of the signal, submit the "Report of Change" portion of the traffic signal permit to the Regional Administrator, with a copy to the State Traffic Engineer. If an intersection approach is going to be signalized that was not signalized when the original signal permit was filed, a "Report of Change" is required.

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, approval, and forwarding to FHWA for approval. The FHWA approval document is to be included in the DDP.

(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*: 🖰 www.wsdot.wa.gov/Design/accessandhearings/tracking.htm

Responsibility for Various Types of Facilities on State Highways				
Area	**Responsibility**	**Emergency Vehicle Signals**	**Traffic Signals, School Signals, & Intersection Control Beacons**	**Reversible Lane Signals & Movable Bridge Signals**
Cities with less than 25,000 population	Finance Construct Maintain Operate	ESD[1] ESD[1] ESD[1] ESD[1]	State State State State	State State State State
Cities with 25,000 or greater population	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]
Beyond corporate limits	Finance Construct Maintain Operate	ESD[1] ESD[1] ESD[1] ESD[1]	State/County[3] State State State	State State State State
Access control	Finance Construct Maintain Operate	ESD[1] ESD[1] ESD[1] ESD[1]	State State State State	State State State State

Notes:

[1] ESD refers to the applicable Emergency Service Department.

[2] State highways without established limited access control (see 1330.04(2)(b)).

[3] See 1330.04(2)d.

Responsibility for Facilities
Exhibit 1330-1

(a) **Inside the corporate limits of cities with a population of less than 25,000:** WSDOT is responsible for 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 25,000 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/

(c) **Inside the corporate limits of cities with a population of 25,000 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 agrees with the alternatives analysis that the proposed traffic signal is justified, but where funding schedules and priorities do not provide for the timely construction of the traffic signal requested by others, the following rules apply:

- 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.
- The third party obtains a traffic signal permit.
- Third party agreement(s) with incorporated cities will be part of the DDP.

1330.05 Signal Warrants

A signal warrant is a minimum condition that is to be met before a signal may be installed. Satisfying a warrant does not mandate the installation of a traffic signal. The warranting condition indicates that an engineering study, including a comprehensive analysis of other traffic conditions or factors, is needed to determine whether the signal or another improvement is justified. For a list of the traffic signal warrants and information on how to use them, see the *Manual on Uniform Traffic Control Devices* (MUTCD) Include the selected signal warrants in the DDP.

A proposal to install a traffic signal on any state route with a posted speed of 45 mph or higher requires an alternatives analysis, approved by the region Traffic Engineer, with review and comment by the HQ Design Office.

1330.06 Conventional Traffic Signal Design

(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.

(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 a consistent system for designing traffic signals. (See Exhibit 1330-2 for standard intersection movements, signal head numbering, and standard phase operation, and see Exhibit 1330-3 for phase diagrams for various traffic signal operations.)

(a) **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.

1. **Permissive Left-Turn Phasing**

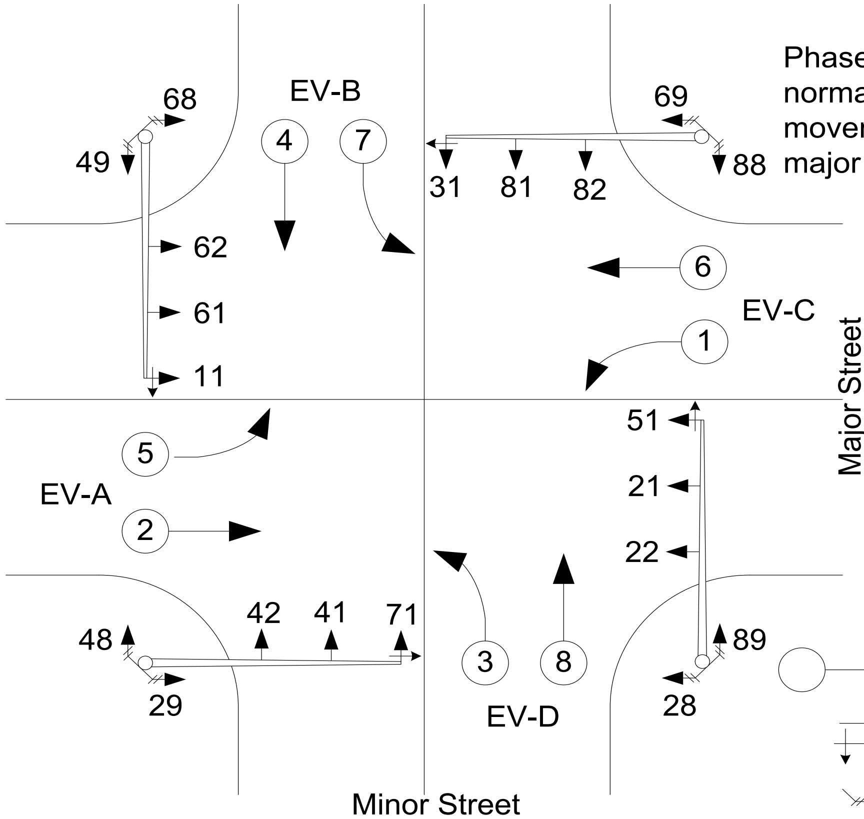
Permissive left-turn phasing requires the left-turning vehicle to yield to opposing through traffic and pedestrians. Permissive left-turn phasing is used when the turning volume is minor and adequate gaps occur in the opposing through movement. This phasing is more effective on minor streets where providing separate protected turn phasing might cause significant delays to the higher traffic volume on the main street. On high-speed (posted speed of 45 mph or above) single-lane approaches or where sight distance is limited, the preferred channelization would 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.

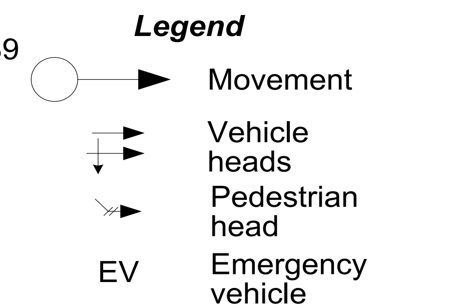
2. **Protected/Permissive Left-Turn Phasing**

Protected/permissive left-turn phasing provides the left-turn movements with an exclusive nonconflicting phase followed by a secondary phase when vehicles are required to yield to opposing traffic. The traffic signal can also operate with the permissive left-turn phase first followed by the protected left-turn phase. 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.

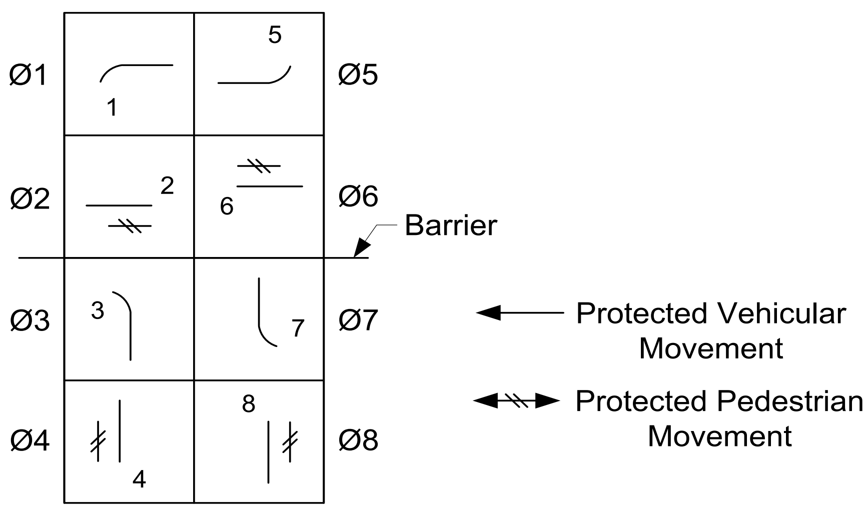
Protected/permissive left-turn phasing is not allowed under the following conditions:

- On the approaches of a signal where Warrant 7 is met and there are five left-turning collisions on that approach included in the warranting collisions.
- When documentation shows that existing protected left-turn phasing was installed due to left-turn collisions.



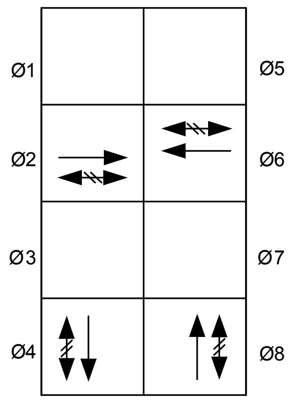


Typical Intersection Movements and Head Numbers

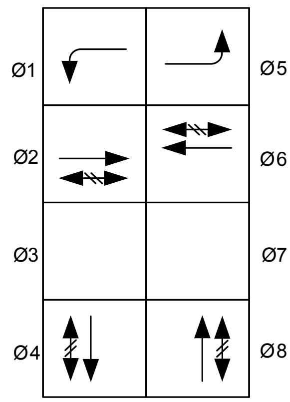


Typical Eight Phase Operation

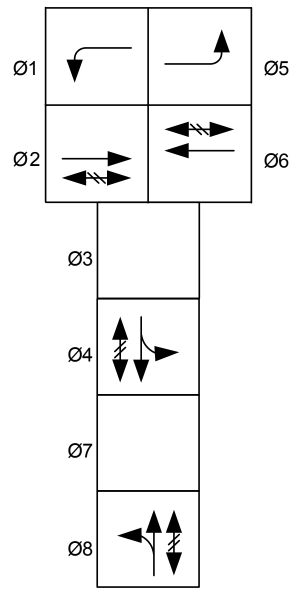
Standard Intersection Movements and Head Numbers
Exhibit 1330-2



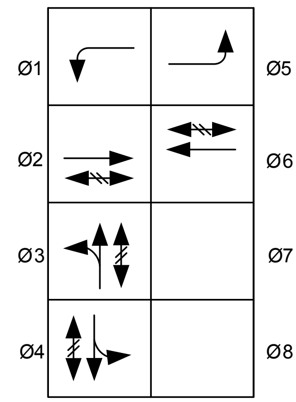
Four-Phase Operation
Permissive lefts



Six-Phase Operation
Main St. protected lefts
Minor St. permissive lefts

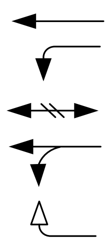


Six-Phase Operation
Main St. protected leading lefts
Minor St. split phasing
(Ø4 first, then Ø8)

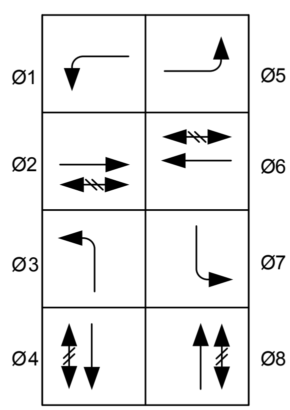


Six-Phase Operation
Alternate phasing
Main St. protected leading lefts
Minor St. split phasing

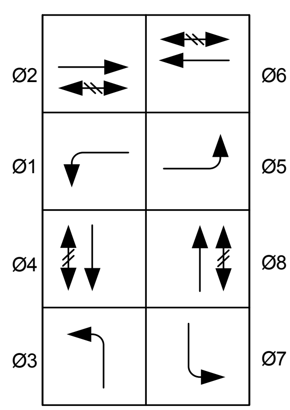
Legend



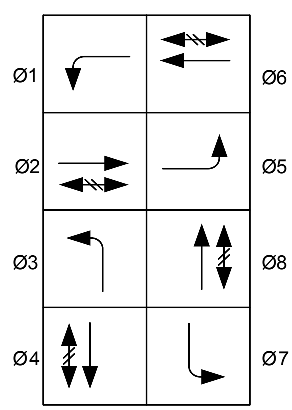
Vehicular through movement
Vehicular left-turn movement
Pedestrian movement
Vehicular through and left-turn movement
Vehicular overlapped right-turn movement



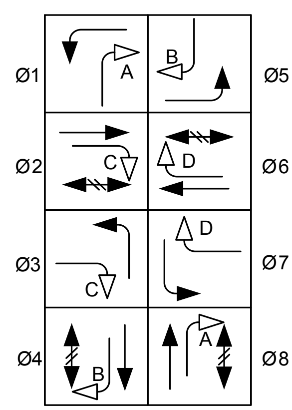
Eight-Phase Operation
Main St. protected leading lefts
Minor St. protected leading lefts



Eight-Phase Operation
Main St. protected lagging lefts
Minor St. protected lagging lefts



Eight-Phase Operation
Main St. protected lead & lag lefts
Minor St. protected lead & lag lefts



Eight-Phase Operation
Protected leading lefts
and overlapped rights
(A Minus Ped. overlap
shall be used for
Phases 2, 4, 6, & 8)

Phase Diagrams: Four-Way Intersections
Exhibit 1330-3

- 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.
- 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.
- On intersection approaches that have dual left-turn lanes.
- At intersections where lead/lag phasing is employed.

A flashing yellow arrow is allowed for protected/permissive left-turn operations under the following conditions:

- The approach has a separate left-turn storage lane.
- At least one separate four-section signal face, in addition to the minimum of two signal faces for the primary traffic movement on the approach, is to be provided for the left-turn movement. The separate left-turn signal face is to display, from top to bottom (or left to right in a horizontally aligned face), the following set of indications: steady left-turn red arrow, steady left-turn yellow arrow, flashing left-turn yellow arrow, and steady left-turn green arrow. If the left-turn movement is always operated in the permissive-only mode, the green arrow signal section is to be omitted.
- During a protected left-turn movement, the left-turn signal face displays only a steady left-turn green arrow signal indication.
- During a permissive left-turn movement, the left-turn signal face displays only a flashing yellow arrow signal indication.
- During a prohibited left-turn movement, the left-turn signal face displays only a steady left-turn red arrow or a steady circular red.
- A steady left-turn yellow arrow signal indication is displayed following every steady left-turn green arrow signal indication.
- A steady left-turn yellow arrow signal indication is displayed following the flashing left-turn yellow arrow signal indication if the permissive left-turn movement is being terminated and the left-turn signal will subsequently display a steady red signal indication. The steady left-turn arrow signal indication and the flashing left-turn yellow arrow signal indication are to be separate displays for permissive left turns.
- When a permissive left-turn movement is changing to a protected left-turn movement, a steady left-turn green arrow signal indication is to be displayed immediately upon termination of the flashing left-turn yellow arrow signal indication. A steady left-turn yellow arrow signal indication is not to be displayed between the display of the flashing left-turn yellow arrow signal indication and the display of the steady left-turn green arrow signal indication.

3. **Protected Left-Turn Phasing**

Protected left-turn phasing provides the left-turning vehicle a separate phase, and conflicting movements are required to stop.

Protected phasing is always required for multilane left-turn movements.

Use protected left-turn phasing when left-turning-type collisions on any approach equal three per year or five in two consecutive years. This includes left-turning collisions involving pedestrians.

Use protected left-turn phasing when the peak-hour turning volume exceeds the storage capacity of the left-turn lane because of insufficient gaps in the opposing through traffic and where one or more of the following conditions is present:

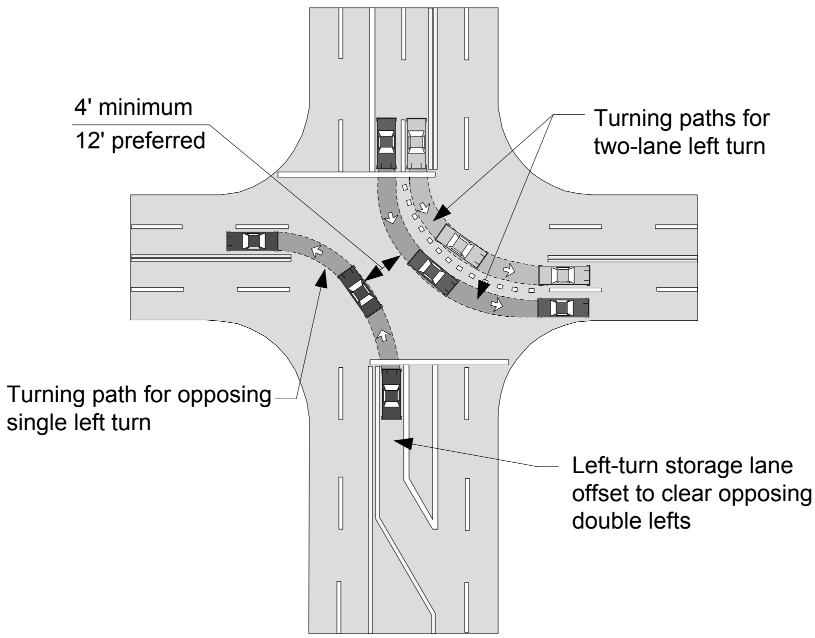
- Either the posted speed or the 85^{th} percentile speed of the opposing traffic exceeds 45 mph.
- The sight distance to oncoming traffic is less than 250 feet when the 85^{th} percentile speed is 35 mph or below, or less than 400 feet when the 85^{th} percentile speed is above 35 mph.
- The left-turn movement crosses three or more lanes (including right-turn lanes) of opposing traffic.
- Geometry or channelization is confusing.

Typically, an intersection with protected left turns operates with leading left turns. This means that on the major street, the left-turn phases, phase 1 and phase 5, time before the through movement phases, phase 2 and phase 6. On the minor street, the left-turn phases, phase 3 and phase 7, time before phase 4 and phase 8. Lagging left-turn phasing means that the through phases time before the conflicting left-turn phases. In lead-lag left-turn phasing, one of the left-turn phases times before the conflicting through phases and the other left-turn phase times after the conflicting through phases. In all of these cases, the intersection phasing is numbered in the same manner. Leading, lagging, and lead-lag left-turn phasing are accomplished by changing the order in which the phases time internally within the controller. 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 lead lag phasing is to be used.

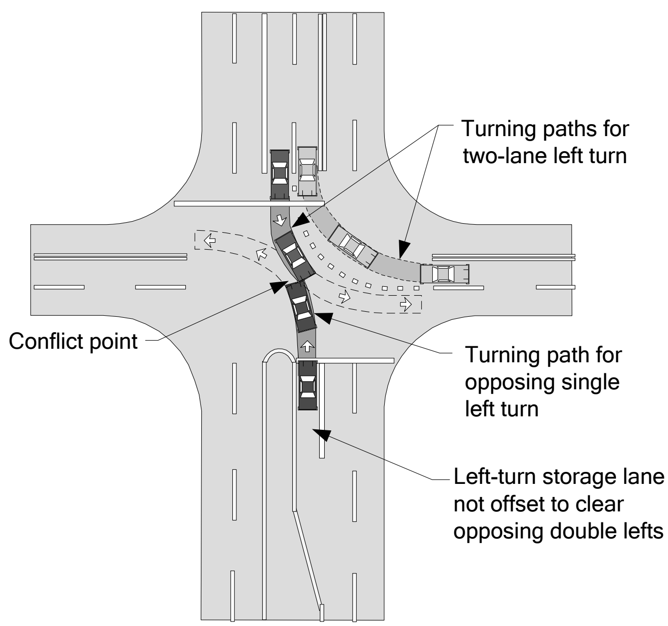
4. **Multilane Left-Turn Phasing**

Multilane left-turn phasing can be effective in reducing traffic signal delay at locations with high left-turning volumes or where the left-turn storage area is limited longitudinally. At locations with closely spaced intersections, a two-lane left-turn storage area might be the only solution to reduce the potential for the left-turn volume to back up into the adjacent intersection. Consider the turning paths of the vehicles when proposing multilane left turns. If the opposing left-turning vehicle paths do not have 4-foot minimum—12-foot desirable—separation between them, split or lead lag phasing is to be used. 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 might be nullified by the requirement for a separate opposing left-turn phase. Exhibit 1330-4 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 lane changes difficult. (See Chapter 1310 for guidance on lane reductions on intersection exits.)



Left-Turn Lane Configuration With Concurrent Phasing



Left-Turn Lane Configuration Preventing Concurrent Phasing

Left-Turn Lane Configuration Examples
Exhibit 1330-4

(b) **Right-Turn Phasing**

1. **Right-Turn Overlapped Phasing**

Consider right-turn overlapped phasing at locations with a dedicated right-turn lane where the intersecting street has a complementary protected left-turn movement and U-turns are prohibited. Several right-turn overlaps are shown in the Phase Diagrams in Exhibit 1330-3. The display for this movement is dependent on whether or not a pedestrian movement is allowed to time concurrently with the through movement adjacent to the right-turn movement.

For locations with a concurrent pedestrian movement, use a five-section signal head consisting of circular red, yellow, and green displays with yellow and green arrow displays. Connect the circular displays to the through phase adjacent to the right-turn movement and connect the arrow displays to an overlap using an auxiliary output file. The right-turn overlap is to be programmed so that the green arrow will not be shown during a conflicting pedestrian phase or emergency vehicle preemption. The capabilities of the signal controller software will determine how the right-turn overlap is to be set up. Some signal software allows use of a negative pedestrian overlap, which prevents the green arrow from being displayed when the conflicting pedestrian phase is being served, and it allows the green arrow when the conflicting pedestrian movement is not being served. If the negative pedestrian overlap can be used, the overlap for the right-turn arrows is driven by both the adjacent through phase and the associated side street left turn. If the software does not have this feature, the overlap for the right-turn arrows is to be driven by the associated side street left-turn phase only. Coordinate with the region Signal Operations Engineer regarding the software features.

For locations without a concurrent pedestrian movement, use a three-section signal head with all arrow displays or visibility-limiting displays (either optically programmed sections or louvered visors) with circular red, yellow arrow, and green arrow displays. This display is in addition to the adjacent through movement displays. Program this display as an overlap to both the complementary left-turn phase and the adjacent through phase.

2. **Two-Lane Right-Turn Phasing**

Two-lane right-turn phasing can be used for an extraordinarily heavy right-turn movement. It can cause operational challenges when “right turn on red” is permitted at the intersection. Verify that there is adequate sight distance and the correct exit lane selections are made to minimize the possibility of collisions. In most cases, a single unrestricted “right-turn-only” lane approach with a separate exit lane (auxiliary lane) will have a similar capacity as the two-lane right-turn phasing.

(c) **Phasing at Railroad Crossings**

Refer to 1330.06(12), Signal Design and Operation Near Railroad Crossings, for more information on phasing at railroad crossings.

(3) Intersection Design Considerations

Intersection design can have a considerable effect on how a traffic signal will operate, and careful consideration is to be given to this aspect of the design. (See Chapter 1310 for further guidance.)

Left-turning traffic can be better accommodated when the opposing left-turn lanes are directly opposite each other. When a left-turn lane is offset into the path of the approaching through lane, the left-turning driver might assume the approaching 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 opposing left-turn clearance.)

Where a railroad crossing is within 88 feet of a signalized intersection, consider installing turn pockets for the movements leading to the leg of the intersection with the railroad crossing. This greatly improves the efficiency of the signal during railroad preemption when turns are restricted. Also consider providing a left-turn pocket for the minor leg opposing the railroad crossing. This will allow limited service during long periods of railroad preemption.

Consider providing an unrestricted through lane on the major street of a T intersection. This design allows for one traffic movement to flow without restriction. At high-speed intersections where this is used, the through lane is to be separated by a physical barrier or the through movement must also be signalized.

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.)

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." This should be determined early so it can be considered and addressed in the design. (See Chapters 530 and 540 for further guidance.) Consider shifting the location of the advance loops upstream to clear an access point so that vehicles entering from the access point will not affect the loops.

Transit stop and pullout locations can affect signal operation. (See Chapter 1430 for transit stop and pullout designs.) When feasible, locate these stops and pullouts on the far side of the intersection to:

- Minimize overall intersection conflict, particularly the right-turn conflict.
- Minimize impact to the signal operation when buses use preemption to pull out at a traffic signal with transit preemption.
- Provide extra pavement area where U-turn maneuvers are allowed.
- Eliminate sight distance obstructions for drivers attempting to turn right on red.
- Eliminate conflict with right-turn pockets.

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.)

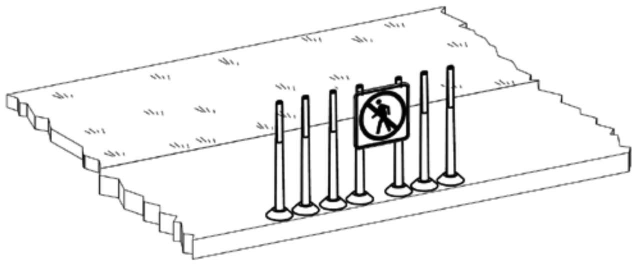
At intersections with large right-turn radii, consider locating signal standards on raised traffic islands to reduce mast arm lengths. These islands are primarily designed as pedestrian refuge areas. (See Chapter 1510 for pedestrian refuge islands and traffic island designs.) Locating signal standards on 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. Place stop bars so they are out of the path of conflicting left turns. Check the geometric layout by using the turning path templates in Chapter 1310 or a computerized vehicle turning path program 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.

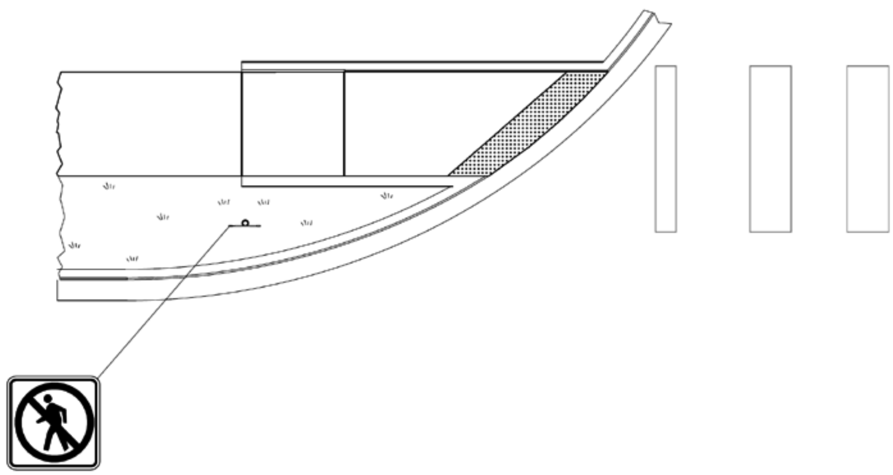
Coordinate with all stakeholders (Maintenance, Signal Operations, Civil Design Engineer, Drainage Engineer, and so on) in the placement of signal equipment to avoid any possible conflicts. Arrange field reviews with the appropriate stakeholders as necessary.

(4) Crosswalks and Pedestrians

Provide pedestrian displays per MUTCD requirements and accessible pedestrian push buttons for all signalized intersection pedestrian movements unless a specific pedestrian movement is prohibited. Accessible pedestrian push buttons shall have audible and vibrotactile features in accordance with MUTCD requirements. Providing countdown pedestrian displays and accessible push buttons is a federal requirement and is essential for efficient signal operations and improving safety for pedestrians that may need to cross the intersection. (See Chapter 1510 for more information on accessible pedestrian routes.)

Crosswalks, whether marked or not, exist at all intersections. If a pedestrian movement will be prohibited at an intersection, provide signing and a physical barrier for this prohibition. Examples of acceptable barriers are: a planter strip with a significantly different material that extends a minimum distance of 4 feet parallel to the accessible pedestrian route; flexible guideposts that extend the full width of the closed accessible route with a spacing of 12 inches between guideposts; and a breakaway fence as shown in Exhibit 1330-5. The signing and barriers are positioned on both the near side and far side of the street to be visible to pedestrians. When positioning these signs and barriers for visibility, consider the location of the stop bar where this crossing will be prohibited. Vehicles stopped at the stop bar might obstruct the view of the signing and barrier. There are normally three crosswalks at a “T” intersection and four crosswalks a at “four-leg” intersection. For pedestrian route continuity, the minimum number of crosswalks is two at T intersections and three at four-leg intersections. For Diamond interchanges with heavy left-turn movements from the off-ramp approach, consider deleting the crosswalk on the left side of the off-ramp approach. This will eliminate a conflict between pedestrians and left-turning vehicles from the off-ramp and increase traffic signal efficiency. There are situations where reducing the minimum number of crosswalks mentioned above is needed; however, approval from the region Traffic Engineer is required. Prohibiting a pedestrian movement requires an Engineering Study documenting the reasons for prohibiting the crossing, as well as region Traffic Engineer approval and inclusion in the DDP. Evaluate pedestrian exposure for all alternatives considered.





Examples of Acceptable Barriers Closing Pedestrian Crossings

Exhibit 1330-5

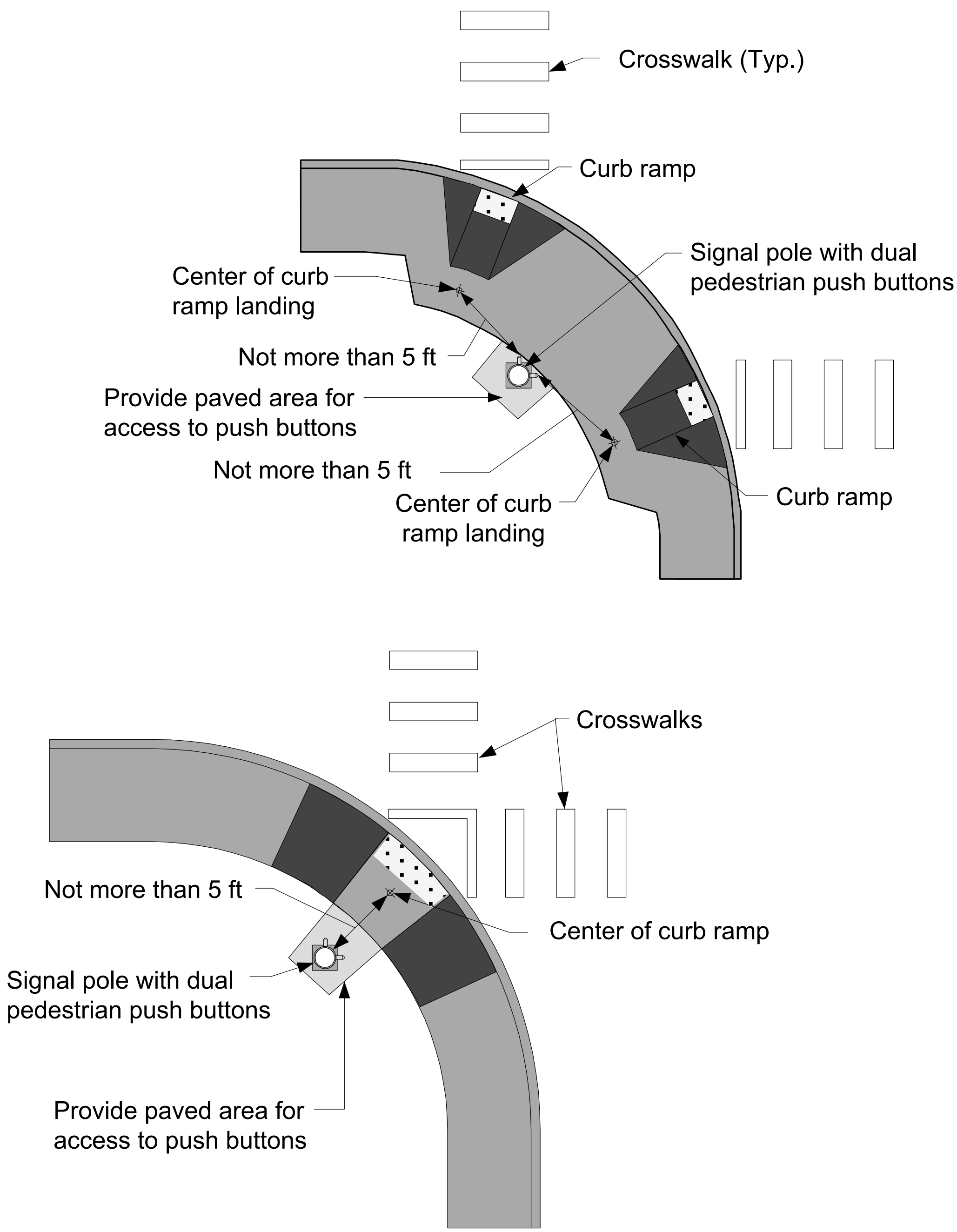
If a crosswalk is installed across the leg where right-turning or left-turning traffic enters, the vehicle display cannot have a green turn arrow indication during the pedestrian WALK phase. If this cannot be accomplished through a negative ped overlap, provide a separate pedestrian or vehicle turn phase. Use of exclusive pedestrian phases should be avoided because of the negative effect they can have on efficient traffic signal operations.

Locate crosswalks as close as practicable to the intersection to improve pedestrian visibility for right-turning traffic. Locate the push buttons inside an area no more than 5 feet from the extension of the crosswalk and no more than 10 feet from the curb or shoulder. Locate the push button no more than 5 feet from the center point of the sidewalk landing or the center point where the sidewalk landing meets the flat sidewalk. At curb and sidewalk areas, locate the pedestrian push buttons adjacent to the curb ramps to make them accessible to people with disabilities. (Exhibits 1330-6a and 6b show examples of the push button locations at raised sidewalk locations.) When pedestrian push buttons are installed on a vehicle signal standard that is not adjacent to a sidewalk, provide a paved path, not less than 4 feet in width, from the shoulder or sidewalk to the standard. If access to the signal standard is not possible, install the push buttons on Type PPB push button posts or on Type PS pedestrian display posts adjacent to the sidewalk. When pedestrian push buttons are installed behind guardrail, use Type PPB posts. Position these posts such that the push button assembly is flush with the face of the guardrail.

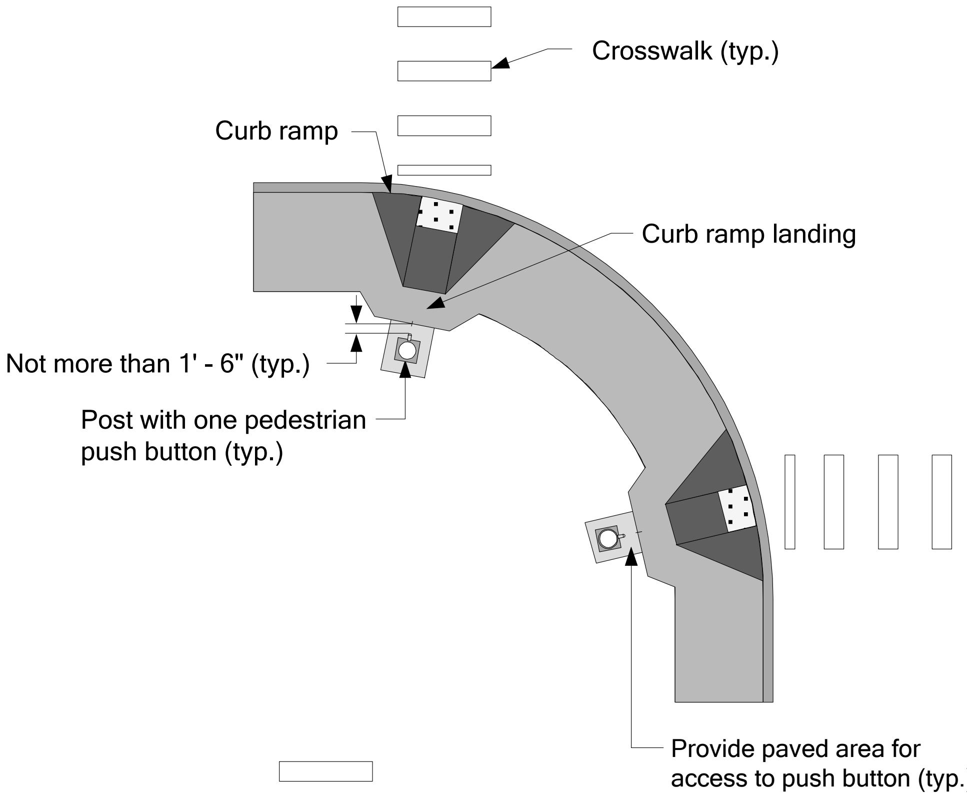
(5) Control Equipment

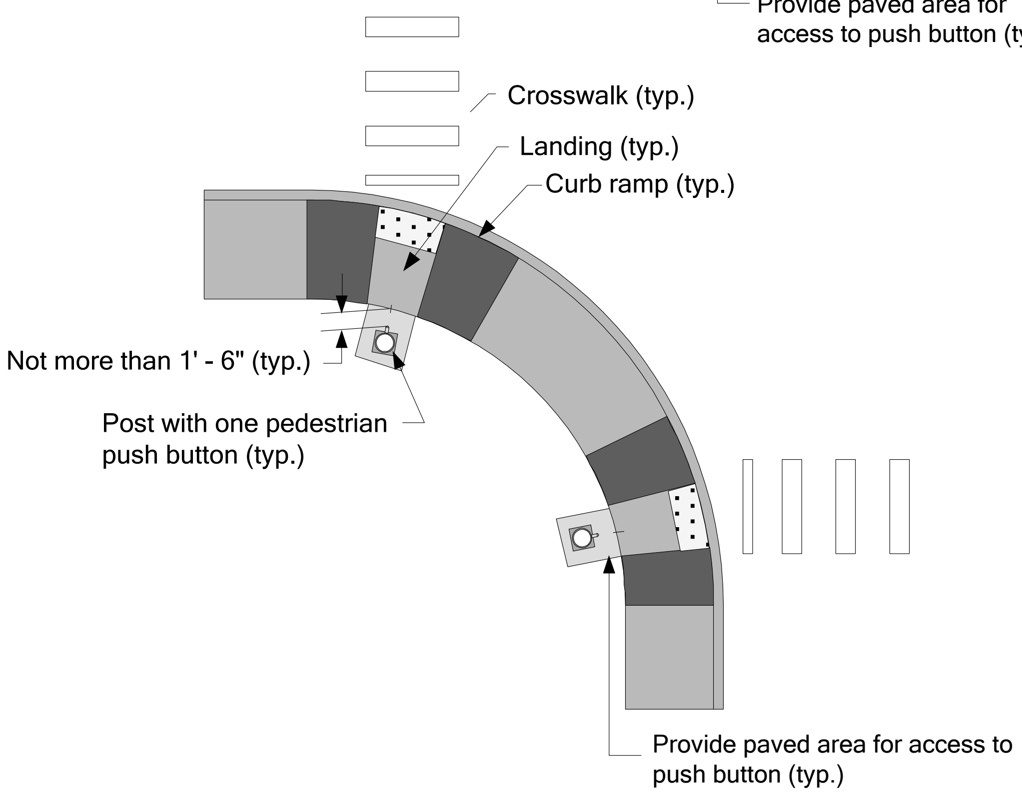
Controller assemblies can be Type 170, Type 2070, or National Electrical Manufacturers Association (NEMA) controllers with dual ring, eight vehicle phases, four pedestrian phases, four overlaps, emergency vehicle preemption, railroad preemption, transit preemption, and start and end daylight savings time dates operational capabilities. From a design perspective, identical operation can be obtained from each controller. Specify Type 2070 unless region policy is to use 170 or NEMA controllers. The local controller software can impact the brand and model of the control equipment installed. Contact the region Signal Operations Engineer for software and controller specifications. The designer needs to specify the type of controller and the operating software to be installed. Include documentation of selected control equipment in the Project File.

Intersections within ½ mile of each other on low-speed state highways should be interconnected. Intersections within 1 mile of each other on high-speed state highways should be interconnected. 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 the region Signal Operations Engineer and approval by the region Traffic Engineer. Add a construction note in the plans stating to coil additional cable in the adjacent junction box, not the controller cabinet. Consider using a separate vault or junction box for coiling the fiber optic interconnect cable to allow for the large-bend radii. This will save on space in the controller cabinet and also allow additional cable in case the cabinet is hit by an errant vehicle. In situations where it is necessary to coordinate the traffic movements with another agency, it is important that the agencies work together.



Pedestrian Push Button Locations
Exhibit 1330-6a





Pedestrian Push Button Locations
Exhibit 1330-6b

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.

When it is necessary to install a NEMA controller in a 332 cabinet, this can be done by using a "C1" plug to NEMA "A" "B" "C" "D" adapters.

The model 210 conflict monitor in the Type 332 cabinet can be used with a NEMA controller by changing a switch setting. The NEMA conflict monitor is not used in this configuration. It does not fit in a Type 332 cabinet and the operation is not compatible. When a NEMA cabinet is used, specify rack mountings for the loop detector amplifiers and the preemption discriminators. Specify a power supply for the loop detectors. Coordinate with the region Signal Operations Engineer when selecting controller cabinets, controller, and controller assembly appurtenances.

Coordinate with the region Signal Operations Engineer and Transportation Systems Technician to determine the optimum controller cabinet location and the cabinet door orientation. The controller cabinet is positioned to provide maintenance personnel access. At this location, a clear view of the intersection, while facing the front of the controller, is desirable. The location is to have adequate room for a maintenance vehicle to park by the cabinet. Avoid placing the controller at locations where it might block the view of approaching traffic for a motorist turning right on red. Avoid locating the controller where flooding might occur or where the cabinet might be hit by errant vehicles. If possible, position the controller where it will not be affected by future highway construction.

If a telephone line, fiber optic, wireless, or other connection is desired for remote signal monitoring and timing adjustments by signal operations personnel, 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.

Vehicle and pedestrian movements are standardized to provide uniformity in signal phase numbering, signal display numbering, preemption channel identification, detection numbering, and circuit identification. The following are general guidelines for the numbering system:

- Assign phases 2 and 6 to the major street through movements, orienting phase 2 to the northbound or eastbound direction of the major street, thereby aligning phase 2 with the direction of increasing mileposts.
- Phasing on new signals installed within an already signalized corridor should match the existing corridor phasing.
- Assign phases 1 and 5 to the major street protected left-turn movements.
- Assign phases 4 and 8 to the minor street through movements.
- Assign phases 3 and 7 to the minor street protected left-turn movements.

- At T intersections, the movement on the stem of the T is normally assigned to either phase 4 or phase 8.
- At intersections with four approaches using split phasing on the minor streets, where each minor street times separately, the minor streets are normally assigned as phases 4 and 8, and a note is added with the phase diagram to indicate that these phases time exclusively.
- Signal displays are numbered as follows: the first number indicates the signal phase and the second number is the number of the signal head counting from centerline to fog stripe. For example, signal displays for phase 2 are numbered 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. 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. With a conventional protected/permissive left-turn display, the circular red, yellow, and green displays are connected to the phase 6 controller output and the steady yellow and green arrow displays are connected to the phase 1 controller output. When a flashing yellow arrow display is used, coordinate with the Signal Operations Engineer and signal maintenance group to determine appropriate wiring. When using flashing yellow operation, ensure an auxiliary output rack is specified in the controller cabinet.
- 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.
- Detection is numbered with the first number representing the phase. The second number represents the lane number from centerline out. The third number represents the loop number counting from the stop line back. Detection loops for phase 2 detectors are numbered 211, 212, 213 for lane 1; 221, 222, 223 for lane 2; and so on. (See Exhibit 1330-8 for standard detector numbering.)
- Emergency vehicle detectors are designated by letters: phase 2 plus phase 5 operation uses the letter “A,” phase 4 plus phase 7 uses the letter “B,” phase 1 plus phase 6 uses the letter “C,” and phase 3 plus phase 8 uses the letter “D.”

(6) Detection Systems

The detection system at a traffic-actuated signal installation provides the control unit with information regarding the presence or movement of vehicles, bicycles, and pedestrians. Vehicle detection systems perform two basic functions: queue clearance and the termination of phases. Depending on the specific intersection characteristics, either of these functions can take priority. The merits of each function are considered and a compromise might be necessary.

The following vehicle detection requirements vary depending on the speeds of the approaching vehicles:

- When the posted speed is below 35 mph, provide stop bar detection from the stop bar to a point 30 to 40 feet in advance of that location. Stop bar detection is usually assigned to detection input “extension/call” channels. Coordinate with the Signal Operations Engineer on detection assignments. When queue/advance loops are installed, calculate the distance traveled by a vehicle in two seconds at the 85th percentile speed and position the advance loops at this distance in advance of the stop bar.

- When the posted speed is at or above 35 mph, provide advance detection based on the "decision zone detection design." When stop bar detection is installed, it should extend from the stop bar to a point 30 to 40 feet in advance of that location. Stop bar detection is required on minor streets. Stop bar detection is usually assigned to detection input "call" channels, and advance detection is usually assigned to detection input "extension/call" channels. Coordinate with the Signal Operations Engineer on detection assignments.

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 collision. Decision zone detection design has been developed to reduce the chances of this occurrence. 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 safely 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 1330-7. Include the calculations in the Project File.

A study of the approach speeds at the intersection is necessary to design the decision zone detection. Speed study data is obtained at the approximate location or just upstream of the decision zone. Only the speed of the lead vehicle in each platoon is considered. Speed study data is gathered during off-peak hours in free-flow and favorable weather conditions. 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 can be used if it is less than 18 months old and driving conditions have not changed significantly in the area.

When permissive left-turn phasing is installed on the major street with left-turn channelization, include provisions for switching the detector input for future protected left-turn phasing. Assign the detector a left-turn detector number and connect to the appropriate left-turn detector amplifier. Most controller software can do this internally. If the controller being specified cannot do this internally, then specify a jumper connector between that amplifier output and the extension input channel for the adjacent through movement detector. The jumper is removed when the left-turn phasing is changed to protected left-turn phasing in the future. Check with the Signal Operations Engineer to see whether this is available with the software being used.

Where:

V_{90} = 90th percentile speed in ft per second

V_{10} = 10th percentile speed in ft per second

UDZ_{90} = Upstream end of decision zone for 90th percentile speed

DDZ_{10} = Downstream end of decision zone for 10th percentile speed

LC_1 = V_{10} travel time to downstream DDZ_{10}

LC_2 = V_{10} travel time from 1st loop to 2nd loop

LC_3 = V_{10} travel time from 3rd loop to DDZ_{10}

G = Grade of roadway in decimal form (include + or -) Example: - 4% = -0.04

Use with grades less than +/- 4%:

$$UDZ_{90} = \frac{(V_{90})^2}{16} + V_{90}$$

$$DDZ_{10} = \frac{(V_{10})^2}{40} + V_{10}$$

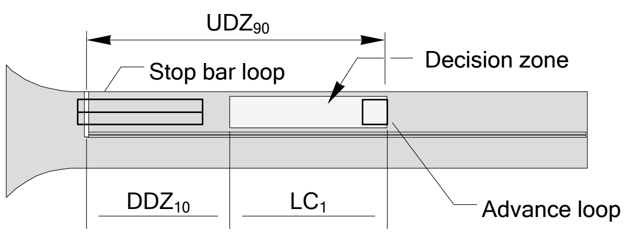
$$LC_1 = \frac{UDZ_{90} - DDZ_{10}}{V_{10}}$$

Use with grades +/- 4% or steeper:

$$UDZ_{90} = \frac{(V_{90})^2}{2(8 + 32.2G)} + V_{90}$$

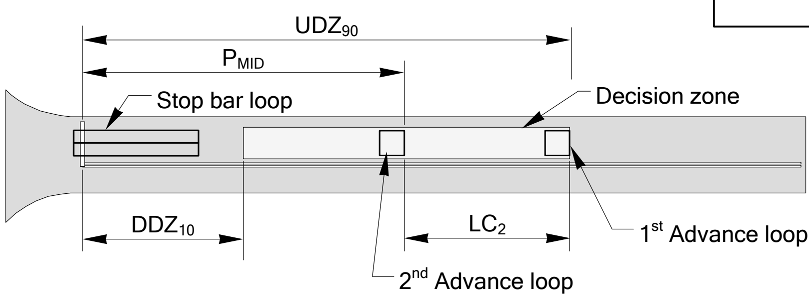
$$DDZ_{10} = \frac{(V_{10})^2}{2(20 + 32.2G)} + V_{10}$$

$$LC_1 = \frac{UDZ_{90} - DDZ_{10}}{V_{10}}$$



Single Advance Loop Design

Use when LC_1 is less than or equal to 3 seconds.

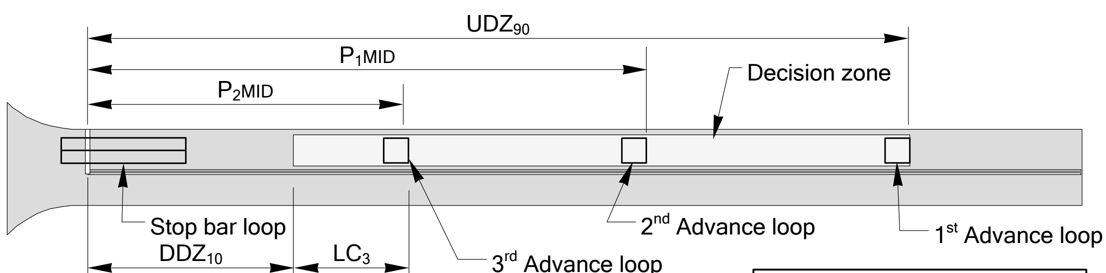


$$LC_2 = \frac{UDZ_{90} - P_{MID}}{V_{10}}$$

$$P_{MID} = \frac{UDZ_{90} + DDZ_{10}}{2}$$

Double Advance Loop Design

Use when LC_2 is less than or equal to 3 seconds.



Triple Advance Loop Design

Use when LC_3 is less than or equal to 3 seconds.

$$LC_3 = \frac{UDZ_{90} - DDZ_{10}}{3V_{10}}$$

$$P_{1\,MID} = \frac{[2(UDZ_{90}) + DDZ_{10}]}{3}$$

$$P_{2\,MID} = \frac{[UDZ_{90} + 2(DDZ_{10})]}{3}$$

Decision Zone Loop Placement

Exhibit 1330-7

In most cases, electromagnetic induction loops provide the most reliable method of vehicle detection. Details of the construction of these loops are shown in the *Standard Plans*. Video detection should be used only for temporary or portable traffic signals or locations with undesirable pavement conditions unless approved for other usage by the region Traffic Engineer. Other types of vehicle detection, such as in-pavement wireless magnetometers, may be used with approval from the region Traffic Engineer. Consider video detection systems for projects at the following locations: projects that have extensive stage construction with numerous alignment changes; on a private leg of an intersection where an easement is not available; and on existing bridge deck where loops or other types of in-pavement detection cannot be placed into the bridge deck.

Video detection functions best when the detectors (cameras) are positioned high above the intersection. In this position, the maximum effective detection area can be about ten times the mounting height in advance of the camera. (Contact the appropriate video detection equipment manufacturer for specific installation requirements.) When video detection is proposed, installation of the cameras on the luminaire mast arms can often provide good detection coverage. However, high wind can adversely affect the video equipment by inducing vibration in the luminaire mast arms. Also, areas that experience frequent high winds are not always suitable for video detection. Snow, fog, and rain can also adversely affect the operation of video detection equipment.

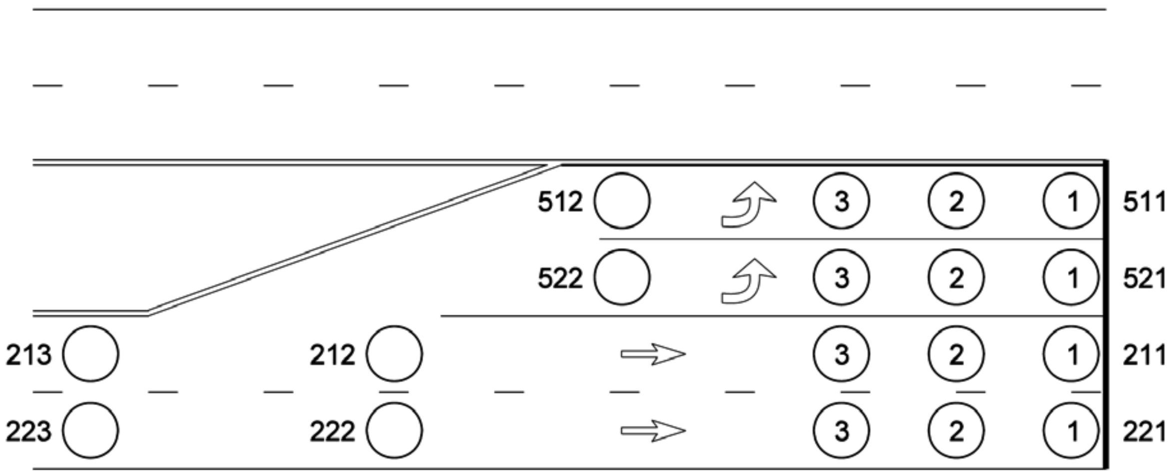
Provide temporary decision zone detection on projects where the decision zone detection will be disconnected for more than 48 hours, unless the designer concurs with the Signal Operations Engineer that the temporary detection is not necessary. The designer needs to find out whether there is a speed reduction during construction and place the temporary decision zone detection accordingly.

For loop numbering, see Exhibit 1330-8.

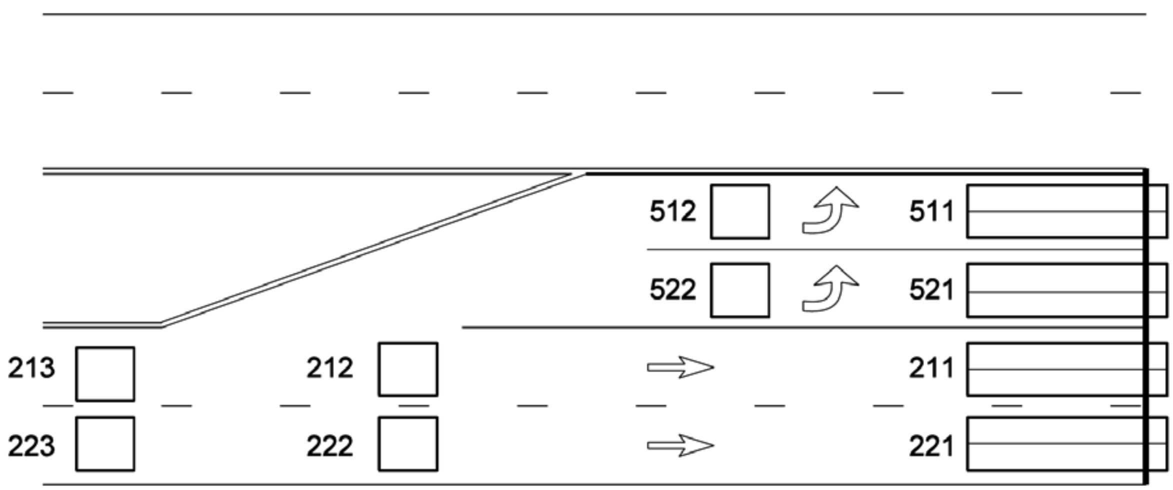
(7) Preemption Systems

(a) Emergency Vehicle Preemption

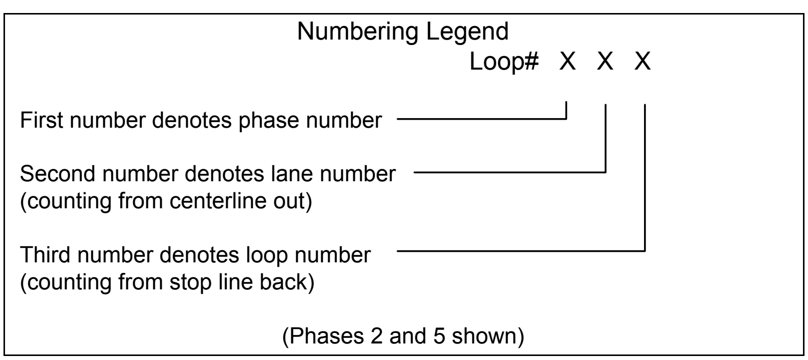
Emergency vehicle preemption is required for all traffic signals unless approved otherwise by the region Traffic Engineer. WSDOT is responsible for the preemption equipment that is permanently installed at the intersection for new construction or rebuild projects. The emergency service agency is responsible for preemption emitters in all cases. If the emergency agency requests additional preemption equipment at an existing signal, that agency is responsible for all installation costs for equipment installed permanently at the intersection. The standard emergency vehicle system is optically activated to be compatible with all area emergency service agency emitters. Approval by the State Traffic Engineer is required for the installation of any other type of emergency vehicle preemption system. Include emergency service vehicle preemption system documentation in the Project File.



Round Loop Layout Example



Square Loop Layout Example



Loop Numbering Layout
Exhibit 1330-8

Optically activated preemption detectors are positioned for each approach to the intersection. These detectors function best when the approach is straight and relatively level. When the approach is in a curve, either horizontal or vertical, it might be necessary to install additional detectors in or in advance of the curve to provide continuous coverage of that approach, as recommended by the region Operations Engineer. Consider the approximate speed of the approaching emergency vehicle and the amount of time necessary for phase termination and the beginning of the preemption phase when positioning these detectors.

(b) **Railroad Preemption**

The Railroad Crossing Evaluation Team will determine the level of preemption required at signalized intersections. (See 1330.06(12) for more information.)

(c) **Transit Priority Preemption**

Signal preemption is sometimes provided at intersections to give priority to transit vehicles. This can be included in mobility projects, but the transit company assumes all costs for providing, installing, and maintaining this preemption equipment. The department's role is limited to approving preemption operational strategies (phasing, timing, software, and so on) and verifying the compatibility of the transit company's equipment with the traffic signal control equipment. Transit priority preemption documentation is part of the Project File.

(8) 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. Typical vehicle signal displays are shown in Exhibits 1330-14a through 14f. In addition to the display requirements contained in the MUTCD, the following also apply:

- Always provide a minimum of two identical indications for the through movement if one exists at an intersection, 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 when viewed from the center of the approach. 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.
- All displays of a phase on an approach are to be a minimum of 8 feet apart. Displays for different phases on an approach should be a minimum of 8 feet apart.
- Use steady 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.
- Whenever possible, locate displays directly overhead and in line with the path of the applicable vehicular traffic as it moves through the intersection. (See Exhibits 1330-14a through 14f for signal head locations.)

- Locate displays a minimum of 40 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 bar. 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 near-side signal face would be beneficial.
- Installation of a near-side supplemental display is required when the visibility requirements of 1330.06(8) and the MUTCD cannot be met.
- Use vertical vehicle-signal display configurations. Horizontal displays are not allowed unless clearance requirements cannot be achieved with vertical displays 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.
- Use 12-inch signal sections for all vehicle displays except the lower display for a post-mounted ramp meter signal.
- Use all arrow displays for protected left turns when the left turn operates independently from the adjacent through movement.
- The preferred layout is all arrow displays for protected left turns when the left turn operates independently from the adjacent through movement. When green and yellow arrows are used in combination with circular red for protected left turns operating independently from the adjacent through movement, use visibility-limiting displays (either optically programmed sections or louvered visors that are programmable for visibility angle and distance) for the circular red display. Contact the local Signal Maintenance Superintendent, Signal Operations Office, or Traffic Engineer to ensure correct programming of the head.
- Use a five-section cluster arrangement (dog house) or the four-section flashing yellow arrow signal head for protected/permitted operations.
- Use either Type M or Type N mountings for vehicle display mountings on mast arms. Provide only one type of mounting for each signal system. Mixing mounting types at an intersection is not acceptable except for supplemental displays mounted on the signal standard shaft.
- Use backplates for all overhead-mounted displays for new, updated, or rebuilt signal faces. Backplates are to have a 1-inch-wide to 3-inch-wide yellow stripe of retroreflective, Type IV, prismatic sheeting around the perimeter to project a rectangular image at night. The 3-inch-wide sheeting is the preferred width and should only be decreased to avoid overlapping the back plate louvers.
- With some exceptions, Type E mountings are to be used for pedestrian displays mounted on signal standard shafts.
- Supplemental signal displays are to be installed when the approach is in a horizontal or vertical curve and the intersection visibility requirements cannot be met unless approved otherwise by the region Traffic Engineer.

The minimum mounting height for cantilevered mast arm signal supports and span wire installations is 16.5 feet from the roadway surface to the bottom of the signal housing. There is also a maximum height for signal displays. The roof of a vehicle can obstruct the motorist's view of a signal display. The maximum heights from the roadway surface to the bottom of the signal housing with 12-inch sections are shown in Exhibit 1330-9.

Distance	Signal Display	Maximum Height
Signal displays 40 feet from the stop bar	Vertical 3-section	17.5 ft
	Vertical 4-section	17.0 ft
	Vertical 5-section*	17.0 ft
Signal displays 45 feet from the stop bar	Vertical 3-section	19.2 ft
	Vertical 4-section	18.0 ft
	Vertical 5-section*	17.5 ft
Signal displays 50 feet from the stop bar	Vertical 3-section	20.9 ft
	Vertical 4-section	19.7 ft
	Vertical 5-section*	18.5 ft
Signal displays 53 to 180 feet from the stop bar	Vertical 3-section	22.0 ft
	Vertical 4-section	20.8 ft
	Vertical 5-section*	19.6 ft

*The 5-section cluster display is the same height as a vertical 3-section signal display.

Signal Display Maximum Heights
Exhibit 1330-9

An advanced signalized intersection warning sign assembly to warn motorists of a signalized intersection should be installed when either of the two following conditions exists:

- The visibility requirements in the MUTCD are not achievable.
- The 85th percentile speed is 55 mph or higher and the nearest signalized intersection is more than 2 miles away; this does not apply to freeway off-ramps.

This warning sign assembly consists of a W3-3 sign with Type IV reflective sheeting and two continuously flashing beacons. Locate the sign in advance of the intersection in accordance with Table 2C-4 (Condition A) of the MUTCD. Approval from the region Traffic Engineer is required if the sign is not installed.

(9) Signal Supports

Signal supports for vehicle displays consist of metal vertical shaft standards (Type I), cantilevered mast arm standards (Type II, Type III, and Type SD Signal Standards), metal strain poles (Type IV and Type V Signal Standards), or timber strain poles (see the *Standard Plans*). Vertical shaft signal standards are generally used for supplemental signal displays to meet visibility requirements. 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. The maximum length for mast arms on signal standards is 65 feet. Mast arm lengths over 65 feet are not allowed, so metal strain poles or a signal bridge will need to be considered. Contact the HQ Bridge and Structures Office for design of a signal bridge. The maximum attachment height for a signal mast arm on preapproved plans is 20 feet. Special design poles are required for a mast arm attachment height over

20 feet. Use mast arm signal standards for permanent installations unless display requirements cannot be met. Metal strain poles are allowed when signal display requirements cannot be achieved with mast arm signal standards or the installation is expected to be in place less than five years. Timber strain pole supports are generally used for temporary installations that will be in place less than two years.

Pedestrian displays can be mounted on the shafts of vehicle display supports or on individual vertical shaft standards (Type PS). The push buttons used for the pedestrian detection system can also be mounted on the shafts of other display supports or on individual pedestrian push button posts. Do not place the signal standard at a location that blocks pedestrian or wheelchair activities. Locate the pedestrian push buttons such that they are accessible to all.

Terminal cabinets mounted on the shafts of mast arm signal standards and steel strain poles are required. The cabinet provides electrical conductor termination points between the controller cabinet and signal displays that allow for easier construction and maintenance. Terminal cabinets are located on the back side of the pole and at a height that reduces the potential for conflicts with pedestrians and bicyclists.

(a) **Signal Standard Placement Considerations**

In the placement of 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. If conditions allow and optimal locations are not compromised, pedestrian displays and pedestrian detectors can be installed on the vehicular display supports.

Another important consideration that can influence the position of signal standards is the presence of overhead and underground utilities. Verify the location of these lines during the preliminary design stage to avoid costly changes during construction. After the underground utilities are located in the field, if they are within 10 feet of equipment being installed, consider potholing for the utility to find its actual location. Field locates are not always accurate and must be verified if a potential conflict exists. Verify aerial clearances. A minimum 10-foot circumferential clearance is required from all overhead power lines rated at 50Kv 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.

(b) **Mast Arm Signal Standards**

Mast arm signal standards are designed based on the total wind load moment on the mast arm. The moment is a function of the XYZ value, and this value is used to select the appropriate mast arm fabrication plan. The preapproved mast arm fabrication plans are listed in the contract special provisions. To determine the XYZ value for a signal standard, the cross-sectional area for each component mounted on the mast arm is determined. Each of these values is multiplied by its distance from the vertical shaft. These values are then totaled to determine the XYZ value. When determining the XYZ values, the worst-case scenarios on head and sign placements are to be used. All signal displays and mast arm-mounted signs, including street name signs, are included in this calculation. The effects of emergency preemption detectors and any required preemption indicator lights are negligible and can be excluded. For mast arm-mounted signs, use the actual sign area to determine the XYZ value. Cross-sectional areas for vehicle displays are shown in Exhibit 1330-10. Include traffic signal support calculations in the DDP.

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

Signal Display Areas
Exhibit 1330-10

(c) **Foundation Design**

Foundation design is a critical component of the signal support. A soils investigation is required to determine the lateral bearing pressure, the friction angle of the soil, and whether groundwater may be encountered. The XYZ value is used in determining the foundation depth for the signal standard. A special foundation design for a mast arm signal standard is required if the lateral bearing pressure is less than 1,000 psf or the friction angle is less than 26°. The region materials group determines whether these unusual soil conditions are present and a special foundation design will be required. The region materials group then sends this information to the HQ Materials Laboratory for confirmation. The HQ Materials Laboratory forwards the findings to the HQ Bridge and Structures Office and requests the special foundation design. The HQ Bridge and Structures Office designs foundations for the regions and reviews designs submitted by others.

(d) **Steel Strain Poles**

Steel strain poles are used in span wire installations and are available in a range of pole classes. A pole class denotes the strength of the pole. The loads and resultant forces imposed on strain poles are calculated and a pole class greater than that load is specified. Exhibits 1330-11a and 1330-11b show the procedure for determining the metal strain pole class and foundation. Exhibit 1330-12 shows an example of the method of calculation. The foundation depth is a function of the pole class and the soil conditions. A special design is required for metal strain pole or timber strain pole support systems if the span exceeds 150 feet, the tension on the span exceeds 7,200 pounds, or the span wire attachment point exceeds 29 feet in height. Contact the HQ Bridge and Structures Office for assistance.

Selection Procedure

1. Determine span length.
2. Calculate the total dead load (P) per span. Use 40 pounds per signal section and 6.25 pounds per square ft of sign area.
3. Calculate the average load (G) per span. G = P/n where (n) is the number of signal head assemblies plus the number of signs.
4. Determine cable tension (T) per span. Enter the proper chart with the average load (G) and the number of loads (n). If (n) is less than minimum (n) allowed on chart, use minimum (n) on chart (see Exhibit 1330-11b).
5. Calculate the pole load (PL) per pole. If only one cable is attached to the pole, the pole load (PL) equals the cable tension (T). If more than one cable is attached, (PL) is obtained by computing the vector resultant of the (T) values.
6. Select the pole class from the "Foundation Design Table." Choose the pole class closest to but greater than the (PL) value.
7. Calculate the required foundation depth (D). Use the formula:

   $$D = a\frac{DT}{\sqrt{S}}$$

   Select the foundation depth (DT) from the "Foundation Design Table." Lateral soil bearing pressure (S) is measured in pounds per square ft (psf). The formula value (a) is a variable for the cross-sectional shape of the foundation. The values for these shapes are:

   a = 50 for a 3-ft round foundation
   a = 43 for a 4-ft round foundation
   a = 41 for a 3-ft square foundation

   Round (D) upward to nearest whole number if 0.10 ft or greater.
8. Check vertical clearance (16.5 ft minimum) assuming 29 ft maximum cable attachment height and 5% minimum span sag.

Notes:

A special design by the HQ Bridge and Structures Office is required if:

- The span length exceeds 150 ft.
- The (PL) value exceeds 7,200 lbs.
- The vertical distance between the base plate and the first cable attachment exceeds 29 ft.

1. Charts (see Exhibit 1330-11b) are based on a cable weight of 3 pounds per ft (1.25 lbs/ft for cable and conductors and 1.75 lbs/ft for ice load).
2. On timber strain pole designs, specify two down guy anchors when the (PL) value exceeds 4,500 lbs.

Foundation Design Table	
Pole Class (Pounds)	**Foundation Depth (DT)**
1,900	6'-0"
2,700	7'-0"
3,700	8'-0"
4,800	9'-6"
5,600	10'-0"
6,300	11'-0"
7,200	12'-0"

DT = initial foundation depth off chart
D = calculated foundation depth for use in contract

Strain Pole and Foundation Selection Procedure
Exhibit 1330-11a

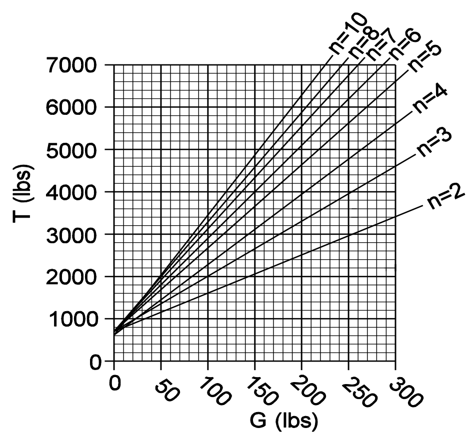


Chart 1 - Span Length 90' and Less

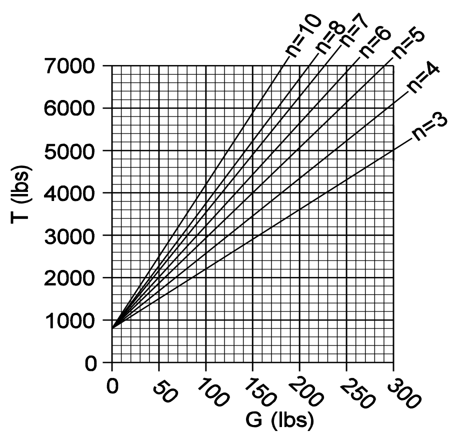


Chart 2 - Span Length 91' to 120'

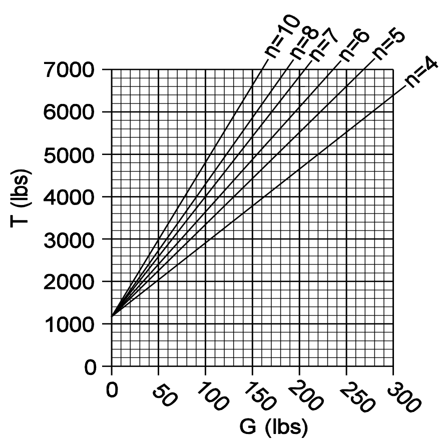
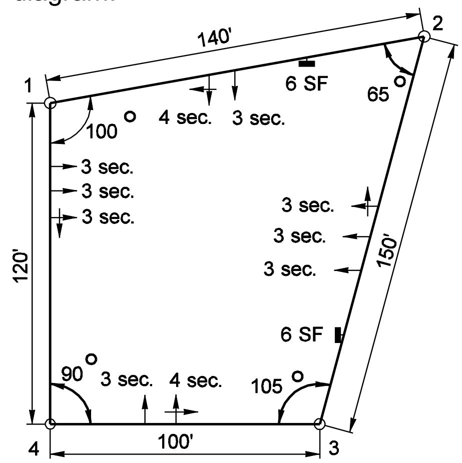


Chart 3 - Span Length 121' to 150'

Strain Pole and Foundation Selection Procedure

Exhibit 1330-11b

Given: Exhibits 1330-11a and 11b, and the following diagram:



Determine the following:

- Cable Tensions (T)
- Pole Loads (PL)
- Pole Classes
- Foundation Depths (D)

Step 1. Span lengths given above.

Step 2. Calculate (P) and (G) values.

Span 1-2, n = 3
7 sections x 40 lbs/sec = 280 lbs
6 s.f. sign x 6.25 lbs/s.f. = 38 lbs
Total (P) = 318 lbs
G = P/n = 318/3 = 106 lbs

Span 2-3, n = 4
9 sections x 40 lbs/sec = 360 lbs
6 s.f. sign x 6.25 lbs/s.f. = 38 lbs
Total (P) = 398 lbs
G = P/n = 398/4 = 100 lbs

Span 3-4, n = 2
7 sections x 40 lbs/sec = 280 lbs
Total (P) = 280 lbs
G = P/n = 280/2 = 140 lbs

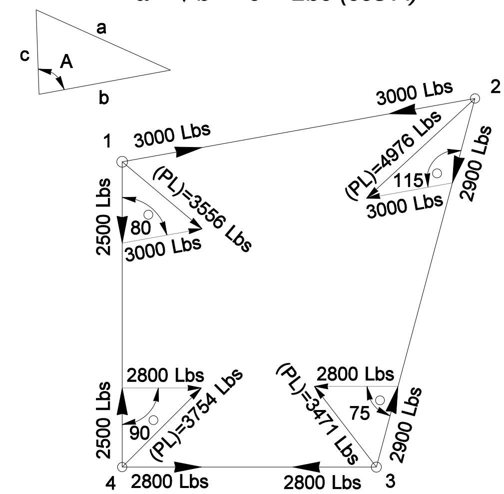
Span 4-1, n = 3
9 sections x 40 lbs/sec = 360 lbs
Total (P) = 360 lbs
G = P/n = 360/3 = 120 lbs

Step 3. Determine Cable Tensions (T) values.

Span	Length	G	Chart	n	min n	T
1-2	140'	106 lbs	3	3	4	3,000 lbs
2-3	150'	100 lbs	3	4	4	2,900 lbs
3-4	100'	140 lbs	2	2	3	2,800 lbs
4-1	120'	120 lbs	2	3	3	2,500 lbs

Step 4.
Calculate (PL) values by computing the vector resultant of the (T) values.

$$a = \sqrt{b^2 + c^2 - 2bc\,(\cos A)}$$



Step 5.

Select the pole class from the Foundation Design Table (see Exhibit 1330-11a).

Pole Number	(PL)	Pole Class
1	3,556 lbs	3,700 lbs
2	4,976 lbs	5,600 lbs
3	3,471 lbs	3,700 lbs
4	3,754 lbs	4,800 lbs

Step 6.

Calculate the required foundation depths.
Given: (S) = 1,000 psf

$$D = a\,\frac{DT}{\sqrt{S}}$$

			Foundation Depths (D)		
Pole No.	Pole Class	DT	3’ Rd (a = 50)	4’ Rd (a = 43)	3’ Sq (a = 41)
1	3,700 lbs	8’	13’	11’	11’
2	5,600 lbs	10’	16’	14’	13’
3	3,700 lbs	8’	13’	11’	11’
4	4,800 lbs	9’-6”	15’	13’	13’

Strain Pole and Foundation Selection Example
Exhibit 1330-12

(10) Preliminary Signal Plan

Develop a preliminary signal plan for the Project File. Include a 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. Use a plan scale of “1 inch = 20 feet” and include:

- Stop bars.
- Crosswalks.
- Sidewalks locations, including curb ramps.
- Guardrail locations.
- Drainage items.
- Left-turn radii, including beginning and ending points.
- Corner radii, including beginning and ending points.
- Vehicle detector locations and proposed detector types.
- Pedestrian detector locations.
- Signal standard types and locations.
- Vehicle signal displays.
- Pedestrian signal displays.
- Phase diagram, including pedestrian movements.
- Emergency vehicle preemption requirements.
- Railroad preemption requirements.
- 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.)
- Cabinet locations with door orientations.
- Traffic counts, including left-turn movements.
- Speed study information indicating 90^{th} and 10^{th} percentile speeds for all approaches.
- Utilities information.

Submit a copy of the preliminary signal plan to the State Traffic Engineer for review and comment. Allow two to three weeks for review of the preliminary signal plan. After addressing all review comments, finalize the plan and preserve as noted in 1330.07, Documentation. Prepare the contract plans in accordance with the *Plans Preparation Manual*.

If HQ Traffic Design is preparing the contract Plans, Specifications, and Estimates (PS&E) for the project, submit the above preliminary signal plan with the following additional items:

- Contact person.
- Charge numbers.
- Critical project schedule dates.
- Existing and proposed utilities, both underground and overhead.

- Existing intersection layout, if different from the proposed intersection.
- 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.
- Electrical service location, source of power, and utility company connection requirements.

After the PS&E is prepared, the entire package is transmitted to the region for incorporation into its contract documents.

(11) Electrical Design

(a) **Circuitry Layout**

Consider cost, flexibility, construction requirements, and ease of maintenance when laying out the electrical circuits for the traffic signal system. Consolidate roadway crossings (signal, illumination, ITS conduits, and so on) whenever possible to minimize the number of crossings. Include all electrical design calculations in the Project File.

(b) **Junction Boxes**

Provide junction boxes at each end of a roadway crossing, where the conduit changes size, where detection circuit splices are required, and at locations where the sum of the bends for the conduit run is equal to or exceeds 360°. Signal standard or strain pole bases are not to be used as junction boxes. Where possible, locate junction boxes out of paved areas and sidewalks. Junction boxes are not to be placed in the pedestrian curb ramp of a sidewalk or where it will impact the ADA requirements found in Chapter 1510. Placing the junction boxes within the traveled way is rarely an effective solution and will present long-term maintenance problems. 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, use heavy-duty junction boxes. Avoid placing junction boxes in areas of poor drainage. Do not place junction boxes within 2 feet of ditch bottoms or drainage areas. The maximum conduit capacities for various types of junction boxes are shown in the *Standard Plans*. Consider using a pull box or cable vault instead of multiple Type 8 junction boxes by the controller cabinet.

(c) **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. With the exception of the ½-inch conduit for the service grounding electrode conductor, the minimum-size conduit is as follows:

- For installations under a roadway in rural areas, 1½ inches on the legs of the intersection and 3 inches minimum for installations under a roadway near and around the intersection perimeter.
- For installations under a roadway inside urban boundaries, 2 inches on the legs of the intersection and 3 inches minimum for installations under a roadway near and around the intersection perimeter.

- The minimum size conduit for installations under a roadway at all other locations is 2 inches.

A 2-inch spare conduit is to be installed for all conduit crossings outside the core of the intersection. A 3-inch spare conduit is to be installed for all conduit crossings around the intersection perimeter. At least one 3-inch spare conduit is to be installed from the controller to the adjacent junction box to provide for future capacity. 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 1330-13 for conduit and signal 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		

Conduit and Conductor Sizes
Exhibit 1330-13

(d) **Electrical Service and Other Components**

Refer to Chapter 1040 for electrical service types, overcurrent protection, and descriptions and requirements for other components.

(e) **Roadway Conduit Crossings**

Minimize roadway crossings whenever possible; usually only three crossings are needed 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 is the method of choice when crossing the state route (main line). One main line crossing is usually sufficient; open cut trenching is acceptable on minor approaches. Open cut trenching to install conduits is allowed on existing roadways where substantial obstacles under the roadway will be encountered or 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. Do not use sign or signal bridges for roadway crossings.

(12) Signal Design and Operation Near Railroad Crossings

If railroad tracks are within 500 feet 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, region Utilities Engineer, region Traffic Design Engineer, region Maintenance Superintendent, and the affected railroad representative.

The Railroad Crossing Evaluation Team will determine what design considerations are needed at all signalized intersections near railroad crossings. A memo with each team member's concurrence with the PS&E documents is required for the Project File and is to be preserved as noted in 1330.07, Documentation. If railroad tracks are located within ¼ mile and are in excess of 500 feet from a signalized intersection, the same procedure will apply unless the region can demonstrate that 95% maximum queue lengths will not extend to within an area 200 feet from the tracks. Such demonstration is to be documented in the Project File and approved by the Railroad Crossing Evaluation Team.

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.

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.
- 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.)

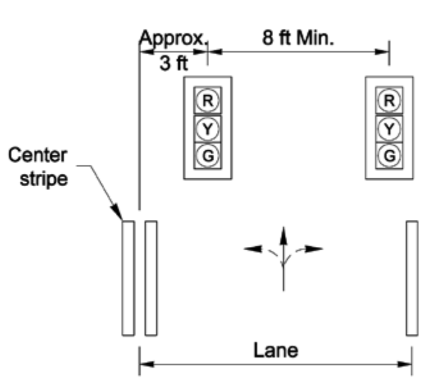
Railroad preemption, interconnection, and a presignal are recommended when any of the following conditions occurs:

- The distance from the stop bar to the nearest rail is less than 88 feet; the longest design vehicle permitted by statute is 75 feet, with 3 feet for front overhang, 4 feet for rear overhang, and 6 feet for downstream clear storage.
- 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 1350-2, cannot be met, and the railroad crossing does not have active control (lights or gates).

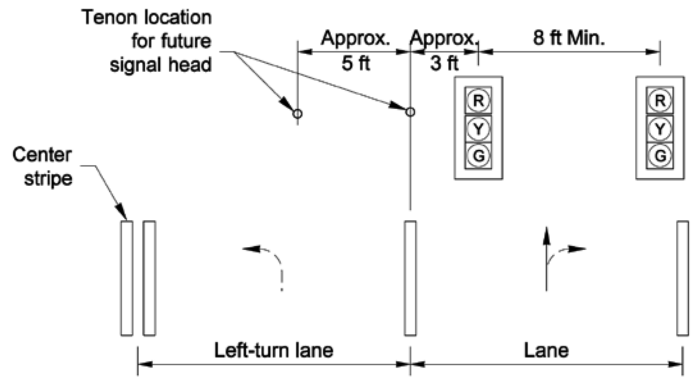
Use the *Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings* to determine the amount of railroad preemption required at an intersection with a traffic signal.

1330.07 Documentation

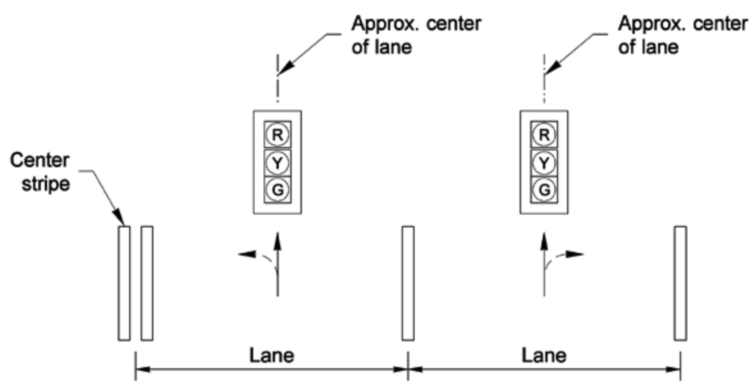
For the list of documents required to be preserved in the Design Documentation Package and the Project File, see the Design Documentation Checklist:
www.wsdot.wa.gov/design/projectdev/



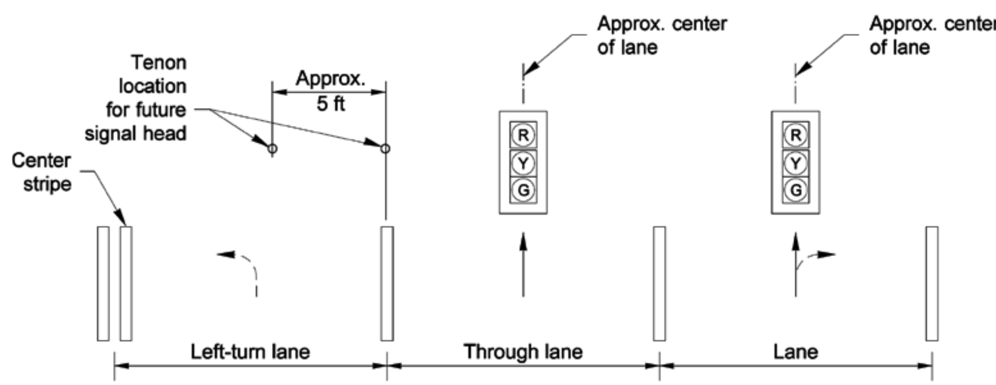
One Through Lane
With Permissive Left Turn



One Through Lane and One Left-Turn Storage Lane
With Permissive Left Turn



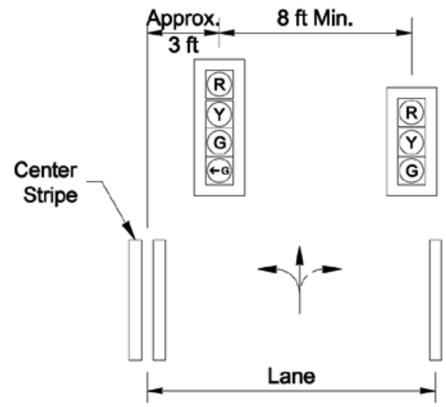
Two Through Lanes With Permissive Left Turn



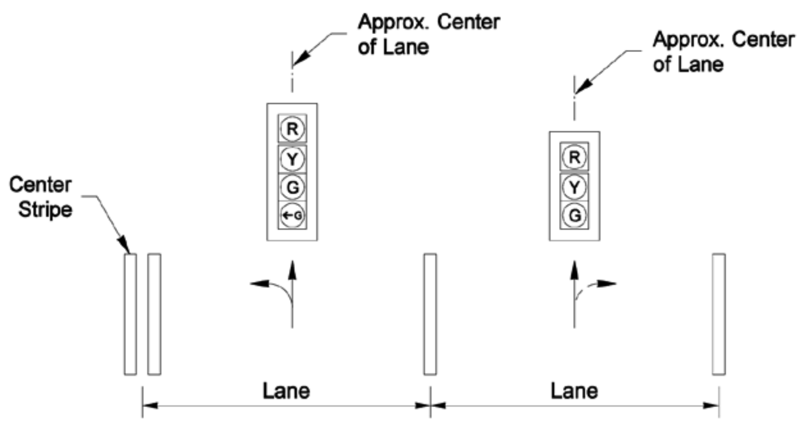
Two Through Lanes and One Left-Turn Storage Lane
With Permissive Left Turn

Note:
Include signal display calculations in the Project File.

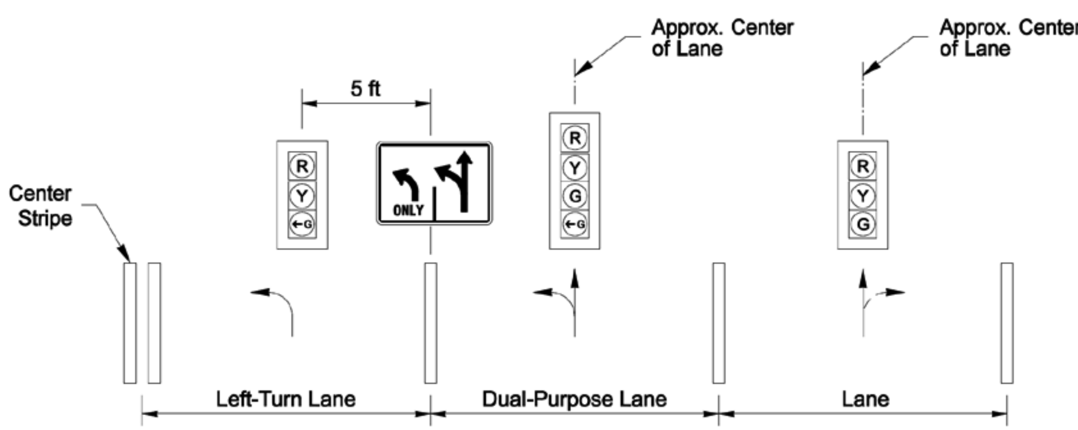
Traffic Signal Display Placements
Exhibit 1330-14a



One Through Lane With Split Phasing for Protected Left Turn
(Left-Turn and Through movements terminate together)

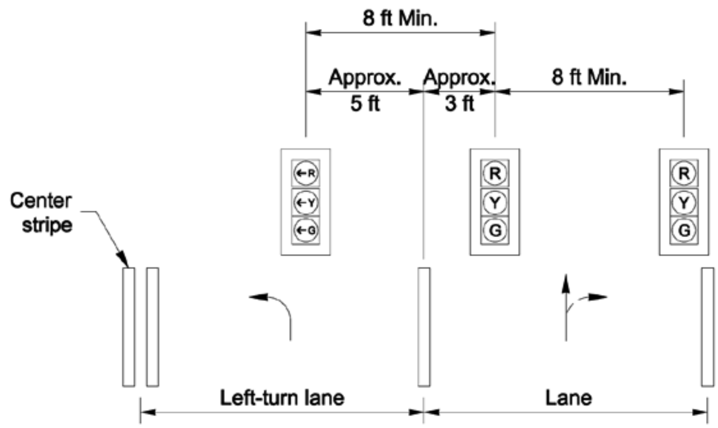


Two Through Lanes With Split Phasing for Protected Left Turn
(Left-Turn and Through movements terminate together)

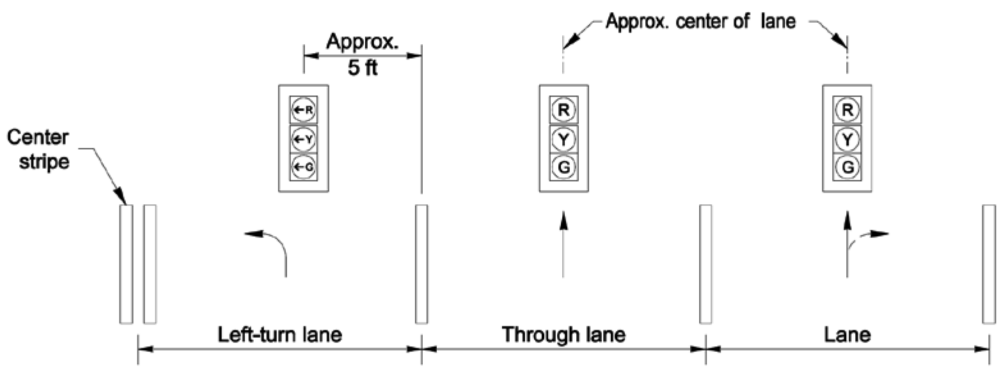


One Through Lane, a Dual-Purpose (Left or Through) Lane and One Left-Turn Storage Lane with Split Phasing for Protected Left Turn
(Left-Turn and Through movements terminate together)

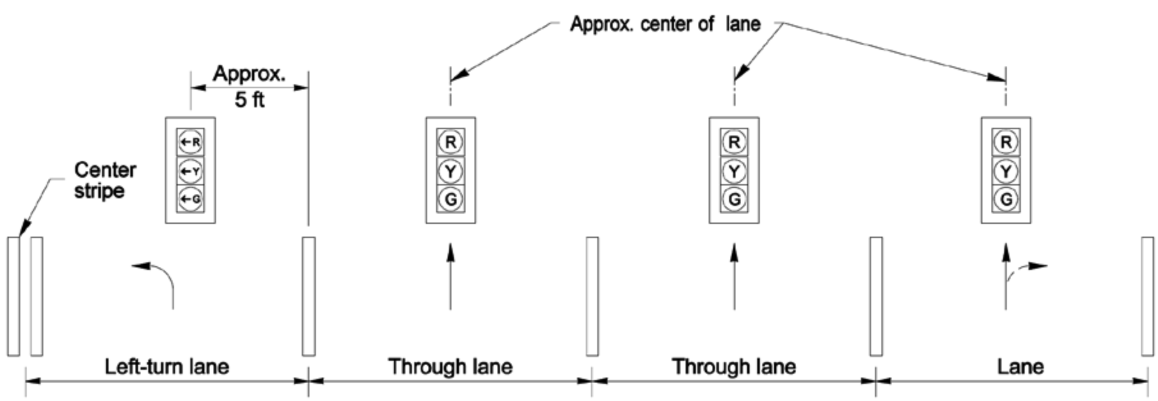
Traffic Signal Display Placements
Exhibit 1330-14b



One Through Lane and One Left-Turn Storage Lane
With Protected Left Turn
(Left-turn and through movements terminate independently)

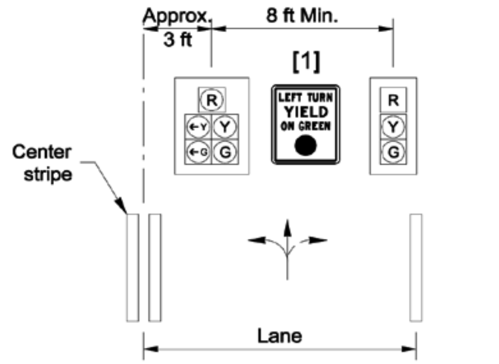


Two Through Lanes and One Left-Turn Storage Lane
With Protected Left Turn
(Left-turn and through movements terminate independently)

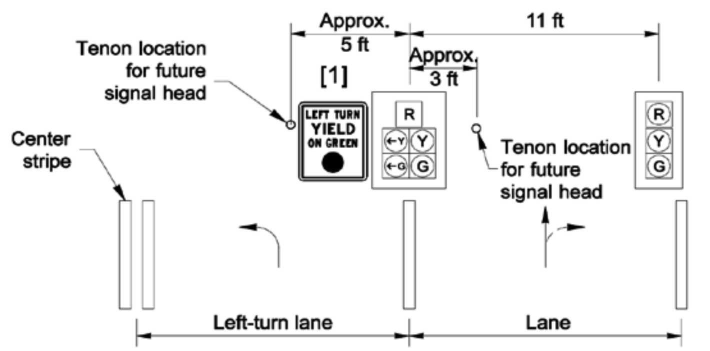


Three Through Lanes and One Left-Turn Storage Lane
With Protected Left Turn
(Left-turn and through movements terminate independently)

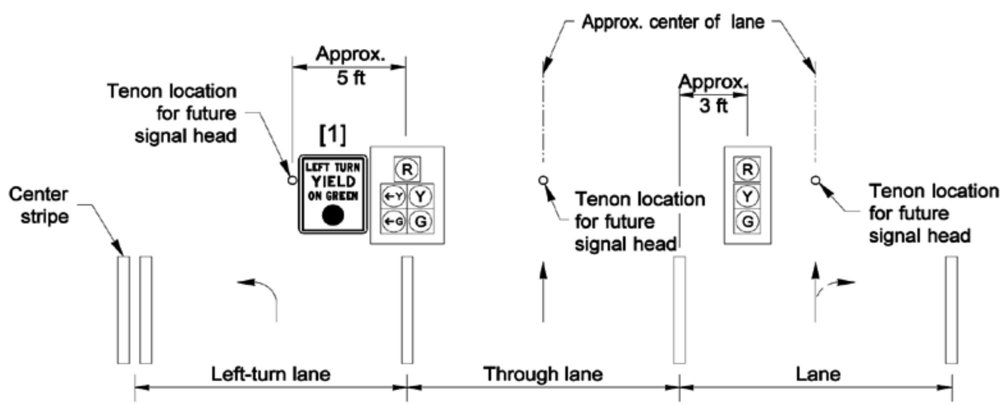
Traffic Signal Display Placements
Exhibit 1330-14c



One Through Lane
With Protected / Permissive Left Turn



One Through Lane and One Left-Turn Storage Lane
With Protected / Permissive Left Turn

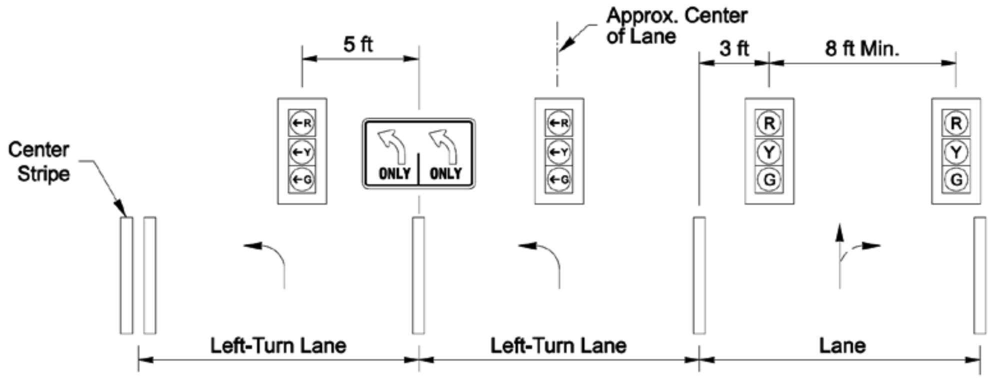


Two Through Lanes and One Left-Turn Storage Lane
With Protected / Permissive Left Turn

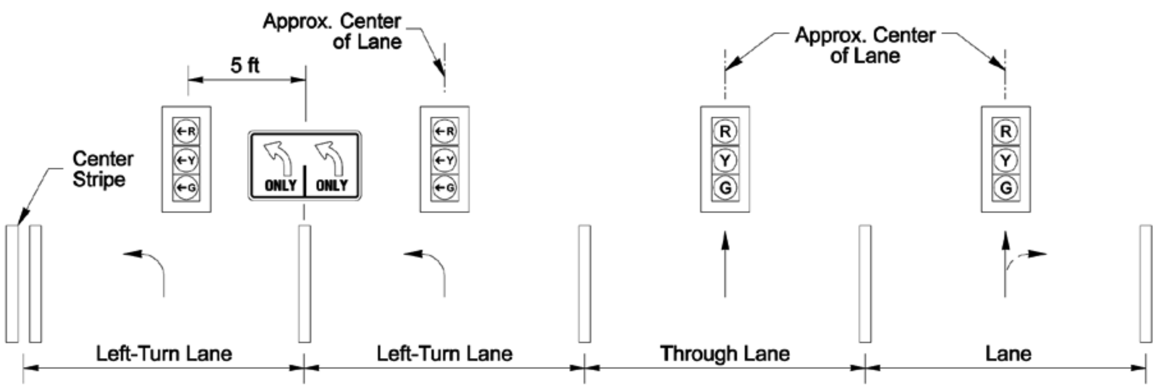
Note:

[1] The "Left-Turn Yield on Green Ball" sign is used for protected/permitted phasing, or permissive phasing, if a demonstrable problem of left-turning vehicles not yielding exists.

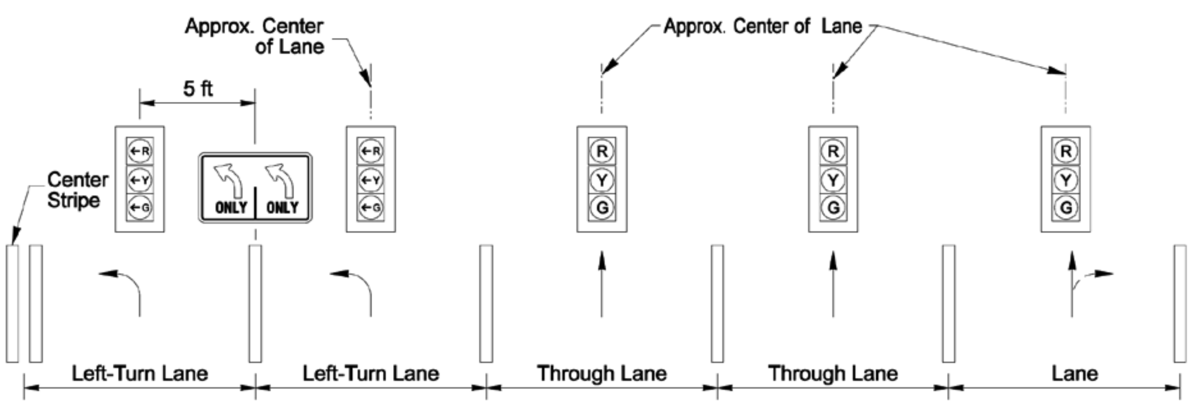
Traffic Signal Display Placements
Exhibit 1330-14d



One Through Lane and Two Left-Turn Storage Lanes
With Protected Left Turn
(Left-Turn and Through movements terminate independently)

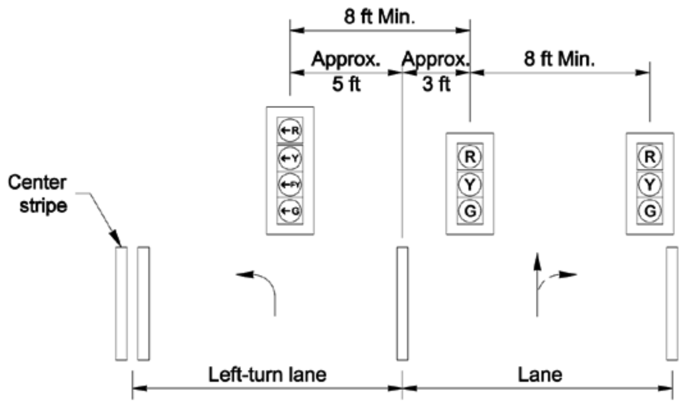


Two Through Lanes and Two Left-Turn Storage Lanes
With Protected Left Turn
(Left-Turn and Through movements terminate independently)

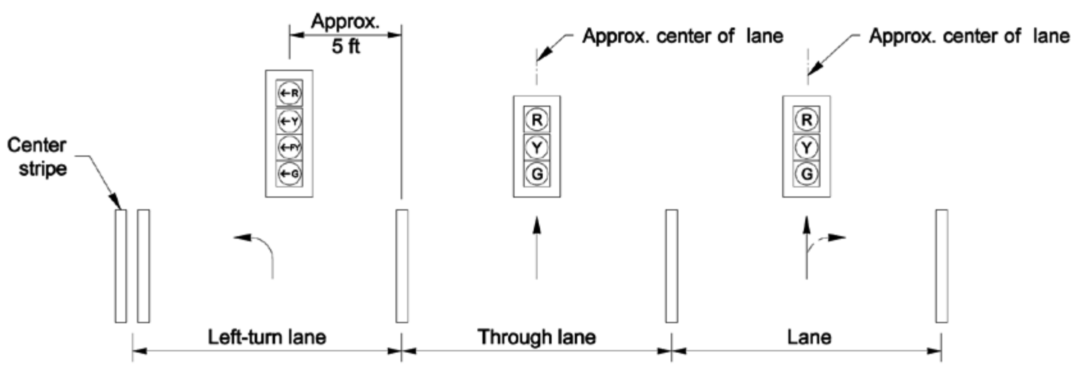


Three Through Lanes and Two Left-Turn Storage Lanes
(Left-Turn and Through movements terminate independently)

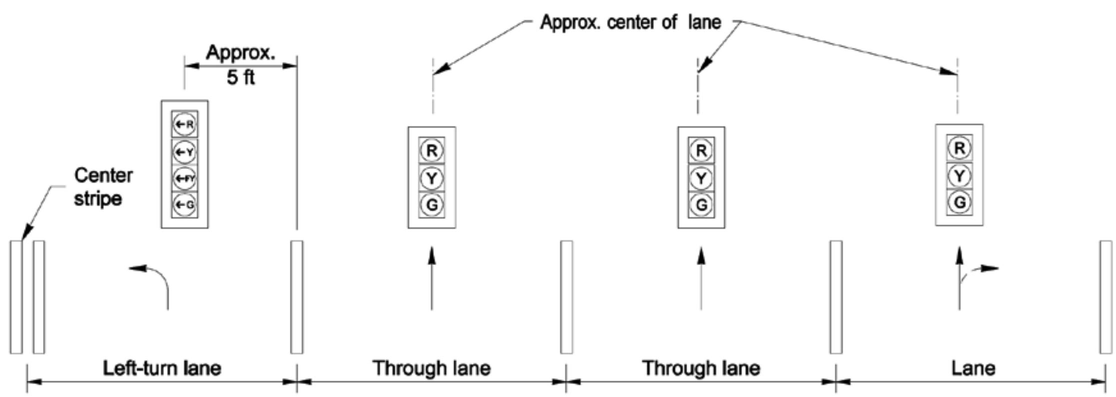
Traffic Signal Display Placements
Exhibit 1330-14e



One Through Lane and One Left-Turn Storage Lane
With Protected / Permissive Flashing Yellow Left-Turn Arrow

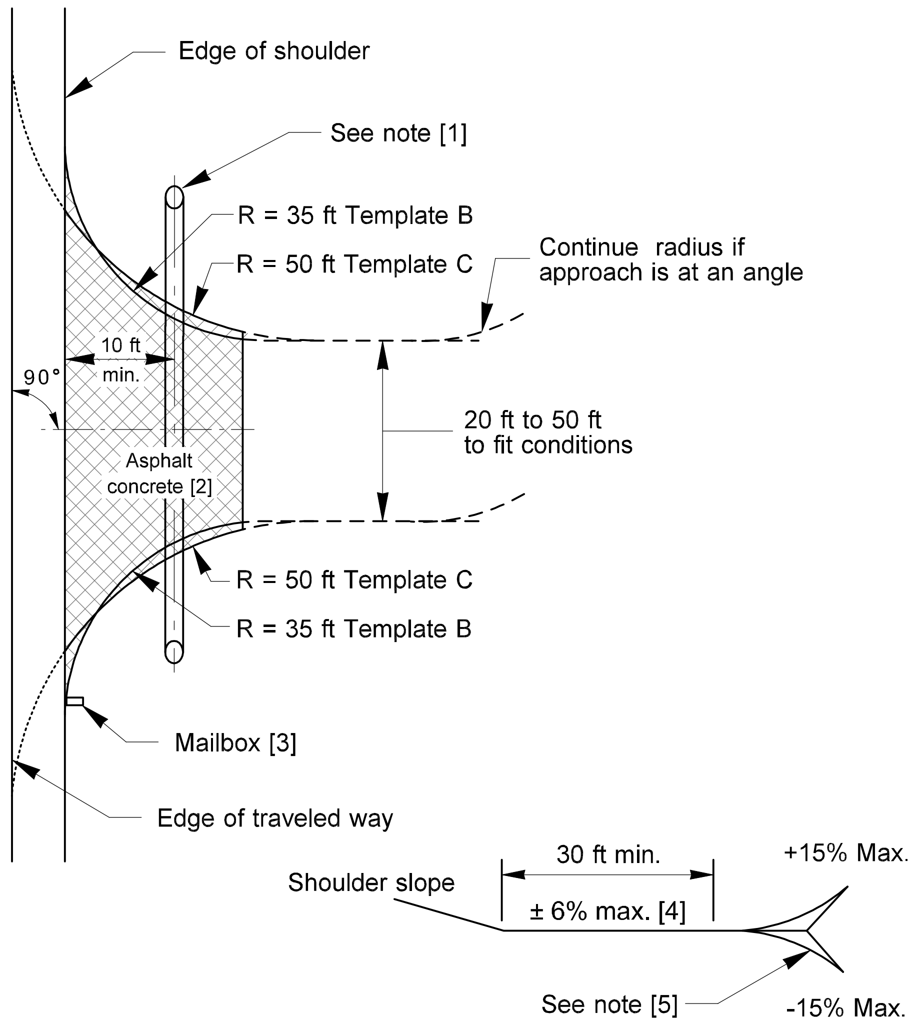


Two Through Lanes and One Left-Turn Storage Lane
With Protected / Permissive Flashing Yellow Left-Turn Arrow



Three Through Lanes and One Left-Turn Storage Lane
With Protected / Permissive Flashing Yellow Left-Turn Arrow

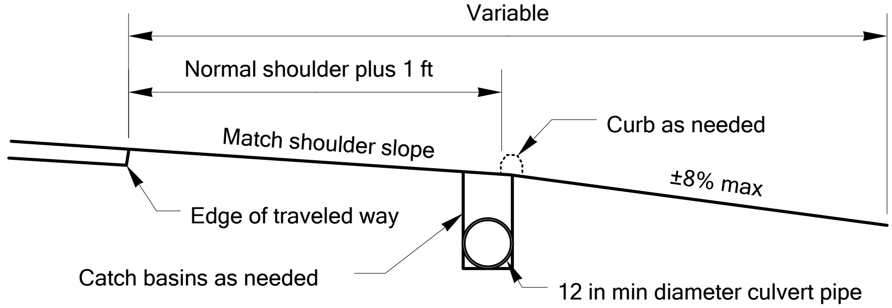
Traffic Signal Display Placements
Exhibit 1330-14f



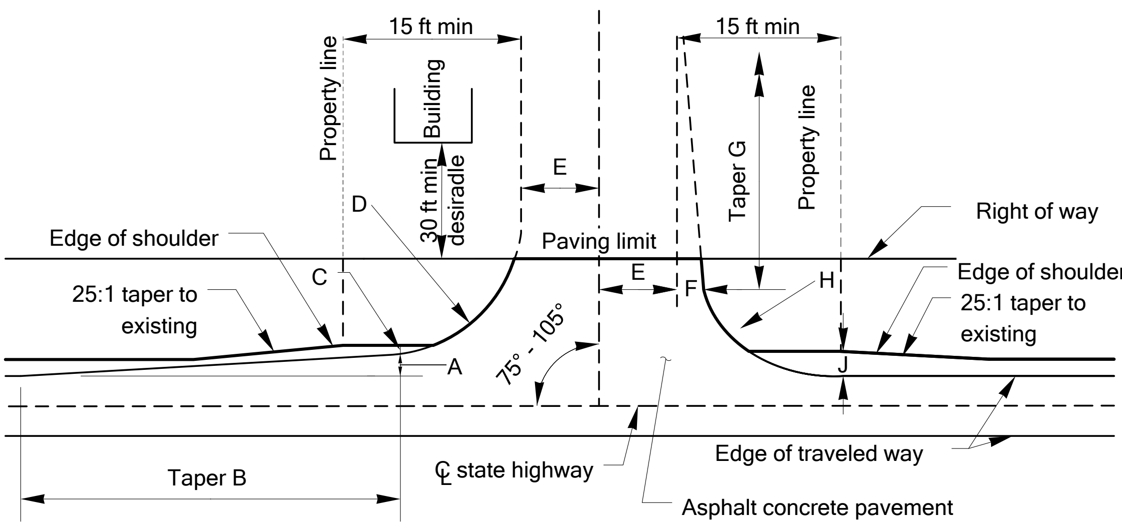
Notes:

[1] Culvert pipe with beveled end treatment (see Chapter 1600).
[2] When the travel lanes are bituminous, a similar type may be used on the approaches.
[3] For mailbox location, see Chapter 1600.
[4] ±8% difference from shoulder slope.
[5] Vertical curves not to exceed a 31/4-inch hump or a 2-inch depression in a 10-foot chord.

Road Approach Design Templates B1 and C1
Exhibit 1340-4



Profile Controls



Condition	A	B	C	D	E	F	G	H	J
Primary SU and less	—	—	[1]	30	15	—	—	30	[1]
Primary combination Vehicle WB 40	—	—	[1]	65	15	—	—	55	[1]
	4	25	[2]	50	15	7	25	45	[1]
Primary combination Vehicle WB 50 and doubles	—	—	[1]	70	20	—	—	50	[1]
	4	25	[3]	55	20	—	—	50	[1]

Notes:

[1] Normal shoulder width (see Chapter 1140).

[2] Normal shoulder width less A.

[3] For larger vehicles, use turning templates (see Chapter 1310).

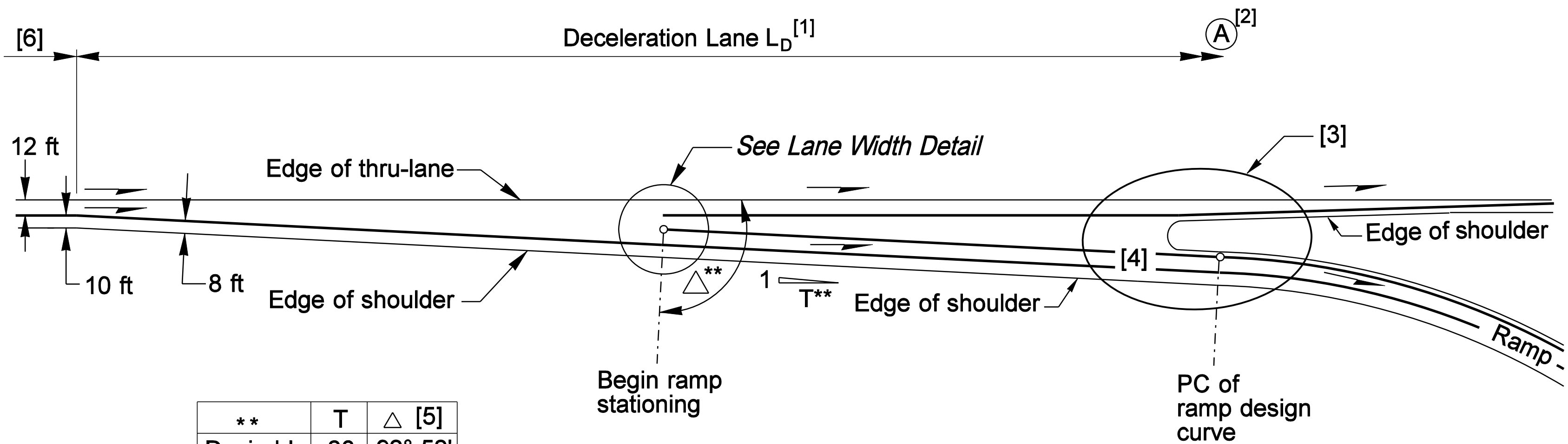
[4] Vertical curves between the shoulder slope and the road approach grade not to exceed a 3¼-inch hump or a 2-inch depression in a 10-ft cord.

General:

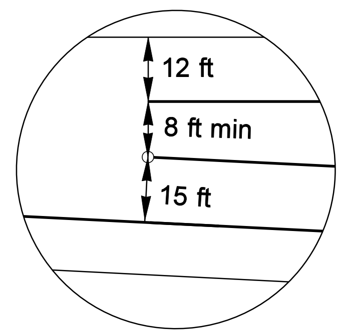
Values given are in ft.

Road Approach Design Template D1

Exhibit 1340-5



**	T	△ [5]
Desirable	20	92° 52'
Minimum	15	93° 49'



Lane Width Detail

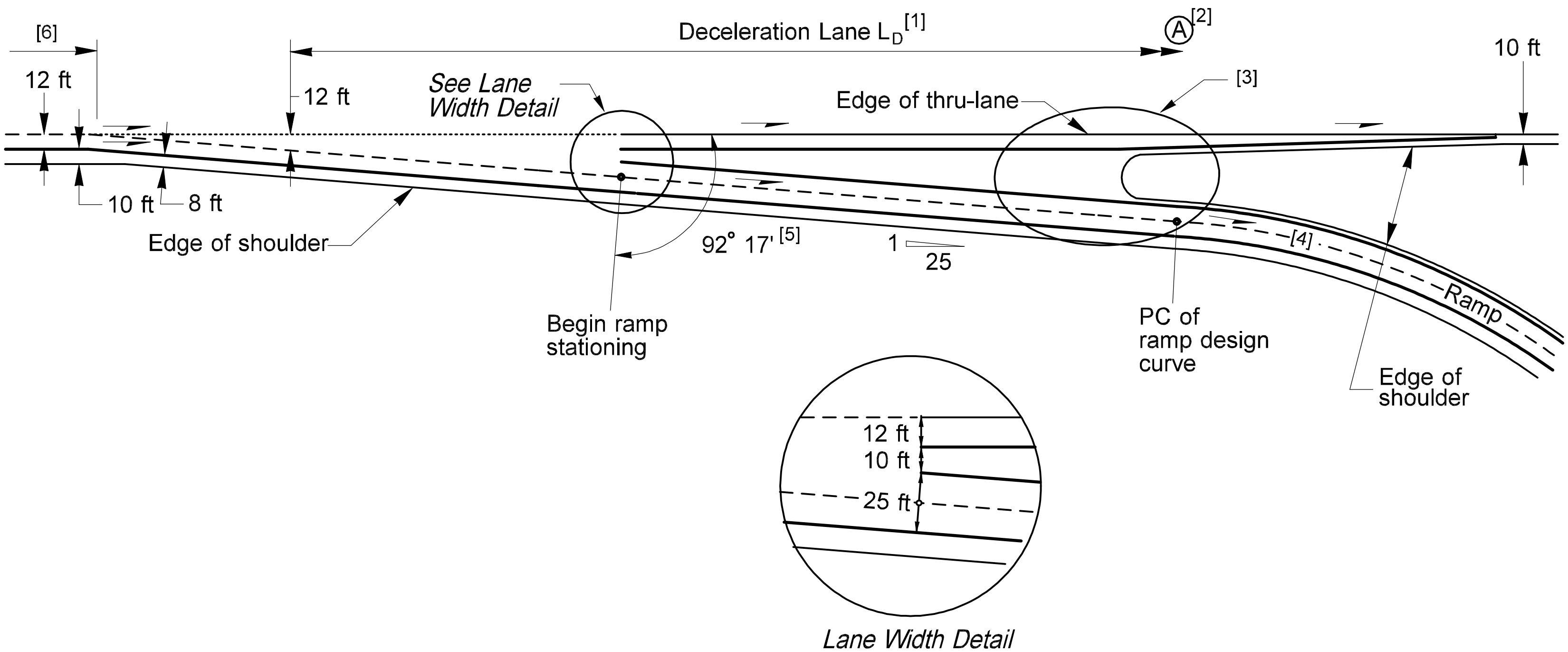
Notes:

[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] 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*.

Off-Connection: Single-Lane, One-Lane Reduction
Exhibit 1360-14c



Notes:

[1] For deceleration lane length L_D, see Exhibit 1360-10.

[2] Point A is the point controlling the ramp design speed.

[3] For gore details, see Exhibit 1360-11b.

[4] For ramp lane and shoulder widths, see Exhibit 1360-6.

[5] Approximate angle to establish ramp alignment.

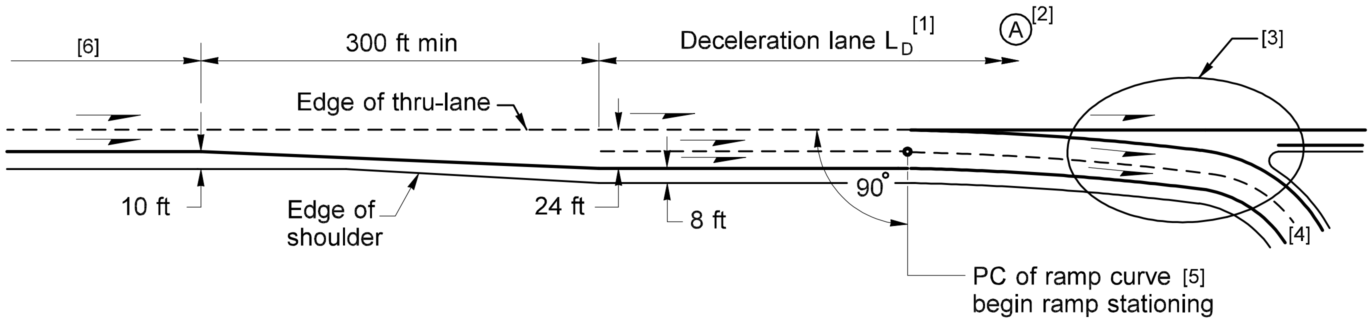
[6] Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300-ft taper.

General:

For striping, see the *Standard Plans*.

Off-Connection: Two-Lane, Tapered

Exhibit 1360-14d



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] For ramp lane and shoulder widths, see Exhibit 1360-6.

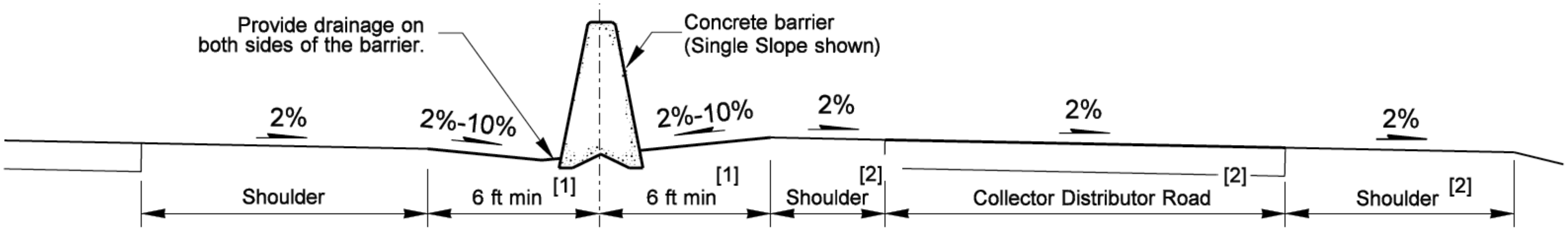
[5] Ramp stationing may be extended to accommodate superelevation transition.

[6] Lane to be dropped or auxiliary lane with a minimum length of 1,500 ft with a 300-ft taper.

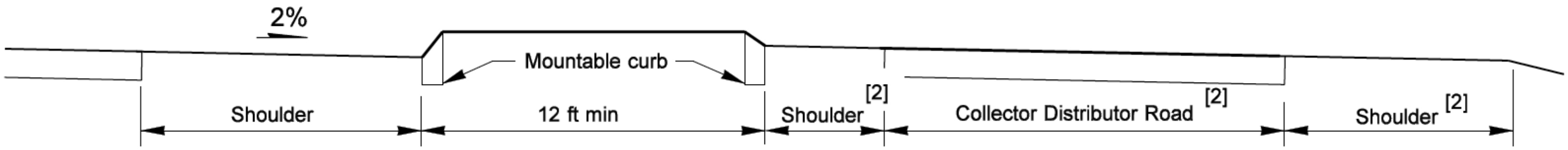
General:

For striping, see the *Standard Plans*.

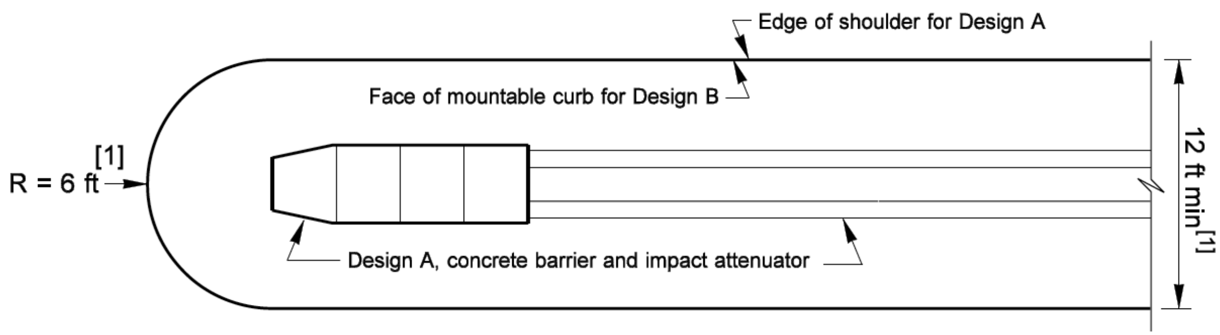
Off-Connection: Two-Lane, Parallel
Exhibit 1360-14e



Design A



Design B
(For facilities with speeds of 40 MPH or less, only)

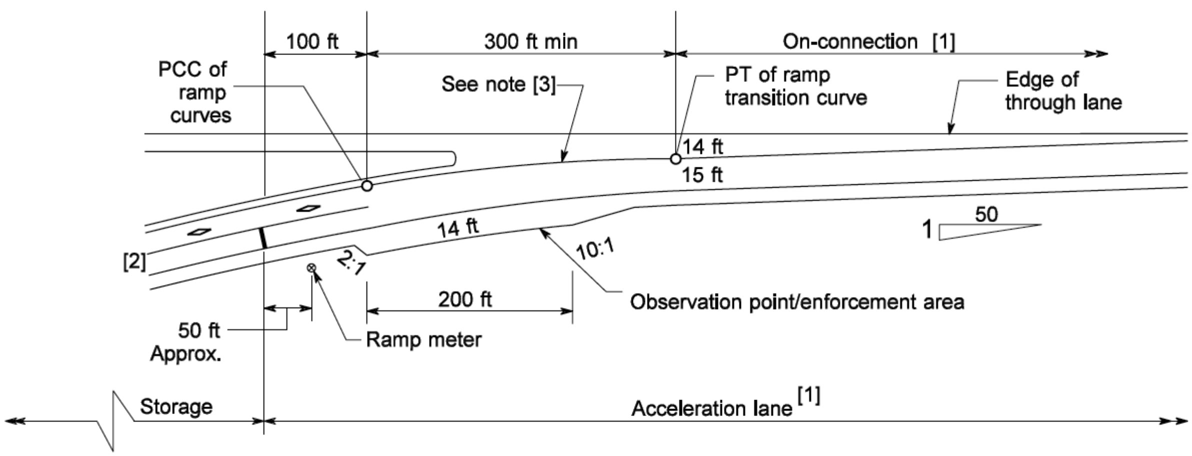


Notes:

[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.

Collector-Distributor: Outer Separations
Exhibit 1360-15a



Notes:

[1] For on-connection details and for acceleration lane length, see Chapter 1360.

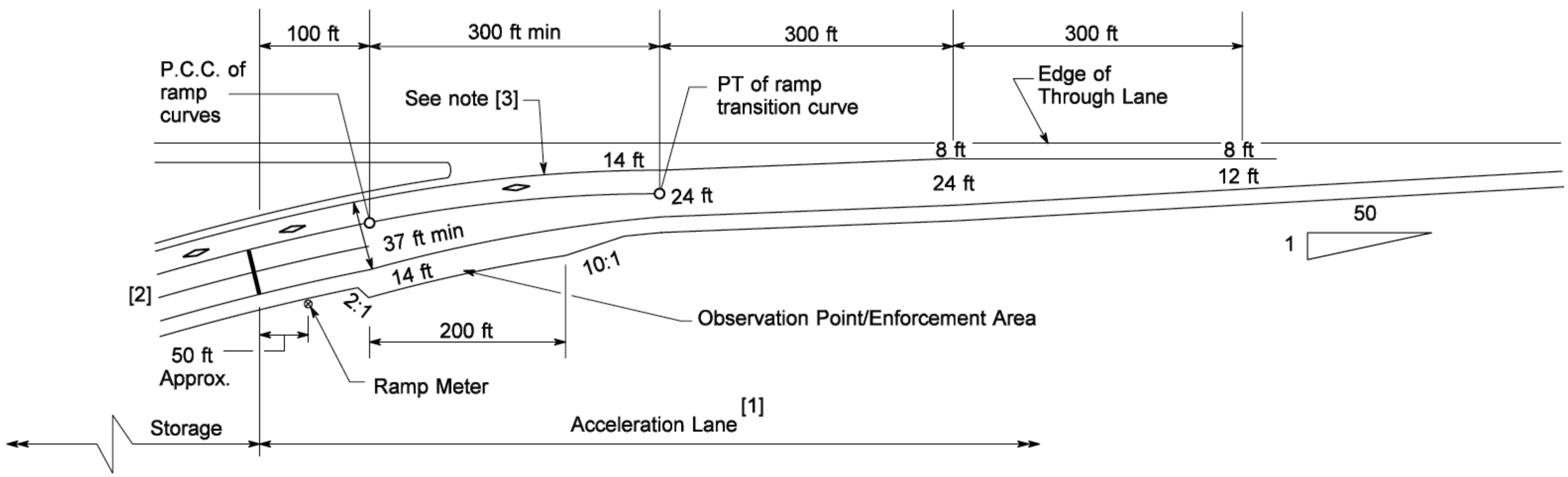
[2] For ramp lane and shoulder widths for a 2-lane ramp, see Chapters 1240 and 1360.

[3] A transition curve with a minimum radius of 3,000 ft is desirable. The minimum length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3,000 ft radius to tangent to the main line.

General:

For striping details, see the *Standard Plans*.

Single-Lane Ramp Meter With HOV Bypass
Exhibit 1410-4a



Notes:

[1] For acceleration lane length, see Chapter 1360.

[2] For 2-lane ramp lane and shoulder widths, see Chapters 1240 and 1360. For 3rd lane width, see Exhibit 1410-3.

[3] A transition curve with a minimum radius of 3000 ft is desirable. The minimum length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000 ft radius to tangent to the main line.

General:

For striping details, see the *Standard Plans*.

Two-Lane Ramp Meter With HOV Bypass
Exhibit 1410-4b

Chapter 1510 Pedestrian Facilities

1510.01 General

Pedestrian travel is a vital transportation mode. It is used at some point by nearly all citizens and is the main link to everyday life for many. Washington State Department of Transportation (WSDOT) designers must be aware of the various physical needs and abilities of pedestrians. Accommodate this variation in design to allow universal access.

The Americans with Disabilities Act of 1990 (ADA) requires that pedestrian facilities be designed and constructed such that they are readily accessible and usable by individuals with disabilities. This chapter provides accessibility criteria for the design of pedestrian facilities that meet state and national standards.

In addition to the ADA requirements, design pedestrian facilities using guidance in the *Roadside Manual*, the *Design Manual*, and the *Standard Plans*.

Designers face multiple challenges developing facilities that address pedestrian needs within a limited amount of right of way. Designers must:

- Become familiar with all the accessibility criteria requirements.
- Evaluate all pedestrian facilities within project limits for compliance with ADA.
- Recognize those features and elements in existing pedestrian facilities that meet or do not meet accessibility criteria.
- Design facilities that meet accessibility criteria.
- Balance intersection designs to meet the needs of pedestrians and vehicles.
- Design pedestrian access routes to be free of obstacles.
- Avoid the use of pedestrian space for snow storage in areas of heavy snowfall. (Coordinate with region maintenance personnel.)

Consider the maintainability of all designs for all pedestrian facilities and accessible features. Coordinate designs with the responsible WSDOT or local agency maintenance entity to ensure the understanding of maintenance requirements. Title II of the Americans with Disabilities Act requires that all necessary features be accessible and maintained in operable working condition for use by individuals with disabilities.

1510.02 References

(1) Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA) (28 Code of Federal Regulations [CFR] Part 36, Appendix A, as revised July 1, 1994)

23 CFR Part 652

28 CFR Part 35

49 CFR Part 27 (Authority: Section 504 of the Rehabilitation Act of 1973, as amended – 29 USC 794)

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 35.78, Streets – Classification and design standards

RCW 46.04.160, Crosswalk

RCW 46.61.235, Crosswalks

RCW 46.61.240, Crossing at other than crosswalks

RCW 46.61.261, Sidewalks, crosswalks – Pedestrians, bicycles

RCW 47.24.010, City streets as part of state highways, Designation – Construction, maintenance – Return to city or town

RCW 47.24.020, City streets as part of state highways – Jurisdiction, control

RCW 47.30.030, Facilities for nonmotorized traffic

RCW 47.30.050, Expenditures for paths and trails

(2) Design Guidance

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

Accessible Rights-of-Way: A Design Guide, U.S. Access Board, Washington D.C.
http://www.access-board.gov/prowac/guide/PROWGuide.htm

Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines (ADAAG), July 23, 2004, U.S. Access Board (The 1991 ADAAG is the current standard for buildings & on-site facilities adopted by US Department of Justice, the 2004 ADA-ABAAG is expected to be adopted.)
www.wbdg.org/ccb/ASTAND/ada_aba.pdf

"Design Guidance, Accommodating Bicycle and Pedestrian Travel: A Recommended Approach," USDOT Policy Statement, 2001
www.fhwa.dot.gov/environment/bikeped/Design.htm

Designing Sidewalks and Trails for Access – Parts I & II, USDOT, FHWA, 2001
http://www.fhwa.dot.gov/environment/sidewalk2/index.htm

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

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)

Pedestrian Facilities Guidebook: Incorporating Pedestrians Into Washington's Transportation System, OTAK, 1997
www.wsdot.wa.gov/publications/manuals/fulltext/M0000/PedFacGB.pdf

Pedestrian Facilities User's Guide – Providing Safety and Mobility, FHWA, 2002. Provides useful information regarding walkable environments, pedestrian crashes and their countermeasures, and engineering improvements for pedestrians.
www.drusilla.hsrc.unc.edu/cms/downloads/PedFacility_UserGuide2002.pdf

Revised Draft Guidelines for Accessible Public Rights-of-Way (PROWAG), Nov. 23, 2005, U.S. Access Board
www.access-board.gov/prowac/draft.htm

Roadside Manual, M 25-30, WSDOT

"Special Report: Accessible Public Rights-of-Way – Planning & Designing for Alterations," Public Rights-of-Way Access Advisory Committee, July 2007
www.access-board.gov/PROWAC/alterations/guide.htm

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

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005

Washington State Bicycle and Pedestrian Plan
www.wsdot.wa.gov/bike/Bike_Plan.htm

1510.03 Definitions

accessible A facility in the public right of way that is usable by persons with disabilities.

accessible pedestrian signals 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.

accessible route See ***pedestrian access route***.

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 facilities or alter existing facilities, including sidewalks and trails, to be accessible to people with disabilities.

alternate pedestrian access route A temporary accessible route to be used when the existing pedestrian access route is blocked by construction, alteration, maintenance, or other temporary condition.

alterations 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:

- Pavement pothole patching.
- Liquid-asphalt sealing, chip seal, or crack sealing.
- Lane restriping that does not involve roadway widening.

bituminous surface treatment (BST) Also known as a seal coat or chip seal, a BST is a thin, protective wearing surface that is applied to the pavement.

blended transition A connection with a grade of 5% or less between the level of the pedestrian walkway and the level of the crosswalk.

buffer A space at least 3 feet wide from the back of the curb to the edge of sidewalk that could be treated with planting or alternate pavement.

clear width The required 4-foot minimum width to provide the pedestrian access route.

counter slope Any slope opposite the running slope of a curb ramp, such as the roadway slope or landing slope.

cross slope The slope measured perpendicular to the direction of travel.

crosswalk A marked or unmarked pedestrian crossing, typically at an intersection, that connects the designated pedestrian access route (such as a sidewalk, shoulder, or pathway) on opposite sides of a roadway. A crosswalk must meet accessibility standards.

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 may be supplemented by contrasting pavement texture, style, or color" (MUTCD, 2003; *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, AASHTO, 2004).

curb extension A curb and sidewalk bulge or extension out into the parking lane or shoulder used to decrease the length of a pedestrian crossing and increase visibility for the pedestrian and driver.

curb flare The sloped area that may occur between the curb ramp and the sidewalk to accommodate the change in grade.

curb line A line at the face of the curb that marks the transition between the curb and the gutter, street, or highway.

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 using wheelchairs. Curb ramp is the term used in the ADA. (The WSDOT *Standard Plans* and *Standard Specifications* use the term "sidewalk ramp.")

> ***parallel curb ramp*** A curb ramp design where the sidewalk slopes down to a landing at road level and then slopes back up to the sidewalk so that the running slope is in line with the direction of sidewalk travel.
>
> ***perpendicular curb ramp*** A curb ramp design where the ramp path is perpendicular to the curb or meets the gutter grade break at right angles.

design area

> ***rural design area*** An area that meets none of the conditions to be an urban area (see Chapter 1140).
>
> ***suburban design area*** A term for the area at the boundary of an urban area. Suburban settings may combine the higher speeds common in rural areas with activities that are associated with urban settings.
>
> ***urban design area*** An area defined by one or more of the following:
>
> - Adjacent to and including a municipality or other urban place having a population of 5,000 or more, as determined by the latest available published official federal census (decennial or special), within boundaries to be fixed by a state highway department, subject to the approval of the FHWA.
> - Within the limits of an incorporated city or town.
> - Characterized by intensive use of the land for the location of structures and receiving such urban services as sewer, water, and other public utilities and services normally associated with an incorporated city or town.
> - With not more than 25% undeveloped land (see Chapter 1140).

detectable warning surface A tactile surface feature of truncated dome material built into or applied to the walking surface to alert persons with impairments of vehicular ways. Detectable warning surfaces shall contrast visually with the adjacent gutter, street or highway, and walkway surface. Note: The only acceptable detectable warnings are truncated domes as detailed in the *Standard Plans*.

driveway A vehicular access point to a roadway or parking facility with a curb or a slope (typically perpendicular to the curb) that cuts through or is built up to the curb to allow vehicles to effectively negotiate the elevation change between the street and the sidewalk.

element An architectural or mechanical component or design feature of a space, site, or public right of way.

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.

flangeway gap The space between the inner edge of a rail and the crossing surface or the gap for the train wheel.

grade break The intersection of two adjacent surface planes of different grade.

gutter slope The counter slopes of adjoining gutters and road surfaces immediately adjacent to the curb ramp.

hand rail A narrow rail for support along walking surfaces, ramps, and stairs.

landing A level (0 to 2% grade in any direction) 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.

maximum extent feasible 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 the existing facility makes it virtually impossible to comply fully with applicable accessibility standards through a planned alteration.

midblock pedestrian crossing A marked pedestrian crossing located between intersections.

passenger loading zone An area where persons can enter a vehicle safely.

pedestrian Any person afoot or using a wheelchair, power wheelchair, or means of conveyance (other than a bicycle) propelled by human power, such as skates or a skateboard.

pedestrian access route (same as ***accessible route***) A continuous, unobstructed walkway within a pedestrian circulation path that provides accessibility.

The pedestrian access route is connected to street crossings by curb ramps or blended transitions. It may include walkways; sidewalks; street crossings and crosswalks; overpasses and underpasses; courtyards; elevators; platform lifts; stairs; ramps; and landings. Where sidewalks are not provided, pedestrian circulation paths may be provided in the shoulder unless pedestrian use is prohibited.

Not all transportation facilities need to accommodate pedestrians. However, those that do accommodate pedestrians need to have an accessible route.

pedestrian circulation path A prepared exterior or interior way of passage provided for pedestrian travel.

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.

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 at a different level.

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.

pedestrian travel zone (same as ***pedestrian access route***) A continuous, unobstructed walkway within a pedestrian circulation path that provides accessibility.

person with disability An individual who has an impairment, including a mobility, sensory, or cognitive impairment, that results in a functional limitation in access to and use of a building or facility.

rail platform A level area for entering and exiting a light rail, commuter rail, and intercity rail system.

railroad track crossings Locations where a pedestrian access route intersects and crosses a railroad track.

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.

ramp A ramp is defined as:

- A sloped transition between two elevation levels (AASHTO).
- A walking surface between two level landings with a running slope steeper than 20H:1V (*Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines*, July, 2004).

roadway See Chapter 1140.

running slope A slope measured in the direction of travel, normally expressed as a percent.

sidewalk That portion of a highway, road, or street between the curb line, or the edge of a roadway and the adjacent property line that is paved or improved and intended for use by pedestrians.

sidewalk ramp See ***curb ramp***.

site A parcel of land bounded by a property line or a designated portion of a public right of way.

street furniture Sidewalk equipment or furnishings, including garbage cans, benches, parking meters, and telephone booths.

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, sidewalk extensions, surface variations, and visual clues in the vertical plane.

train dynamic envelope The clearance required for a train and its cargo overhang due to any combination of loading, lateral motion, or suspension failure.

transit stop An area designed for bus boarding and disembarking.

traveled way (same as ***vehicular way***) A route provided for vehicular traffic. The portion of the roadway intended for the movement of vehicles, exclusive of shoulders and lanes for parking, turning, and storage for turning.

truncated domes Small raised protrusions of a detectible warning surface that are between ⅞ inch and $1^{7}/_{16}$ inch in diameter and $^{3}/_{16}$ inch in height arranged in a distinctive pattern that is readily detected and understood by a vision-impaired person using the sense of touch guidance. The *Standard Plans* shows the appropriate pattern and dimensions.

universal access A facility that provides access to all persons regardless of ability or stature.

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.

walkway The continuous portion of the pedestrian access route that is connected to street crossings by curb ramps or blended transitions (*Revised Draft Guidelines for Accessible Public Rights-of-Way*, 11-23-05, and *Pedestrian Facilities Guidebook*, WSDOT et al., 1997).

wheeled mobility device A wheelchair, scooter, walker, or other wheeled device that provides mobility to those with limited physical abilities.

1510.04 Policy

(1) General

Provide pedestrian facilities along and across sections of state routes and city streets 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 on all highway Improvement projects. Coordinate with the region Planning and Traffic offices to identify planning studies that detail current traffic and forecast growth and pedestrian generators in the project vicinity. FHWA is designated by the Department of Justice to ensure compliance with the Americans with Disabilities Act of 1990 (ADA) for transportation projects. Design pedestrian facilities to provide universal access for all people. Provide pedestrian facilities on highway projects unless one or more of the following conditions are met:

- Pedestrians are prohibited by law from using the facility.
- Planning/land use documents indicate that low population density is projected for the area in the 20-year planning horizon.

Consider whether or not the project is within a city or an urban growth area that is ultimately intended to be developed as an urban density area with urban services, including transit. Inside incorporated cities, design pedestrian facilities in accordance with the city design standards adopted in accordance with RCW 35.78.030 on the condition they comply with the most current ADA requirements. Exceptions to adopted design standards—other than ADA (see below)—require a deviation approved by the designated authority identified in Chapter 300.

Title II of the Americans with Disabilities Act requires that a public entity shall 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. Consider the maintenance needs of accessible pedestrian facilities during the design of those elements.

(2) ADA Compliance

Wherever pedestrian facilities are intended to be a part of the transportation facility, 28 CFR Part 35 requires that those pedestrian facilities meet ADA guidelines. Federal regulations require that all new construction, reconstruction, or alteration of existing transportation facilities be designed and constructed to be accessible and useable by those with disabilities and that existing facilities be retrofitted to be accessible. Design pedestrian facilities to accommodate all types of pedestrians, including children, adults, the elderly, and persons with mobility, sensory, or cognitive impairments.

(a) **Improvement Projects**

Improvement projects address the construction of a new roadway, reconstruction such as roadway widening to add an additional lane, and modal (transit or bicycle) or lane configuration changes that widen the existing roadway cross section. For these projects, pedestrians' needs are assessed and included in the project. Develop pedestrian facilities consistent with the accessibility criteria listed in Exhibits 1510-23 and 1510-27.

(b) **Pavement Preservation (Alteration) Projects**

Preservation projects are considered alterations. Alterations include, but are not limited to, renovation; rehabilitation; reconstruction; historic restoration; lane restriping as part of an overlay; resurfacing of circulation paths or vehicular ways; or changes or rearrangement of structural parts or elements of a facility. The following guidance applies to alteration projects:

- All existing curb ramps and crosswalks (marked or not) need to be assessed to determine whether curb ramp and crosswalk design elements meet the accessibility criteria in Exhibit 1510-27.
- Modify existing and proposed crosswalk slopes to meet the accessibility criteria by grinding or preleveling. Justify the reasons for not meeting the accessibility criteria for crosswalks slopes and document in the DDP. (See Chapter 300 for discussion of the DDP.)
- Modify existing curb ramps that do not meet the accessibility criteria to the maximum extent feasible. Where some curb ramps exist at intersections, it is also necessary to make sure they exist on both ends of a crosswalk. A crosswalk must be accessible from both ends. This also may require reconstruction or modification of other ADA features (see Exhibit 1510-27) to ensure all elements of a curb ramp will meet the accessibility criteria. It is not always possible to build a curb ramp to full ADA standards. If such a situation is encountered, the designer needs to contact the appropriate Assistant State Design Engineer (ASDE) to confirm the finding. After the ASDE confirms the finding that it is not possible to build the curb ramp to full ADA standards, the designer then designs the curb ramp to the maximum extent feasible and documents which elements were and which were not designed to ADA standards; include documentation in the DDP. If the project is within a city, coordinate with the city to develop an assessment of ADA compliance.

The following are not considered alterations and therefore are not subject to accessibility requirements:

- Pavement pothole patching.
- Liquid-asphalt sealing, chip seal, or crack sealing.
- Lane restriping that does not involve roadway widening.

(3) Jurisdiction

When city streets form a part of the state highway system within the corporate limits of cities and towns, the city has full responsibility for and control over any facilities beyond the curbs and, if no curb is installed, beyond that portion of the highway used for highway purposes (RCW 47.24.020). When proposed projects will damage or remove existing sidewalks or other pedestrian access routes or features within a city's jurisdiction, work with the city to reconstruct the affected facilities to meet accessibility criteria. When proposed alteration projects are within the city limits, curb ramps will be assessed, and any that do not meet the accessibility criteria for alterations will need to be modified.

The title to limited access facilities within incorporated cities and towns remains with the state. If a turnback agreement has not been completed, the state maintains full jurisdiction within these areas (see Chapters 510, 520, and 530).

(4) Access Control

Access control on highways is either *limited* or *managed* and is discussed in detail in Division 5. Various designations of access control affect how and where pedestrian facilities are located, as follows:

(a) **Full Limited Access Control**

On roadways designated as having full limited access control, pedestrian access routes, hiking trails, and shared-use paths within the right of way are separated from vehicular traffic with physical barriers. These facilities can connect with other facilities outside the right of way once proper documentation has been obtained. Contact the Headquarters (HQ) Access and Hearings Section and HQ Real Estate Services to determine the required documentation. Grade separations are provided when the trail or path crosses the highway. (See Chapter 530 for limited access.)

(b) **Partial or Modified Limited Access Control**

On these facilities, pedestrian access routes and shared-use paths may be located between the access points of interchanges or intersections. Pedestrian crossings are usually either at grade or grade-separated. Consider midblock pedestrian crossings at pedestrian generators when the roadway has the characteristics associated with an urban or suburban area and has appropriate operational and geometric characteristics that allow for a crossing. Note that the installation of a midblock pedestrian crossing on a state highway is a design deviation that requires approval and documentation. Pedestrian circulation paths must include a pedestrian access route.

Consider providing sidewalks at signalized intersections. Evaluate extending sidewalks on a project-by-project basis. (See Chapter 530 for limited access.)

(c) **Managed Access Control Highways**

On these routes, in rural areas, paved shoulders are normally used for pedestrian travel. When pedestrian activity is high, separate walkways may be provided. Sidewalks are typically used in urban growth areas where there is an identified need for pedestrian facilities.

Consider providing sidewalks at signalized intersections. Evaluate extending sidewalks on a project-by-project basis.

Trails and shared-use paths, separated from the roadway alignment, are used to connect areas of community development. Pedestrian crossings are typically at grade.

1510.05 Pedestrian Facility Design

(1) Facilities

The type of pedestrian facility provided is 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); safety-economic analyses; and the continuity of local walkways along or across the roadway. Pedestrian access routes can either be immediately adjacent to streets and highways or separated from them by a buffer.

(2) Pedestrian Travel Along Streets and Highways

Examples of various types of pedestrian access routes are shown in Exhibit 1510-23. A generalized method of assessing the need for and adequacy of pedestrian facilities is shown in Exhibit 1510-24.

To determine what type of pedestrian facility to use, consider a study that addresses roadway classification, traffic speed, collision data, pedestrian generators, school zones, transit routes, and land use designation.

Chapter 1600 provides guidance on the design clear zone, based on various conditions such as rural or urban routes, speeds, traffic volumes, and jurisdiction.

(a) Basic Criteria for Pedestrian Accessible Routes

1. **Surfacing**

   The surface of the pedestrian access route needs to be firm, stable, slip-resistant, and smooth. Use cement or asphalt concrete surfaces; crushed gravel is not considered to be a stable, firm surface.

   Locate utility vaults and junction boxes outside the sidewalk. Where this is not practicable, use utility vaults and junction boxes with lids designed to reduce tripping and slipping (see the *Standard Plans*).

2. **Vertical Clearance**

   Hanging or protruding objects within the walkway may present obstacles for pedestrians with visual impairments. The minimum vertical clearance for objects (including signs) overhanging a walkway is 7 feet (84 inches).

3. **Horizontal Encroachment**

   The minimum clear width for an ADA pedestrian accessible route is 4 feet. Where the pedestrian access route is less than 5 feet wide, provide a 5-foot x 5-foot passing space at 200-foot intervals.

   Fixtures located in the sidewalk are obstacles for pedestrians, and they reduce the clear width of the sidewalk. Provide a continuous, unobstructed route for pedestrians. When an unobstructed route is not possible, provide the minimum clear width for an accessible route around obstructions.

Objects that protrude more than 4 inches into the walkway are considered to be obstacles, and warning devices are necessary wherever feasible. Equip wall-mounted and post-mounted objects that protrude 4 inches or more into the walkway between 27 inches and 80 inches above the sidewalk with warning devices detectable by persons with impaired vision using a cane (see Exhibit 1510-1).

When relocation of utility poles and other fixtures is necessary for a project, determine the impact of their new location on all pedestrian walkways. Look for opportunities to eliminate obstructions, including existing utilities that obstruct the pedestrian route.

Acceptable Pedestrian Access Route

Unacceptable Pedestrian Access Route

Accessible Sidewalk

Sidewalk With Obstructions

Pedestrian Route Geometrics
Exhibit 1510-1

4. **Geometrics of the Pedestrian Accessible Route**

When considering both new and existing pedestrian-accessible routes, the geometric elements need to be evaluated for the running slope of the route, cross slope, width, amount of vertical rise over the length of the route, vertical differences at changes in surface grades (tripping hazards), and access across and through a vertical barrier (curb ramps).

Where the walkway is located behind guardrail, address guardrail bolts or install a rub rail to prevent snagging. Consider the installation of "W" beam guardrail on the pedestrian side of the posts to reduce snagging and as a guide for sight-impaired pedestrians. Specify these construction requirements in the contract.

Provide a nonsnagging finish to vertical surfaces adjacent to a pedestrian facility to prevent snagging or abrasive injuries from accidental contact with the surface.

(3) Shoulders

Paved shoulders are an extension of the roadway and are not considered pedestrian facilities; however they can be used by pedestrians and may serve as a pedestrian access route. Although pedestrians are allowed to travel along the shoulder, its main purpose is to provide an area for disabled vehicles, a recovery area for errant vehicles, and positive drainage away from the roadway.

Determine whether the roadway shoulders are of sufficient width and condition to permit travel for pedestrians. Paved shoulders are preferable. A 4-foot-wide shoulder is acceptable where pedestrian activity is minimal and where school and other pedestrian generators are not present. Wider shoulders are desirable along high-speed highways, particularly when truck volumes or pedestrian activities are high.

Longitudinal travel along shoulders with cross slopes greater than 2% can be difficult for people with disabilities. Horizontal curves are usually superelevated and can have cross slopes steeper than 2%. The shoulders on these curves often have the same cross slope as the roadway. If pedestrians will use the shoulder frequently, consider a separate pedestrian access route.

(4) Shared-Use Paths

Shared-use paths are used by pedestrians and bicyclists (see Exhibit 1510-2). Comply with accessibility criteria in their design. Pedestrian facilities differ from bicycle facilities in their design criteria and goals, and they are not always compatible. When it is determined that a shared-use path is in the best interests of both groups, see Chapter 1520, Bicycle Facilities, AASHTO's *Guide for the Development of Bicycle Facilities,* and FHWA's *Designing Sidewalks and Trails for Access, Part II*.

Shared-Use Path
Exhibit 1510-2

(5) Sidewalks

Plan the design of sidewalks carefully to include a pedestrian access route that provides universal access. Sidewalk design elements are found in Exhibits 1510-23 and 1510-27, and details for raised sidewalks are shown in the *Standard Plans*. Wherever appropriate, make sidewalks continuous and provide access to side streets. The most desirable installation for the pedestrian is a sidewalk separated from the traveled way by a planted buffer. This provides a greater separation between vehicles and pedestrians than curb alone.

(a) **Buffers and Widths**

Where a sidewalk is separated from the travelled way with only a curb, the WSDOT minimum sidewalk width is 6 feet.

The WSDOT minimum width for a sidewalk is 5 feet, when used with a buffer at least 3 feet wide. (See the *Standard Plans* and Exhibit 1510-23).

Driveway/Sidewalk Crossings
Exhibit 1510-4

Wider sidewalks are preferable in areas of high pedestrian traffic, such as a central business district (CBD) and along parks, schools, and other major pedestrian generators. Coordinate with the city for appropriate sidewalk and buffer designs and funding participation in these cases.

Consider buffers of 4 feet for collector routes and 6 feet for arterial routes. If trees or shrubs are included, coordinate with the region or HQ Landscape Architect and refer to the *Roadside Manual*. Plants should not limit the visibility of motorists or pedestrians or pose obstructions on the pedestrian access route (see Chapter 1340). 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.

In areas with snowfall consider wider sidewalks or a sidewalk with a buffer to accommodate snow storage while at the same time 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 buffer, but they do offer the advantage of further separation between vehicles and pedestrians.

(b) **Alignment, Grade, and Cross Slope**

Where the walkway (sidewalk) of a pedestrian access route is adjacent to a street or highway, its running slope can match, but not exceed, the general grade established for the adjacent street or highway. On roadways with prolonged grades greater than 8.3%, consider providing hand railings* and level landings adjacent to the sidewalk as resting areas.

**Guide for the Planning, Design, and Operation of Pedestrian Facilities*, AASHTO, 2004

If the sidewalk follows a separate horizontal or vertical alignment, the running slope must comply with ADA standards. The maximum running slope allowed is 8.3%.

Design sidewalks with cross slopes no more than 2%. Steeper cross slopes are difficult for people in wheelchairs to negotiate.

(c) **Driveways**

Driveways can be a barrier for persons with disabilities. Provide accessible crossings in locations where a sidewalk meets a driveway. An accessible route is 4 feet wide minimum with a cross slope of 2% or less. (See Exhibit 1510-4 for examples of driveway/sidewalk crossings.)

Consider limiting or consolidating driveways (vehicle access points). Construct driveways in accordance with ADA requirements, or provide an ADA accessible route. (See Chapter 520 for access control information and the *Standard Plans* for vehicle approach details and ADA requirements.) Where a driveway is present within the longitudinal limits of the sidewalk, provide a pedestrian-accessible route to maintain continuity along the sidewalk. (See Exhibit 1510-27 for design element requirements.)

Driveway/Sidewalk Crossings
Exhibit 1510-4

(d) **Sideslopes, Railing, and Barriers**

The sideslope adjacent to the sidewalk is a critical design element. Exhibit 1510-23 provides guidance on slope rounding and railings for various conditions. When there is a vertical drop-off of 2 feet 6 inches or more directly behind the sidewalk, provide a pedestrian railing when embankment widening is not possible (see Exhibit 1510-23).

The pedestrian railing is installed between the walkway and the vertical drop-off. Ensure pedestrian railing does not encroach on the sidewalk width.

Pedestrian railings are not always designed to withstand vehicular impacts or redirect errant vehicles. Chapter 1600 addresses the Design Clear Zone for vehicles. A crashworthy traffic barrier is required if the drop-off is within the Design Clear Zone.

Where the walkway is adjacent to a vertical drop-off and is separated from the roadway, consider installing the traffic barrier between the traveled way and the walkway. The pedestrian railing is installed between the walkway and the vertical drop-off.

(6) Curb Ramps (Sidewalk Ramps)

Curb ramps provide an accessible connection from a raised sidewalk down to the roadway surface. A curb ramp is required at every corner of all intersections where curbs and sidewalks are present, except where pedestrian crossing is prohibited. (See 1510.05(8)(b), Exhibit 1510-7, and Chapter 1330 for guidance on closed crossings.) For new construction, a curb ramp oriented in each direction of pedestrian travel aligned with the crosswalk it serves is required. For alterations, a separate curb ramp oriented in each direction of pedestrian travel aligned with the crosswalk it serves is required if feasible. 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 the opposite side. Curb ramps are also required at midblock crossings where sidewalks are present.

(a) **Types of Curb Ramps**

Different types of curb ramps can be used: perpendicular, parallel, and combination. Wherever possible, it is desirable to provide a buffer around the corner to separate the sidewalk from the curb, allowing the curb ramp to be installed with curb returns that facilitate direction-finding for the visually impaired.

1. **Perpendicular**

   This curb ramp is commonly used to provide access from the sidewalk to the street. The landing is to be located at the top of the curb ramp.

   a. **Advantages**

   - Ramp aligned with the crosswalk.
   - Straight path of travel on tight radius.
   - Two ramps per corner.

   b. **Disadvantage**

   - May not provide a straight path of travel on larger-radius corners.
   - May not fit with the required flares on small radius corners.

2. **Parallel**

   This curb ramp works well in a narrower area with right of way limitations or where blending a curb ramp into steep grades is required. The landing is to be located at the bottom of the curb ramp.

   a. **Advantages**

   - Requires minimal right of way.
   - Provides a level area that aligns with the crossing. The landing is contained in the sidewalk and not the street.
   - Allows ramps to be extended to reduce ramp grade or blend into steep grades of sidewalk.
   - Provides edges on the side of the ramp that are clearly defined for pedestrians with vision impairments.

   b. **Disadvantages**

   - Pedestrians need to negotiate two or more ramp grades possibly making it more difficult to traverse.
   - Improper design/construction of the landing can result in the accumulation of water or debris at the bottom of the ramp.

3. **Combination**

   This combines the use of perpendicular and parallel types of curb ramps. The landing may be shared in this application.

   a. **Advantages**

   - Works well in areas where grades may be a problem.
   - Does not require turning or maneuvering on the ramp.
   - Ramp aligned perpendicular to the crosswalk.
   - Level maneuvering area between ramps.
   - Allows transition of running slopes in steep terrain

b. **Disadvantage**

- Generally require more space.
- Might require more extensive alterations in retrofits.

(b) **Curb Ramp Common Elements**

To comply with ADA requirements, the following represents the design requirements for curb ramps:

1. **Clear Width**

   - 4 feet wide minimum

2. **Landings**

   A level landing is necessary at the top of a perpendicular ramp or the bottom of a parallel curb ramp as noted above for the type of curb ramp used. The top landing is provided to allow a person in a wheelchair room to maneuver into a position to use the ramp or bypass it. The lower landing allows a wheelchair user to transition from the ramp to the roadway crossing.

   - The width of the landing matches the width of the curb ramp.
   - In Preservation projects on existing landings, the length of the landing must be at least 3 feet. The width of the landing needs to match the width of the curb ramps.
   - In new construction, provide a 4-foot-square landing.
   - When right of way constraints are not an issue, it is desirable to provide a larger landing.
   - If the landing is next to a vertical wall, a 5-foot-wide clear area is desirable to allow a person in a wheelchair more room to maneuver and change directions.
   - The running and cross slopes of landings for curb ramps on midblock crossings are permitted to be warped to meet street or highway grade.

3. **Running Slope**

   - 12H:1V or flatter (in new construction and Preservation projects).

4. **Cross Slope**

   - Not greater than 2%.

5. **Curb Ramp Flares**

   - Do not exceed 10%.

6. **Counter Slope**

   - Provide a counter slope of the gutter or street at the foot of the curb ramp or landing of 5% maximum. When the algebraic difference between the counter slope of the gutter or street and ramp running slope is equal to or greater than 11%, consider a 2-foot level strip at the base of the ramp (see Exhibits 1510-8 and 1510-27).

7. **Detectable Warning Surfaces**

- Are to be installed where curb ramps or landings connect to a roadway.

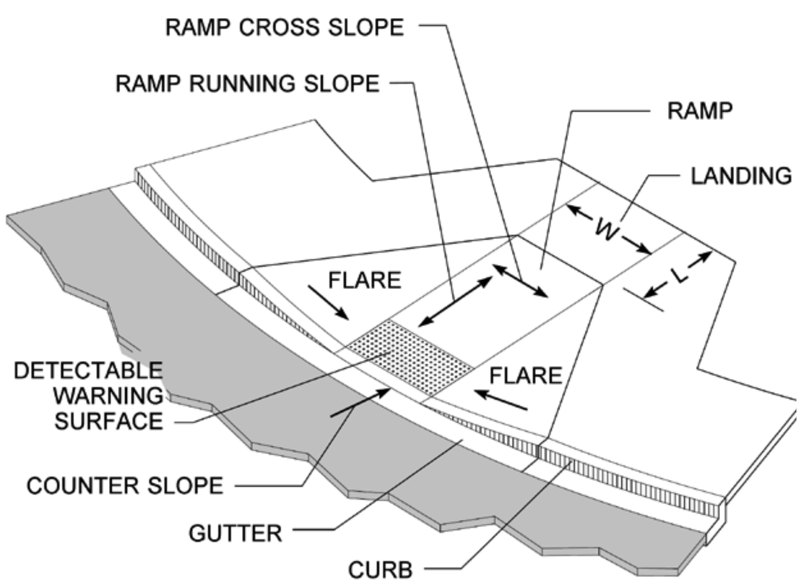
In all cases, detectable warning surfaces are to be installed, including at channelizing islands (median and right-turn lanes as shown in Exhibit 1510-14). Detectable warning surfaces must contrast visually with the background material. ADAAG requires that detectable warnings "shall contrast visually with adjoining surfaces either light-on-dark or dark-on-light." WSDOT requires the use of federal yellow as the visual contrast on its projects. Other contrasting colors may be used on projects where cities have jurisdiction.

At signalized intersections, it is desirable to provide pedestrian push buttons on separate poles located near each curb ramp landing for ADA accessibility. Provide paved access to the pedestrian push button. (See Chapter 1330 for information on pedestrian guidelines at traffic signal locations.)

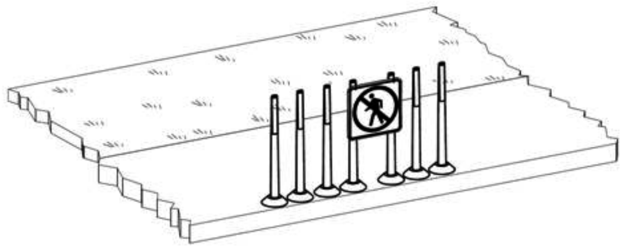
Perpendicular Ramps

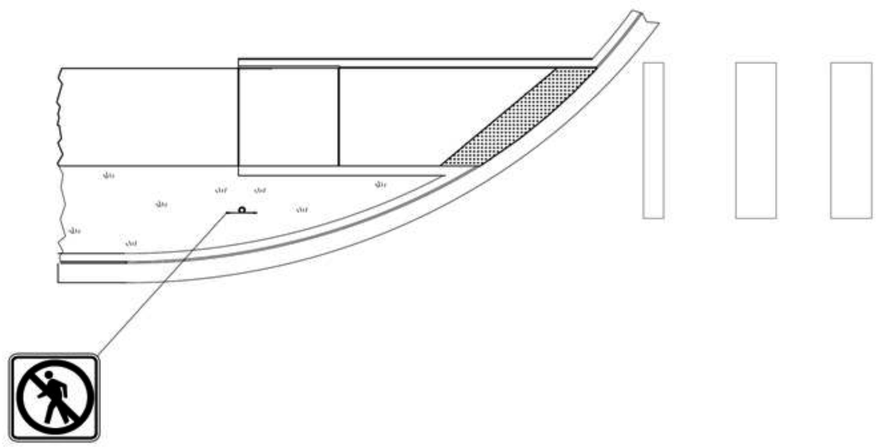
Parallel Ramp Combination Ramp

Curb Ramps
Exhibit 1510-5

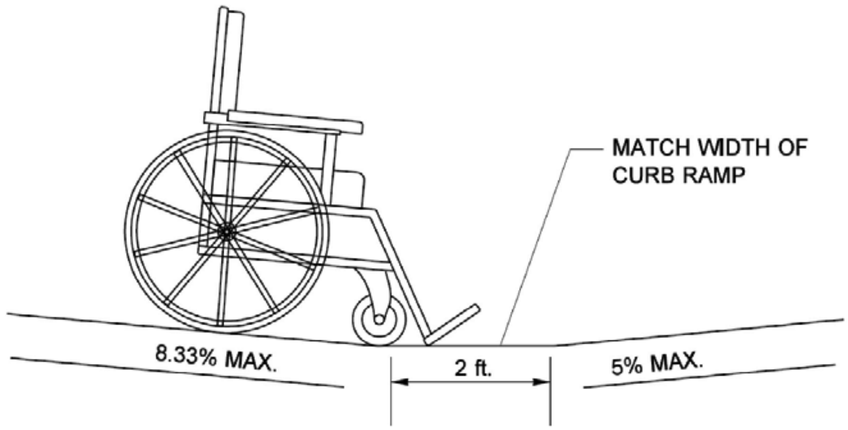


Curb Ramp Common Elements
Exhibit 1510-6





Examples of Acceptable Barriers Closing Pedestrian Crossings
Exhibit 1510-7

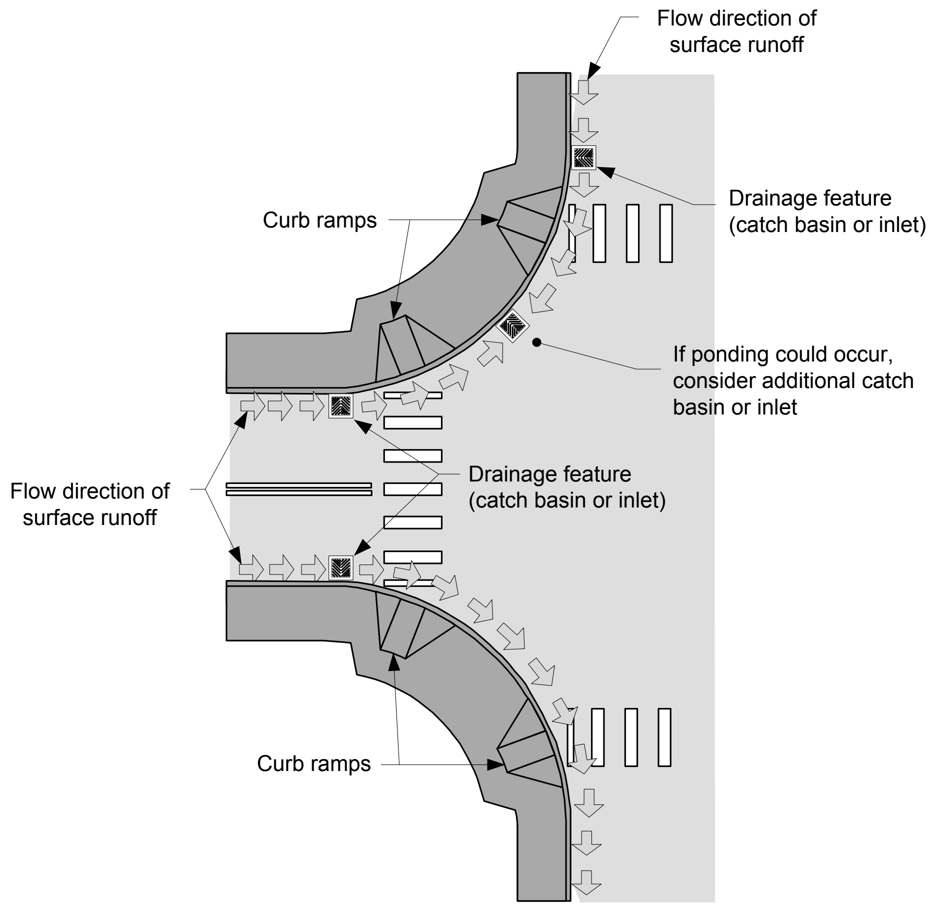


Consider a 2-foot level strip if algebraic difference ≥ 11%.

Source: *Guide for the Planning, Design, and Operation of Pedestrian Facilities,* AASHTO

Counter Slope Alternative
Exhibit 1510-8

The lower terminus of the curb ramp is located at the beginning of a marked or unmarked crosswalk. Surface water runoff from the roadway can flood the lower end of a curb ramp. Determine the grades along the curb line and verify that the base of the curb ramp is not the lowest point of the gutter. Provide catch basins or inlets to prevent the flooding of the ramps. Exhibit 1510-9 shows examples of how drainage structures are located. Verify that drainage structures will not be in the pedestrian access route.



Curb Ramp Drainage
Exhibit 1510-9

(7) Vehicle Bridges and Underpasses

Provide for pedestrians on vehicle bridges and underpasses where pedestrians are allowed (contact the HQ Bridge and Structures Office). Provide either raised sidewalks or ramps on the approaches to bridges when there are raised sidewalks on the bridge. The ramp is constructed of either asphalt or cement concrete and has a slope of 20H:1V or flatter. These ramps can also be used as a transition from a raised sidewalk down to a paved shoulder. The ramp provides pedestrian access and mitigates the raised, blunt end of the concrete sidewalk for vehicles.

In 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, consider placing the walkway between the roadway and the columns for pedestrian visibility and security. Provide adequate lighting and drainage for pedestrian safety and comfort.

(8) Pedestrian Crossings at Grade

(a) Design Considerations for Crossing Facilities

Designing intersections for the needs of all users, including pedestrians, requires various considerations and tradeoffs. The following list presents design considerations for creating crossing facilities that meet pedestrian needs:

- Minimize turning radii to keep speeds low (see Chapter 1310 for design vehicle guidance).
- Place crosswalks such that they are visible and adjacent to the pedestrian facility.
- 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 for a pedestrian refuge in the median.
- Use pedestrian signals (APS).
- Use signage.
- Place crosswalks as close as practicable to the intersection traveled way.
- Provide pedestrian-level lighting.

(b) Closed Crossings

To meet ADA requirements, equal access to cross the highway shall be provided to all pedestrians unless pedestrian crossing is prohibited. Consult with the region Traffic Office when considering a prohibited crossing. Also:

- Provide an accessible alternative to the closed crossing.
- Make the leg on each side of the crossing inaccessible to all pedestrians.
- Install signs and a barrier detectable to persons with visual disabilities, restricting all pedestrians from crossing at that location (see Exhibit 1510-7).

All pedestrian crossings need to provide a pedestrian access route that meets ADA guidelines. Exhibit 1510-25 provides recommendations for determining pedestrian markings based on vehicular traffic volume and speed. Pedestrian crossings at grade are permitted along the length of most highways. Pedestrian crossing on all legs of an intersection is also permitted. An illegal pedestrian crossing only occurs when signs prohibit a particular crossing at an intersection or the crossing occurs between two adjacent signalized intersections (RCW 46.61.240).

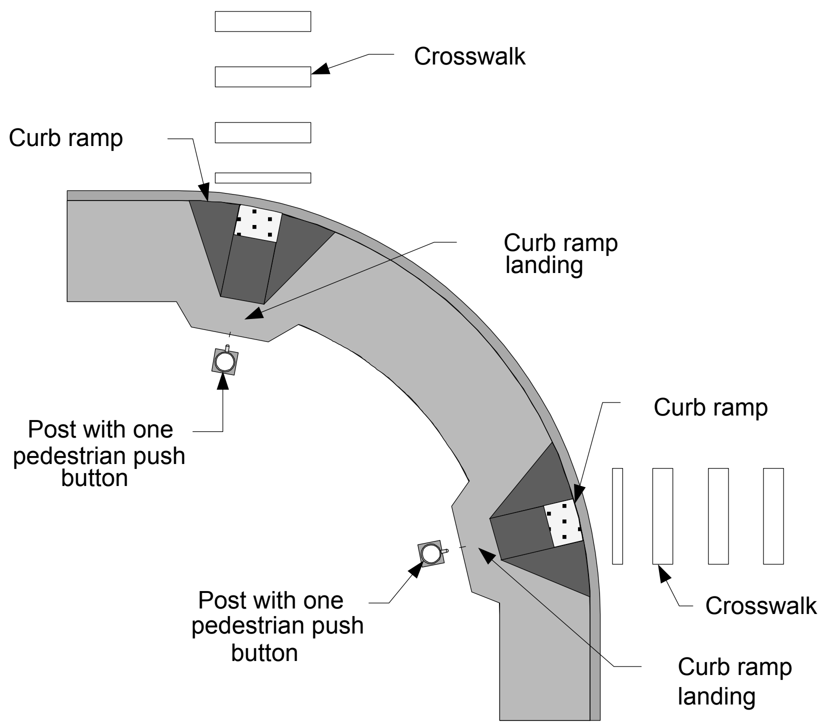
(c) Accessible Pedestrian Signals (APS)

In locations of pedestrian facilities, use ADA-compliant audible/vibrotactile pedestrian signals at all locations where pedestrian signals are newly installed or replaced. Consult with region and city maintenance personnel regarding maintenance requirements for these devices. Installation of these devices may require improvements to existing sidewalks and ramps to ensure ADA compliance. (See Chapter 1330 and the MUTCD for additional information.)

When designing pedestrian signals, consider the needs of older pedestrians and pedestrians with disabilities as they might walk at a significantly slower pace than the average pedestrian. Determine whether there are pedestrian generators in the project vicinity that might attract older and disabled pedestrians. Adjust signal timing accordingly, and include countdown clocks where appropriate. Consult with region and city maintenance personnel regarding maintenance requirements for these devices.

- Locate pedestrian push buttons within reasonable proximity to the curb ramp and crosswalk (see Exhibit 1510-10, Chapter 1330 and the MUTCD).
- Clearly identify which crossing is controlled by the push button.
- Provide a level surface at each push button for wheelchair users.
- Locate push button a maximum height of 3 feet 6 inches from level landing surface.*

*FHWA, Designing Sidewalks and Trails for Access, Pedestrian-Actuated Traffic Controls, 1999



Pedestrian Push Button Locations
Exhibit 1510-10

(9) Crosswalks at Intersections

Legal crosswalks, whether marked or not, exist at all intersections. An unmarked crosswalk is the 10-foot-wide area across the intersection behind a prolongation of the curb or edge of the through traffic lane (RCW 46.04.160). At roundabouts and intersections with triangular refuge islands or slip lanes (see Chapter 1310), the desired pedestrian crossings are not consistent with the definition of an unmarked crosswalk, and marked crossings are necessary. Inside city limits where the population exceeds 25,000, coordinate the decision to mark crosswalks with the city. WSDOT approves the installation and type only (RCW 47.24.020(13)). In unincorporated areas and within cities with populations less than 25,000, WSDOT has decision authority. WSDOT maintains decision authority in limited access areas. Coordinate with the city regardless of population.

ADA requires that a pedestrian access route be provided at all marked and unmarked pedestrian crossings. This can be part or all of the crosswalk width. The accessibility criteria require a pedestrian access route within crosswalks of 4 feet minimum, with a running slope less than or equal to 5% and a cross slope less than or equal to 2% (see Exhibits 1510-26 and 1510-27).

Marked crosswalks are not to be used indiscriminately. Marked crosswalks are used at signalized intersections, intersections with triangular refuge islands, and roundabouts so pedestrians know where they are to cross. Perform an engineering study before installing marked crosswalks away from highway traffic signals or stop signs. Note that the installation of a midblock pedestrian crossing on a state highway is a design deviation that requires approval and documentation. When considering a marked crosswalk, at a minimum evaluate the following factors:

- The crosswalk would serve 20 pedestrians per hour during the peak hour, 15 elderly and/or children per hour, or 60 pedestrians total for the highest consecutive 4-hour period.
- The crossing is on a direct route to or from a pedestrian generator such as a school, library, hospital, senior center, community center, shopping center, park, employment center, or transit center (see the MUTCD). Generators in the immediate proximity of the highway are of primary concern. Pedestrian travel distances greater than ¼ mile do not generally attract many pedestrians.
- The local agency's comprehensive plan includes the development of pedestrian facilities in the project vicinity.
- The location is 300 or more feet from another crossing.
- Safety considerations do not preclude a crosswalk.

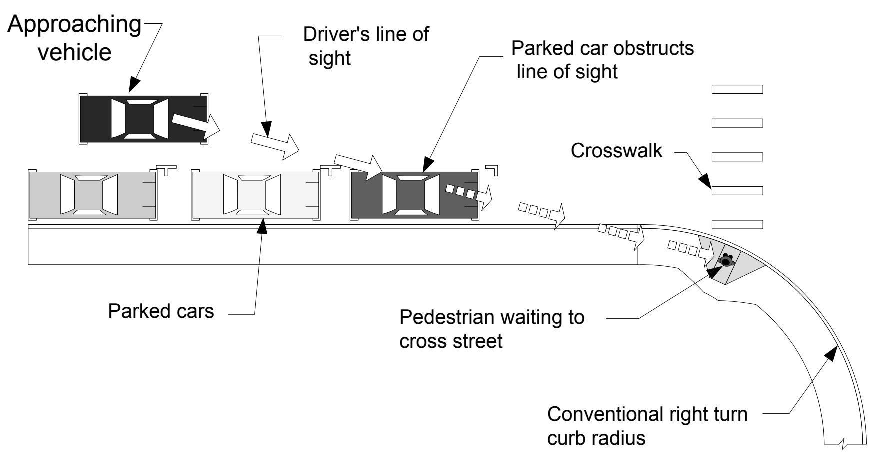
For marked crosswalks, the standard crosswalk marking consists of a series of wide white lines parallel with the longitudinal axis of the roadway. Crosswalk widths are at least 8 feet. A width of 10 feet is preferred in central business districts.* The lines are positioned at the edges and centers of the traffic lanes to place them out of the normal wheel path of vehicles. The preferred type of crosswalk is a longitudinal pattern known as a Ladder Bar and is shown in the *Standard Plans*. Set back "stop" and "yield" lines to provide for sight distance to all approaches to an intersection. Stop and yield line dimensions and placement must conform to the MUTCD and are shown in the *Standard Plans*.

**Guide for the Planning, Design, and Operation of Pedestrian Facilities*, AASHTO, 2004: 6 feet minimum, 10 feet desirable.

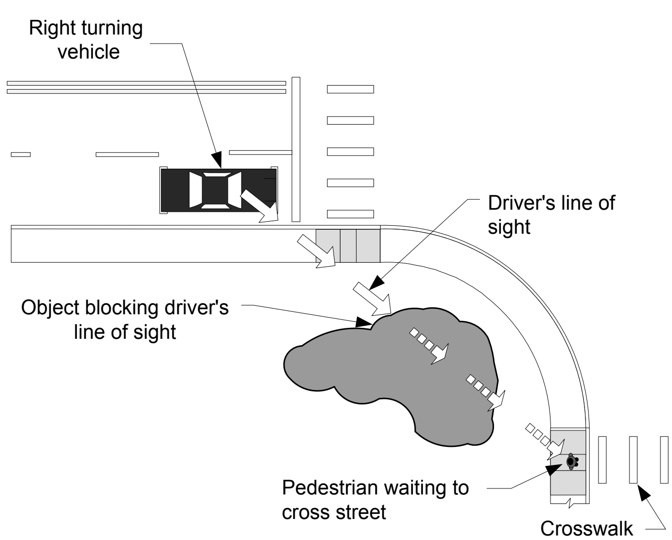
*MUTCD crosswalks should be at least 6 feet wide.

Communities sometimes request specially textured crosswalks (such as colored pavement, bricks, or other materials). Consider that some textured materials may cause confusion for visually impaired pedestrians and can create discomfort for wheelchair users. These crosswalks do not always fall within the legal definition of a marked crosswalk, and parallel white crosswalk lines are recommended to enhance visibility and delineate the crosswalk (see the MUTCD or Local Agency Crosswalk Options website: www.wsdot.wa.gov/Design/Standards/PlanSheet/PM-2.htm). Provide a nonslip surface on crosswalk markings appropriate for wheelchair use.

When locating crosswalks at intersections, consider the visibility of the pedestrian from the motorist's point of view. Shrubbery, signs, parked cars, and other roadside appurtenances can block the motorist's view of the pedestrian. Exhibit 1510-11 illustrates these sight distance considerations.



Parked car blocking line of sight



Obstructed line of sight

Obstructed Line of Sight at Intersection
Exhibit 1510-11

(10) Midblock Crossings

On roadways with pedestrian crossing traffic caused by nearby pedestrian generators, consider a midblock pedestrian crossing. (See 1510.05(9) for crosswalk criteria and Exhibit 1510-25 for marked crosswalk recommendations at unsignalized intersections.) For midblock crossings, the pedestrian access route may have a cross slope that matches the running slope of the roadway (PROWAG R305.2.2.3). Note that the installation of a midblock pedestrian crossing on a state highway is a design deviation that requires ASDE approval and documentation. An example of a midblock crossing is shown in Exhibit 1510-12.

Midblock Pedestrian Crossing
Exhibit 1510-12

Conditions that might favor a midblock crossing include the following:

- Significant pedestrian crossings demand.
- Pedestrians fail to recognize the best or safest place to cross along a highway and it is advisable to delineate the optimal location.
- The adjacent land use creates high concentrations of pedestrians needing to cross the highway at that location.
- The proposed crossing can concentrate or channel multiple pedestrian crossings to a single location.
- The crossing is at an approved school crossing on a school walk route.
- There is adequate sight distance for motorists and pedestrians.
- It is farther than 300 feet from an existing intersection.
- Speeds are less than 40 mph.

Consider the use of a warning beacon, as shown in Exhibit 1510-13.

Midblock Crossing With Beacon
Exhibit 1510-13

(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 the use of raised medians and traffic islands with a pedestrian refuge area (see Exhibit 1510-14) on roadways with the following conditions:

- Two-way, multilane arterial with high speeds (above 45 mph), high average daily traffic (ADT), and large pedestrian volumes.
- Significant pedestrian collision history, especially near a school or other community center.
- Crossing distance exceeds 60 feet.
- Complex or irregularly shaped intersections.

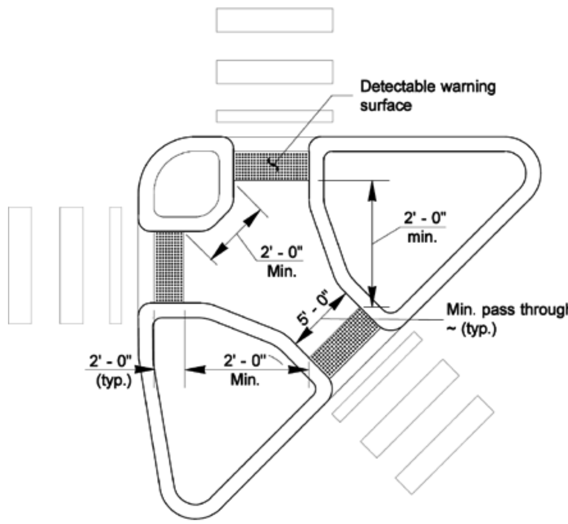
The pedestrian access route through a raised median or traffic island can be either raised with curb ramps or a pass-through type (see Exhibit 1510-14). The edges of pass-throughs and curb ramps are useful as cues to the direction of a crossing. Consider this when designing an angled route through a median or island. Curb ramps in medians and islands can add difficulty to the crossing for some users. There are many factors to consider when deciding whether to ramp up to the median or island grade or create a pass-through median or island matching the roadway grade. Those factors may include profile grade and cross slope of the road, drainage and width, and length of the median or island.

The minimum length of a pedestrian access route through a raised median or traffic island is 6 feet. This provides for a 2-foot detectable warning surface, 2 feet of pedestrian refuge, and 2 feet for another detectable warning surface. Lengths greater than the 6-foot minimum provide more refuge and pedestrian comfort. The width of the pedestrian access route is 5 feet minimum, with a running slope not to exceed 5% (with the exception of curb ramps, if used) and a cross slope not steeper than 2%. When the pedestrian access route of a shared-use path goes through a raised median or traffic island, the width should be the same as the shared-use path.

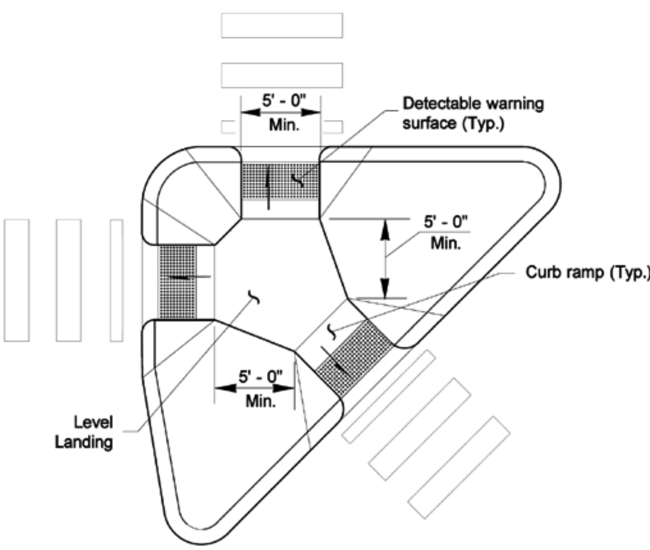
Detectable warning surfaces are located at each curb ramp or roadway entrance of a pedestrian access route through a raised median or traffic island. The detectable warning surface shall be located at the back of curb line or at the edge of the roadway where there is no curb.

A traffic island used for channelized right-turn slip lanes can provide a pedestrian refuge, but may promote faster turning speeds. Minimize turning radii as much as possible to keep speeds as low as possible. To reduce conflicts, keep the slip lane as narrow as practicable and attempt to maintain a 90º crosswalk angle. (See Chapter 1310 for turn lanes, Chapter 1360 for interchange ramps, and Chapter 1320 for pedestrian accommodations in roundabouts.)

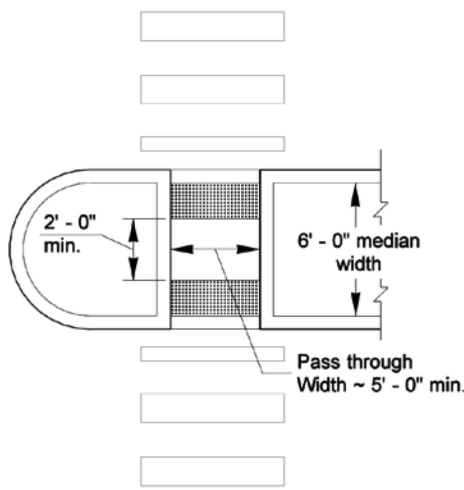
Island Pass-Through



Island Pass-Through



Raised Traffic Island With Curb Ramps



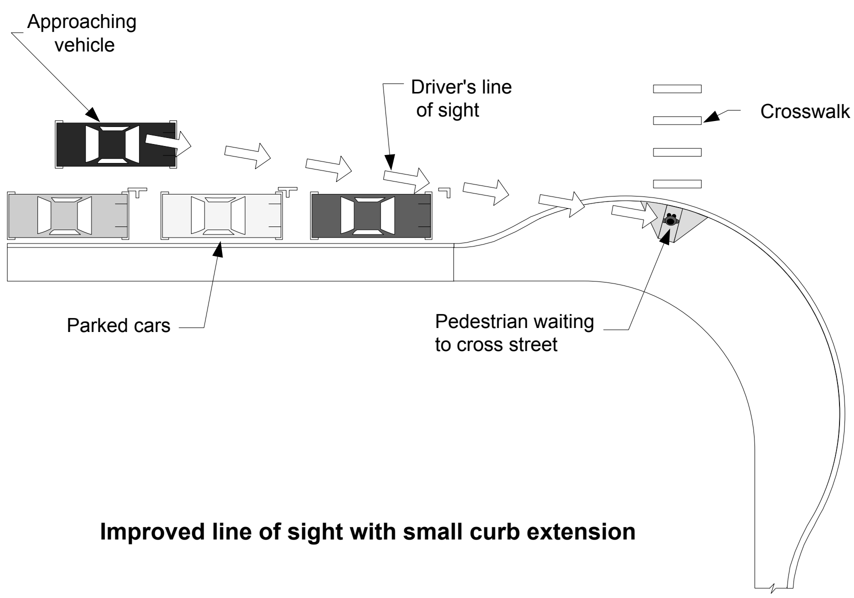
Median Island Pass-Through

Raised Island With Pedestrian Pass-Through
Exhibit 1510-14

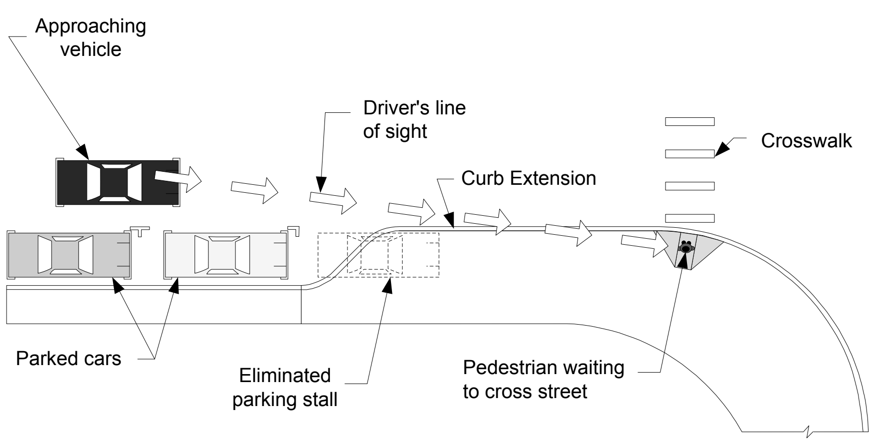
(12) Curb Extensions

Curb extensions are traffic calming measures that may improve sight distance and reduce pedestrian crossing times, which limits pedestrian exposure. Designing a curb extension will help eliminate the sight distance problem with parked cars that limit driver/pedestrian visibility. Curb extensions may allow for better curb ramp design.

Extend the curb no farther than the width of the parking lane. (See Chapter 1140 for shoulder width guidance.) Consider an approach nose and low-level landscaping that does not create a sight obstruction. 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 1510-15 and 1510-16.



Improved line of sight with small curb extension



Improved line of sight with longer curb extension

Improved Line of Sight at Intersection
Exhibit 1510-15

Curb Extension Examples
Exhibit 1510-16

The right-turn path of the design vehicle or the vehicle most likely to make this turn is a critical element in determining the size and shape of the curb extension. Sidewalk curb extensions tend to restrict the width of the roadway and can make right turns difficult for large trucks.

Avoid interrupting bicycle traffic with curb extensions. Do not use curb extensions on state highways when:

- The design vehicle (see Chapter 1310) is required to encroach on curbs, opposing lanes, or same-direction lanes, and mountable curbs or other solutions will not improve the circumstances.
- Parking is not present.
- The posted speed is above 35 mph.

Plantings that do not obstruct the vision of pedestrians or drivers may be used within curb extension areas. Consider motorist and pedestrian visibility and Design Clear Zone guidelines (see Chapter 1600).

(13) Railroad Crossings at Grade

The design of pedestrian facilities across railroad tracks often presents challenges due to the conflicting needs of pedestrians and trains. In particular, the flangeway gap required for trains to traverse a crossing surface may create a significant obstacle for a person who requires a wheelchair, crutches, or walking aids for mobility. Whenever practicable, make crossings perpendicular to the tracks in order to minimize potential problems related to flangeway gaps (see Exhibit 1510-18). 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 stop line placement requirements in the MUTCD.

There are a number of railroad crossing warning devices intended specifically for pedestrian facilities (see the MUTCD). When selecting warning devices, consider such factors as train and pedestrian volumes, train speeds, available sight distance, number of tracks, and other site-specific characteristics. Coordinate with the HQ Design Office Railroad Liaison early in the design process so that all relevant factors are considered and agreement may be reached regarding design of warning devices and crossing surfaces.

Pedestrian Railroad Warning Device
Exhibit 1510-17

Except for crossings located within the limits of first-class cities,* the Washington Utilities and Transportation Commission (WUTC) must approve 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 crossings surfaces will require a railroad construction and maintenance agreement. Contact the HQ Design Office Railroad Liaison to coordinate with both WUTC and the railroad company. Coordinate with the HQ Utilities, Railroad, and Agreements Section.

*RCW 35.10.010: 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.

There are few first-class cities in the state of Washington. Consult with the HQ Railroad Liaison.

Undesirable

Recommended

Pedestrian Railroad Crossings
Exhibit 1510-18

1510.06 Pedestrian Facility Design: Structures

(1) Pedestrian Grade Separations

In extreme cases where there is a pedestrian collision history and the roadway cannot be redesigned to accommodate pedestrians at grade, consider providing a pedestrian grade separation along freeways and other high-speed facilities. When considering a pedestrian structure, determine whether the conditions that require the crossing are permanent. If there is a 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. The HQ Bridge and Structures Office is responsible for the design of pedestrian structures.

Consider grade-separated crossings 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 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 high-speed traffic).*
- The crossing conditions are extremely hazardous for pedestrians.
- *There are documented collisions 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).*

**Guide for the Planning, Design, and Operation of Pedestrian Facilities*, AASHTO, 2004

(2) Pedestrian Bridges

Pedestrian grade-separation bridges (see Exhibit 1510-19) are more effective when the roadway is below the natural ground line, as in a “cut” section. Elevated grade separations, where pedestrians are required to climb stairs or use long approach ramps, tend to be underutilized. Pedestrian bridges require adequate right of way to accommodate accessible ramps.

For the minimum vertical clearance from the bottom of the pedestrian structure to the roadway beneath, see Chapter 720. This minimum height requirement can affect the length of the pedestrian ramps to the structure. To comply with ADA requirements, the approaches to the pedestrian bridge are identified as either a pedestrian access route or a pedestrian access ramp and shall meet the requirements of 1510.07(2). When ramps are not feasible, provide both elevators and stairways. Stairways are to be designed in accordance with the *Standard Plans*.

Railings are provided on pedestrian bridges. Protective screening is sometimes desirable to deter objects from being thrown 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 bicycles or equestrians.

Pedestrian Bridges
Exhibit 1510-19

(3) 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 possible, design the tunnel with a nearly level profile to provide complete vision from portal to portal (see Exhibit 1510-20). Some pedestrians may be reluctant to enter a tunnel with a depressed profile because they are unable to see whether the tunnel is occupied. Police officers also have difficulty patrolling depressed profile tunnels.

Provide vandal-resistant daytime and nighttime illumination within the pedestrian tunnel. Installing gloss-finished tile walls and ceilings can also enhance light levels within the tunnel. The minimum overhead clearance for a 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.

The approaches to the pedestrian tunnel are identified as either a pedestrian access route or a pedestrian access ramp and shall comply with ADA requirements as outlined in 1510.07(2).

Pedestrian Tunnel
Exhibit 1510-20

1510.07 Other Pedestrian Facilities

(1) Transit Stops and School Bus Stops

The location of transit stops is an important consideration in providing appropriate pedestrian facilities. (Coordinate with the local transit provider.) Newly constructed transit stops must conform to ADA requirements (see Chapter 1430). On new construction, design the transit stop such that it is accessible from the sidewalk or paved shoulder. A transit stop on one side of a street usually has a counterpart on the opposite side because transit routes normally function in both directions on the same roadway. Provide adequate crossing facilities for pedestrians.

When locating transit stops, consider transit ridership and land use demand for the stop. Also, consider compatibility with the following roadway/traffic characteristics:

- ADT
- Traffic speed
- Crossing distance
- Collision 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.

When analyzing locations with high pedestrian collision rates, consider the presence of nearby transit stops and opportunities for pedestrians to reasonably safely cross the street. 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 Exhibit 1510-25 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 the motorist's 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.

(2) Access Ramps Within Transit, Park & Ride, Rest Areas, and Buildings and Facilities

An access ramp provides an accessible pedestrian route from a sidewalk to a facility such as a transit stop, park & ride, rest area, pedestrian overcrossing/undercrossing structure, building, or other facilities. When the running slope is 5% or less, it is a pedestrian access route; when the running slope is greater than 5%, it is a pedestrian access ramp. (See Exhibit 1510-27 for the design requirements.)

- Provide a running slope not steeper than 12H:1V (8.3%) on newly constructed pedestrian access ramps. The cross slope is not to exceed 2%.
- The minimum clear width of ramps is 3 feet; however, it is desirable to match the width of the connecting pedestrian facility.
- Do not exceed 2 feet 6 inches on the vertical rise of ramps between landings.
- Provide landings at the top and bottom of each access ramp run.
- Provide handrails on all ramp runs with a rise greater than 6 inches.

Match ramp landing widths to the widest ramp entering the landing. Landings must have a minimum clear length of 5 feet with a 2% maximum cross slope. If a change in direction is needed, a 5-foot x 5-foot landing is required (see Exhibit 1510-27).

Pedestrian Access Ramp
Exhibit 1510-21

1510.08 Illumination and Signing

In Washington State, the highest number of collisions between vehicles and pedestrians occur during November through February when there is poor visibility and fewer daylight hours. Illumination of pedestrian crossings and other walkways is an important design consideration because lighting has a major impact on a pedestrian's safety and sense of security. Illumination provided solely for vehicular traffic is not always effective in lighting parallel walkways for pedestrians. Consider pedestrian-level (mounted at a lower level) lighting for walkways, intersections, and other pedestrian crossing areas with high nighttime pedestrian activity, such as shopping districts, transit stops, schools, community centers, and other major pedestrian generators or areas with a history of pedestrian collisions (See Chapter 1040 for design guidance on illumination and Chapter 1020 and the MUTCD for pedestrian-related signing.)

1510.09 Work Zone Pedestrian Considerations

Providing access and mobility for pedestrians through and around work zones is an important design concern and must be addressed 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 process and through field visits. In work zones:

- 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 provide accessible and convenient travel paths duplicating, as closely as feasible, the characteristics of the existing pedestrian facilities.

Provide walkways that are clearly marked and pedestrian barriers that are continuous, nonbendable, and detectable to persons with impaired vision using 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 (see Exhibits 1510-22 and 1510-27).

Consider the use of flaggers if pedestrian generators such as schools are in the work zone vicinity. Consider spotters prepared to help pedestrians through the work zone.

Provide the requirement of 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.

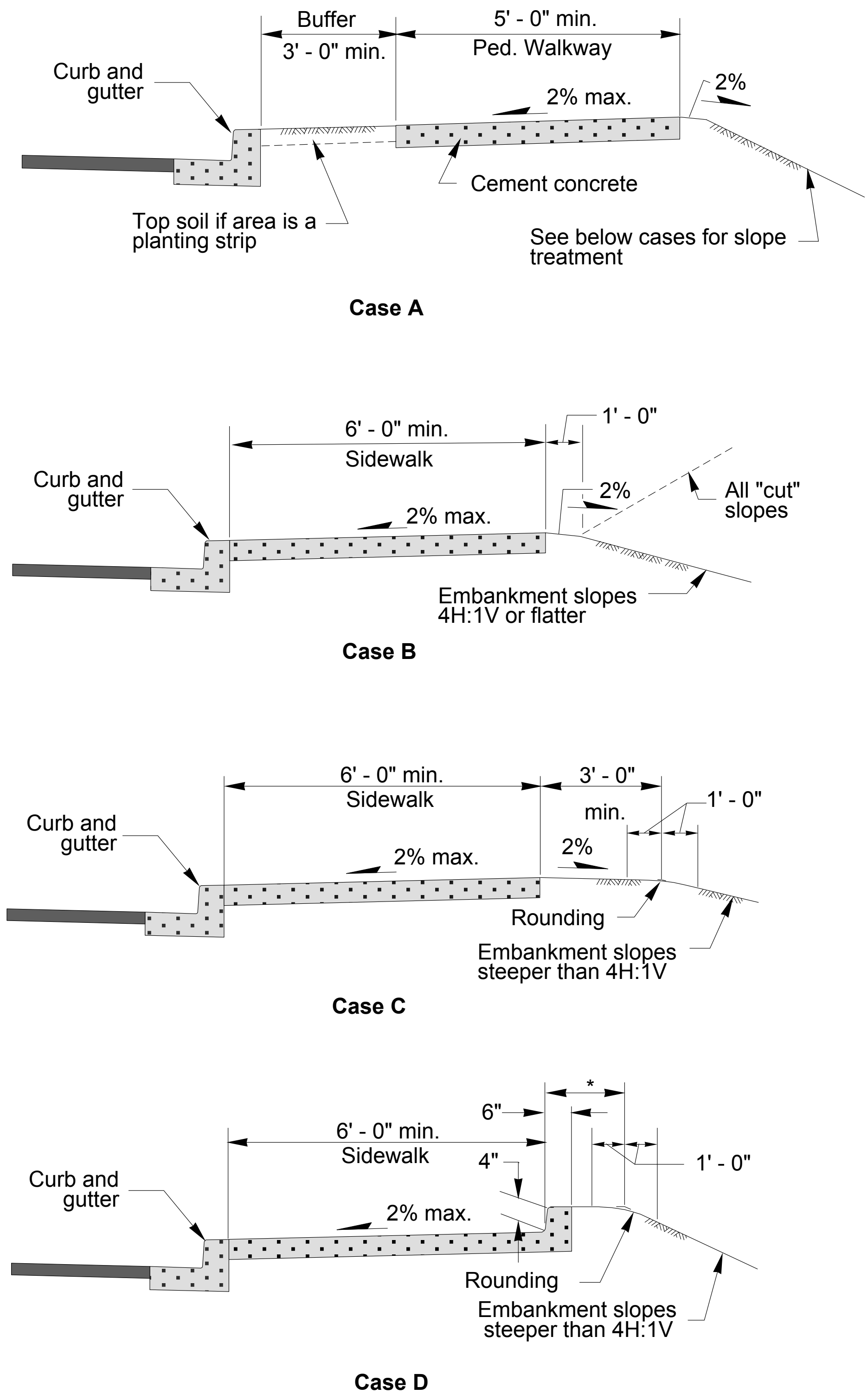
For further information or guidance on work zone pedestrian considerations, see Chapter 1010 and the MUTCD.

Meets ADA Requirements Does Not Meet ADA Requirements

Work Zones and Pedestrian Facilities
Exhibit 1510-22

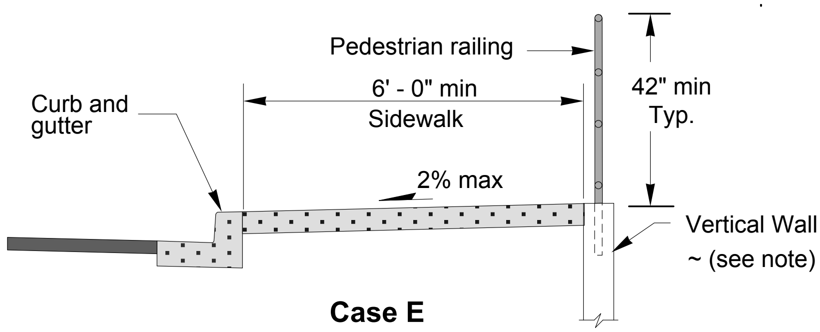
1510.10 Documentation

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/

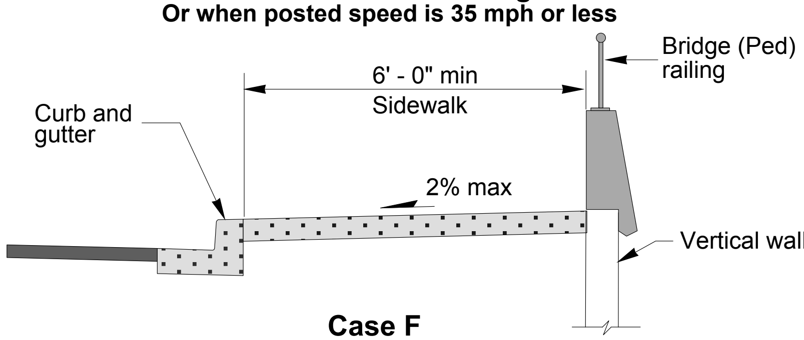


*See the *Standard Plans*.

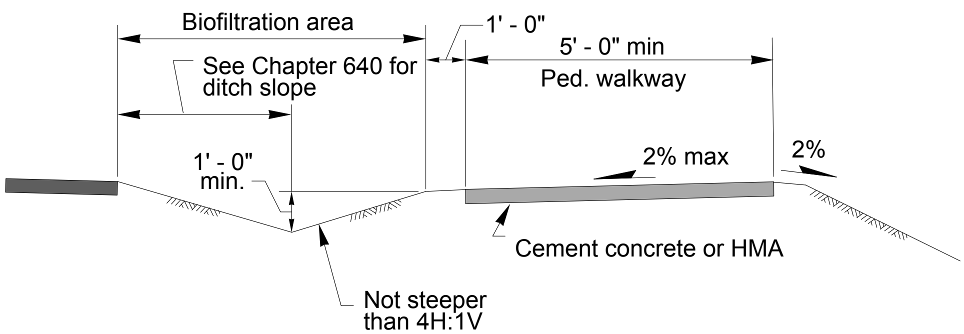
Pedestrian Access Route
Exhibit 1510-23



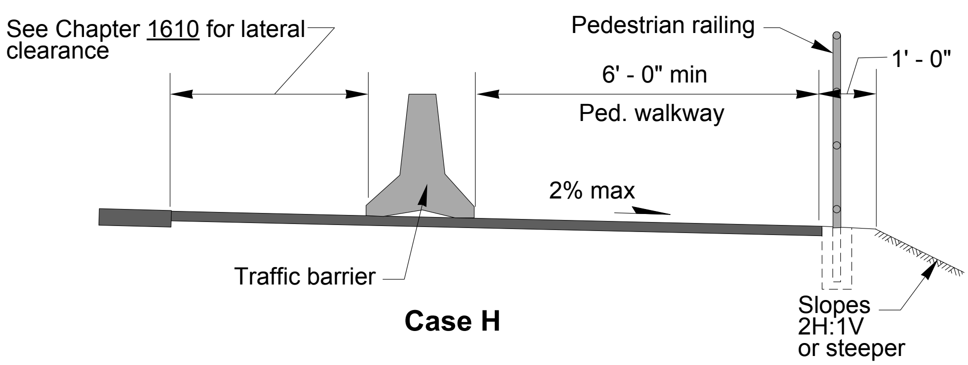
Case E
When the wall is outside the Design Clear Zone
Or when posted speed is 35 mph or less



Case F
When the wall is within the Design Clear Zone



Case G



Case H

Notes for Case E:

- If vertical drop is >2 feet 6 inches, railing is indicated.
- If vertical drop is < 2 feet 6 inches, a 4-inch curb is adequate.

Pedestrian Access Route
Exhibit 1510-23 (continued)

Roadway Classification and Land Use Designation	Sidewalk Recommendations					
			Desirable		Recommended	
	No sidewalk recommended	4-foot-wide paved shoulders adequate	Sidewalk on one side	Sidewalks on both sides	Sidewalk on one side	Sidewalks on both sides
Rural highways/interchanges outside urban growth areas	X[1]	X[1]				
Suburban highways with 1 or less dwelling unit per acre		X	X			
Suburban highways with 2–4 dwelling units per acre				X	X	
Major arterial in residential area						X
Collector or minor arterial in residential area						X
Local street in residential area with less than 1 dwelling unit per acre		X	X			
Local street in residential area with 1–4 dwelling units per acre				X	X	
Local street in residential area with more than 4 dwelling units per acre						X
Streets in commercial area						X
Streets in industrial area				X	X	

Note:
[1] Consider an engineering study to identify a need.

Sidewalk Recommendations
Exhibit 1510-24

Traffic Volume (ADT)	Posted Speed	Roadway Type			
		2 lanes	2 lanes, raised median[1]	4 lanes, raised median[1]	6 lanes, raised median[1]
Less than or equal to 9,000	30 mph and lower	Marked crosswalk	Marked crosswalk	Additional enhancement	
	35 mph to 40 mph	Marked crosswalk	Marked crosswalk	Additional enhancement	
	45 mph and higher	Additional enhancement	Additional enhancement	Active enhancement	
9,000 to 15,000	30 mph and lower	Marked crosswalk	Marked crosswalk	Additional enhancement	
	35 mph to 40 mph	Marked crosswalk	Marked crosswalk	Additional enhancement	
	45 mph and higher	Additional enhancement	Additional enhancement	Active enhancement	
15,000 to 30,000	30 mph and lower	Additional[2] enhancement	Additional enhancement	Additional[2] enhancement	Active[4] enhancement
	35 mph to 40 mph	Additional[2] enhancement	Additional enhancement	Active enhancement	Active[4] enhancement
	45 mph and higher	Active[5] enhancement	Active enhancement	See note[3]	See note[3]
Greater than 30,000	45 mph and lower	Active[5] enhancement	Active enhancement	Pedestrian[6] traffic signal	Pedestrian[6] traffic signal

Inside city limits where the population exceeds 25,000, the decision to mark crosswalks resides with the city, subject to WSDOT approval of the installation and type. Provide documentation for all marked crosswalks.

For additional considerations that may be appropriate based on site-specific engineering analyses, see 1510.05(3).

Notes:

[1] Raised median/traffic island with a pass-through path minimum width of 5 feet and a median width of 6 feet..

[2] Consider active enhancement treatment for roadways exceeding 20,000 ADT.

[3] Provide alternate routes for pedestrian crossings or construct a grade-separated facility.

[4] Location may be approaching the need for a controlled crossing. A pedestrian signal may be appropriate, based on engineering analysis.

[5] Raised median/traffic island required.

[6] Refer to region Traffic Engineer for approval and design of a pedestrian traffic signal. Midblock pedestrian crossings are deviations that require ASDE approval.

Minimum Guidelines (additive for each level):

“Marked crosswalk”

- Marked/signed in accordance w/MUTCD (signed @ crossing only)
- Pedestrian-view warning signs
- Illumination

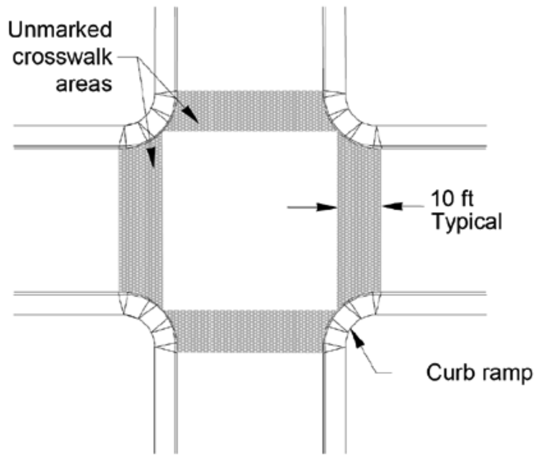
“Additional enhancement”

- Minimum guidelines listed under “Marked crosswalk”
- Stop line in accordance w/MUTCD
- Advance signing in accordance w/MUTCD

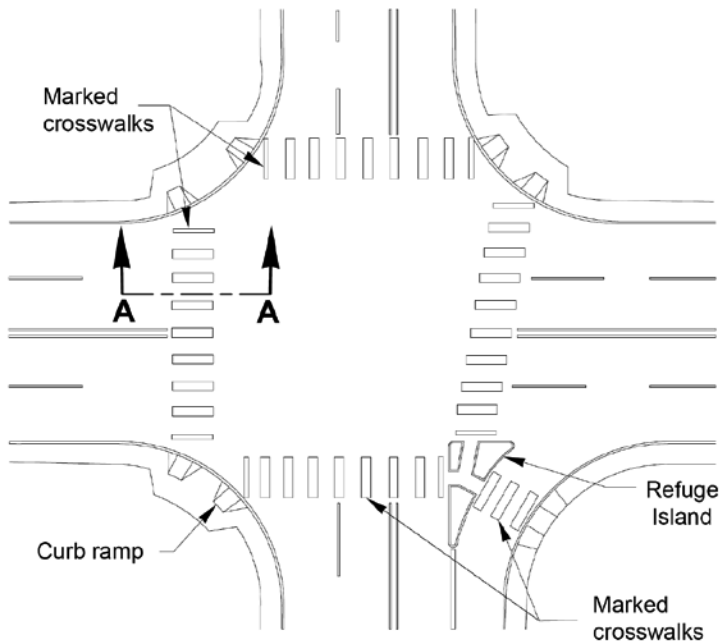
“Active enhancement”

- Minimum guidelines listed under “Additional enhancement”
- Pedestrian-actuated warning beacons—overhead for roadway w/4 or more lanes

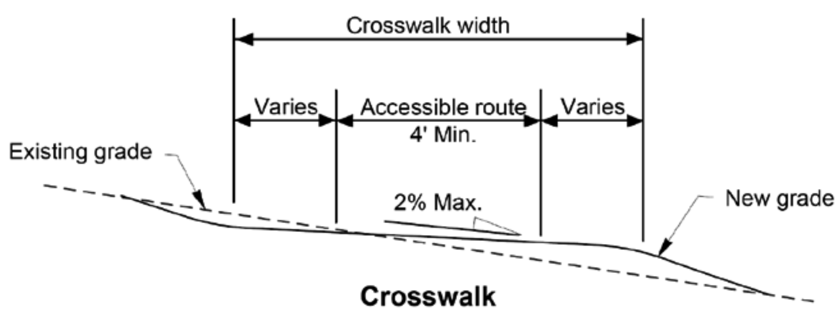
Crosswalk Guidelines
Exhibit 1510-25



Unmarked Crosswalks



Marked Crosswalk



Crosswalk

Section A - A

Crosswalks and Pedestrian Access Route Cross Slope

Exhibit 1510-26

Design Element \ Design Feature	Curb Ramp	Sidewalk	Driveway Crossing	Crosswalk	Landing	Crossing Through Island/Median	Pedestrian Circulation Path (Inc. Shared-Use Paths)	Building and Facilities Ramp[1][2]
Clear Width	4 ft Min [1510.05(6)]	4 ft Min for accessible route within sidewalk width[3][5] [1510.05(5)]	4 ft Min – See Std Plans	4 ft Min for accessible route within crosswalk[4] [1510.05(8),(9),(10)]	See **Curb Ramp** or **Building and Facilities Ramp** requirements	Pass-through: 5 ft Min – Island: 6 ft Min [1510.05(11)]	4 ft Min[5] [1510.05(2)] [1510.05(4)]	At least the width of widest ramp run connected to landing – 3 ft Min
Cross Slope	2% Max [1510.05(6)]	2% Max [1510.05(5)]	2% Max – See Std Plans	2% Max for accessible portion	2% Max	2% Max	2% Max	2% Max
Running Slope	8.3% Max[7] (12H:1V) [1510.05(4)]	5% Max[6] [1510.05(5)]	See Note 6 [1510.05(5)]	5% Max	2% Max	5% Max [1510.05(11)] If curb ramp is used, see **Curb Ramp** requirements	5% Max[6] [1510.05(2)] [1510.05(4)]	8.3% Max[7]
Maximum Vertical Rise	N/A	N/A	N/A	N/A	N/A	N/A	2.5 ft[6] when grade is greater than 5%	Landing every 2.5 ft vertical rise [1510.07(2)]
Grade Break	Flush – See Std Plans	Flush	½ inch between roadway gutter & curb	Flush	Flush	Flush	Flush	Flush
Surface Discontinuities	N/A	**New:** Flush **Existing:** See Note 8	N/A	N/A	N/A	N/A	**New:** Flush **Existing:** See Note 8	**New:** Flush **Existing:** See Note 8
Curb Flare Slope	10% Max	N/A	10% Max[9]	N/A	N/A	If curb ramp is used, see **Curb Ramp** requirements	N/A	N/A
Horizontal [12] Encroachment	4 inches Max [1510.05(2)(a)(3)]	4 inches Max	4 inches Max	4 inches Max	4 inches Max	4 inches Max	4 inches Max	4 inches Max

U.S. Access Board Accessibility Requirements for Pedestrian Facility Design
(For WSDOT guidance, see referenced chapter sections in table)
Exhibit 1510-27

Design Element \ Design Feature	Curb Ramp	Sidewalk	Driveway Crossing	Crosswalk	Landing	Crossing Through Island/Median	Pedestrian Circulation Path (Inc. Shared-Use Paths)	Building and Facilities Ramp[1][2]
Vertical Clear Area	80 inches Min[10] [1510.05(2)]	80 inches Min[10] [1510.05(2)]	80 inches Min[10]	80 inches Min[10]	80 inches Min[10]	80 inches Min[10]	80 inches Min[10]	80 inches Min[10]
Counter Slope	5% Max [1510.05(6)]	N/A	N/A	See **Curb Ramp**	N/A	N/A	N/A	N/A
Landing	Width: Min match curb ramp width Length: **New:** 4 ft min **Alteration:** 3 ft [1510.05(6)]	N/A	N/A	Diag. curb ramp: Provide 4 ft by 4 ft clear area within crosswalk markings or outside traveled way [1510.05(6)]	– – – –	N/A unless a curb ramp is used – See **Curb Ramp** requirements	When grade > 5% & for separate alignment, provide level landing every 2.5 ft vertical rise[6]	Level landing required for every 2.5 ft vertical rise – Match landings to the width of the widest ramp leading into the landing[11]
Detectable Warning Surface	2 ft wide, 6 inches behind face of curb, full width of ramp	N/A	N/A	N/A	N/A	2 ft wide, each side, 6 inches behind face of curb, full width of opening	2 ft wide, full width when path joins roadway shoulder	N/A

Notes:

[1] A ramp with a rise greater than 6 inches in this context is on a walkway on a separate alignment that is not adjacent to or parallel to a roadway; ramps may have slopes greater than 5% and 8.3% max.

[2] Ramps with a rise greater than 6 inches. Also, ramps require edge protection and shall have handrails.

[3] Required sidewalk width: 5 ft where buffer is included, 6 ft when sidewalk is next to curb.

[4] Unmarked crosswalks require a 10 ft wide area across intersection. Marked crosswalks are required to be 8 ft min., 10 ft desirable. (See RCW 46.04.160 and the MUTCD for crosswalks.)

[5] If less than 5 ft wide, provide 5 ft x 5 ft passing areas every 200 ft.

[6] Allowed to match the roadway grade when located adjacent to and parallel to the roadway; landings would not be required.

[7] For Preservation projects: 10H:1V to 12H:1V for rises to 6 inches; 8H:1V to 10H:1V for rises to 3 inches.

[8] Changes in level of ¼ inch max are allowed to be vertical; changes between ¼ inch and ½ inch max to be beveled at 2H:1V.

[9] Required when sidewalk is provided behind the driveway.

[10] 7 ft min. vertical clearance required to bottom of signs (see the MUTCD and the *Standard Plans*).

[11] Change of direction requires 5 ft x 5 ft landing.

[12] Shall not reduce the clear width required for pedestrian access routes.

Access Board Accessibility Requirements for Pedestrian Facility Design
(For WSDOT guidance, see referenced chapter sections in table)
Exhibit 1510-27 (continued)

(5) At-Grade Railroad Crossings

Whenever a bikeway crosses railroad tracks, continue the crossing at least as wide as the approach bikeway. Use special construction and materials to keep the flangeway depth and width to a minimum. Wherever possible, design the crossing at right angles to the rails (see Exhibit 1520-13). For on-street bikeways where a skew is unavoidable, widen the shoulder (or bike lane) to permit bicyclists to cross at right angles (see Exhibit 1520-13). For signing and pavement marking for a shared-use path crossing a railroad track, see the MUTCD and the *Standard Plans*.

(6) Separation, Barrier, and Fencing

When possible, provide a wide separation between a shared-use path and the roadway's traveled way where the path is located near a roadway (see 1520.06(2)).

If the shared-use path is inside the Design Clear Zone, provide a concrete traffic barrier (see Exhibit 1520-11b). A concrete barrier presents a lower risk to bicyclists than beam guardrail and is preferred. However, if the edge of the path is farther than 10 feet from the barrier, a beam guardrail is also acceptable. For Design Clear Zone guidance, see Chapter 1600, and for barrier location and deflection, see Chapter 1610.

All barrier and railing adjacent to a shared-use path must meet the criteria for pedestrians (see Chapter 1510). When the edge of the path is within 5 feet of a barrier or railing, provide a taller barrier (a minimum of 42 inches) to reduce the potential for bicyclists falling over the barrier. For barrier between the path and a roadway, if the roadway shoulder is 6 feet or wider, additional barrier height is not needed (see Exhibits 1520-14a and 14b).

Where the path is to be located next to a limited access facility, provide an access barrier. Where space permits, provide fencing as described in Chapter 560, in conjunction with a normal height barrier. Otherwise, provide a taller barrier (54-inch minimum height).

Fencing between a shared-use path and adjacent property may also be installed to restrict access to the private property. Discuss the need for fencing and the appropriate height with the property owners during project design.

On structures, the bridge railing type and height are part of the structure design. Contact the Headquarters (HQ) Bridge and Structures Office for additional information. (See Chapter 720 for further considerations.)

Evaluate the impacts of barriers and fencing on sight distances.

(7) Design Speed

The design speed for a shared-use path is dependent on the terrain and the expected conditions of use. Design the path to encourage bicycles to maintain speeds at or below the speeds shown in Exhibit 1520-5. Higher speeds are inappropriate in a mixed-use setting.

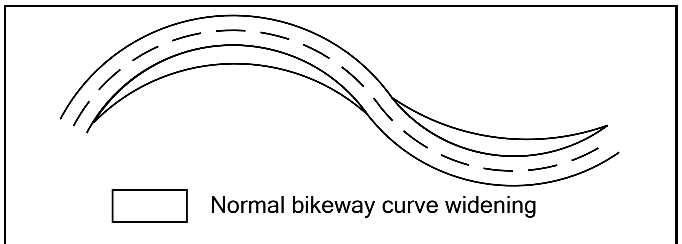
Conditions	Design Speed (mph)	Minimum Curve Radius (ft)
Open country (level or rolling); shared-use path in urban areas	20	90
Long downgrades (steeper than 4% and longer than 500 ft)	30	260

Bicycle Design Speeds
Exhibit 1520-5

(8) Horizontal Alignment and Cross Section

On tangent path sections, the desirable cross slope is 2%. The maximum superelevation is also 2%. A greater superelevation can cause maneuvering difficulties for adult tricyclists and wheelchair users (see Exhibits 1520-11a and 11b).

When radii less than given in Exhibit 1520-5 are needed, increase pavement width by up to 4 feet on the inside of a curve to compensate for bicyclist lean (see Exhibit 1520-6). For sharp curves on two-way facilities, consider providing centerline pavement markings.



Radius (ft)	Additional Pavement Width (ft)
0 – 25	4
25 – 50	3
50 – 75	2
75 – 100	1
100 +	0

Bikeway Curve Widening
Exhibit 1520-6

(9) Stopping Sight Distance

Exhibit 1520-15 gives the minimum stopping sight distances for various design speeds and grades

(10) Sight Distance on Crest Vertical Curves

Exhibit 1520-16 gives the minimum lengths of crest vertical curves for varying design speeds. The values are based on a 4.5-foot eye height for the bicyclist and a 0-foot height for the object (roadway surface).

1610.01 General

The Washington State Department of Transportation (WSDOT) uses traffic barriers to reduce the overall severity of collisions that occur when a vehicle leaves the traveled way. Consider whether a barrier is preferable to the recovery area it replaces. In some cases, installation of a traffic barrier may result in more collisions, 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 collisions. However, when impacts occur, traffic barriers are not guaranteed to redirect vehicles without injury to the occupants or additional collisions.

Barrier performance is affected by the characteristics of the types of vehicles that collide with them. For example, motor vehicles with large tires and high centers of gravity are commonplace on our highways and they are designed to mount obstacles. Therefore, they are at greater risk of mounting barriers or of not being decelerated and redirected as conventional vehicles would be.

When barriers are crash-tested, it is impossible to replicate the innumerable variations in highway conditions. Therefore, barriers are crash-tested under standardized conditions. Barriers are not placed with the assumption that the system will restrain or redirect all vehicles in all conditions. They are placed with the assumption that under normal conditions, they might provide an improved safety condition for most collisions. Consequently, barriers should not be used unless an improved safety situation is likely. No matter how well a barrier system is designed, optimal performance is dependent on drivers' proper use, maintenance, and operation of their vehicles and the proper use of vehicle restraint systems.

At the time of installation, the ultimate choice of barrier type and placement is made by using engineering judgment and having a thorough understanding of and using the criteria presented in Chapters 1600 and 1610.

1610.02 References

(1) Design Guidance

Bridge Design Manual, M 23-50, WSDOT

Roadside Design Guide, AASHTO, 2006

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

Traffic Manual, M 51-02, WSDOT

1610.03 Definitions

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.

controlled releasing terminal (CRT) post A standard-length guardrail post that has two holes drilled through it so it might break away when struck.

crash-accepted device A feature that has been proven acceptable for use under specified conditions, either through crash testing or in-service performance.

fixed feature (object to be mitigated) A fixed object, a sideslope, 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.

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.

length of need The length of a traffic barrier used to shield a fixed feature.

shy distance The distance from the edge of the traveled way beyond which a roadside object might not be perceived by a typical driver as an immediate feature to be avoided to the extent that the driver will change the vehicle's placement or speed.

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, unrestrained rigid, semirigid, and flexible. They can be installed as roadside or median barriers.

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.

1610.04 Project Criteria

This section identifies the barrier elements that are addressed according to the Design Matrices in Chapter 1100. Remove barrier that is not needed. Use the criteria in Chapter 1600 as the basis for removal.

(1) Barrier Terminals and Transitions

Install, replace, or upgrade transitions as discussed in 1610.06(5), Transitions and Connections.

Impact attenuator criteria can be found in Chapter 1620, Impact Attenuator Systems. Concrete barrier terminal criteria can be found in 1610.08(3).

When installing new terminals, consider extending the guardrail to meet the length-of-need criteria found in 1610.05(4) as a spot safety enhancement, which is a modification to isolated roadway or roadside features that, in the engineer's judgment, reduce potential for collision frequency or severity.

When the end of a barrier has been terminated with a small mound of earth, remove and replace with a crash-tested terminal, except as noted in 1610.09.

Redirectional landforms, also referred to as earth berms, were formerly installed to help mitigate collisions 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 land forms currently exist as mitigation for a fixed object, provide alternative means of mitigation of the fixed object, such as remove, relocate, upgrade with crash-tested systems, or shield with barrier. Landforms may be used to provide a smooth surface at the base of a rock cut slope.

Replace guardrail terminals that do not have a crash-tested design with crash-tested guardrail terminals (see 1610.06(5), Terminals and Anchors). 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—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 26 inches.

When the height of a standard terminal will be reduced to less than 26 inches from the ground to the top of the rail element, adjust the height to a minimum of 26 inches and a maximum of 28 inches. A rail height of 28 inches is desirable to accommodate future overlays. Terminals are equipped with CRT posts with drilled holes that need to remain at the surface of the ground.

One terminal that was used extensively on Washington's highways was the Breakaway Cable Terminal (BCT). This system used a parabolic flare similar to the Slotted Rail Terminal (SRT) and a Type 1 anchor. (Type 1 anchor posts are wood set in a steel tube or a concrete foundation.)

Replace BCTs on Interstate routes. On non-Interstate routes, BCTs that have at least a 3-foot offset may remain in place unless the guardrail run or anchor is being reconstructed or reset. (Raising the rail element is not considered reconstruction or resetting.)

Existing transitions that do not have a curb but are otherwise consistent with the designs shown in the *Standard Plans* may remain in place.

For Preservation projects, terminal and transition work may be programmed under a separate project, as described in Chapter 1120.

(2) Standard Run of Barrier

In Chapter 1100, the Design Matrices offer guidance on how to address standard barrier runs for different project types. A "Standard Run" of barrier consists of longitudinal barrier as detailed in the *Standard Plans*.

(a) **Basic Design Level (B)**

When the basic design level (B) is indicated in the Standard Run column of a Design Matrix, and the height of W-beam guardrail is or would be reduced to less than 26 inches from the ground to the top of the rail element, adjust the height to a minimum of 26 inches and a maximum of 28 inches. A rail height of 28 inches is desirable to accommodate future overlays.

If Type 1 Alternate W-beam guardrail is present, raise the rail element after each overlay. If Type 1 Alternate is not present, raise the existing blockout up to 4 inches higher than the top of the existing post by boring a new hole in the post.

Overlays in front of safety shape concrete barriers can extend to the top of the lower, near-vertical face of the barrier before adjustment is necessary.

- Allow no more than 1 foot 1 inch from the pavement to the beginning of the top near-vertical face of the safety shape barriers.
- Allow no less than 2 feet 8 inches from the pavement to the top of the single-slope barrier.
- Allow no less than 2 feet 6 inches to the center of the top cable for three-cable systems and 35 inches to the center of the top cable for four-cable high-tension cable barriers.

Note: There are new high-tension cable barrier systems under development, which may change the selection and placement criteria. The Headquarters (HQ) Design Office will circulate guidance on these new developments as they are adopted as WSDOT policy.

(b) **Full Design Level (F)**

When the full design level (F) is indicated, in addition to the criteria for the basic design level, the barrier is to meet the criteria in the following:

Chapter	Subject
1600.06	Median considerations
1610.05(1)	Shy distance
1610.05(2)	Barrier deflections
1610.05(3)	Flare rate
1610.05(4)	Length of need
1610.05(5)	Median barrier selection and placement considerations
1610.06	Beam guardrail
1610.07	Cable barrier
1610.08	Concrete barrier

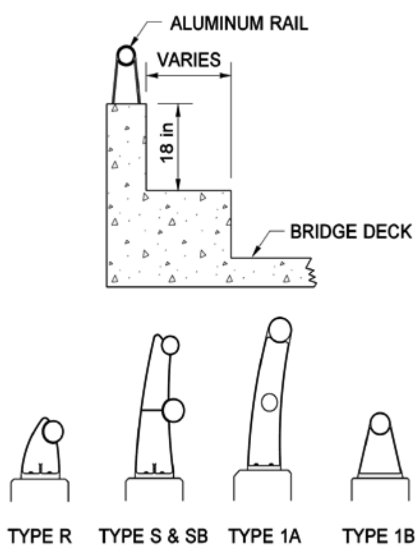
Examples of barriers that *are not* acceptable as a "Standard Run" are:

- 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.

(3) Bridge Rail

When the Bridge Rail column of a Design Matrix applies to the project, the bridge rails, including crossroad bridge rail, are to meet the following criteria:

- Use an approved, crash-tested concrete bridge rail on new bridges or bridges to be widened. The *Bridge Design Manual* provides examples of typical bridge rails. Consult the HQ Bridge and Structures Office regarding bridge rail selection and design and for design of the connection to an existing bridge.
- An existing bridge rail on a highway with a posted speed of 30 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 1610.10 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 1610-1. Consult the HQ Bridge and Structures Office for assistance in evaluating other bridge rails.



Aluminum Rail Type	Curb Width	
	9 Inches or Less	**Greater Than 9 Inches***
Type R, S, or SB	Bridge rail adequate	Bridge rail adequate
Type 1B or 1A	Bridge rail adequate	Upgrade bridge rail
Other	Consult the HQ Bridge and Structures Office	
*When the curb width is greater than 9 inches, the aluminum rail must be able to withstand a 5 kip load.		

Type 7 Bridge Rail Upgrade Criteria
Exhibit 1610-1

1610.05 Barrier Design

When selecting a barrier, consider the flexibility, cost, and maintainability of the system. It is generally desirable to use the most flexible system possible to minimize damage to the impacting vehicle and injury to the vehicle's occupant(s). However, since nonrigid systems sustain more damage during an impact, the exposure of maintenance crews to traffic might be increased with the more frequent need for repairs.

Maintenance costs for concrete barrier are lower than for other barrier types. In addition, deterioration due to weather and vehicle impacts is less than most other barrier systems. Unanchored precast concrete barrier can usually be realigned or repaired when moved from its alignment. 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.

Drainage, alignment, and drifting snow or sand are considerations that can influence the selection of barrier type. Beam guardrail and concrete barrier can contribute to snow drifts. Consider long-term maintenance costs associated with snow removal at locations prone to snow drifting. Slope flattening is recommended when the safety benefit justifies the additional cost to eliminate the need for the barrier. Cable barrier is not an obstruction to drifting snow and can be used if slope flattening is not feasible.

With some systems, such as concrete and beam guardrail, additional shoulder widening or slope flattening is common. However, selection of these types of barriers is sometimes limited due to the substantial environmental permitting and highway reconstruction needs. 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.

When designing a barrier for use on a Scenic Byway, consider barriers that are consistent with the recommendations in the associated corridor management plan (if one is available). Contact the region Landscape Architect or the Scenic Byways Coordinator in the HQ Highways and Local Programs Office to determine whether the project is on such a designated route. Low-cost options, such as using weathering steel beam guardrail (see 1610.06) or cable barrier (see 1610.07), might be feasible on many projects. Higher-cost options, such as steel-backed timber rail and stone guardwalls (see 1610.09), might necessitate a partnering effort to fund the additional costs. Grants might be available for this purpose if the need is identified early in the project definition phase (see Chapter 120).

(1) Shy Distance

Provide 2 feet of additional widening for shy distance when a barrier is to be installed in areas where the roadway is to be widened and the shoulder width will be less than 8 feet. This shy distance is not needed when the section of roadway is not being widened or the shoulders are at least 8 feet wide. (See criteria in Chapter 1140 for exceptions.)

(2) Barrier Deflections

Expect all barriers except rigid barriers (such as concrete bridge rails) 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 also affect the amount of barrier deflection. For flexible and semirigid roadside barriers, the deflection distance is designed to help 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).

In median installations, design systems such that the anticipated deflection will not enter the lane of opposing traffic using deflection values that were determined from crash tests. When evaluating new barrier installations, consider the impacts where significant traffic closures are necessary to accomplish maintenance. Use a rigid system where deflection cannot be tolerated, such as in narrow medians or at the edge of bridge decks or other vertical drop-off areas. Runs of rigid concrete barrier can be cast in place or extruded with appropriate footings.

In some locations where deflection distance is limited, anchor precast concrete barrier. Unless the anchoring system has been designed to function as a rigid barrier, some movement can be expected and repairs may be more expensive. Use of a nonrigid barrier on top of a retaining wall requires approval from the HQ Design Office.

Refer to Exhibit 1610-2 for barrier deflection design values when selecting a longitudinal barrier. The deflection distances for cable and beam guardrail are the minimum measurements from the face of the barrier to the fixed feature. The deflection distance for unanchored concrete barrier is the minimum measurement from the back edge of the barrier to the drop-off or slope break.

Barrier Type	System Type	Deflection
Cable barrier or beam guardrail, Types 20 and 21, on G-2 posts	Flexible	Up to 12 ft (face of barrier to object)
Beam guardrail, Types 1, 1a, 2, 10, and 31	Semirigid	3 ft (face of barrier to object)
Two-sided W-beam guardrail, Types 3 and 4	Semirigid	2 ft (face of barrier to object)
Permanent concrete barrier, unanchored	Unrestrained Rigid	3 ft[1] (back of barrier to object)
Temporary concrete barrier, unanchored	Unrestrained Rigid	2 ft[2] (back of barrier to object)
Precast concrete barrier, anchored	Rigid	6 inches (back of barrier to object)
Rigid concrete barrier	Rigid	No deflection

Notes:

[1] When placed in front of a 2H:1V or flatter fill slope, the deflection distance can be reduced to 2 feet.

[2] When used as temporary bridge rail, anchor all barrier within 3 feet of a drop-off.

Longitudinal Barrier Deflection
Exhibit 1610-2

(3) Flare Rate

Flare the ends of longitudinal barriers where possible. The four functions of a flare are to:

- Locate the barrier and its terminal as far from the traveled way as feasible.
- 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 practicable preserves the barrier's redirectional performance and minimizes the angle of impact. However, it has been shown that an object (or barrier) close to the traveled way might cause a driver to shift laterally, slow down, or both. The flare reduces this reaction by gradually introducing the barrier so the driver does not perceive the barrier as an object to be avoided. The flare rates in Exhibit 1610-3 are intended to satisfy the four functions listed above. More gradual flares may be used. Flare rates are offset parallel to the edge of the traveled way. Transition sections are not normally flared.

Posted Speed (mph)	Rigid System	Unrestrained Rigid System	Semirigid System
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

Longitudinal Barrier Flare Rates
Exhibit 1610-3

(4) Length of Need

The length of traffic barrier needed to shield a fixed feature (length of need) is dependent on the location and geometrics of the object, direction(s) of traffic, posted speed, 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, Exhibits 1610-10a and 10b show 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 1610-10c. 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 1610-10d).

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 1610-2 for barrier deflections.) Place the barrier as far from the edge of the traveled way as possible while maintaining the deflection distance.

If the end of the length of need is near an adequate cut slope, extend the barrier and embed it in the slope (see 1610.06(5)). Avoid gaps of 300 feet or less. Short gaps are acceptable when the barrier is terminated in a cut slope. If the end of the length of need is near the end of an existing barrier, it is recommended that the barriers be connected to form a continuous barrier. Consider maintenance access issues when determining whether or not to connect barriers.

(5) Median Barrier Selection and Placement Considerations

The most desirable barrier installation uses the most flexible system appropriate for the location and one that is placed as far from the traveled way as practicable. Engineers are faced with the fact that barrier systems and vehicle fleets continue to evolve. What may be an optimal choice of barrier based on the majority of vehicles on the road today may not be the best selection for vehicles on the road in the foreseeable future. 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 and feasibility do not permit new designs to be employed as soon as they are invented. The fact that a new design has been developed does not mean that the old design is unsafe. Although new designs may have been tested under controlled conditions, their performance under relevant applications may demonstrate unexpected performance aspects. Therefore there may be a need to modify application methods based on that practical experience.

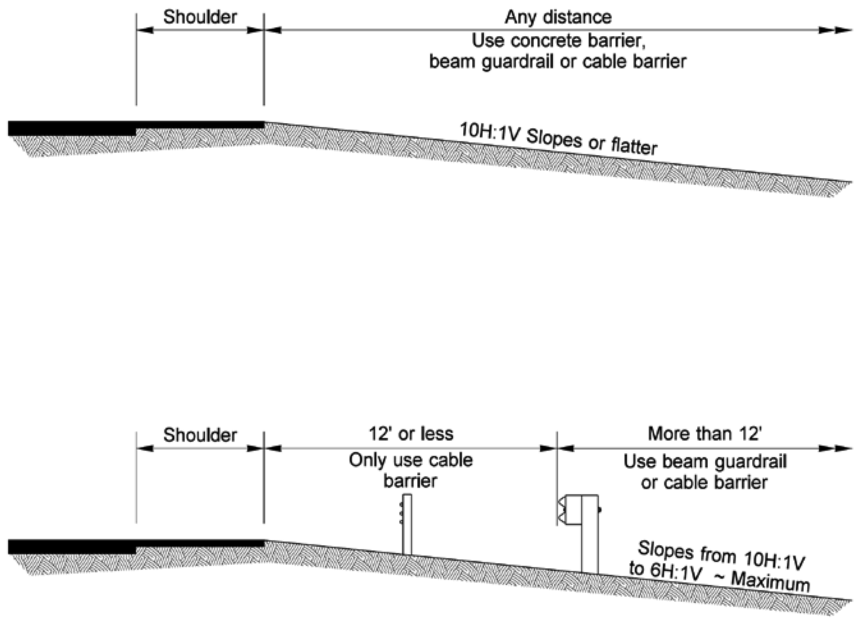
Good engineering judgment is called for in determining the appropriate placement of barrier systems. Solutions may need to be arrived at while considering competing factors such as accident frequency and severity. As discussed previously, performance of the system relies on the interaction of the vehicle, driver, and system design at any given location.

With median barriers, the deflection characteristics and placement of the barrier for a traveled way in one direction can have an impact on the traveled way in the opposing direction. In addition, the median slopes and environmental issues often influence the type of barrier that is appropriate.

In narrow medians, avoid placement of barrier where the design deflection extends into oncoming traffic. Narrow medians provide little space for maintenance crews to repair or reposition the barrier. Therefore, avoid installing deflecting barriers in medians that provide less than 8 feet from the edge of the traveled way to the face of the barrier.

In wider medians, the selection of barrier might depend on the slopes in the median. At locations where the median slopes are relatively flat (10H:1V or flatter), unrestrained precast concrete barrier, beam guardrail, and cable barrier can be used depending on the available deflection distance. At these locations, position the barrier as close to the center as possible so that the recovery distance can be maximized for both directions. 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. In wide medians where the slopes are steeper than 10H:1V but not steeper than 6H:1V, cable barrier placed near the center of the median is preferable. Place beam guardrail at least 12 feet from the slope breakpoint, as shown in Exhibit 1610-4. Do not use concrete barrier at locations where the foreslope into the face of the barrier is steeper than 10H:1V.



Traffic Barrier Locations on Slopes
Exhibit 1610-4

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.

When W-beam barrier is placed in a median as a countermeasure for cross-median collisions, design the barrier to be struck from either direction of travel. For example, the installation of beam guardrail might be double-sided (Types 3, 4, or 31-DS).

1610.06 Beam Guardrail

(1) Beam Guardrail Systems

Beam guardrail systems are shown in the *Standard Plans*.

Strong post W-beam guardrail (Types 1 through 4, and 31) and thrie beam guardrail (Types 10 and 11) are semirigid barriers used predominantly on roadsides. They have limited application as median barrier. 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 strong posts. However, avoid the use of blockouts that extend from the post to the rail element for a distance exceeding 16 inches. Placement of curb at guardrail installation also requires careful consideration.

W-beam guardrail has typically been installed with a rail height of 27 inches. However, there are some newer designs that use a 31-inch rail height. One is the 31-inch-high WSDOT Type 31. The Type 31 system uses many of the same components as the WSDOT Type 1 system. However, the main differences are that the blockouts extend 12 inches from the posts, the rail height is 31 inches from the ground, and the rail elements are spliced between posts.

The 31-inch-high system offers tolerance for future HMA overlays. The Type 31 system allows a 4-inch tolerance from 31 inches to 27 inches without adjustment of the rail element.

(2) W-Beam Barrier Selection and Placement

During the project development processes, consult with maintenance staff to help identify guardrail runs that may need to be upgraded.

- Use the 31-inch-high guardrail design for new runs. When guardrail is installed along existing shoulders with a width greater than 4 ft, the shoulder width may be reduced by 4 inches to accommodate the 12-inch blockout without processing a deviation.
- Existing runs with rail height at 27 inches are acceptable to leave in place and can be extended if the design height of 27 inches is maintained in the extended section. Where future overlays are anticipated, extend with Type 1 alternate or the 31-inch design.
- For existing runs below 26 inches, adjust or replace the rail to a height of 26 inches minimum to 28 inches maximum, or replace the run with the 31-inch-high guardrail design.
- Some 31-inch-high proprietary guardrail designs that do not incorporate the use of blockouts have been successfully crash-tested. The use of this type of system may be appropriate for some applications. Contact the HQ Design Office for further details.

Some designs for Type 31 applications are under development and will be added to the HQ Design Standards (Plan Sheet Library) as soon as they are completed (www.wsdot.wa.gov/Design/Standards/PlanSheet). Plans will be housed at this location until they are transitioned into the *Standard Plans*. Note: If a design is not available for the Type 31 guardrail system, a Type 1 guardrail design may be used without processing a deviation.

(3) Beam Guardrail Post Selection Criteria

- Use steel posts for new beam guardrail runs. (Note: For projects with Design Approval prior to December 2009, wood posts may remain as an option for new installations.)
- Existing runs of guardrail with wooden posts are acceptable to leave in place if in good condition and minimum height criteria can be maintained. (See 1610.06(2) for additional guidance.)
- Posts in an existing wooden guardrail run may be replaced in kind.
- It is acceptable to extend existing guardrail runs with like materials.
- When removing and resetting guardrail runs, consider using steel posts and reusing or replacing other components and hardware depending on condition.

(4) Additional Guidance

Weak post W-beam guardrail (Type 20) and thrie beam guardrail (Type 21) are flexible barrier systems that can be used where there is adequate deflection distance. These systems use weak steel posts. The primary purpose of these posts is to position the guardrail vertically, and they are designed to bend over when struck. These more flexible systems will likely result in less damage to the impacting vehicle. Since the weak posts will not result in snagging, blockouts are not necessary.

Keep the slope of the area between the edge of the shoulder and the face of the guardrail 10H:1V or flatter. On fill slopes between 6H:1V and 10H:1V, avoid placing within 12 feet of the break point. Do not place beam guardrail on a fill slope steeper than 6H:1V. (See Exhibit 1610-4 for additional guidance on beam guardrail slope placement.)

On the high side of superelevated sections, place beam guardrail at the edge of shoulder prior to the slope break.

For W-beam guardrail installed at or near the shoulder, 2 feet of shoulder widening behind the barrier is generally provided from the back of the post to the beginning of a fill slope (see Exhibit 1610-11, Case 2). If the slope is 2H:1V or flatter, this distance can be measured from the face of the guardrail rather than the back of the post (see Exhibit 1610-11, Case 1).

On projects where no roadway widening is proposed and the minimum 2-foot shoulder widening behind the barrier is not practicable, long post installations are available as shown in Exhibit 1610-11, Cases 3, 4, 5, and 6. When guardrail is to be installed in areas where the roadway is to be widened or along new alignments, the use of Cases 4, 5, and 6 requires a design deviation.

Rail washers on beam guardrail are not normally used. If rail washers are present, removal is not necessary except for posts 2 through 8 of an existing BCT installation. However, if the rail element is removed for any reason, do not reinstall rail washers. In areas where heavy snow accumulations are expected to cause the bolts to pull out, specify snowload post washers and rail washers in the contract documents. (Snowload post washers are used to help prevent the bolts from pulling through the posts, and snowload rail washers are used to help prevent the bolt head from pulling through the rail.) In other installations, it is normal to have the rail pull loose from the bolt head when impacted. Do not use rail washers within the limits of a guardrail terminal except at the end post where they are needed for anchorage of the rail.

The use of curb in conjunction with beam guardrail is discouraged. If a curb is needed, the 3-inch-high curb is preferred. If necessary, the 4-inch-high extruded curb can be used behind the face of rail at any posted speed. The 6-inch-high extruded curb can be used at locations where the posted speed is 50 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.)

When curb is used in conjunction with 31-inch-high Type 31 W-beam guardrail, it is acceptable to place a 6-inch-high curb at a 7-inch offset outside the face of the rail.

Beam guardrail is usually galvanized and has a silver color. It can also be provided in weathering steel that has a brown or rust color. Along Scenic Byways, Heritage Tour Routes, state highways through national forests, or other designated areas, consider using weathering steel guardrail, weathering steel terminals, and colored steel posts (galvanized weathering steel, etched galvanized steel, or powder-coated galvanized steel) to minimize the barrier's visual impact (see 1610.05).

Note: In areas where weathering steel will be used and the steel post options cannot be used, the wood post option may be used with justification (Design Decision Memo).

(5) Terminals and Anchors

A guardrail anchor is needed at the end of a run of guardrail to develop tensile strength throughout its length. In addition, when the end of the guardrail is subject to head-on impacts, a crash-tested guardrail terminal is needed (see the *Standard Plans*).

(a) **Buried Terminal (BT)**

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.

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 distance between the beginning length of need point at the terminal end to the mitigated object to be protected.

For new BT installations, use the Buried Terminal Type 2. Note: Previously, another BT option (the Buried Terminal Type 1) was an available choice. For existing situations, it is acceptable to leave this option in service.

1. **Buried Terminal Type 2**

   Flare the guardrail to the foreslope/backslope intersection using a flare rate that meets the criteria in 1610.05(3). 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.)

(b) **Nonflared Terminal**

If a BT terminal cannot be installed as described above, consider a nonflared terminal (see Exhibit 1610-12a). There are currently two acceptable sole source proprietary designs: the ET–PLUS 31 and the SKT-MGS. These systems use W-beam guardrail with a special end piece that fits over the end of the guardrail. Steel posts are used throughout the length of the terminal. When hit head on, the end piece is forced over the rail and either flattens or bends the rail and then forces it away from the impacting vehicle.

Both the SKT-MGS and the ET-PLUS 31 terminals include an anchor for developing the tensile strength of the guardrail. The length of need begins at the third post for both terminals.

While these terminals do not need to have an offset at the end, a flare is recommended so that the end piece does not protrude into the shoulder. These terminals may have a 2-foot offset to the first post. Four feet of widening is needed at the end posts to properly anchor the system. For each foot of embankment height, 3 cubic yards of embankment are needed. (See the *Standard Plans* for widening details.)

When the entire barrier run is located farther than 12 feet beyond the shoulder break point and the slopes are greater than 10H:1V and 6H:1V or flatter, additional embankment at the terminal is not needed.

No snowload rail washers are allowed within the limits of these terminals.

When a Beam Guardrail Type 1 nonflared terminal is needed, two sole source proprietary terminals, the ET-PLUS or the Sequential Kinking Terminal (SKT), may be used (see Exhibit 1610-12b). Both of these Type 1 barrier terminals are available in two designs based on the posted speed of the highway. The primary difference in these designs is the length of the terminal. For highways with a posted speed of 45 mph or above, use the 50-foot-long ET PLUS TL3 or the SKT 350 terminal. For lower-speed highways (a posted speed of 40 mph or below), use the 25-foot-long ET PLUS TL2 or SKT-TL2.

The FHWA has granted approval to use the above sole source proprietary terminals without justification.

(c) **Flared Terminal**

WSDOT does not use a flared terminal system for the Type 31 system. However, if a flared terminal is needed for other applications, there are currently two acceptable sole source proprietary designs: the Slotted Rail Terminal (SRT) and the FLared Energy Absorbing Terminal (FLEAT). Both of these designs include an anchor for developing the tensile strength of the guardrail. The length of need begins at the third post for both flared terminals.

1. The SRT uses W-beam guardrail with slots cut into the corrugations and posts throughout the length of the terminal. The end of the SRT is offset from the tangent guardrail run by the use of a parabolic flare. When struck head on, the first two posts are designed to break away, and the parabolic flare gives the rail a natural tendency to buckle, minimizing the possibility of the guardrail end entering the vehicle. The buckling is facilitated by the slots in the rail. The remaining posts provide strength to the system for redirection and deceleration without snagging the vehicle. The SRT has a 4-foot offset of the first post.

   The SRT terminal can be supplied with wood or steel posts. Match the type of SRT posts with those of the longitudinal barrier run to which the terminal will be connected.

2. The FLEAT uses W-beam guardrail with a special end piece that fits over the end of the guardrail and posts. The end of the FLEAT is offset from the tangent guardrail run by the use of a straight flare. When struck head on, the end piece is forced over the rail, bending the rail and forcing it away from the impacting vehicle.

The FLEAT is available in two designs based on the posted speed of the highway. For highways with a posted speed of 45 mph or above, use a FLEAT 350, which has a 4-foot offset at the first post. For lower-speed highways (a posted speed of 40 mph or below), use a FLEAT TL-2, which has a 1-foot-8-inch offset at the first post.

The FLEAT terminal can be supplied with wood or steel posts. Match the type of FLEAT posts with those of the longitudinal barrier run to which the terminal will be connected.

When a flared terminal is specified, it is critical that embankment quantity also be specified so that the area around the terminal can be constructed as shown in the *Standard Plans*. For each foot of height of the embankment, 13 cubic yards of embankment are needed.

When the entire barrier run is located greater than 12 feet beyond the shoulder break point and the slopes are greater than 10H:1V and 6H:1V or flatter, additional embankment at the terminal is not needed.

Snowload rail washers are not allowed within the limits of these terminals.

The FHWA has granted approval to use these sole source proprietary terminals without justification.

(d) **Terminal Evolution Considerations**

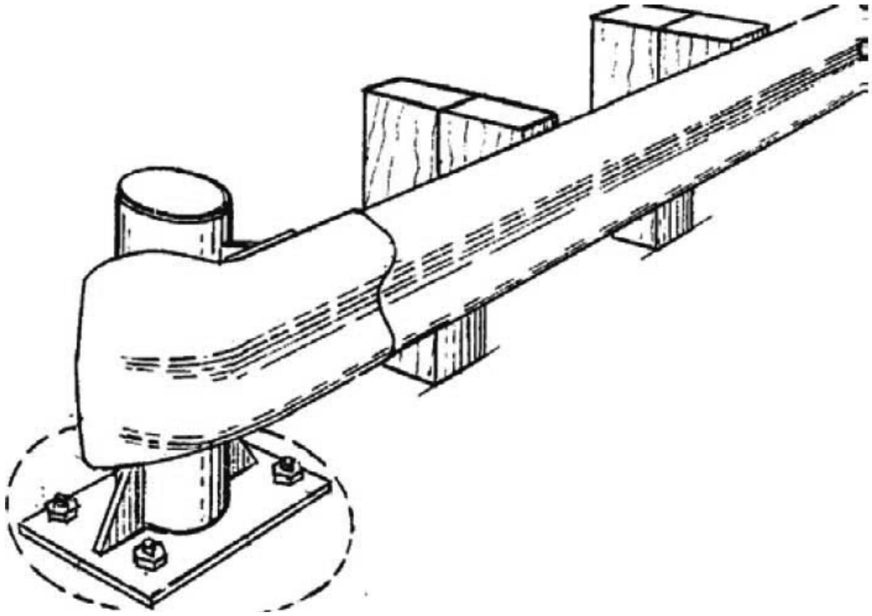
Some currently approved terminals have been in service for a number of years. During this time, there have been minor design changes. However, these minor changes have not changed the devices' approval status. Previous designs for these terminals may remain in place. (For guidance on BCT terminals, see 1610.04(1).) If questions arise concerning the current approval status of a device, contact the HQ Design Office for clarification when replacement is being considered.

(e) **Other Anchor Applications**

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. The Type 1 or Type 4 anchor is currently used for Beam Guardrail Type 1 where a crash-tested terminal is not needed. Use the Type 5 anchor with the Weak Post Intersection Design (see 1610.06(7)(b), Cases 12 and 13). Use the Type 7 anchor to develop tensile strength in the middle of a guardrail run when the guardrail curves and weak posts are used (see 1610.06(7)(b), Cases 9, 12, and 13).

The old Type 3 anchor was primarily used at bridge ends (see Exhibit 1610-5). This anchor consisted of a steel pipe mounted vertically in a concrete foundation. Bridge approach guardrail was then mounted on the steel pipe.

- On one-way highways, these anchors were usually positioned so that neither the anchor nor the bridge rail posed a snagging potential. When these cases are encountered, the anchor may remain in place if a stiffened transition section is provided at the connection to the post.
- On two-way highways, the anchor may present a snagging potential. In these cases, install a connection from the anchor to the bridge rail if the offset from the bridge rail to the face of the guardrail is 1 foot 6 inches or less. If the offset is greater than 1 foot 6 inches, remove the anchor and install a new transition and connection.



Old Type 3 Anchor
Exhibit 1610-5

Locations where crossroads and driveways cause gaps in the guardrail create situations for special consideration. Elimination of the need for the barrier is the preferred solution. Otherwise, a barrier flare might be needed to provide sight distance. If the slope is 2H:1V or flatter and there are no fixed features on or at the bottom of the slope, a terminal can be used to end the rail. Place the anchor of this installation as close as possible to the road approach radius PC. If there is a feature at or near the bottom of the slope that cannot be mitigated, then the Weak Post Intersection Design (see 1610.06(7)(b) and the *Standard Plans*) can be used. This system can also be used at locations where a crossroad or road approach is near the end of a bridge and where installing a bridge approach guardrail placement, including guardrail transition and terminal, is not possible.

(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 is likely to be caught in the deflected barrier pocket and directed into the more rigid barrier. This is commonly referred to as "pocketing." A transition stiffens the more flexible barrier by decreasing the post spacing, increasing the post size, and using stiffer beam elements to eliminate the possibility of pocketing.

When connecting beam guardrail to a more rigid barrier or a structure, or when a rigid object is within the deflection distance of the barrier, use the transitions and connections that are shown in Exhibits 1610-6 and 1610-9 and detailed in the *Standard Plans*. The transition pay item includes the connection.

Condition	Connection
Unrestrained concrete barrier	A
Rigid untapered safety shape bridge rails or barriers[1]	B
Bridge rails with curbs 9 inches or less in width	B
Bridge rails with curbs between 9 and 18 inches wide	C
Vertical walls or tapered safety shape barrier[1]	D

Note:
[1] New safety shape bridge rails are designed with the toe of the barrier tapered so that it does not project past the face of the approach guardrail.

Guardrail Connections
Exhibit 1610-6

(7) Guardrail Placement Cases

The *Standard Plans* contains placement cases that show beam guardrail elements needed for typical situations. For some applications, the *Standard Plans* provides options for both Type 1 and Type 31 guardrail for similar installations. For new applications, use the appropriate Type 31 placement option. Additional placement cases incorporate other combinations of barrier types.

(a) **Beam Guardrail Type 31 Placements**

- **Case 1-31** is used with Type 31 barrier 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 with Type 31 barrier 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 accidents, 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. A curve in the guardrail is shown to shift it to the bridge rail. However, the length of the curve is not critical. The criterion is to provide a smooth curve that is not more abrupt than the allowable flare rate (see Exhibit 1610-3).
- **Case 5-31** is a typical bridge approach where a terminal and a transition are needed.
- **Case 6** is used on bridge approaches where opposing traffic is separated by a median that is 36 feet or wider. This case is designed so that the end of the guardrail will be outside the Design Clear Zone for the opposing traffic.

- **Case 10 (A-31, B-31, and C-31)** is used at roadside fixed features (such as bridge piers) when 3 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.
- **Case 11 (A-31, B-31, and C-31)** is used at roadside fixed features (such as bridge piers) when the guardrail is to be placed within 3 feet of the feature. Since there is no room for deflection, the rail in front of the feature is to be considered a rigid system and a transition is needed. The trailing end cases are the same as described for Case 10.
- **Beam Guardrail Type 31 (12'6", 18'9", or 25' Span)** is used when it is necessary to omit one, two, or three posts. This application is typically used when guardrail is installed over drainage structures but may have other applications if adequate deflection distance is present. Three CRT posts are provided on each end of the omitted post(s).
- **Guardrail Placement Strong Post – Type 31** is the “Strong Post Intersection Design for Type 31 barrier” that provides a stiff barrier. This design is to be used as a last resort at crossroads or road approaches where a barrier is needed and there isn’t a clear area behind the nose or minimum distances for a “Weak Post Intersection Design” (see Cases 12 and 13).

Note: Some placement cases for use with Beam Guardrail Type 31 are currently under development. As plans become available, they will be housed in the HQ Design Standards (Plan Sheet Library) until they become Standard Plans (www.wsdot.wa.gov/Design/Standards/PlanSheet).

(b) **Additional Placement Cases**

- **Case 1** is used where there is one-way traffic. It uses a crash-tested terminal on the approach end and a Type 4 anchor on the trailing end.
- **Case 2** is used where there is two-way traffic. A crash-tested terminal is used on both ends. When flared terminals are used on both ends, use a minimum of 25 feet of guardrail between the terminal limits when feasible.
- **Case 3** is used at railroad signal supports on one-way or two-way roadways. A terminal is used on the approach end, but usually cannot be used on the trailing end because of its proximity to the railroad tracks. If there is a history of crossover accidents, consider additional protection such as an impact attenuator.
- **Case 4** is used where guardrail on the approach to a bridge is to be shifted laterally to connect with the bridge rail. A terminal is used on the approach end and a transition is needed at the bridge end. A curve in the guardrail is shown to shift it to the bridge rail. However, the length of the curve is not critical. The criterion is to provide a smooth curve that is not more abrupt than the allowable flare rate (see Exhibit 1610-3).
- **Case 5** is a typical bridge approach where a terminal and a transition are needed.

- **Case 6** is used on bridge approaches where opposing traffic is separated by a median that is 36 feet or wider. This case is designed so that the end of the guardrail will be outside the Design Clear Zone for the opposing traffic.
- **Cases 7 and 8** are used with beam guardrail median barrier when median fixed features such as bridge piers are encountered. A transition is needed on the approach end for each direction, and the flare rate is not to be more abrupt than the allowable flare rate (see Exhibit 1610-3).
- **Case 9 (A, B, and C)** is used on bridge approaches where opposing traffic is separated by a median less than 36 feet wide. This design, called a "Bull Nose Terminal," treats both bridge ends and the opening between the bridges. The "nose" is designed to collapse when struck head on, and the ribbon strength of the rail brings the vehicle to a controlled stop. Type 7 anchors are installed on each side of the nose to develop the ribbon strength.
- Since an impacting vehicle might penetrate into the system, it is critical that no fixed feature be located within the first 65 feet of the system.
- **Case 10 (A, B, and C)** is used at roadside fixed features (such as bridge piers) when 3 or more feet are available from the face of the guardrail to the object. The approach end is the same for one-way or two-way traffic. Case 10A is used with two-way traffic; therefore, a terminal is needed on the trailing end. Case 10B is used for one-way traffic when there is no need to extend guardrail past the bridge pier and a Type 4 anchor is used to end the guardrail. Case 10C is used for one-way traffic when the guardrail will extend for a distance past the bridge pier.
- **Case 11 (A, B, and C)** is used at roadside fixed features (such as bridge piers) when the guardrail is to be placed within 3 feet of the object. Since there is no room for deflection, the rail in front of the feature is to be considered a rigid system and a transition is needed. The trailing end cases are the same as described for Case 10.
- **Cases 12 and 13** are called "Weak Post Intersection Designs." They are used where an intersection design needs a gap in the guardrail or there is not adequate space for a bridge approach installation that includes a transition, a terminal, or both. These placements are designed to collapse when hit at the nose, and the ribbon strength of the rail brings the vehicle to a stop. A Type 7 anchor is used to develop the ribbon strength. These designs include a Type 5 transition for connection with bridge rail and a Type 5 anchor at the other end of the rail. The Type 5 anchor is not a breakaway anchor and therefore can typically be used only on low-speed side roads and driveways.

Since an impacting vehicle might penetrate into the system, it is critical that no fixed feature be located within the clear area shown in the *Standard Plans*. The 25 feet of barrier length beyond the PC along the side road are critical for the operation of this system.

These designs were developed for intersections that are approximately perpendicular. Evaluate installation on skewed intersections on a case-by-case basis. Use the Case 22 placement if it is not feasible to install this design according to the *Standard Plans*.

- **Case 14** shows the approach rail layout for a Service Level 1 bridge rail system. Type 20 guardrail is used on the approach and no transition is needed between the Type 20 guardrail and the Service Level 1 bridge rail since they are both weak post systems. A Type 6 transition is used when connecting the Type 20 to a strong post guardrail or a terminal.
- **Case 15** is used to carry guardrail across a box culvert where there is insufficient depth to install standard posts for more than 17 feet 8 inches. This design uses steel posts anchored to the box culvert to support the rail. Newer designs—Cases 19, 20, and 21—have replaced this design for shorter spans.
- **Cases 16 and 17** are similar to Cases 1 and 2, except that they flare the rail and terminal as far from the road as possible and reduce the length of need.
- **Case 18** is used on the trailing end of bridge rail on a one-way roadway. No transition is needed.
- **Case 19 (A and B)** is used where it is not possible to install a post at the 6-foot-3-inch spacing. This design omits one post (resulting in a span of 11 feet 6 inches, which is consistent with a post spacing of 12 feet 6 inches) and uses nested W-beam to stiffen the rail. The cases differ by the location of the splice. No cutting of the rail or offsetting of the splices is needed or desirable.
- **Case 20** is similar to Cases 19A and 19B, except that it allows for two posts to be omitted, which results in a span consistent with post spacing of 18 feet 9 inches.
- **Case 21** has a similar intent as Cases 19A, 19B, and 20 in that it allows for the omission of posts to span an obstruction. This design uses CRT posts with additional post blocks for three posts before and after the omitted posts. The design allows for three posts to be omitted, which results in a span consistent with a post spacing of 25 feet.
- **Case 22** is the “Strong Post Intersection Design” that provides a stiff barrier. This design is to be used as a last resort at crossroads or road approaches where a barrier is needed and there isn’t a clear area behind the nose or minimum distances for a “Weak Post Intersection Design” (see Cases 12 and 13).

Note: Some placement cases for use with Beam Guardrail Type 31 are currently under development. As plans become available, they will be housed in the HQ Design Standards (Plan Sheet Library) until they become Standard Plans (www.wsdot.wa.gov/Design/Standards/PlanSheet).

1610.07 Cable Barrier

Cable barrier is a flexible barrier system that can be used on a roadside or as a median barrier. It is used primarily in medians and is preferred for many installations due in part to its high benefit-to-cost ratio. Some of the advantages of cable barrier are:

- It provides effective vehicle containment and redirection while imposing the lowest deceleration forces on the vehicle’s occupant(s).

- It reduces the severity of collisions, which is of significant importance on high-speed facilities.
- After it is struck, it has a tendency not to redirect vehicles back into traffic, which can help reduce the frequency of secondary collisions.
- It can often be placed on existing facilities without the delay of extended environmental permitting and the expense of complex highway reconstruction that might be needed for other barrier system choices.
- It has advantages in heavy snowfall areas because it has minimal potential to create snowdrifts.
- In crucial wildlife habitats, it can aid in some types of animal movements.
- It does not present a visual barrier, which may make it desirable on Scenic Byways (see 1610.05).
- The effort (time and materials) needed to maintain and repair cable barrier systems is much less than the effort needed for a W-beam system.

Deflection is a consideration in narrower median areas. In many urban and other limited-width situations, use of cable barrier may not be possible or may require special designs.

For new installations, use four-cable high-tension (H.T.) cable barrier systems, which are available from several manufacturers.

(1) High-Tension Cable Barrier Placement

- For shoulder applications of single-runs of cable median barrier, with at least 13 feet from edge of the nearest traveled lane to the slope breakpoint, place the cable median barrier at least 1 foot in front of the slope breakpoint. Any four-cable high-tension barrier system may be used in this location (see Exhibit 1610-13a).
- Typically, double-runs of cable median barrier are not needed. However, if this type of application is used on shoulders with at least 11 feet from edge of the nearest traveled lane to the slope breakpoint, place the cable median barrier at least 1 foot in front of the slope breakpoint. Any approved four-cable high-tension barrier system may be used in this location.
- For non-median shoulder applications, cable barrier can be installed up to 1 foot in front of slope breakpoints as steep as 2H:1V. Cable barrier is the barrier option that can be placed on a sideslope steeper than 10H:1V within the 12-foot area immediately beyond the slope breakpoint. Do not place this barrier on a sideslope steeper than 6H:1V. Exhibit 1610-13b shows the placement of cable barrier for shoulder applications.
- 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 cable barrier.
- When cable barrier is to be connected to a more rigid barrier, a transition section is needed. Contact the HQ Design Office for further details.

Note: 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 when selecting these systems.

(2) High-Tension Cable Barrier Deflection Distances

Depending on the system and post spacing, deflection distances for high-tension barrier systems may range from approximately 6 to 12 feet. Provide deflection distance guidance in the contract documents. (See Exhibits 1610-13a and 13b for placement details.)

Note: There are new high-tension cable barrier systems under development that may change selection and placement criteria. The HQ Design Office will circulate guidance on these new developments as they are adopted as WSDOT policy.

(3) High-Tension Cable Barrier Termination

Do not connect the cables directly to beam guardrail runs when terminating new runs of high-tension cable barrier. Instead, use a separate anchorage system. Note: Existing runs connected to beam guardrail may remain in place.

(4) High-Tension Cable Barrier Height Criteria

Select a high-tension four-cable barrier system with a height to the center of the top cable of not less than 35 inches and a height to the center of the bottom cable not greater than 19 inches.

Note: There are high-tension cable barrier systems under development that may change selection and placement criteria. The HQ Design Office will circulate guidance on these new developments as they are adopted as WSDOT policy.

1610.08 Concrete Barrier

Concrete barriers are rigid or unrestrained rigid systems. Commonly used in medians, they are also used as shoulder barriers. These systems are stiffer than beam guardrail or cable barrier, and impacts with these barriers tend to be more severe.

Light standards mounted on top of concrete median barrier must not have breakaway features. (See the concrete barrier light standard section in the *Standard Plans*.)

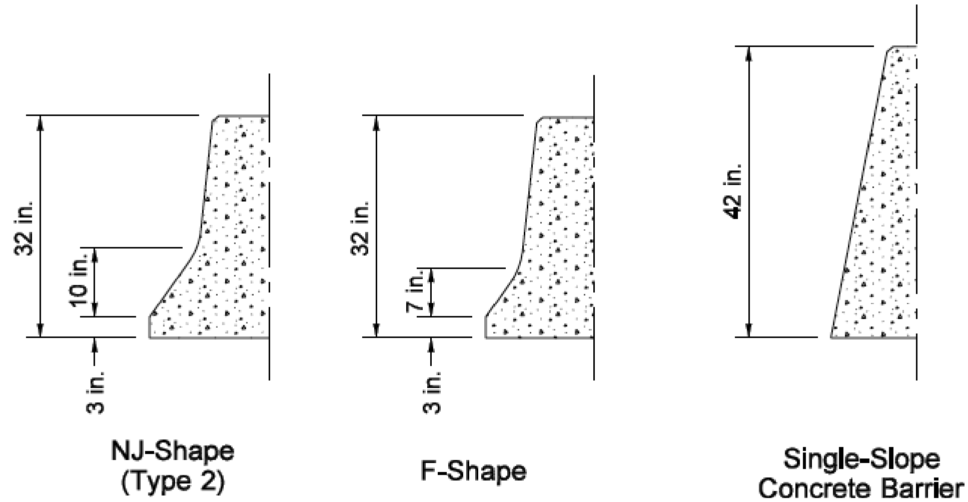
When concrete barrier is considered for use in areas where drainage and environmental issues (such as stormwater, wildlife, or endangered species) might be adversely impacted, contact the HQ Hydraulics Office and the appropriate environmental offices for guidance.

(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 1610-7.

The single-slope barrier face is the recommended option for embedded rigid concrete barrier applications.

Note: There are new precast concrete barrier systems under development that may change future selection and placement criteria. The HQ Design Office will circulate guidance on these new developments as they are adopted as WSDOT policy.



Concrete Barrier Shapes
Exhibit 1610-7

When the single-slope or F-Shape face is used on structures, and precast barrier is selected for use on the approaches, a cast-in-place transition section is needed so that no vertical edges of the barrier are exposed to oncoming traffic. For details on bridge rail designs, see the *Bridge Design Manual*.

For aesthetic reasons, avoid changes in the shape of the barrier face within a project or corridor.

(a) **New Jersey Shape Barrier**

The New Jersey shape face is primarily used on precast concrete barrier.

Concrete barrier Type 2 (see the *Standard Plans*) is a precast barrier that has the New Jersey shape on two sides and can be used for both median and shoulder installations. This barrier is 2 feet 8 inches in height, which includes 3 inches for future pavement overlay.

The cost of precast Type 2 barrier is significantly less than the cost of the cast-in-place barriers. Therefore, consider the length of the barrier run and the deflection needs to determine whether transitioning to precast Type 2 barrier is desirable. If precast Type 2 barrier is used for the majority of a project, use the New Jersey face for small sections that need cast-in-place barrier, such as for a light standard section.

Concrete barrier Type 4 is also a precast, single-faced New Jersey shape barrier. These units are not freestanding and are to be placed against a rigid structure or anchored to the pavement. If Type 4 barriers are used back to back, consider filling any gap between them to prevent tipping.

Concrete barrier Type 5 is a precast barrier that has a single New Jersey face and is intended for use at bridge ends where the flat side is highly visible. Both Type 2 and Type 5 designs are freestanding, unanchored units connected with steel pins through wire rope loops. For permanent installation, this barrier is placed on a paved surface and a 2-foot-wide paved surface is provided beyond the barrier for its displacement during impact (see Chapter 1230).

Precast barrier can be anchored where a more rigid barrier is needed. (Anchoring methods are shown in the *Standard Plans*.) The Type 1 and Type 2 anchors are for temporary installations on a rigid pavement. Type 3 anchors can be used in temporary or permanent installations on an asphalt pavement. Consult the HQ Bridge and Structures Office for details when anchoring permanent precast concrete barrier to a rigid pavement.

Precast barrier used on the approach to bridge rail is to be connected to the bridge rail by installing wire rope loops embedded 1 foot 3 inches into the bridge rail with epoxy resin.

Place unrestrained (unanchored) precast concrete barrier on foundation slopes of 5% or flatter. In difficult situations, a maximum slope of 8% may be used. Keep the slope of the area between the edge of the shoulder and the face of the traffic barrier as flat as possible. The maximum slope is 10H:1V (10%).

(b) **Single-Slope Barrier**

The single-slope concrete barrier can be cast in place, slipformed, or precast. The most common construction technique for this barrier has been slipforming, but some precast single-slope barrier has been installed. The primary benefit of using precast barrier is that it can be used as temporary barrier during construction and then reset into a permanent location.

Single-slope barrier is considered a rigid system regardless of the construction method used. For new installations, the minimum height of the barrier above the roadway is 2 feet 10 inches, which allows 2 inches for future overlays. The minimum total height of the barrier section is 3 feet 6 inches, with a minimum of 3 inches embedded in the roadway wearing surface. This allows for use of the 3-foot-6-inch barrier between roadways with grade separations of up to 5 inches. A grade separation of up to 10 inches is allowed when using a 4-foot-6-inch barrier section, as shown in the *Standard Plans*. The barrier is to have a depth of embedment equal to or greater than the grade separation. Contact the HQ Bridge and Structures Office for grade separations greater than 10 inches.

(c) **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.

(2) High-Performance Concrete Barrier

High-Performance Concrete Barrier (HP Barrier) is a rigid 42-inch-high barrier designed to function more effectively during heavy-vehicle collisions. This taller barrier may also offer the added benefits of reducing headlight glare and reducing noise in surrounding environments. HP Barrier is generally considered single-slope barrier. (See the *Standard Plans* for barrier details.) For additional available shapes, contact the HQ Design Office.

For new/reconstruction, use HP Barrier in freeway medians of 22 feet or less. Also, use HP Barrier on Interstate or freeway routes where accident history suggests a need or where roadway geometrics increase the possibility of larger trucks hitting the barrier at a high angle (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 nonfreeway narrow medians, near highly sensitive environmental areas, near densely populated areas, over or near mass transit facilities, or on vertically divided highways.

(3) Concrete Barrier Terminals

Whenever possible, bury the end of the concrete barrier in the backslope. The backslope needed to bury the end is to be 3H:1V or steeper and at least 4 feet in height above the roadway. Flare the concrete barrier into the backslope using a flare rate that meets the criteria in 1610.05(3). Provide a 10H:1V or flatter foreslope into the face of the barrier and maintain the full barrier height to the foreslope/backslope intersection. This might create the need to fill ditches and install culverts in front of the barrier face.

The 7-foot-long precast concrete terminal end section for concrete barrier Type 2 and the 10- to 12-foot single-slope barrier terminal may be used:

- Outside the Design Clear Zone.
- On the trailing end of the barrier when it is outside the Design Clear Zone for opposing traffic.
- On the trailing end of one-way traffic.
- Where the posted speed is 25 mph or below.

Another available end treatment for Type 2 barriers is a precast or cast-in-place tapered terminal section with a minimum length of 48 feet and a maximum length of 80 feet. It is used infrequently for special applications and is designed to be used for posted speeds of 35 mph or below. For details, contact the HQ Design Office or refer to the Plan Sheet Library: www.wsdot.wa.gov/Design/Standards/PlanSheet/

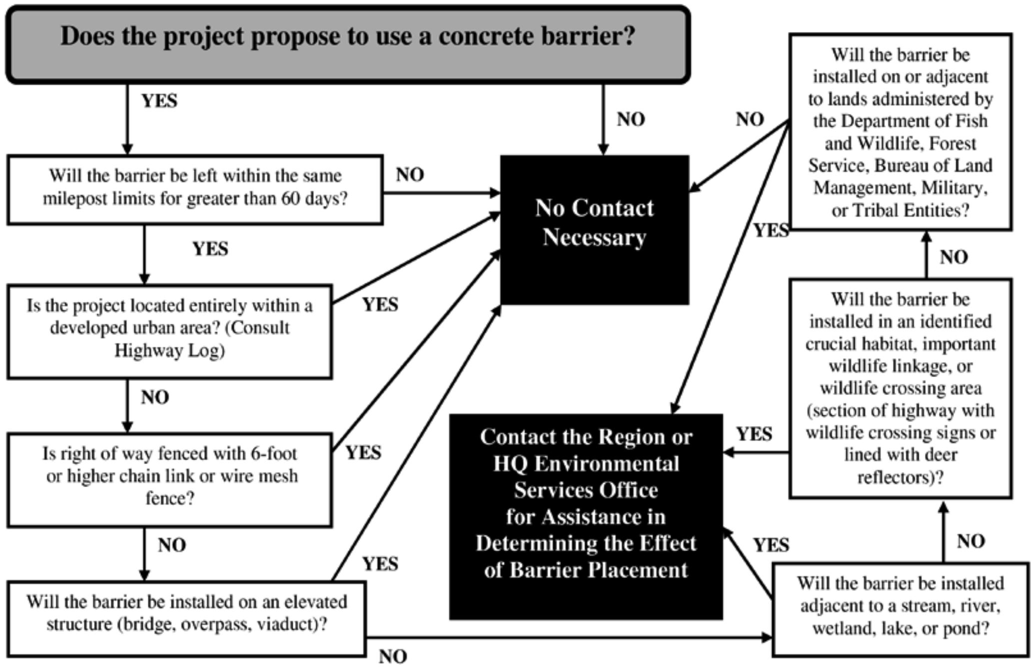
When the "Barrier Terminals and Transitions" column of a Design Matrix applies to a project, existing sloped-down concrete terminals that are within the Design Clear Zone are to be replaced when they do not meet the above criteria.

When the end of a concrete barrier cannot be buried in a backslope or terminated as described above, terminate the barrier using a guardrail terminal and transition or an impact attenuator (see Chapter 1620).

(4) Assessing Impacts to Wildlife

The placement of concrete barriers in locations where wildlife frequently cross the highway can influence traffic safety and wildlife mortality. When wildlife encounter physical barriers that are difficult to cross, they often travel parallel to those barriers. With traffic barriers, this means that they often remain on the highway for a longer period, increasing the risk of wildlife/vehicle collisions or vehicle/vehicle collisions as motorists attempt avoidance.

Traffic-related wildlife mortality may play a role in the decline of some species listed under the Endangered Species Act. To address public safety and wildlife concerns, see Exhibit 1610-8 to assess whether concrete 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.



Concrete Barrier Placement Guidance: Assessing Impacts to Wildlife
Exhibit 1610-8

(5) Assessing Impacts to Stormwater and Wetlands

In locations where medians or roadsides are used for drainage, the retention of stormwater or the existence of wetlands can influence the choice and use of barrier systems. For example, the placement of concrete barrier and beam guardrail in many of these cases may create the need for additional impervious material, which can result in complete retrofit and reconstruction of the existing systems. When water is drained, stored, or treated, and where wetlands exist, the ability to provide alternative facilities that replace the functions of the existing ones may be nonexistent or prohibitively expensive to provide elsewhere.

To address public safety, stormwater, and wetland concerns, 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 development process to allow adequate time for discussion of options.

1610.09 Special-Use Barriers

The following barriers may be used on designated Scenic Byway and Heritage Tour routes if funding can be arranged (see 1610.05 and Chapter 120).

(1) Steel-Backed Timber Guardrail

Steel-backed timber guardrails consist of a timber rail with a steel plate attached to the back to increase its tensile strength. There are several variations of this system that have passed crash tests. The nonproprietary systems use a beam with a rectangular cross section that is supported by either wood or steel posts. A proprietary (patented) system called the Ironwood Guardrail is also available. This system uses a beam with a round cross section and is supported by steel posts with a wood covering to give the appearance of an all-wood system from the roadway. The Ironwood Guardrail can be allowed as an alternative to the nonproprietary system. However, specifying this system exclusively needs approval by an Assistant State Design Engineer of a public interest finding for the use of a sole source proprietary item.

The most desirable method of terminating the steel-backed timber guardrail is to bury the end in a backslope, as described in 1610.06(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 and terminated in a berm.

For details on these systems, contact the HQ Design Office.

(2) Stone Guardwalls

Stone guardwalls function like rigid concrete barriers but have 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 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 1610.08(3). 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.

1610.10 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.)

For new bridge rail installations, use a 2-foot-10-inch-high single slope or a 2-foot-8-inch-high safety shape (F-Shape) bridge barrier. A transition is available to connect the New Jersey shape (Type 2 concrete barrier) and the F-Shape bridge barrier. (See the *Standard Plans* for further details.) Use taller 3-foot-6-inch safety shape or single-slope bridge barriers on Interstate or freeway routes where accident history suggests a need or where roadway geometrics increase the possibility of larger trucks hitting the barrier at a high angle (such as on-ramps for freeway-to-freeway connections with sharp curvature in the alignment).

For further guidance on bridges where high volumes of pedestrian traffic are anticipated, see Chapter 1520.

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 1610.06(6) for guidance on transitions.)

If the bridge barrier system does not meet the criteria for strength and geometrics, modifications to improve its redirectional characteristics and its strength may be needed. The modifications can be made using one of the retrofit methods described below.

(1) Concrete Safety Shape

Retrofitting with a new concrete bridge barrier is costly and needs to have justification when no widening is proposed. Consult the HQ Bridge and Structures Office for design details and to determine whether the existing bridge deck and other superstructure elements are of sufficient strength to accommodate this bridge barrier system.

(2) Thrie Beam Retrofit

Retrofitting with thrie beam is an economical way to improve the strength and redirectional performance of bridge barriers. The thrie beam can be mounted to steel posts or the existing bridge barrier, depending on the structural adequacy of the bridge deck, the existing bridge barrier type, the width of curb (if any), and the curb-to-curb roadway width carried across the structure.

The HQ Bridge and Structures Office is responsible for the design of thrie beam bridge barrier. Exhibit 1610-14 shows typical retrofit criteria. Contact the HQ Bridge and Structures Office for assistance with thrie beam retrofit design.

Consider the Service Level 1 (SL-1) system on bridges with wooden decks and for bridges with concrete decks that do not have the needed strength to accommodate the thrie beam system. Contact the HQ Bridge and Structures Office for information needed for the design of the SL-1 system.

A sidewalk reduction of up to 6 inches as a result of a thrie beam retrofit can be documented as a design exception.

The funding source for retrofit of existing bridge rail is dependent on the length of the structure. Bridge rail retrofit, for bridges less than 250 feet in length, or a total bridge rail length of 500 feet, is funded by the project (Preservation or Improvement). For longer bridges, the retrofit can be funded by the I-2 subprogram. Contact the HQ Program Development Office to determine whether funding is available.

1610.11 Other Barriers

(1) Dragnet

The Dragnet Vehicle Arresting Barrier consists of chain link or fiber net that is attached to energy absorbing units. When a vehicle hits the system, the Dragnet brings the vehicle to a controlled stop with 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

For permanent installations, this system can be installed between towers that lower the unit into position when needed and lift it out of the way when it is no longer needed. For work zone applications, it is critical to provide deflection space for stopping the vehicle between the system and the work zone. For additional information on the Dragnet, contact the HQ Design Office.

1610.12 Documentation

For the list of documents needed to be preserved in the Design Documentation Package and the Project File, see the Design Documentation Checklist:
www.wsdot.wa.gov/design/projectdev/

Connecting W-Beam Guardrail to: Transitions and Connections			Transition Type*	Connection
Bridge Rail	New Installation		20, 21, 4[4]	D
	Existing Concrete	Concrete Parapet > 20 inches	20, 21, 4[4]	Exhibit 1610-6
		Concrete Parapet < 20 inches	2, 4[4]	Exhibit 1610-6
		Existing W-Beam Transition	2[1][5], 4[4]	[1]
	Thrie Beam at Face of Curb[3]	Approach End	23	n/a
		Trailing End (two-way traffic only)	23	n/a
	Thrie Beam at Bridge Rail (curb exposed)[3]	Approach End	22	n/a
		Trailing End (two-way traffic only)	22	n/a
	Weak Post Intersection Design (see 1610.06(7)(b), Cases 12 & 13)		5	Exhibit 1610-6
Concrete Barrier	Rigid Restrained		21, 4[4]	Exhibit 1610-6
	Unrestrained		2, 4[4]	A
Weak Post Barrier Systems (Type 20 and 21)			6	n/a
Rigid Structures such as Bridge Piers	New Installation (see Cases 11–31)		21	n/a
	Existing W-Beam Transition		[2]	n/a
Connecting Thrie Beam Guardrail to:			**Transition Type***	**Connection**
Bridge Rail or Concrete Barrier	New Installation (example: used with thrie beam bull nose)		1B	Exhibit 1610-6

*Consult Section C of the *Standard Plans* for details on transition types.

Notes:

[1] If work creates the need for reconstruction or resetting of the transition, upgrade as shown above. Raising the guardrail is not considered reconstruction. If the transition is not being reconstructed, the existing connection may remain in place. When Type 3 anchors are encountered, see 1610.06(5)(e) for guidance.

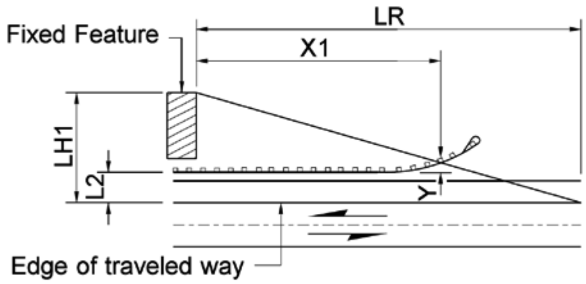
[2] For new/reconstruction, use Case 11 (thrie beam). For existing Case 11 with W-beam, add a second W-beam rail element.

[3] For Service Level 1 bridge rail, see 1610.06(7)(b), Case 14.

[4] Use on highways with speeds 45 mph or below.

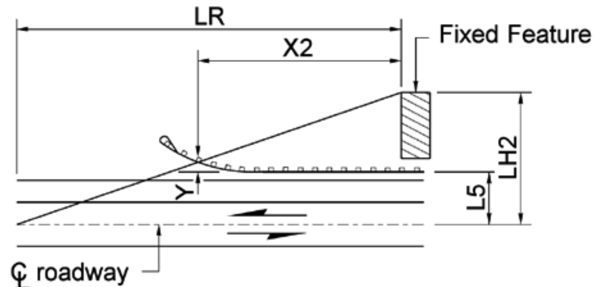
[5] If existing transition has the needed guardrail height—three 10″ x 10″ (nominal) posts and three 6″ x 8″ (nominal) posts spaced 3′-1.5″ apart—it is acceptable to nest existing single W-beam element transitions.

Transitions and Connections
Exhibit 1610-9



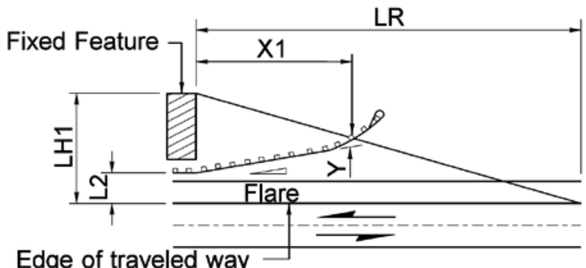
$$X1 = \frac{LH1 - (L2+Y)}{(LH1/LR)}$$

Adjacent-Side Fixed Feature
Barrier Parallel to Roadway



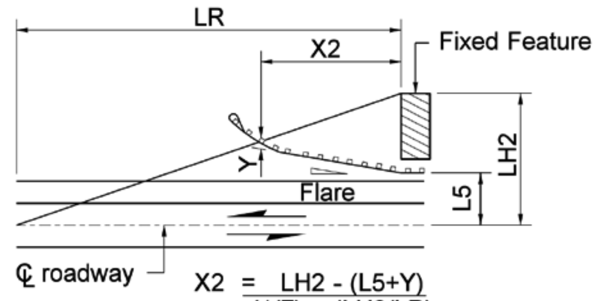
$$X2 = \frac{LH2 - (L5+Y)}{(LH2/LR)}$$

Opposite-Side Fixed Feature
Barrier Parallel to Roadway



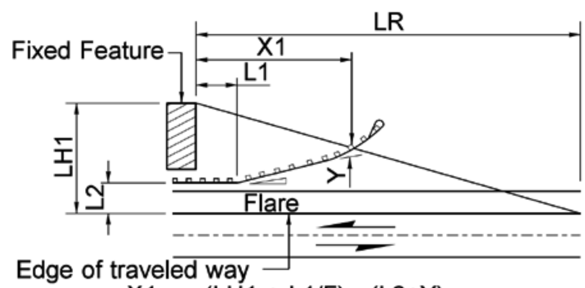
$$X1 = \frac{LH1 - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Fixed Feature
Barrier Flare Begins at Fixed Feature



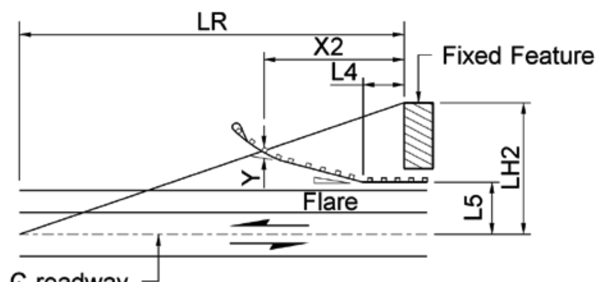
$$X2 = \frac{LH2 - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Fixed Feature
Barrier Flare Begins at Fixed Feature



$$X1 = \frac{(LH1 + L1/F) - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Fixed Feature
Barrier Flare Begins Before Fixed Feature



$$X2 = \frac{(LH2 + L4/F) - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Fixed Feature
Barrier Flare Begins Before Fixed Feature

Note:
For supporting length of need equation factors, see Exhibit 1610-10b.

Barrier Length of Need on Tangent Sections
Exhibit 1610-10a

Posted Speed (mph)	Design Parameters						
	ADT				Barrier Type		
	Over 10,000	5,000 to 10,000	1,000 to 4,999	Under 1,000	Rigid Barrier	Unrestrained Barrier	Semirigid Barrier
	LR (ft)	LR (ft)	LR (ft)	LR (ft)	F	F	F
65 & 70	460	395	345	295	20	18	15
60	360	295	260	230	18	16	14
55	310	260	230	195	16	14	12
50	260	215	180	165	14	12	11
45	245	195	165	150	12	11	10
40	215	180	150	130	11	10	9
35	185	155	130	115	11	10	9
30	165	135	115	105	11	10	9
25	150	125	105	95	11	10	9

L1 = Length of barrier parallel to roadway from adjacent-side 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.

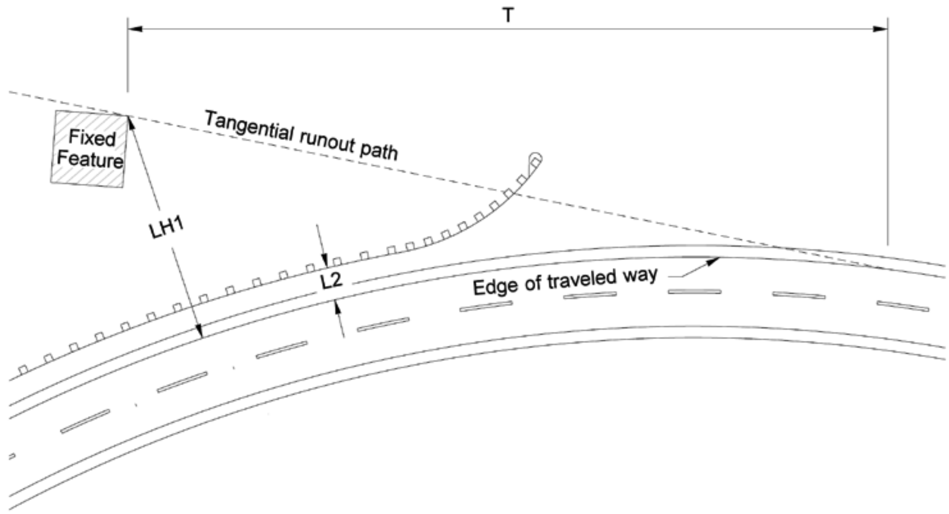
Y = Offset distance needed at the beginning of the length of need.

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 nonflared terminals or impact attenuator systems. Use Y = 0.
- Buried terminal end treatments are used with barrier flares and have no offset. Use Y = 0.

Barrier Length of Need

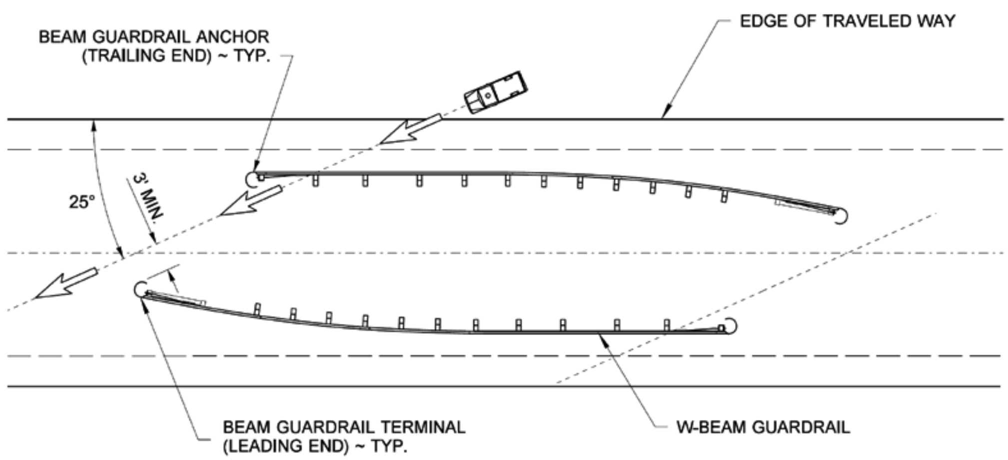
Exhibit 1610-10b



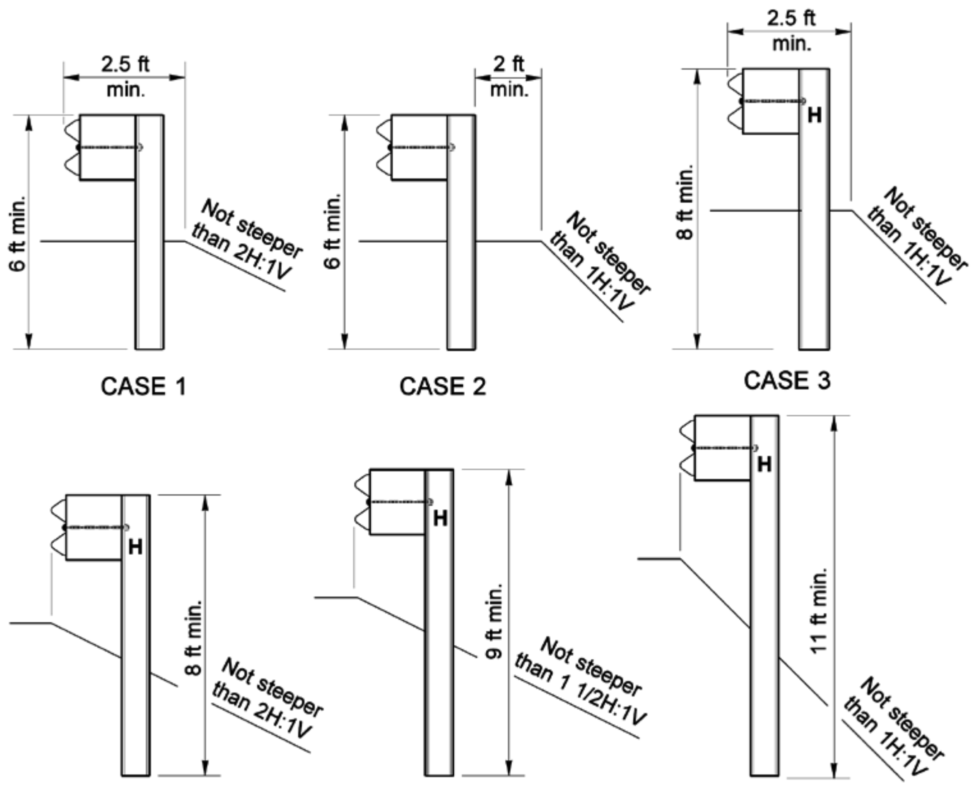
Notes:

- 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 1610-10b and use the shorter value.
- If using LR, follow Exhibits 1610-10a and 10b.
- If using T, draw the intersecting barrier run to scale and measure the length of need.

Barrier Length of Need on Curves
Exhibit 1610-10c



W-Beam Guardrail Trailing End Placement for Divided Highways
Exhibit 1610-10d

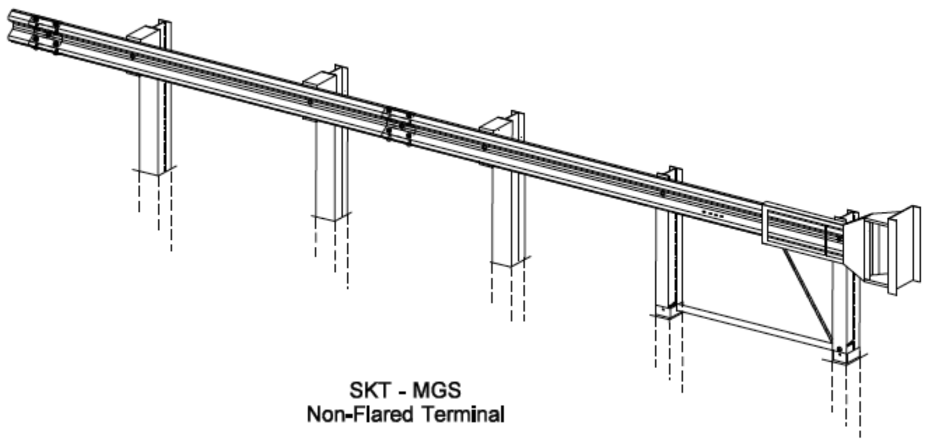


Type 31 Shown

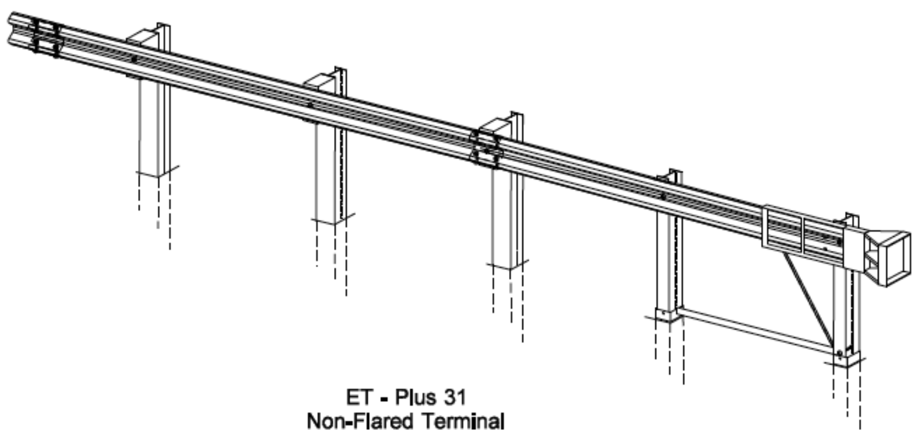
Notes:

- Use Cases 1 and 3 when there is a 2.5-foot or greater shoulder widening from face of guardrail to the breakpoint.
- Use Case 2 when there is a 4.0-foot or greater shoulder widening from the face of the guardrail to the breakpoint.
- Use Cases 4, 5, and 6 when there is less than a 2.5-foot shoulder widening from face of guardrail to the breakpoint.

Beam Guardrail Post Installation
Exhibit 1610-11

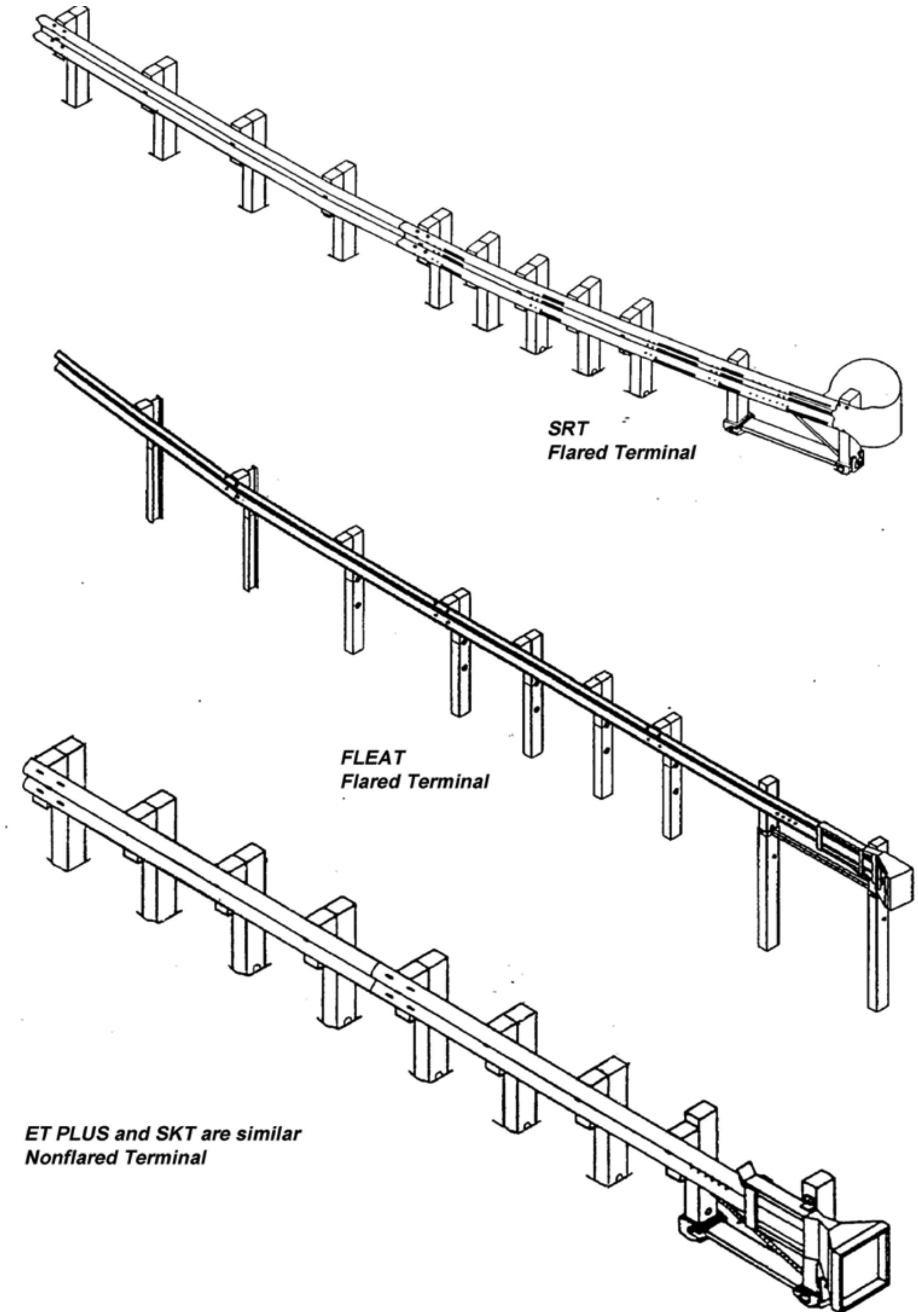


SKT - MGS
Non-Flared Terminal

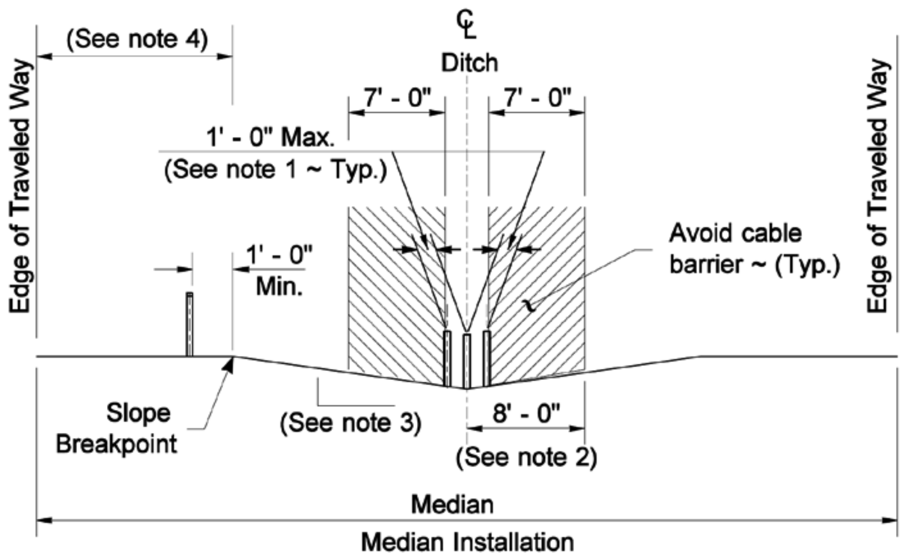


ET - Plus 31
Non-Flared Terminal

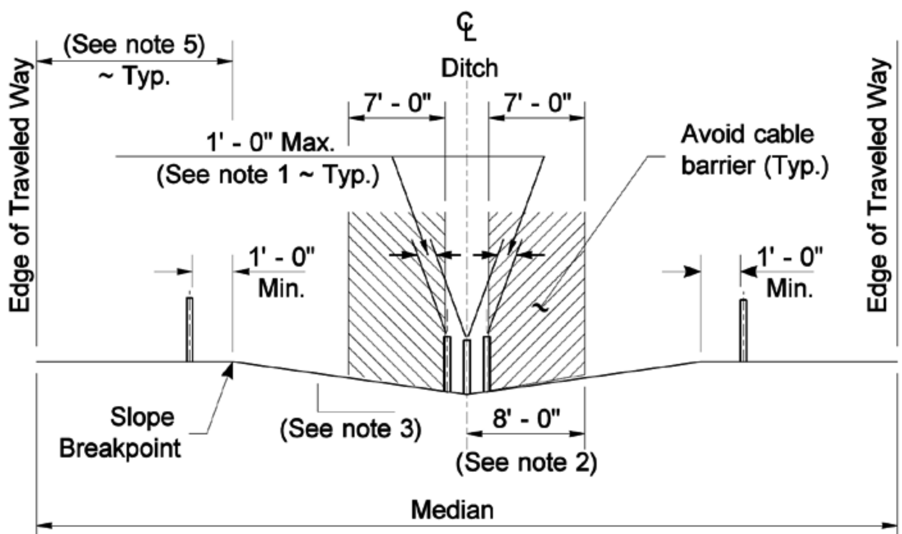
Beam Guardrail Terminals
Exhibit 1610-12a



Beam Guardrail Terminals
Exhibit 1610-12b



Median Installation
(Single Run)



Median Installation
(Double Run)

Notes:

[1] Cable barrier may be installed in the center of the ditch. The cable barrier may be offset from the ditch centerline a maximum of 1 foot in either direction.

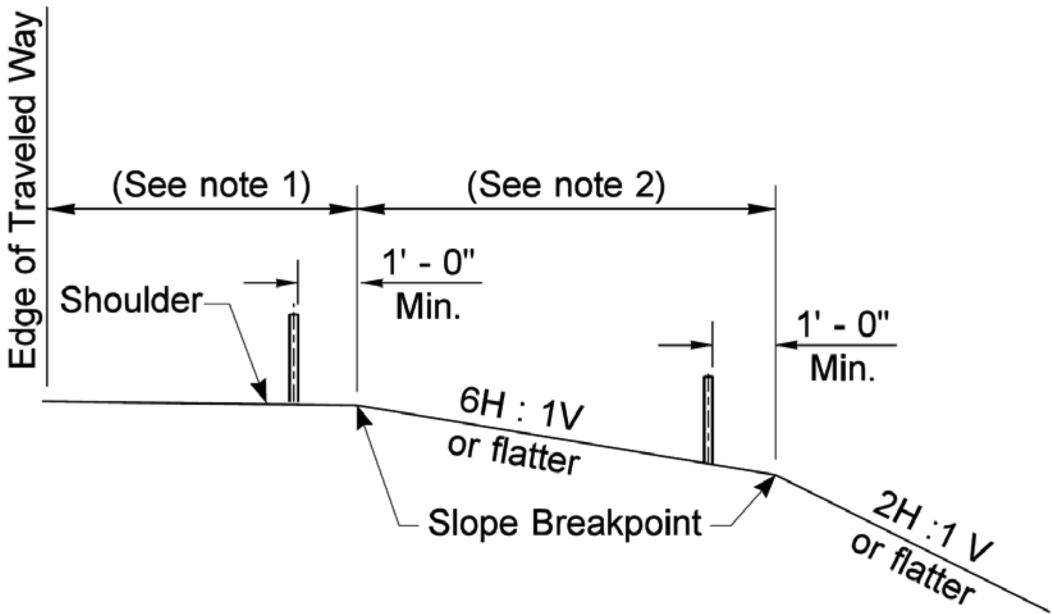
[2] Avoid installing cable barrier within a 1-foot to 8-foot offset from the ditch centerline.

[3] Applies to slopes between 10H:1V and 6H:1V.

[4] For single-runs of cable median barrier, with at least 13 feet from edge of the nearest traveled lane to the slope breakpoint, place the cable median barrier at least 1 foot in front of the slope breakpoint. Any approved four-cable high-tension barrier system may be used in this location.

[5] Double runs of cable barrier are typically not needed. However, if used in situations with at least 11 feet from edge of the nearest traveled lane to the slope breakpoint, place the cable median barrier at least 1 foot in front of the slope breakpoint. Any approved four-cable high-tension barrier system may be used in this location.

Cable Barrier Locations on Median Slopes
Exhibit 1610-13a



Shoulder Installation

Notes:

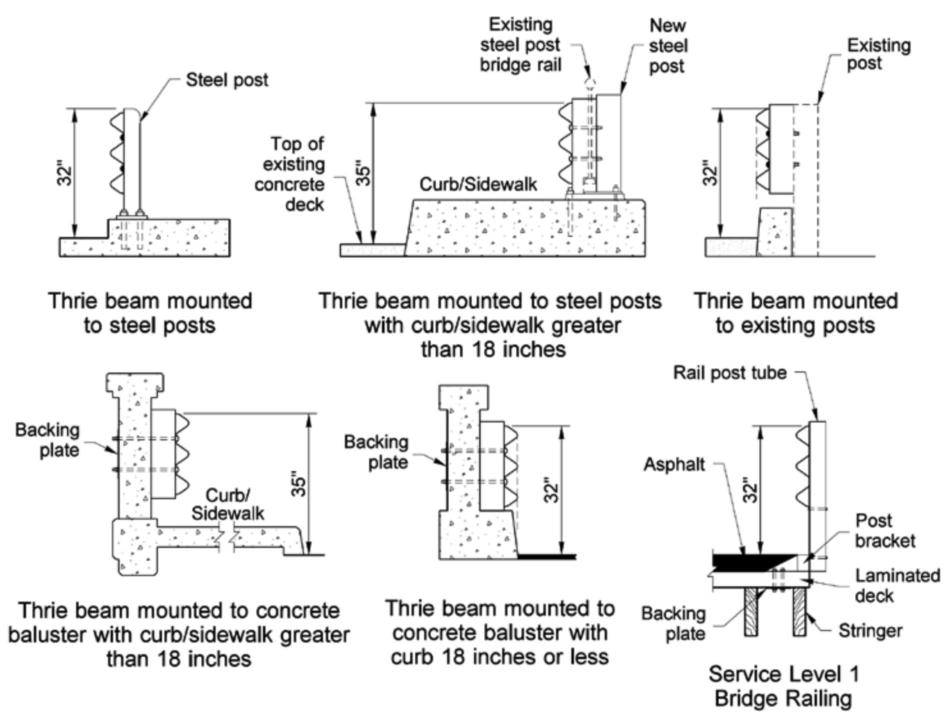
[1] Any approved four-cable high-tension barrier system may be used in this location.

[2] Use an approved four-cable high-tension cable barrier system within the acceptable locations shown between slope breakpoints.

Cable Barrier Locations on Shoulder Slopes

Exhibit 1610-13b

Curb Width	Bridge Width	Concrete Bridge Deck		Wood Bridge Deck or Low-Strength Concrete Deck
		Concrete Bridge Rail (existing)	**Steel or Wood Post Bridge Rail (existing)**	
<18 inches		Thrie beam mounted to existing bridge rail[2] and blocked out to the face of curb. Height = 32 inches	Thrie beam mounted to steel posts[2] at the face of curb. Height = 32 inches	• Service Level 1 Bridge Rail[2] • Height = 32 inches • Curb or wheel guard needs to be removed
>18 inches	**> 28 ft (curb to curb)**	Thrie beam mounted to steel posts[2] at the face of curb.[1] Height = 32 inches		
>18 inches	**< 28 ft (curb to curb)**	Thrie beam mounted to existing bridge rail.[2] Height = 35 inches	Thrie beam mounted to steel posts[2] in line with existing rail. Height = 35 inches	



Notes:

[1] Where needed, thrie beam may be mounted to the bridge rail to accommodate pedestrians (height = 35 inches).

[2] Contact the HQ Bridge and Structures Office for design details on bridge rail retrofit projects.

Thrie Beam Rail Retrofit Criteria
Exhibit 1610-14

Chapter 1620 Impact Attenuator Systems

1620.01 General

Impact attenuator systems are protective systems that help aid an errant vehicle from impacting an object by either gradually decelerating the vehicle to a stop when hit head-on or by redirecting it away from the feature when struck on the side. These barriers are used for rigid objects or other features that cannot be removed, relocated, or made breakaway.

Approved systems are shown in Exhibits 1620-2a through 1620-4b and on the Washington State Department of Transportation (WSDOT) Headquarters (HQ) Design Office web page: www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

Approved systems shall meet standardized testing defined in NCHRP Report 350 or the *Manual for Assessing Safety Hardware* (MASH). In addition, these devices shall have an acceptance letter from FHWA that documents that the device meets the appropriate crash test criteria and can be used on the National Highway System (NHS).

(1) Permanent Installations

For systems used in permanent installations, a description of the system's purpose, parts, and function, as well as transition needs, foundation, and slope, are provided as follows and in Exhibit 1620-5.

(a) **Crash Cushion Attenuating Terminal (CAT-350)**

1. **Purpose:** The CAT-350 is an end treatment for W-beam guardrail. It can also be used for concrete barrier if a transition is provided.
2. **Description:** The system consists of slotted W-beam guardrail mounted on both sides of breakaway timber posts. Steel sleeves with soil plates hold the timber posts in place (see Exhibit 1620-2a).
3. **Function:** When hit head-on, the slotted guardrail is forced over a pin that shears the steel between the slots. This shearing dissipates the energy of the impact.
4. **Foundation:** Concrete footings or foundations are not needed.
5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Manufacturer/Supplier:** Trinity Industries, Inc.

(b) **Brakemaster 350**

1. **Purpose:** The Brakemaster 350 system is an end treatment for W-beam guardrail. It can also be used for concrete barrier if a transition is provided.
2. **Description:** The system contains an embedded anchor assembly, W-beam fender panels, transition strap, and diaphragm (see Exhibit 1620-2a).

3. **Function:** The system uses a brake and cable device for head-on impacts and for redirection. The cable is embedded in a concrete anchor at the end of the system.
4. **Foundation:** A concrete foundation is not needed for this system, but a paved surface is recommended.
5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Manufacturer/Supplier:** Energy Absorption Systems

(c) **QuadTrend 350**

1. **Purpose:** The QuadTrend 350 is an end treatment for 2-foot-8-inch-high concrete barriers. The system's short length allows it to be used at the ends of bridges where the installation of a beam guardrail transition and terminal is not feasible.
2. **Description:** This system consists of telescoping quadruple corrugated fender panels mounted on steel breakaway posts (see Exhibit 1620-2a).
3. **Function:** Sand-filled boxes attached to the posts dissipate a portion of the energy of an impact. An anchored cable installed behind the fender panels directs the vehicle away from the barrier end.
4. **Foundation:** The system is installed on a concrete foundation to support the steel posts.
5. **Slope:** A 6H:1V or flatter slope is needed behind the barrier to allow for vehicle recovery.
6. **Manufacturer/Supplier:** Energy Absorption Systems

(d) **Universal TAU-II**

1. **Purpose:** The Universal TAU-II crash cushion system is an end treatment for concrete barrier, beam guardrail, and fixed objects up to 8 feet wide.
2. **Description:** The system is made up of independent collapsible bays containing energy-absorbing cartridges that are guided and supported during a head-on hit by high-strength galvanized steel cables and thrie beam rail panels. Each bay is composed of overlapping thrie beam panels on the sides and structural support diaphragms on the ends. Structural support diaphragms are attached to two cables running longitudinally through the system and attached to foundations at each end of the system (see Exhibit 1620-2c).
3. **Function:** Overlapping panels, structural support diaphragms, cable supports, cables, and foundation anchors allow the system to resist angled impacts and mitigate head-on impacts.
4. **Foundation:** The system is installed on a concrete foundation or asphaltic concrete foundations conforming to the manufacturer's recommendations.
5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Manufacturer/Supplier:** Barrier Systems, Inc.

(e) **QuadGuard**

1. **Purpose:** The QuadGuard is an end treatment for concrete barrier and beam guardrail and is also used to mitigate fixed objects up to 10 feet wide.
2. **Description:** The system consists of a series of Hex-Foam cartridges surrounded by a framework of steel diaphragms and quadruple corrugated fender panels (see Exhibit 1620-2b).
3. **Function:** The internal shearing of the cartridges and the crushing of the energy absorption material absorb impact energy from end-on hits. The fender panels redirect vehicles impacting the attenuator on the side.
4. **Foundation:** The system is installed on a concrete foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the QuadGuard.
6. **Manufacturer/Supplier:** Energy Absorption Systems

(f) **QuadGuard Elite**

1. **Purpose:** The QuadGuard Elite is an end treatment for concrete barrier and beam guardrail and is also used for fixed objects up to 7 feet 6 inches wide.
2. **Description:** The system consists of telescoping quadruple corrugated fender panels mounted on both sides of a series of polyethylene cylinders (see Exhibit 1620-2b).
3. **Function:** The cylinders are compressed during a head-on impact and return to their original shape when the system is reset. It is anticipated that this system will need very few replacement parts or extensive repair.
4. **Foundation:** The system is installed on a concrete foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the QuadGuard Elite.
6. **Manufacturer/Supplier:** Energy Absorption Systems

(g) **Reusable Energy Absorbing Crash Terminal (REACT 350)**

1. **Purpose:** The REACT 350 is an end treatment for concrete barriers and is also used for fixed objects up to 3 feet wide.
2. **Description:** The system consists of polyethylene cylinders with varying wall thickness, redirecting cables, a steel frame base, and a backup structure (see Exhibit 1620-2d).
3. **Function:** The redirecting cables are anchored in the concrete foundation at the front of the system and in the backup structure at the rear of the system. When hit head-on, the cylinders compress, absorb the impact energy, and immediately return to much of their original shape, position, and capabilities. For side impacts, the cables restrain the system enough to help prevent penetration and redirect the vehicle. It is anticipated that this system will need very few replacement parts or extensive repair.

4. **Foundation:** The system is installed on a concrete foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the REACT 350.
6. **Manufacturer/Supplier:** Energy Absorption Systems

(h) **REACT 350 Wide**

1. **Purpose:** The REACT 350 Wide is a device that can be used to shield objects with widths up to 10 feet wide.
2. **Description:** The system consists of polyethylene cylinders with varying wall thickness, internal struts, space frame diaphragms, and a monorail (see Exhibit 1620-2d).
3. **Function:** When hit head-on, the cylinders compress, absorb the impact energy, and immediately return to much of their original shape, position, and capabilities. For side impacts, the system is designed to restrain and redirect the vehicle. It is anticipated that this system will need very few replacement parts or extensive repairs.
4. **Foundation:** The system is installed on a concrete foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the REACT 350 Wide.
6. **Manufacturer/Supplier:** Energy Absorption Systems

(i) **Inertial Barrier**

Inertial barrier configurations are shown in the *Standard Plans*. If a situation is encountered where the configurations in the *Standard Plans* are not appropriate, contact the HQ Design Office for further information.

1. **Purpose:** Inertial barrier is an end treatment for concrete barrier and is used to mitigate fixed objects. This system does not provide redirection from a side impact.
2. **Description:** This system consists of an array of plastic containers filled with varying weights of sand (see Exhibit 1620-2d).
3. **Function:** The inertial barriers slow an impacting vehicle by the transfer of the momentum of the vehicle to the mass of the barrier. This system is not suitable where space is limited to less than the widths shown in the *Standard Plans*. Whenever possible, align inertial barriers so that an errant vehicle deviating from the roadway by 10° would be on a parallel path with the attenuator alignment (see the *Standard Plans*). In addition, inertial barriers do not provide any redirection and are not appropriate where high-angle impacts are likely.

If it is anticipated that a large volume of traffic will be traveling at speeds higher than the posted speed limit, then the next larger unit may be specified.

For a comparison summary of space and initial cost information related to the impact attenuator systems, see Exhibit 1620-5.

When maintenance costs are considered, anticipate the average annual impact rate. If few impacts are anticipated, lower-cost devices such as inertial barriers might meet the need. Inertial barriers have the lowest initial cost and initial site preparation. However, maintenance will be costly and necessary after each impact. Labor and equipment are needed to clean up the debris and install new containers (barrels). Also, inertial barriers are not be used where flying debris might be a danger to pedestrians.

The REACT 350 and the QuadGuard Elite have a higher initial cost, requiring substantial site preparation, including a backup or anchor wall in some cases and cable anchorage at the front of the installation. However, repair costs are comparatively low, with labor being the main expense. Maintenance might not be needed after minor side impacts with these systems.

For new installations where at least one impact is anticipated per year, limit the selection of impact attenuators to the low-maintenance devices. The QuadGuard Elite and REACT 350 are considered to be low-maintenance devices. Consider upgrading existing ADIEM, G-R-E-A-T, and Hex-Foam impact attenuators with these low-maintenance devices when the repair history shows one to two impacts per year over a three- to five-year period.

Approved attenuator systems that have little or no performance history in Washington State may be considered for trial service as low-maintenance devices if their usage has concurrence from the HQ Design Office and the Area Maintenance Superintendant, or a designated contact, responsible for maintaining the device. Product vendors or distributors are responsible for obtaining the concurrence from HQ Design Office representatives. Attenuators selected for trial service as low-maintenance devices will:

- Be approved for use in Washington State (see 1620.01).
- Have been in use in other states for a minimum of six months.
- Have a point of contact and documented repair cost data from other states representing at least five impacts as a basis for the repair costs.
- Be limited to no more than four devices under the trial service clause.

Permanent status as a low-maintenance device will be considered after reviewing repair costs once a system has obtained a minimum of five impacts, provided the collision repair history includes side impacts and leading end impacts.

In selecting a system, one consideration is how dangerous it will be for the workers making repairs. In areas with high exposure to danger, a system that can be repaired quickly is most desirable. Some systems need nearly total replacement or replacement of critical components (such as cartridges or braking mechanisms) after a head-on impact, while others simply need resetting.

It is very important to consider that each application is unique when selecting impact attenuators for use in particular applications. This applies to both permanent and temporary installations. When specifying the system or systems that can be used at a specific location, the list shown in Exhibit 1620-5 is to be used as a starting point.

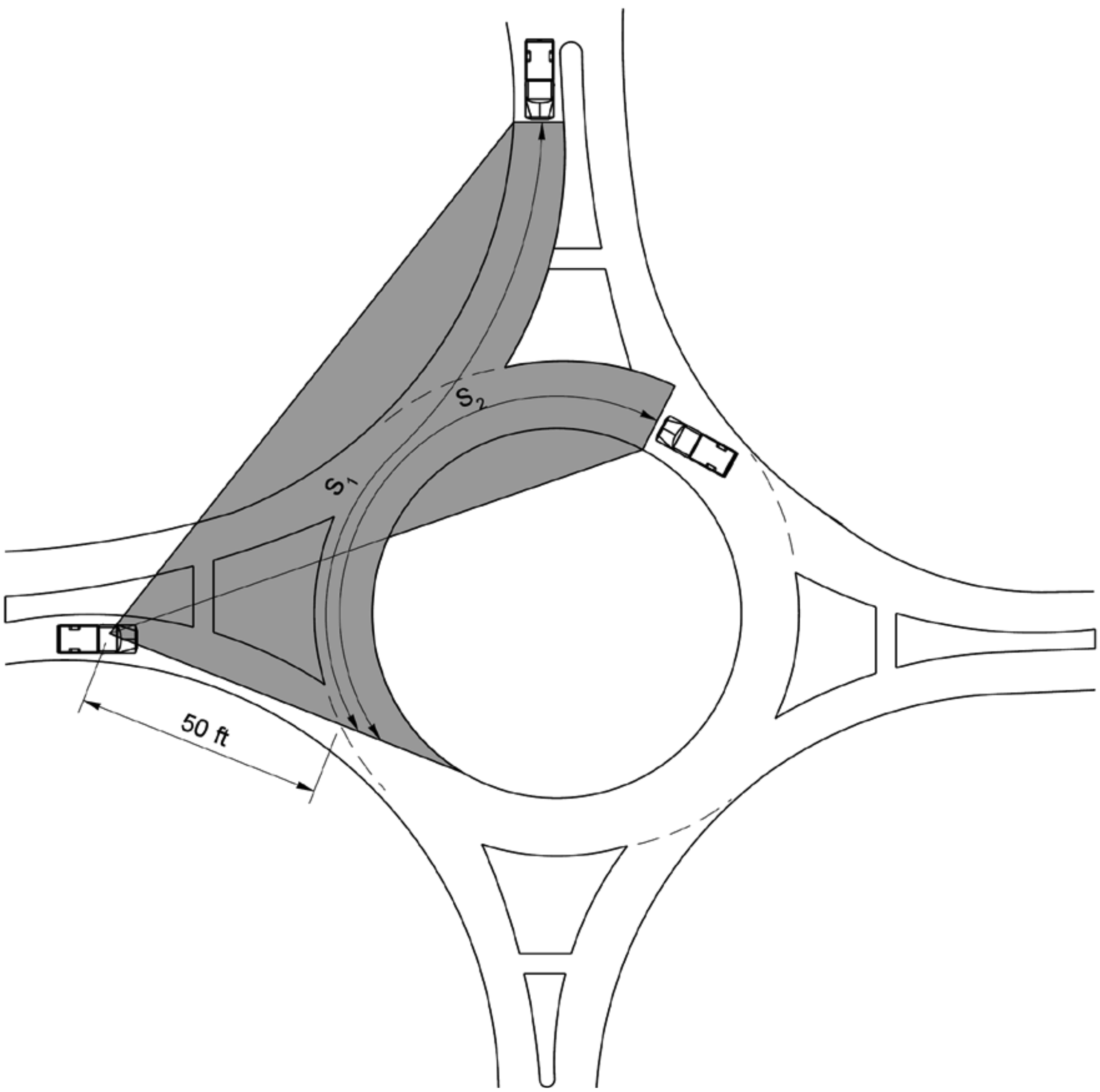
As the considerations discussed previously are analyzed, inappropriate systems may be identified and eliminated from further consideration. Systems that are not eliminated may be appropriate for the project. When the site conditions vary, it might be necessary to have more than one list of acceptable systems within a contract. Systems are not to be eliminated without documented reasons. Also, wording such as "or equivalent" is not to be used when specifying these systems. If only one system is found to be appropriate, then approval from the Assistant State Design Engineer of a public interest finding for the use of a sole source proprietary item is needed.

When a transition to connect with a concrete barrier (see Exhibit 1620-5) is needed, the transition type and connection are to be specified and are included in the cost of the impact attenuator. (See Chapter 1610 for information on the transitions and connections to use.)

Contractors can be given more flexibility in the selection of work zone (temporary) systems, since long-term maintenance and repair are not a consideration.

1620.04 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/

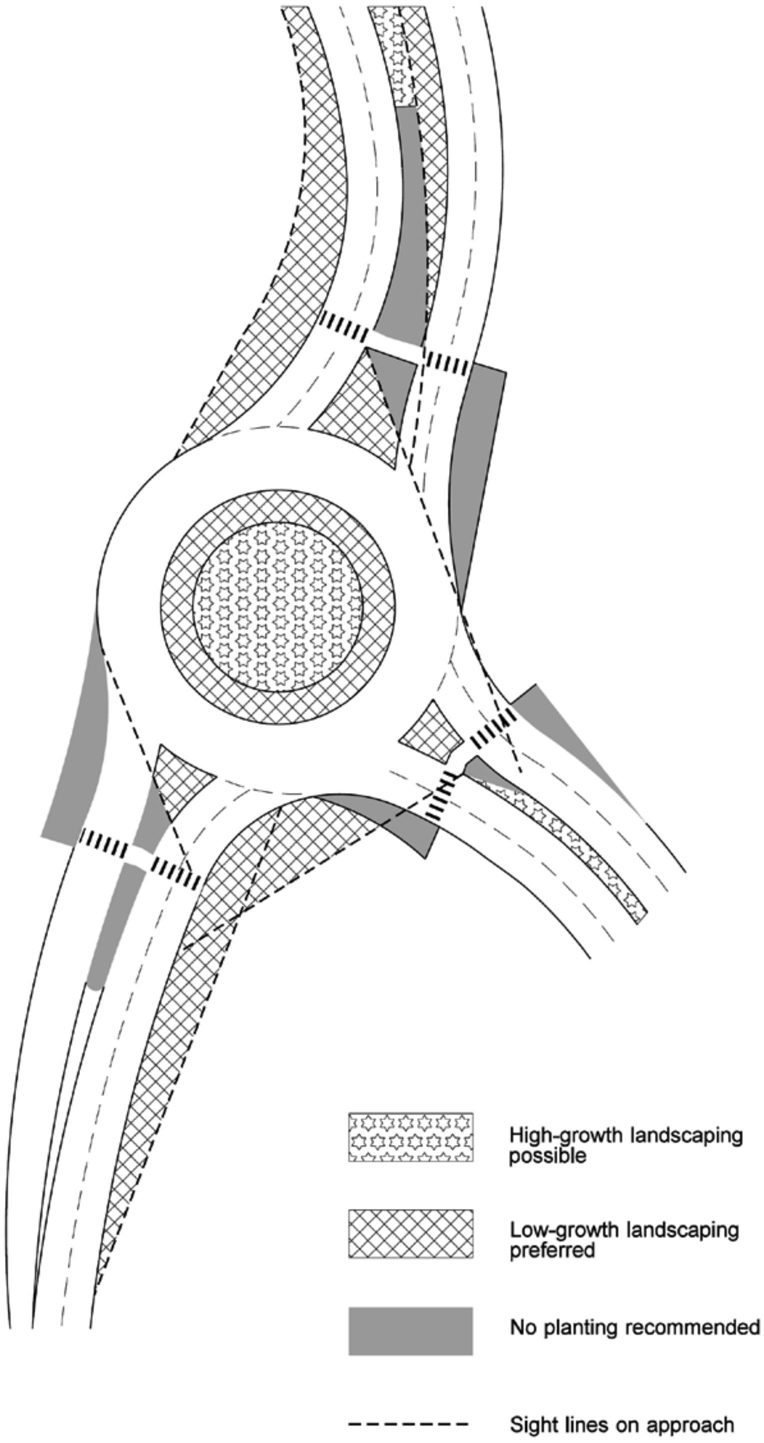


S_1 = Entering stream sight distance

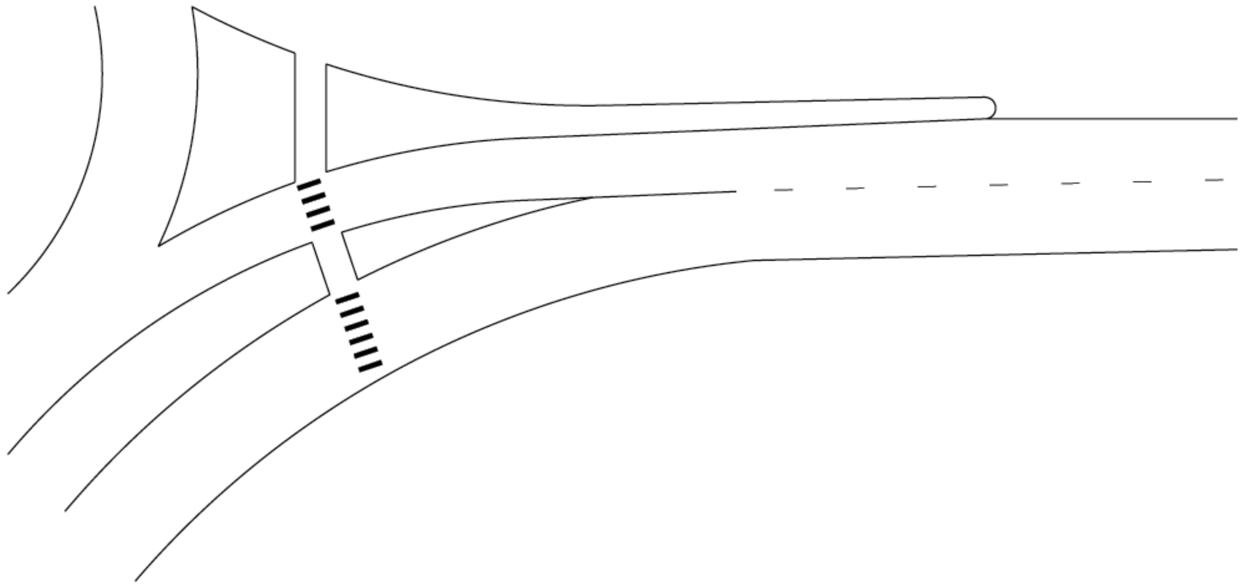
S_2 = Circulating stream sight distance

Intersection Sight Distance

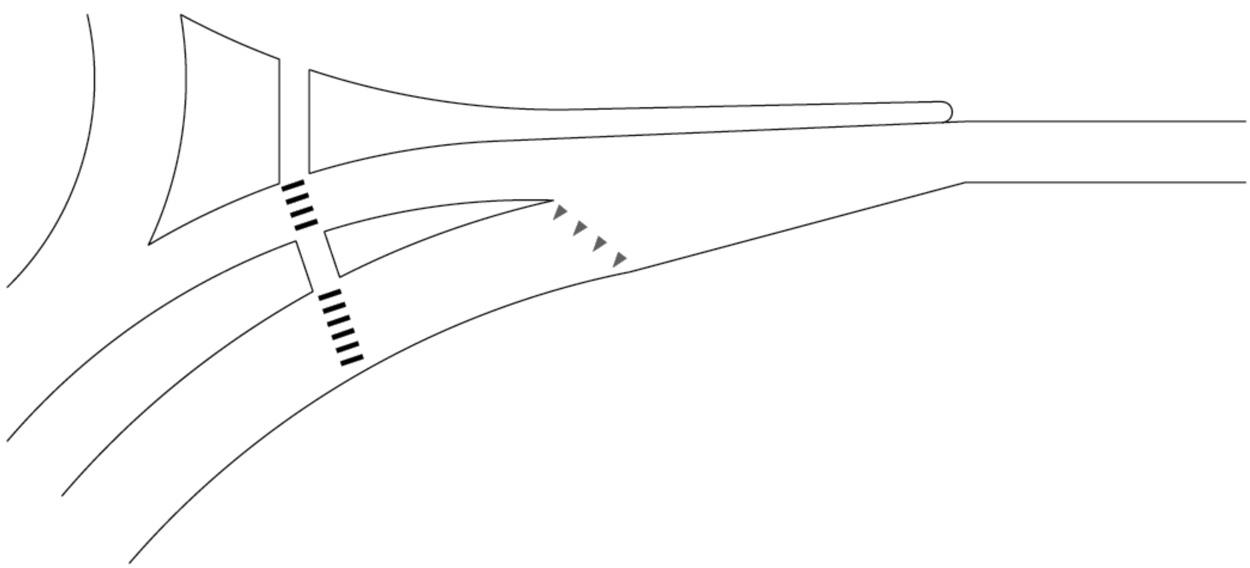
Exhibit 1320-24



Landscaping Height Restrictions for Intersection Sight Distance
Exhibit 1320-25

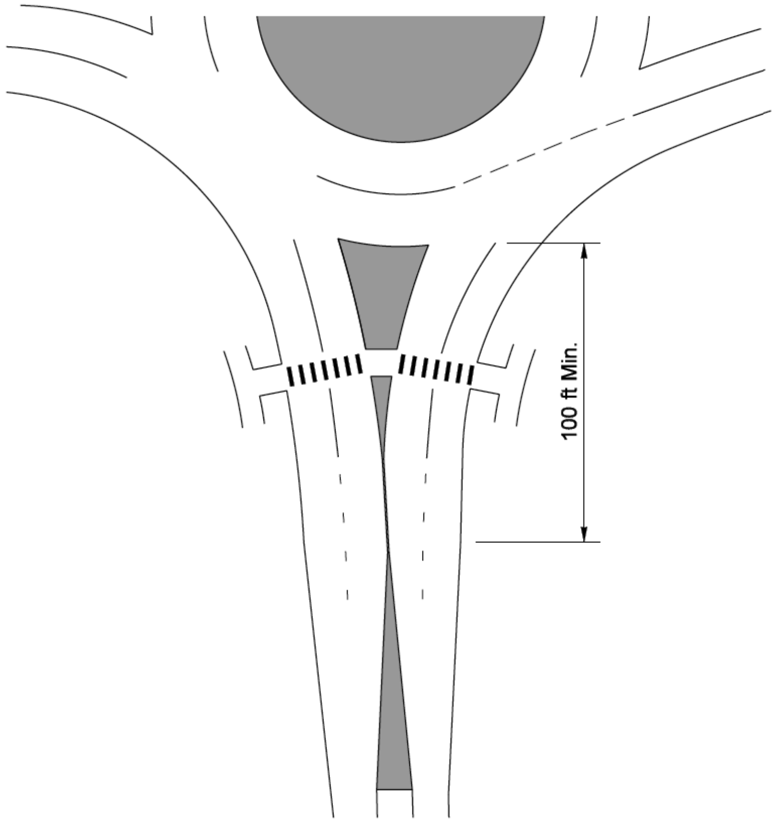


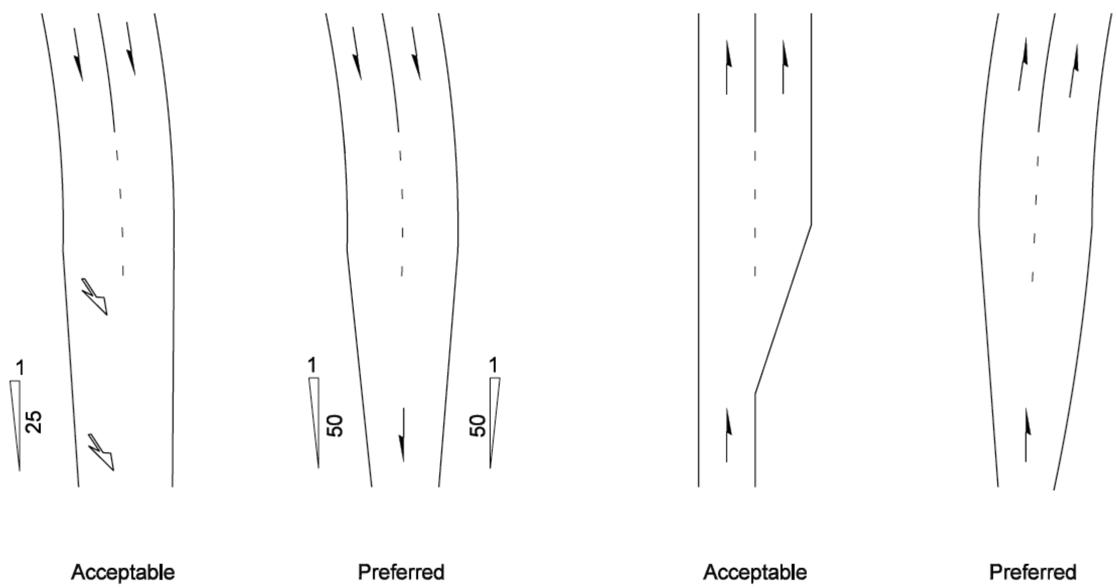
Merge Termination



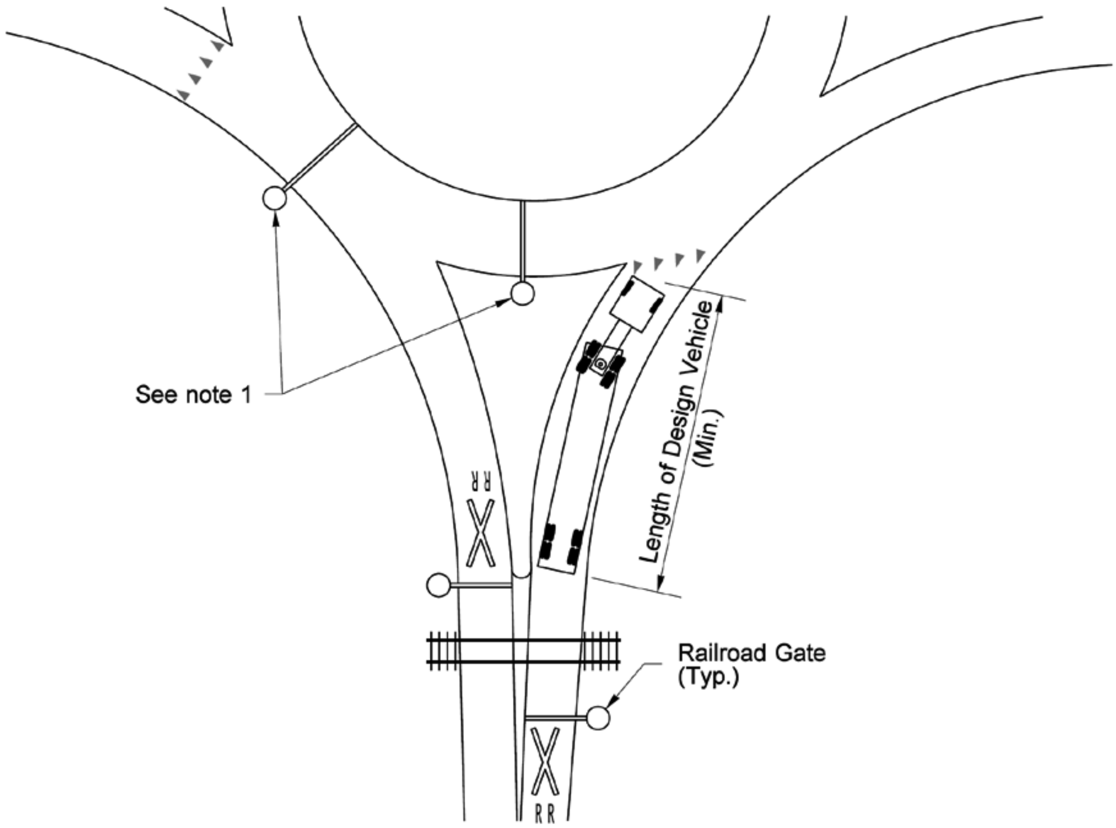
Yield Termination

Right-Turn Slip Lane Termination
Exhibit 1320-26





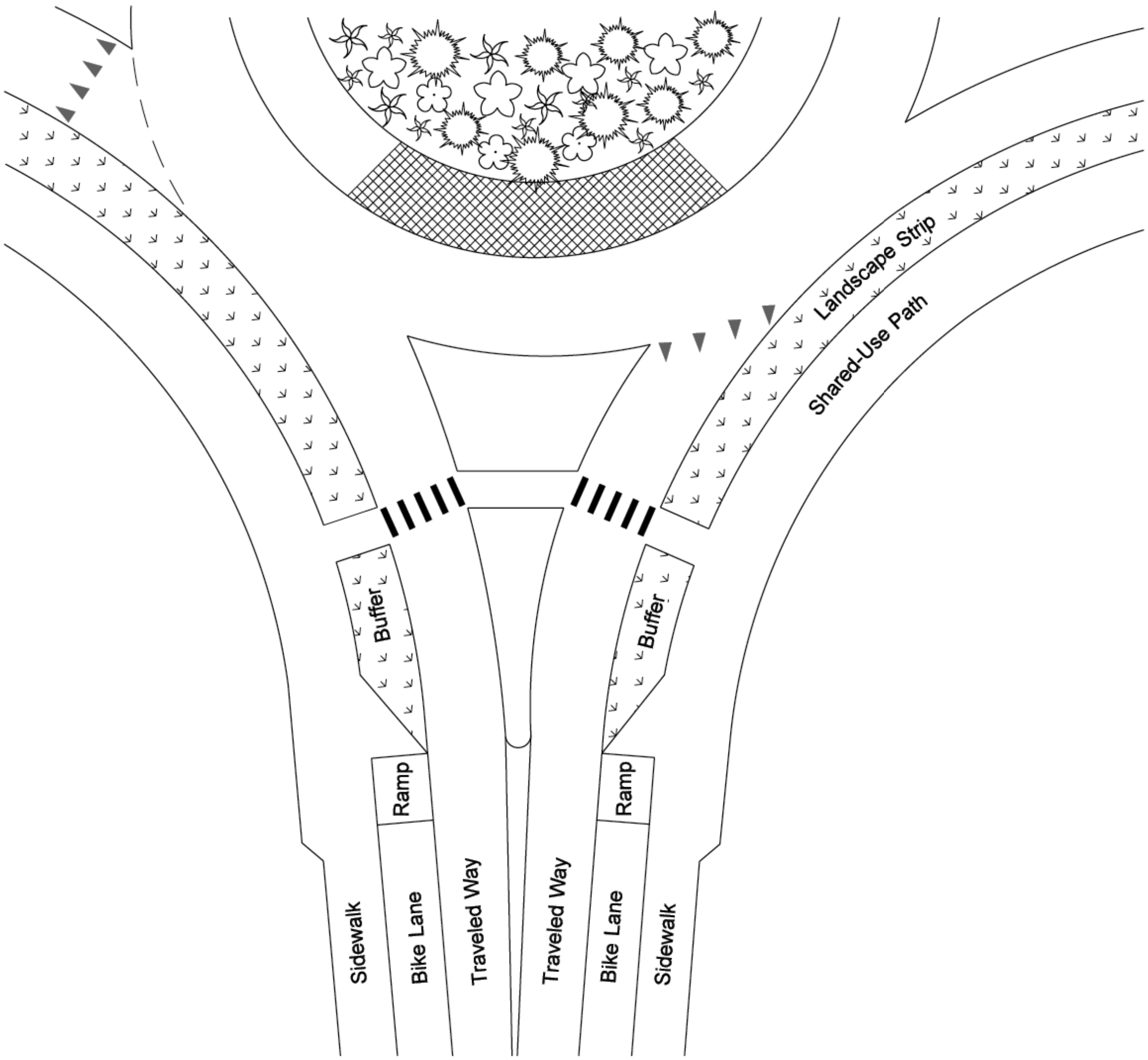
Add and Drop Lanes
Exhibit 1320-27



Note:

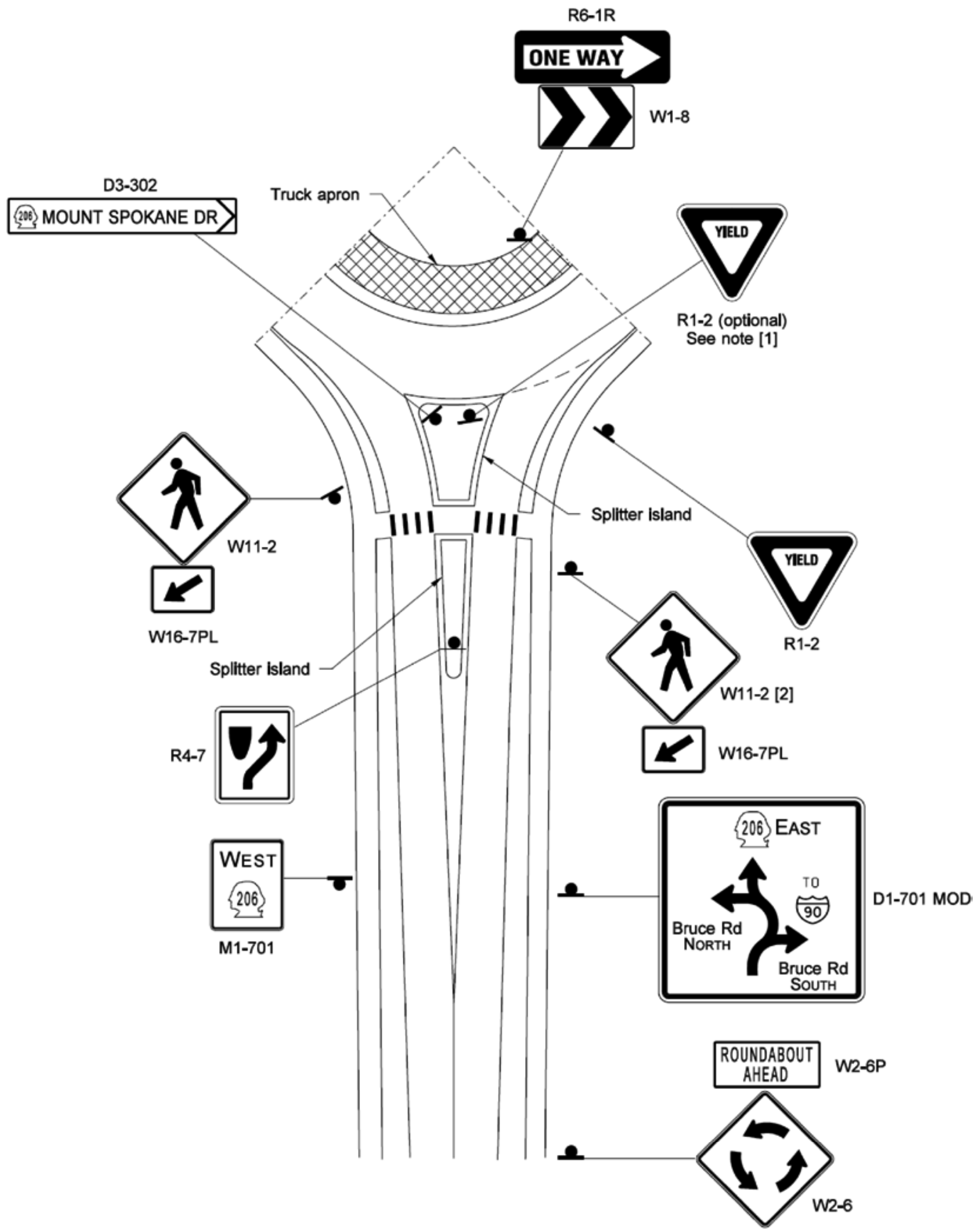
[1] Use the intersection analysis and site-specific conditions to help determine the need for, and optimum placement of, a gate on the circulating roadway (see 1320.06(3)(k))

Railroad Gate Configuration
Exhibit 1320-28



Note:
For pedestrian and bicycle design guidance, see Chapters 1510 and 1520.

Bicycle Lanes
Exhibit 1320-29



Notes:

[1] Provide on two-lane entries; consider when view of right-side sign might become obstructed.

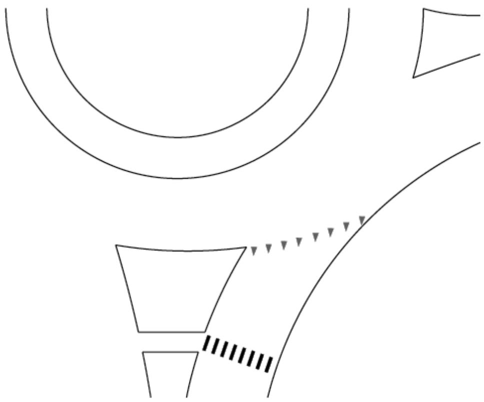
[2] Locate in such a way as to not obstruct view of yield sign.

General:

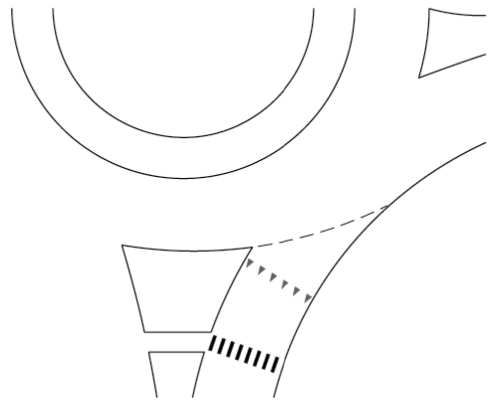
For additional information on sign installation, see Chapter 1020.

Roundabout Signing

Exhibit 1320-30



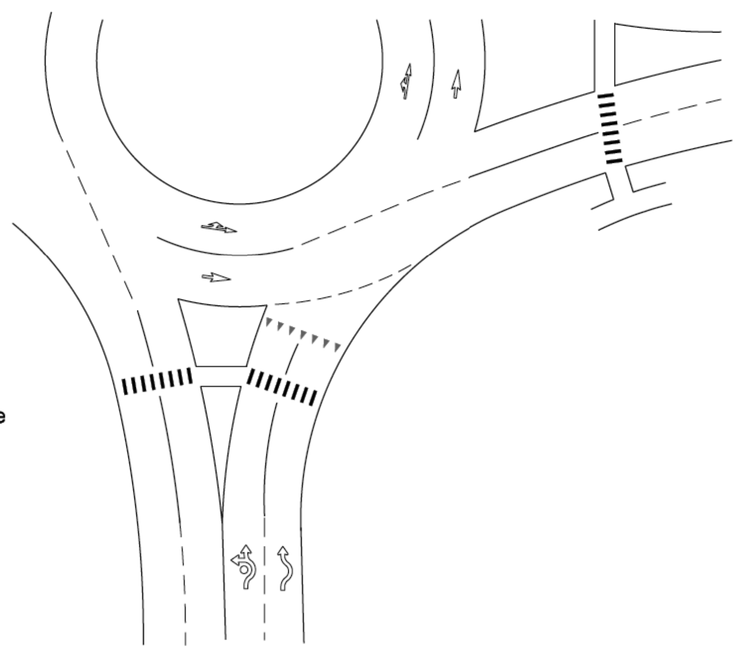
Single-Lane Striping
Option 1



Single-Lane Striping
Option 2

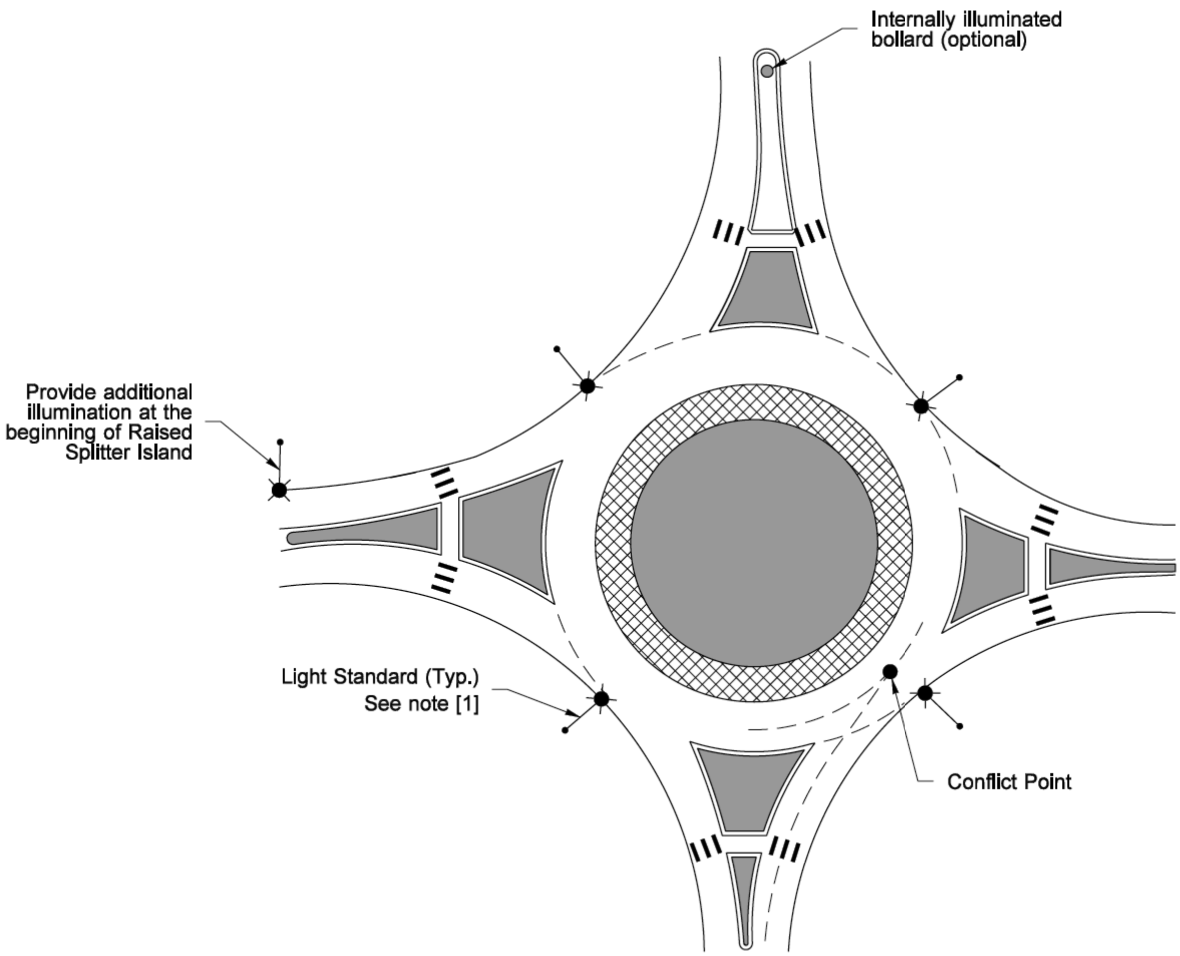
Note:

For Single and Multilane Roundabouts use Option 1 or Option 2 for placement of "yield symbols" at or near entry line.



Multilane Striping

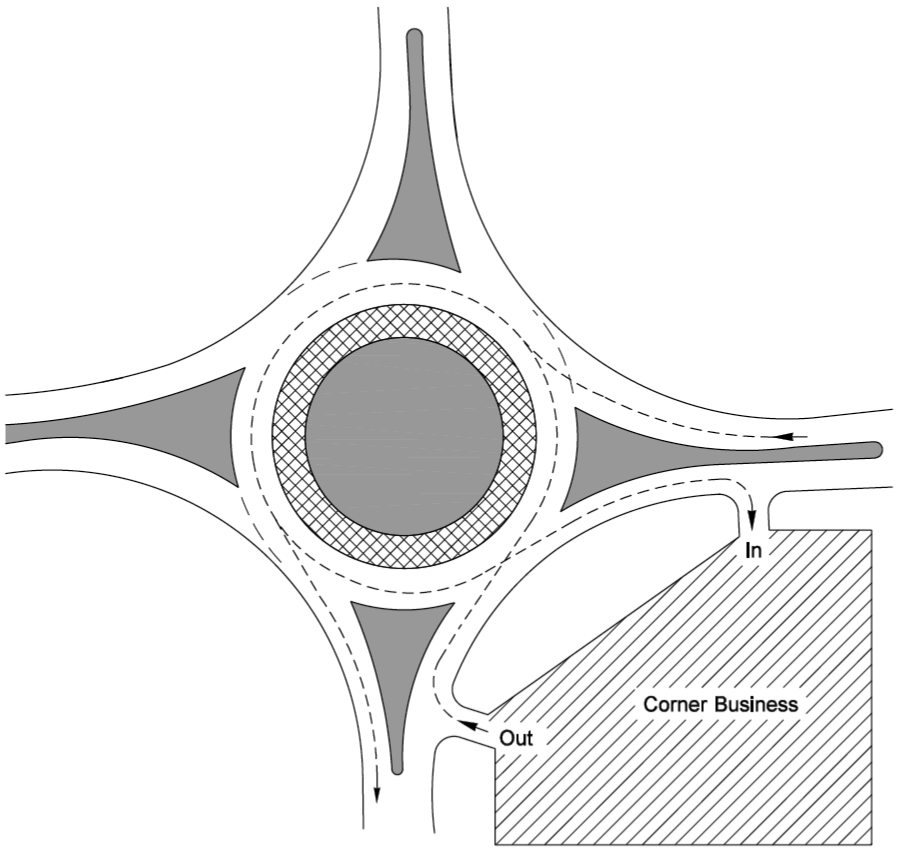
Roundabout Striping and Pavement Marking
Exhibit 1320-31



Note:

[1] Consider additional lighting for walkways and crosswalks to provide visibility for pedestrians. Also use to provide illumination of the roadway behind the pedestrian from the driver's perspective.

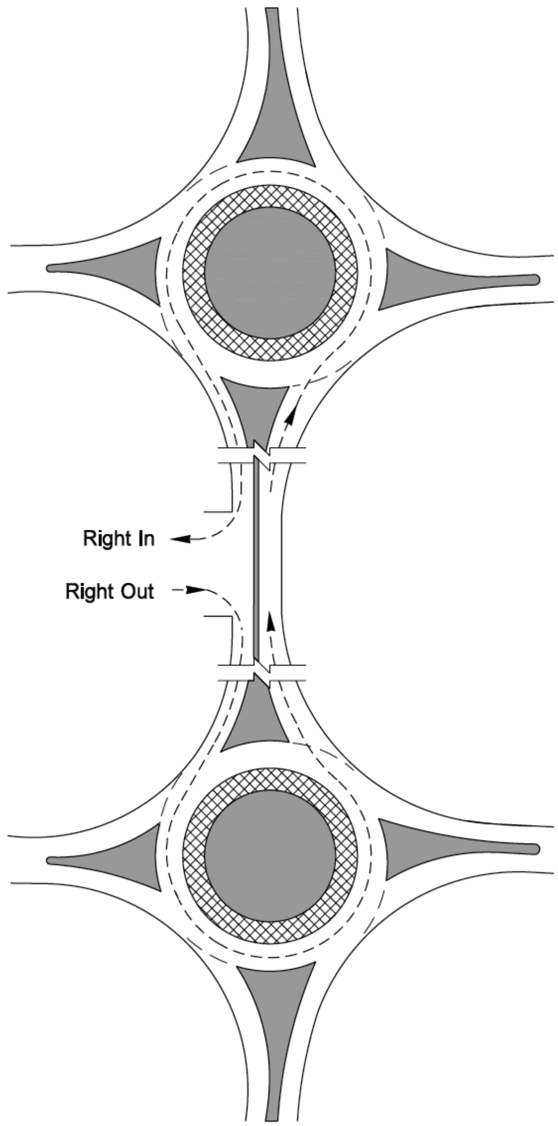
Roundabout Illumination
Exhibit 1320-32



Notes:

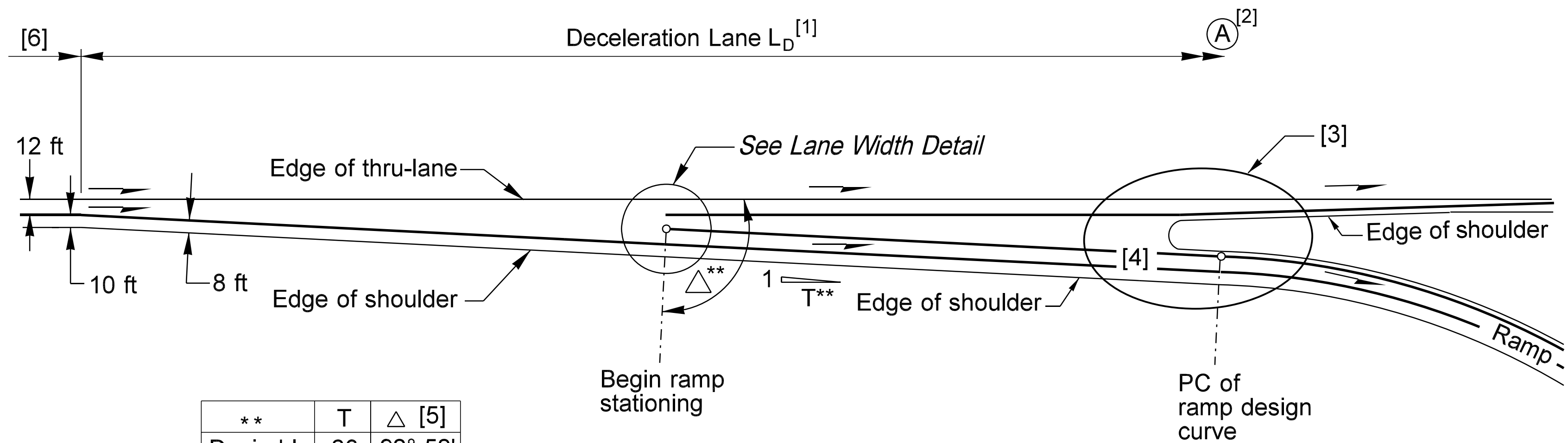
- For additional restrictions on limited access highways, see Chapter 530.
- For corner clearance criteria on managed access highways, see Chapter 540.

Multiple Access Circulation
Exhibit 1320-33a

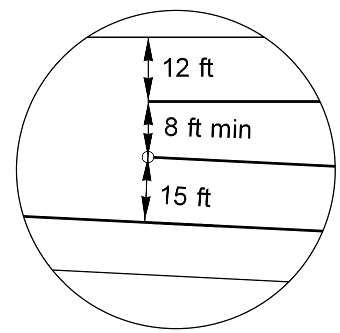


Left-turn access between roundabouts using U-turns at the roundabouts.

Multiple Access Circulation
Exhibit 1320-33b



**	T	△ [5]
Desirable	20	92° 52'
Minimum	15	93° 49'



Lane Width Detail

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] For ramp lane and shoulder widths, see Exhibit 1360-6.

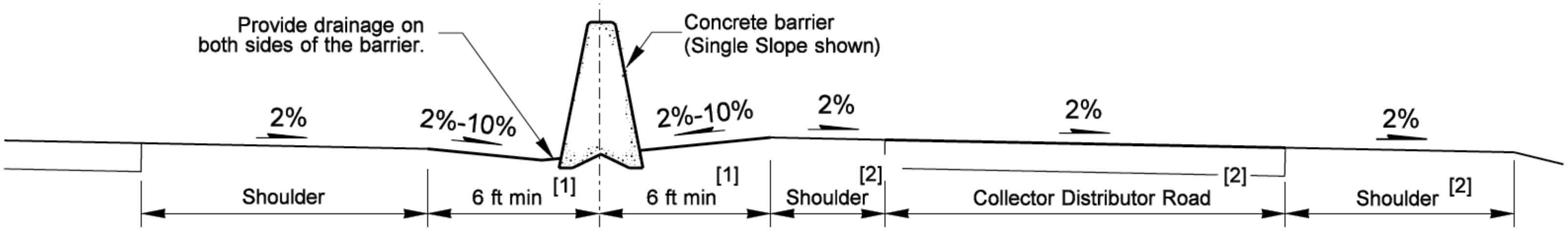
[5] Approximate angle to establish ramp alignment.

[6] Auxiliary lane between closely spaced interchanges to be dropped.

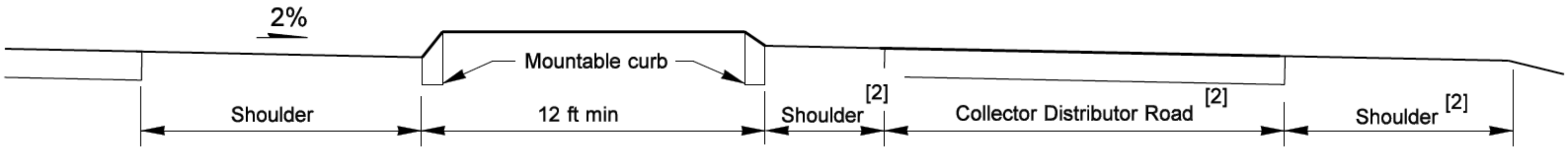
General:

For striping, see the *Standard Plans*.

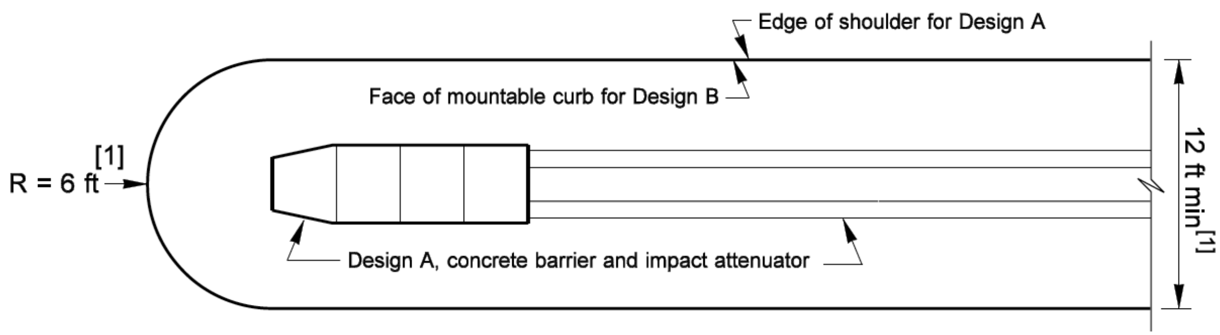
Off-Connection: Single-Lane, One-Lane Reduction
Exhibit 1360-14c



Design A



Design B
(For facilities with speeds of 40 MPH or less, only)



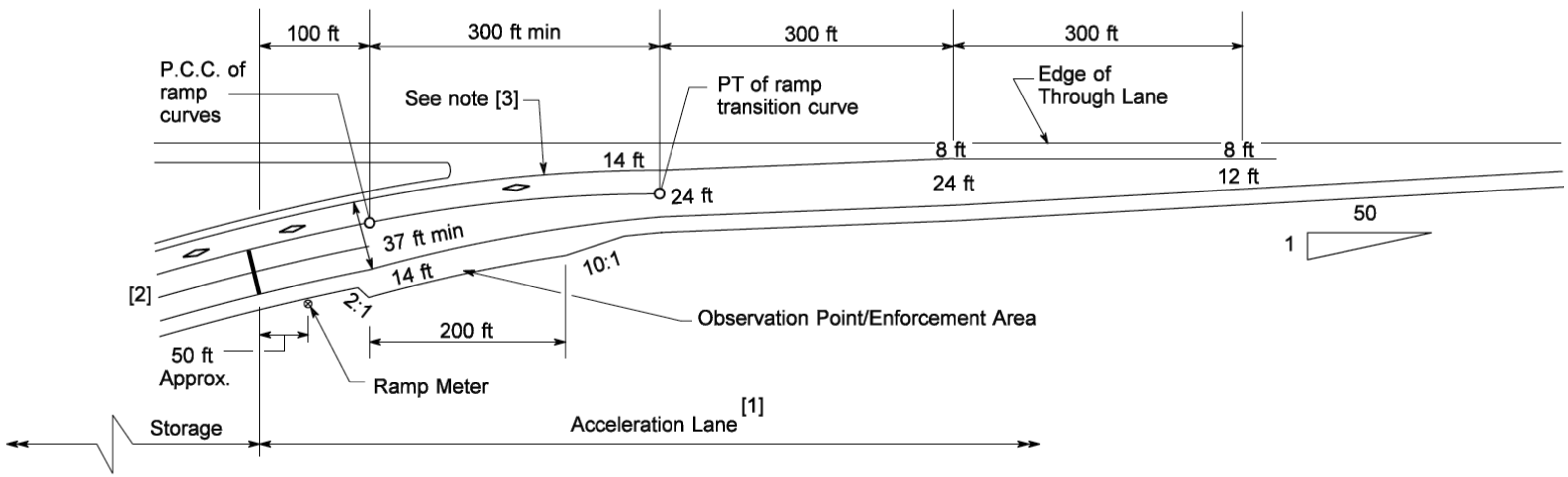
Notes:

[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.

Collector-Distributor: Outer Separations

Exhibit 1360-15a



Notes:

[1] For acceleration lane length, see Chapter 1360.

[2] For 2-lane ramp lane and shoulder widths, see Chapters 1240 and 1360. For 3rd lane width, see Exhibit 1410-3.

[3] A transition curve with a minimum radius of 3000 ft is desirable. The minimum length is 300 ft. When the main line is on a curve to the left, the transition may vary from a 3000 ft radius to tangent to the main line.

General:

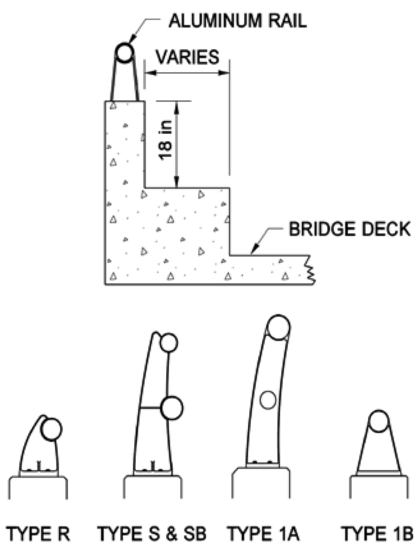
For striping details, see the *Standard Plans*.

Two-Lane Ramp Meter With HOV Bypass
Exhibit 1410-4b

(3) Bridge Rail

When the Bridge Rail column of a Design Matrix applies to the project, the bridge rails, including crossroad bridge rail, are to meet the following criteria:

- Use an approved, crash-tested concrete bridge rail on new bridges or bridges to be widened. The *Bridge Design Manual* provides examples of typical bridge rails. Consult the HQ Bridge and Structures Office regarding bridge rail selection and design and for design of the connection to an existing bridge.
- An existing bridge rail on a highway with a posted speed of 30 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 1610.10 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 1610-1. Consult the HQ Bridge and Structures Office for assistance in evaluating other bridge rails.

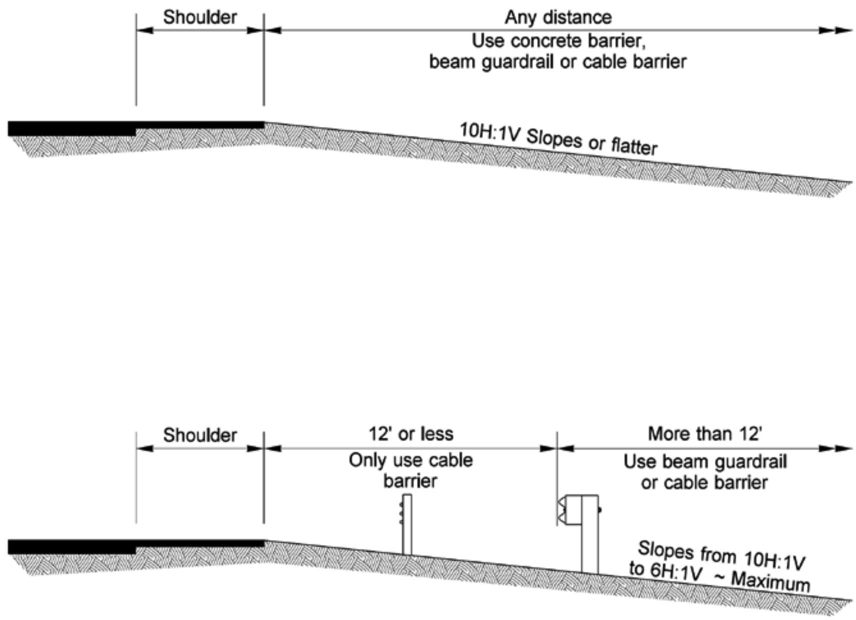


Aluminum Rail Type	Curb Width	
	9 Inches or Less	**Greater Than 9 Inches***
Type R, S, or SB	Bridge rail adequate	Bridge rail adequate
Type 1B or 1A	Bridge rail adequate	Upgrade bridge rail
Other	Consult the HQ Bridge and Structures Office	
*When the curb width is greater than 9 inches, the aluminum rail must be able to withstand a 5 kip load.		

Type 7 Bridge Rail Upgrade Criteria
Exhibit 1610-1

1610.05 Barrier Design

When selecting a barrier, consider the flexibility, cost, and maintainability of the system. It is generally desirable to use the most flexible system possible to minimize damage to the impacting vehicle and injury to the vehicle's occupant(s). However, since nonrigid systems sustain more damage during an impact, the exposure of maintenance crews to traffic might be increased with the more frequent need for repairs.



Traffic Barrier Locations on Slopes
Exhibit 1610-4

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.

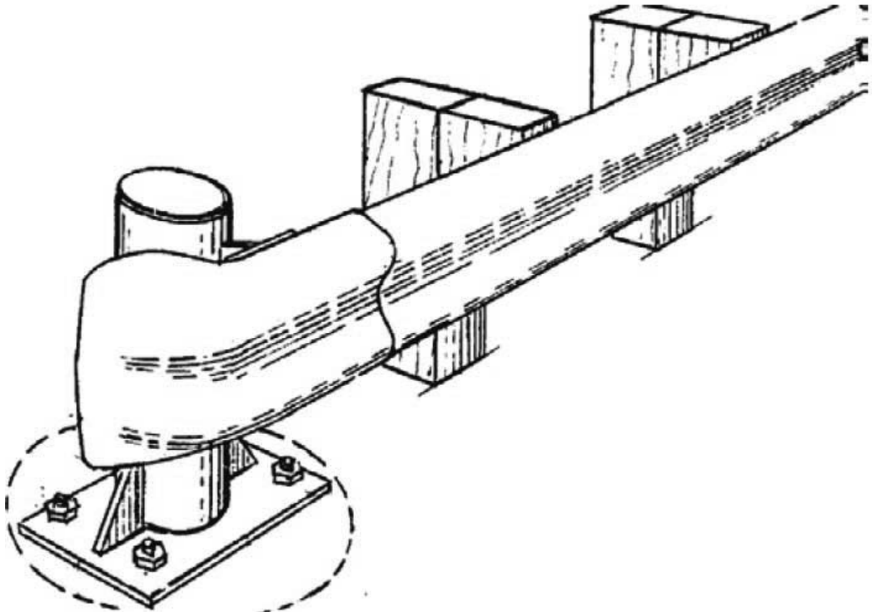
When W-beam barrier is placed in a median as a countermeasure for cross-median collisions, design the barrier to be struck from either direction of travel. For example, the installation of beam guardrail might be double-sided (Types 3, 4, or 31-DS).

1610.06 Beam Guardrail

(1) Beam Guardrail Systems

Beam guardrail systems are shown in the *Standard Plans*.

Strong post W-beam guardrail (Types 1 through 4, and 31) and thrie beam guardrail (Types 10 and 11) are semirigid barriers used predominantly on roadsides. They have limited application as median barrier. 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 strong posts. However, avoid the use of blockouts that extend from the post to the rail element for a distance exceeding 16 inches. Placement of curb at guardrail installation also requires careful consideration.



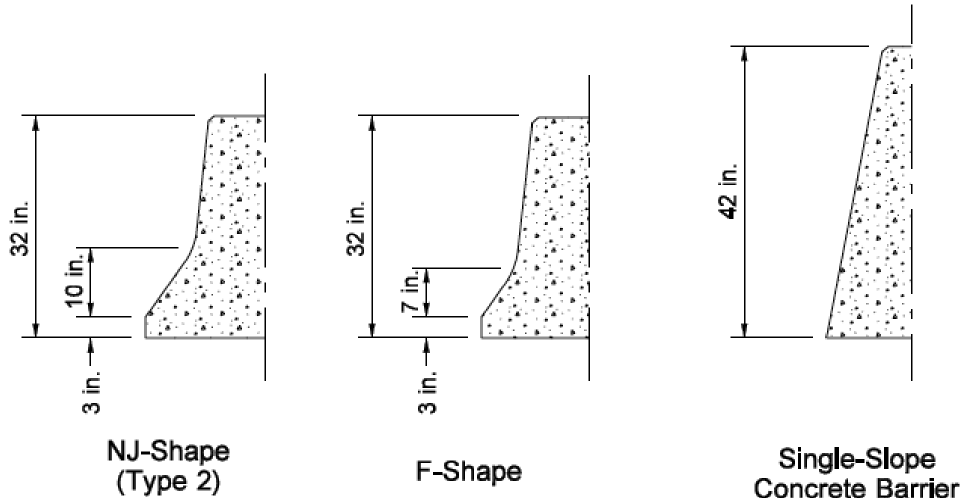
Old Type 3 Anchor
Exhibit 1610-5

Locations where crossroads and driveways cause gaps in the guardrail create situations for special consideration. Elimination of the need for the barrier is the preferred solution. Otherwise, a barrier flare might be needed to provide sight distance. If the slope is 2H:1V or flatter and there are no fixed features on or at the bottom of the slope, a terminal can be used to end the rail. Place the anchor of this installation as close as possible to the road approach radius PC. If there is a feature at or near the bottom of the slope that cannot be mitigated, then the Weak Post Intersection Design (see 1610.06(7)(b) and the *Standard Plans*) can be used. This system can also be used at locations where a crossroad or road approach is near the end of a bridge and where installing a bridge approach guardrail placement, including guardrail transition and terminal, is not possible.

(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 is likely to be caught in the deflected barrier pocket and directed into the more rigid barrier. This is commonly referred to as "pocketing." A transition stiffens the more flexible barrier by decreasing the post spacing, increasing the post size, and using stiffer beam elements to eliminate the possibility of pocketing.

When connecting beam guardrail to a more rigid barrier or a structure, or when a rigid object is within the deflection distance of the barrier, use the transitions and connections that are shown in Exhibits 1610-6 and 1610-9 and detailed in the *Standard Plans*. The transition pay item includes the connection.



Concrete Barrier Shapes
Exhibit 1610-7

When the single-slope or F-Shape face is used on structures, and precast barrier is selected for use on the approaches, a cast-in-place transition section is needed so that no vertical edges of the barrier are exposed to oncoming traffic. For details on bridge rail designs, see the *Bridge Design Manual*.

For aesthetic reasons, avoid changes in the shape of the barrier face within a project or corridor.

(a) **New Jersey Shape Barrier**

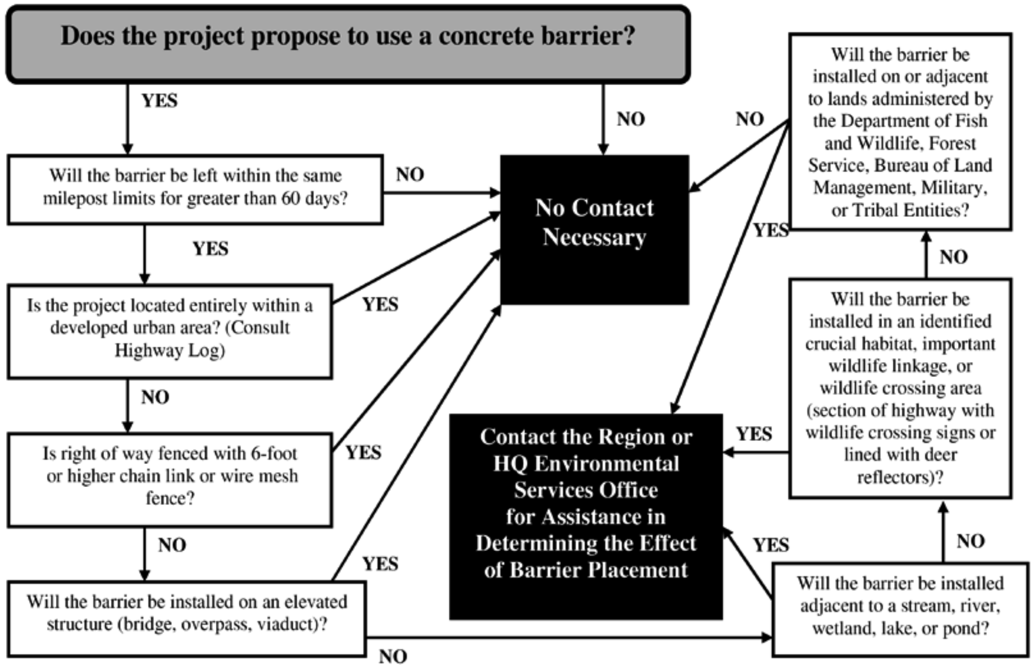
The New Jersey shape face is primarily used on precast concrete barrier.

Concrete barrier Type 2 (see the *Standard Plans*) is a precast barrier that has the New Jersey shape on two sides and can be used for both median and shoulder installations. This barrier is 2 feet 8 inches in height, which includes 3 inches for future pavement overlay.

The cost of precast Type 2 barrier is significantly less than the cost of the cast-in-place barriers. Therefore, consider the length of the barrier run and the deflection needs to determine whether transitioning to precast Type 2 barrier is desirable. If precast Type 2 barrier is used for the majority of a project, use the New Jersey face for small sections that need cast-in-place barrier, such as for a light standard section.

Concrete barrier Type 4 is also a precast, single-faced New Jersey shape barrier. These units are not freestanding and are to be placed against a rigid structure or anchored to the pavement. If Type 4 barriers are used back to back, consider filling any gap between them to prevent tipping.

Concrete barrier Type 5 is a precast barrier that has a single New Jersey face and is intended for use at bridge ends where the flat side is highly visible. Both Type 2 and Type 5 designs are freestanding, unanchored units connected with steel pins through wire rope loops. For permanent installation, this barrier is placed on a paved surface and a 2-foot-wide paved surface is provided beyond the barrier for its displacement during impact (see Chapter 1230).



Concrete Barrier Placement Guidance: Assessing Impacts to Wildlife
Exhibit 1610-8

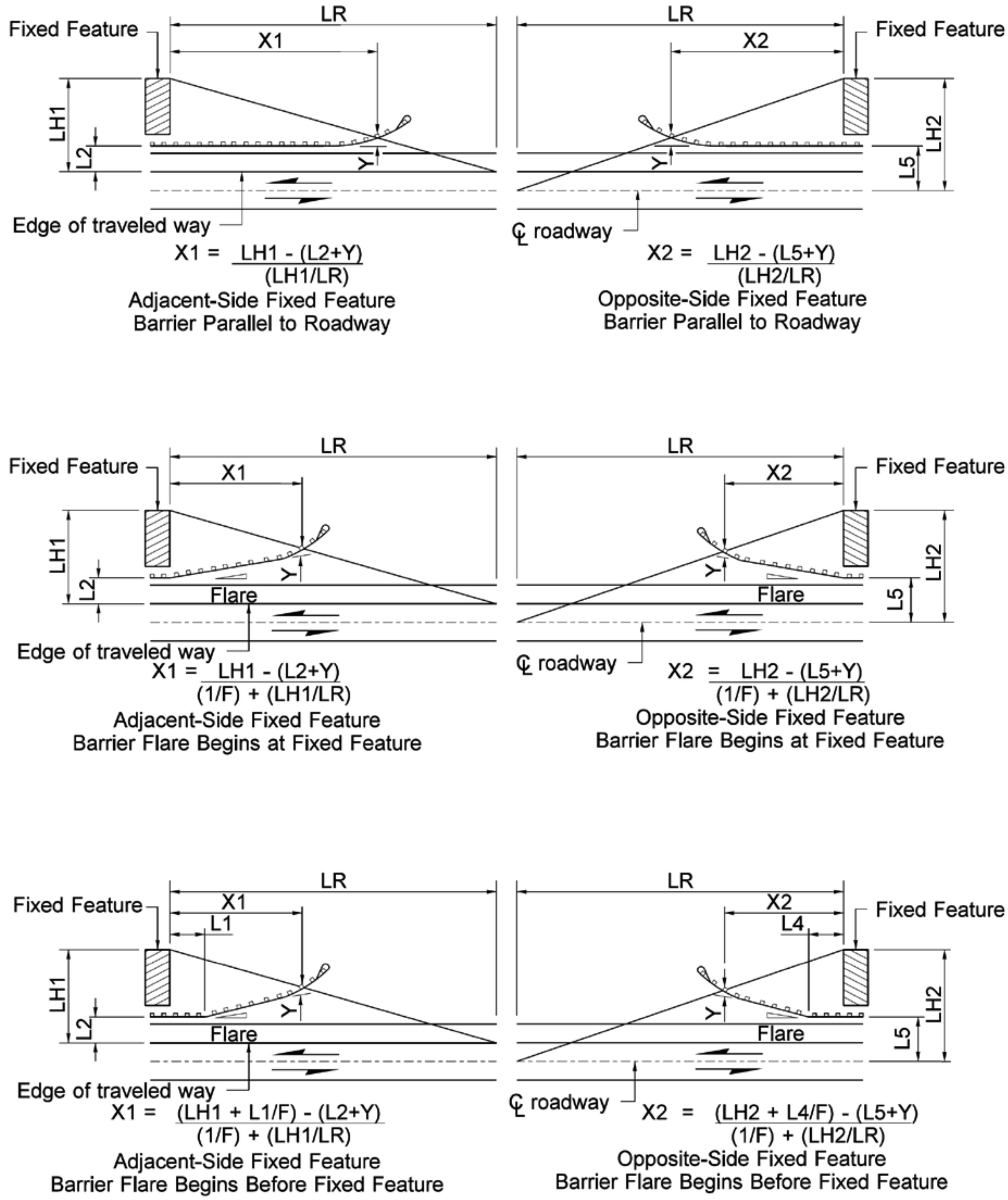
(5) Assessing Impacts to Stormwater and Wetlands

In locations where medians or roadsides are used for drainage, the retention of stormwater or the existence of wetlands can influence the choice and use of barrier systems. For example, the placement of concrete barrier and beam guardrail in many of these cases may create the need for additional impervious material, which can result in complete retrofit and reconstruction of the existing systems. When water is drained, stored, or treated, and where wetlands exist, the ability to provide alternative facilities that replace the functions of the existing ones may be nonexistent or prohibitively expensive to provide elsewhere.

To address public safety, stormwater, and wetland concerns, 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 development process to allow adequate time for discussion of options.

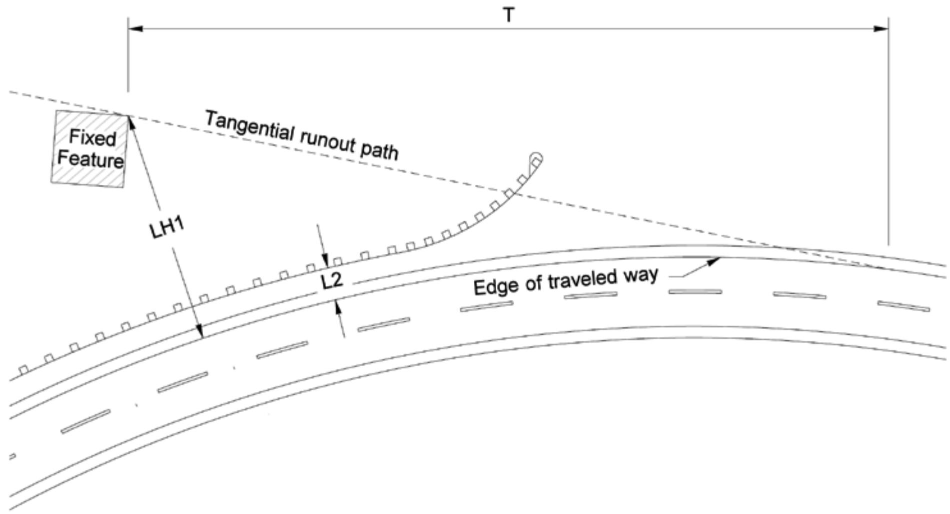
1610.09 Special-Use Barriers

The following barriers may be used on designated Scenic Byway and Heritage Tour routes if funding can be arranged (see 1610.05 and Chapter 120).



Note:
For supporting length of need equation factors, see Exhibit 1610-10b.

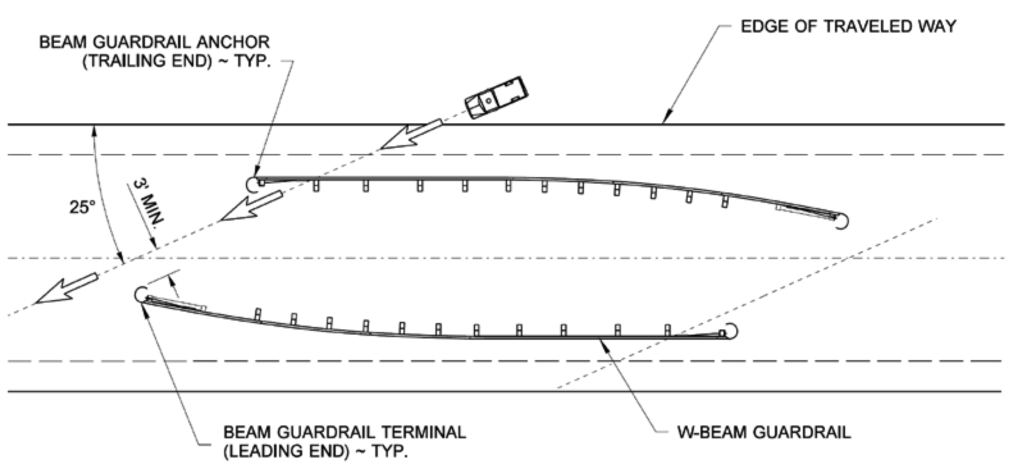
Barrier Length of Need on Tangent Sections
Exhibit 1610-10a



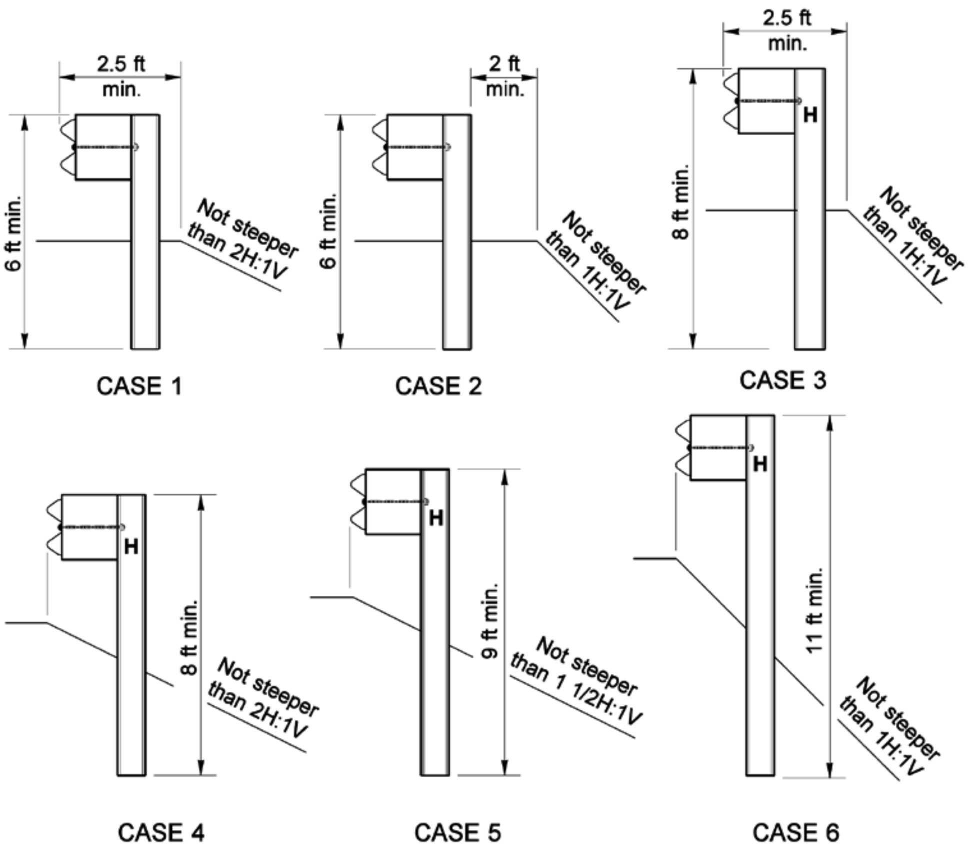
Notes:

- 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 1610-10b and use the shorter value.
- If using LR, follow Exhibits 1610-10a and 10b.
- If using T, draw the intersecting barrier run to scale and measure the length of need.

Barrier Length of Need on Curves
Exhibit 1610-10c



W-Beam Guardrail Trailing End Placement for Divided Highways
Exhibit 1610-10d

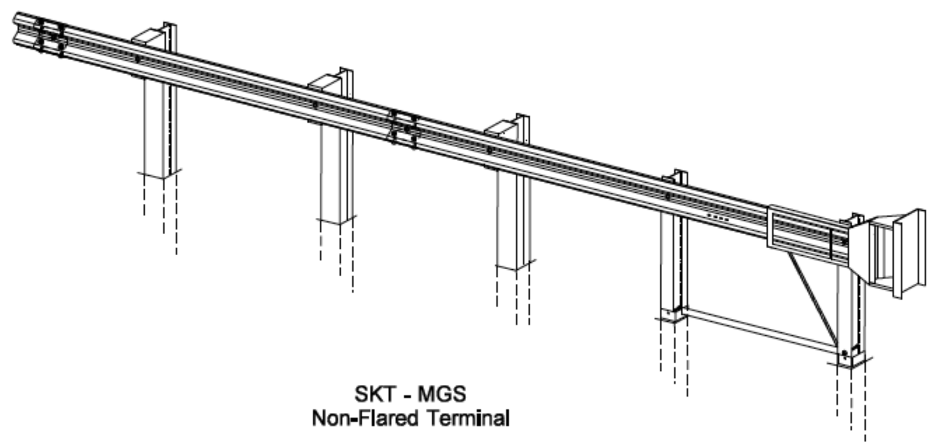


Type 31 Shown

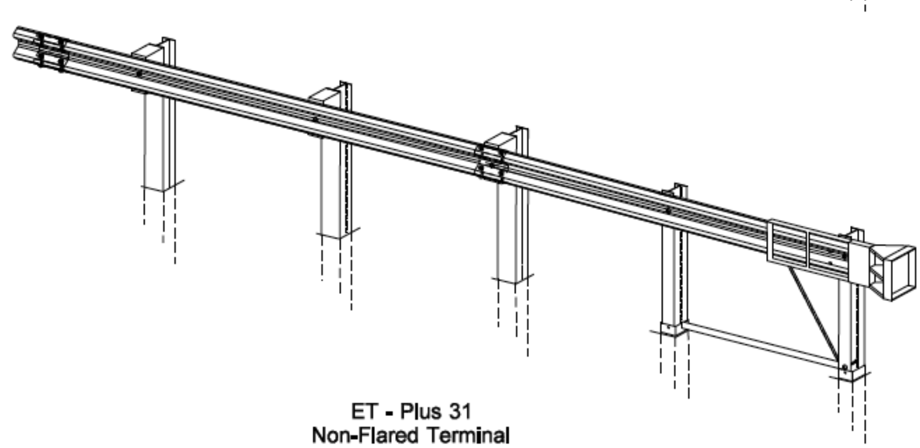
Notes:

- Use Cases 1 and 3 when there is a 2.5-foot or greater shoulder widening from face of guardrail to the breakpoint.
- Use Case 2 when there is a 4.0-foot or greater shoulder widening from the face of the guardrail to the breakpoint.
- Use Cases 4, 5, and 6 when there is less than a 2.5-foot shoulder widening from face of guardrail to the breakpoint.

Beam Guardrail Post Installation
Exhibit 1610-11

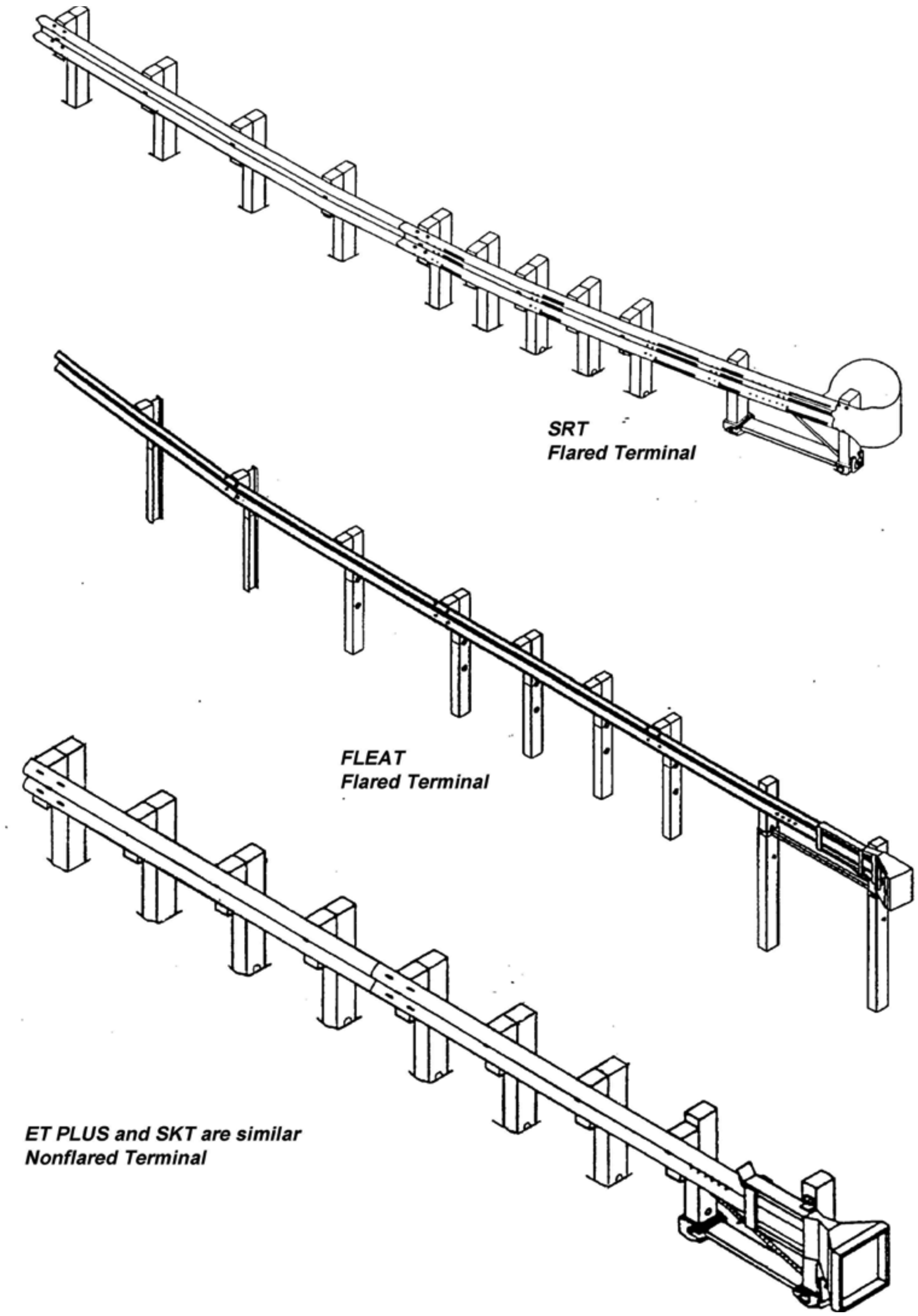


SKT - MGS
Non-Flared Terminal

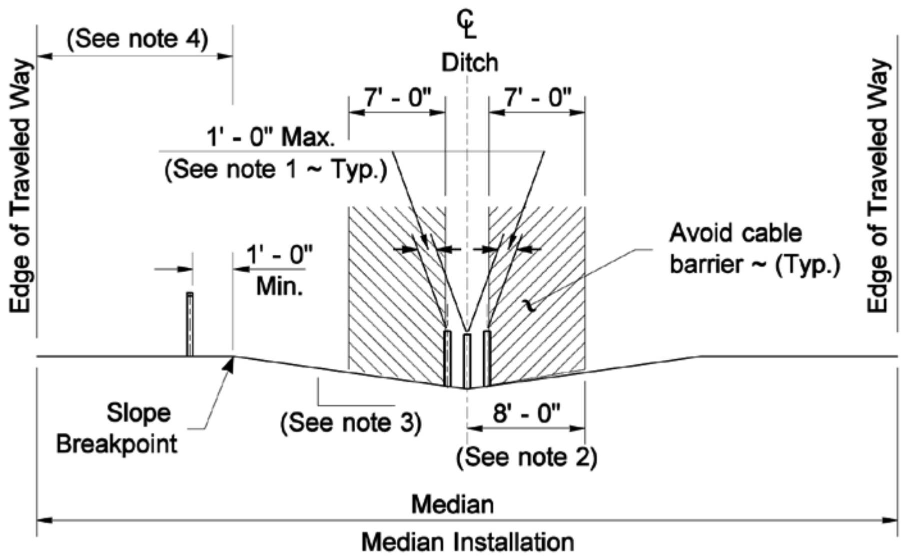


ET - Plus 31
Non-Flared Terminal

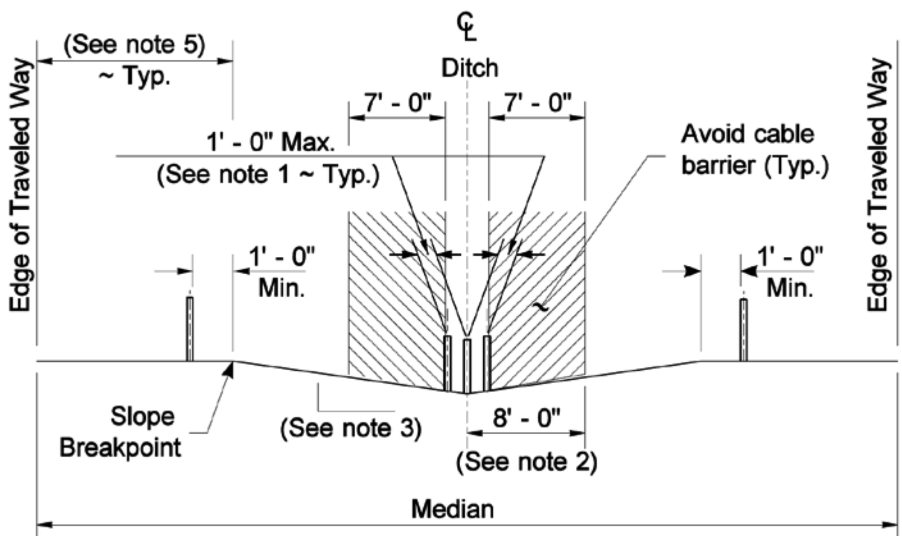
Beam Guardrail Terminals
Exhibit 1610-12a



Beam Guardrail Terminals
Exhibit 1610-12b



Median Installation
(Single Run)



Median Installation
(Double Run)

Notes:

[1] Cable barrier may be installed in the center of the ditch. The cable barrier may be offset from the ditch centerline a maximum of 1 foot in either direction.

[2] Avoid installing cable barrier within a 1-foot to 8-foot offset from the ditch centerline.

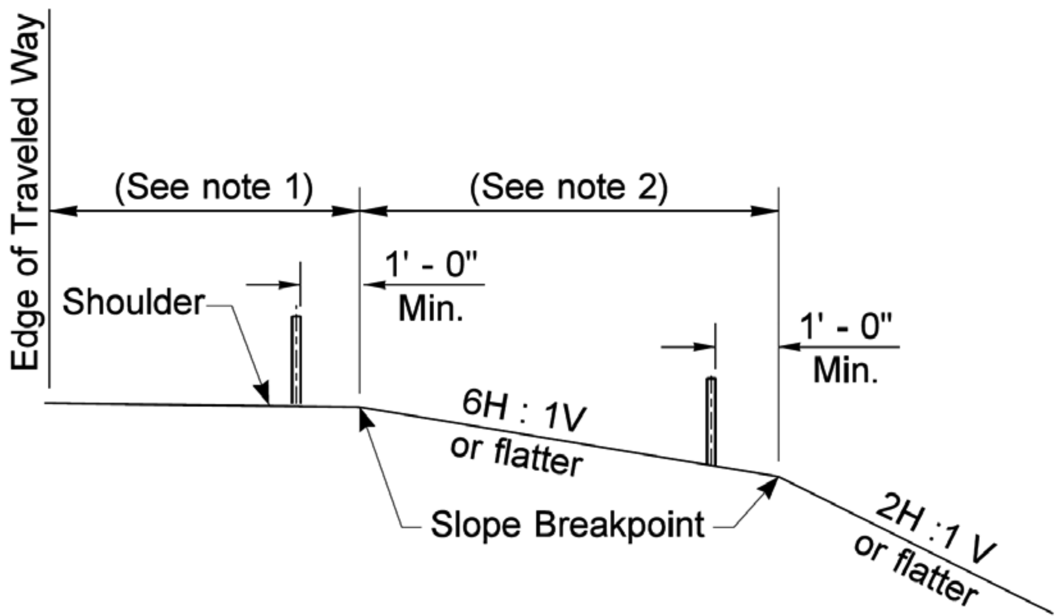
[3] Applies to slopes between 10H:1V and 6H:1V.

[4] For single-runs of cable median barrier, with at least 13 feet from edge of the nearest traveled lane to the slope breakpoint, place the cable median barrier at least 1 foot in front of the slope breakpoint. Any approved four-cable high-tension barrier system may be used in this location.

[5] Double runs of cable barrier are typically not needed. However, if used in situations with at least 11 feet from edge of the nearest traveled lane to the slope breakpoint, place the cable median barrier at least 1 foot in front of the slope breakpoint. Any approved four-cable high-tension barrier system may be used in this location.

Cable Barrier Locations on Median Slopes

Exhibit 1610-13a



Shoulder Installation

Notes:

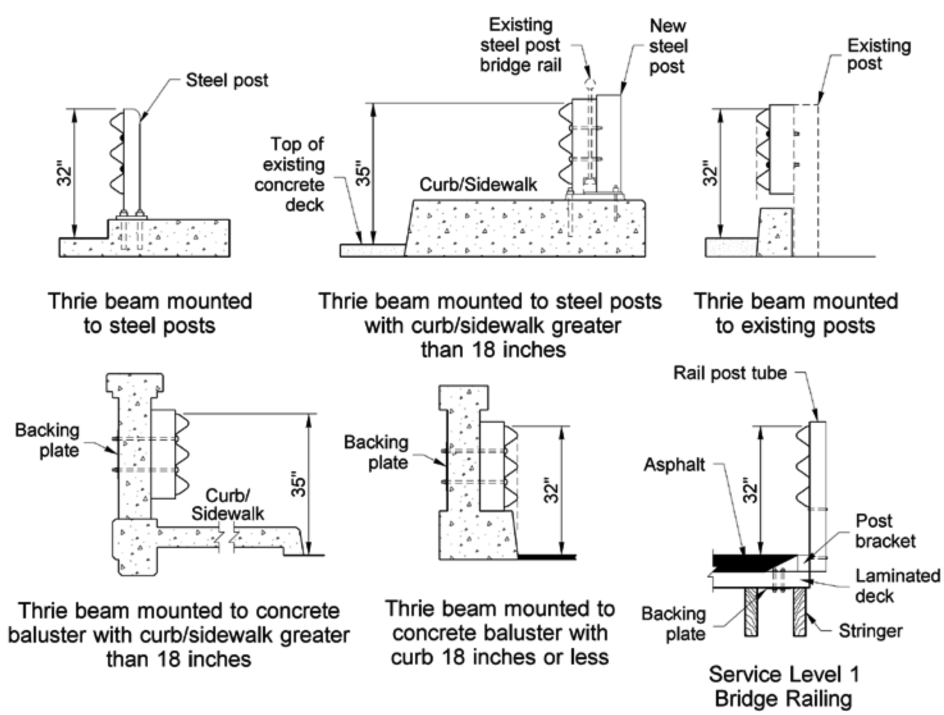
[1] Any approved four-cable high-tension barrier system may be used in this location.

[2] Use an approved four-cable high-tension cable barrier system within the acceptable locations shown between slope breakpoints.

Cable Barrier Locations on Shoulder Slopes

Exhibit 1610-13b

Curb Width	Bridge Width	Concrete Bridge Deck		Wood Bridge Deck or Low-Strength Concrete Deck
		Concrete Bridge Rail (existing)	**Steel or Wood Post Bridge Rail (existing)**	
<18 inches		Thrie beam mounted to existing bridge rail[2] and blocked out to the face of curb. Height = 32 inches	Thrie beam mounted to steel posts[2] at the face of curb. Height = 32 inches	• Service Level 1 Bridge Rail[2] • Height = 32 inches • Curb or wheel guard needs to be removed
>18 inches	**> 28 ft (curb to curb)**	Thrie beam mounted to steel posts[2] at the face of curb.[1] Height = 32 inches		
>18 inches	**< 28 ft (curb to curb)**	Thrie beam mounted to existing bridge rail.[2] Height = 35 inches	Thrie beam mounted to steel posts[2] in line with existing rail. Height = 35 inches	



Notes:

[1] Where needed, thrie beam may be mounted to the bridge rail to accommodate pedestrians (height = 35 inches).

[2] Contact the HQ Bridge and Structures Office for design details on bridge rail retrofit projects.

Thrie Beam Rail Retrofit Criteria

Exhibit 1610-14