Chapter 1210 Geometric Plan Elements

1210.01 General

This chapter provides guidance on the design of horizontal alignment, frontage roads, number of lanes, arrangement of lanes, and pavement transitions. For additional information, see the following chapters:

Chapter	**Subject**
1230	Lane and shoulder widths
1240	Lane widths on turning roadways for full design level
1250	Superelevation rate and transitions
1260	Sight distance
1310	Guidelines for islands
1360	Ramp lane and shoulder guidelines

1210.02 Horizontal Alignment

1210.02(1) General

Horizontal and vertical alignments (see Chapter 1220) are the primary controlling elements for highway design. It is important to coordinate these two elements with design speed, drainage, intersection design, and aesthetic principles in the early stages of design. How horizontal alignments are designed depends largely on the context and selected design controls. Lower-speed environments can be more forgiving than higher-speed environments.

1210.02(1)(a) Low-Speed Alignments

Consider the following when designing low-speed horizontal alignments:

a. Determine whether sufficient contextual elements exist within the roadway cross section to indicate the desired low-speed environment (street trees, lack of building setbacks, streetside amenities, etc.).

b. Determine whether horizontal geometric traffic calming treatments will be needed to maintain the selected design speed (see Chapter 1103).

c. Avoid placing pedestrian midblock crossings within horizontal curves.

1210.02(1)(b) High-Speed Alignments

Horizontal alignments designed for high speed are likely to have modal priorities for freight and passenger vehicles, and it is necessary to strive for forgiving and predictable alignments within high-speed environments. Exhibits 1210-2a through 1210-2c show desirable and undesirable alignment examples for use with the following considerations:

a. Make the highway alignment as direct as practicable and still blend with the topography while considering developed and undeveloped properties, community boundaries, and environmental concerns.

b. Make highway alignment consistent by:

 - Using gentle curves at the end of long tangents.
 - Using a transition area of moderate curvature between the large radius curves of rural areas and the small radius curves of populated areas.
 - Making horizontal curves visible to approaching traffic.

c. Avoid minimum radii and short curves unless:

 - Restrictive conditions are present and alternatives are not readily or economically avoidable.
 - On two-lane highways, minimum radii result in tangent sections long enough for needed passing.

d. Avoid any abrupt change in alignment. Design reverse curves with an intervening tangent long enough for complete superelevation transition for both curves. (See Chapter 1250 for more information on superelevation transitions.)

e. Avoid the use of curves in the same direction connected by short tangents (broken back curves); substitute a single larger curve.

f. Avoid compound curves on open highway alignment if a simple curve can be obtained. When compound curves are used, make the shorter radius at least two-thirds the longer radius. Make the total arc length of a compound curve not less than 500 feet.

g. On divided multilane highways, take advantage of independent alignment to produce a flowing alignment along natural terrain.

h. The desirable locations for bridges, interchanges, intersections, and temporary connections are on tangent sections in clear view of drivers.

i. On two-lane two-way highways, strive for as much passing sight distance as possible (see Chapter 1260).

1210.02(2) Horizontal Curve Radii

Design speed is the governing variable of horizontal curves. For guidance regarding design speed selection, see Chapter 1103, and see Chapter 1360 for ramps.

Use the following factors to determine the radius for a curve:

- Low to intermediate design speed environments may need to utilize horizontal curves to maintain the desired operating speed. Horizontal curvature, more than any other design element or treatment, provides the best speed management results. (See Chapter 1103 for more information on speed management.)
- Stopping sight distance where sight obstructions are on the inside of a curve. Median barriers, bridges, walls, cut slopes, wooded areas, buildings, and guardrails are examples of sight obstructions. (See Chapter 1260 to check for stopping sight distance for the selected design speed.)
- Superelevation is the rotation or banking of the roadway cross section to overcome part of the centrifugal force that acts on a vehicle traversing a curve. Design information on the relationship between design speed, radius of curve, and superelevation is in Chapter 1250.
- Coordinate vertical and horizontal alignment (see Chapter 1220).

Spiral curves, although no longer used on new highway construction or major realignment, still exist on Washington's highways. Spirals were used to transition between tangents and circular curves with the horizontal curvature rate increasing from tangent to the central curve and decreasing from curve to tangent. Spirals do not pose an operational concern and may remain in place. (See *A Policy on Geometric Design of Highways and Streets* for information on spirals.)

1210.02(3) Horizontal Curve Length

A curve is not required for small deflection angles. Exhibit 1210-1 gives the maximum allowable angle without a curve. (See Chapter 1310 for guidance on angle points or short radii curves in the vicinity of intersections at grade.)

To avoid the appearance of a kink in the road, the desirable length of curve for deflection angles larger than given in Exhibit 1210-1 is at least 500 feet.

Exhibit 1210-1 Maximum Angle Without Curve

Design Speed (mph)	Maximum Angle Without Curve
25	2°17’
30	1°55’
35	1°38’
40	1°26’
45	1°16’
50	1°09’
55	1°03’
60	0°57’
65	0°53’
70	0°49’
75	0°46’
80	0°43’

1210.03 Distribution Facilities

1210.03(1) General

In addition to the main highway under consideration, other facilities can be used to distribute traffic to and from the highway and to provide access. Highway flexibility can be augmented by:

- Frontage roads
- Collector-distributor roads
- On and off connections
- Parallel arterial routes with connections between them and the main highway
- Loop highways around large metropolitan areas

A city or county may be asked to accept a proposed distribution facility as a city street or county road. Plan and design these facilities according to the applicable design values as city streets or county roads (see Chapter 1230).

1210.03(2) Frontage Roads

Frontage roads constructed as part of highway development may serve to:

- Reestablish continuity of an existing road severed by the highway.
- Provide service connections to adjacent property that would otherwise be isolated as a result of construction of the highway.
- Control access to the highway.
- Maintain circulation of traffic on each side of the highway.
- Segregate local traffic from the higher speed through traffic and intercept driveways of residences and commercial establishments along the highway.
- Relieve congestion on the arterial highway during periods of high use or in emergency situations.

Frontage roads are generally not permanent state facilities. They are usually turned back to the local jurisdiction. Plan and design frontage roads as city streets or county roads (see Chapter 1230). Initiate coordination with the local agency that will be the recipient of the facility early in the planning process, and continue through design and construction. (See Chapter 530 for additional guidance on frontage roads and turnbacks.)

Outer separations function as buffers between the through traffic on the highway and the local traffic on the frontage road. The width is governed by requirements for grading, signing, barriers, aesthetics, headlight glare, and ramps. Where possible, make the separation wide enough to allow for development on both sides of the frontage road. Wider separations also move the intersection with the frontage road and a crossroad farther from the intersection with the through roadway, and they can reduce the amount of limited access control rights to be acquired (see Chapter 530).

Where two-way frontage roads are provided, make the outer separation wide enough to minimize the effects of approaching traffic on the right, particularly the headlight glare. (See Chapter 1600 for information on headlight glare considerations.) With one-way same-direction frontage roads, the outer separation need not be as wide as with two-way frontage roads.

Wide separations lend themselves to landscape treatment and can enhance the appearance of both the highway and the adjoining property.

A substantial width of outer separation is particularly advantageous at intersections with cross streets. The wider separation reduces conflicts with pedestrians and bicycles.

Where ramp connections are provided between the through roadway and the frontage road, the minimum outer separation width depends on design of the ramp termini.

1210.04 Number of Lanes and Arrangement

1210.04(1) General

The basic number of lanes is designated and maintained over a length of highway. The total number of lanes is the basic number of lanes plus any auxiliary lanes provided to meet:

- Level of service (volume-capacity)
- Lane balance
- Flexibility of operation

1210.04(2) Basic Number of Lanes

In certain situations, it is appropriate to keep the basic number of lanes constant over a highway route, or a significant portion thereof, regardless of changes in traffic volume. However, this can lead to unnecessary property or environmental impacts that need to be balanced throughout a design. Consider the impacts, human factors, and traffic analysis before making decisions regarding basic number of lane consistency throughout a highway route.

Change the basic number of lanes for general changes in traffic volume over a substantial length of the route. The desirable location for a reduction in the basic number of lanes is on a tangent section between interchanges or intersections. <u>However, there can be advantages in using dedicated turn lanes at intersections as a means to reduce the number of lanes.</u>

To accommodate high traffic volumes for short distances, such as between adjacent interchanges, use auxiliary lanes. When auxiliary lanes are provided on consecutive sections between interchanges, consider increasing the basic number of lanes through the entire length.

1210.04(3) Auxiliary Lanes

Auxiliary lanes are added to the basic number of lanes to allow additional traffic movements on short segments. These added lanes are based primarily on volume-to-capacity relationships (see Chapter 320). For efficient operation of auxiliary lanes, see the following:

Chapter	Subject
1270	Truck climbing and passing lanes
1310	Left- and right-turn lanes and storage for turning
1360	Weaving and auxiliary lanes associated with interchanges

1210.05 Pavement Transitions

1210.05(1) Lane Transitions

1210.05(1)(a) Change Lane Width

For lane width changes that create an angle point in an adjacent lane, the maximum angle is given in Exhibit 1210-1. When a lane width change does not create an angle point in an adjacent lane, a 25:1 taper is sufficient.

1210.05(1)(b) Reduce Number of Lanes

To reduce the number of lanes, provide a transition with the following guidelines:

- Locate transitions where decision sight distance exists, desirably on a tangent section and on the approach side of any crest vertical curve, except the end of climbing lanes, which are transitioned in accordance with Chapter 1270.
- Supplement the transition with traffic control devices.
- Reduce the number of lanes by dropping only one at a time from the right side in the direction of travel. (See the MUTCD when dropping more than one lane in a single direction.)
- Use the following formula to determine the minimum length of the lane transition for speeds 45 mph or more:

$$L = VT$$

Where:
L = Length of transition (ft)
V = Design speed (mph)
T = Tangential offset width (ft)

- Use the following formula to determine the minimum length of the lane transition for speeds less than 45 mph:

$$L = \frac{TV^2}{60}$$

Where:
L = Length of transition (ft)
V = Design speed (mph)
T = Tangential offset width (ft)

1210.05(1)(c) Increase Number of Lanes

To increase the number of lanes, a tangential rate of change in the range of 1:4 to 1:15 is sufficient. Aesthetics are the main consideration.

1210.05(1)(d) Turning Roadway

For turning roadway widening width transitions, see Chapter 1240.

1210.05(2) Median Width Transitions

Whenever two abutting sections have different median widths, use long, smooth transitions (L = VT or flatter). When horizontal curves are present, this can be accomplished by providing the transition throughout the length of the curve. For transitions on tangent sections, the transitions may be applied symmetrically about the centerline or on only one side of the median based on whether or not the abutting existing section is programmed for the wider median in the future. For aesthetics, make the transition length as long as feasible.

1210.06 Procedures

When the project realigns the roadway, develop horizontal alignment plans for inclusion in the Plans, Specifications & Estimates. Show the following as needed to maintain clarity and provide necessary information:

- Horizontal alignment details (tangent bearing, curve radius, and superelevation rate)
- Stationing
- Number of lanes
- Intersections, road approaches, railroad crossings, and interchanges (see Chapters 1310, 1340, 1350, and 1360)
- Existing roadways and features affecting or affected by the project

For additional plan guidance, see the *Plans Preparation Manual*.

Justify any realignment of the roadway. Include the reasons for the realignment, profile considerations, and alternatives considered, and the reasons the selected alignment was chosen.

When the project changes the number of lanes, include a capacity analysis supporting the number selected (see Chapter 320) with the justification for the number of lanes.

Include with the justification for a frontage road any traffic analyses performed; the social, environmental, and economic considerations; the options considered; and the reasons for the final decision.

1210.07 Documentation

Refer to Chapter 300 for design documentation requirements.

1210.08 References

1210.08(1) Federal/State Laws and Codes

Washington Administrative Code (WAC) 468-18-040, Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings

1210.08(2) Design Guidance

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

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

Plans Preparation Manual, M 22-31, WSDOT

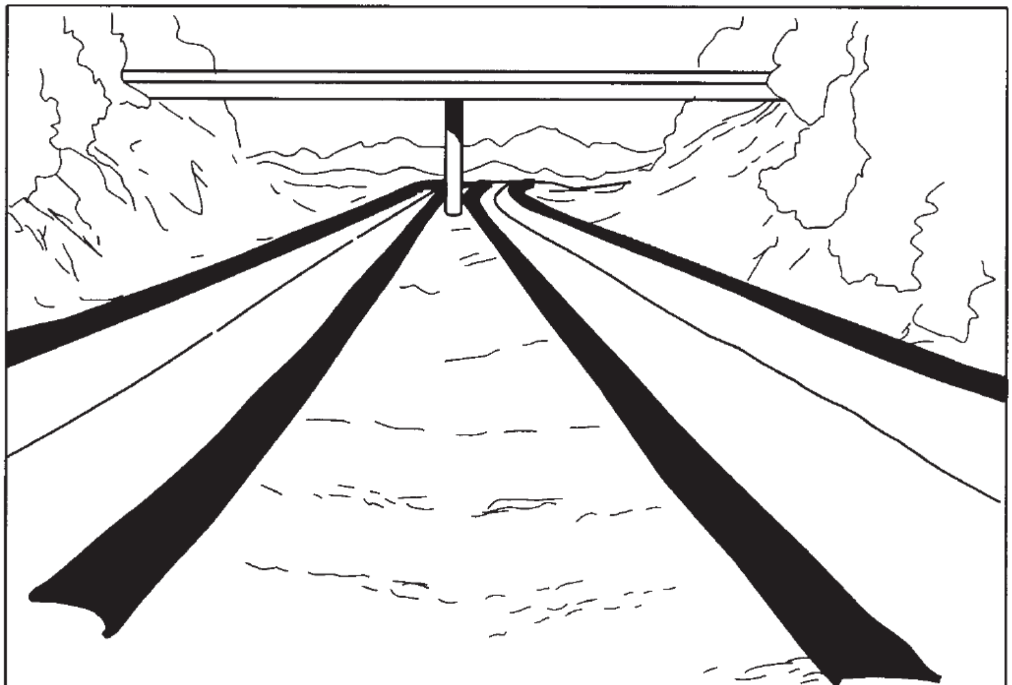
Right of Way Manual, M 26-01, WSDOT

Utilities Manual, M 22-87, WSDOT

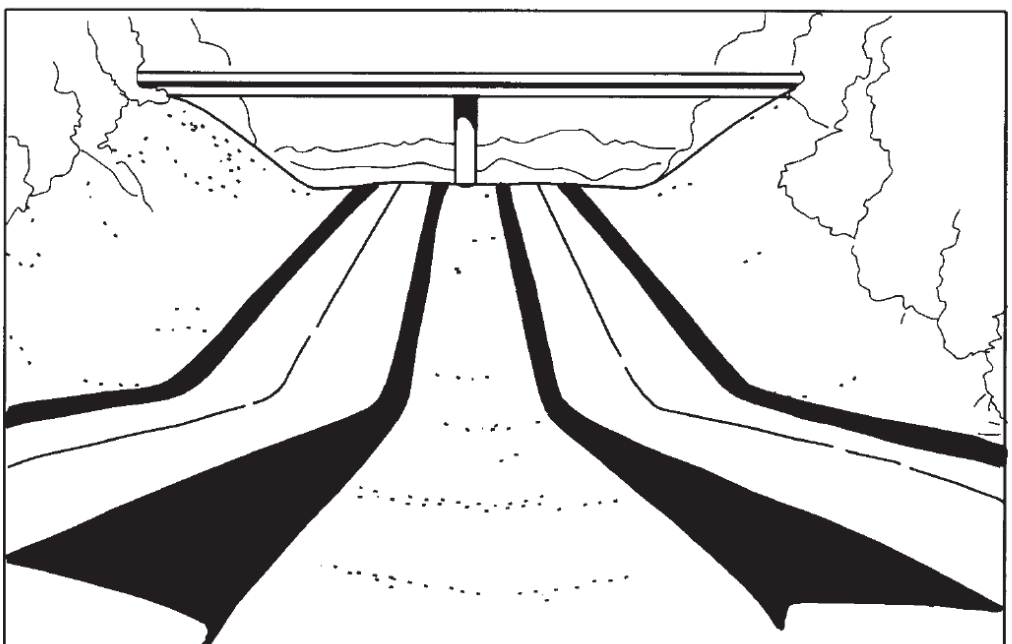
1210.08(3) Supporting Information

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

Exhibit 1210-2a Alignment Examples

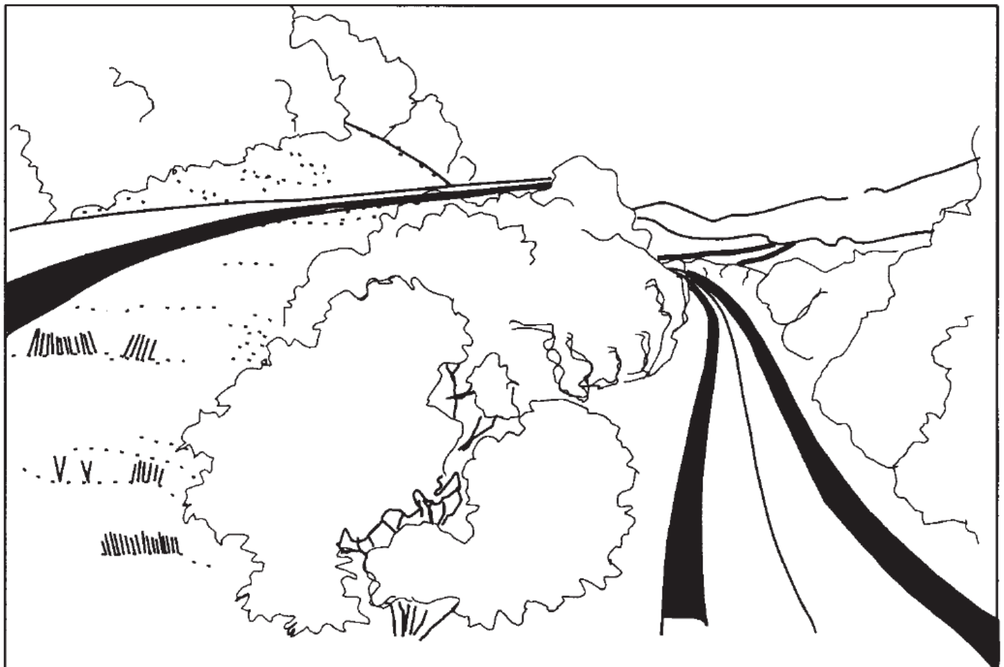


Desirable - Vertical Curves Lengthened

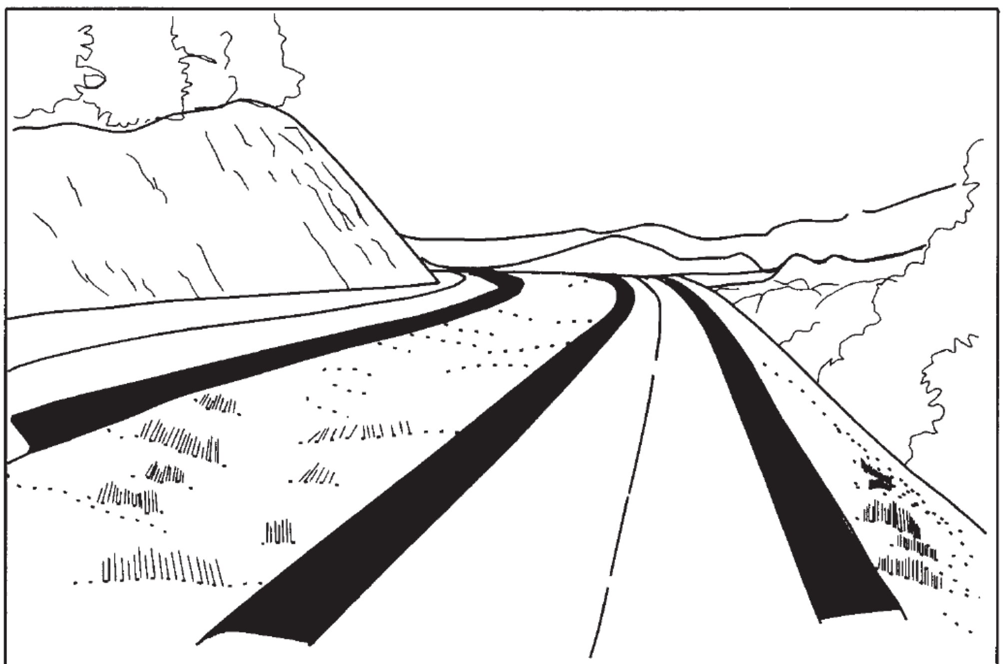


Undesirable - Minimum Vertical Curves Used

Exhibit 1210-2b Alignment Examples



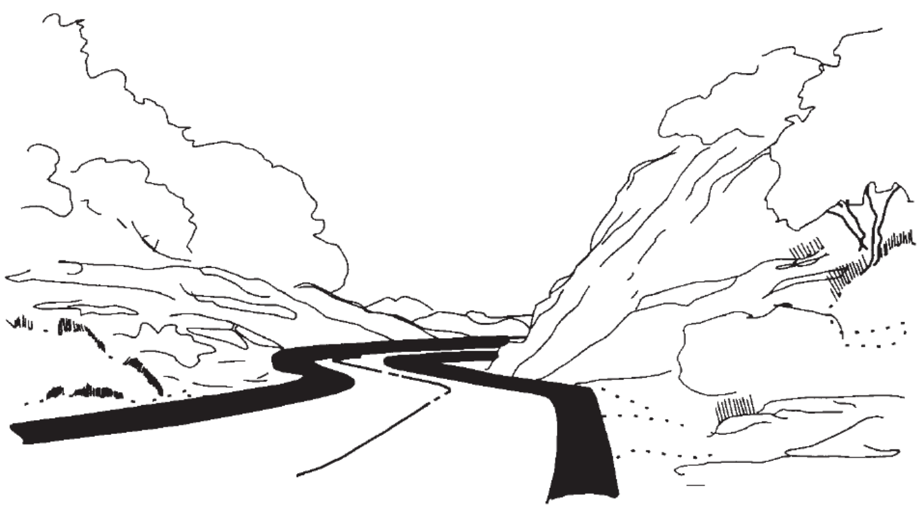
Desirable - Consistency with Topography



Undersirable - Heavy Cuts and Fills

Exhibit 1210-2c Alignment Examples

Desirable - Daylighting and a Simple Curve



Undesirable - Short Curve Reversals