212 Intersections

212.1 General

This chapter provides design criteria and guidance for the geometric layout of at-grade conventional intersections. Conventional intersections include, 3-leg (T), 4-leg, and Multi-leg (5 or more legs).

Multi-leg conventional intersections should be avoided. Alternatives to existing multi-leg intersections include:

(1) Converting to a roundabout.

(2) Converting one or more legs to a one-way operation

(3) Reconfiguring or realigning the intersection to create separate intersections, each with no more than four legs.

See ***FDM 201*** for design vehicle selection and design speed requirements.

See ***FDM 210*** for lane width, median width, and deflection angle requirements.

See ***FDM 222*** for requirements concerning pedestrian facilities and ***FDM 223*** for bicycle facilities.

212.1.1 Alternative Intersections

Alternative intersection design is a key component of upgrading our transportation facilities and improving the mobility and safety of all road users. These innovative designs are becoming more common as increasing traffic demand exceed the limitations of traditional intersection solutions.

Alternative intersections offer the potential to improve safety and reduce delay at lower cost and with fewer impacts than traditional solutions such as adding lanes or grade separation. Three of the more common alternative intersection types are:

- Displaced Left Turn (a.k.a. Continuous Flow Intersection)
- Restricted Crossing U-Turn (RCUT)
- Median U-Turn (MUT)

The FHWA has published comprehensive informational guides for alternative intersections which include guidance on how to plan, design, construct, and operate them. The following link provides access to these guides: ***FHWA Alternative Designs***.

These types of alternate intersection designs should be coordinated with the Central Office Roadway Design.

212.2 Intersection Control

Conventional intersections utilize one of four control types; yield, stop, all-way stop and signal.

212.2.1 Yield Control

Certain channelized movements at intersections and interchanges, and all approaches to roundabouts are often yield controlled. Refer to the ***MUTCD*** for information on the locations where yield control traffic control devices may be appropriate.

212.2.2 Stop Control

Stop-controlled intersections have one or more legs of the intersection controlled by a "STOP" sign (R1-1).

Intersections with stop control are a common, low-cost control, which require the traffic on the minor roadway to stop before entering the major roadway. It is used where application of the normal R/W rule is not appropriate for certain approaches at the intersection.

To meet the requirements for the assigned access classification, or where U-turn opportunities exist within a corridor, consider limiting stop controlled minor roads or driveways to “right-in, right-out” only.

212.2.3 All-Way Stop Control

For an all-way stop intersection, traffic approaching it from all directions is required to stop before proceeding through the intersection. An all-way stop may have multiple approaches and typically marked with a supplemental signing stating the number of approaches.

All-way stop control is most effective at the intersection of low-speed, 2-lane roadways not exceeding 1,400 vehicles during the peak hour. All-way stop control should not be used on multilane highways. Guidance for consideration of the application of all-way stop control is provided in the ***MUTCD***.

All-way stop control may be used as an interim measure when a traffic signal or roundabout is warranted, but the installation is delayed.

212.2.4 Signal Control

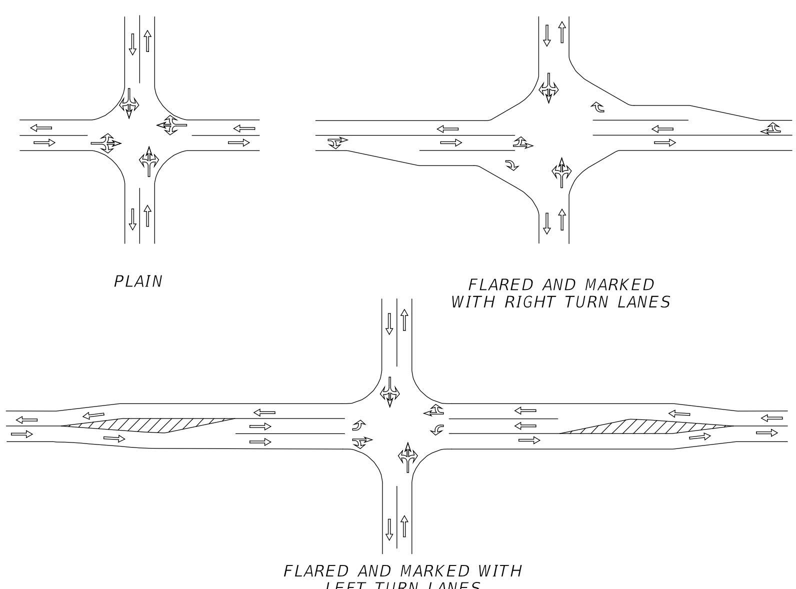
Signalization provides an orderly and predictable movement of motorized and non-motorized traffic throughout the highway transportation system. It also provides guidance and warnings to ensure the safe and informed operation of the traffic stream.

Refer to ***FDM 232*** for design criteria for signalization.

212.3 Intersection Types

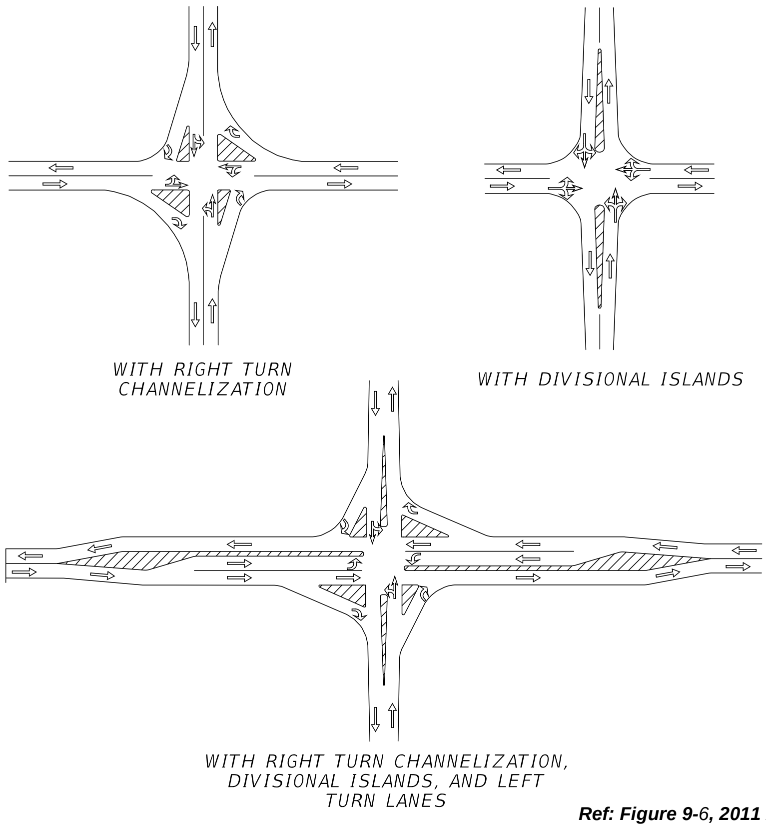
Conventional intersection configurations include flared and channelized intersections (divided and undivided). Flared intersections are illustrated in ***Figure 212.3.1*** and channelized intersections in ***Figure 212.3.2***.

Figure 212.3.1 Flared Intersections



***Ref: Figure 9-5, 2011 AASHTO** Green Book*

Figure 212.3.2 Channelized Intersections



Ref: Figure 9-6, 2011 AASHTO Green Book

212.4 Intersection Functional Area

The functional area of an intersection extends in both directions including auxiliary lanes and their associated channelization. This is illustrated in ***Figures 212.4.1*** and ***212.4.2***.

The functional area on the approach to an intersection or driveway consists of three basic elements:

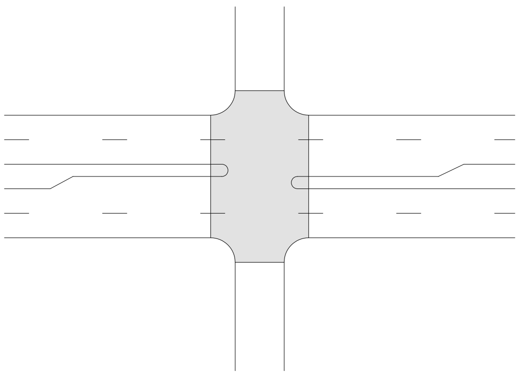
(1) Perception-reaction-decision distance

(2) Maneuver distance

(3) Queue-storage distance (see ***FDM 212.14.2***)

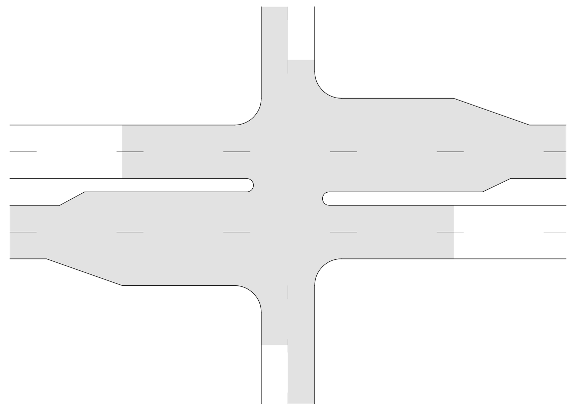
These elements are shown in ***Figure 212.4.3***. The maneuver distance includes the length needed for both braking and lane changing when there is a left or right turning lane. In the absence of turn lanes, the maneuver distance is the distance to brake to a comfortable stop. The storage length includes the most distant extent of any intersection-related queue expected to occur during the design period.

Figure 212.4.1 Physical Definition



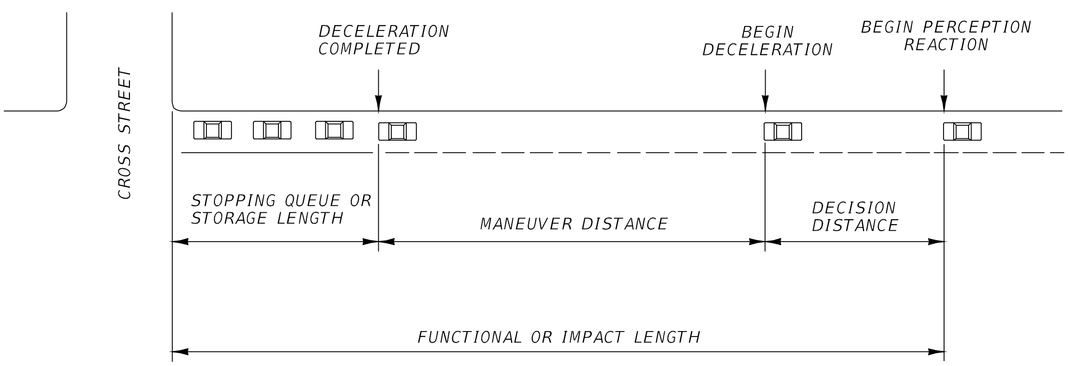
Ref: Figure 9-1, 2011 AASHTO Green Book

Figure 212.4.2 Functional Definition



Ref: Figure 9-1, 2011 AASHTO Green Book

Figure 212.4.3 Elements of the Functional Area



Ref: Figure 9-2, 2011 AASHTO Green Book

212.5 Intersection Angle

The intersection angle between two roadways has a significant influence on the safety and operation of an intersection. Intersection angles are to be as close to 90 degrees as practical. Intersection angles less than 75 degrees should be avoided for the following reasons:

(1) Heavy skew angles increase the intersection crossing length, exposing vehicles, pedestrians, and cyclists to conflicting traffic streams for longer periods of time. This is of particular concern at stop-controlled approaches on high speed facilities.

(2) The road user's sight angle to the crossing leg becomes restricted due to the skew, making it difficult to see conflicting vehicles and to perceive safe crossing gaps.

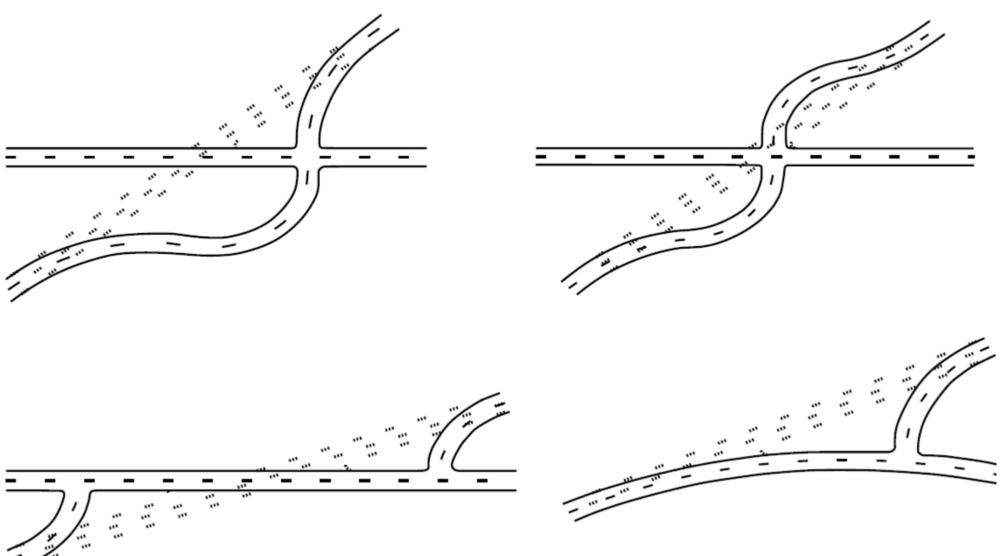
(3) Turning movements are difficult because of the skew. Additional pavement may be necessary to accommodate the turning of large trucks.

(4) Turning movements or positioning may be confusing and require additional channelization.

(5) Increased open pavement areas of highly skewed intersections increase construction and maintenance costs.

Evaluate intersections with severe skew angles and crash histories for geometric improvements as shown in ***Figure 212.5.1***. A high incidence of right-angle crashes is an indicator that improvements may be justified.

Figure 212.5.1 Intersection Reconfigurations



Ref: Figure 9-14, 2011 AASHTO Green Book

212.6 Lane Tapers

Standard taper lengths for auxiliary lanes are given in ***FDM 212.14***. Taper length is based on the following equations:

(1) Merging Taper (L):

(a) For design speeds ≤ 40 mph: $L = (W*S^2)/60$

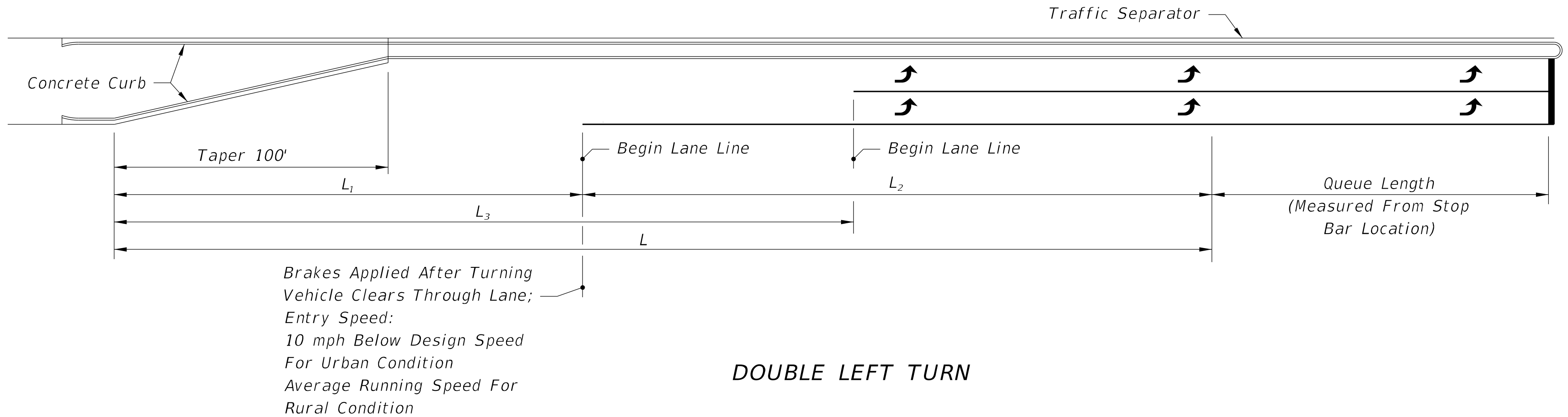
(b) For design speeds ≥ 45 mph: $L = W*S$

Where: L = Taper length (feet)
W = Width of offset (feet)
S = Design speed (mph)

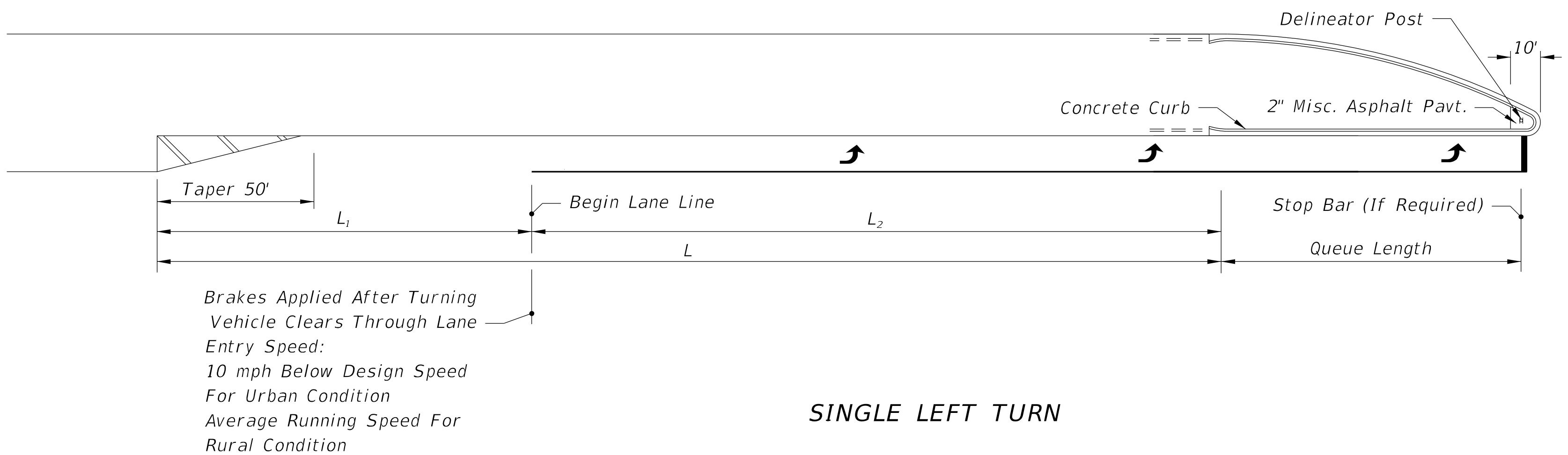
(2) Shifting Taper is equal to Merging Taper (L) / 2.

Minimum deceleration lengths are illustrated in ***Exhibit 212-1***. Additional information on lane transitions (add or drop) are provided in ***Exhibits 212-2*** and ***212-3***.

MEDIAN TURN LANES
MINIMUM DECELERATION LENGTHS



DOUBLE LEFT TURN



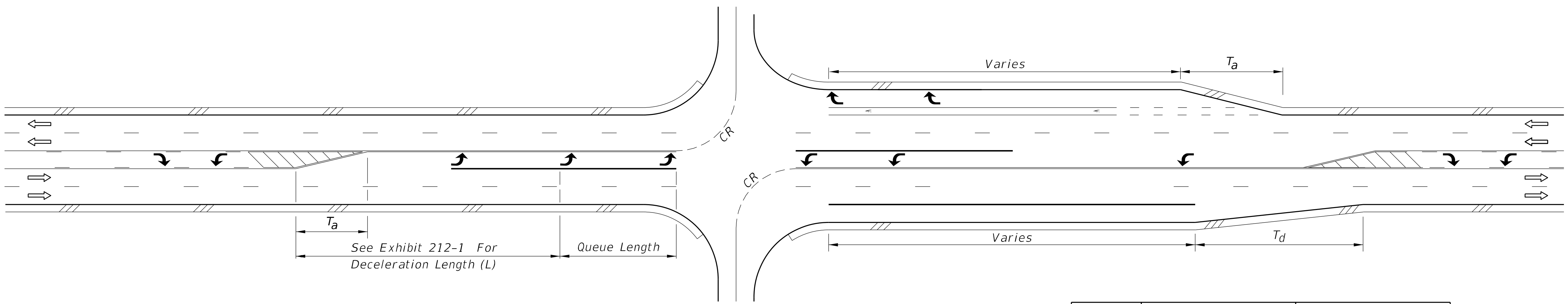
SINGLE LEFT TURN

MEDIAN TURN LANES								
			URBAN CONDITIONS			RURAL CONDITIONS		
Design Speed (mph)	Entry Speed (mph)	Clearance Distance L_1 (ft.)	Brake To Stop Distance L_2 (ft.)	Total Decel. Distance L (ft.)	Clearance Distance L_3 (ft.)	Brake To Stop Distance L_2 (ft.)	Total Decel. Distance L (ft.)	Clearance Distance L_3 (ft.)
35	25	70	75	145	110	—	—	—
40	30	80	75	155	120	—	—	—
45	35	85	100	185	135	—	—	—
50	40/44	105	135	240	160	185	290	160
55	48	125	—	—	—	225	350	195
60	52	145	—	—	—	260	405	230
65	55	170	—	—	—	290	460	270

NOT TO SCALE

EXHIBIT 212-1
01/01/2018

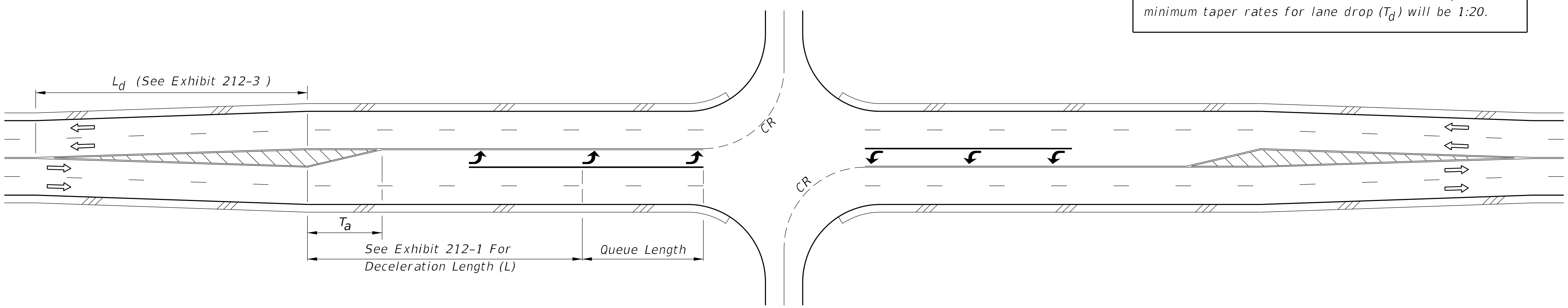
LANE TRANSITIONS: 4-LANE ROADWAYS



TWO-WAY LEFT-TURN LANES

DESIGN SPEED (mph)	T_a (ft.)	T_d
<30	1:4, 50 ft. min.	1:25
30-45		1:30
>45		1:40

Note: For locations with unrelocatable control points minimum taper rates for lane drop (T_d) will be 1:20.

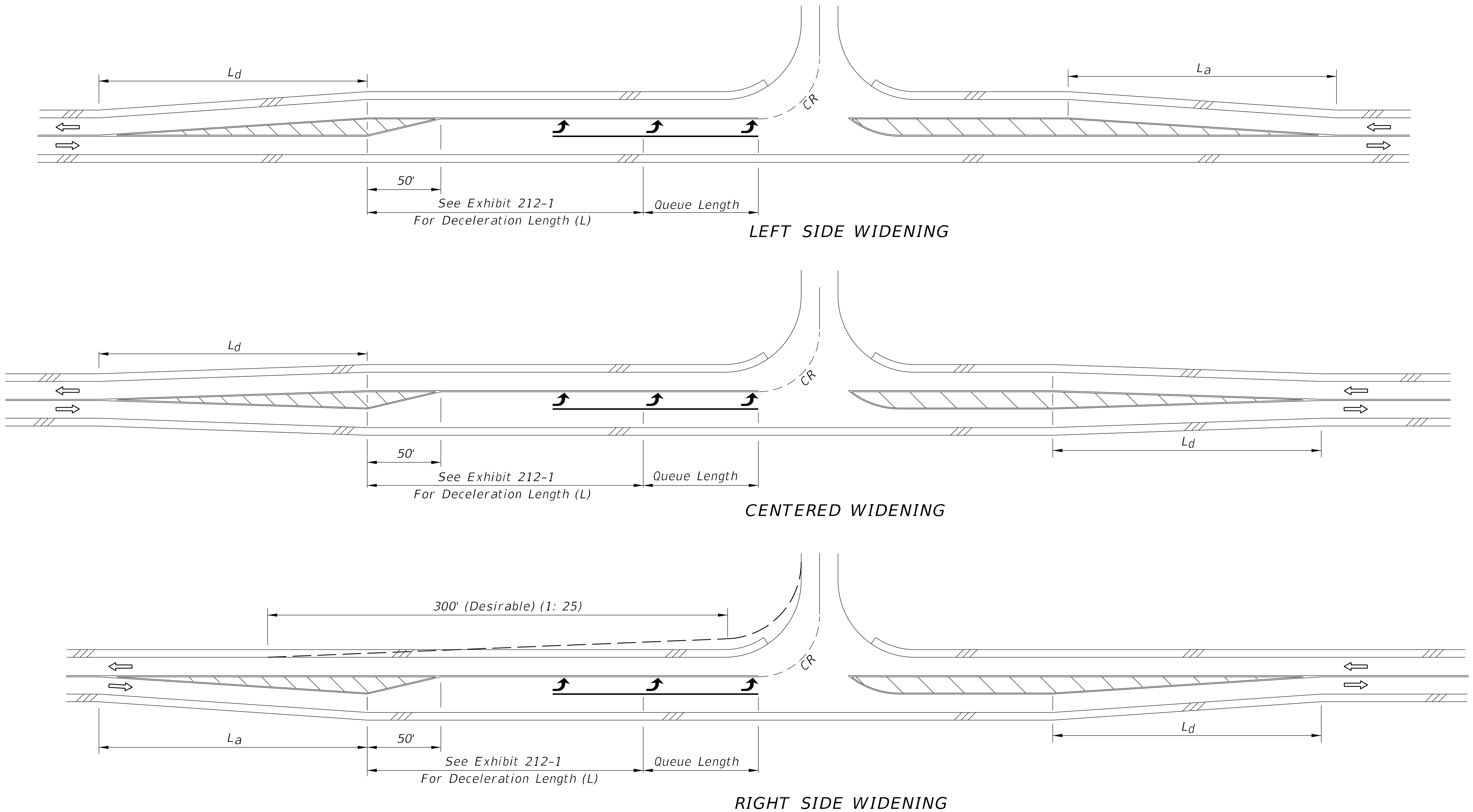


UNDIVIDED FLARED - SYMMETRICAL

NOT TO SCALE

EXHIBIT 212-2
01/01/2018

LANE TRANSITIONS: 2-LANE ROADWAYS



FLARED & PAINTED LEFT TURNS FOR 2-LANE ROADWAYS

DESIGN SPEED (mph)	L_a (Ft.)		L_d (Ft.)	
	STANDARD	MINIMUM UNDER CONSTRAINTS	STANDARD	MINIMUM UNDER CONSTRAINTS
30	180	120	180	120
40	320	150	240	150
50	500	180	360	180
60	720	240	480	240

NOT TO SCALE

EXHIBIT 212-3
01/01/2018

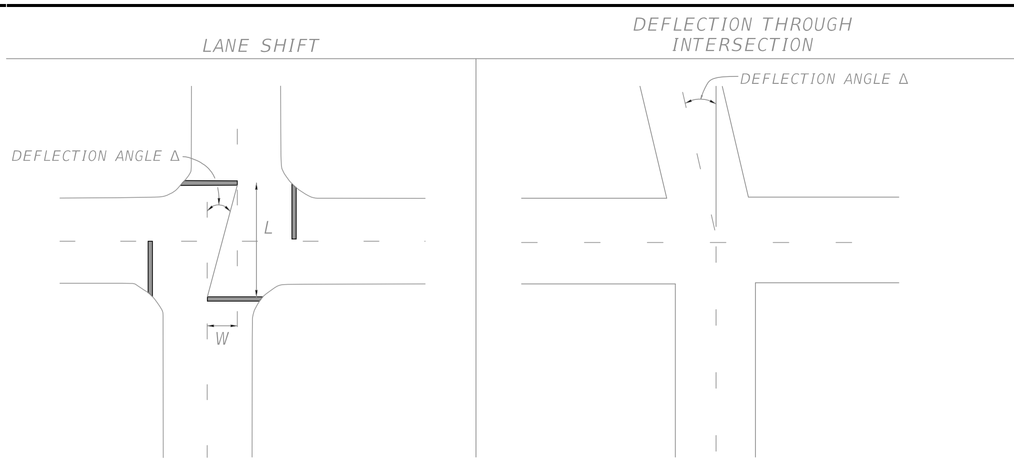
212.7 Lane Shifts

Lane shifts through intersections should meet the requirements for non-merging conditions. Pavement markings should be used through the intersection to provide positive guidance to the motorist. The shifting taper length is controlled by the size of the intersection and the deflection angle. Although deflections through intersections are discouraged, there may be conditions where they are necessary.

The maximum deflection angles at intersections to be used in establishing the horizontal alignment are given in ***Table 212.7.1***.

Table 212.7.1 Maximum Deflection Angle Through Intersection

Maximum Deflection Angle Through Intersection (DM)					
Design Speed (mph)					
≤ 20	25	30	35	40	45
16° 00'	11° 00'	8° 00'	6° 00'	5° 00'	3° 00'
(1) Deflection angle used is not to cause a lane shift (W) of more than 6 feet from stop bar to stop bar.					



212.8 Profile Grades

The profile grade line defines the vertical alignment for construction. The grade line of the mainline road is typically carried through the intersection and the minor cross road (or cross street) is adjusted to it. This design involves a transition in the crown of the cross road to an inclined cross section at its junction with the mainline road, as illustrated in ***Figure 212.8.1***.

The break in the cross road profile at the center of the intersection should be accomplished with a vertical curve.

Vertical alignments at or near intersections should provide traffic lanes that are:

(1) Clearly visible and understandable to drivers for any desired direction of travel,

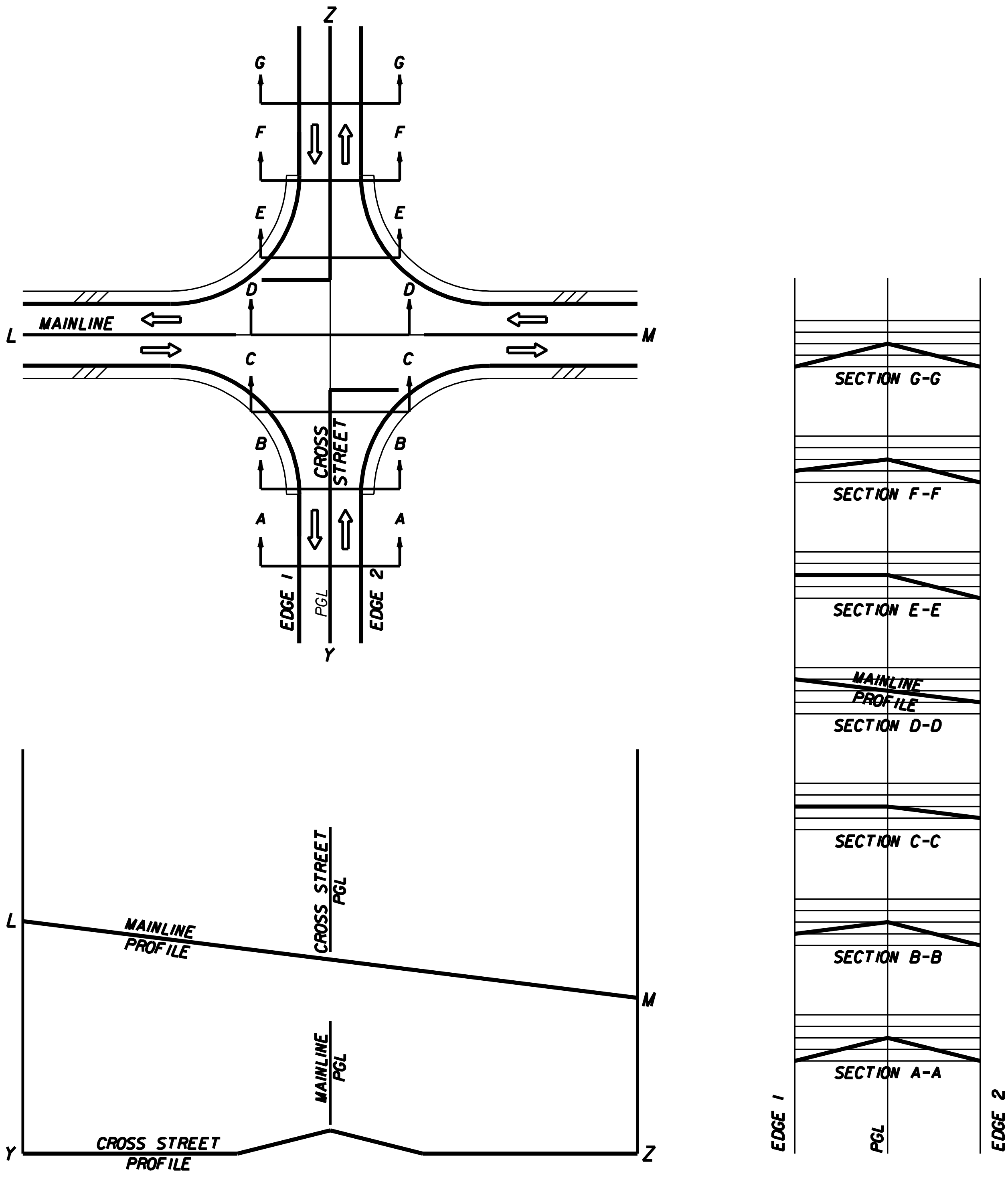
(2) Free from sudden appearance of potential conflicts, and

(3) Consistent in design with the portions of the highway just traveled.

Steep grades at intersections may increase or decrease stopping or acceleration distance. Avoid grades in excess of 3% on intersecting roads in the vicinity of the intersection. Where conditions make such designs impractical, grades should not exceed 6%.

Provide adequate sight distance along both intersecting roads and across their included corners, even where one or both intersecting roads are on vertical curves. The gradients of intersecting roads should be as flat as practical on those sections that are to be used for storage of stopped vehicles.

Figure 212.8.1 Cross Street Intersection Transition



212.8.1 Special Profiles

Special profiles for certain roadway elements may be necessary to ensure a safe, efficient, well-drained and smooth roadway system. Elements that may require special profiles include pavement edges or gutter flow lines at street intersections, profile grade lines, intersection plateaus, curb returns, and special superelevation details. Special profiles are developed at close intervals and large scale to clearly identify all construction details of these elements.

212.8.2 Plateauing

In some instances, it is desirable for the cross road to receive the same profile considerations as the mainline road. To provide this "equal treatment", with respect to profile, a technique commonly known as intersection plateauing is applied. Plateauing refers to flattening of the intersection and the transition of both roadway profiles and cross slopes on the intersection approaches.

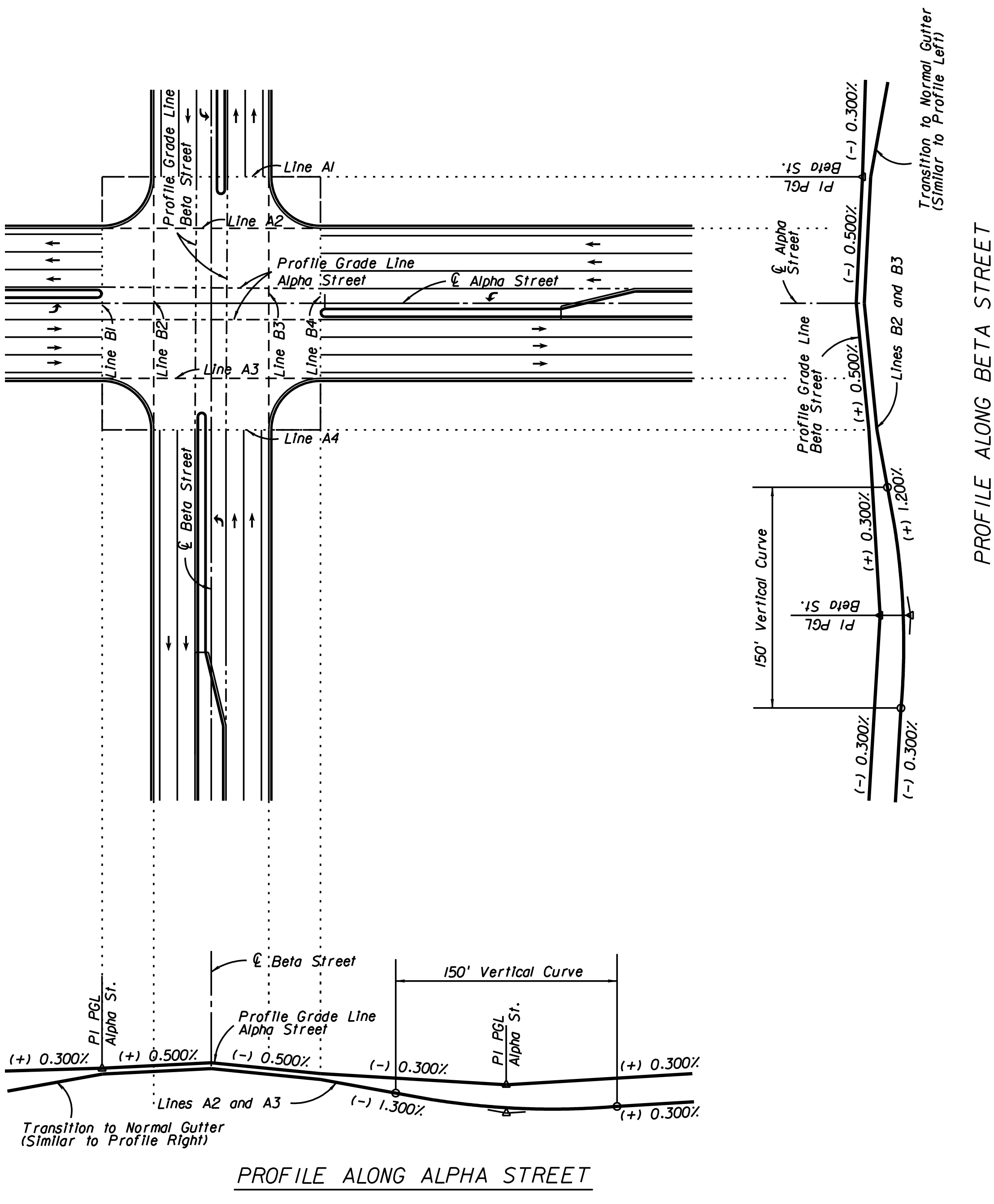
Provide a profile combination that provides a smooth transition and adequate drainage when applying intersection plateauing. Transition slope rates are to meet the values provided in ***Table 212.8.1***; however, the minimum length of cross slope transition is 50 feet for design speeds less than or equal to 35 mph and 75 feet for design speeds of 40 mph or greater.

An example of a plateaued intersection is illustrated in ***Figure 212.8.2***.

Table 212.8.1 Slope Rates for Intersection Approaches

Design Speed (mph)	Slope Ratio
25-35	1:100
40	1:125
45-50	1:150
55-60	1:170
65-70	1:190

Figure 212.8.2 Example of Plateaued Intersection



212.9 Median Openings

Locate and design median openings to meet traffic requirements in accordance with the access management plan for the facility. See ***FDM 201.3*** for more information on access management plans and decision making.

See ***FDM 210.3*** for additional requirements for medians at intersections**.**

The following conditions may require additional median width:

- accommodation for trees (provide space above and below ground for growth)
- offset turn lanes
- directional median openings
- dual and triple left turn lanes

The overall length of a full median opening is typically the same width as the intersecting road (including shoulders) which is sufficient to accommodate the swept path of left turning vehicles. Median functions and minimum widths are provided in ***Table 212.9.1***.

For un-signalized intersections, median openings should not be longer than the required length to avoid multiple vehicles attempting to stop within the opening.

Table 212.9.1 Minimum Median Width

Median Function	Minimum Width (feet)
Separation of opposing traffic	4
Provision for pedestrian refuge	6
Provision for storage of left-turning vehicles	See ***Table 210.3.1***
Provision for protection of vehicles crossing through lanes	22
Provision for U-turns, left turn lane to outside lanes	30
Provision for Dual Left Turn Lanes and U Turns	42

The control radius refers to a radius that must be considered in establishing the location of median or traffic separator ends on divided highways and the stop bar on undivided highways. Provide this radius for left-turn movements when appropriate.

Design guidance on minimum edge-of-traveled-way design for various design vehicles is provided in ***FDM 212.12.1***.

For the central part of the turn the use of compound curves is not necessary and the use of simple curves is satisfactory. ***Table 212.9.2*** provides control radii for minimum-speed turns (10 to 15 mph) that can be used for establishing the location of the median ends.

Table 212.9.2 Control Radii for Minimum Speed Turns

Design Vehicles Accommodated	Control Radius (feet)			
	50 (40 min)	60 (50 min)	75	130
Predominant	P	SU-30	SU-40, WB-40	WB-62FL
Occasional	SU-30	SU-40, WB-40	WB-62	WB-67

212.9.1 U-Turns

Median width should accommodate passenger vehicle (P) left-turn and U-turn maneuvers. If adequate median width does not exist for accommodating U-turns, then consider adding extra pavement width such as a taper or additional shoulder width. See ***FDM 210.3*** for information on median width criteria.

In cases where U-turn traffic volumes are high, consider the use of jug handles, loop designs, or indirect left turn designs.

212.10 Stopping Sight Distance

See ***FDM 210.11.1*** for stopping sight distance requirements.

212.11 Clear Sight Triangles

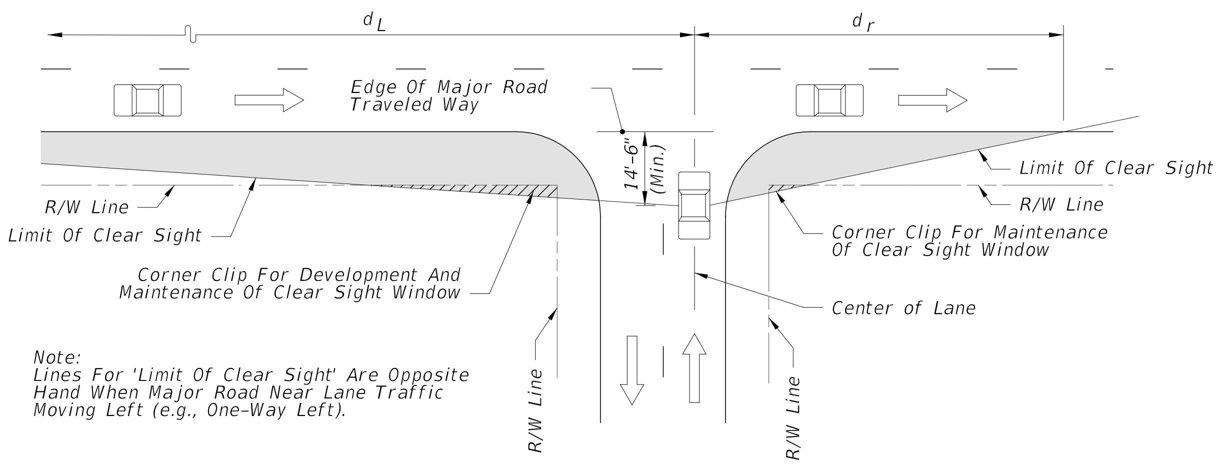
Establish clear sight triangles to assure that drivers are provided a sufficient view of the intersecting highway to identify gaps in traffic and decide when it is safe to proceed. Document the analysis of sight distance for all intersections.

Clear sight triangles are the areas along intersection approach legs and across their common corners that should be clear of visual hindrances. Dimensions of clear sight triangles are based on design speed, design vehicle, and the type of traffic control used at the intersection.

212.11.1 Stop Control (AASHTO Case B)

Figure 212.11.1 illustrates clear sight triangles for intersections and driveways.

Figure 212.11.1 Clear Sight Triangles



The minimum driver-eye setback of 14.5 feet from the edge of the traveled way may be adjusted on any intersection leg only when justified by a documented, site-specific field study of vehicle stopping position and driver-eye position.

Exhibits 212-4 through ***212-7*** provide intersection sight distances for stop controlled intersections. The tables in the exhibits provide sight distance values for Passenger vehicles, Single Unit (SU) Trucks, and Combination vehicles for design speeds ranging from 30 mph to 65 mph. Intersection sight distance based on Passenger vehicles is suitable for most intersections; however, consider the values for SU Vehicles or Combination vehicles for intersections with high truck volumes.

The following guidance applies to ***Exhibits 212-4*** through ***212-7***:

(1) Limitations

 (a) The exhibits apply to intersections in all context classifications with stop control or flashing beacon control.

 (b) The exhibits apply only to intersections with intersecting angles between 60°and 120°, and where vertical and horizontal curves are not present.

(2) Dimensions

(a) Sight distance (d) is measured from the center of the entrance lane of the crossroad to the center of the near approach lane (right or left) of the highway.

(b) Distances 'd_L' and 'd_r' are measured from the centerline of the entrance lane of the crossroad to a point on the edge of the near side outer traffic lane on the highway.

(c) Distance 'd_m' is measured from the centerline of the entrance lane of the crossroad to a point on the median clear zone limit or horizontal clearance limit for the far side road of the highway.

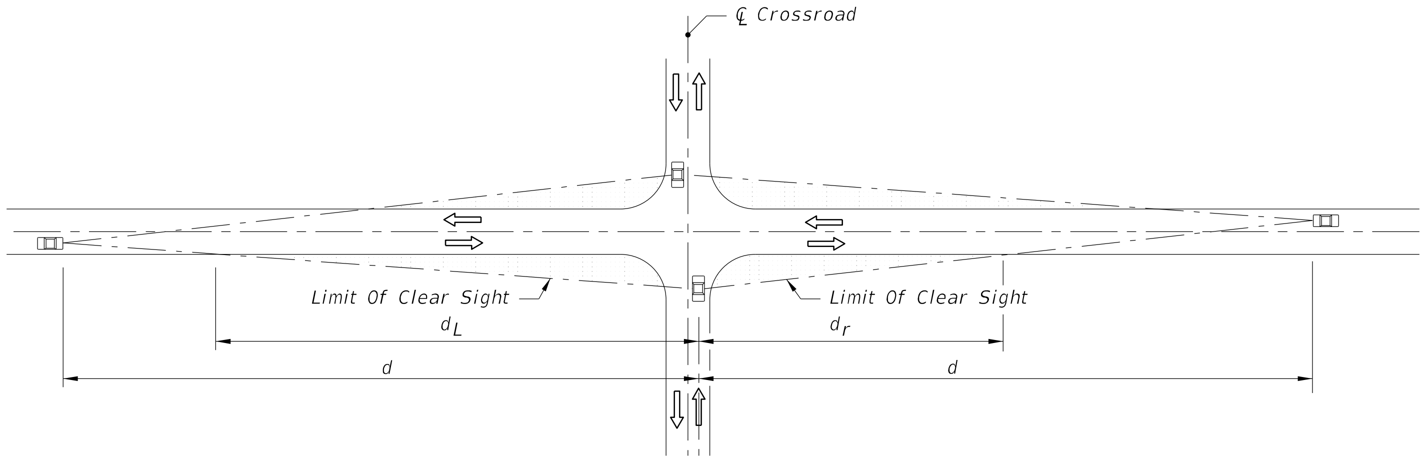
(3) Vertical limits

(a) Provide a clear sight window throughout the limits of all intersection sight triangles.

(b) Provide a clear line of sight between vehicles at intersection stop locations and vehicles on the highway throughout the limits of all intersection sight triangles.

(c) The reference datum between roadways is 3'-6" above respective pavements since observations are made in both directions along the line of sight.

INTERSECTION SIGHT DISTANCE: 2-LANE UNDIVIDED



2-LANE UNDIVIDED

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	335	240	155
35	390	275	175
40	445	315	200
45	500	355	225
50	555	395	250
55	610	435	275
60	665	470	300
65	720	510	325

Passenger Vehicle

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	420	300	190
35	490	350	220
40	560	400	250
45	630	450	285
50	700	495	315
55	770	545	345
60	840	595	375
65	910	645	410

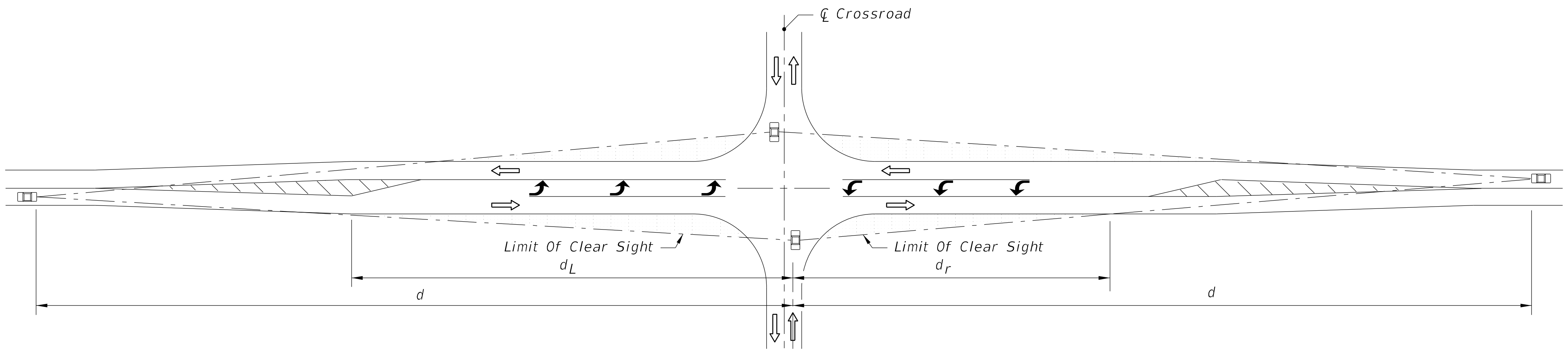
SU Vehicle

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	510	365	230
35	595	420	265
40	680	480	305
45	765	545	345
50	845	600	380
55	930	660	415
60	1015	720	455
65	1100	780	495

Combination Vehicle

SIGHT DISTANCE (d) AND RELATED DISTANCES (d_L, d_r) (FEET)

2 LANE UNDIVIDED



2-LANE WITH LEFT TURN LANE

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	355	195	135
35	415	230	160
40	475	260	180
45	530	290	200
50	590	325	225
55	650	355	245
60	710	390	270
65	765	420	290

Passenger Vehicle

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	450	250	170
35	525	290	200
40	600	330	230
45	675	370	255
50	750	410	285
55	825	455	315
60	900	495	340
65	975	535	370

SU Vehicle

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	540	295	205
35	630	345	240
40	720	395	275
45	810	445	305
50	900	495	340
55	990	545	375
60	1080	590	410
65	1170	640	440

Combination Vehicle

SIGHT DISTANCE (d) AND RELATED DISTANCES (d_L, d_r) (FEET)

2-LANE WITH LEFT TURN

NOT TO SCALE

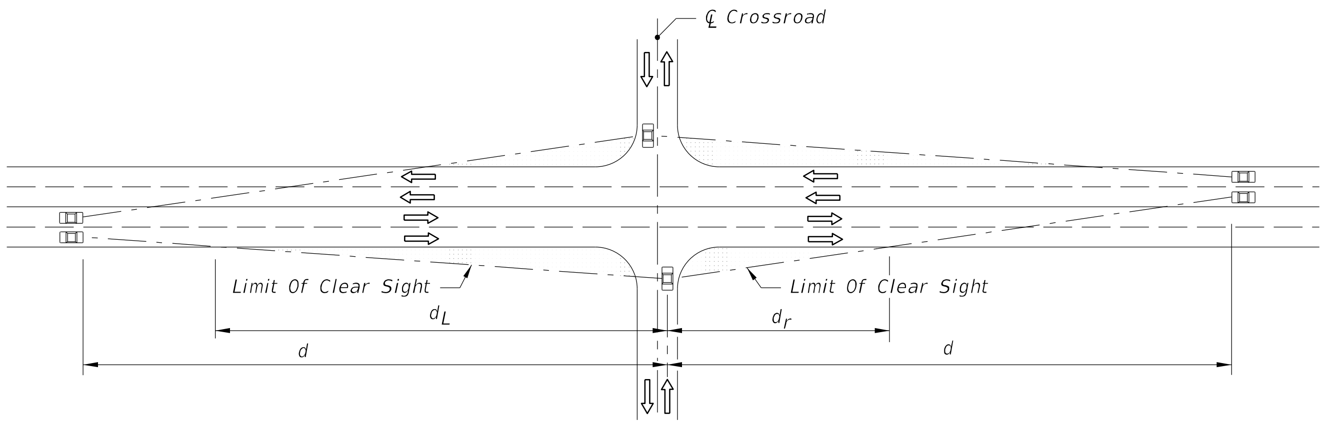
NOTE:
1. See Figure 212.11.1 for origin of clear sight line on the minor road.

LEGEND

Areas Free Of Sight Obstructions

EXHIBIT 212-4
01/01/2018

INTERSECTION SIGHT DISTANCE: 4-LANE UNDIVIDED



4-LANE UNDIVIDED

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	355	255	120
35	415	295	135
40	475	335	155
45	530	375	175
50	590	420	195
55	650	460	215
60	705	500	230
65	765	545	250

Passenger Vehicle

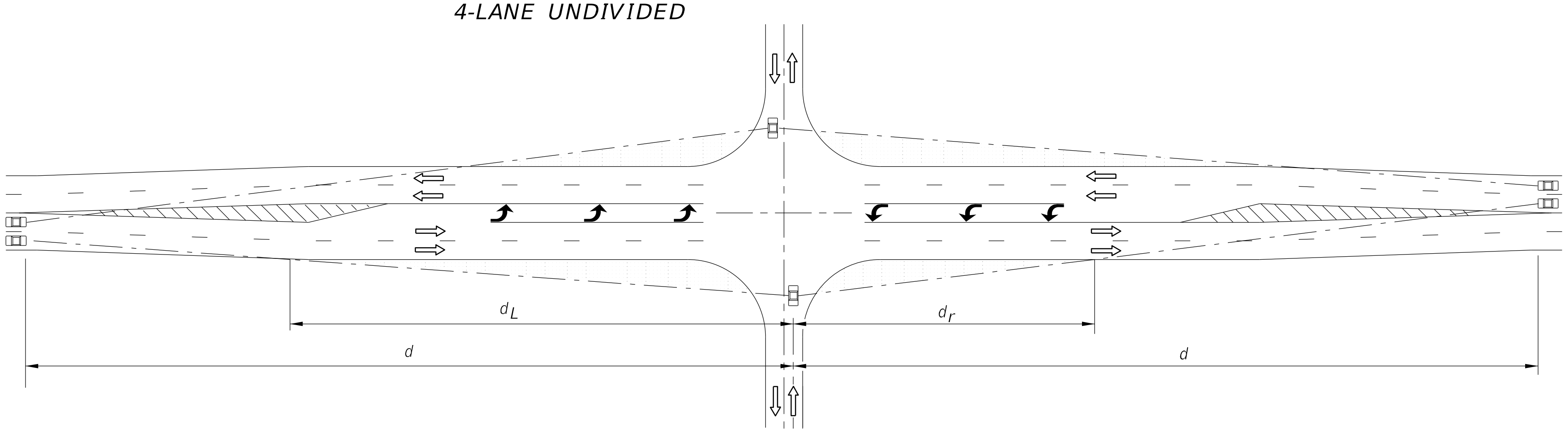
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	450	320	150
35	525	375	175
40	600	425	200
45	675	480	220
50	750	530	245
55	825	585	270
60	900	640	295
65	975	690	320

SU Vehicle

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	540	385	180
35	630	450	205
40	720	510	235
45	810	575	265
50	900	640	295
55	990	700	325
60	1080	765	355
65	1170	830	385

Combination Vehicle

SIGHT DISTANCE (d) AND RELATED DISTANCES (d_L, d_r) (FEET)
4 LANE UNDIVIDED



4-LANE UNDIVIDED WITH LEFT TURN LANE

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	375	205	110
35	440	245	130
40	500	275	145
45	565	310	165
50	625	345	180
55	690	380	200
60	750	410	215
65	815	450	235

Passenger Vehicle

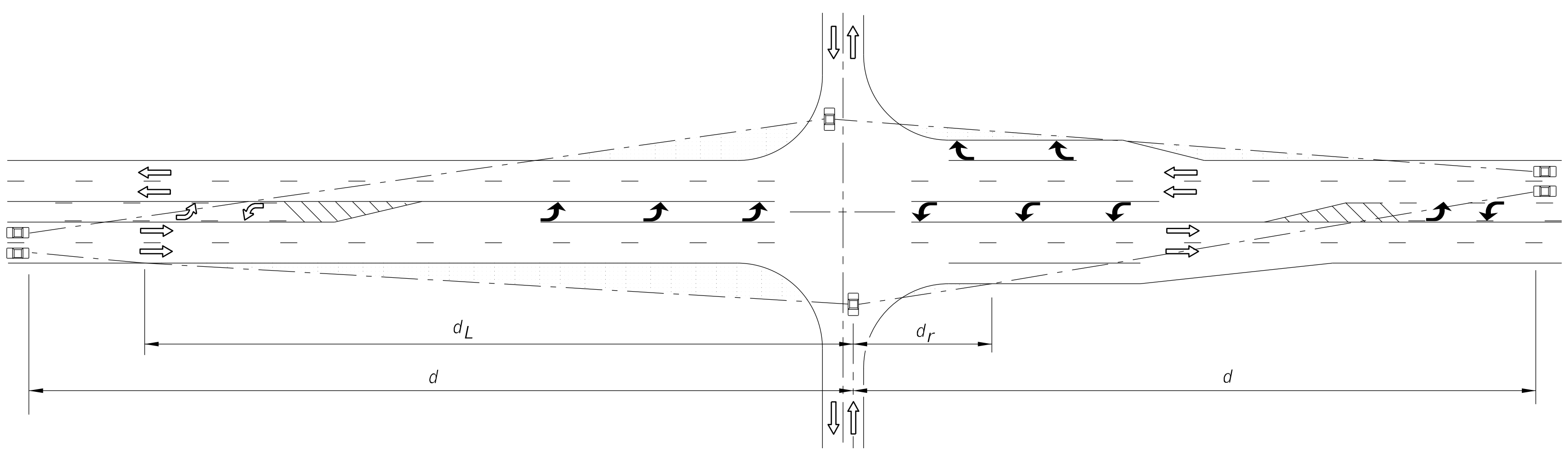
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	480	265	140
35	560	310	165
40	640	350	185
45	720	395	210
50	800	440	230
55	880	485	255
60	960	525	280
65	1040	570	300

SU Vehicle

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	570	315	165
35	665	365	195
40	760	420	220
45	855	470	245
50	950	520	275
55	1045	575	300
60	1140	625	330
65	1235	675	355

Combination Vehicle

SIGHT DISTANCE (d) AND RELATED DISTANCES (d_L, d_r) (FEET)
4-LANE UNDIVIDED WITH LEFT TURN LANE



4-LANE UNDIVIDED WITH LEFT TURN LANE AND OPTIONAL LANE

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	375	265	80
35	440	315	95
40	500	355	110
45	565	400	120
50	625	445	135
55	690	490	150
60	750	530	160
65	815	580	175

Passenger Vehicle

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	480	340	105
35	560	400	120
40	640	455	135
45	720	510	155
50	800	570	170
55	880	625	190
60	960	680	205
65	1040	740	220

SU Vehicle

Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)
30	570	405	125
35	665	470	145
40	760	540	165
45	855	605	185
50	950	675	205
55	1045	740	225
60	1140	810	245
65	1235	875	265

Combination Vehicle

SIGHT DISTANCE (d) AND RELATED DISTANCES (d_L, d_r) (FEET)
4-LANE UNDIVIDED WITH LEFT TURN LANE AND OPTIONAL LANE

NOT TO SCALE

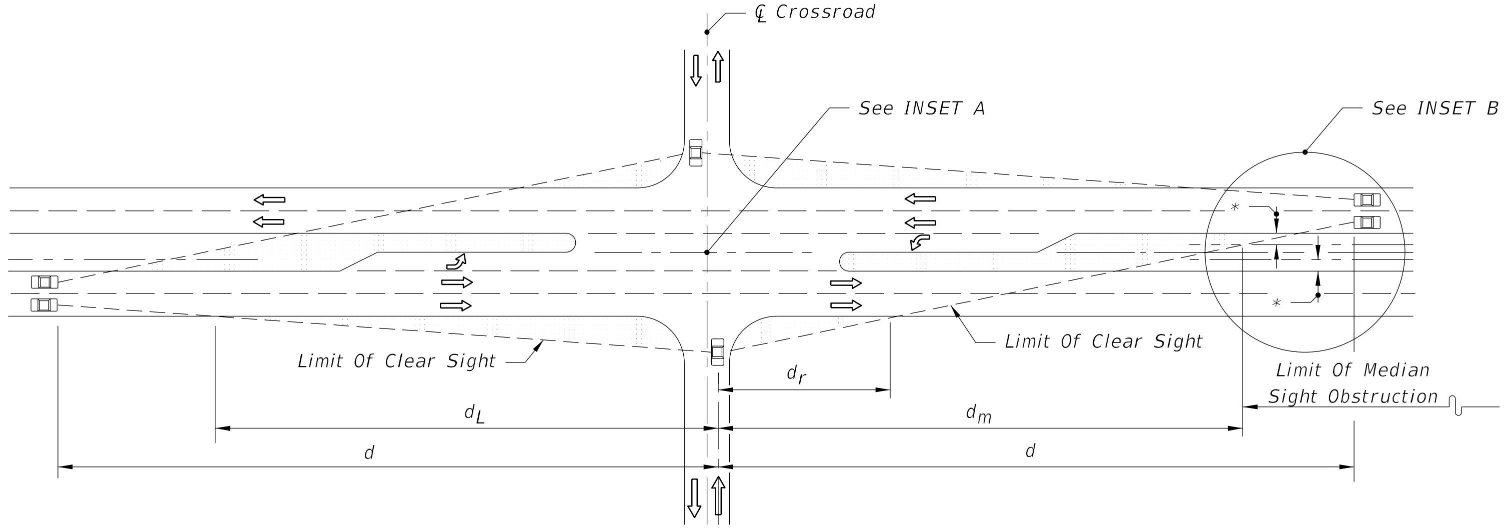
LEGEND

Areas Free Of Sight Obstructions

NOTE:
1. See Figure 212.11.1 for origin of clear sight line on the minor road.

EXHIBIT 212-5
01/01/2018

INTERSECTION SIGHT DISTANCE: 4-LANE DIVIDED



4-LANE DIVIDED

Passenger Vehicle

Median 22' or Less				
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)	d_m (Ft.)
30	395	280	90	325
35	460	325	100	380
40	525	375	115	430
45	590	420	130	485
50	655	465	145	540
55	720	510	160	590
60	785	555	175	645
65	850	605	185	700

25'–64' Median				
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_v (Ft.)	d_{vL} (Ft.)
30	355	255	330	240
35	415	295	390	280
40	470	335	445	320
45	530	375	500	360
50	590	420	550	400
55	650	460	610	440
60	705	500	665	480
65	765	545	720	520

Passenger Vehicle

Median 35' or Less				
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)	d_m (Ft.)
30	540	385	110	460
35	630	450	125	535
40	720	510	145	615
45	810	575	160	685
50	900	640	180	760
55	990	700	195	840
60	1080	765	215	915
65	1170	830	230	990

40'–64' Median				
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_v (Ft.)	d_{vL} (Ft.)
30	450	320	420	330
35	525	375	490	385
40	600	425	560	440
45	675	480	630	490
50	750	530	700	545
55	825	585	770	600
60	900	640	840	655
65	975	690	910	710

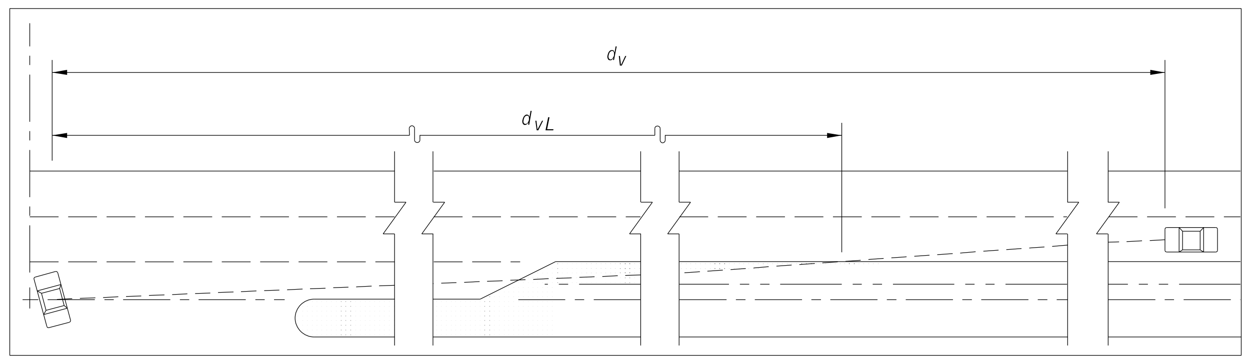
SU Vehicle

Median 30' or Less				
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)	d_m (Ft.)
30	615	435	120	520
35	720	510	140	605
40	820	580	160	690
45	925	655	180	780
50	1025	725	200	860
55	1130	800	220	950
60	1230	870	240	1035
65	1335	945	260	1120

35'–50' Median				
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_r (Ft.)	d_m (Ft.)
30	670	475	105	585
35	780	555	120	680
40	890	630	140	780
45	1000	710	155	875
50	1110	790	170	970
55	1225	870	190	1070
60	1335	945	205	1165
65	1445	1025	225	1265

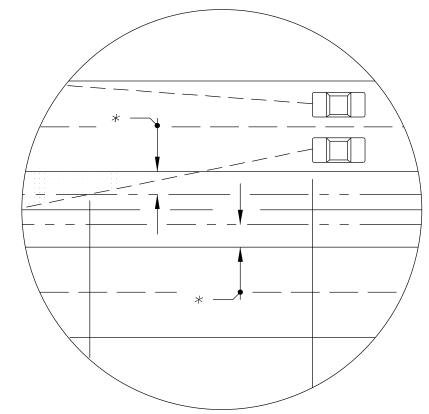
64' Median				
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_v (Ft.)	d_{vL} (Ft.)
30	540	385	510	435
35	630	450	595	500
40	720	510	680	575
45	810	575	760	645
50	900	640	845	720
55	990	700	930	790
60	1080	765	1015	865
65	1165	825	1100	935

Combined Vehicles



Where The Median Is Sufficiently Wide For The Design Vehicle To Pause In The Median (Vehicle Length Plus 6' Min.) The Clear Line Of Sight To The Right (d_V) Is Measured From The Vehicle Pause Location, i.e., Not From The Cross Road Stop Position; Distances d_r & d_m Do Not Apply.

INSET A



INSET B

* Lateral Offset For Restricted Conditions
Clear Zone For Nonrestricted Conditions

Vehicle Type	Vehicle Length (Ft.)
Passenger (P)	19
Single Unit (SU)	30
Large School Bus	40
WB-40	45.5
WB-50	55

NOTES FOR 4-LANE DIVIDED ROADWAY

1. See Figure 212.11.1 for origin of clear sight line on the minor road.

2. Values shown in the tables are the governing (controlling) sight distances calculated based on 'AASHTO Case B – Intersection with Stop Control on the Minor Road.'

SIGHT DISTANCES (d) & (d_v) AND RELATED DISTANCES (d_L, d_r, d_m & d_{VL}) (FEET)

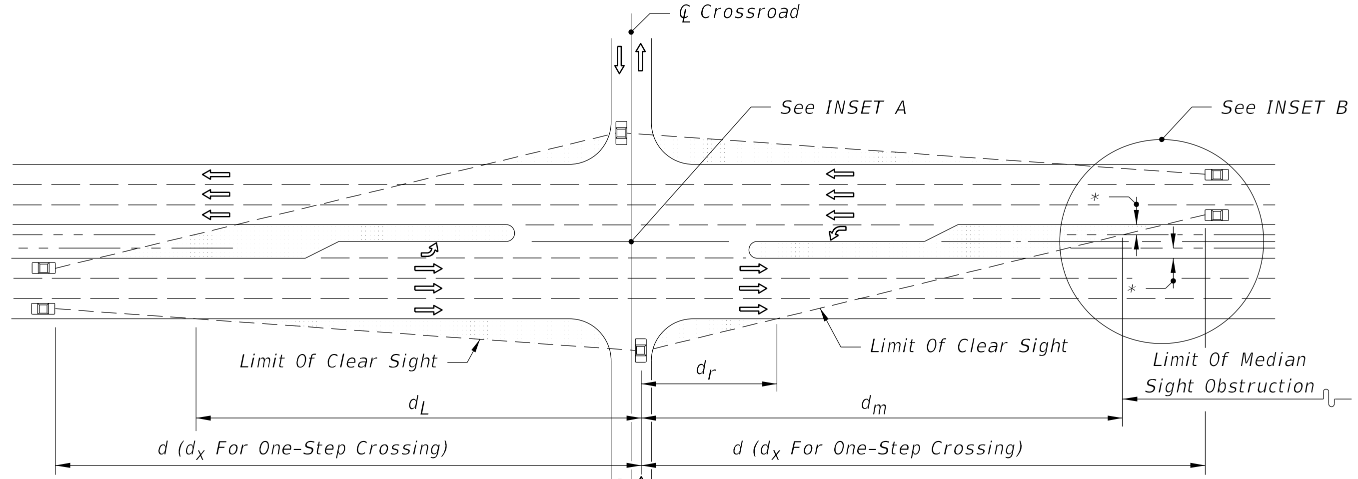
NOT TO SCALE

LEGEND

Areas Free Of Sight Obstructions

EXHIBIT 212-6
01/01/2018

INTERSECTION SIGHT DISTANCE: 6-LANE DIVIDED



6-LANE DIVIDED

Median 22' or Less				
Design Speed (mph)	d_x (Ft.)	d_L (Ft.)	d_r (Ft.)	d_m (Ft.)
30	415	295	80	355
35	485	345	90	415
40	555	395	105	470
45	625	445	115	530
50	690	490	130	585
55	760	540	140	645
60	830	590	155	705
65	900	640	170	765

25'-64' MEDIAN				
Design Speed	d	d_L	d_v	d_{vL}
30	375	265	330	240
35	440	315	385	280
40	500	355	445	320
45	565	400	500	360
50	625	445	555	400
55	690	490	610	440
60	750	530	665	480
65	815	580	720	520

Passenger Vehicle

Median 35' or Less				
Design Speed (mph)	d_x (Ft.)	d_L (Ft.)	d_r (Ft.)	d_m (Ft.)
30	570	405	90	495
35	665	470	105	580
40	760	540	120	660
45	855	605	135	745
50	955	675	155	830
55	1050	745	170	915
60	1145	810	185	995
65	1240	880	200	1080

40'-64' Median				
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_v (Ft.)	d_{vL} (Ft.)
30	480	340	420	330
35	560	400	490	385
40	640	455	560	440
45	720	510	630	490
50	805	570	700	545
55	885	625	770	600
60	965	685	840	665
65	1045	740	910	710

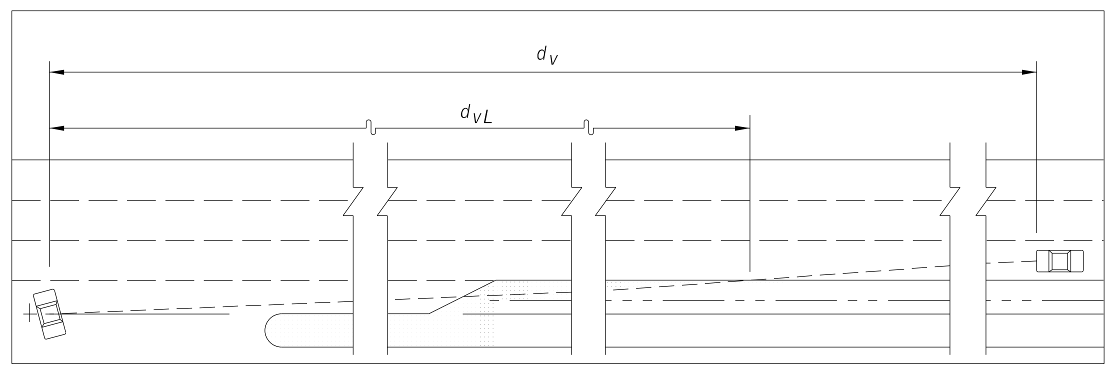
SU Vehicle

Median 30' or Less				
Design Speed (mph)	d_x (Ft.)	d_L (Ft.)	d_r (Ft.)	d_m (Ft.)
30	650	460	110	560
35	755	535	130	655
40	865	615	145	745
45	970	690	165	835
50	1080	765	185	930
55	1185	840	200	1025
60	1290	915	220	1115
65	1400	990	235	1210

35'-50' Median				
Design Speed (mph)	d_x (Ft.)	d_L (Ft.)	d_r (Ft.)	d_m (Ft.)
30	700	495	95	625
35	815	580	115	725
40	930	660	130	825
45	1045	740	145	930
50	1165	825	160	1035
55	1280	905	175	1140
60	1395	990	190	1240
65	1510	1070	210	1340

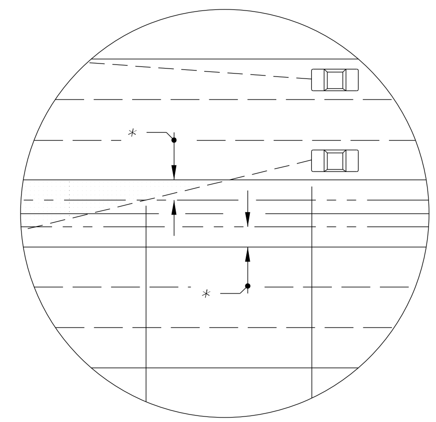
64' Median				
Design Speed (mph)	d (Ft.)	d_L (Ft.)	d_v (Ft.)	d_{vL} (Ft.)
30	570	405	510	435
35	665	470	590	500
40	760	540	680	575
45	855	605	760	645
50	950	675	845	720
55	1045	740	930	790
60	1140	805	1015	865
65	1235	875	1100	935

Combined Vehicles



Where The Median Is Sufficiently Wide For The Design Vehicle To Pause In The Median (Vehicle Length Plus 6' Min.) The Clear Line Of Sight To The Right (d_V) Is Measured From The Vehicle Pause Location, i.e., Not From The Cross Road Stop Position; Distances d_r & d_m Do Not Apply.

INSET A



INSET B

* Lateral Offset For Restricted Conditions
Clear Zone For Nonrestricted Conditions

Vehicle Type	Vehicle Length (Ft.)
Passenger (P)	19
Single Unit (SU)	30
Large School Bus	40
WB-40	45.5
WB-50	55

NOTES FOR 6-LANE DIVIDED ROADWAY

1. See Figure 212.11.1 for origin of clear sight line on the minor road.
2. Values shown in the tables are the governing (controlling) sight distances calculated based on 'AASHTO Case B – Intersection with Stop Control on the Minor Road.'

SIGHT DISTANCES (d), (d_V) & (d_X) AND RELATED DISTANCES (d_L , d_r , d_m & d_{vL}) (FEET)

NOT TO SCALE

LEGEND

Areas Free Of Sight Obstructions

EXHIBIT 212-7
01/01/2018

212.11.2 All-Way Stop Control (AASHTO Case E)

Provide clear sight lines on each of the approach legs for all-way stop controlled intersections.

212.11.3 Signal Control (AASHTO Case D)

For signalized intersections incorporate the following:

(1) Develop sight distances based on AASHTO ‘Case D-Intersections with Signal Control’.

(2) The first vehicle stopped on any approach leg is visible to the driver of the first vehicle stopped on each of the other approach legs.

(3) For permissive left turns provide sufficient sight distance for left turning vehicles to select gaps in oncoming traffic and complete left turns.

(4) If a traffic signal is to be placed on two-way flashing operation (i.e. flashing yellow on the major road approaches and flashing red on the minor road approaches) under off peak or nighttime conditions, then provide the appropriate departure sight triangles for AASHTO Case B (Stop Control on the Minor Road).

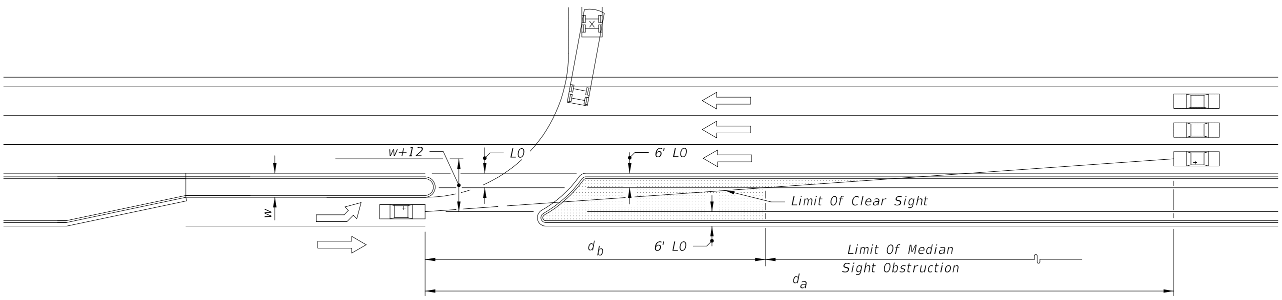
(5) If right turns on red are permitted from any approach leg then provide the appropriate departure sight triangle to the left for AASHTO Case B above.

212.11.4 Left Turn from Highway (AASHTO Case F)

Provide sufficient sight distance to accommodate a left turn maneuver for locations where left turns across opposing traffic are permitted. ***Table 212.11.1*** provides clear sight distance values for left turn from highway.

For additional information on determining the sight distance refer to Chapter 9 of AASHTO’s ***A Policy on Geometric Design of Highways and Streets***.

Table 212.11.1 Sight Distance for Left Turn from Highway



Design Speed (mph)	d_a (feet)								
	1 Lane Crossed			2 Lane Crossed			3 Lane Crossed		
	P	SU	Comb.	P	SU	Comb.	P	SU	Comb.
25-30	245	290	330	265	320	365	290	350	395
35	285	335	385	310	370	425	335	410	460
40	325	385	440	355	425	485	385	465	525
45	365	430	495	400	475	545	430	525	590

Notes:

(1) Provide a lateral offset (LO) of 6' as shown in the diagram above. d_b may be determined by the equation $d_b = d_a (w/(w+12))$. For roadways with non-restricted conditions, d_a and d_b should be based on the geometry for the left turn storage and on clear zone widths.

(2) For wide medians where the turning vehicle can approach the through lane at or near 90°, use d values from tables in ***Exhibits 212-6*** and ***212-7***. (The clear sight line origin is assumed to be 14.5 feet from the edge of the near travel lane.

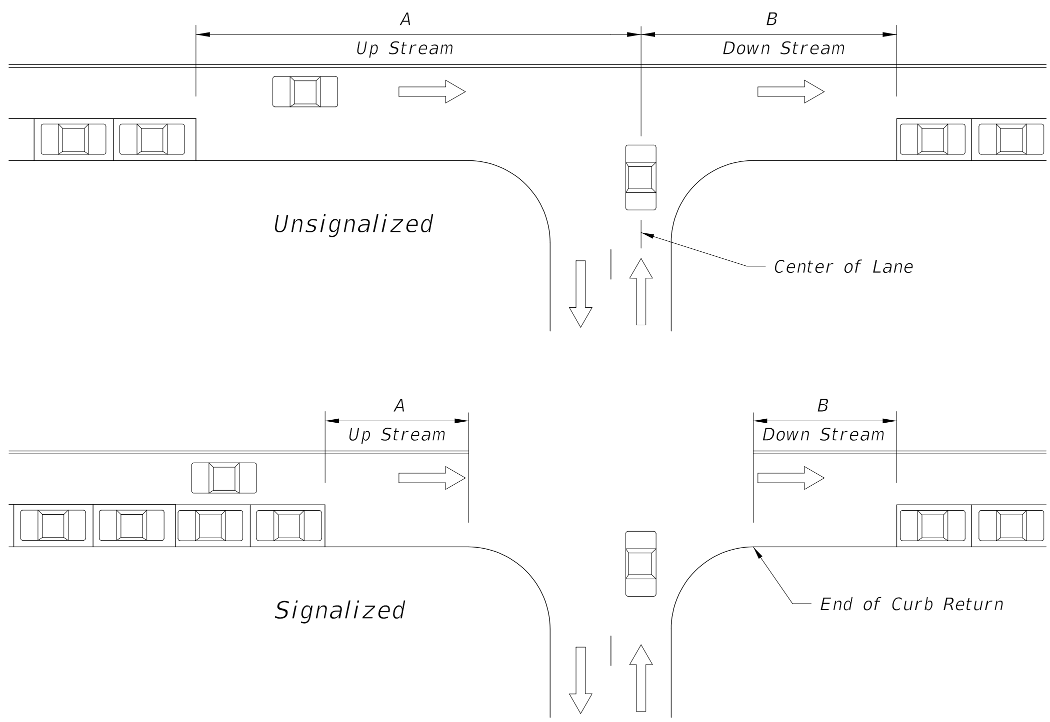
212.11.5 On-Street Parking

Table 212.11.2 provides parking restrictions for intersections; including mid-block crossings and roundabout approaches. For additional information, see the following:

- ***FDM 210.2.3*** for additional information concerning on-street parking.
- ***FDM 222.2.6*** for information concerning curb extensions (bulb-outs).
- ***Chapter 316, Florida Statutes*** (***F.S.***), for laws governing parking spaces.

Table 212.11.2 Parking Restrictions for Driveways and Intersections

Control Type	Posted Speed (mph)	A - Up Stream (ft)	B – Down Stream (ft)	
			2-Lane	4-Lane or more
Unsignalized	< 35	90	60	45
	35	105	70	50
Signalized	< 35	30	30	30
	35	50	50	50



Notes:

(1) For entrances to one-way streets, the downstream restriction (B) may be reduced to 20 feet.

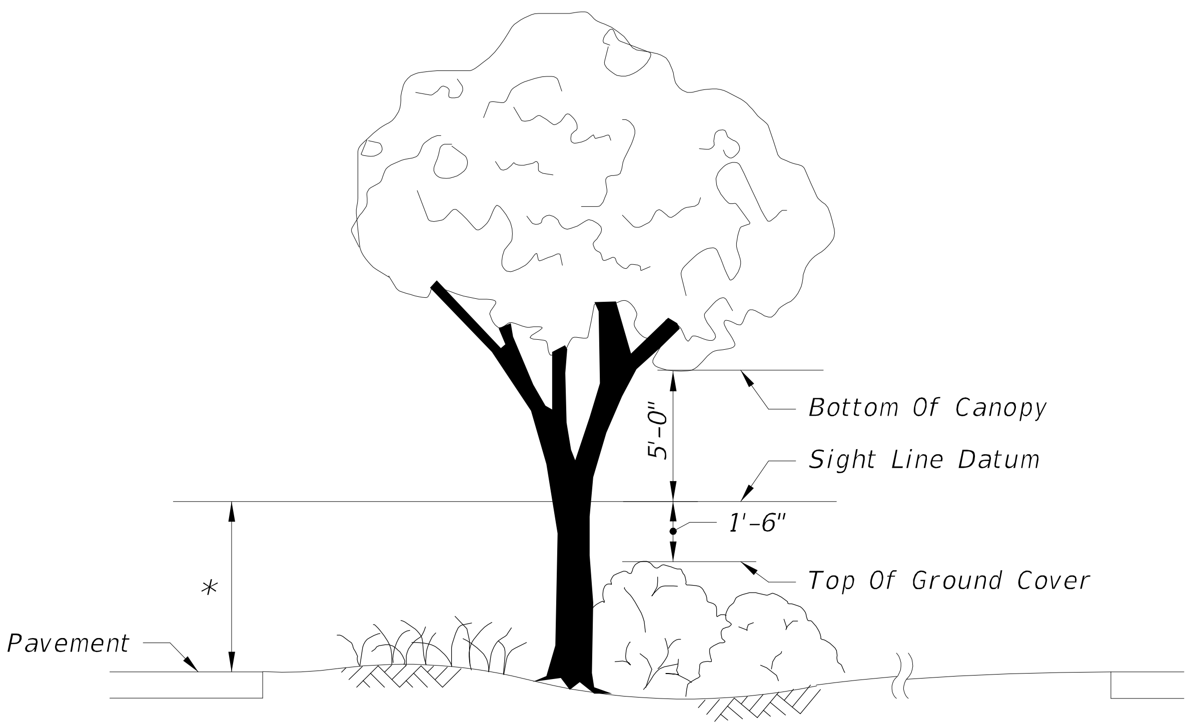
(2) Do not place parking within 20 feet of a marked crosswalk.

212.11.6 Trees and Vegetation

Intersections should be designed to accommodate the placement of trees and other desired vegetation in urbanized context classifications. Space above and below ground is necessary for trees to grow and provide shade. Coordinate the placement of vegetation with the Project Landscape Architect so that clear sight triangles are maintained for all approaches.

The clear sight window concept may provide opportunities for vegetation within the limits of intersection sight triangles. This concept is illustrated in ***Figure 212.11.2.*** This detail provides the required vertical clear sight limits with respect to the sight line datum. The horizontal limits of the window are defined by clear sight triangles. Within the limits of clear sight triangles, the tree canopy must be at least 5 feet above the sight line datum and the top of the ground cover must be at least 1.5 feet below the sight line datum. Maintaining these limits will provide a clear line of sight for approaches to an intersection.

Figure 212.11.2 Window Detail



* Since observations are made in both directions, the line of sight datum between roadways is 3.5 feet above both pavements.

When trees are located in the median of a divided roadway and fall within the limits of a clear sight triangle, conform to ***Table 212.11.3*** for tree size and spacing. Spacing values for trees with diameter of 11 inches or less were derived assuming a maximum 6-foot wide shadow band on a vehicle at the stop bar location when viewed by a mainline driver beginning at sight distance 'd'. This is illustrated in ***Figure 212.11.3***. Spacing values for trees with diameter greater than 11 inches and less than or equal to 18 inches were derived assuming a 2 second full view of the vehicle at the stop bar when viewed by the mainline driver beginning at sight distance 'd'. (See ***Figure 212.11.4***).

Do not place trees within the hatched-out areas as shown in ***Figure 212.11.5***. The hatched-out area is for ground cover only.

Table 212.11.3 Minimum Tree Spacing

Design Speed (mph)	Minimum Tree Spacing (Center-to-Center of Trunk) (feet)	
	4" < Tree Diameter ≤ 11"	11" < Tree Diameter ≤ 18"
25-30	25	90
35	30	105
40	35	120
45	40	135
50	50	150
55	55	165
60	60	180

Notes:

(1) Size and spacing are based on the following conditions:

(a) A single line of trees in the median parallel to but not necessarily collinear with the centerline.

(b) A straight approaching mainline and intersection angle between 60° and 120°.

(c) Space trees with 4" < Dia. ≤ 11" intermixed with trees with 11" < Dia. ≤ 18" based on trees with 11" < Dia. ≤ 18".

(2) Detail tree size, spacing, and location in the plans for any other conditions.

Figure 212.11.3 Shadow Diagram

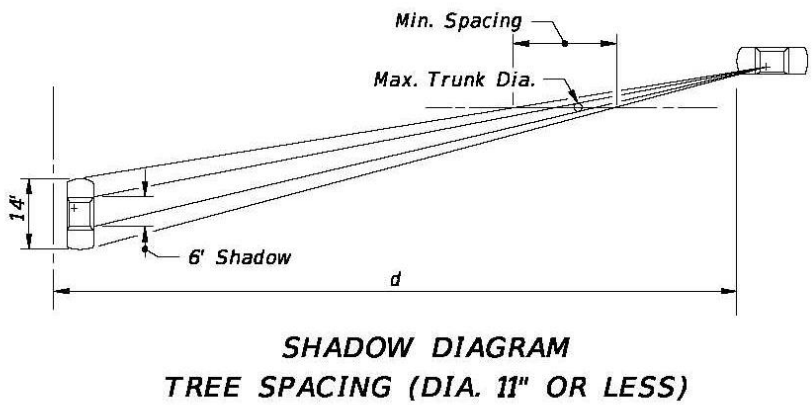


Figure 212.11.4 Perception Diagram

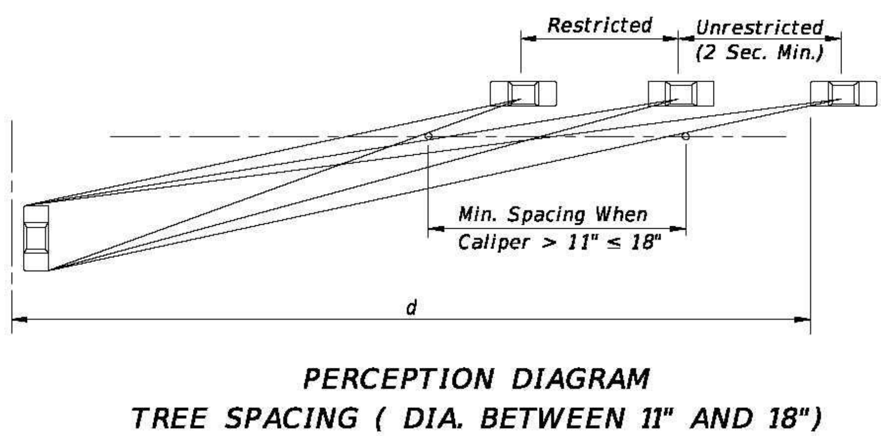
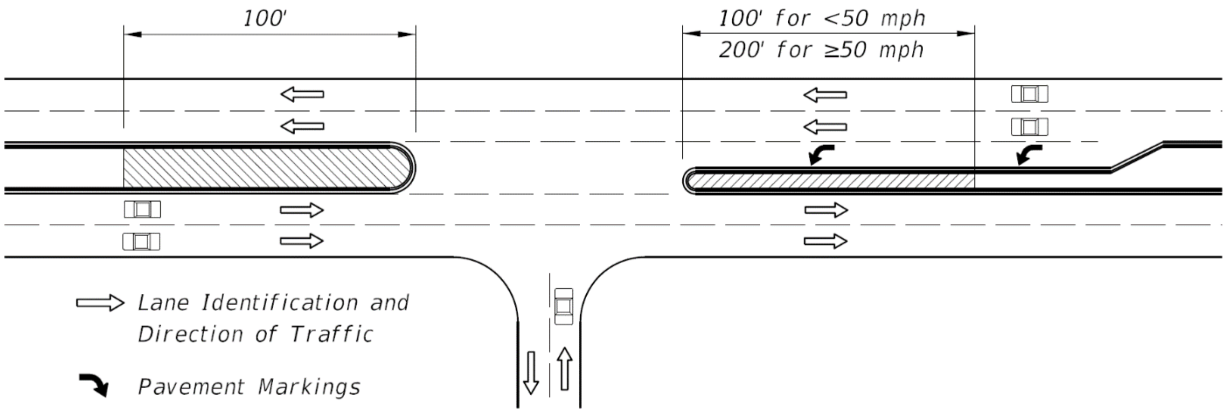


Figure 212.11.5 Special Areas Limited to Ground Cover



212.12 Turning Roadways

Turning roadways are typically designed for use by right-turning traffic at intersections. There are three types of right-turning roadways:

- edge-of-traveled-way design
- design with a corner triangular island
- free-flow design using a simple radius or compound radii

The turning radii and the pavement cross slopes for free-flow right turns are functions of design speed and design vehicle.

212.12.1 Edge-of-Traveled-Way Design

When selected design vehicle is to be accommodated within minimum space, corner radii should be based on the required turning path.

Table 212.12.1 provides simple curve radii with and without tapers. ***Table 212.12.2*** provides symmetric and asymmetric three centered compound curve radii for a range of design vehicles. These values provide the minimum turning paths attainable at design speeds of 10 mph and less.

Figure 212.12.1 demonstrates the angle of turn for use in these tables.

The minimum edge-of-traveled-way values provided in these tables are based on the assumption that the vehicle is properly positioned within the traffic lane at the beginning and end of the turn (2 feet from the edge-of-traveled-way on the tangents approaching and leaving the intersection curve). Such designs follow closely the inner wheel path of the selected design vehicle, with a clearance of 2 feet or more throughout most of the turn, and with a clearance at no point less than 9 inches. Differences in the inner paths of vehicles turning left and right are not sufficient to be significant in design. For this reason these edge designs also apply to left-turn maneuvers, such as a left turn by a vehicle leaving a divided highway at a very low speed.

Figure 212.12.1 Turn Angle for Turning Roadway Designs

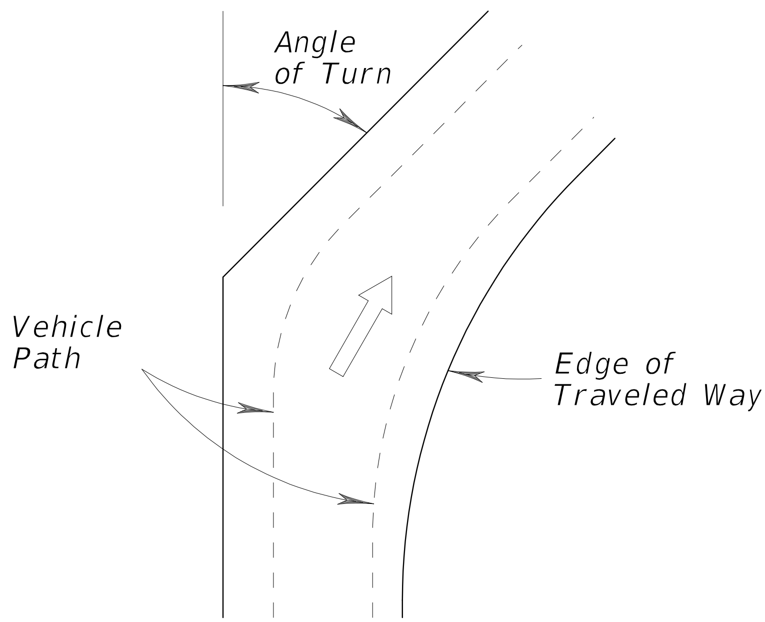


Table 212.12.1 Edge-of-Traveled-Way, Simple Curve Radii

Angle of Turn (degrees)	Design Vehicle	Simple Curve Radius (feet)	Simple Curve Radius with Taper		
			Radius (feet)	Offset (feet)	Taper H:V
30	P	60	----	----	----
	SU-30	100	----	----	----
	SU-40	140	----	----	----
	WB-40	150	----	----	----
	WB-62	360	220	3.0	15:1
	WB-62FL	380	220	3.0	15:1
	WB-67	380	220	3.0	15:1
	WB-92D	365	190	3.0	15:1
	WB-100T	260	125	3.0	15:1
	WB-109D	475	260	3.5	20:1
45	P	50	----	----	----
	SU-30	75	----	----	----
	SU-40	115	----	----	----
	WB-40	120	----	----	----
	WB-62	230	145	4.0	15:1
	WB-62FL	250	145	4.5	15:1
	WB-67	250	145	4.5	15:1
	WB-92D	270	145	4.0	15:1
	WB-100T	200	115	2.5	15:1
	WB-109D	----	200	4.5	20:1
60	P	40	----	----	----
	SU-30	60	----	----	----
	SU-40	100	----	----	----
	WB-40	90	----	----	----
	WB-62	170	140	4.0	15:1
	WB-62FL	200	140	4.5	15:1
	WB-67	200	140	4.5	15:1
	WB-92B	230	120	5.0	15:1
	WB-100T	150	95	2.5	15:1
	WB-109D	----	180	4.5	20:1

Table 212.12.1 Edge-of-Traveled-Way, Simple Curve Radii, con't

Angle of Turn (degrees)	Design Vehicle	Simple Curve Radius (feet)	Simple Curve Radius with Taper		
			Radius (feet)	Offset (feet)	Taper H:V
75	P	35	25	2.0	10:1
	SU-30	55	45	2.0	10:1
	SU-40	90	60	2.0	10:1
	WB-40	----	60	2.0	15:1
	WB-62	----	145	4.0	20:1
	WB-62FL		145	4.0	20:1
	WB-67	----	145	4.5	20:1
	WB-92D	----	110	5.0	15:1
	WB-100T	----	85	3.0	15:1
	WB-109D	----	140	5.5	20:1
90	P				
	SU-30	50	40	2.0	10:1
	SU-40	80	45	4.0	10:1
	WB-40	----	45	4.0	10:1
	WB-62	----	120	4.5	30:1
	WB-62FL		125	4.5	30:1
	WB-67	----	125	4.5	30:1
	WB-92D	----	95	6.0	10:1
	WB-100T	----	85	2.5	15:1
	WB-109D	----	115	2.9	15:1
105	P	----	20	2.5	8:1
	SU-30	----	35	3.0	10:1
	SU-40	----	45	4.0	10:1
	WB-40	----	40	4.0	10:1
	WB-62	----	115	3.0	15:1
	WB-62FL		115	3.0	15:1
	WB-67	----	115	3.0	15:1
	WB-92B	----	80	8.0	10:1
	WB-100T	----	75	3.0	15:1
	WB-109D	----	90	9.2	20:1

Table 212.12.1 Edge-of-Traveled-Way, Simple Curve Radii, con't

Angle of Turn (degrees)	Design Vehicle	Simple Curve Radius (feet)	Simple Curve Radius with Taper		
			Radius (feet)	Offset (feet)	Taper H:V
120	P	----	20	2.0	10:1
	SU-30	----	30	3.0	10:1
	SU-40	----	35	6.0	8:1
	WB-40	----	35	5.0	8:1
	WB-62	----	100	5.0	15:1
	WB-62FL		105	5.2	15:1
	WB-67	----	105	5.2	15:1
	WB-92D	----	80	7.0	10:1
	WB-100T	----	65	3.5	15:1
	WB-109D	----	85	9.2	20:1
135	P	----	20	1.5	10:1
	SU-30	----	30	4.0	10:1
	SU-40	----	40	4.0	8:1
	WB-40	----	30	8.0	15:1
	WB-62	----	80	5.0	20:1
	WB-62FL		85	5.2	20:1
	WB-67	----	85	5.2	20:1
	WB-92D	----	75	7.3	10:1
	WB-100T	----	65	5.5	15:1
	WB-109D	----	85	8.5	20:1
150	P	----	18	2.0	10:1
	SU-30	----	30	4.0	8:1
	SU-40	----	35	7.0	8:1
	WB-40	----	30	6.0	8:1
	WB-62	----	60	10.0	10:1
	WB-62FL		65	10.2	10:1
	WB-67	----	65	10.2	10:1
	WB-92B	----	65	11.0	10:1
	WB-100T	----	65	7.3	10:1
	WB-109D	----	65	15.1	10:1

Table 212.12.1 Edge-of-Traveled-Way, Simple Curve Radii, con't

Angle of Turn (degrees)	Design Vehicle	Simple Curve Radius (feet)	Simple Curve Radius with Taper		
			Radius (feet)	Offset (feet)	Taper H:V
180	P	----	15	0.5	20:1
	SU-30	----	30	1.5	10:1
	SU-40				
	WB-40	----	20	9.5	5:1
	WB-62	----	55	10.0	15:1
	WB-62FL	----	55	13.8	10:1
	WB-67	----	55	13.8	10:1
	WB-92D	----	55	16.8	10:1
	WB-100T	----	55	10.2	10:1
	WB-109D	----	55	20.0	10:1

Table 212.12.2 Edge-of-Traveled-Way, 3-Centered Compound Curves

Angle of Turn (degrees)	Design Vehicle	3-Centered Compound Curve			
		Curve Radii (ft)	Symmetric Offset (ft)	Curve Radii (ft)	Asymmetric (ft)
30	P	----	----	----	----
	SU-30	----	----	----	----
	SU-40	----	----	----	----
	WB-40	----	----	----	----
	WB-62	----	----	----	----
	WB-62FL	460-175-460	4.0	300-175-550	2.0-4.5
	WB-67	460-175-460	4.0	300-175-550	2.0-4.5
	WB-92D	550-155-550	4.0	200-150-500	2.0-6.0
	WB-100T	220-80-220	4.5	200-80-300	2.5-5.0
	WB-109D	550-250-550	5.0	250-200-650	1.5-7.0

Table 212.12.2 Edge-of-Traveled-Way, 3-Centered Compound Curves, cont.

Angle of Turn (degrees)	Design Vehicle	3-Centered Compound Curve			
		Curve Radii (ft)	Symmetric Offset (ft)	Curve Radii (ft)	Asymmetric (ft)
45	P	P	----	----	----
	SU-30	SU-30	----	----	----
	SU-40	SU-40	----	----	----
	WB-40	WB-40	----	----	----
	WB-62	WB-62	460-240-460	2.0	120-140-500
	WB-62FL	WB-62FL	460-175-460	4.0	250-125-600
	WB-67	WB-67	460-175-460	4.0	250-125-600
	WB-92D	WB-92D	525-155-525	5.0	200-140-500
	WB-100T	WB-100T	250-80-250	4.5	200-80-300
	WB-109D	WB-109D	550-200-550	5.0	200-170-650
60	P	----	----	----	----
	SU-30	----	----	----	----
	SU-40	----	----	----	----
	WB-40	----	----	----	----
	WB-62	400-100-400	15.0	110-100-220	10.0-12.5
	WB-62FL	400-100-400	8.0	250-125-600	1.0-6.0
	WB-67	400-100-400	8.0	250-125-600	1.0-6.0
	WB-92D	480-110-480	6.0	150-110-500	3.0-9.0
	WB-100T	250-80-250	4.5	200-80-300	2.0-5.5
	WB-109D	650-150-650	5.5	200-140-600	1.5-8.0
75	P	100-25-100	2.0	----	----
	SU-30	120-45-120	2.0	----	----
	SU-40	200-35-200	5.0	60-45-200	1.0-4.5
	WB-40	120-45-120	5.0	120-45-195	2.0-6.5
	WB-62	440-75-440	15.0	140-100-540	5.0-12.0
	WB-62FL	420-75-420	10.0	200-80-600	1.0-10.0
	WB-67	420-75-420	10.0	200-80-600	1.0-10.0
	WB-92B	500-95-500	7.0	150-100-500	1.0-8.0
	WB-100T	250-80-250	4.5	100-80-300	1.5-5.0
	WB-109D	700-125-700	6.5	150-110-550	1.5-11.5

Table 212.12.2 Edge-of-Traveled-Way, 3-Centered Compound Curves, cont.

Angle of Turn (degrees)	Design Vehicle	3-Centered Compound Curve			
		Curve Radii (ft)	Symmetric Offset (ft)	Curve Radii (ft)	Asymmetric (ft)
90	P	35	25	2.0	10:1
	SU-30	55	45	2.0	10:1
	SU-40	90	60	2.0	10:1
	WB-40	----	60	2.0	15:1
	WB-62	----	145	4.0	20:1
	WB-62FL		145	4.0	20:1
	WB-67	----	145	4.5	20:1
	WB-92D	----	110	5.0	15:1
	WB-100T	----	85	3.0	15:1
	WB-109D	----	140	5.5	20:1
105	P				
	SU-30	50	40	2.0	10:1
	SU-40	80	45	4.0	10:1
	WB-40	----	45	4.0	10:1
	WB-62	----	120	4.5	30:1
	WB-62FL		125	4.5	30:1
	WB-67	----	125	4.5	30:1
	WB-92D	----	95	6.0	10:1
	WB-100T	----	85	2.5	15:1
	WB-109D	----	115	2.9	15:1
120	P	----	20	2.5	8:1
	SU-30	----	35	3.0	10:1
	SU-40	----	45	4.0	10:1
	WB-40	----	40	4.0	10:1
	WB-62	----	115	3.0	15:1
	WB-62FL		115	3.0	15:1
	WB-67	----	115	3.0	15:1
	WB-92B	----	80	8.0	10:1
	WB-100T	----	75	3.0	15:1
	WB-109D	----	90	9.2	20:1

Table 212.12.2 Edge-of-Traveled-Way, 3-Centered Compound Curves, cont.

Angle of Turn (degrees)	Design Vehicle	3-Centered Compound Curve			
		Curve Radii (ft)	Symmetric Offset (ft)	Curve Radii (ft)	Asymmetric (ft)
135	P	100-20-100	1.5	----	----
	SU-30	100-30-100	4.0	----	----
	SU-40	200-40-200	4.0	60-40-180	1.5-5.0
	WB-40	120-30-120	6.5	100-25-180	3.0-13.0
	WB-62	600-60-600	12.0	100-60-640	14.0-7.0
	WB-62FL	550-45-550	16.0	200-60-600	2.0-12.5
	WB-67	550-45-550	16.0	200-60-600	2.0-12.5
	WB-92D	450-70-450	9.0	150-65-450	7.0-13.5
	WB-100T	250-60-250	5.5	100-60-300	2.5-7.0
	WB-109D	700-70-700	12.5	150-65-500	14.0-18.4
150	P	75-20-75	2.0	----	----
	SU-30	100-30-100	4.0	----	----
	SU-40	200-35-200	6.5	60-40-200	1.0-4.5
	WB-40	100-30-100	6.0	90-25-160	1.0-12.0
	WB-62	480-55-480	15.0	140-60-560	8.0-10.0
	WB-62FL	550-45-550	19.0	200-55-600	7.0-16.4
	WB-67	550-45-550	19.0	200-55-600	7.0-16.4
	WB-92D	350-60-350	15.0	120-65-450	6.0-13.0
	WB-100T	250-60-250	7.0	100-60-300	5.0-8.0
	WB-109D	700-65-700	15.0	200-65-500	9.0-18.4
180	P	50-15-50	0.5	----	----
	SU-30	100-30-100	1.5	----	----
	SU-40	150-35-150	6.2	50-35-130	5.5-7.0
	WB-40	100-20-100	9.5	85-20-150	6.0-13.0
	WB-62	800-45-800	20.0	100-55-900	15.0-15.0
	WB-62FL	600-45-600	20.5	100-55-400	6.0-15.0
	WB-67	600-45-600	20.5	100-55-400	6.0-15.0
	WB-92B	400-55-400	16.8	120-60-400	9.0-14.5
	WB-100T	250-55-250	9.5	100-55-300	8.5-10.5
	WB-109D	700-55-700	20.0	200-60-500	10.0-21.0

For curbed intersections, corner radii should follow the guidance in ***Table 212.12.3***, and accommodate the following:

- The design vehicle and design speed for each street
- Available R/W
- Angle of turn between intersection legs
- The number of pedestrians using the crosswalk
- The width and number of lanes on the intersecting street

Table 212.12.3 Recommended Corner Radii

Corner Radius (ft)	Operational Characteristics
25 - 30	P vehicles and SU vehicles with minor lane encroachment
40	P vehicles, SU vehicles, and WB-40 vehicles with minor encroachment
50	All vehicles up to WB-40

Often it is not practical to provide designs that do not require larger design vehicles to encroach on adjacent or opposing lanes. Guidelines for corner radii in urbanized context classifications are as follows:

(1) Radii of 15 to 25 feet are adequate for passenger vehicles. These radii are suitable for minor cross streets where there is little occasion for trucks to turn and at major intersections where there are parking lanes;

(2) Radii of 25 feet or more should be provided at minor cross streets on new construction or reconstruction projects;

(3) Radii of 30 feet or more should be provided at minor cross streets where practical so that an occasional truck can turn without too much encroachment;

(4) Radii of 40 feet or more or preferably three-centered curves or simple curves with tapers to fit the paths of large truck combinations, should be provided where such combinations or buses turn frequently. Where speed reductions would cause problems, larger radii should be considered; and,

(5) Curb radii should be coordinated with crosswalk distances or special designs should be used to make crosswalks efficient for all pedestrians. Where larger radii are used, an intermediate refuge or median island is desirable or crosswalks may need to be offset so that crosswalk distances are not excessive.

212.12.2 Free-Flow Design

Provide superelevation on free-flow turning roadways. An important part of the design on some intersections is the design of a free-flow alignment for turns. Ease and smoothness of operation can result when the free-flow turning roadway is designed with compound curves preceded by a deceleration lane. Turning radii and pavement cross slope for free-flow right turns at speeds greater than 10 mph are a function of the design speed and design vehicle. In general, the design speed of the turning roadway should be equal to, or within 10 to 20 mph less than the through roadway design speed.

It is desirable to provide as much superelevation as practical on intersection curves, particularly where the intersection curve is sharp and on a downgrade. However, the short curvature and short lengths of turning roadways often prevents the development of a desirable rate of superelevation. ***Table 212.12.4*** provides the minimum superelevation rates in relation to design speed. The wide variation in likely speeds on intersection curves precludes the need for precision, so only the minimum superelevation rate is given for each design speed and intersection curve radius.

Table 212.12.4 Superelevation Rates for Turning Roadways

	Design Speed (mph)							
	10	15	20	25	30	35	40	45
Minimum Superelevation Rate	NC	NC	0.02	0.04	0.06	0.08	0.09	0.10
Minimum Radius (feet)	25	50	90	150	230	310	430	540

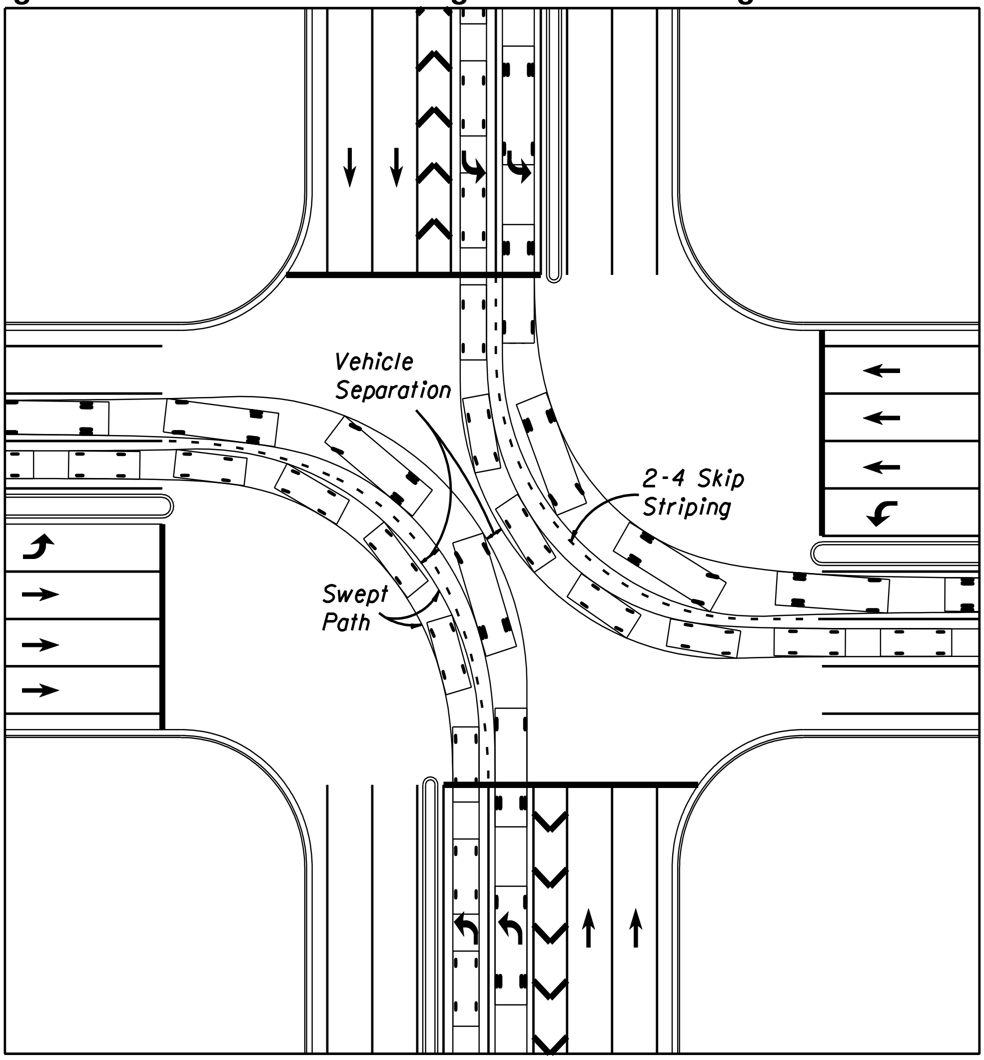
See ***FDM 210.9*** for additional superelevation criteria.

212.12.3 Dual and Triple Left Turns

Double and triple turn lanes require turning radii that will accommodate the selected design vehicles turning simultaneously. The radius of curvature in combination with the track width of the design vehicles will establish the required width within the turn. Lane lines (i.e., guide lines) and width requirements should be determined by plotting the swept paths of the selected design vehicles. For preliminary layout of intersection geometry, use the swept path of the design vehicle on the inside turning lane to locate the median nose on the crossing street (at the receiving point of the left turn).

Design of dual turns should accommodate a SU-40 vehicle and a P vehicle turning simultaneously, as illustrated in ***Figure 212.12.2***.

Figure 212.12.2 P and SU Design Vehicles Turning Simultaneously



Design of triple left turns should accommodate a WB-62FL (outside lane), a SU-40 (center or inside lane), and a P vehicle (center or inside lane) turning simultaneously.

Establish control radius for the inside turning lane based on the guidance in ***FDM 212.14.5*** and ***Table 212.9.2***. Establish the inside edge of the outer lane by providing a minimum 4-foot separation between swept paths of the selected design vehicles traveling in the same direction. Except for turns with large radii, the inside edge of the outer lane will not be concentric with the selected control radius. Radius for the inside edge of the outer turn lane should be determined by analysis of the plotted swept path of the design vehicles.

Provide minimum 8-foot separation between vehicles traveling in opposing direction. Separation may be less than 8 feet when:

(1) Turning paths are highly visible and speeds are low, or

(2) Signal left turn phases are not concurrent for the opposing directions.

212.13 Islands

An island is an area between traffic lanes that provide one or more of these primary functions:

(1) Channelization – to control and direct traffic movement (usually turning).

(2) Division (Median Islands and Traffic Separators) – to divide opposing or same direction traffic (usually through movements).

(3) Refuge – to provide refuge for pedestrians.

Islands are generally elongated or triangular in shape and located in areas where vehicle use is restricted. The placement of mast arms in channelizing islands is discouraged. The placement of mast arms in median islands is not permitted.

Island delineation is divided into three types:

(1) Curbing that raises the island

(2) Pavement markings or reflectorized markers placed on paved areas

(3) Pavement edges, possibly supplemented by flexible delineators or other flexible guideposts, or a mounded-earth treatment beyond and adjacent to the pavement edges.

Delineation of small islands is primarily by curbs. Large curbed islands may be sufficiently delineated by color and texture contrast of vegetative cover, mounded earth, shrubs, guideposts, tubular markers, signs or any combination of these. Curbed islands should not be used on high speed flush shoulder roadways. Standard markings for islands are provided in the ***Standard Plans*, Index 711-001**.

212.13.1 Channelization Islands

Meet the following requirements when designing channelization islands:

(1) Size of island should be:

  (a) 50 square feet or larger within curbed intersections

(b) 75 square feet or larger for flush shoulder intersections.

(c) 100 square feet or larger for all other locations.

(2) Triangular islands should be at least 15 feet on a side, but not less than 12 feet, after rounding of corners.

(3) Side dimensions should not exceed 100 feet.

The approach and departure noses are rounded with radii of at least 3.5 feet. ***Figure 212.13.1*** illustrates a small island with a parallel offset. ***Figure 212.13.2*** illustrates a large island with a taper offset.

Approach ends of the island should be offset from the edges of the traveled way in order to funnel drivers smoothly into the desired path. The amount that a curbed island is offset from the through-traffic lane is influenced by the type of edge treatment and other factors such as island contrast, length of taper or auxiliary pavement preceding the curbed island. If a bike lane is adjacent to an island curb, no offset is needed.

Figure 212.13.1 Typical Small Curbed Island

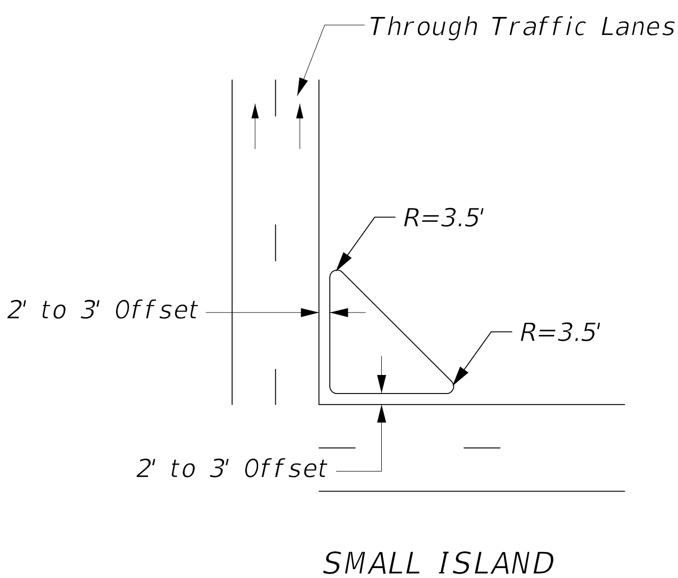
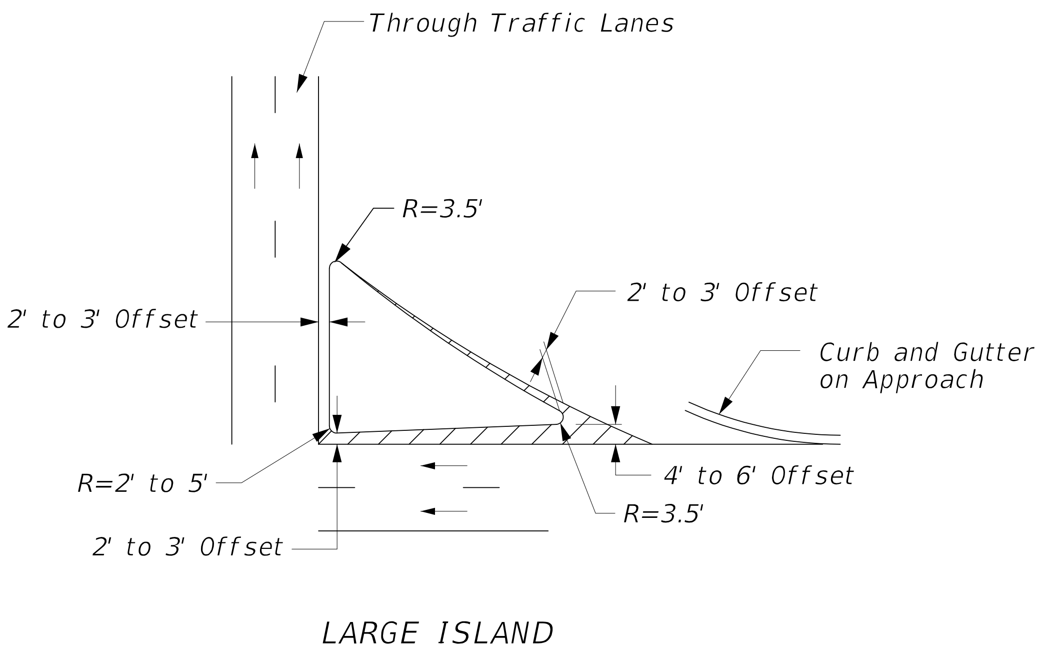


Figure 212.13.2 Typical Large Curbed Island



Where there are no curbs on the approach traveled way, the minimum offset of the edge of the curbed island to the through lane should be 1.5 to 3.5 feet. Where the approach roadway has a Type E curb, a similar curb on the island may be located at the edge of the through lane if there is sufficient length of curbed island to provide a gradual taper from the nose offset. Type F curbs should be offset from the through traveled way edge, regardless of the size of the curbed island. For intermediate and large-size islands that are uncurbed, offsets are desirable but not required. Fixed objects within the island areas must meet clear zone and lateral offset criteria found in ***FDM 215.2.3*** and ***215.2.4***.

212.13.2 Median Islands and Traffic Separators

Meet the following requirements when designing median islands and traffic separators:

(1) A minimum of 4 feet wide and 25 feet long.

(2) 100 feet or more in length is allowed on high speed roadways when providing high visibility for the islands.

(3) Approach noses should be offset 2 to 6 feet from the through (approach) lanes to minimize impacts. Pavement markings in advance of the nose can be used to transition from the centerline to the edge of island.

(4) The shape of the island should be based on design turning paths and the island function. Curvilinear tapers comprised of parabolic or circular curves generally suffice.

(5) The length of the island should be related to the approach speed. An estimate is to use the length based on 3-second driving time to the intersection.

(6) Median islands should begin on tangent alignments and on upgrades or beyond crest vertical curves. In some cases it is appropriate to extend a median island to avoid its introduction on a horizontal curve or within an area of limited sight distance.

***Standard Plans*, Index 520-020** provides detailed dimensional design for traffic separators.

212.13.3 Refuge Islands

Refuge islands aid and assist pedestrians and bicyclists crossing a roadway. Raised curb corner islands and center channelizing or divisional islands can provide refuge areas. Refuge islands should be a minimum of 6 feet wide when they will be used for bicyclists. Pedestrians and bicyclists should have a clear path through the island and should not be obstructed by objects such as poles, sign posts, or utility boxes.

Roundabout splitter islands provide pedestrian refuge and are discussed in ***FDM 213.5***.

212.13.4 Corner Islands

Where the inside edges of the traveled way for right turns are designed to accommodate semi-trailer combinations or where the design permits passenger vehicles to turn at speeds greater than 10 mph, the pavement area within the intersection may become excessively large and may create longer crossing paths for pedestrians. This may also occur at intersections with turning angles greater than 90 degrees. To avoid this condition, a corner channelizing island can be provided to form a separate turning roadway.

FDM 212.12 provides information on the design of turning roadways with corner islands.

212.14 Auxiliary Lanes

The primary function of auxiliary lanes at intersections is to accommodate speed changes, storage and maneuvering of turning traffic. The length of the auxiliary lanes is the sum of the deceleration length, queue length and approach end taper. Pavement marking requirements for auxiliary lanes are included in ***Standard Plans*, Index 711-001**.

212.14.1 Deceleration Length

The required total deceleration length is that needed for a safe and comfortable stop from the design speed of the highway. See ***Exhibit 212-1*** for minimum deceleration lengths (including taper) for left turn lanes.

Right turn lane tapers and lengths are identical to left turn lanes under stop control conditions. Right turn lane tapers and lengths are site-specific for free-flow or yield conditions.

212.14.2 Queue Length

The queue length provided should be based on a traffic study.

For low volume intersections where a traffic study is not justified, a minimum 50-foot queue length (2 vehicles) should be provided for rural context classifications. A minimum 100-foot queue length (4 vehicles) should be provided in urbanized context classifications. Locations with over 10% truck traffic should accommodate at least one car and one truck.

For queue lengths at signalized intersections, refer to ***FDM 232.2***.

212.14.3 Approach End Taper

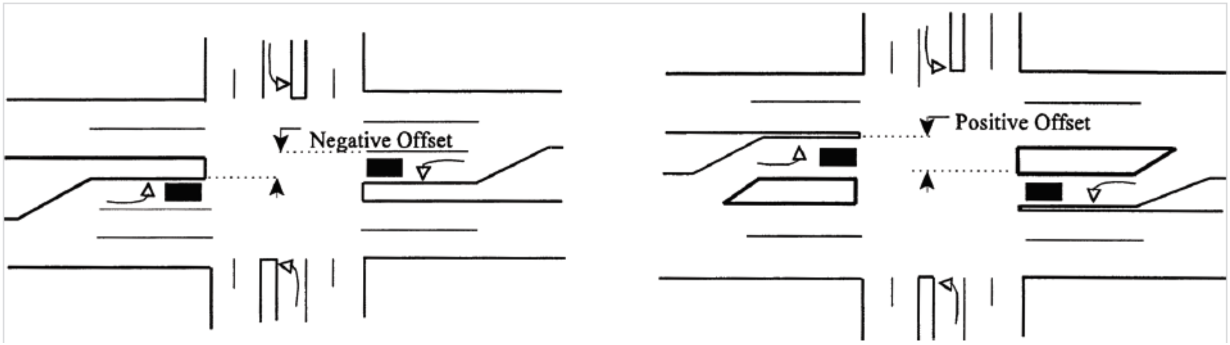
The length of approach end tapers is 50 feet for a single turn lane and 100 feet for two or more turn lanes, as shown ***Exhibit 212-1***. These taper lengths apply to all design speeds.

212.14.4 Offset Left Turn Lanes

The alignment of opposing left-turn lanes and the horizontal and vertical curvature on the approaches are the principal geometric design elements that determine how much sight distance is available to a left-turning driver. Vehicles queuing in opposing left-turn lanes restrict each other's view of oncoming traffic in the through lanes. The level of restricted view depends on the alignment of opposing left-turn lanes with respect to each other and the type of vehicles in the opposing queue.

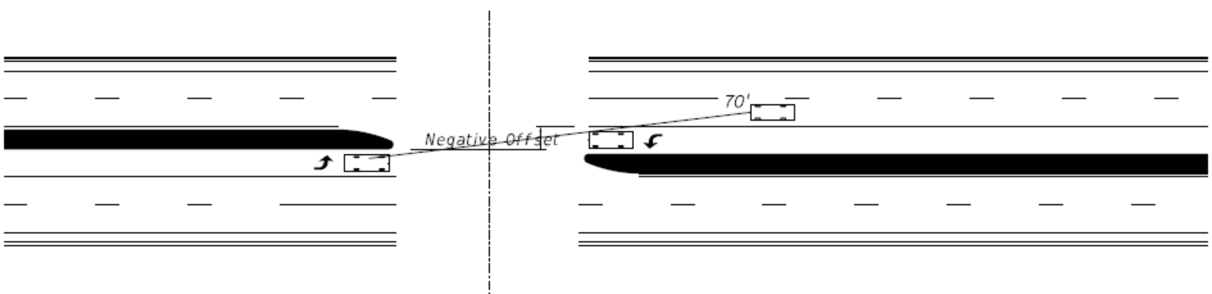
The offset distance is defined as the distance between the left edge of the turn lane and the right edge of the opposing turn lane. If the offset distance is to the left of the turn lane it is considered a negative offset, and if it is to the right of turn lane it is considered a positive offset, as illustrated in ***Figure 212.14.1***.

Figure 212.14.1 Negative and Positive Offset Left Turns



The conventional method of designing left turn lanes is to place the left turn lanes adjacent to the through lanes. This design creates a negative offset which restricts the sight distance of the left-turning driver's view of oncoming traffic when another vehicle is in the opposing turn lane. ***Figure 212.14.2*** indicates the negative offset when the conventional design is used.

Figure 212.14.2 Opposing Left Turns (22' Median with Negative 10' Offset)

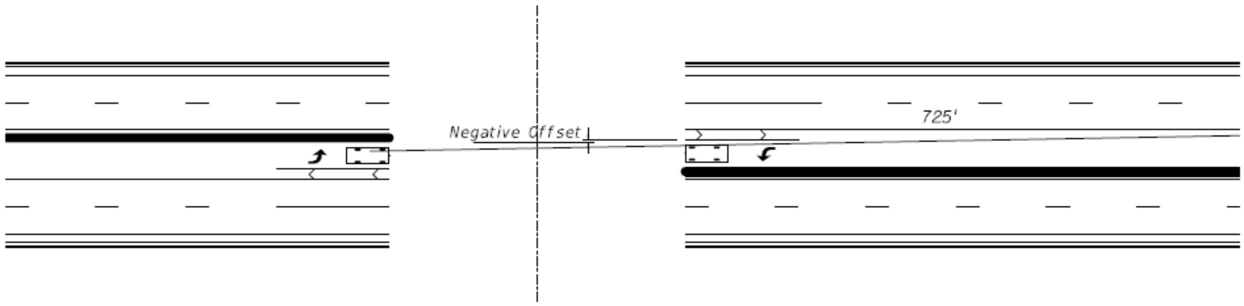


On curbed roadway designs, offset left-turn lanes should be used with median widths greater than 18 feet. A 4-foot traffic separator should be used when possible to channelize the left turn and provide separation from opposing traffic.

Consider offset left-turn lanes at rural intersections with high turning movements. For median widths 30 feet or less, use a parallel offset left-turn lane. Stripe the area between the offset left-turn lane and the traffic lane where vehicles are moving in the same direction. For medians wider than 30 feet, consider a tapered offset left-turn lane. An offset left is illustrated in ***Figure 212.14.3***.

2011 AASHTO Green Book Figure 9-52 illustrates the design of parallel and tapered left turn lanes.

Figure 212.14.3 Typical Opposing Left Turns (22' Median with Negative 1' Offset)



At locations where the full offset distances cannot be obtained, it is recommended that the minimum offset distances shown in ***Table 212.14.1*** be provided to achieve minimum required sight distances according to design speed. It is recommended that the "Opposing Truck" values be used where the opposing left-turn traffic includes a moderate to heavy volume of large trucks.

Table 212.14.1 Minimum Offset Distances for Left-Turn Lanes

Design Speed (mph)	Minimum Offset (feet)	
	Opposing Car	Opposing Truck
≤ 30	1.0	3.0
35	1.5	3.5
40 - 45	2.0	4.0
50 - 55	2.5	4.5
60 - 65	3.0	4.5
70	3.0	5.0

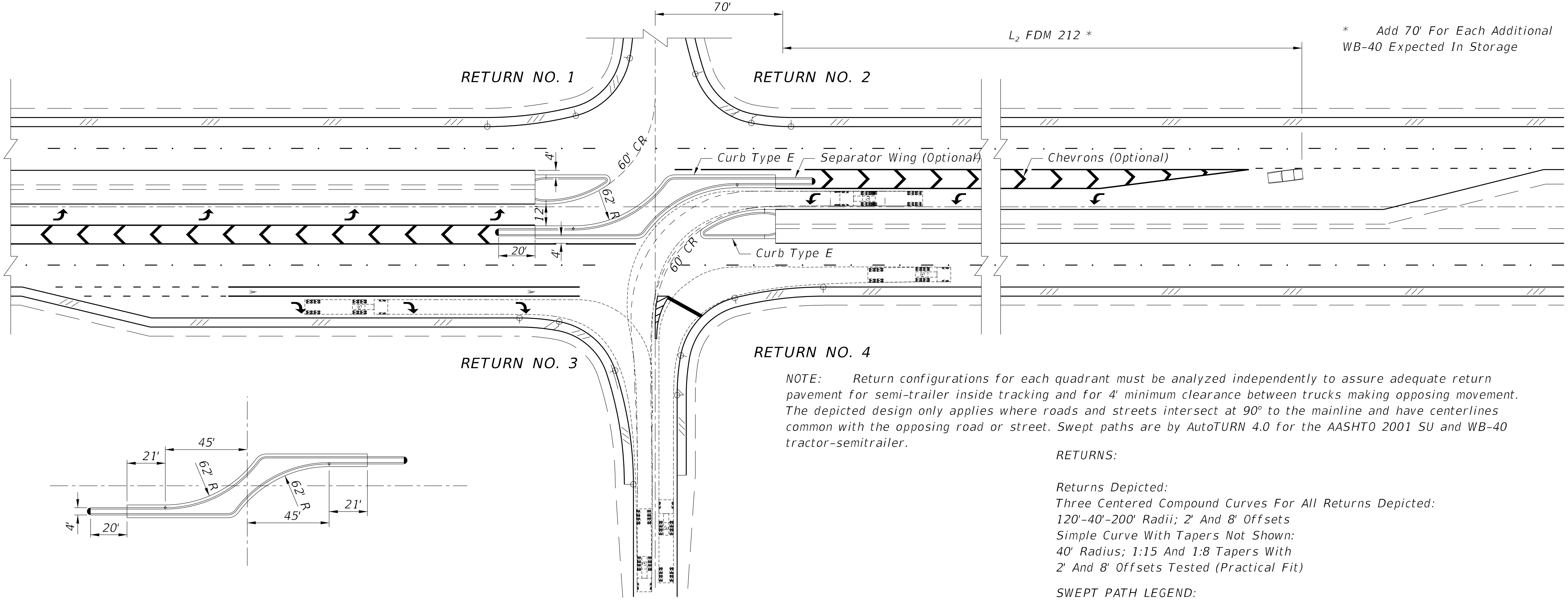
212.14.5 Directional Median Openings

Directional (channelized) median openings are designed to accommodate left-turn movements from the through roadway and prevent or discourage left-turn and crossing movements by traffic from a side road or driveway. Directional median openings are to be provided in accordance with the access management plan for the roadway.

The design of a directional median opening must accommodate the swept path of the predominant design vehicle. Channelization may be achieved using a combination of traffic separators, raised islands, or high performance traffic delineators. See ***Standard Plans***, ***Index 520-020*** for standard details for 4 feet, 6 feet and 8.5 feet wide traffic separators. See ***FDM 230.2.7*** for additional information on high performance delineators.

Typical layouts for directional median openings for high speed roadways with 40-feet-wide medians are provided in ***Exhibits 212-8***, ***212-9*** and ***212-10***. Type E curb and raised islands in conjunction with the minimum offsets shown in these figures may be used on high speed roadways for directional median openings.

DIRECTIONAL MEDIAN OPENING: SU & WB-40
PARALLEL TURN BAY



NOTE: Return configurations for each quadrant must be analyzed independently to assure adequate return pavement for semi-trailer inside tracking and for 4' minimum clearance between trucks making opposing movement. The depicted design only applies where roads and streets intersect at 90° to the mainline and have centerlines common with the opposing road or street. Swept paths are by AutoTURN 4.0 for the AASHTO 2001 SU and WB-40 tractor-semitrailer.

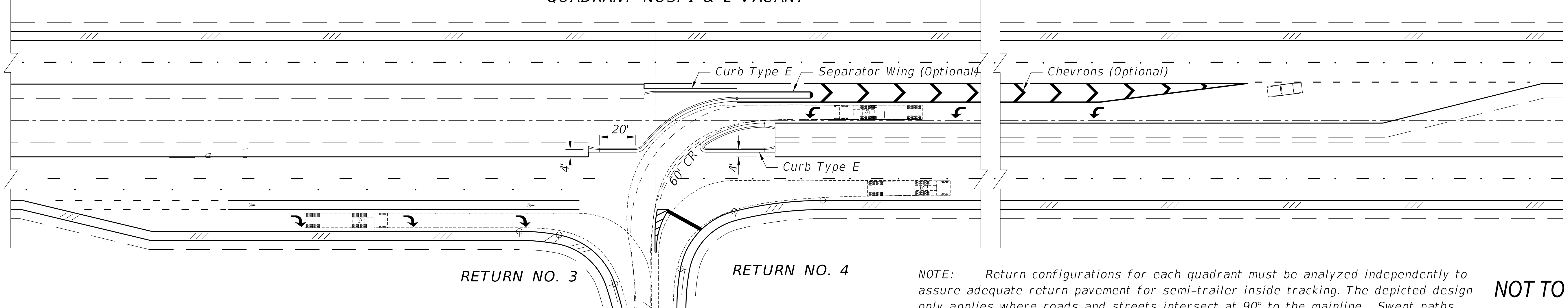
RETURNS:

Returns Depicted:
Three Centered Compound Curves For All Returns Depicted:
120'-40'-200' Radii; 2' And 8' Offsets
Simple Curve With Tapers Not Shown:
40' Radius; 1:15 And 1:8 Tapers With
2' And 8' Offsets Tested (Practical Fit)

SWEPT PATH LEGEND:

WB 40 ------------
SU — — — — —

QUADRANT NOS. 1 & 2 VACANT

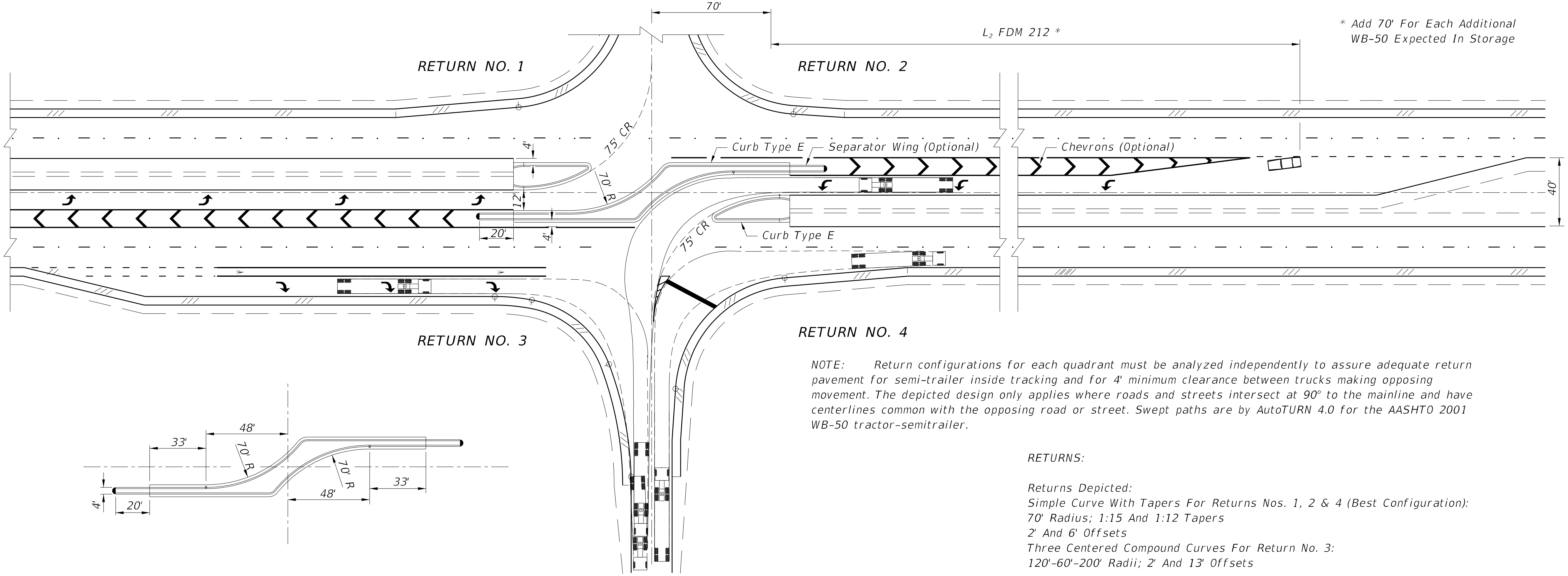


NOTE: Return configurations for each quadrant must be analyzed independently to assure adequate return pavement for semi-trailer inside tracking. The depicted design only applies where roads and streets intersect at 90° to the mainline. Swept paths are by AutoTURN 4.0 for the AASHTO 2001 SU and WB-40 tractor-semitrailer.

NOT TO SCALE

EXHIBIT 212-8
01/01/2018

DIRECTIONAL MEDIAN OPENING: WB-50
PARALLEL TURN BAY

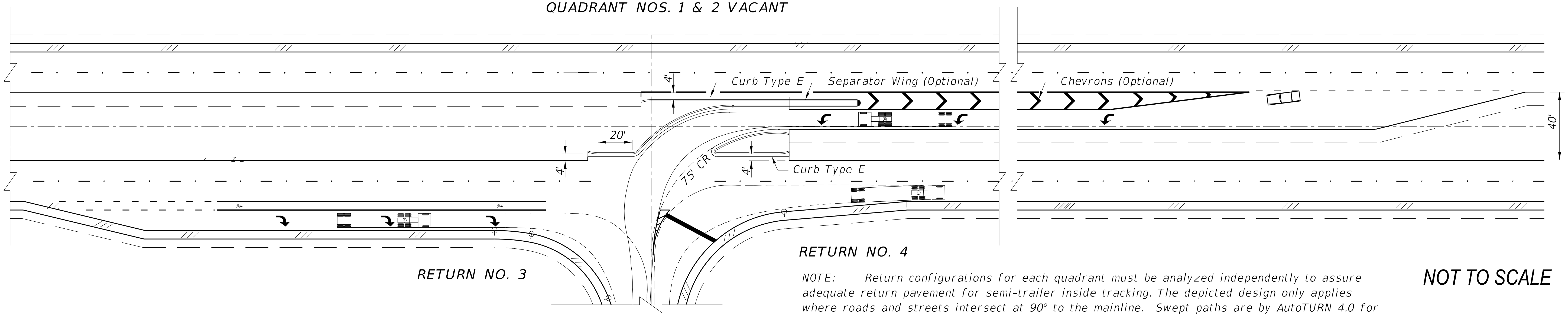


NOTE: Return configurations for each quadrant must be analyzed independently to assure adequate return pavement for semi-trailer inside tracking and for 4' minimum clearance between trucks making opposing movement. The depicted design only applies where roads and streets intersect at 90° to the mainline and have centerlines common with the opposing road or street. Swept paths are by AutoTURN 4.0 for the AASHTO 2001 WB-50 tractor-semitrailer.

RETURNS:

Returns Depicted:
Simple Curve With Tapers For Returns Nos. 1, 2 & 4 (Best Configuration):
70' Radius; 1:15 And 1:12 Tapers
2' And 6' Offsets
Three Centered Compound Curves For Return No. 3:
120'-60'-200' Radii; 2' And 13' Offsets

QUADRANT NOS. 1 & 2 VACANT

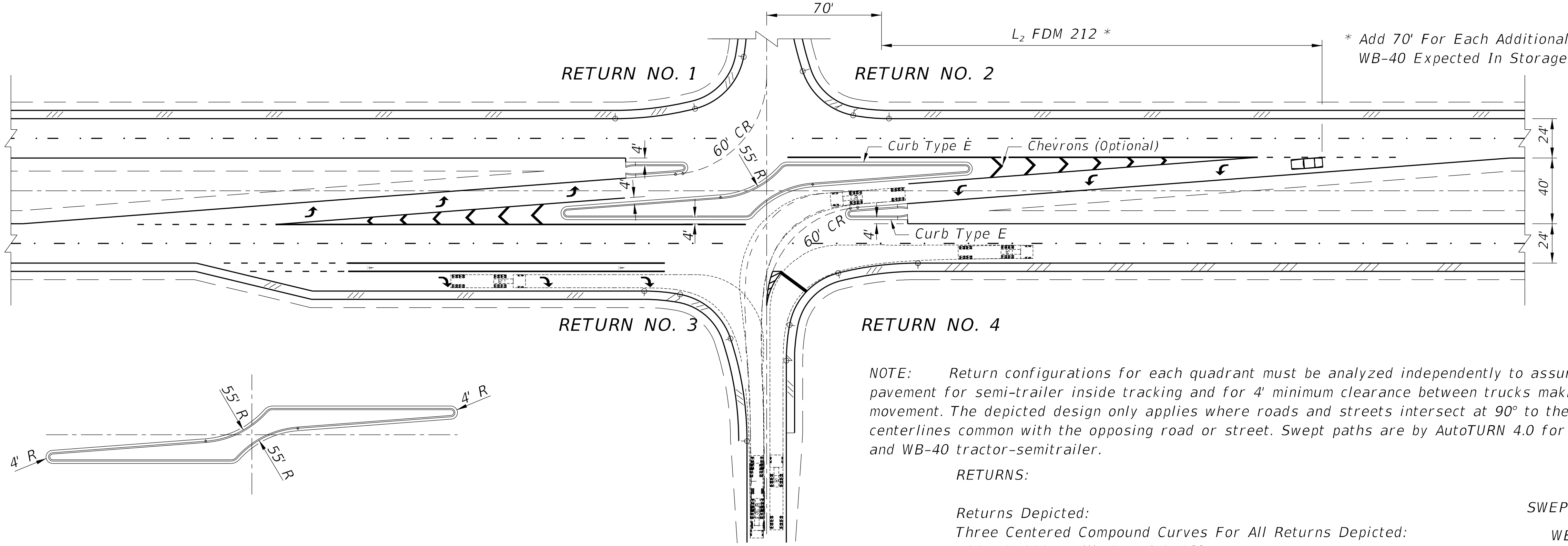


NOTE: Return configurations for each quadrant must be analyzed independently to assure adequate return pavement for semi-trailer inside tracking. The depicted design only applies where roads and streets intersect at 90° to the mainline. Swept paths are by AutoTURN 4.0 for the AASHTO 2001 WB-50 tractor-semitrailer.

NOT TO SCALE

EXHIBIT 212-9
01/01/2018

DIRECTIONAL MEDIAN OPENING: SU & WB-40
TAPERED TURN BAY



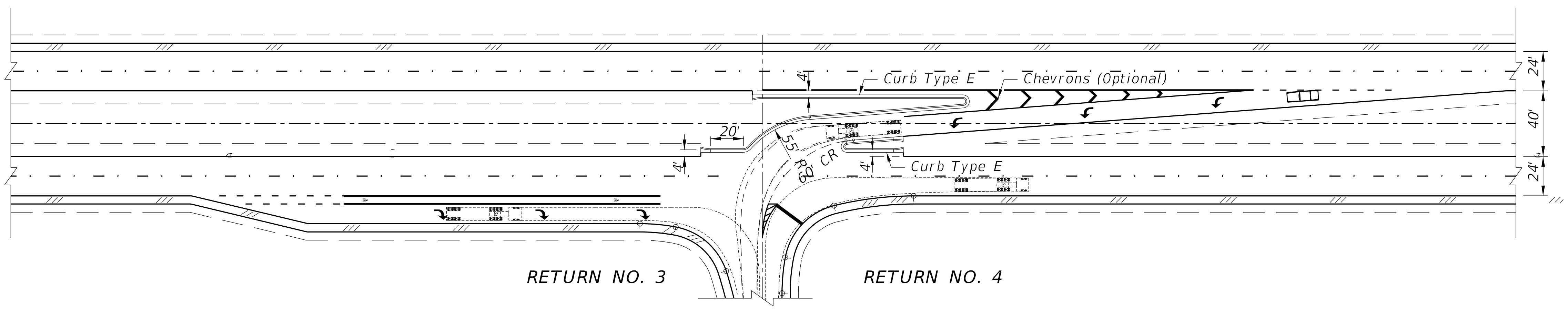
NOTE: Return configurations for each quadrant must be analyzed independently to assure adequate return pavement for semi-trailer inside tracking and for 4' minimum clearance between trucks making opposing movement. The depicted design only applies where roads and streets intersect at 90° to the mainline and have centerlines common with the opposing road or street. Swept paths are by AutoTURN 4.0 for the AASHTO 2001 SU and WB-40 tractor-semitrailer.

RETURNS:

Returns Depicted:
Three Centered Compound Curves For All Returns Depicted:
120'-40'-200' Radii; 2' And 8' Offsets
Simple Curve With Tapers Not Shown:
40' Radius; 1:15 And 1:8 Tapers With
2' And 8' Offsets Tested (Practical Fit)

SWEPT PATH LEGEND:
WB 40 ·············
SU – – – –

QUADRANT NOS. 1 & 2 VACANT



NOTE: Return configurations for each quadrant must be analyzed independently to assure adequate return pavement for semi-trailer inside tracking. The depicted design only applies where roads and streets intersect at 90° to the mainline. Swept paths are by AutoTURN 4.0 for the AASHTO 2001 SU and WB-40 tractor-semitrailer.

NOT TO SCALE

EXHIBIT 212-10
01/01/2018