CHAPTER D
AT-GRADE INTERSECTIONS

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CHAPTER D
AT-GRADE INTERSECTIONS

D.1 INTRODUCTION

D.1.1 Definition and General Description

An intersection is defined as the general area where two or more roadways join or cross. It is an integral part of the highway system since much of the safety, speed, level of service, cost of operation and maintenance, as well as capacity, depend upon its design.

Each road radiating from an intersection and forming part of it is an intersection leg. Channelization of an intersection at grade consists of directing traffic into definite paths by the use of islands or traffic markings.

The spacing of intersections along a highway has a large impact on the operation, level of service, and capacity of the highway. Ideally, intersection spacing along a highway should be selected based on function, traffic volume and other considerations so that highways with the highest function will have the least number (greatest spacing) of intersections. Designers should refer to Chapter I Access Management Guidelines for additional information on intersection spacing.

This chapter deals with intersections at grade for both rural and semi-urban areas.

D.1.2 Comparison of At-Grade Intersections and Interchanges

Intersections at grade differ from interchanges in several aspects, the most significant being that interchanges have at least one grade separation. As a result, interchanges can carry a much higher traffic volume than intersections and, for any given volume, the level of service is considerably higher at interchanges. Other differing aspects include costs of construction and maintenance, safety, signing and complexity of design features and traffic signals.

A well designed at-grade intersection can handle traffic efficiently and safely until volumes are such that delays, congestion and collision records indicate an interchange should be introduced.

D.1.3 Design Objectives

Due to turning manoeuvres at intersections, the number of potential conflict points is very high. In Alberta, annual traffic collision statistics compiled over several years have shown consistently that 26 percent of all casualty collisions, and 27 percent of all fatal collisions occurring on rural highways are intersection related. For example, for the years 1987 to 1990, the average number of fatal collisions per year at rural highway intersections was 76 (105 fatalities), and the average number of personal injury collisions per year was 963 (1,773 people injured). This collision experience, coupled with the department's goal to improve highway safety, places a high priority on safe, consistent intersection design. The designer should minimize the number of conflict points in the design and provide adequately for reasonable vehicle speeds and vehicle sizes in the through, crossing and turning movements.

Careful consideration should be given to the driver's view of an intersection on each approach leg. As in other aspects of geometric design, it is of primary importance to ensure that drivers are not surprised by the sudden appearance of an intersection. Abrupt changes in main road horizontal alignment in the vicinity of an intersection should be avoided where possible. The geometric criteria included in this chapter are intended to ensure a safe intersection is provided; for example, minimum sight distance requirements and alignment requirements. However, it is good practice to exceed minimum sight distance requirements by a large margin whenever possible.

D.1.4 Design Considerations

The principal factors that determine the character of an intersection are discussed in the following order: physical, vehicle, traffic, economic and human factors.

A warrant system has been prepared to assist designers in choosing the appropriate intersection treatment, based on the main and intersecting road volumes. However, designers still need to carefully review each proposed intersection to ensure all potential problems are addressed.

On rural highways in Alberta, the capacity of an intersection is usually not a design concern because of generally low traffic volumes. Alternatively, because of the generally high running speeds and the expectation of a high level of service (free flow conditions on most rural highways), it is appropriate to provide auxiliary lanes for turning vehicles at many medium and high volume intersections to ensure that a consistently high level of service is maintained. The warrants that follow clearly indicate the types of treatments appropriate for each combination of traffic volumes and for the nature of the turning movements.

Auxiliary lane warrants for left or right turning manoeuvres off the main road (presented in Section D.7) are based on main alignment conditions. Where extremely high volumes are encountered, as in urban or semi-urban areas, and where the capacity or level of service for the intersecting road becomes an issue, designers may use the analysis methods described in the current Highway Capacity Manual (HCM) published by the Transportation Research Board, U.S.A. The HCM results will indicate the level of service for vehicles on the intersecting road only. However, this may be a consideration where delays are frequent or long. Extremely long delays may indicate the need to signalize, or possibly to consider building an interchange in the case of a divided highway.

In the case of intersections in urban or semi-urban areas, designers should consider the current or future need to provide signalization, illumination, crosswalks and curb-cuts. Within city limits in Alberta, city transportation departments will decide on the need for signalization based on their own criteria. Outside of cities, AI (through Technical Standards Branch) will assess the need for signalization on primary highways, if required.

Generally, if barrier curbs are to be built adjacent to the shoulder on high speed facilities (design speed exceeding 70 km/h), illumination of intersections will be required. For illumination purposes, yielding poles are recommended for design speeds less than 80 km/h and breakaway poles are recommended for higher speeds.

Yielding poles generally have hollow steel sections which are designed to buckle on impact by motor vehicles, excluding motorcycles. Non-breakaway structures for illumination on rural highways are generally only used for masts at interchange locations, where the structures are located outside of the clear zone.

Where there are sidewalks leading up to curbed intersections, curb-cuts and crosswalks should be installed to allow crossings by persons using wheelchairs and others with disabilities. The department’s standard drawings for curb-cuts (including layouts) should be used when designing intersections to be used by pedestrians.

D.2 DESIGN PRINCIPLES

D.2.1 Elements Affecting Design

Design is affected by the following factors:

- Physical factors which contribute to intersection design are: functional classification and design speed of each roadway, basic lane requirements (present and future), land use adjacent to the intersection, setback of physical obstructions from corners, rural or urban environment, grades and sight distance, angle of intersection, the need to introduce channelization, site topography, environmental considerations and aesthetics.

- Vehicle factors entail designing to accommodate the physical and operating characteristics of anticipated vehicle types likely to use the intersection. Designers generally select the largest vehicle expected to use the intersection for turning on a regular basis, which may be five times per week, as the design vehicle for that intersection. Using the design vehicle, the sight distance requirements are determined based on the turning characteristics (radius and off-tracking) and acceleration characteristics. The layout is also checked, using the design vehicle turning template to ensure that rear wheels will not off-track beyond the shoulder and that other conflicts do not occur: for example, with islands and medians.

- Traffic factors to be considered are: present and projected through and turning traffic volumes for each leg, the capacity and service volumes for each movement, the design hour volumes and directional split, posted and operating speeds, collision experience, pedestrian movements, warrants for traffic signals, and requirements for regulatory, directional and destination signing.

- Economic factors include: land cost, construction cost, collision costs that may be reduced, maintenance cost and the economic effects on abutting businesses (where access management measures restrict or prohibit certain vehicular movements within the vicinity).

- Human factors such as driving habits, driver expectations, ability of drivers to make decisions and react positively, and physical comfort of the driver in making natural paths of movements should also be considered.

D.2.2 Types of Manoeuvres

At an intersection at-grade, there is the possibility for five different types of driver manoeuvres, namely:

- Diverging
- Merging
- Weaving
- Crossing
- Turning.

These manoeuvres are shown in Figure D-2.2. It is the highway designer's responsibility to produce a design which allows these manoeuvres to be completed safely.

D.2.3 Conflicts

A conflict occurs whenever the paths followed by vehicles diverge, merge or cross. The four types of conflicts as illustrated in Figure D.2.3a are:

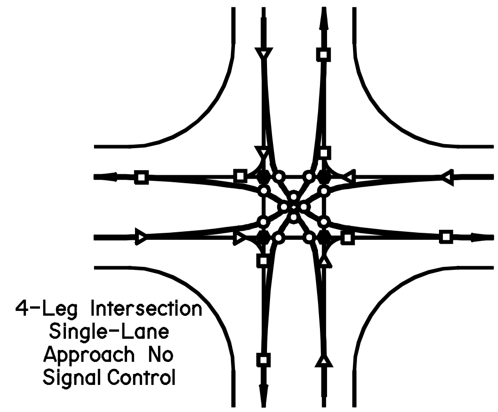
- Diverging
- Merging
- Through-flow crossing
- Turning-flow crossing.

The number of conflicts at intersections depends on the:

- Number of one-way or two-way approaches to the intersection
- Number of lanes at each approach
- Signal control
- Volume of traffic
- Percentage of right or left turns.

Figure D-2.3a illustrates the number and types of conflicts that can be expected at four-legged, no signal control intersections. Figure D-2.3b illustrates the conflict areas at the same type of intersection. In the interest of safety, it is desirable to minimize the conflict areas as much as possible.

FIGURE D-2.3a INTERSECTION CONFLICTS



Possible Conflicts

△ Diverging	8
□ Merging	8
⬣ Through-flow crossing	4
○ Turning-flow crossing	12
Number of Conflicts:	32

FIGURE D-2.3b CONFLICT AREAS

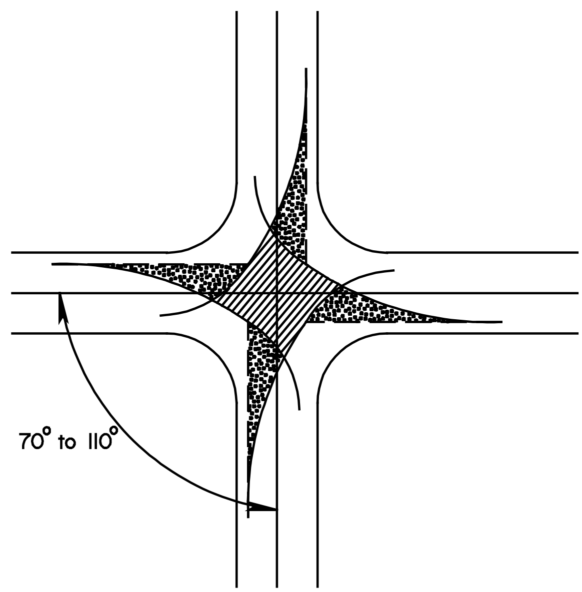
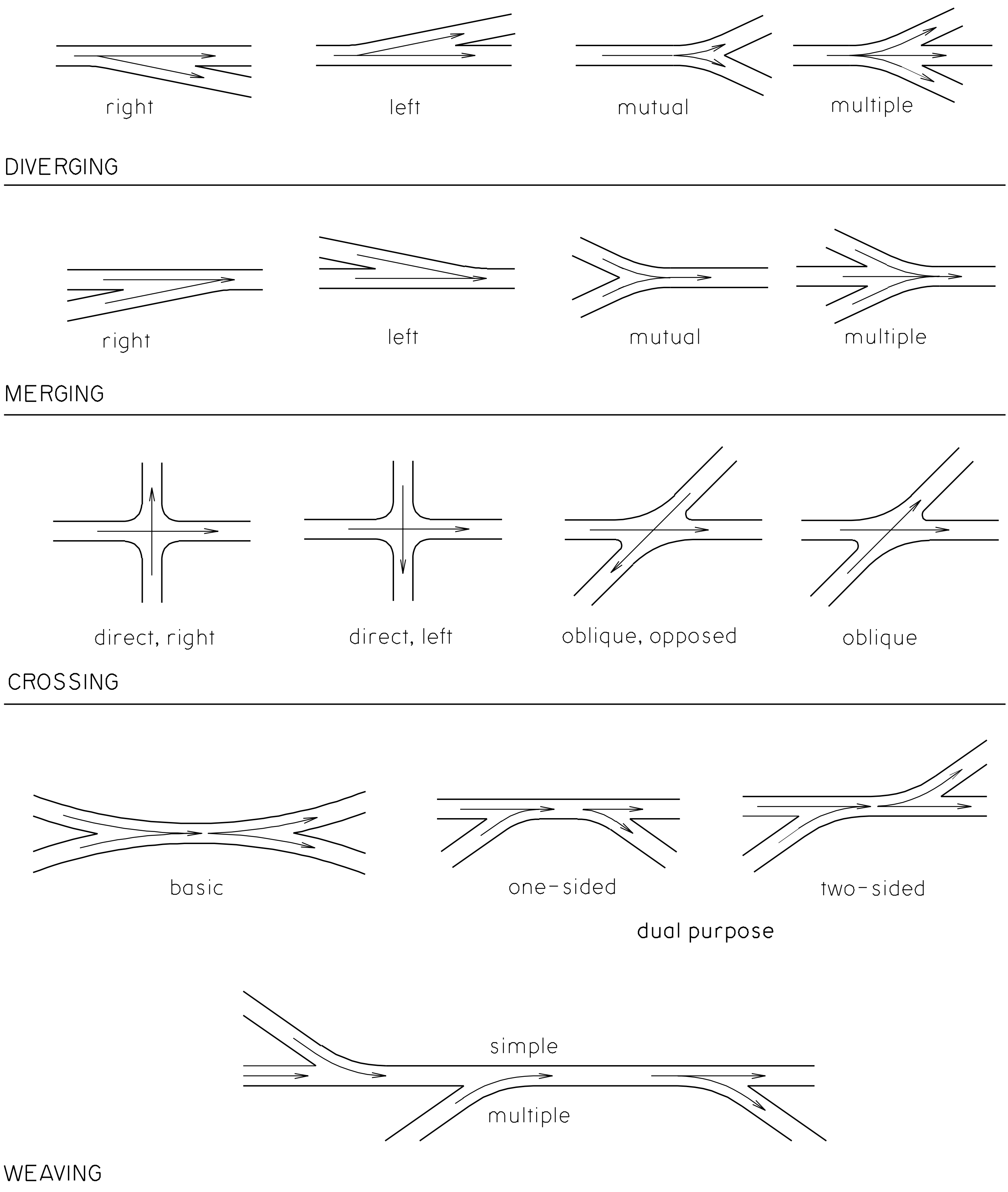


FIGURE D-2.2 TYPES OF MANOEUVRES



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D.2.4 Basic Intersection Types

The two basic types of intersections used by the department are as follows:

1. Three-leg Intersection: An intersection having three intersecting approach legs. A three-leg intersection is normally referred to as a T-intersection because of the general configuration of the intersection as shown in plan.

2. Four-leg Intersection: An intersection having four intersecting approach legs. Four-leg intersections may be generally described as right angle or skewed, cross or offset, channelized or unchannelized. These terms are indicative of the general configuration of the intersection as shown in plan.

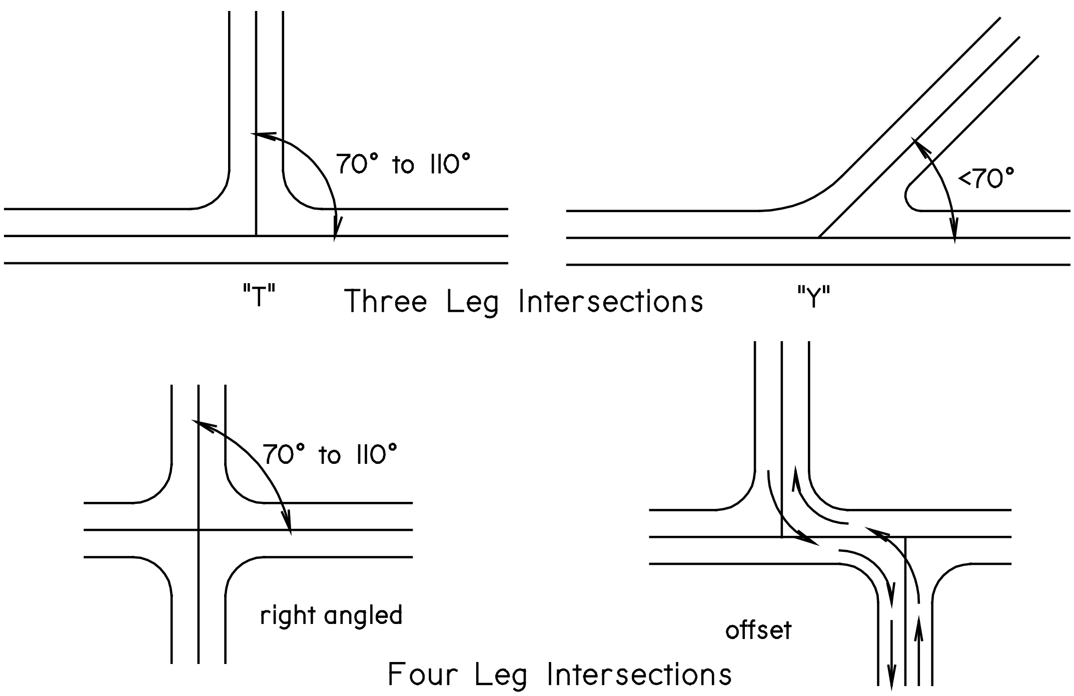
The type of an intersection is determined chiefly by the number of legs. Once the intersection type is selected, the next task is to apply the design controls and guidelines to arrive at a suitable geometric plan.

Ideally, intersections should be designed so the angle of intersection is at 90^0, or near 90^0, and it should have no more than four, two-way intersecting legs. Multi-leg intersections should be reduced to a maximum of four legs, when possible, by realigning the additional legs to tie in on the intersecting road. Multi-leg intersections are discouraged for use on rural highways because they can cause confusion for drivers.

Offset intersections are undesirable unless the lateral distance between the two intersection side roads is adequate for weaving and/or storage of left turning vehicles. A left offset intersection is better than a right offset, since a vehicle having entered and travelled along the main highway can make a non-stop right turn to exit the highway with a minimum of interference to through vehicles.

These intersection types are illustrated in Figure D-2.4.

FIGURE D-2.4 INTERSECTION TYPES



D.3 GEOMETRIC CONTROLS AT INTERSECTIONS

This section covers the following geometric design features:

- Horizontal alignment of the main road
- Horizontal alignment of the intersecting road
- Vertical alignment of the main road
- Vertical alignment of the intersecting road
- Cross slope at intersections
- Lane and shoulder widths at intersections.

Co-ordination of the above design aspects is required for the detailed design of an at-grade intersection. Careful consideration must be given to the combined effects of the horizontal and vertical alignments on each approach leg. A sharp horizontal curve following the crest of a vertical curve is very undesirable on any of the approaches. Horizontal and vertical alignment should provide for safe continuous operation. Generally, it is preferable that horizontal alignments be straight and that gradients be as low as possible. Sight distance values should meet or exceed the values shown in the following sections, which are generally based on design speed, design vehicle and intersection configuration. The intersection sight distance (as defined in Section D.4) for the appropriate design vehicle and design speed is considered a minimum requirement.

Decision sight distance is desirable and is to be provided where economical for the main traffic stream on the approaches to major intersections. An example of an area where decision sight distance is beneficial to drivers is on the approach to a gore area separating the turning roadway from the main alignment at a channelized intersection or interchange. Decision sight distance is also desirable at flared intersections, although it is not as important as at a channelized intersection because of the lower traffic volumes.

Sight distance requirements must be considered both for vehicles approaching and departing from the stopped position at the intersection. The line of sight should be checked for restrictions due to vertical curvature and obstacles.

D.3.1 Horizontal Alignment of the Main (or Through) Road (Intersections on Curve)

It is preferable to have the main (or through) highway alignment on tangent through the entire intersection area. Intersections on curve are undesirable for safety reasons and should be avoided where possible. Superelevation requirements on the curve have an adverse effect on turning vehicles. When these slopes are high, problems arise in adjusting the intersecting roadway's approach grade to the superelevated section while maintaining the required sight distance. Other reasons why intersections on curve are undesirable include the following:

- Sight distances can be deceiving for drivers on the intersecting road who must judge the distance and speed of approaching vehicles, and

- Run-off-road collisions that occur on curves in the vicinity of intersections will likely be more severe due to the approach blocking an otherwise smooth roadside area.

In recognizing these factors, the following criteria have been developed for locating intersections on curve:

- On new construction, intersections on curve are permitted for certain combinations of design speed and radius. Table B.3.6a includes an inset table which identifies those curves where intersections may be permitted. The inset table also allows the designer to use slightly lower superelevation rates on circular curves. The option of using a lower superelevation rate on curves is offered because this option provides some operational benefits for slow moving and turning vehicles with no significant disadvantages for through traffic.

- The designer should use engineering judgment to decide if the regular or reduced superelevation rate is appropriate for a particular intersection. Generally the lower rates are used where there is a large number or percentage of turning vehicles.

According to Table B.3.6a the minimum radii for curves with intersections are 1150m, 1400m, 1800m, and 2200m, for design speeds of 100, 110, 120, and 130 km/h, respectively.

The following conditions will permit these minimum standards to be exceeded:

- The intersection's location is at a point on the spiral where superelevation has not been fully developed and does not exceed the maximum allowable (0.038 m / m).

- Where the approach is for a field or single farm entrance, an exception to the rule may be allowed.

Where the above criteria cannot be met, the intersection should be relocated outside of the curve. In this case, each intersection should be analysed individually to ensure that its layout will promote safe operation.

D.3.2 Horizontal Alignment of the Intersecting Road

At all types of intersections on divided and undivided highways, it is desirable that the intersecting roads meet at, or nearly at, right angles. Roads intersecting at acute angles require extensive turning roadway areas, tend to limit visibility and increase the exposure time of vehicles crossing the main traffic flow. When a truck turns left from a side road on an obtuse angle intersection, the driver has a blind area to the right of the vehicle. Whenever possible, roads are designed and located to intersect at angles between 70 and 110 degrees. These factors have led to the development of minimum realignment criteria for intersections occurring on undivided highways. The same criteria are generally applied to divided highways.

Where the intersecting road is a primary highway, secondary highway, or town access road, the minimum allowable intersection angle is 70 degrees. When realignment is required the minimum desirable intersection angle is 80 degrees, and the absolute minimum is 70 degrees. Figure D-3.2a shows a typical realignment layout when the main (or through) road is divided. A similar layout may be used when the main (or through) road is undivided.

Where the intersecting road is a local road, the minimum intersection angle depends on whether it is designated as a right-hand-forward (RHF) or left-hand-forward (LHF) intersection. The designation is based on the perspective of the driver on the main road. If the intersecting road on the right hand side appears to be forward from the main road driver's perspective, then it is designated as right hand forward. Otherwise, it is designated as left-hand-forward. Figures D-3.2b and D-3.2c illustrate the concepts of right-hand-forward and left-hand-forward intersection designation.

The rationale for having two different criteria (that is, RHF and LHF) for local road realignment is related to the sight distance available to the driver. In the right-hand-forward situation, a driver stopped on a local road, attempting to make a left turn onto the highway, could have obscured vision looking to the right if the vehicle is a truck with a cab in the back. In the left-hand-forward situation, the driver looking to the right would have no obstacles to obstruct the line of sight and therefore can tolerate a greater skew angle for the intersection. On local road intersections, the minimum allowable angle of intersection is 60 degrees for right-hand-forward and 50 degrees for left-hand-forward designation. Figure D-3.2d shows the typical realignment layout for a local road intersection where the main (or through) road is divided. A similar layout may be used when the main (or through) road is undivided. At any intersection where realignment takes place, the original roadway should be obliterated and the land returned to its original use if possible.

When the horizontal alignment of an intersecting road is adjusted to provide a better intersection angle, as shown on Figure D-3.2a, this can create the impression (for drivers on the intersecting road at night, from oncoming headlights in the distance) that the roadway alignment is continuous when, in fact, it has been realigned. To avoid this misleading impression, it is desirable to erect some type of solid barrier such as an earth berm on both sides of the abandoned alignment to block headlight penetration.

In cases where the intersecting road has several kilometres of straight uninterrupted alignment, which suddenly intersects a through highway with poor observance of the stop sign, there is a high incidence of collisions due to drivers failing to stop at the stop sign. This situation can usually be improved by placing a "STOP AHEAD" sign 200-300m in advance of the stop sign. The safety aspect could also be improved by introducing a curve, or series of curves, on the intersecting road before the intersection. The use of a curve or series of curves tends to prepare the driver for the highway signs and the need to stop ahead.

FIGURE D-3.2a MINIMUM REALIGNMENT CRITERIA/TYPICAL LAYOUT AT JUNCTION OF MAJOR HIGHWAY/PRIMARY WITH SECONDARY HIGHWAY OR TOWN ACCESS ROAD

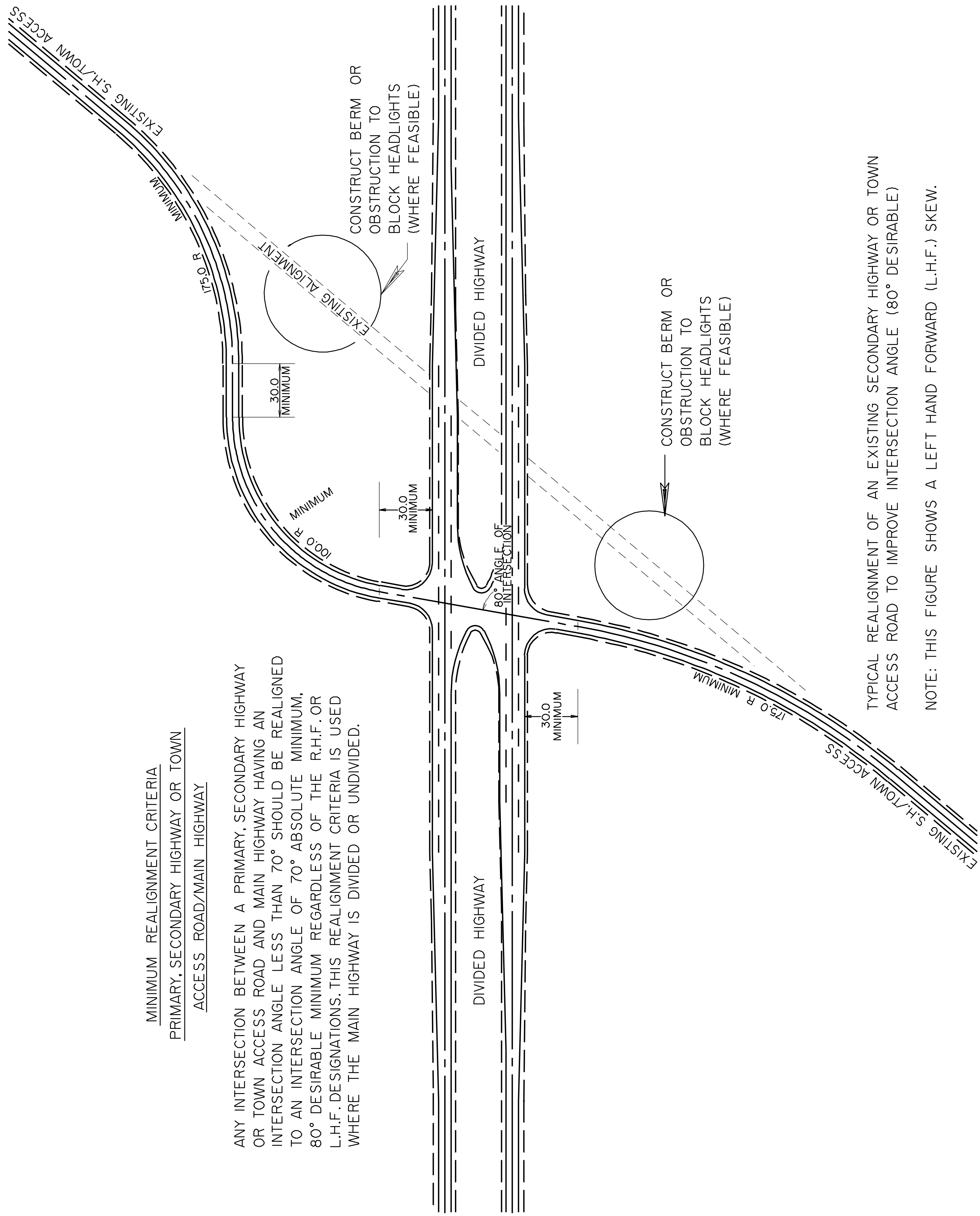


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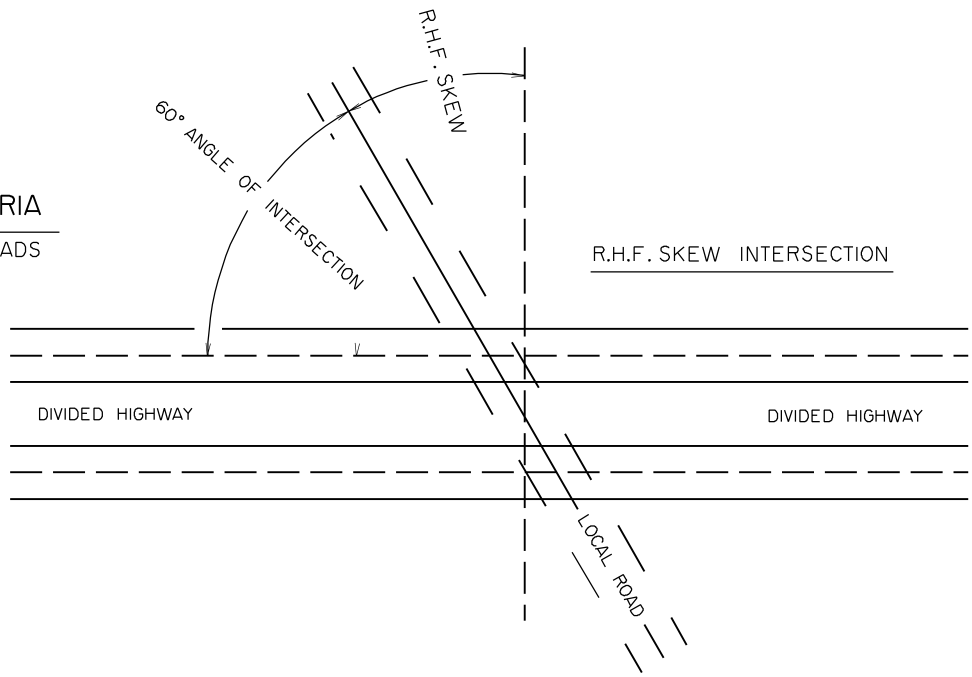
FIGURE D-3.2b ILLUSTRATION OF RIGHT-HAND-FORWARD INTERSECTION DESIGNATION

REALIGNMENT CRITERIA

JCT. DIVIDED HWY/LOCAL ROADS

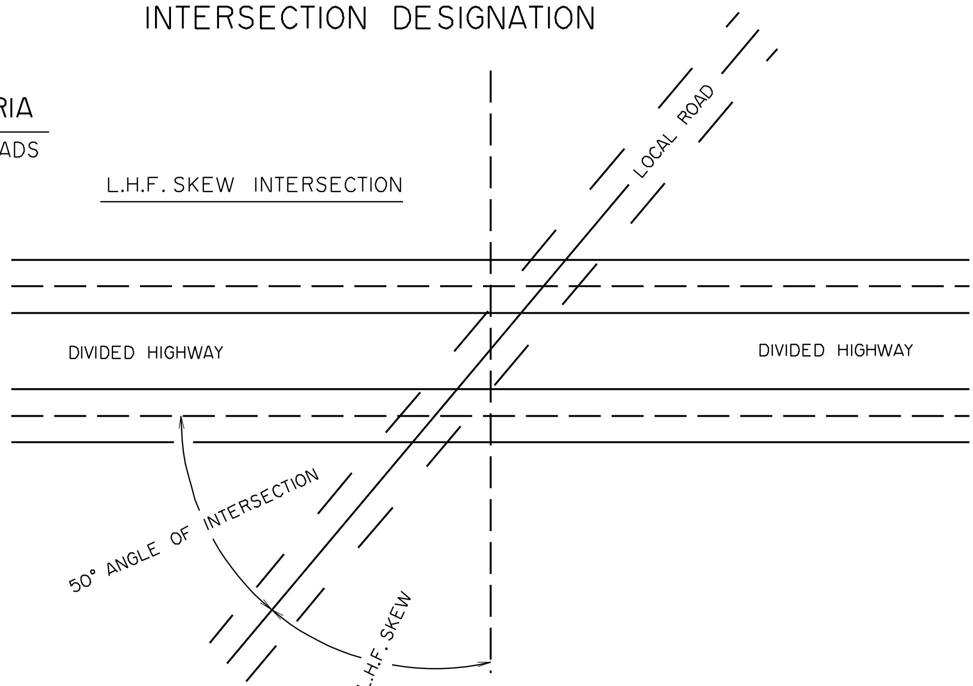


THE ABOVE FIGURE ILLUSTRATES A RIGHT-HAND-FORWARD SKEW INTERSECTION WITH A 60° INTERSECTION ANGLE. ANY R.H.F. SKEW INTERSECTION BETWEEN A DIVIDED HIGHWAY AND A LOCAL ROAD HAVING AN INTERSECTION ANGLE LESS THAN 60°, SHOULD BE REALIGNED TO A MINIMUM DESIRABLE INTERSECTION ANGLE OF 80°, OR TO A ABSOLUTE MINIMUM INTERSECTION ANGLE OF 70°.

FIGURE D-3.2c ILLUSTRATION OF LEFT-HAND-FORWARD INTERSECTION DESIGNATION

REALIGNMENT CRITERIA

JCT. DIVIDED HWY/LOCAL ROADS



THE ABOVE FIGURE ILLUSTRATES A LEFT-HAND-FORWARD SKEW INTERSECTION WITH A 50° INTERSECTION ANGLE. ANY L.H.F. SKEW INTERSECTION BETWEEN A DIVIDED HIGHWAY AND A LOCAL ROAD HAVING AN INTERSECTION ANGLE LESS THAN 50°, SHOULD BE REALIGNED TO A MINIMUM DESIRABLE INTERSECTION ANGLE OF 80°, OR TO AN ABSOLUTE MINIMUM INTERSECTION ANGLE OF 70°.

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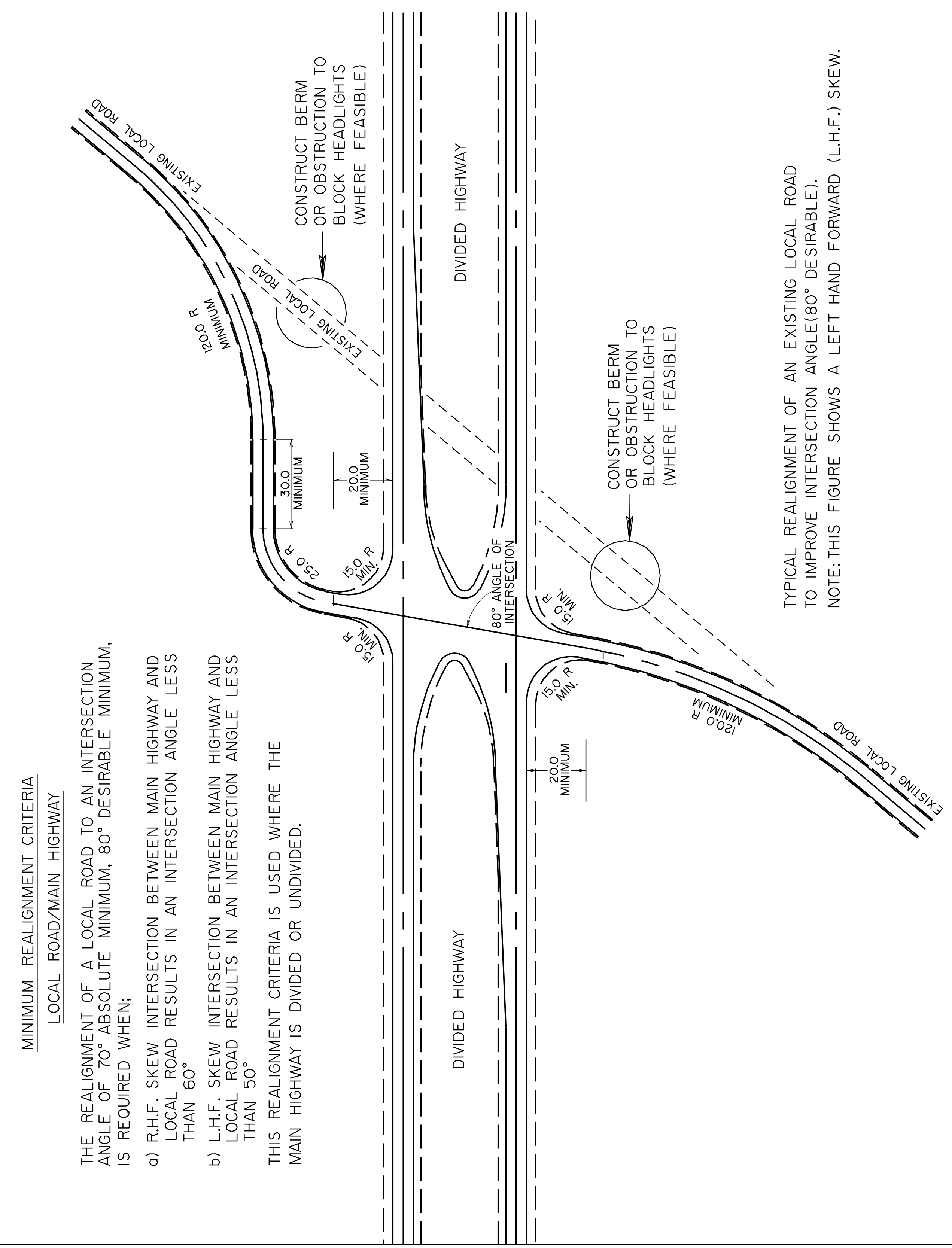
FIGURE D-3.2d MINIMUM REALIGNMENT CRITERIA/TYPICAL LAYOUT AT JUNCTION OF MAJOR HIGHWAY AND LOCAL ROAD



D.3.3 Vertical Alignment of the Main (or Through) and Intersecting Roads

At all at-grade intersections, vertical curves and grades on the through and intersecting roadways should be designed so that there is good visibility on all approaches. Section D.4 deals with sight distance requirements in detail.

Combinations of grade lines which make vehicle control difficult should be avoided. Gradients for each intersecting leg should be as level as practical. This is particularly important on those sections where vehicles must stop and wait, as in left turn storage lanes and on the approach grade of the intersecting roadways. Most vehicles, having automatic or manual transmissions, must apply their brakes to stand still on grades steeper than one percent. Stopping and accelerating distances for passenger cars on grades of three percent or less differ only slightly from those on level, however, on grades steeper than three percent, several design factors must be adjusted to provide conditions equivalent to those on level. Accordingly, gradients in excess of three percent should be avoided. In exceptional circumstances where conditions are such that flatter gradients would cause undue expense, a maximum allowable grade of five percent on the main alignment may be used with a corresponding adjustment in design factors.

On at-grade intersections, the cross section and gradeline of the main alignment are held constant throughout the intersection area and the intersecting roadway is adjusted to fit. Figures D-3.3a and D-3.3b illustrate the design guidelines for approach grades on main and minor intersecting roadways, respectively.

Those guidelines are as follows:

- Generally the approach grade should be falling away from the main (or through) road centreline elevation
- The desirable minimum grade is one percent, to prevent ponding and subsequent icing at the intersection
- The desirable maximum grade is two percent, for ease of operation in all weather conditions
- Approach road grades between 1/2 percent and three percent are desirable. Approach road grades up to six percent maximum are considered acceptable where required due to constraints
- Approach grades up to one percent sloping down towards the highway may be used to match superelevation on the main (or through) road if desirable for engineering reasons: for example, to improve visibility for vehicles on the intersecting road.

FIGURE D-3.3a APPROACH TREATMENT FOR MAIN INTERSECTING ROADWAY

INTERSECTION OF HIGHWAY AND MAIN ROAD

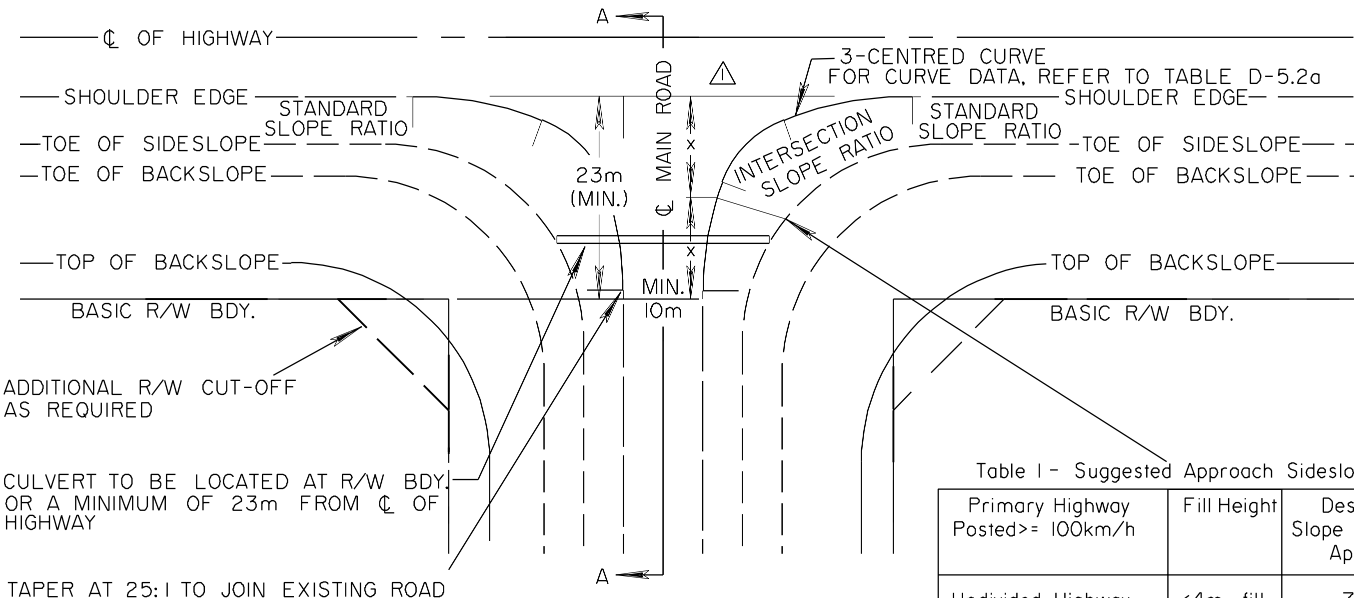
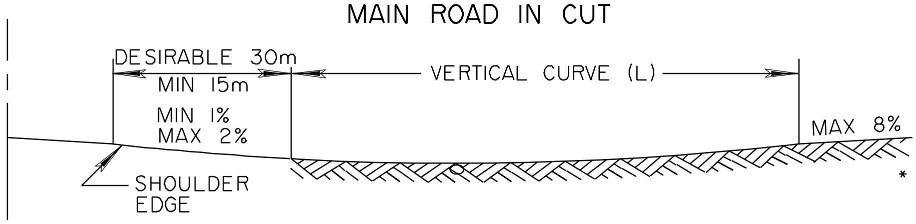


Table 1 - Suggested Approach Sideslopes *

Primary Highway Posted>= 100km/h	Fill Height	Desirable Slope on New Approach
Undivided Highway AADT <1,000	<4m fill >4m fill	7:1 4:1
Undivided Highway 1,000<AADT<3,000	<4m fill >4m fill	7:1 5:1
Undivided Highway AADT >3,000	<4m fill >4m fill	7:1 6:1
Divided Highway AADT <6,000	<4m fill >4m fill	7:1 7:1
Divided Highway 6,000 <AADT 15,000	<4m fill >4m fill	8:1 7:1
Divided Highway AADT <15,000	<4m fill >4m fill	10:1 7:1

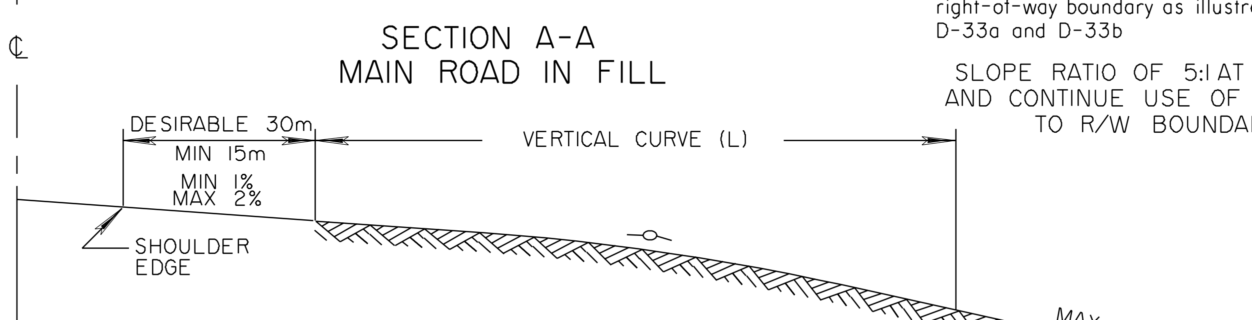
* Approach slop to be measured at a point midway between the highway shoulder and basic right-of-way boundary as illustrated on figures D-33a and D-33b

SECTION A-A
MAIN ROAD IN CUT



SECTION A-A
MAIN ROAD IN FILL

SLOPE RATIO OF 5:1 AT CULVERT AND CONTINUE USE OF 5:1 SLOPE TO R/W BOUNDARY.



NOTE:

DESIRABLE MINIMUM 1% IS TO PREVENT PONDING AND SUBSEQUENT ICING AT THE INTERSECTION.
DESIRABLE MAXIMUM 2% IS FOR EASE OF OPERATION IN ALL WEATHER CONDITIONS.

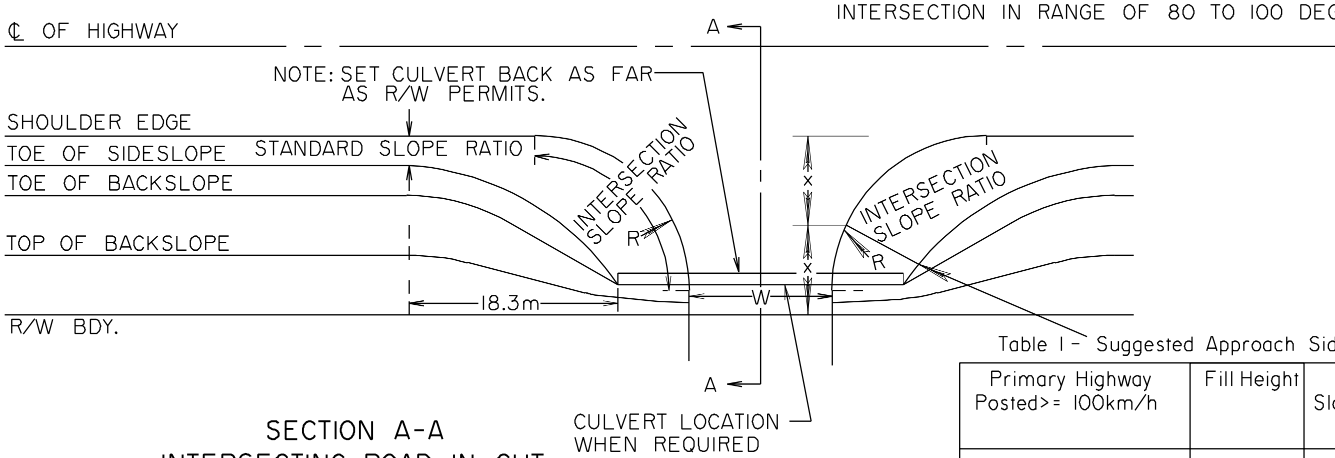
APPROACH GRADES BETWEEN 0.5% and 3%, ABSOLUTE MAXIMUM 6% ARE CONSIDERED ACCEPTABLE. APPROACH ROAD GRADES UP TO 1% SLOPING DOWN TOWARD THE HIGHWAY MAY BE USED TO MATCH SUPERELEVATION ON THE HIGHWAY, IF DESIRABLE FOR ENGINEERING REASONS.

MINIMUM LENGTH OF VERTICAL CURVE		
ALGEBRAIC DIFFERENCE IN GRADIENT %	LENGTH L (m)	
	CREST	SAG
1	60	60
2	60	60
3	60	60
4	75	60
5	90	80
6	105	95
7		110
8		130
9		145

FIGURE D-3.3b APPROACH TREATMENT FOR MINOR INTERSECTING ROADWAY

INTERSECTION OF HIGHWAY AND MINOR ROAD

NOTE: ACCESS TO BE PROVIDED ONLY WHEN ANGLE OF INTERSECTION IN RANGE OF 80 TO 100 DEGREES.



SECTION A-A
INTERSECTING ROAD IN CUT

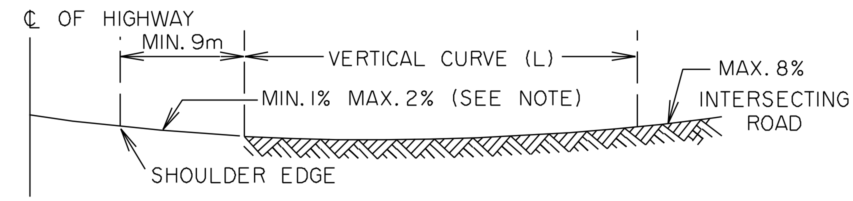
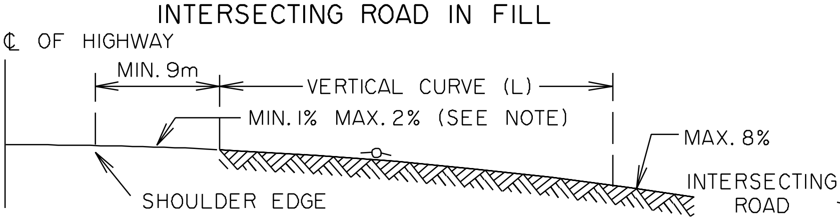


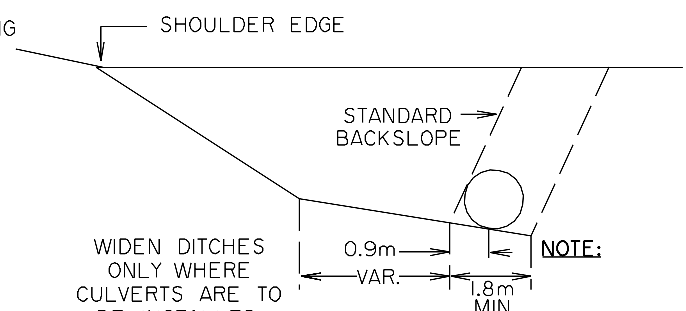
Table I - Suggested Approach Sideslopes *

Primary Highway Posted>= 100km/h	Fill Height	Desirable Slope on New Approach
Undivided Highway AADT <1,000	<4m fill >4m fill	7:1 4:1
Undivided Highway 1,000<AADT<3,000	<4m fill >4m fill	7:1 5:1
Undivided Highway AADT >3,000	<4m fill >4m fill	7:1 6:1
Divided Highway AADT <6,000	<4m fill >4m fill	7:1 7:1
Divided Highway 6,000 <AADT 15,000	<4m fill >4m fill	8:1 7:1
Divided Highway AADT <15,000	<4m fill >4m fill	10:1 7:1

* Approach slop to be measured at a point midway between the highway shoulder and basic right-of-way boundary as illustrated on figures D-33a and D-33b

SECTION A-A
INTERSECTING ROAD IN FILL





DETAIL OF DITCH AND CULVERT LOCATION

MINIMUM LENGTH OF VERTICAL CURVE		
ALGEBRAIC DIFFERENCE IN GRADIENT (%)	LENGTH L (m)	
	CREST	SAG
1	6	8
2	12	15
3	18	23
4	24	30
5	30	38
6	37	46
7		46
8		46
9		46

NOTE:
WHERE THE MINOR INTERSECTING ROADWAY HAS A LARGE NUMBER OF WB-15 VEHICLES TURNING, THE APPROACH TREATMENT SHOWN IN FIGURE D-3.3a SHOULD BE USED.

TABLE FOR DETERMINATION OF ROADWAY WIDTH			RADIUS OF INTERSECTION EDGE OF SHOULDER (R)
USE	ROADWAY WIDTH W*(m)		
	SINGLE	JOINT	SINGLE OR JOINT ACCESS
RESIDENTIAL	8	10	10
AGRICULTURAL	10	10.5	15
UTILITY MAINTENANCE	8		15
PUBLIC ROAD ALLOWANCE	8		15

* ENGINEERING DISCRETION SHOULD BE USED IN SELECTING A ROADWAY WIDTH TO SUIT THE NEEDS OF THE ACCESS.

NOTE:
DESIRABLE MINIMUM 1% IS TO PREVENT PONDING AND SUBSEQUENT ICING AT THE INTERSECTION.

DESIRABLE MAXIMUM 2% IS FOR EASE OF OPERATION IN ALL WEATHER CONDITIONS.

APPROACH GRADES BETWEEN 0.5% AND 3%, ABSOLUTE MAXIMUM 6% ARE CONSIDERED ACCEPTABLE. APPROACH ROAD GRADES UP TO 1% SLOPING DOWN TOWARD THE HIGHWAY MAY BE USED TO MATCH SUPERELEVATION ON THE HIGHWAY, IF DESIRABLE FOR ENGINEERING REASONS.

GRAPHICS FILE: debd33b.man

D.3.4 Cross-slope at Intersections

In general for rural at-grade intersections, the rate of cross-slope does not vary across the intersection surface (that is, the rate of cross-slope for turning lanes and shoulders is kept the same as the through lane). Therefore, where a flared at-grade intersection is constructed on tangent, the finished pavement has a crown at centerline. On a superelevated intersection, the superelevation at any particular cross-section is held constant across the entire roadway surface (except in that portion of the superelevation transition where a difference in cross-slope is required, as shown in Figures B-3.7a, B-3.7b and B-3.7c).

D.3.5 Lane and Shoulder Widths at Intersections

The lane width for the through lane at intersections is the same as the through lane width on the standard cross-section (that is, 3.7m for RAU-211.8-110 and higher designations and 3.5m for RAU-210-110 and lower designations).

The width for all auxiliary lanes on intersections is 3.5m.

The shoulder width adjacent to an auxiliary or bypass lane on an undivided highway flared intersection is the lesser of 1.5m or the standard shoulder width on that highway design designation. The minimum 1.5m width on higher designation roadways is required to accommodate cyclists on the highway system. It also provides some benefits for pedestrians and should reduce the incidence of rear wheel off-tracking by large vehicles when turning on or off the highway.

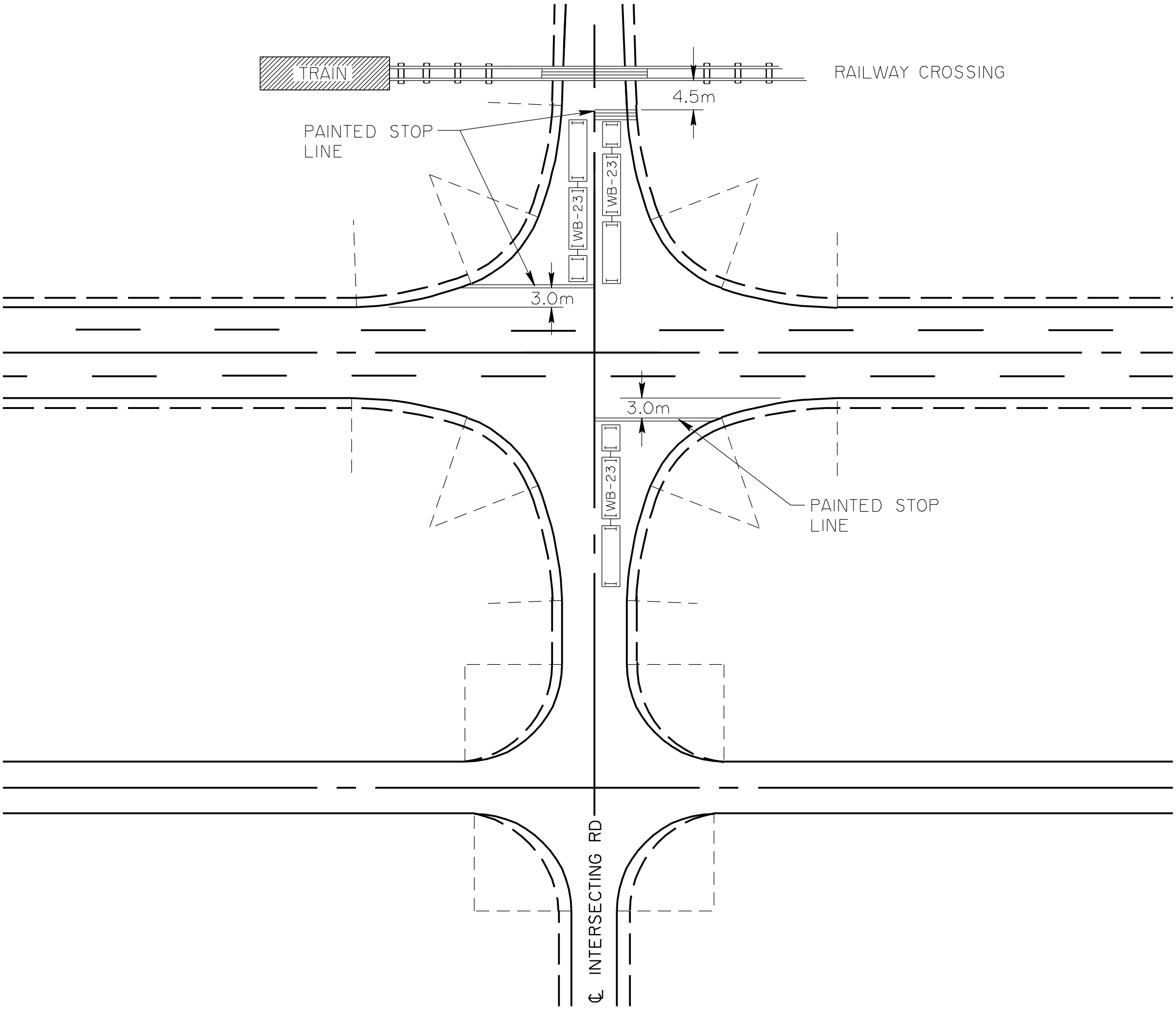
At divided highway intersections, the minimum shoulder on the right hand side is 1.5m. On the left hand side the shoulder can be reduced to 0.5m adjacent to an auxiliary lane.

To reduce the occurrence of motor vehicles encroaching onto the shoulder, rumble strips installed on the highway shoulder should not be continued through the intersection because of the reduced shoulder width. Normally rumble strips on the shoulder are only used if the shoulder width is at least 1.8m.

D.3.6 Offset from Minor Intersections or Railway Crossings

Where a major intersection is to be built in close proximity to a railway crossing on the minor road, it is prudent to ensure that the spacing is great enough to allow the design vehicle to stop at either stop line without blocking off the railway tracks or the highway. The same consideration applies where a minor road or frontage service road parallels a major roadway.

FIGURE D-3.6 STACKING DISTANCE FROM HIGHWAY TO A MINOR INTERSECTION OR RAILWAY CROSSING



NOT TO SCALE

NOTE:
TRANSPORT CANADA'S CURRENT "GRADE CROSSING CONSTRUCTION, ALTERATION AND MAINTENANCE MANUAL" (DRAFT), STATES THAT THE CLEAR SPACE BETWEEN ANY PART OF THE TRAVELLING SURFACE OF A NEW UNRESTRICTED RAILWAY GRADE CROSSING AND THE TRAVELLED WAY OF ANY ROAD SHOULD BE A MINIMUM OF 30m IF THE TRAIN SPEED EXCEEDS 24km/h. GIVEN THAT THIS IS A "DRAFT" REGULATION FOR NEW CROSSINGS, THERE MAY BE SOME FLEXIBILITY WHEN DESIGNING ALTERATIONS OR IMPROVEMENTS ON EXISTING CROSSINGS, HOWEVER IT IS GOOD DESIGN PRACTISE TO ENSURE THAT THE DESIGN VEHICLE CAN STOP AT ANY OF THE STOP LINES WITHOUT ENCROACHING ON THE PATH OF TRAVEL FOR TRAINS OR THROUGH VEHICLES. THE BUFFER ZONE TO BE PROVIDED IS 3.0m FROM FRONT OF VEHICLE TO TRAVEL LANE AND 4.5m FROM FRONT OF VEHICLE TO EDGE OF TRACK. THESE DIMENSIONS ARE SUGGESTED TO ALLOW FOR TYPICAL DRIVER BEHAVIOUR WHEN APPROACHING A POTENTIAL CONFLICT POINT.

D.4. SIGHT DISTANCE AT INTERSECTIONS

D.4.1 Introduction

Although there are potential vehicle conflicts at every intersection, the possibility of these conflicts actually occurring can be greatly reduced through proper channelization and appropriate traffic controls. The intersection design must provide sufficient sight distances for the driver to perceive potential conflicts and to carry out the actions needed to negotiate the intersection safely.

Sight distance requirements must be considered both for vehicles approaching the intersection and for vehicles departing the intersection from the stopped position.

In the case of all rural highway intersections at grade, with the exception of signalized intersections, the intersecting highway or road is controlled by a stop or yield sign. For design purposes the stop condition should be assumed. The standard intersectional sight distance requirement used in Alberta is based on providing for vehicles turning left into a major highway without interfering with vehicles approaching from the left at design speed. The stopped vehicles must also have sufficient sight distance to the right to allow the operator of the vehicle to turn left and accelerate to a speed where he or she does not significantly interfere with vehicles coming from the right. This is described as Case IIIB in the 1994 AASHTO publication "A Policy on Geometric Design of Highways and Streets". For design purposes, the sight distance for left turning without interfering with vehicles approaching from the left is used for both directions.

Intersection sight distance is defined as the sight distance available from a point where vehicles are required to stop on the intersecting road, while drivers are looking left and right along the main roadway, before entering the intersection. The intersection sight distance is adequate when it allows the design vehicles to safely make all the manoeuvres that are permitted by the layout; for example, left turn onto the highway or crossing the highway, based on certain design assumptions. Those assumptions include a perception / reaction time, vehicles on major road travelling at design speed, minimum turning radii and typical acceleration rates for design vehicles. The intersection sight distance requirements for a particular intersection must be modified when necessary due to skew angle, gradients, special design vehicles, etc., as shown in the following sections.

The sight distance available in both the horizontal and vertical planes must be determined preferably through field measurements, or, if necessary in the case of new construction, through measurements on the plan and profile. These measurements can be used in conjunction with intersection sight distance requirements to determine if physical changes need to be made to meet design requirements. These changes may include removing obstructions, such as trees or buildings, to maintain the horizontal sight lines or flattening vertical crest curves to ensure that oncoming vehicles can be seen (maintaining a clear line of sight in the vertical plane).

Measurements of intersection sight distance must be based on the design assumptions for the particular intersections. The three principle factors that affect sight distance requirements and availability are design speed, design vehicle and intersection layout. Section D.5 discusses design vehicles. The design speed for an intersection, or the design speed to be used for selection of intersection sight distance, tapers, length of auxiliary lanes, etc., is normally based on the design speed of the major road at that location. The design speed for the intersecting road at an intersection is generally consistent with the design speed of the intersecting road elsewhere, although consideration of the low running speed due to the requirement to stop may be used to lower superelevation rates where appropriate. The intersecting road design speed has little impact on the major road alignment at the intersection.

In order to measure the sight distance available, the surveyor or designer must use all of the design vehicles considered appropriate for the intersection. The eye height (and consequently the sight distance available) for each design vehicle will be different and therefore must be checked. Because the longest design vehicle generally requires the largest sight distance, this vehicle will normally control. However, this is not always the case. Generally, the crucial manoeuvre for sight distance purposes is the left turn onto the highway. However, the crossing manoeuvre may be crucial in some cases depending on width of roadway, length of vehicle, etc. Therefore, the availability of sight distance should be measured based on the initial vehicle positions for these manoeuvres. These positions are: design vehicle on intersecting road (location of eye) and passenger vehicle approaching on main (or through) road (object height 1.3m). The height of eye to be used depends on the design vehicle (see Figure D-5a). The height of object to be used is 1.3m in all cases. This dimension represents the passenger vehicle, which is the smallest oncoming vehicle to be accommodated. Meeting the right distance criteria using a 1.3m object height is a "minimum", that is the ability to see the pavement surface is desirable, seeing a portion of an oncoming vehicle is acceptable however the ability to see only the roof of an oncoming passenger vehicle is a "minimum" requirement.

FIGURE D-4.1a SIGHT TRIANGLE (HORIZONTAL PLANE)

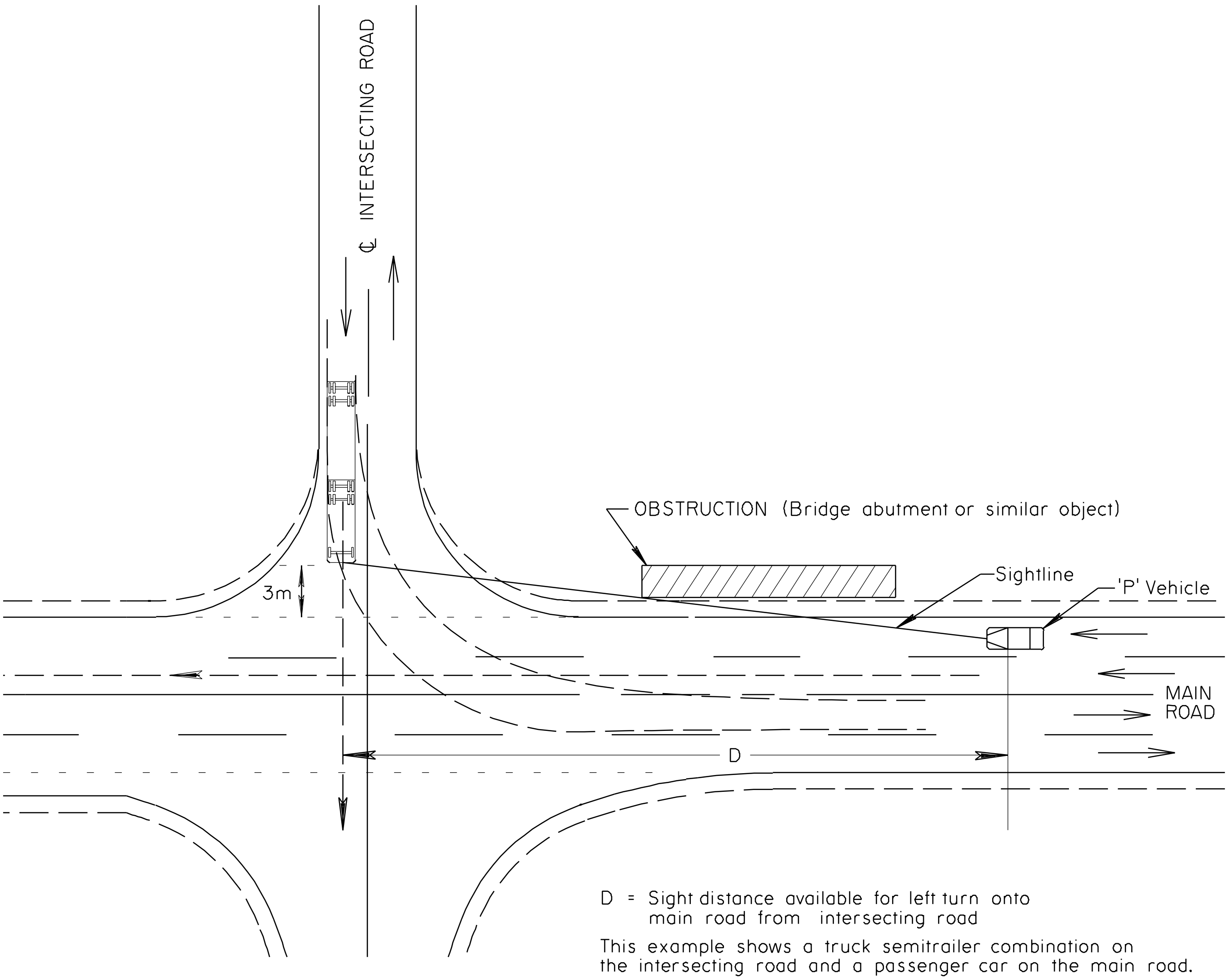
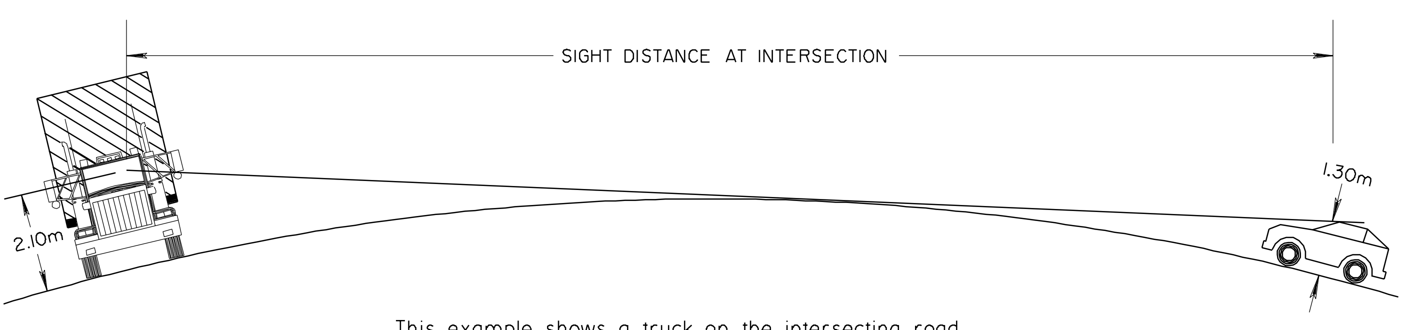


FIGURE D-4.1b SIGHT LINE (VERTICAL PLANE)



This example shows a truck on the intersecting road and a passenger car on the main road.

D.4.2 Minimum Sight Triangle

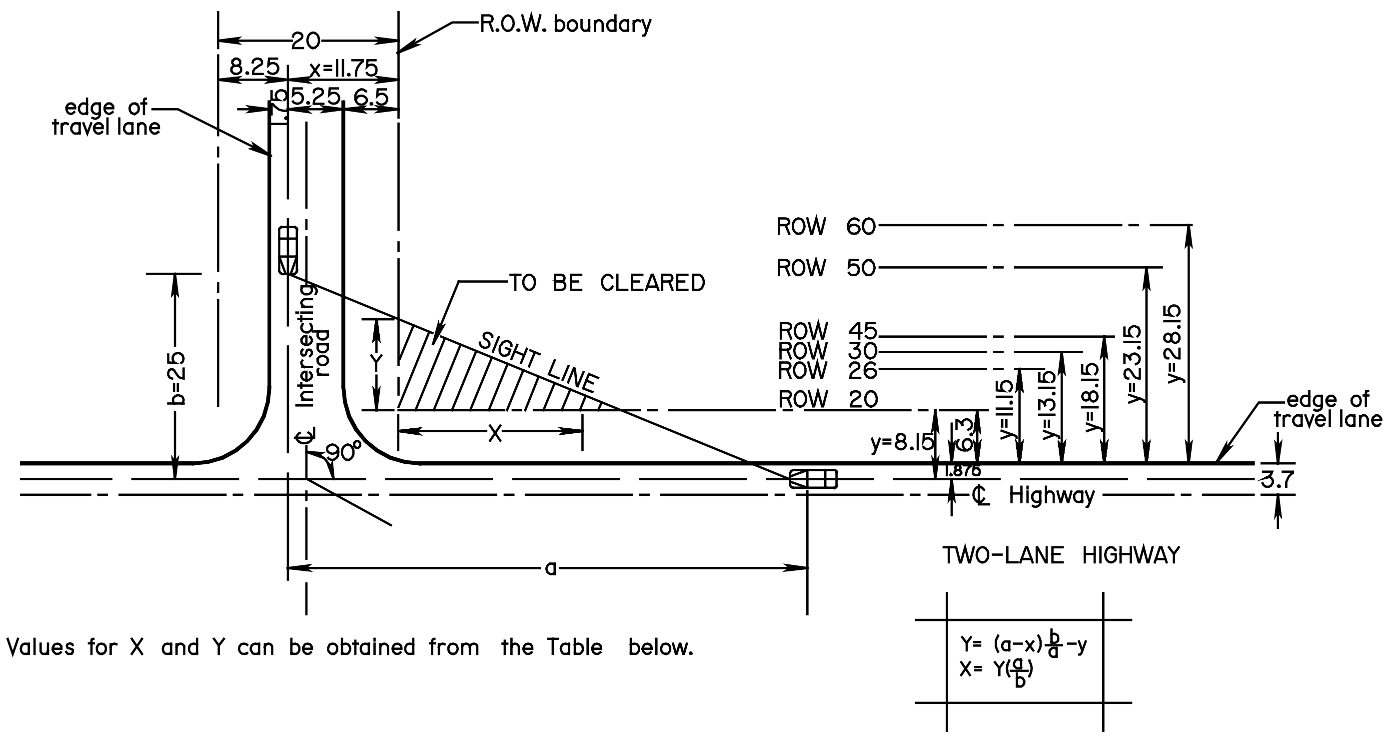
D.4.2.1 Approaches

On the approaches to an intersection, the required sight distances depend upon the approach speeds and the particular action that the drivers may be required to take before reaching the point of potential conflict.

In general, each driver has four possible actions: accelerate, continue at present speed, slow down or stop.

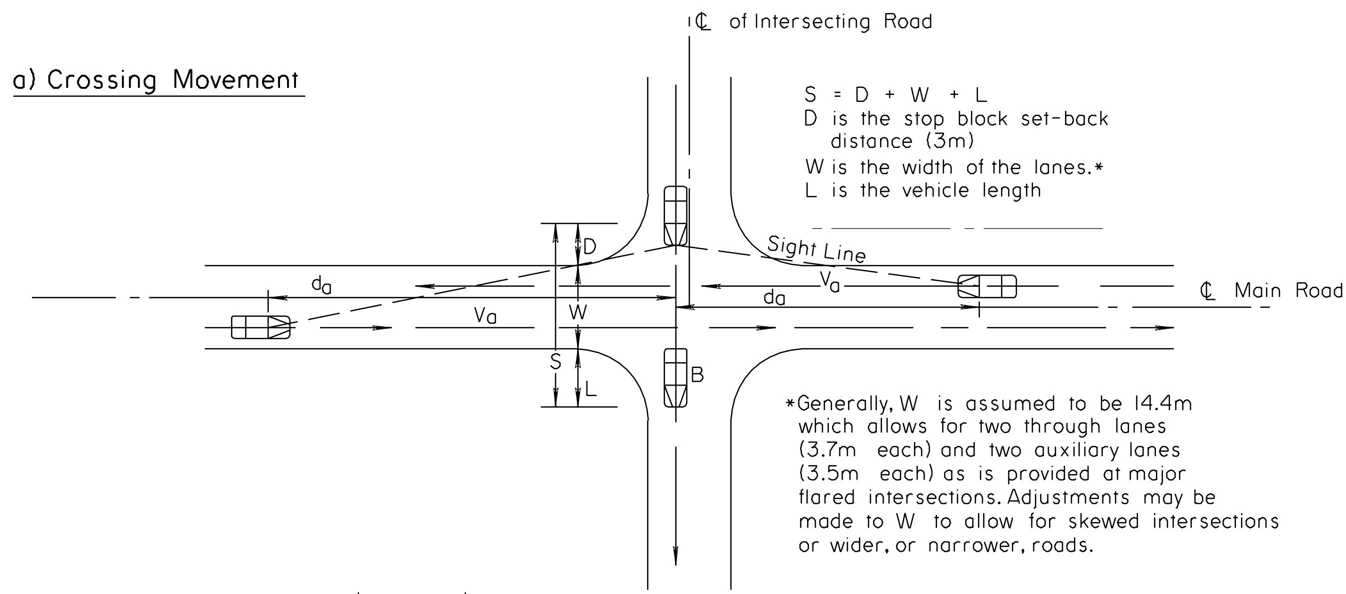
Rural highway intersections in Alberta generally have a stop control for the intersecting road and free flow for the main road.

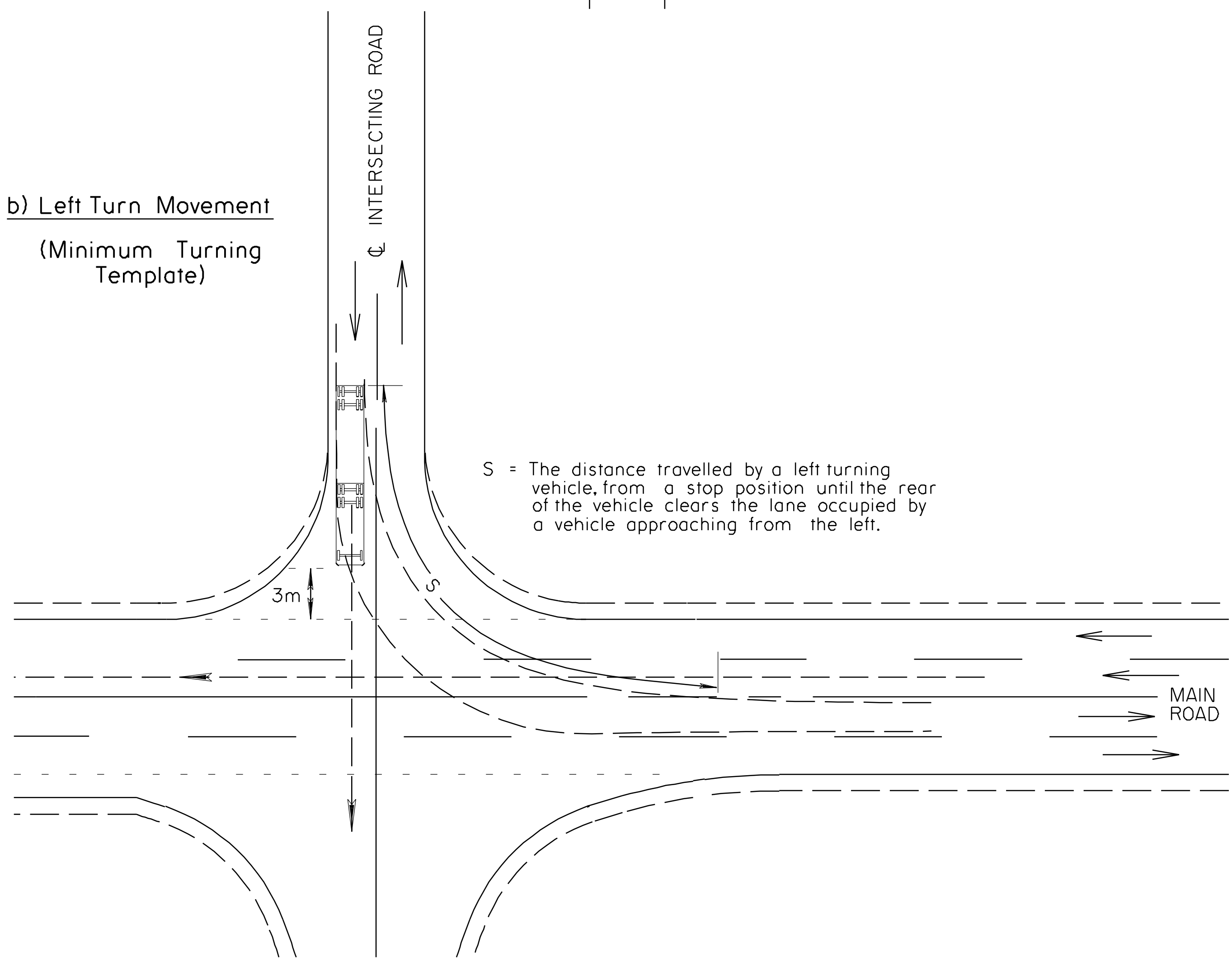
FIGURE D-4.2.1 SIGHT DISTANCE AND VISIBILITY AT 90° INTERSECTIONS FOR APPROACHES WITH STOP CONTROL



Design Speed on Highway km/h	Approach Distance "a" Based on 3 s m	Visibility Triangle Highway Right of Way (m)															
		20		26		30		35		40		45		50		60	
		X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
40	30	8	7	5	4	2	2	0	0	0	0	0	0	0	0	0	0
50	40	15	10	10	7	7	5	3	2	0	0	0	0	0	0	0	0
60	50	22	11	16	8	12	6	7	4	2	1	0	0	0	0	0	0
70	60	29	12	22	9	17	7	11	5	5	2	0	0	0	0	0	0
80	65	32	12	24	9	19	7	13	5	6	2	0	0	0	0	0	0
90	75	39	14	30	10	24	8	17	6	9	3	2	1	0	0	0	0
100	85	46	14	36	10	29	8	20	6	12	3	3	1	0	0	0	0
110	95	53	14	41	11	34	9	24	6	15	4	5	1	0	0	0	0
120	100	56	14	44	11	36	9	26	6	16	4	6	1	0	0	0	0
130	110	62	14	48	11	40	9	29	7	18	4	8	2	0	0	0	0

FIGURE D-4.2.2 SIGHT DISTANCE AT INTERSECTIONS FOR DEPARTURES





D.4.2.2 Departures

After a vehicle has stopped at an intersection, the driver must have sufficient sight distance to make a safe departure (whether crossing or turning) within the intersection area.

Figure D-4.2.2, examples a and b, illustrate the required sight lines for a safe crossing or left turning manoeuvre from a stopped position.

Distance d_a on Figure D-4.2.2 (example a) shows the length travelled by vehicles at the design speed V_a of the main highway during the time it takes for the vehicle to leave its stopped position and cross the intersection over the distance S = D + W + L. D, W) and L are defined in Figure D-4.2.2.

In the case of turning manoeuvres, the left turn from the minor road shown in Figure D-4.2.2 (example b) is generally the controlling value. For left turns, S is the distance travelled while turning from the stopped position to the point where the turning vehicle has completely cleared the lane occupied by a vehicle approaching from the left. The minimum turning template for each design vehicle is used for this calculation. The time taken for each design vehicle to travel through the distance required from a stopped position can be obtained from Figure D-4.2.2.1a. These values have been tabulated based on the performance of fully loaded design vehicles. The sight distances required as a result of these turning distances are shown on Figure D-4.2.2.2.

The intersection design should provide adequate sight distances for each of the vehicle manoeuvres permitted upon departure from a stopped position as described here. A full description of crossing and left turn sight distance are provided in Section D.4.2.2.1 and D.4.2.2.2, respectively.

D.4.2.2.1 Crossing Sight Distance

The driver of a stopped vehicle must be able to see a sufficient distance along the main (or through) highway in order to cross over it safely before an approaching vehicle reaches the intersection, even if a vehicle comes into view just as the stopped vehicle departs. The length of the main (or through) highway open to view must be greater than the product of its design speed and the time necessary for the stopped vehicle to start and cross the road. The minimum required sight distance along the main (or through) road is given by the formula:

$$D = \frac{V(J+t)}{3.6}$$

Where

D — is the minimum crossing sight distance along the main (or through) road from the intersection in metres.

V — is the design speed of the main (or through) roadway in kilometres per hour.

J — is the perception-reaction time of the crossing driver (assume two seconds).

t — is the acceleration time to cross the main (or through) road’s pavement in seconds. The time (t) is given for a range of crossing distances for the six design vehicles in Figure D-4.2.2.1a.

J represents the time necessary for the driver that’s crossing to look in both directions along the main roadway, perceive there is sufficient time to cross the road safely, and shift gears if necessary prior to starting. It is the time from the driver's first look for possible oncoming traffic to the instant the vehicle begins to move. Some of these operations are done simultaneously by many drivers, and some operations, such as shifting of gears, may be done before looking up or down the road. Even though most drivers may require only a fraction of a second, a value of J used in design should be large enough to cater to all but the slowest drivers.

The time t required to cover a given distance during acceleration depends on the vehicle acceleration. For passenger cars, this seldom equals the rate the vehicle is capable of attaining. Rather, the vehicle acceleration rate is considerably less, as governed by the temperament and other characteristics of the driver and by the prevailing conditions. Few drivers operate at the maximum acceleration potential of their vehicles in crossing a main (or through) highway. Most drivers accelerate somewhat more rapidly than normal but less than the full potential vehicle acceleration rate.

The solid line curve labeled P in Figure D-4.2.2.1a is the recommended time-distance relationship of a typical passenger vehicle to be used in computing **t**, the time required to cross a main (or through) highway. This figure is also used to calculate the time required to safely complete a left turn onto the highway from the intersecting road for each design vehicle. The time-distance data for the P design vehicle shown in Figure D-4.2.2.1a was developed from studies performed by the University of Michigan Transportation Research Institute (UMTRI) published in 1984. The time-distance data for the SU and WB-15 design vehicles is based on the 1990 AASHTO Green Book. It has been assumed that the acceleration characteristics of all tractor, semi-trailer units from WB-12 to WB-21 and the Super B-train (WB-23) are the same because their mass/power ratios are generally in the same range. The time-distance data for log haul truck, also shown in Figure D-4.2.2.1a, is based on field studies performed by Alberta Infrastructure in 1992.

The acceleration of buses and trucks is substantially lower than that of passenger vehicles, particularly for heavily loaded trucks and truck combinations. The high gear ratios (in low gear) necessary in moving the larger units result in very low accelerations. From vehicle operation studies, the speed-distance relationships for acceleration of design passenger vehicles have been determined. Their relationships are plotted in Figures D-4.2.2.1b and D-4.2.2.1c. On flat grades the acceleration time for the SU and WB-15 vehicles is about 140 and 170 percent respectively of that for passenger vehicles.

A plot of speed versus time for passenger cars is provided on Figure D-4.2.2.1d.

The crossing distance is calculated using the formula:

$$S = d + W + L$$

Where S is the distance travelled during acceleration, in metres.

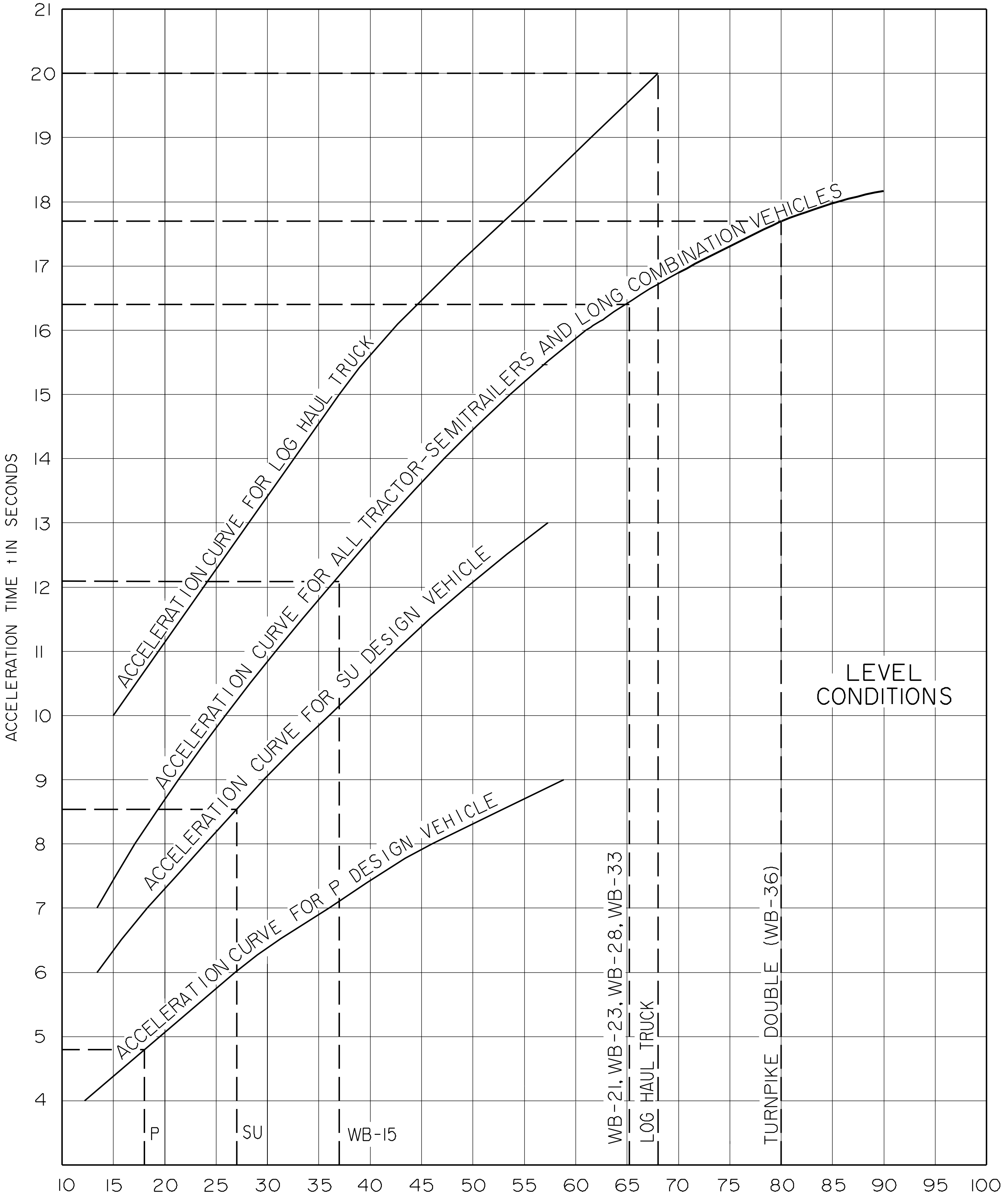
d is the distance from the near edge of lane to the front of the stopped vehicle, in metres (assume three metres).

W is the width of pavement (lanes only along the path of the crossing. In general on undivided highways, this is assumed to be 14.4m which allows for two through lanes (3.7m each) and two auxiliary lanes (3.5m each), as is provided at major flared intersections. This length must be divided by the sine of the intersection angle for skewed intersections.

L is the overall length of the crossing vehicle in metres.

In the case of divided highways, widths of median equal to or greater than the length of vehicle enable the crossing to be made in two steps. The vehicle crosses the first pavement, stops within the protected area of the median opening, and there awaits an opportunity to complete the second crossing step. For divided highways with medians less than L, the median width is considered to be part of the W value.

FIGURE D-4.2.2.1a DATA ON ACCELERATION FROM STOP



NOTE: The dashed lines on this figure show the distance travelled and time required by each design vehicle to complete a left turn onto a major highway. It is assumed that the design vehicle starts from a stop position 3m back from the edge of auxiliary lane on a flared intersection with a 90 degree angle of intersection and continues to a point where the vehicle has completely cleared the lane occupied by a vehicle approaching from the left. The minimum turning template is used for each vehicle.

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FIGURE D-4.2.2.Ib ACCELERATION CURVES:
SPEED-DISTANCE RELATIONSHIP FOR PASSENGER CARS

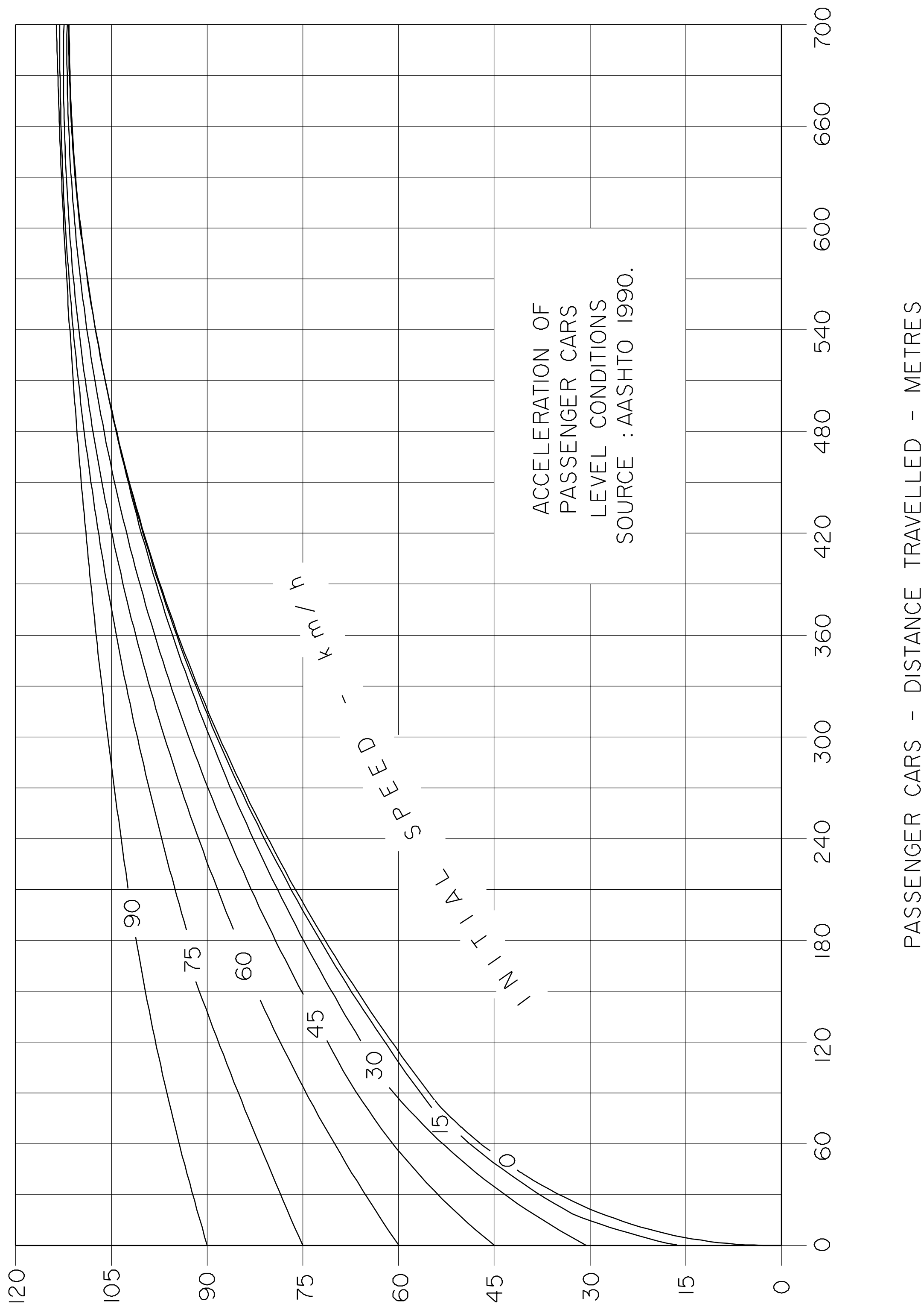


FIGURE D-4.2.2.1c ACCELERATION CURVES:

SPEED-DISTANCE RELATIONSHIP FOR HEAVY TRUCKS ON GRADES

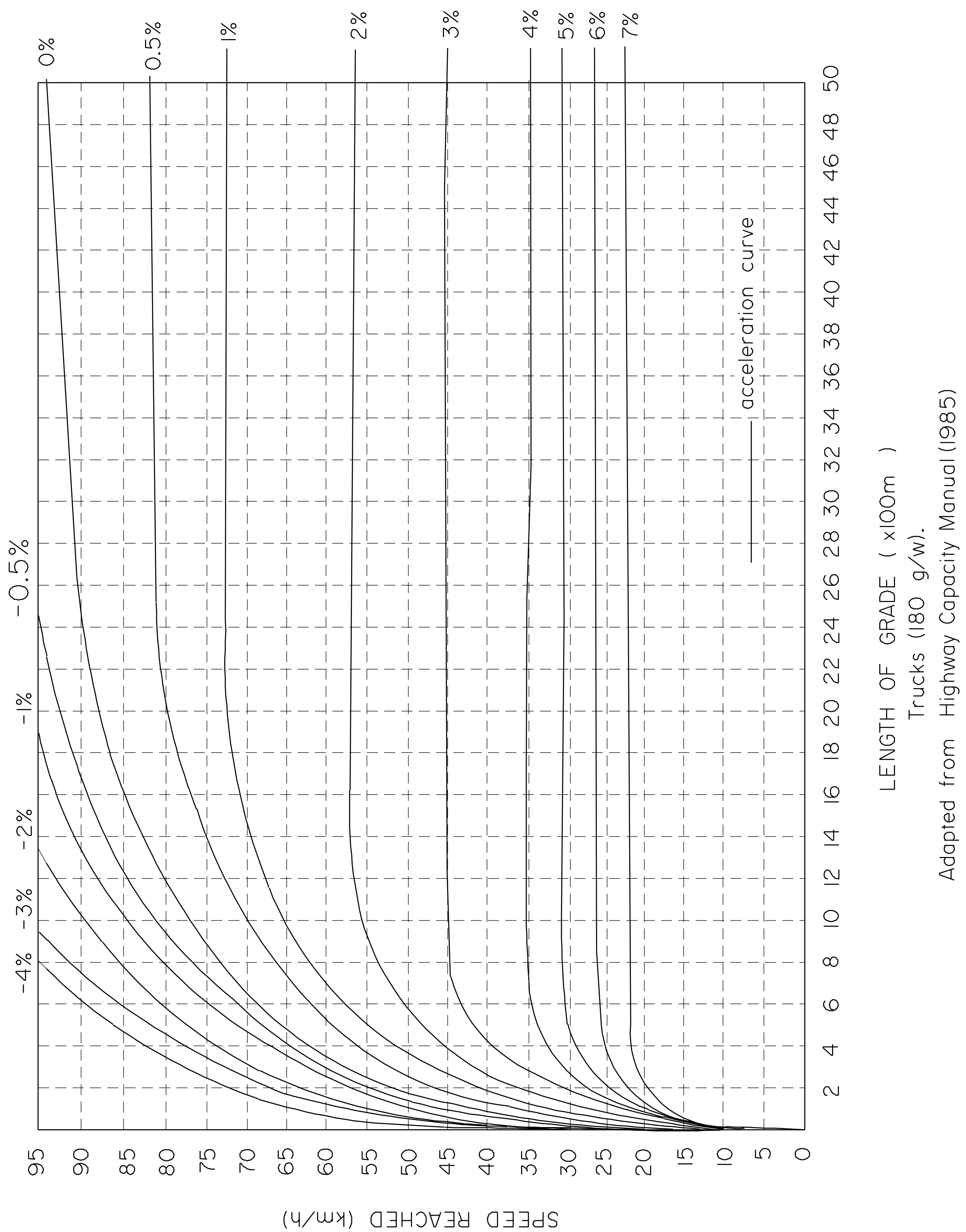
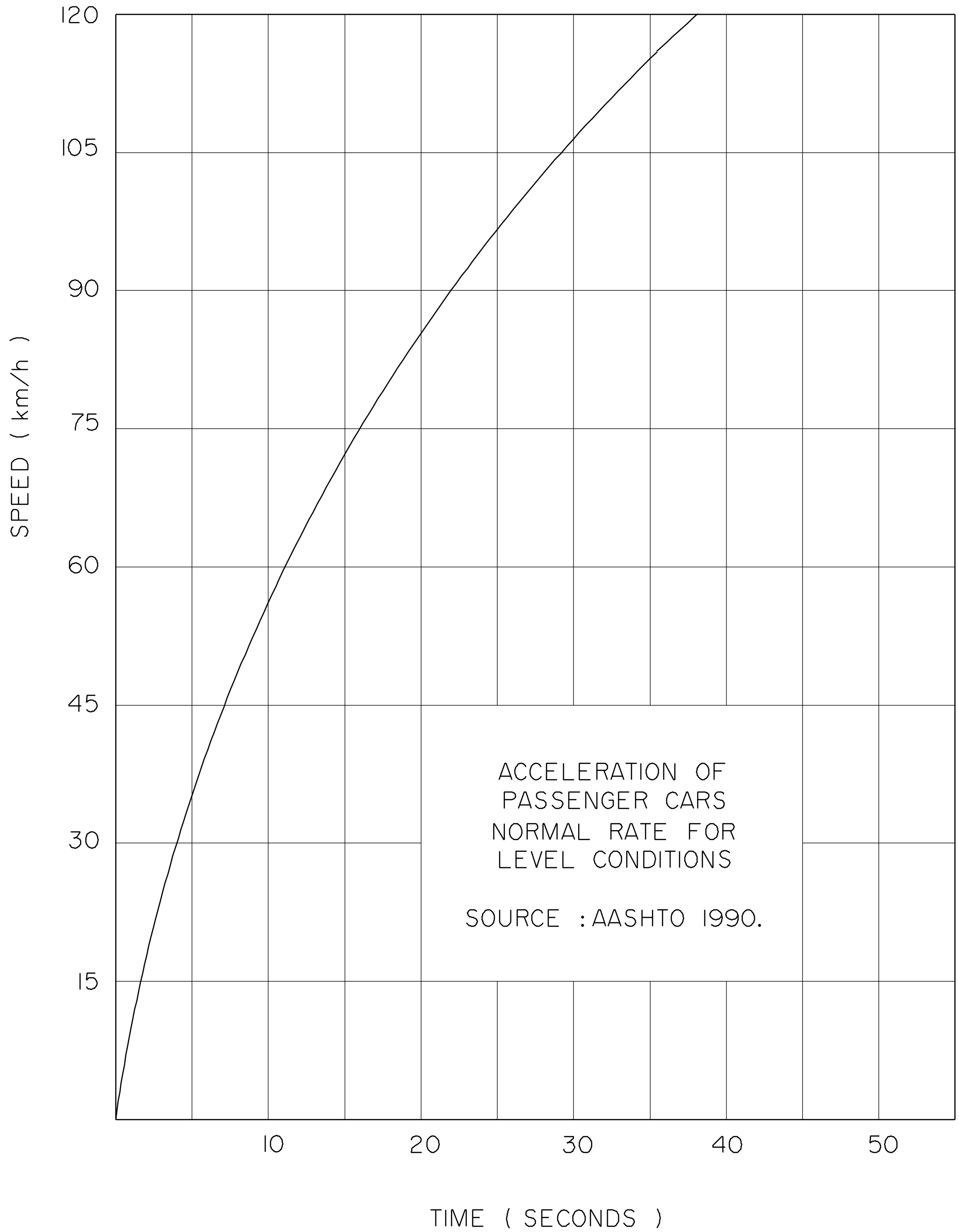


FIGURE D-4.2.2.1d ACCELERATION CURVES:
SPEED-TIME RELATIONSHIP FOR PASSENGER VEHICLES



D.4.2.2.2 Minimum Sight Distance for Left Turn onto Highway

The only difference between this condition and that discussed in the preceding section, is the time and distance travelled by a vehicle negotiating the left turn, rather than crossing the highway. The distances travelled by vehicles entering a main (or through) two-lane highway, before clearing the lane used by a vehicle approaching from the left, are about: 18m for passenger cars, 27m for a single axle truck (SU design vehicle), 37m for intermediate size semi-trailer trucks (WB-15 and WB-17 design vehicle), 65m for a 25m long Super-B Train (WB-23), 65m for the largest allowable semi-trailer (WB-21), and 68m for a design log haul truck. These distances are based on the minimum turning templates for each vehicle (with the exception of WB-21 and WB-23), which are appropriate for vehicles leaving a stop position. In the case of WB-21 and WB-23, a radius of 18m was used because the minimum turning radii of 15m and 12.2m, respectively, represent sharper turns than can be typically expected in highway conditions. Turning distances for long combination vehicles WB-28 (Rocky Mountain Double), WB-33 (Triple Trailer) and WB-36 (Turnpike Double) have also been calculated using a turning radius of 18m.

Figure D-4.2.2.2 shows the minimum sight distance required along a main (or through) highway at intersections necessary to permit the stopped vehicle to turn left onto the main (or through) two-lane highway. The six sloping lines give the minimum intersection sight distances for 90 degree intersections, assuming level conditions, with the turning vehicles stopped 3.0m back from the edge of auxiliary lane, crossing one 3.5m and one 3.7m lane, and turning into a 3.7m lane. The design assumptions used to determine the intersection sight distance for left turns include a 3.0m initial setback from the edge of auxiliary lane. This is more than adequate when compared to the pavement marking standard which calls for the painted stop bar to be placed a minimum of 1.2m back from the edge of the through pavement. Where the intersection differs from the standard layout assumed; for example, due to a skew angle, painted median or no auxiliary lane, the designers should take this into account when calculating the distance travelled during the turning manoeuvre.

On Figure D-4.2.2.2 the SU design vehicle is suggested for minor road intersections while the WB-15 design vehicle or larger design vehicle is suggested for all major intersections, whenever larger vehicles are likely to be using the minor road on a daily basis. The P, WB-21, WB-23 and LOG vehicle sight distance requirements are also included for intersections where these are the design vehicles.

In the case of divided highways with the width of median equal to or greater than the length of the vehicle, the crossing can be made in two steps. This somewhat reduces the sight distance required along the main (or through) highway. However, for design purposes, Figure D-4.2.2.2 should still be used. For a divided highway with median width less than the length of the design vehicle, the median width should be included as part of the travel distance of the accelerating vehicle when calculating required sight distance. This will require the designer to determine the sight distance needs using the formula below rather than the Figure.

$$D = \frac{V(J+t)}{3.6}$$

Where the sight distance along the main (or through) highway is less than that required at the intersection for negotiation of a left turn, it is unsafe for vehicles on the main (or through) highway to proceed at the assumed highway design speed. Signs indicating the safe approach speed should be provided. The safe speed may be obtained directly from Figure D-4.2.2.2, or calculated by use of the formula :

$$V = \frac{3.6(D)}{J+t}$$

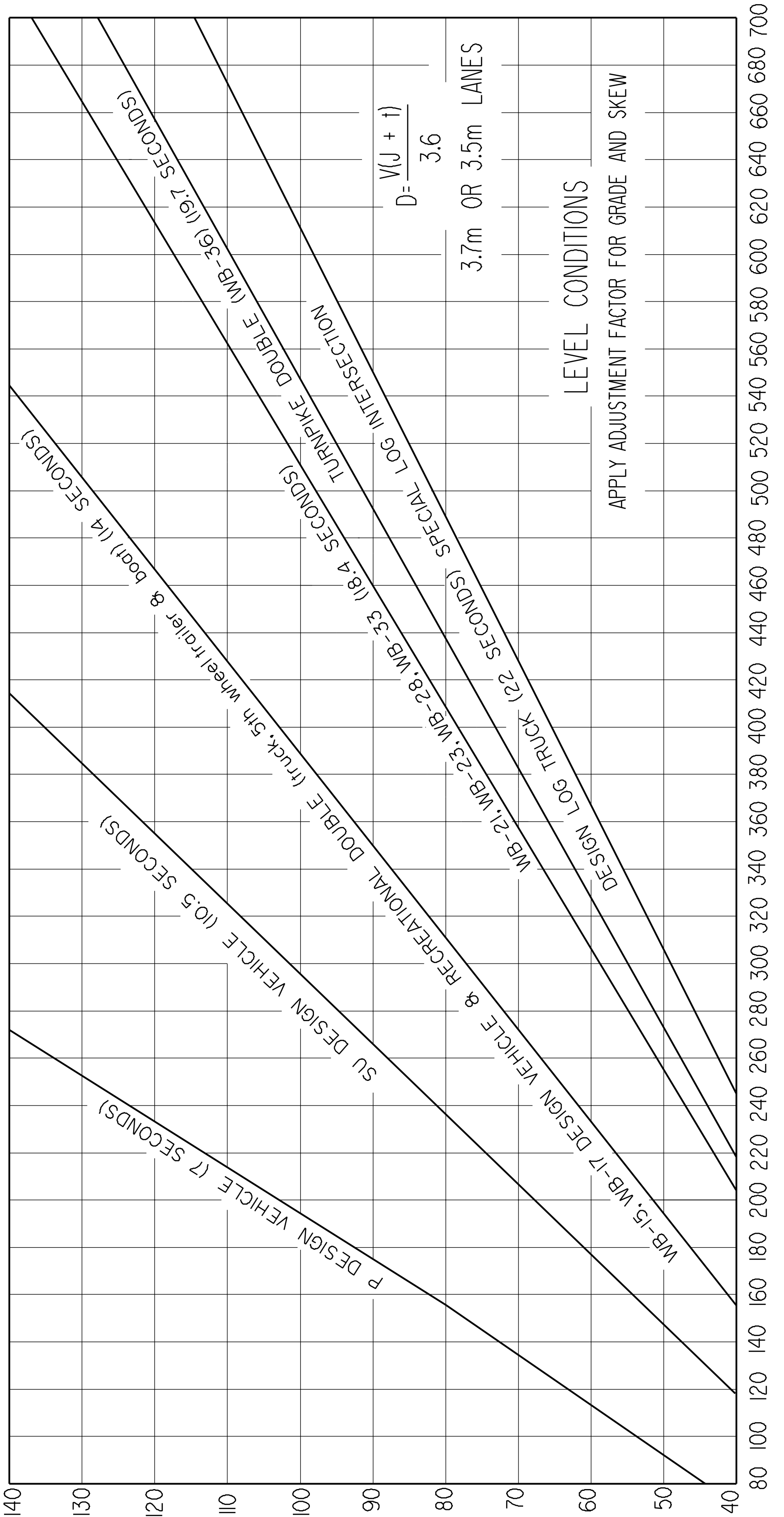
Where D is the minimum crossing sight distance along the main (or through) road from the intersection in metres.

V is the design speed of the main (or through) roadway in kilometres per hour.

J is the perception-reaction time of the driver of the stopped vehicle (assume two seconds).

t is the acceleration time to make a left turn onto the highway and clear the lane occupied by a vehicle approaching from the left, in seconds. The time (t) is given in Figure D-4.2.2.1a for a range of crossing distances for various design vehicles.

FIGURE D-4.2.2.2 SIGHT DISTANCES FOR LEFT TURN ONTO HIGHWAY*



* INTERSECTION SIGHT DISTANCE (I.S.D.)

- THE I.S.D.'s SHOWN IN THIS FIGURE ARE BASED ON THE DISTANCE TRAVELLED AT DESIGN SPEED DURING A CRITICAL TIME (SHOWN ON THE FIGURE IN SECONDS). THE CRITICAL TIME INCLUDES THE TIME TAKEN FOR THE MANOEUVRE (LEFT TURN FROM THE MINOR ROAD) PLUS 2 SECONDS FOR PERCEPTION/REACTION TIME.
- THE INTERSECTION SIGHT DISTANCE AVAILABLE IS TO BE DETERMINED USING AN EYE HEIGHT (BASED ON THE DESIGN VEHICLE) LOCATED AT THE JUNCTION AND AN OBJECT HEIGHT OF 1.3m (REPRESENTING THE ROOF OF A PASSENGER VEHICLE) ON THE THROUGH ALIGNMENT. THE EYE HEIGHTS TO BE USED ARE SHOWN IN FIGURE D-5a.

NOTES:

1. To determine the sight distance requirements at an intersection, the designer should select the longest vehicle or vehicle with the greatest I.S.D. need, that uses the intersection on a regular basis, i.e., daily. Because of the various eye heights, the I.S.D. available for several design vehicles may have to be checked.
2. The usefulness of intersection sight distances in excess of 500m has been debated and will be the subject of future research into gap acceptance by large trucks on rural highways in Alberta. Changes to this table may be made based on that research.

* THIS CHART IS BASED ON CRITERIA USED BY AASHTO FOR "SIGHT DISTANCE" AT STOP LOCATIONS. THE SET OF CRITERIA IS DESCRIBED AS CASE IIIB IN THE AASHTO PUBLICATION "A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS, 1994"

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	No. 1	BY BK	ADDED NOTE	DATE	AUG / 99

D.4.3 Signal Control

Generally, traffic signals are only used where posted speed is 80 km / h or less. Intersections controlled by traffic signals presumably do not require sight distance between intersecting traffic flows because the flows move at separate times. However, it is desirable to provide drivers with some view of the intersecting approaches in case a crossing vehicle should violate the signal indication. A time of three seconds is provided to allow vehicles on the side road and the highway to adjust their speeds in avoiding a collision while continuing through the intersection. The sight distance requirements for signal controlled intersections are the same as for approaches to a stop control; see Figure D-4.2.1, based on minimum distance travelled in three seconds.

At a signalized intersection of two highways, the three second criteria with corresponding design speed applies to all approaches. The side road approach speed, as noted in the stop control, does not apply.

It is a basic requirement for all signal controlled intersections that drivers must be able to see the control device soon enough to perform the action it indicates. For this requirement the signal head must be clearly visible for a distance as shown in Table D.4.3.

Table D.4.3 Minimum Distance to Signal Heads[7]

Posted Speed (km/h)	50	60	80
Distance (m)	100	120	165

The sight distance for right turn movements on the red phase of a signal controlled intersection is the same as for stop control.

D.4.4 Effect of Grade on Intersection Sight Distance

The time it takes a vehicle to travel across a major (or through) highway can be impacted by the approach grades of the intersecting road. Normally, the grade change across an intersection is so small that its effect is negligible, but when curvature on the main (or through) road requires the use of superelevation, the grade across it may be significant. In this case, the sight distance requirement along the main (or through) road needs to be increased.

A correction for the effect of grade on acceleration time can be made by multiplying by a constant ratio — the time (t) as determined by level conditions. Ratios of the accelerating time on various grades to those on the level are shown in Table D.4.4. The adjusted value of time (t), can then be used to determine the minimum crossing sight distance.

Table D.4.4 Ratios of Acceleration Times on Grade

Design Vehicle	Cross Road Grade (%)				
	-4	-2	0	+2	+4
P	0.7	0.9	1.0	1.1	1.3
SU	0.8	0.9	1.0	1.1	1.3
WB	0.8	0.9	1.0	1.2	1.7

D.4.5 Decision Sight Distance

Stopping sight distances (SSD) are usually sufficient to allow reasonably competent and alert drivers to come to a hurried stop under ordinary conditions. Stopping sight distance is a minimum requirement at all highway locations.

Intersection sight distance (ISD) is an additional requirement (more stringent than stopping sight distance). It must be satisfied at intersections to ensure that safe turning and crossing movements are possible.

Decision sight distance is a further requirement, in addition to SSD and ISD, which designers should consider at locations where drivers must make complex or instantaneous decisions, when information is difficult to perceive or when unexpected or unusual manoeuvres are required. Generally, decision sight distance should be provided at changes in cross section, such as lane drops or beginning of taper for turning roadway at channelized intersections or interchanges. Other locations where the provision of decision sight distance is desirable are areas of concentrated demand where there is likely to be visual noise. This occurs whenever sources of information compete; such as roadway elements, traffic, traffic control devices and advertising signs.

[7] Manual of Uniform Traffic Control Devices, February 1982. B.5.02, Distance Visibility.

For a full description of decision sight distance and a range of values for each design speed, designers should refer to Section B.2.6 in this guide.

Decision sight distances should be considered for crests near main (or through) intersections and for ramp exits. Each main (or through) intersection or ramp exit should be checked on a site-specific basis, and analyzed individually to determine if decision sight distance is achieved. Other sight distance requirements such as intersection sight distance and stopping sight distance, must also be met.

For measuring decision sight distance, the height of eye of 1.05m is used together with an appropriate height of object depending on the anticipated prevailing conditions. In some circumstances, the driver needs to see the road surface, in which case the height is zero.

Figure B-5.2.7 shows an example of how decision sight distance should be measured. The example is a lane drop at the end of a climbing or passing lane. In this case, the critical point is considered to be 120m past the beginning of taper. This point is selected because the driver, seeing the pavement surface here, will know that there is a taper. That is, the driver will have seen two merge arrows on the pavement, the end of the auxiliary lane line and the narrower pavement.

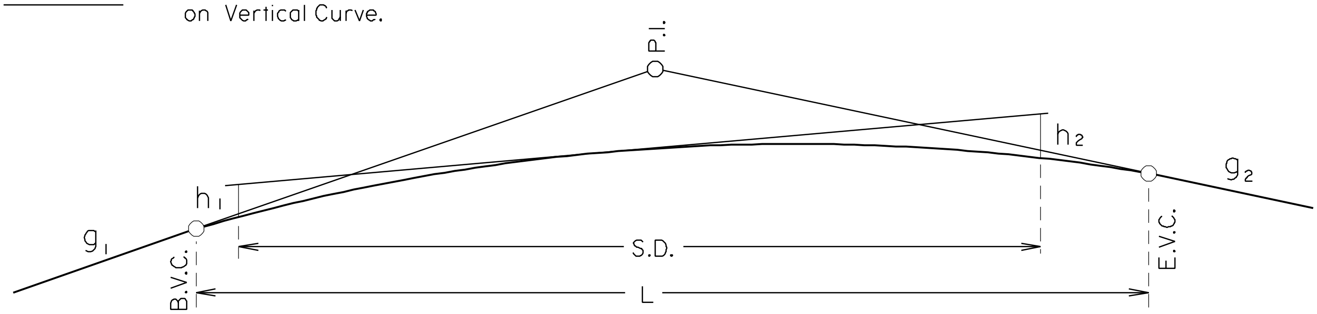
D.4.6 Application of Intersection Sight Distance to Highway Design

Both the horizontal sight triangle (Sight Triangle) and the vertical curvature shown in Figures D-4.1a and D-4.1b should be checked to ensure that the minimum sight distance in Figure D-4.2.2.2, Sight Distances for Left Turn onto Highway is provided at each intersection. The sight distance required for left turns is generally used for both directions, even in the case of T intersections where left turn criteria for both directions is a result of a trade-off between theoretical requirements and practical considerations. In theory, intersections should ideally be designed so that both left and right turns from the minor road can be made without causing any conflict with through traffic, assuming that through traffic is advancing along the main alignment at design speed. This would require sufficient sight distance so that vehicles making right turns from a minor road can accelerate up to design speed before being overtaken by a vehicle advancing from the left. Similarly, it would also require sufficient sight distance so that vehicles making a left turn from the minor road could accelerate up to design speed before being overtaken by a vehicle advancing from the right. The sight distances required to meet these two criteria are extremely long, especially where the turning vehicle has poor acceleration capabilities, and therefore it is considered impractical to use these criteria for design purposes. The sight distance required to allow left turns from the minor road to be made without being in conflict with vehicles approaching from the left is expected by motorists and is not impractical and therefore is adopted as a minimum for both directions for design purposes.

When checking for vertical curve sight distance at intersections, the formulae described in Figure D-4.6 may be used to determine the sight distance, if the intersection is on a vertical crest curve or at a point outside of the vertical curve. Alternatively, the available sight distance can be determined graphically from the profile, for any given vehicle. The minimum sight triangle, as required for approaches to intersections, should also be provided as described in Section D.4.2.1.

FIGURE D-4.6 FORMULAE FOR DETERMINATON OF SIGHT DISTANCE AT INTERSECTIONS ON OR NEAR VERTICAL CREST CURVES

CASE I — Intersection and Object on Vertical Curve.



When S.D. is less than L

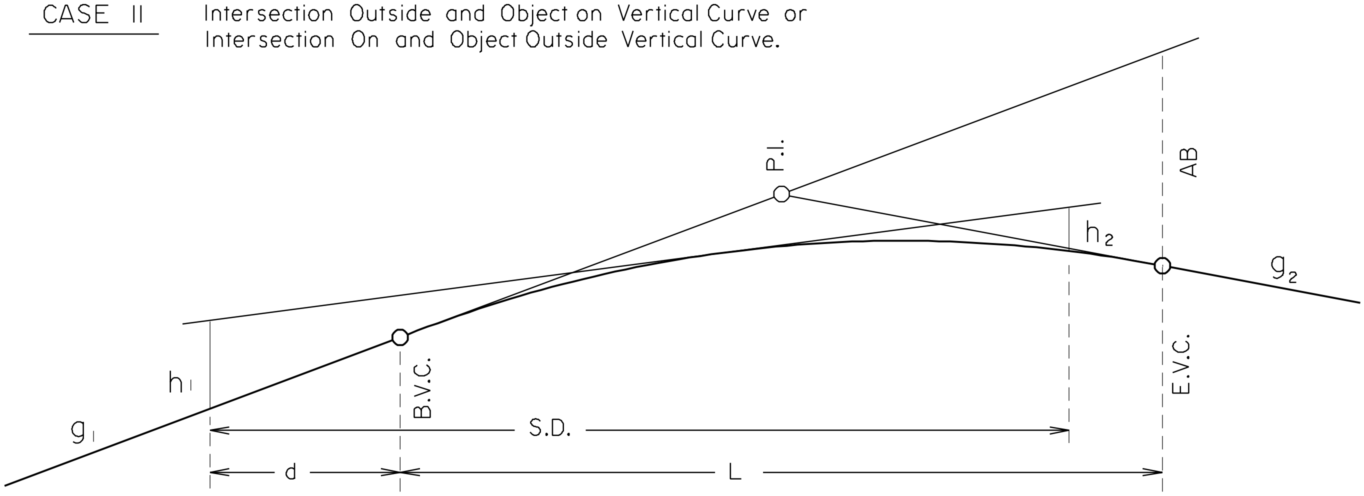
$$S.D. = \sqrt{\frac{100L(\sqrt{2h_1} + \sqrt{2h_2})^2}{A}}$$

or when S.D. is greater than L

$$S.D. = \frac{L}{2} + \frac{200(\sqrt{h_1} + \sqrt{2h_2})^2}{2\ A}$$

Where S.D. = sight distance, metres
L = length of vertical curve, metres
A = algebraic difference in grades, percent
h_1 = height of eye above roadway surface, metres
h_2 = height of object above roadway surface, metres

CASE II — Intersection Outside and Object on Vertical Curve or Intersection On and Object Outside Vertical Curve.



$$S.D. = \sqrt{d^2 + \frac{h_1\ L^2}{(AB)}} + L\sqrt{\frac{h_2}{(AB)}}$$

Where

S.D. = sight distance, metres
L = length of vertical curve, metres
A = algebraic difference in grades, percent
h_1 = height of eye or object outside the vertical curve, metres
h_2 = height of eye or object on vertical curve, metres
d = distance on tangent from point to the B.V.C. or E.V.C., metres

$$AB = \frac{L}{200} \times A$$

D.5 DESIGN VEHICLE

A design vehicle is a selected motor vehicle which is used to establish highway design controls to accommodate the weight, dimensions and operating characteristics for vehicles of a designated type. The use of design vehicles, as established by the American Association of State Highways and Transportation Officials (AASHTO), and the Transportation Association of Canada (TAC), has provided a means of properly designing intersections and at-grade ramp terminals. Figure D-5a illustrates the six principal design vehicles, showing their exterior dimensions and height of eye used for intersection sight distance purposes. Figure D-5b illustrates the external dimensions of the larger design vehicles (large semi-trailers, long combination vehicles and log haul trucks) which are allowed on Alberta highways.

Long combination vehicles (LCV) in excess of 25m in overall length are only allowed to operate under permit on Alberta highways. The permit specifies particular routes and intersections that may be used. These routes are shown in Figure D-5c.

Log haul (using the special oversize log haul truck) is also only allowed under special permits which specify the routes to be used. In the case of log haul it is not possible to show all of the routes on a provincial map due to the changeable nature of log haul operations.

To allow intersections to be designed to accommodate the appropriate vehicles, a set of turning templates has been developed for each of the design vehicles. These templates are reproduced here. To facilitate the checking of intersection layouts, these templates may be copied onto transparent sheets and overlayed on the plans. Computer vehicle simulation programs are also available from Technical Standards Branch. These programs will plot the wheelpaths and load sweep, if required, to check layouts that include radii or angles that are not provided by the templates.

In addition to verifying the properties of intersection design, the turning templates may be used to facilitate the design of parking areas, garages, service areas, shopping centres and bus terminals.

Table D.5 Design Vehicles and Minimum Turning Radii

Vehicle Types	Vehicle Designation	Turning Radius +		
		Minimum	Medium	Maximum
Log Haul Truck*	Log	15.0m	25.0m	50.0m
Turnpike Double*	WB-36(T.D.)	18.5m	21.0m	25.0m
Triple Trailer Comb.	WB-33(T.T.C.)	15.5m	20.0m	25.0m
Rocky Mountain Double*	WB-28(R.M.D.))	16.0m	20.0m	25.0m
Double Trailer Comb.	WB-23(D.T.C.)	12.2m	18.3m	22.9m
Semi-Trailer Comb.	WB-21	15.0m	18.5m	24.0m
Semi-Trailer Combination	WB17	14.6m	18.3m	22.9m
	WB15	13.7m	18.3m	22.9m
	WB12	12.2m	18.3m	22.9m
Articulated Bus	A-BUS	12.2m	16.8m	-
Intercity Bus	I-BUS	15.2m	19.8m	-
City Bus	BUS	12.2m	16.8m	-
Single Unit Truck	SU9	12.8m	18.3m	-
Travel Trailer	Pt	7.3m	-	-
Boat Trailer	Pb	7.3m	-	-
Recreational Double	Rd	7.3m	-	-
Passenger Car	P	7.3m	-	-

Note: The minimum turning radius is a practical minimum based on the maximum turn angle of the typical steering axle and is applicable to low speed operations only (under 15 km/h). The other two radii are representative of above minimum turns which can be performed at slightly higher speeds. The two above minimum radii are referred to as medium and maximum for convenience.

*These vehicle types, LOG, WB-36, WB-28 and WB-33 may operate under special permit only.

+The turning radii listed here represent the radii for the steering axle of the design vehicle. This should not be confused with the edge of lane radii needed to accommodate those vehicles. See pages D-56 to D-61.

Templates are provided for four different tractor semi-trailer combinations ranging from WB-21 to WB-12. The largest units have longer trailers and slightly larger wheelbase tractors. Because WB-21 has the greatest off-tracking and may be used on any highway throughout the province without special permit, this is generally the design vehicle that should be used at intersections or other locations where semi-trailers are turning.

For each of the two smaller semi-trailer combinations, WB-15 and WB-12, three turning radii described by the outer front wheel are presented. These radii are the practical minimum (13.7m for WB-15, 12.2m for WB-12), and two representative above minimum radii (18.3m and 22.9m) for intersection turning conditions. For convenience, henceforth, these two above minimum radii shall be called medium and maximum. For the standard single unit truck, SU9, turning radii of 12.8m (minimum) and 18.3m (medium) are presented and for the passenger car design vehicle, P, only the minimum turning radius of 7.3m is given.

Templates are also provided for a 25m double-trailer combination (WB-23) commonly known as the Super B train. This design vehicle also covers the A and C trains with similar dimensions. Details of A, B and C-train connectors are shown in Figure D-5e. This is the longest tractor-trailer combination allowed on Alberta highways without special permit.

Bus templates BUS and A-BUS give turning paths for newer and larger types of city buses, conventional and articulated respectively, while template I-BUS is representative of the rural inter-city bus (with dual rear axle) capable of high-speed freeway operation. For each of these types of buses, two turning radii are given, (that is, minimum and medium).

Turning templates at the minimum turning radius are included for recreational vehicles, Pt and Pb, representing a passenger car towing a travel trailer and boat trailer. These templates are recommended for use in the design and layout of such recreational areas as trailer and camping parks and boat landing / launch areas.

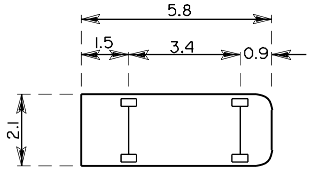
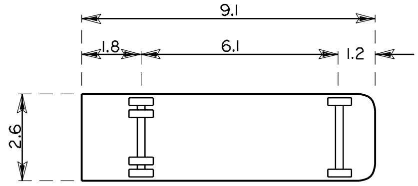
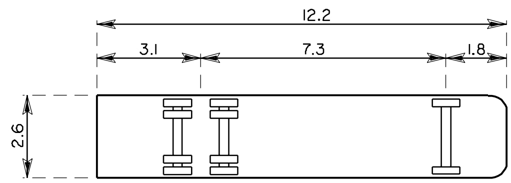
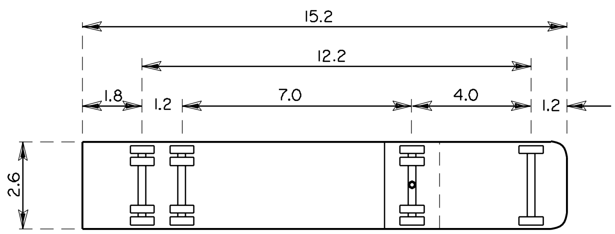
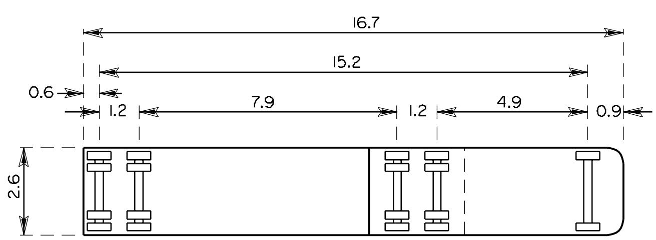
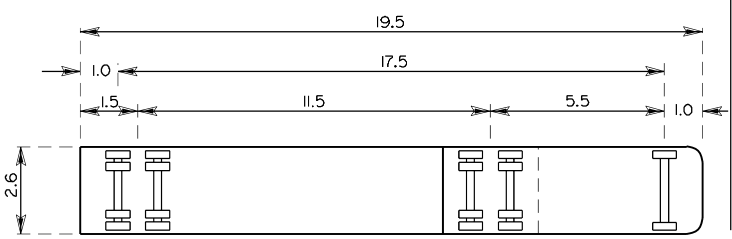
A special template for passenger cars has been introduced which gives the minimum radius wheel paths for a representative American sedan with a 3.4m wheel base, Ps.

Figures D-5f through D-5l illustrate the turning templates for all of the design vehicles.

In addition to these nationally recognized standard design vehicles, other design vehicles have been included to provide for special conditions. Templates for long combination vehicles, turnpike double, triple trailer unit and Rocky Mountain double have been included because of their current use on Alberta highways. The provincial map shown on Figure D-5c, identifies the routes on which long combination vehicles can operate under permit.

The special Alberta log haul truck design vehicle has also been included to represent the worst-case turning characteristics for this group of vehicles. The log haul design vehicle has been selected, tested and verified through exhaustive field testing conducted in Alberta in 1991 and 1992.

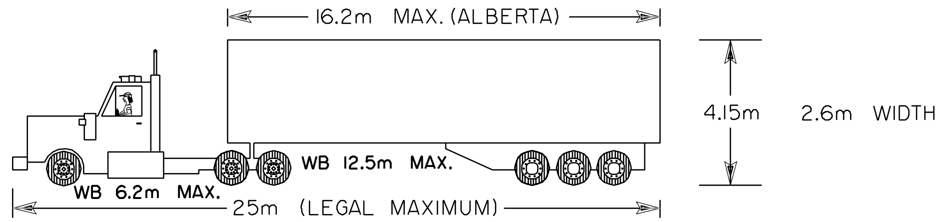
FIGURE D-5a DESIGN VEHICLES

			HEIGHT OF VEHICLE	HEIGHT OF EYE
Passenger car	P		1.30m	1.05m
Single unit or bus	SU		4.15m	1.80m
Intercity bus	I-BUS		4.15m	1.80m
Semitrailer combination	WB12		4.15m	2.10m
Semitrailer combination	WB15		4.15m	2.10m
Semitrailer combination	WB17		4.15m	2.10m

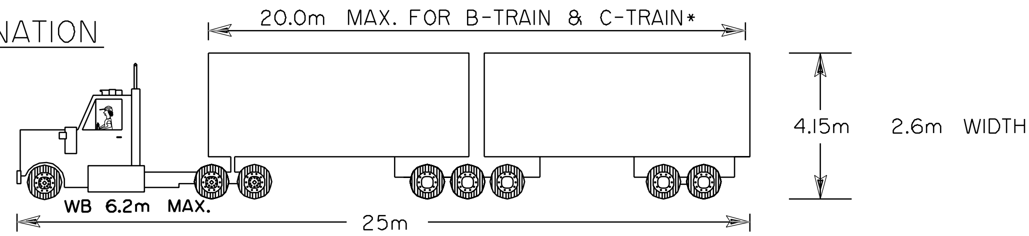
GRAPHICS FILE: debd5a.man

FIGURE D-5b DESIGN VEHICLES: LARGE SEMI-TRAILERS, LCVs AND LOG HAUL TRUCKS

SEMI-TRAILER (WB-21)



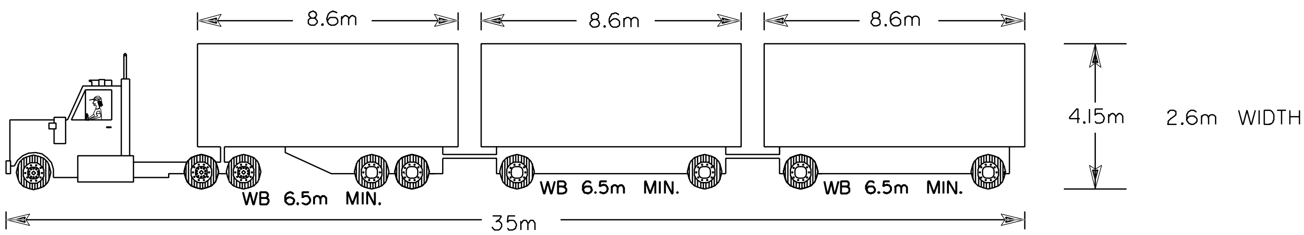
DOUBLE TRAILER COMBINATION (WB-23)



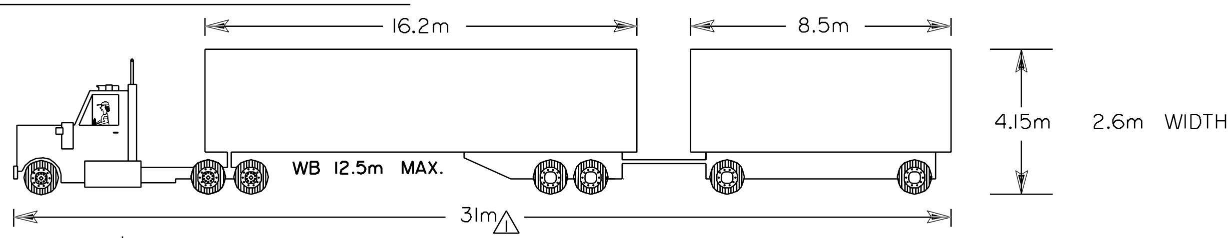
* MAXIMUM FOR A-TRAIN IS 18.5 IN ALBERTA.

NOTE: TRACTOR-TRAILER COMBINATIONS WITH OVERALL LENGTH UP TO 25m ARE ALLOWED ON ALL ALBERTA HIGHWAYS.

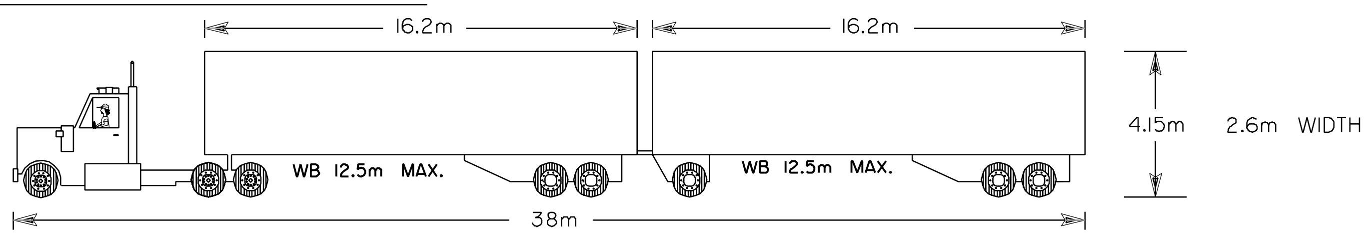
TRIPLE TRAILER COMBINATION+ (WB-33)



ROCKY MOUNTAIN DOUBLE+ (WB-28)



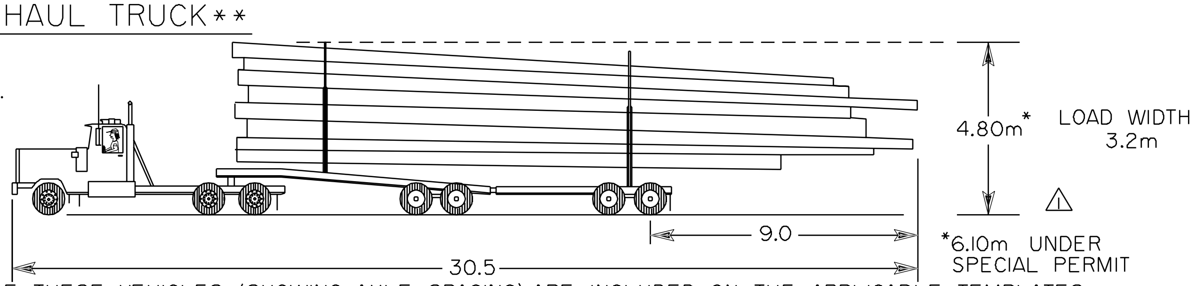
TURNPIKE DOUBLE+ (WB-36)



\+ ALLOWED UNDER SPECIAL PERMIT ONLY IN ALBERTA. THE PERMIT SPECIFIES THE ALLOWABLE ROUTES ON WHICH VEHICLES IN EXCESS OF 25m OVERALL LENGTH CAN BE USED. REFER TO PROVINCIAL MAP.

ALBERTA LOG HAUL TRUCK**

** LOG HAUL UNDER SPECIAL PERMIT ONLY.



NOTE: PLAN VIEWS OF THESE VEHICLES (SHOWING AXLE SPACING) ARE INCLUDED ON THE APPLICABLE TEMPLATES.

REVISIONS	No. 2	BY		DATE	
	No. 1	BY BK	REV DIMENSIONS	DATE	AUG//

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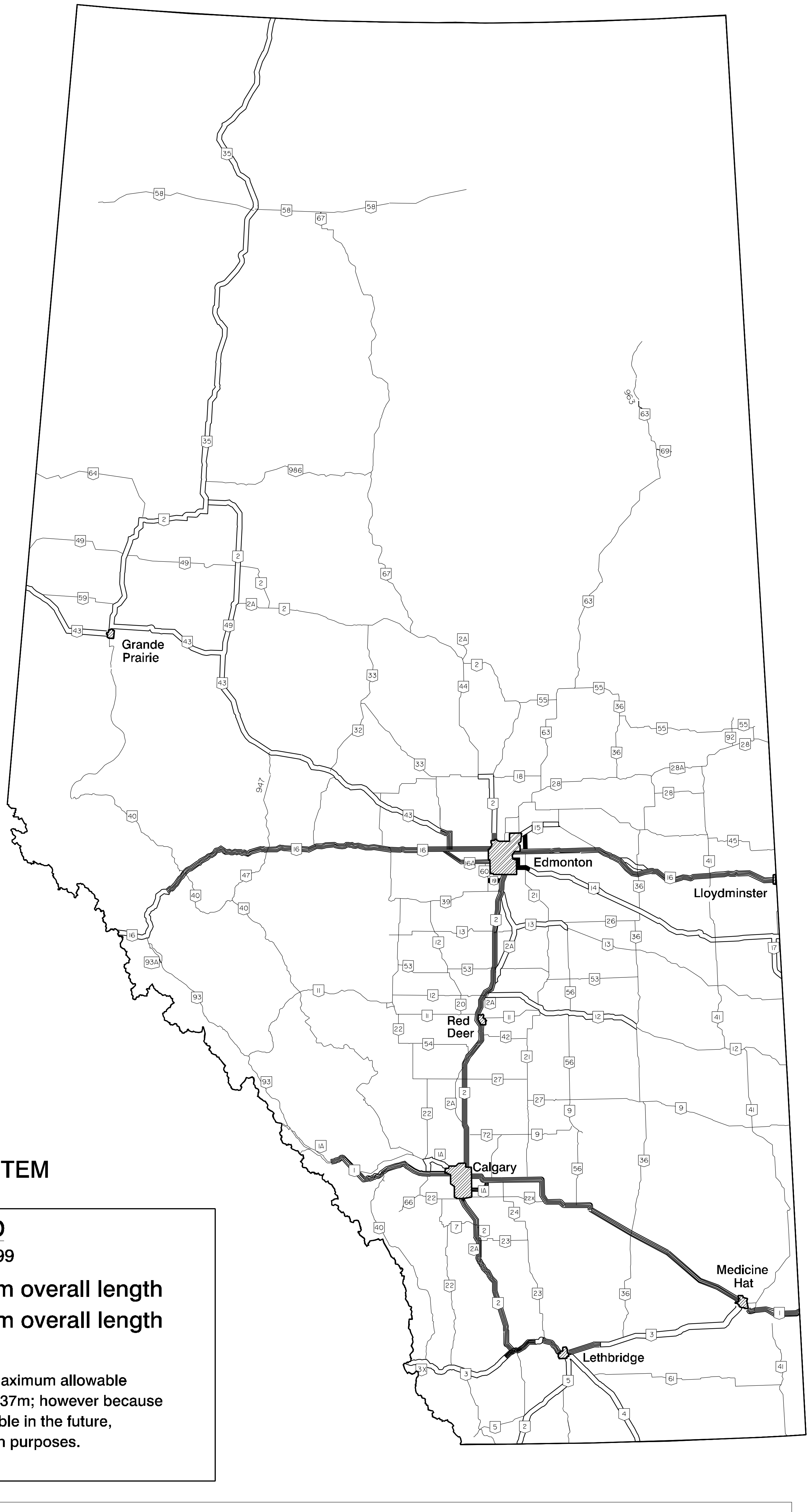
FIGURE D-5c LONG COMBINATION VEHICLE ROUTES
(for units in excess of 25m length)



INFRASTRUCTURE

PROVINCIAL
PRIMARY HIGHWAY SYSTEM

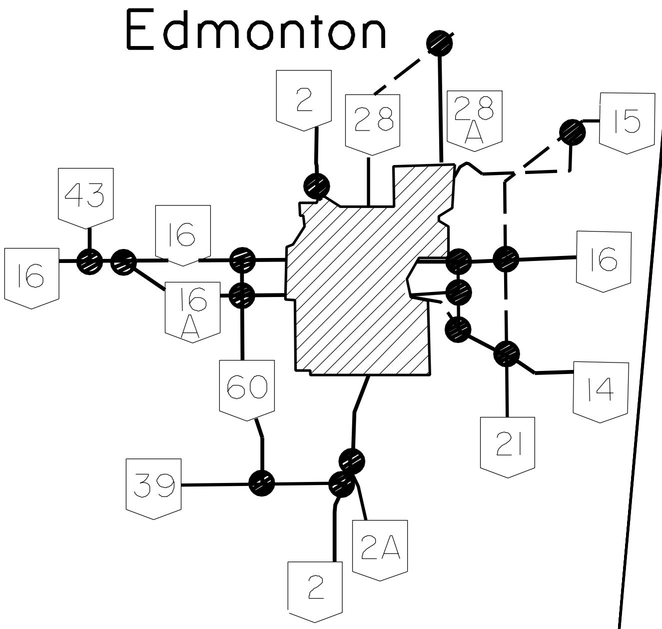
LEGEND
AUGUST 1999

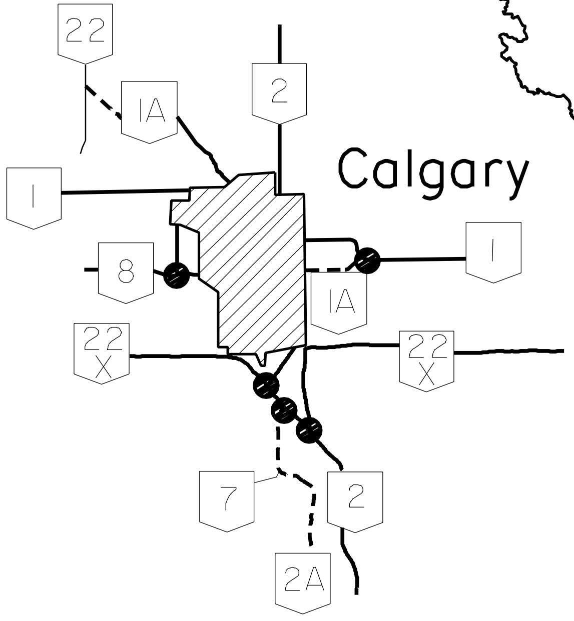
*38 metres maximum overall length
31 metres maximum overall length

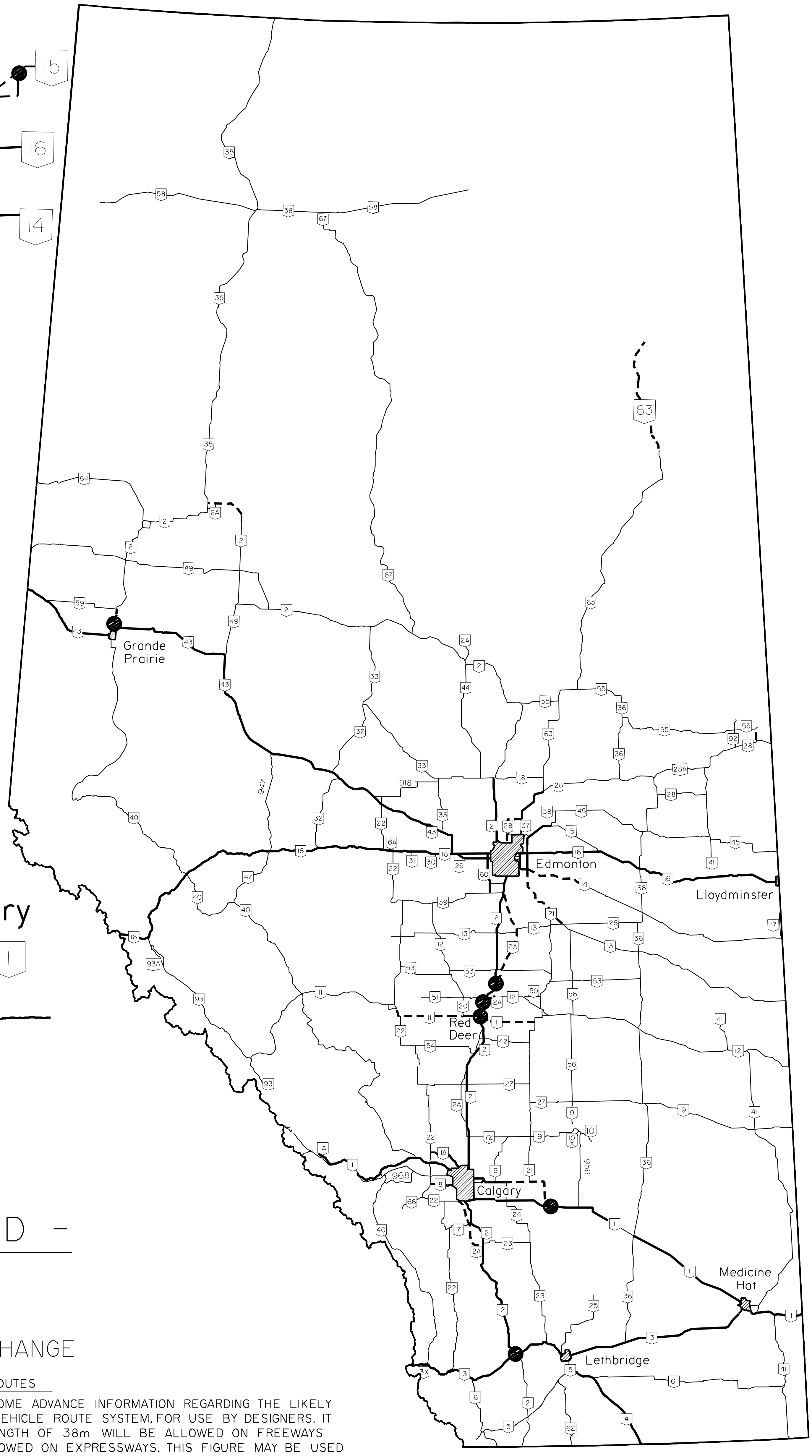
NOTE: * At the time of printing the maximum allowable length on these routes was 37m; however because an increase to 38m is possible in the future, 38m is suggested for design purposes.

GRAPHICS FILE: debd5c.man

FIGURE D-5d PROPOSED ULTIMATE CLASSIFICATION
OF PRIMARY HIGHWAY SYSTEM
(Long Combination Vehicle Routes)







- LEGEND -

FREEWAY

EXPRESSWAY

SYSTEM INTERCHANGE

NOTES Re: LONG COMBINATION VEHICLE ROUTES

THIS FIGURE IS INCLUDED TO PROVIDE SOME ADVANCE INFORMATION REGARDING THE LIKELY EXPANSION OF THE LONG COMBINATION VEHICLE ROUTE SYSTEM, FOR USE BY DESIGNERS. IT IS LIKELY THAT A MAXIMUM OVERALL LENGTH OF 38m WILL BE ALLOWED ON FREEWAYS AND A MAXIMUM OF 30m WILL BE ALLOWED ON EXPRESSWAYS. THIS FIGURE MAY BE USED TO GAUGE THE EXPANSION OF THE SYSTEM. HOWEVER, BECAUSE L.C.V.s ARE CURRENTLY ALLOWED ON SOME TWO-LANE UNDIVIDED HIGHWAYS, REFERENCE SHOULD BE MADE TO FIGURE D-5c TO ASSESS THE WHOLE NETWORK.

FIGURE D-5e A,B AND C-TRAIN CONNECTORS

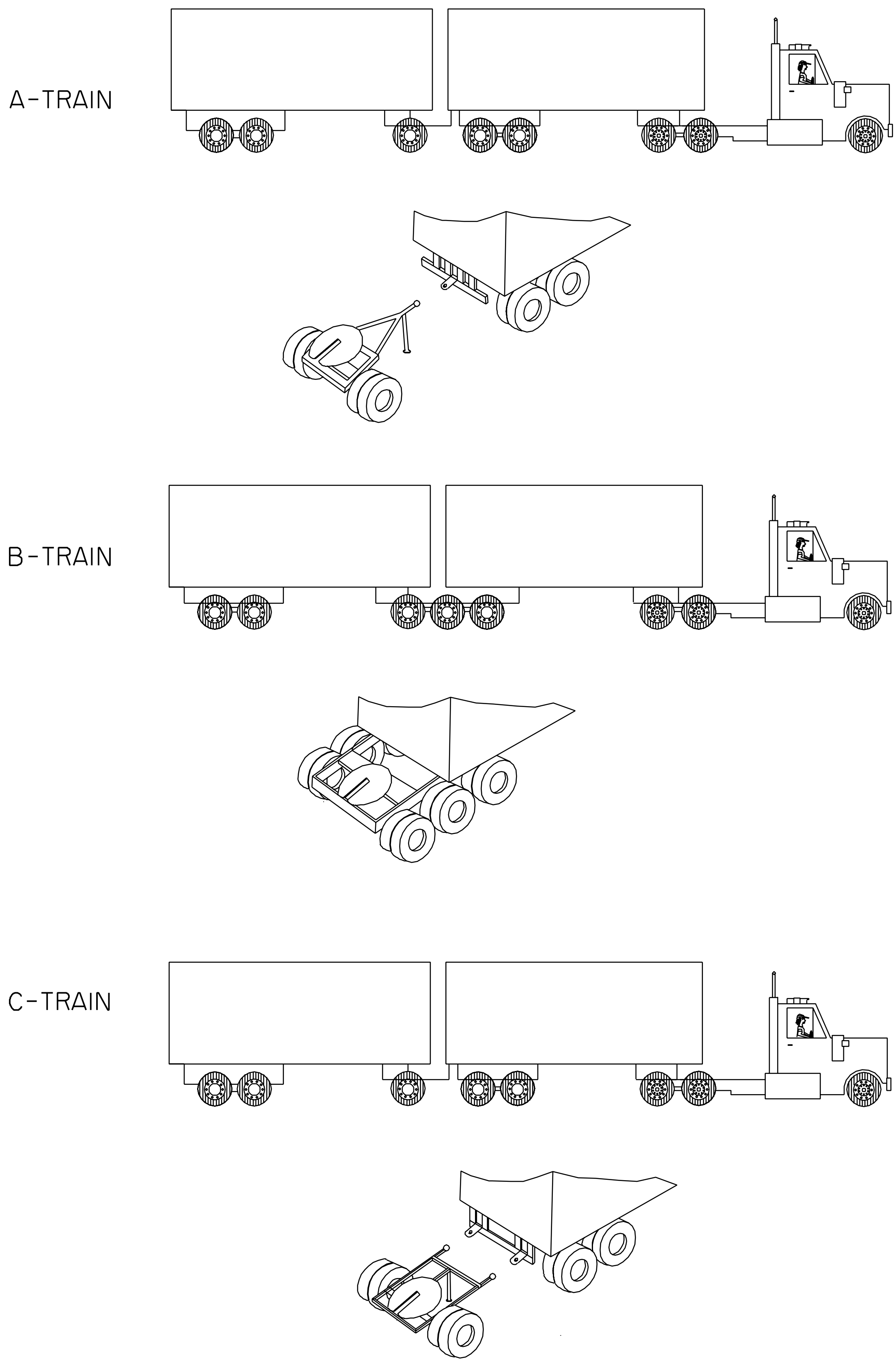


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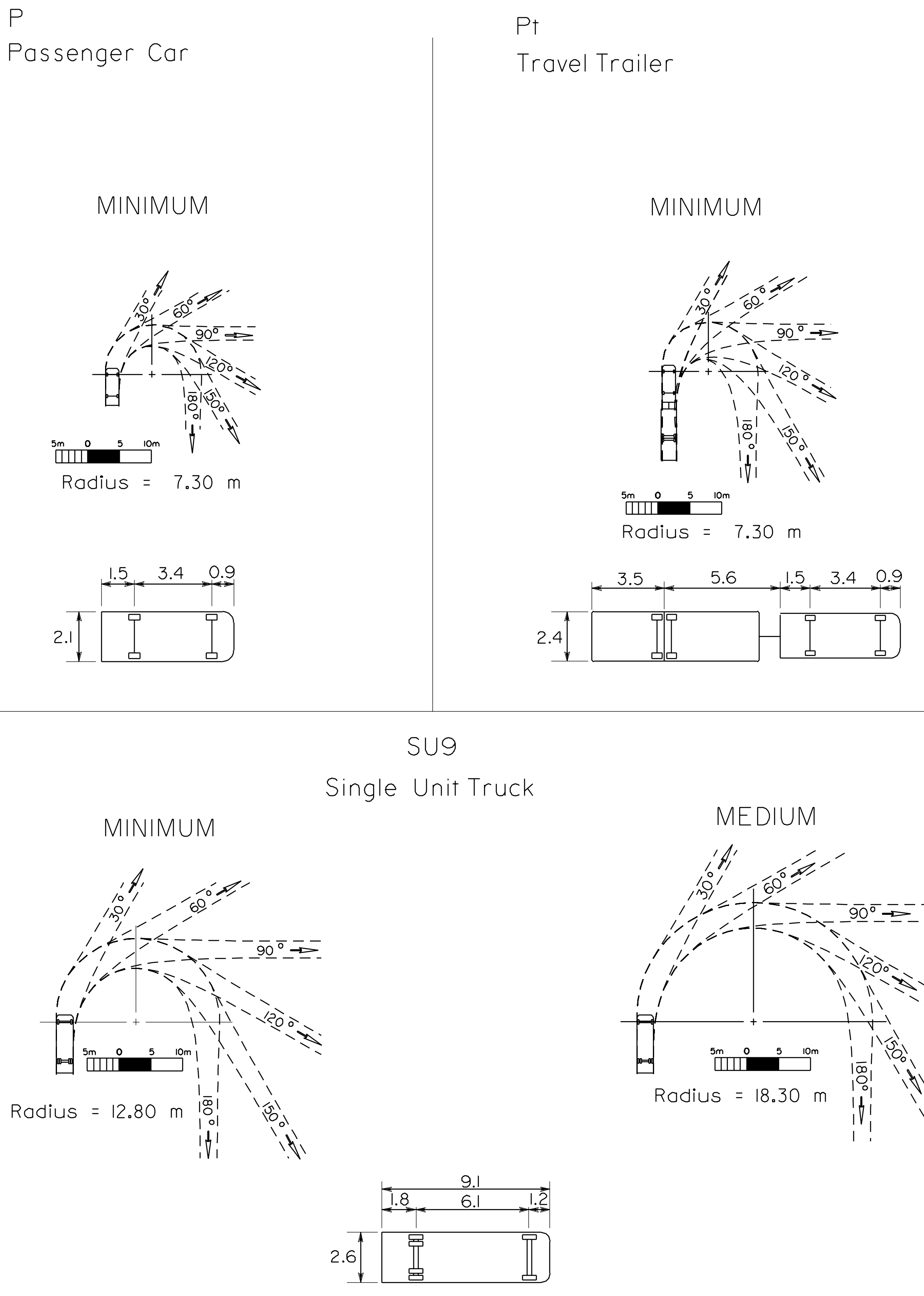
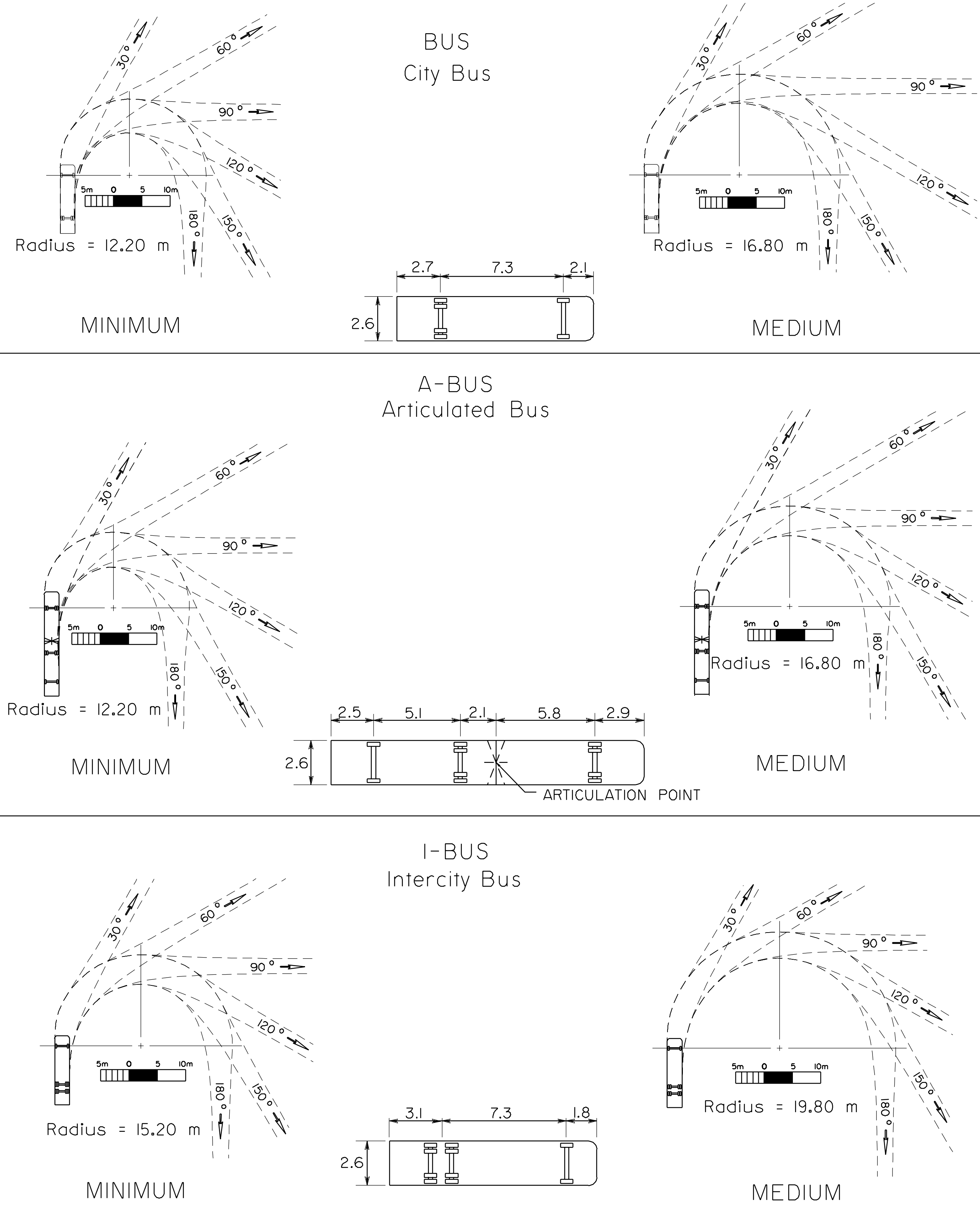
FIGURE D-5f TURNING TEMPLATES
(Passenger Car, Car with Recreation Trailer and Single Unit Truck)



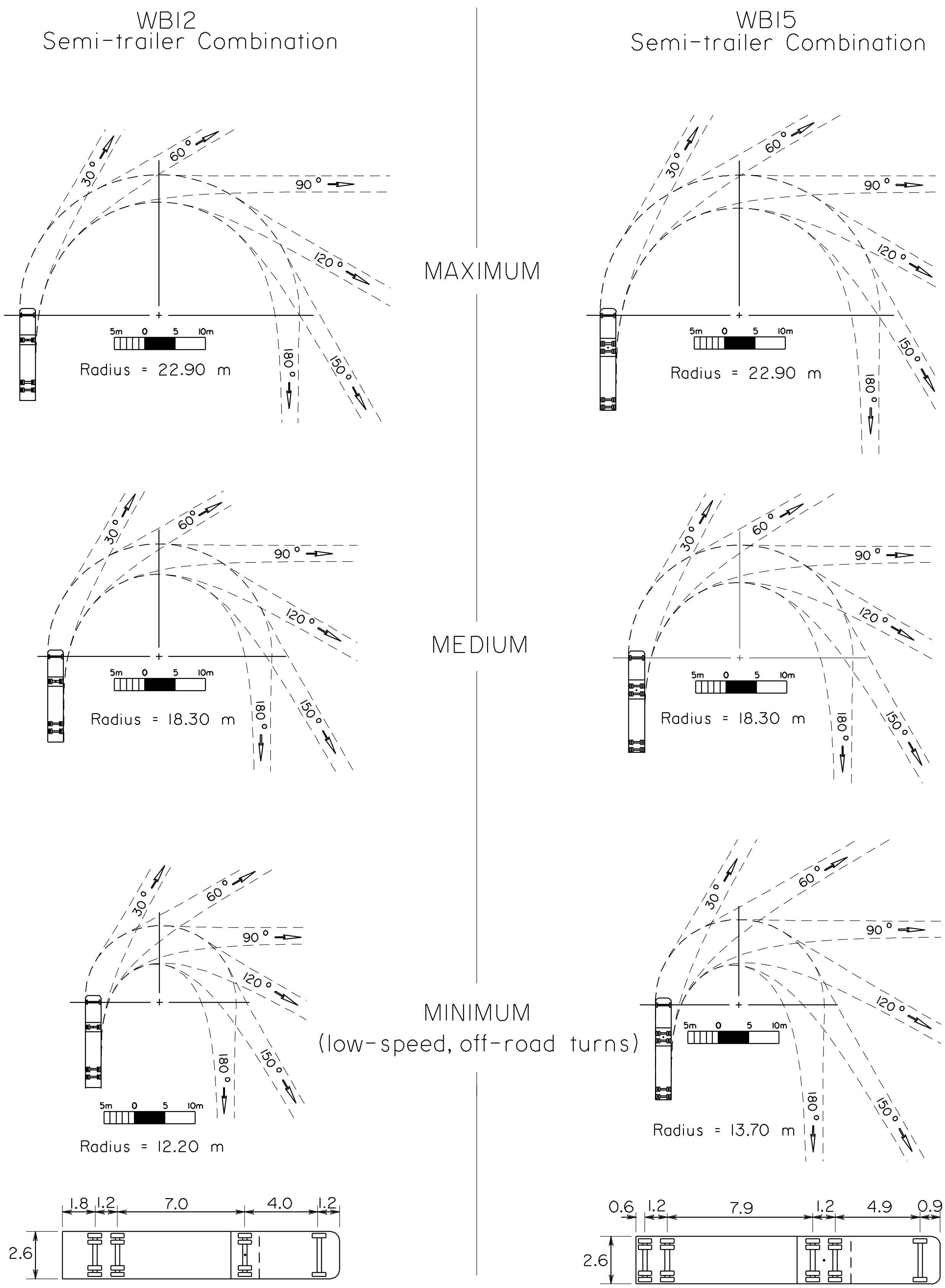
SCALE 1:1000

FIGURE D-5g TURNING TEMPLATES (Intercity Bus, Articulated Bus and City Bus)



SCALE 1:1000

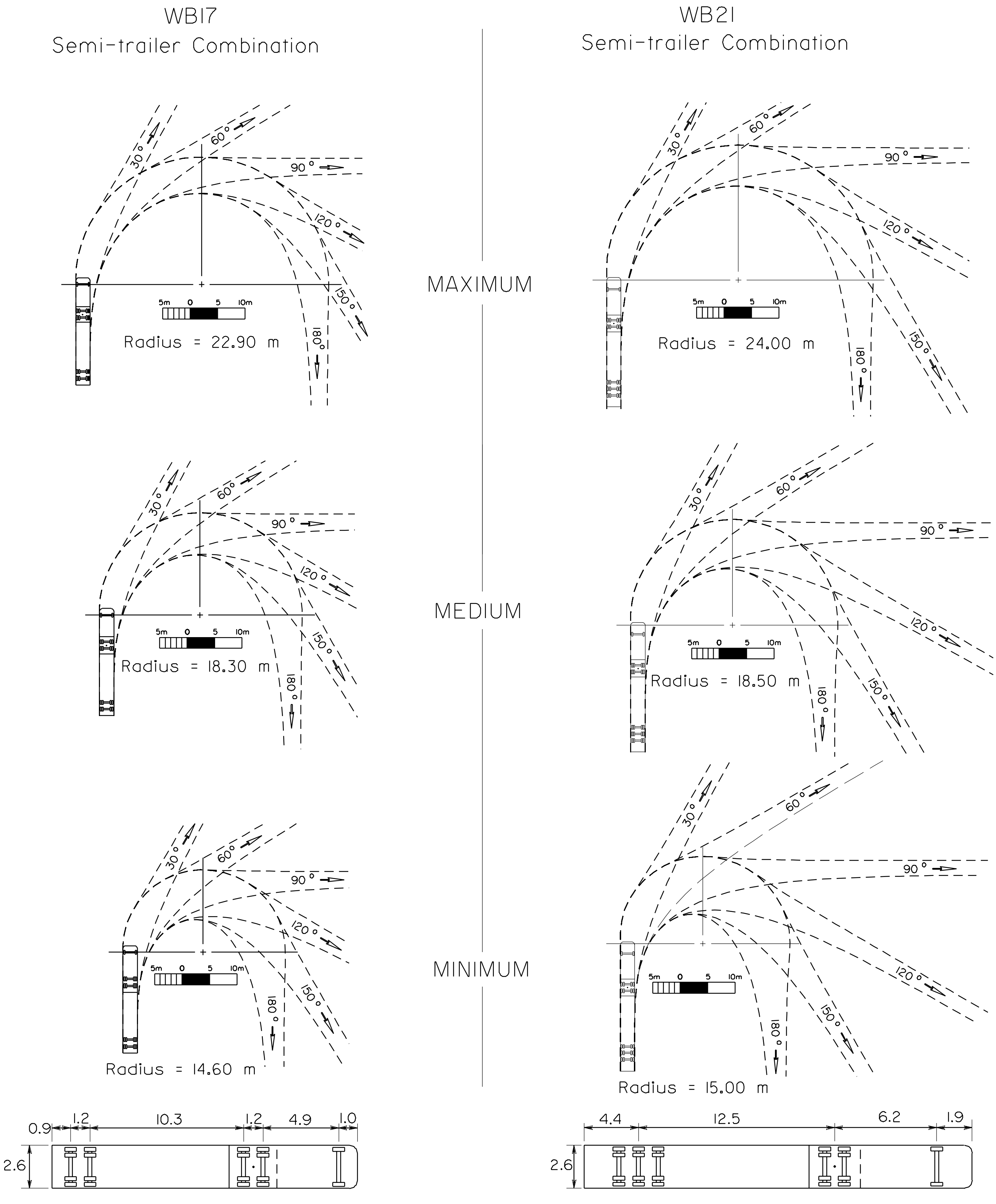
FIGURE D-5h TURNING TEMPLATES (Semi-trailer)



SCALE 1:1000

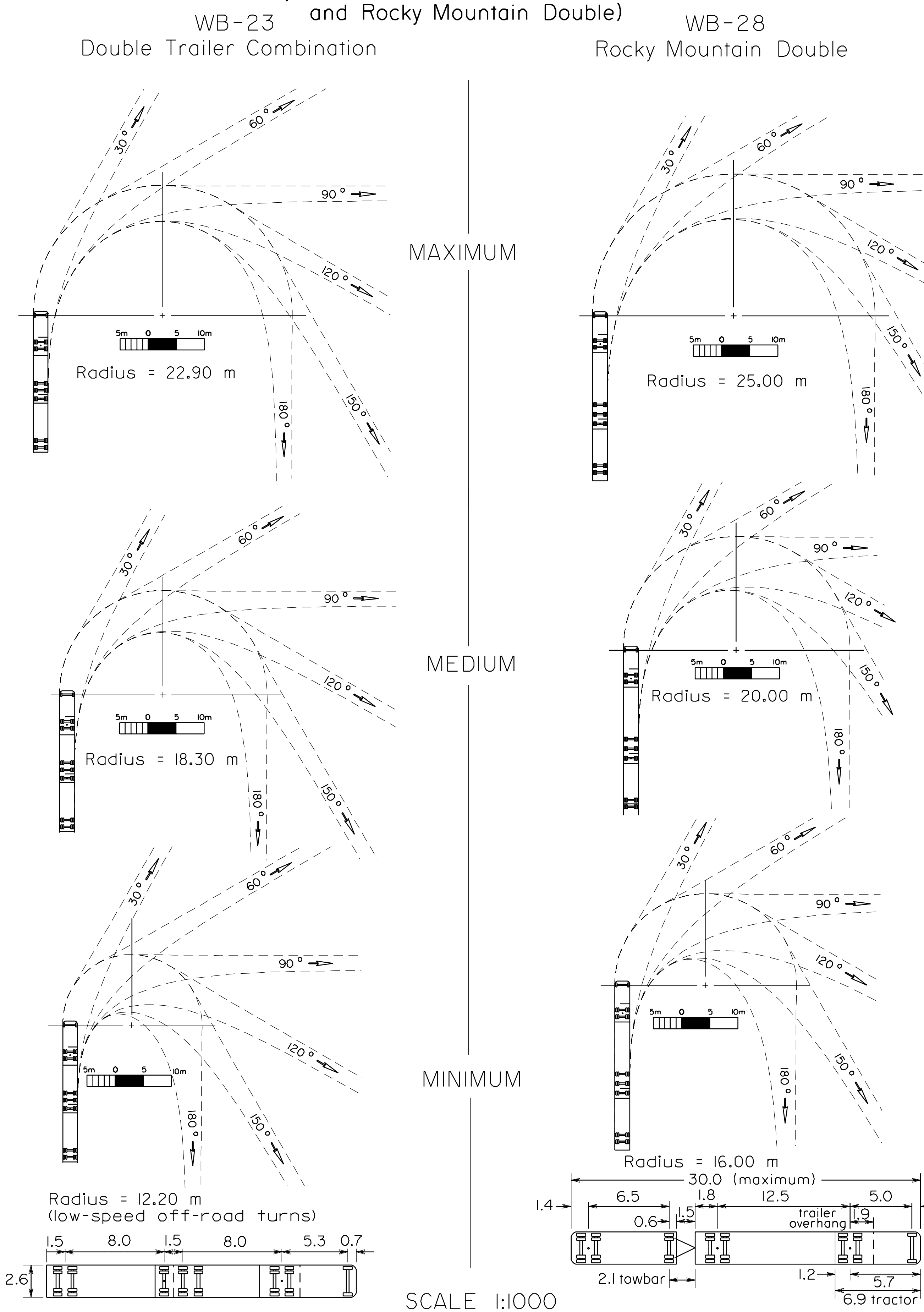
GRAPHICS FILE: debd5f.man

FIGURE D-5i TURNING TEMPLATES (Semi-trailer Combination)



SCALE 1:1000

FIGURE D-5j TURNING TEMPLATES (Double-Trailer Combination and Rocky Mountain Double)



SCALE 1:1000

FIGURE D-5k TURNING TEMPLATES (Triple Trailer Combination and Turnpike Double)

WB-33 Triple Trailer Combination

WB-36 Turnpike Double

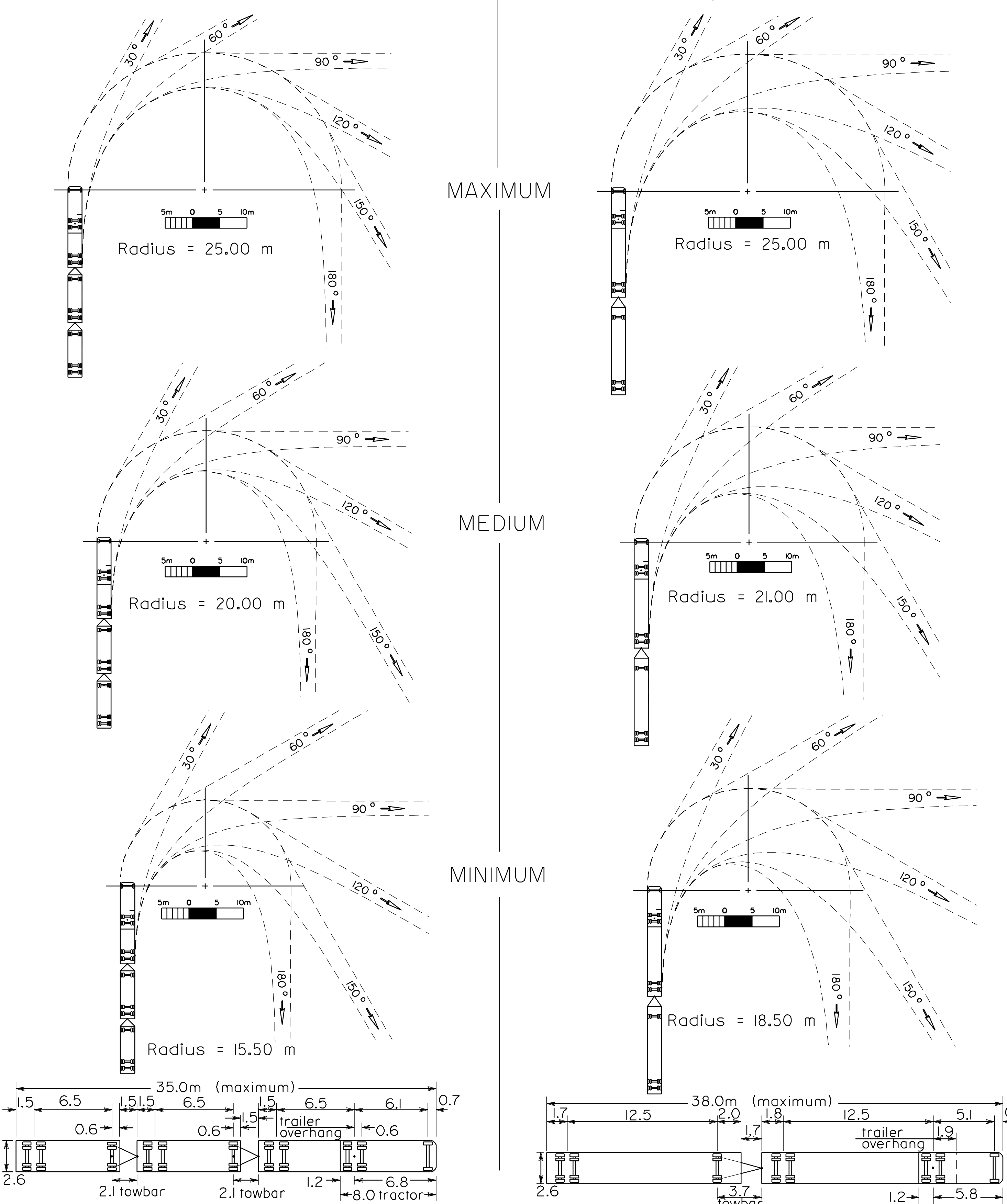
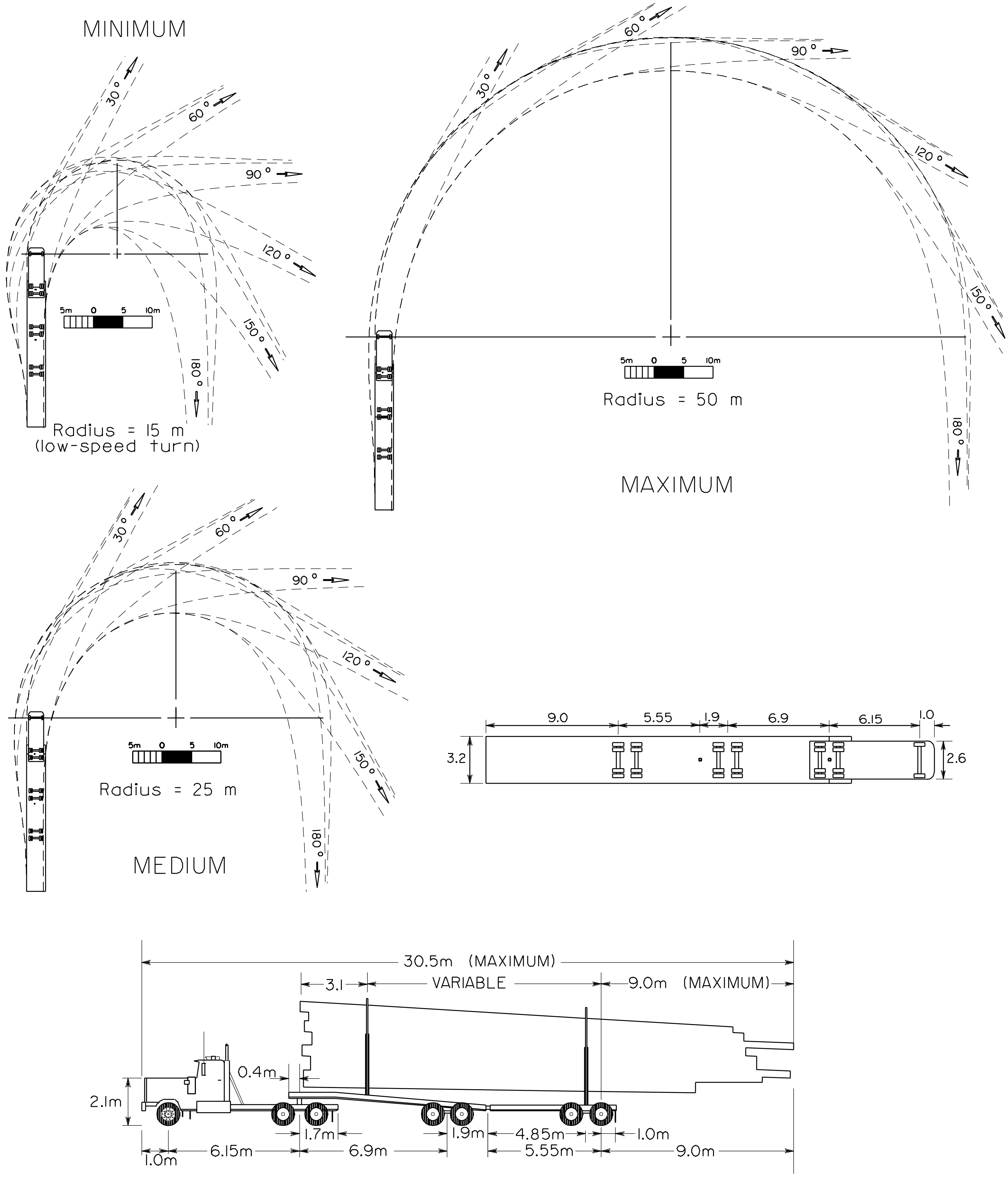


FIGURE D-51 TURNING TEMPLATES (Log Haul Truck)



TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

This template is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck - Trailer configurations used in Alberta up to the maximum dimensions shown.

SCALE 1:1000

D.5.1 Guidelines for Use of Design Vehicles

Highways should ideally be designed for all vehicles that will use them. However, for practical reasons it is sometimes not possible to design for all the oversized or otherwise unusual vehicles that will use the highway occasionally.

When selecting a design vehicle for a particular design parameter such as intersection sight distance, it is appropriate to include all vehicles that use the intersection on a regular basis. This is frequently interpreted as daily use. In the case of intersection sight distance, where the critical manoeuvre is usually the left turn off the minor road, the design vehicle is generally the longest vehicle that makes a left turn off the minor road on a daily basis. Although the longest vehicle will almost always need a greater intersection sight distance, it may also have considerably more available because of the higher eye elevation. Therefore, it is necessary to check the intersection sight distance requirement and availability for all other design vehicles also.

Because large tractor semi-trailer combinations up to WB-21 size and double trailer units up to WB-23 size (commonly known as the Super-B train) are allowed to travel throughout the rural primary highway system without restriction, it is prudent to design to allow for these units at any intersection that will have daily truck traffic entering or leaving the highway. There has been a strong trend recently in North America towards the use of larger trucks. Currently, it is estimated that more than half of the new trailers built in Canada and the U.S. are 16.14m (53 feet) long. This trailer is frequently combined with a long wheel-base tractor (6.2m) which results in a WB-21 configuration. Because of the obvious benefits to the trucking industry, it is likely that the WB-21 configuration will become very common in the future. All major intersections and interchanges, especially those that include raised islands or medians, should be designed to allow for at least a WB-21 design vehicle. Longer vehicles should also be accommodated where they are allowed (as shown in Figure D-5c).

Figure D-5c shows the provincial routes where long combination vehicles are currently allowed. In the case of routes where the maximum overall length is 30m, the largest truck trailer combination is the Rocky Mountain double (WB-28). Therefore, WB-28 is an appropriate design vehicle for any intersection along these routes, where trucks will be turning.

On routes where the maximum overall length is 38m, it is likely that there will be a considerable number of triple trailer combinations (WB-33) and turnpike doubles (WB-36). Both of these design vehicles should be accommodated. Designers should be aware that the triple trailer combinations and turnpike double combinations operate under specific permit conditions. Some of these have an impact on design parameters, including:

1. Limited to multi-lane highways with four or more driving lanes
2. Not allowed to operate on statutory holidays or weekends
3. Not allowed to operate during adverse weather conditions or when the highway is icy or heavily snow covered
4. No entrance to or exit from Highway #2 may be made except at interchanges, rest area turnouts, or where acceleration or deceleration lanes are provided
5. Access to and egress from Red Deer is via four-lane roadways only
6. Where routes fall within a city boundary, the operation of over-length combination units is controlled by the city.

The main impact of the above conditions is that, along Highway #2, triple trailers and turnpike doubles will be entering or leaving the highway at interchanges only. Consequently on Highway #2, only the interchanges (including all at-grade intersections that form a component of those interchanges) need to be designed for triples and turnpike doubles. At-grade intersections on Highway #2, should be designed for the Rocky Mountain double (WB-28). On all other highways, where the maximum length is 38m, access to the highway by long combination vehicles is not restricted to interchanges.

The use of long combination vehicles on two-lane undivided highways in Alberta is currently being evaluated. A draft report prepared in September 1995 for AI by ADI limited in association with Keith Walker Consulting and John Morrall Ph.D. entitled "Study of Long Combination Vehicle Operations on Two-Lane Highways in Alberta", is a good reference on this subject. Designers should be aware that long combination vehicles are at times issued permits to use undivided highways and therefore it is prudent to provide for these special characteristics where practical.

Table D.5.1 has been provided as a general guide to the selection of a design vehicle, based on route and general intersection type. However, exceptions may be warranted based on detailed traffic information.

Table D.5.1 Selection of Design Vehicle for Intersection

Description of Main Highway	Design Vehicle* (*largest)	Geometric Elements to be Checked
LCV Route (38m max.) Highway 2	Turnpike Double (WB-36) Rocky Mountain Double (WB-28)	ISD at interchange ramp terminals. Pavement edge layout at interchanges. Median opening size and location at interchange ramp terminals. ISD at major at-grade intersections. Pavement layout at at-grade intersections.
LCV Route (38m max.) (except Highway 2)	Turnpike Double (WB-36)	ISD and pavement layout at major at-grade intersections and interchanges.
LCV Route (30m max.)	Rocky Mountain Double (WB-28)	ISD and pavement layout at major at-grade intersections and interchanges.
All other Primary Highways and Secondary Highways with significant truck traffic.	Large Semi-trailer (WB-21) Super B-Train (WB-23)	ISD at major at-grade intersections ISD and layout of pavement, islands and median opening at intersections.
Primary Highway Secondary Highway or Local Road	SU	For intersections where the largest vehicle turning on a daily basis is a school bus or single unit truck. ISD and pavement edge at intersections.
Primary Highway Secondary Highway or Local Road	P	For intersections where the largest vehicle turning on a daily basis is a passenger vehicle. This includes passenger car, half ton truck and minivan. ISD at all intersections.
Log Haul Routes	Alberta Log Haul Truck	For intersections where log haul trucks are allowed to turn under special permit. Layout and ISD to be designed for log truck.

LCV = Long Combination Vehicles. For LVC routes, see Figure D-5c.

D.5.2 Minimum Designs for Sharpest Turns

Where it is necessary to provide for turning vehicles within a minimum space, as at unchannelized intersections, the medium turning path of the design vehicle should be used. The width of the design vehicle turning path is established by the outer front wheel, plus an allowance for overhang, and the inner rear wheel (the inner rear wheel does not track on a constant radius).

In Alberta, because of the extensive trucking industry, all main (or through) rural intersections are designed to accommodate the medium turning paths of semi-trailer combinations. Specifically the WB-21 design vehicle is used to check the layout of channelized intersections, which include medians, islands or separate turning roadways and interchanges. Median openings on wide median rural divided highways are generally designed to accommodate both the WB-21 and WB-23 design vehicles. An exception to the above occurs where an intersection or interchange will serve long combination vehicles, or log haul trucks, in which case the appropriate turning template should be used. The design of intersections for log haul is covered in more detail in Section D.5.3.

To fit the edge of pavement closely to the medium turning path of a semi-trailer combination, the application of a symmetrical arrangement of three-centred curves has proven advantageous. For a 90 degree turn angle, these curves have radii of 55, 18 and 55m, with the middle curve arc being offset from the extension of the tangent edges on the approach and exit sides. This design is the practical equivalent to a curve transition for most or all of its length. In an operational sense, it is superior to the minimum circular arc design because it better fits the medium inner rear wheel turning path of the WB-21 design vehicle, while providing some margin for error and requiring less pavement. Three-centred curves are used on all of the main (or through) intersection treatments where the turning volume is sufficiently high to warrant an exclusive left or right turn lane (on Type IV and Type V standard intersection treatments).

Note: The standard intersection types are described in more detail in Sections D.6.1, D.6.2 and D.6.3 and shown schematically in Figure D-7.5.

On less important intersections such as Type II and III standard treatments, a two-centred curve is used to lay out the right shoulder for vehicles making a right turn from the intersecting road. In these cases, a three-centred curve is still used for the right shoulder for vehicles making a right turn off the main (or through) roadway. The benefits of using a two-centred curve are:

1. Less pavement area
2. Intersecting road vehicles are forced to proceed slowly
3. Stop sign can be placed close to the intersecting road centreline (more visible) and
4. Lower cost.

The two-centred curve provides for WB-21 off-tracking, however there is not as much room for driver error as there is on the three-centred curve.

Design for angles of turn more than 90 degrees may result in unnecessarily large paved intersections, portions of which are often unused. This situation may lead to confusion among drivers and present a hazard to pedestrians. These conditions may be alleviated to a considerable extent by the use of asymmetrical three-centred compound curves, or by using large radii, coupled with corner islands. In Figure D-5.2a, the geometrics of three-centred symmetric/asymmetric compound curves are illustrated. The design values shown in Table D.5.2a are those suggested to fit the sharpest turns of the different design vehicles. The designer may choose from any of the designs shown in the table, depending on the type and sizes of the vehicles that will be turning and to what extent they should be accommodated.

In cases where two-centred curves are being used but the angle of intersection is not 90 degrees, the formulae shown on Figure D-5.2b or the values given in Table D.5.2b may be used (for angles between 70° and 110°).

The use of a two-centred curve is permitted in situations where a three-centred curve would normally be used, but extra costly right-of-way is required, or where surrounding roadway geometrics do not allow for the application of a three-centred compound curve. A two-centred compound curve fits the medium turning path of the WB-21 design vehicle closer than a three-centred compound curve and requires less paved area. Figure D-5.2b illustrates the geometrics of two-centred compound curves. Sixteen metre and 80m radii compound curves have proven to be an ideal combination for accommodating the medium turning path of the WB-21 design vehicle on a 90 degree turn with slight modification to radii being required for small and larger skew angles. Table D.5.2b provides the curve data required for turning angles between 70° and 110°.

Table D.5.2a Edge of Lane Design for Right Turn at Intersection and Data for Three-Centred Curves

(Refer to Figure D-5.2a)

Design Vehicle	Angle of Turn (degrees)	Simple Curve Radius (metres)	Three-Centred Compound Curve Symmetric		Three-Centred Compound Curve Asymmetric	
			Radii R_1 - R_2 - R_1 (metres)	Offset P (metres)	Radii R_1 - R_2 - R_3 (metres)	Offset P Min. - Max. (metres)
P	30	18	-	-	-	-
SU-9		30	-	-	-	-
WB-12		46	-	-	-	-
WB-15		61	-	-	-	-
P	45	15	-	-	-	-
SU-9		23	-	-	-	-
WB-12		37	-	-	-	-
WB-15		52	61 - 30 - 61	1	-	-
P	60	12	-	-	-	-
SU-9		18	-	-	-	-
WB-12		27	-	-	-	-
WB-15		-	61 - 23 - 61	1.5	61 - 23 - 84	0.5 - 2.0
P	75	11	30 - 8 - 30	0.5	-	-
SU-9		17	37 - 14 - 37	0.5	-	-
WB-12		26	37 - 14 - 37	1.5	37 - 14 - 61	0.5 - 2.0
WB-15		-	46 - 15 - 46	2.0	46 - 15 - 69	0.5 - 3.0
P	90	9	30 - 16 - 30	1.0	-	-
SU-9		15	37 - 12 - 37	0.5	-	-
WB-12		-	37 - 12 - 37	1.5	37 - 12 - 61	0.5 - 2.0
WB-15		-	55 - 18 - 55	2.0	37 - 12 - 61	0.5 - 3.0
P	105	-	30 - 6 - 30	1.0	-	-
SU-9		-	30 - 11 - 30	1.0	-	-
WB-12		-	30 - 11 - 30	1.5	30 - 11 - 61	0.5 - 2.5
WB-15		-	55 - 14 - 55	2.5	46 - 12 - 64	0.5 - 3.0
P	120	-	30 - 6 - 30	0.5	-	-
SU-9		-	30 - 9 - 30	1.0	-	-
WB-12		-	37 - 9 - 37	2.0	30 - 9 -55	0.5 - 3.0
WB-15		-	55 - 12 - 55	2.5	46 - 11 - 67	0.5 - 3.5
P	135	-	30 - 6 - 30	0.5	-	-
SU-9		-	30 - 9 - 30	1.0	-	-
WB-12		-	37 - 9 - 37	2.0	30 - 8 - 55	1.0 - 4.0
WB-15		-	49 - 11 - 49	3.0	40 - 9 - 56	1.0 - 4.0
P	150	-	23 - 5 - 23	0.5	-	-
SU-9		-	30 - 9 - 30	1.0	-	-
WB-12		-	30 - 9 - 30	2.0	26 - 8 - 49	1.0 - 3.0
WB-15		-	49 - 11 - 49	2.0	37 - 9 - 55	1.0 - 4.0
P	180	-	15 - 5 - 15	0.1	-	-
SU-9		-	30 - 9 - 30	0.5	-	-
WB-12		-	30 - 6 - 30	3.0	26 - 6 - 46	2.0 - 4.0
WB-15		-	40 - 8 - 40	3.0	30 - 8 - 55	2.0 - 4.0

Note: The edge of lane design shown here for the WB-15 design vehicle will accommodate the wheel path of large semi-trailer units (WB-21) on the medium turning template without any wheels encroaching on the shoulder. The WB-23 (Super B-train) and all of the smaller design vehicles are also accommodated. The use of the "medium" turning radius plus the additional width of the shoulder provide a suitable margin of safety to reduce the occurrence of rear wheels tracking off the pavement surface.

Table D.5.2b Edge of Lane Design for Right Turn at Intersection and Data for Two-Centred Curves [Stop condition from intersecting road tomain (or through) highway on tangent alignment]

(Refer to Figure D-5.2b)

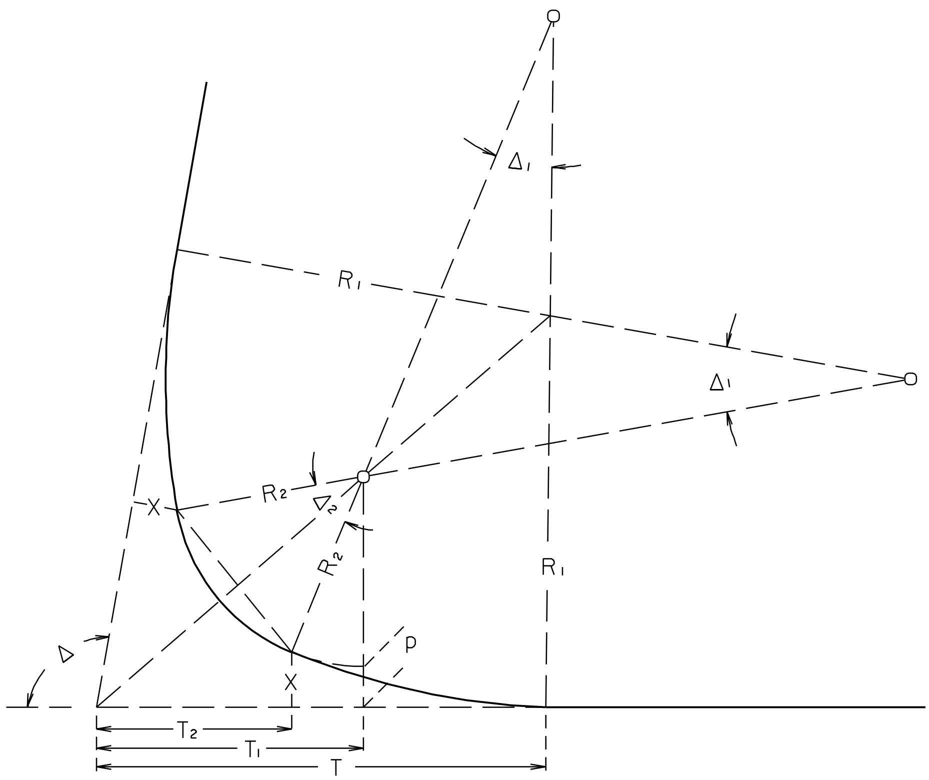
Δ (deg)	Δ_2 (deg min)	R_2 (m)	T_2 (m)	L_2 (m)	Δ_1 (deg min)	R_1 (m)	T_1 (m)	L_1 (m)	a (m)	b (m)
70°	53°30'	18	9.073	16.808	16°30'	80	11.599	23.038	29.283	15.321
71°	54°35'	18	9.287	17.148	16°25'	80	11.540	22.922	29.491	15.513
72°	55°40'	18	9.504	17.488	16°20'	80	11.481	22.806	29.701	15.709
73°	56°45'	18	9.722	17.829	16°15'	80	11.421	22.689	29.911	15.909
74°	57°50'	18	9.943	18.169	16°10'	80	11.362	22.573	30.124	16.115
75°	58°55'	17	9.602	17.481	16°05'	80	11.303	22.457	29.837	15.597
76°	60°00'	17	9.815	17.802	16°00'	80	11.243	22.340	30.039	15.797
77°	61°00'	17	10.014	18.099	16°00'	80	11.243	22.340	30.324	16.027
78°	62°00'	17	10.215	18.396	16°00'	80	11.243	22.340	30.613	16.261
79°	63°00'	17	10.418	18.692	16°00'	80	11.243	22.340	30.904	16.500
80°	64°00'	17	10.623	18.989	16°00'	80	11.243	22.340	31.200	16.743
81°	65°00'	17	10.830	19.286	16°00'	80	11.243	22.340	31.498	16.990
82°	66°00'	17	11.040	19.583	16°00'	80	11.243	22.340	31.800	17.242
83°	67°00'	17	11.252	19.879	16°00'	80	11.243	22.340	32.106	17.499
84°	68°00'	17	11.467	20.176	16°00'	80	11.243	22.340	32.416	17.761
85°	69°00'	16	10.996	19.268	16°00'	80	11.243	22.340	32.085	17.150
86°	70°00'	16	11.203	19.548	16°00'	80	11.243	22.340	32.388	17.406
87°	71°00'	16	11.413	19.827	16°00'	80	11.243	22.340	32.694	17.666
88°	72°00'	16	11.625	20.106	16°00'	80	11.243	22.340	33.005	17.932
89°	73°00'	16	11.839	20.385	16°00'	80	11.243	22.340	33.321	18.203
90°	74°00'	16	12.057	20.665	16°00'	80	11.243	22.340	33.641	18.479
91°	75°00'	16	12.277	20.944	16°00'	80	11.243	22.340	33.966	18.761
92°	76°00'	15	11.719	19.897	16°00'	80	11.243	22.340	33.537	18.052
93°	77°00'	15	11.932	20.159	16°00'	80	11.243	22.340	34.855	18.328
94°	78°00'	15	12.147	20.420	16°00'	80	11.243	22.340	34.178	18.610
95°	79°00'	15	12.365	20.682	16°00'	80	11.243	22.340	34.506	18.897
96°	80°00'	15	12.586	20.944	16°00'	80	11.243	22.340	34.840	19.191
97°	81°00'	15	12.811	21.206	16°00'	80	11.243	22.340	35.180	19.491
98°	82°00'	15	13.039	21.468	16°00'	80	11.243	22.340	35.526	19.798
99°	83°00'	15	13.271	21.729	16°00'	80	11.243	22.340	35.878	20.111
100°	84°00'	14	12.606	20.525	16°00'	90	12.649	25.133	38.152	19.674
101°	85°00'	14	12.829	20.769	16°00'	90	12.649	25.133	38.504	19.983
102°	86°00'	14	13.055	21.014	16°00'	90	12.649	25.133	38.863	20.298
103°	87°00'	14	13.286	21.258	16°00'	90	12.649	25.133	39.229	20.622
104°	88°00'	14	13.520	21.502	16°00'	90	12.649	25.133	39.602	20.953
105°	89°10'	14	13.798	21.788	15°50'	90	12.515	24.871	39.754	21.230
106°	90°20'	14	14.082	22.073	15°40'	90	12.382	24.609	39.911	21.516
107°	91°30'	14	14.371	22.358	15°30'	90	12.248	24.347	40.075	21.810
108°	92°40'	14	14.667	22.643	15°20'	90	12.115	24.086	40.245	22.114
109°	93°50'	14	14.969	22.928	15°10'	90	11.982	23.824	40.422	22.427
110°	95°00'	14	15.278	23.213	15°00'	90	11.849	23.562	40.607	22.750

Note: In cases where the angle (Δ) is not an exact even number of degrees, the designers should round off to the nearest degree, then use the exact numbers as shown on the table for R_1, R_2 and Δ_2. The difference (either more or less) can be made up by varying the value of Δ_1.

Note: The edge of lane design shown here will accommodate the wheel path of large semi-trailer units (WB-21) on the medium turning template without any wheels encroaching on the shoulder. The WB-23 (Super B-train) and all of the smaller design vehicles are also accommodated. The use of the "medium" turning radius plus the additional width of the shoulder provide a suitable margin of safety to reduce the occurrence of rear wheels tracking off the pavement surface.

FIGURE D-5.2a FORMULAE FOR THREE-CENTRED CURVES
(Edge of Lane Design for WB-21 Design Vehicle)

3 - CENTRED CURVE (SYMMETRIC)



GIVEN: Δ, R_1, R_2, p

REQUIRED: $\Delta_1, \Delta_2, T_1, T_2, T, X$

SOLUTION

$$\cos \Delta_1 = \frac{R_1 - R_2 - p}{R_1 - R_2}$$

$$\Delta_2 = \Delta - 2\Delta_1$$

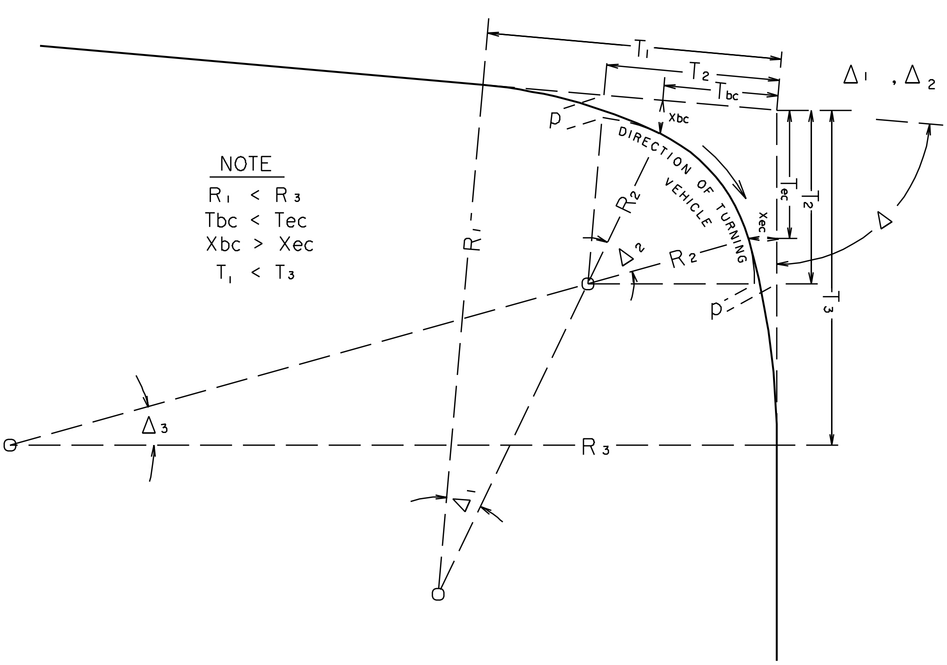
$$T_1 = (R_2 + p)\tan\frac{\Delta}{2}$$

$$T_2 = T_1 - R_2 \sin \Delta_1$$

$$T = T_1 + (R_1 - R_2)\sin \Delta_1$$

$$X = R_1 - R_1 \cos \Delta_1$$

3 - CENTRED CURVE (ASYMMETRIC)



GIVEN

Δ, p, R_1, R_2, R_3

REQUIRED

$\Delta_1, \Delta_2, \Delta_3, X_{bc}, X_{ec}, T_1, T_2, T_3, T_{bc}, T_{ec}$

SOLUTION

$$\cos \Delta_1 = \frac{R_1 - R_2 - p}{R_1 - R_2}$$

$$\cos \Delta_3 = \frac{R_3 - R_2 - p}{R_3 - R_2}$$

$$\Delta_2 = \Delta - (\Delta_1 + \Delta_3)$$

$$T_2 = (R_2 + p)\tan\frac{\Delta}{2}$$

$$T_1 = T_2 + \sin \Delta_1 (R_1 - R_2)$$

$$T_3 = T_2 + \sin \Delta_3 (R_3 - R_2)$$

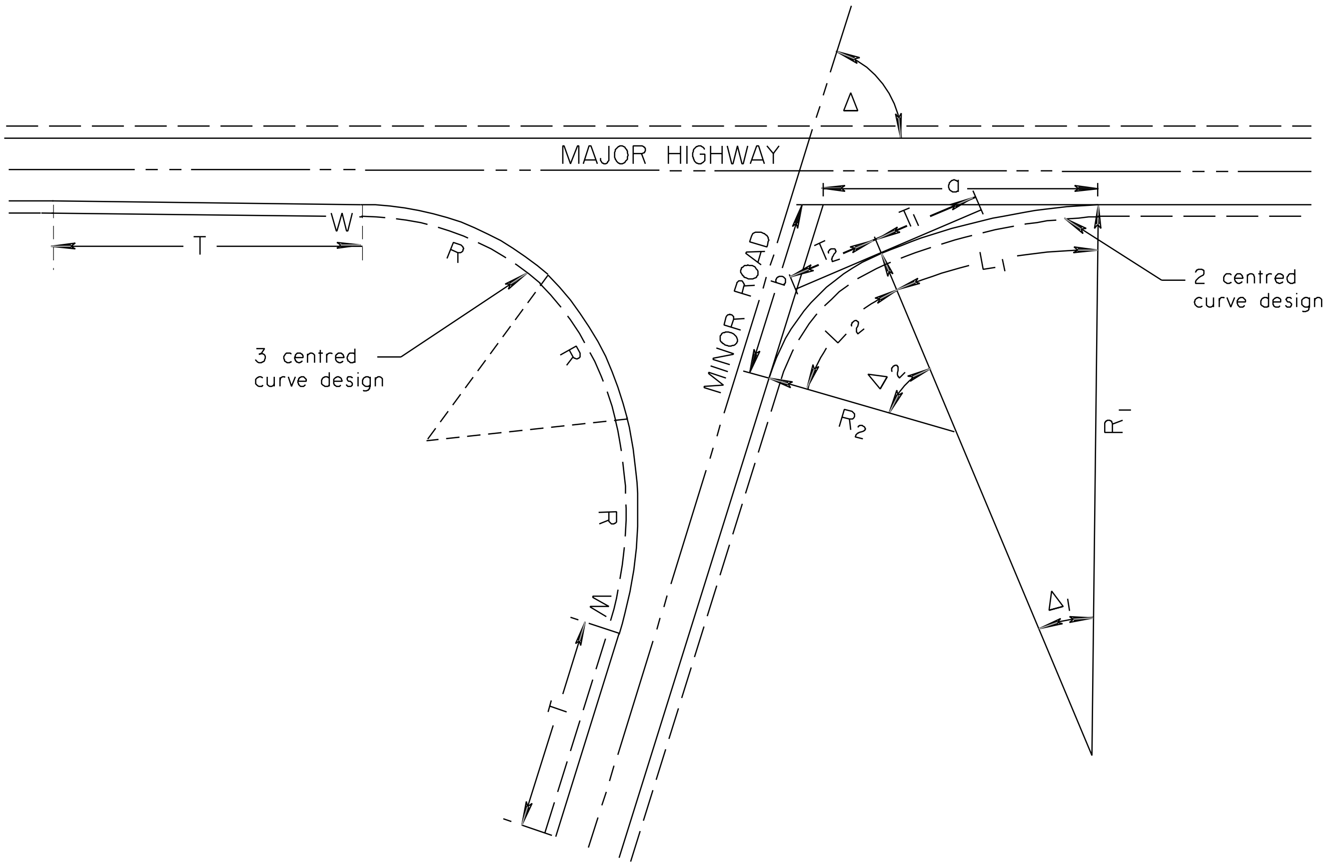
$$T_{bc} = T_2 - R_2 \sin \Delta_1$$

$$T_{ec} = T_2 - R_2 \sin \Delta_3$$

$$X_{bc} = R_1 - R_1 \cos \Delta_1$$

$$X_{ec} = R_3 - R_3 \cos \Delta_3$$

FIGURE D-5.2b FORMULAE FOR TWO-CENTRED CURVES
(Edge of Lane Design for WB-21 Design Vehicle)



Δ – Intersection angle of the two roads minus the taper angles where applicable.
R_1 – Radius of curve Δ_1
R_2 – Radius of curve Δ_2
Δ_1 – Angle subtended at the centre by Radius R_1
Δ_2 – Angle subtended at the centre by Radius R_2
$T_1 T_2$ – Length of tangent
$L_1 L_2$ – Length of curve
a – Long tangent of the compound circular curve
b – Short tangent of the compound circular curve

THERE ARE SEVEN COMPONENTS TO THE COMPOUND CURVE, Δ, R_1, Ta, Δ_1, R_2, Tb, and Δ_2. IN ALL CASES, $\Delta = \Delta_1 + \Delta_2$. WHEN FOUR OF THESE, INCLUDING AN ANGLE, ARE GIVEN OR ASSUMED, THE OTHER THREE MAY BE DETERMINED BY THE FOLLOWING EQUATIONS.

⚠1 $$a = \frac{R_2 - R_1 \cos\Delta + (R_1 - R_2)\cos\Delta_2}{\sin\Delta}$$

⚠1 $$b = \frac{R_1 - R_2 \cos\Delta - (R_1 - R_2)\cos\Delta_1}{\sin\Delta}$$ ⚠1

$$\text{Vers}\Delta_1 = \frac{b \sin\Delta - R_2 \text{Vers}\Delta}{R_1 - R_2}$$

$$\text{Vers}\Delta_2 = \frac{R_1 \text{Vers}\Delta - a \sin\Delta}{R_1 - R_2}$$

$$\tan\frac{\Delta_1}{2} = \frac{b \sin\Delta - R_2 \text{Vers}\Delta}{a + b\cos\Delta - R_2 \sin\Delta}$$

$$\tan\frac{\Delta_2}{2} = \frac{R_1 \text{Vers}\Delta - a \sin\Delta}{R_1 \sin\Delta - a\cos\Delta - b}$$

$$R_1 = R_2 + \frac{b \sin\Delta - R_2 \text{Vers}\Delta}{\text{Vers}\Delta_1}$$

$$R_2 = R_1 - \frac{R_1 \text{Vers}\Delta - a \sin\Delta}{\text{Vers}\Delta_2}$$

NOTE: $\text{Vers}\Delta = 1 - \cos\Delta$

REVISIONS	No. ⚠2	BY		DATE	
	No. ⚠1	BY TDN	REVISED VALUES IN FORMULAS, CHANGED b TO a AND a TO b, ADDED SinΔ	DATE	JULY/ 98

D.5.3 Design of Intersections for Log Haul

The design of intersections to accommodate log haul is a special task which should only be undertaken by designers who are aware of the special characteristics and hazards of log haul trucks.

Unlike other large trucks, log truck configurations vary widely. Typically, fully loaded logging trucks accelerate slower and off-track more. In addition, some may be wider than standard highway trucks and may be permitted to have rear overhangs of up to 13.0 metres. Because of the long overhang and the special configuration of log haul trucks, the end of the load typically sweeps outside of the wheel path on sharp turns. One typical configuration is a pole trailer that utilizes a telescoping mechanism on the body of the trailer. This allows the axle spacing to vary as the vehicle is turning from tangent to curve and then back to tangent. The telescoping mechanism is required to allow the articulated vehicle to turn while carrying a fixed (non-articulated) load. Because of the telescoping mechanism the load of a log haul truck has a much wider sweep than a conventional truck with the same overhang. The log sweep described above and shown in Figure D-5.3a, is potentially hazardous to other vehicles on the highway, especially if they attempt to pass a log haul truck that is turning. This log sweep hazard can be minimized or eliminated by constructing special intersection layouts which provide a separation between the highway user and the log sweep.

A series of such layouts have been prepared for log haul intersections to accommodate the various movements that may occur at at-grade intersections (see Figures D-5.3a through D-5.3j). These movements include left and right turns off an intersecting or main (through) roadway in either a rural or urban environment. These typical plans are based on a 9.0 metre log overhang. If larger overhangs are expected, the proposed intersection plan should be checked with log truck turning templates.

Because of the high cost of some of the treatments, several solutions (some lower cost) have been used in this province. Although many factors should be considered in selection of a treatment type (for example: the number of log trucks per day, month and year and the duration of the haul in years), it is useful for designers to refer to Table D.5.3 which provides a guideline for treatment type based on AADT and environment (rural/urban) only. Designers should use judgement in applying these guidelines, together with other considerations and site specific information, to develop an appropriate plan.

It should be noted that although these treatments are suggested for new construction of log haul intersections, this does not imply that all existing intersections where log haul is permitted must be upgraded to the same standard. In the case of existing log haul routes, the placement of warning signs may be appropriate in lieu of geometric upgrading.

As well, sight distance requirements for log haul intersections are typically greater than at conventional intersections. This is due to the longer vehicle and slower acceleration characteristics of log haul trucks.

The intersection sight distance requirements for each intersection layout are shown on the plans. For other layouts, the intersection sight distance requirements should be calculated from first principles as described in Section D.4.

Table D.5.3 Guideline for Selection of Special Log Haul Intersection Treatment on New Construction Projects

Treatment Type	Figure	Description	Suggested Conditions
1.	D-5.3b	Right Turn from Intersecting Road	Intersecting Road AADT < 100
2.	D-5.3c	Left Turn from Intersecting Road	Intersecting Road AADT < 100
3.	D-5.3d	Left or Right Turn from Intersecting Road (Channelized)	Intersecting Road AADT > 100
4a.	D-5.3e	Right Turn from Main (or through) Road (Rural Channelized)	All Main (or through) Rural Roads
4b.	D-5.3f	Right Turn from Main (or through) Road (Urban Channelized)	All Main (or through) Urban Roads with R / W restrictions
5a.	D-5.3g	Left Turn from Main (or through) Road (Rural Divided Highway)	Main (or through) Rural Highway AADT > 2000
5b.	D-5.3h	Left Turn from Main (or through) Road (Urban Divided Highway)	All Urban Highways
5c.	D-5.3i	Left Turn from a Main (through) Road (Rural Two-Lane Highway with Narrow Shoulder)	Main (or through) Rural Highway is narrow (RAU-209 or less) and low volume AADT < 1000
6.	D-5.3j	Jughandle (Right Turn Off-Ramp and 90º Crossing)	Main (or through) Road AADT less than 2000
Note: The above guideline should be used together with other design considerations to select an appropriate intersection layout.			

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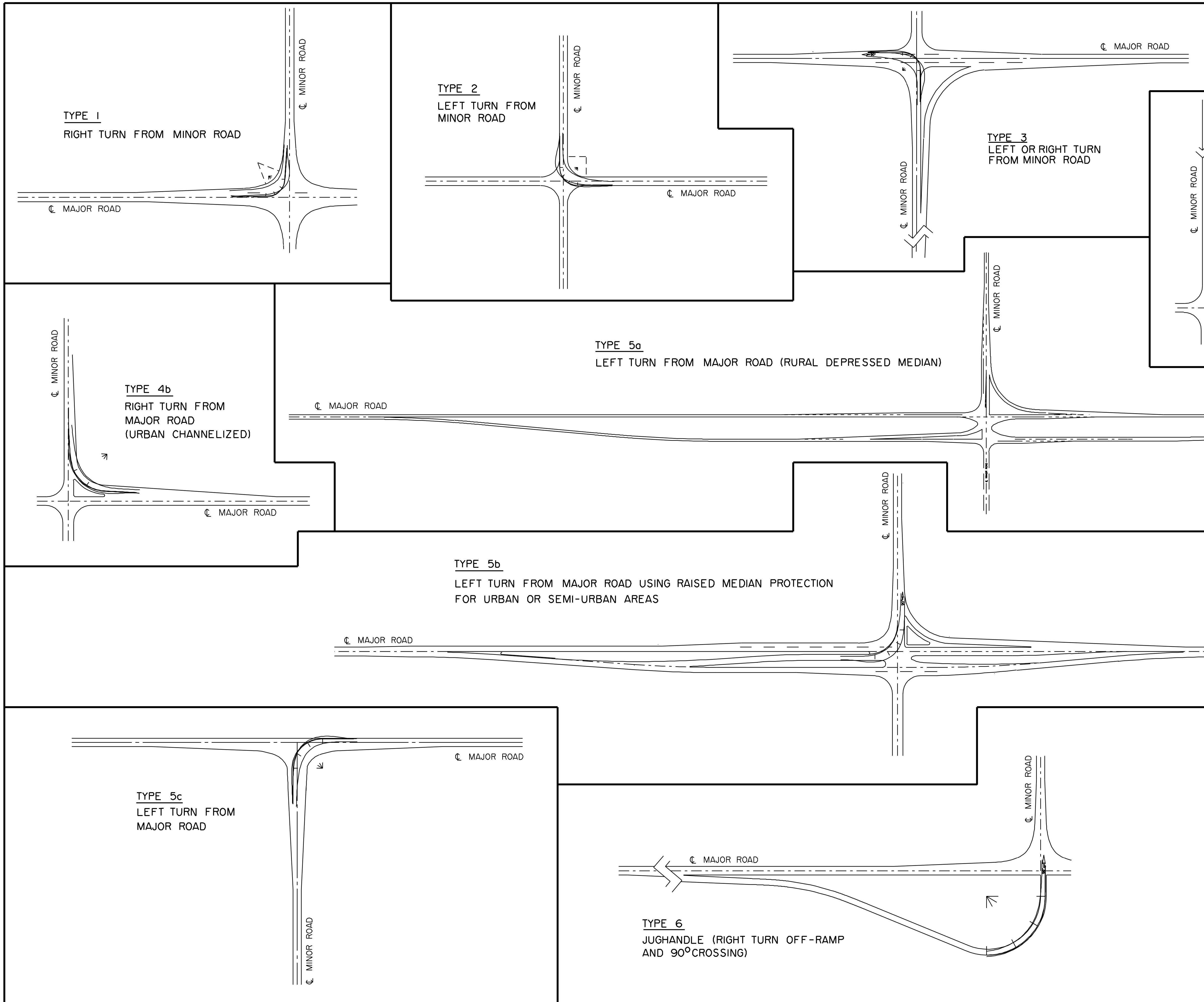


No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

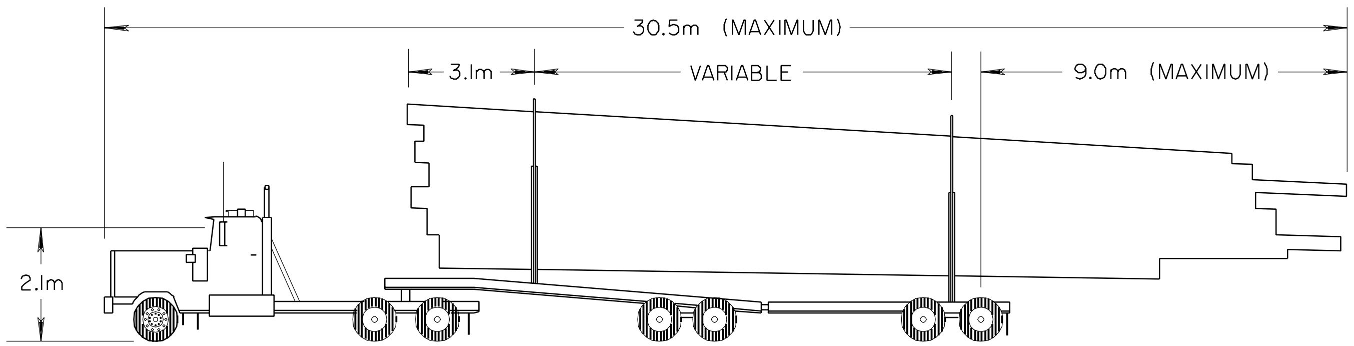
FIGURE D-5.3a

Date: APRIL 1995

LOG HAUL INTERSECTION TYPES

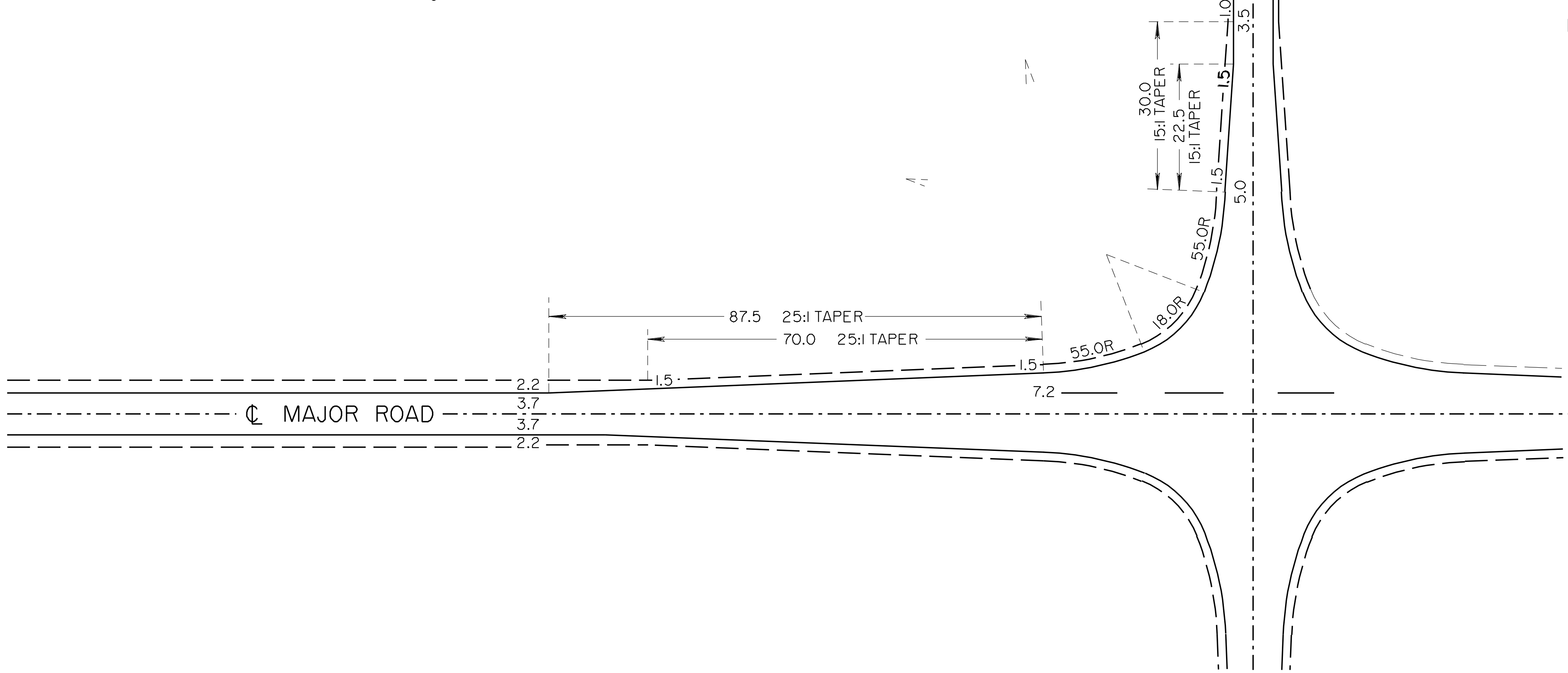
Prepared By: LT	Checked By: B.K.	Scale: N.T.S.	PAGE D-65

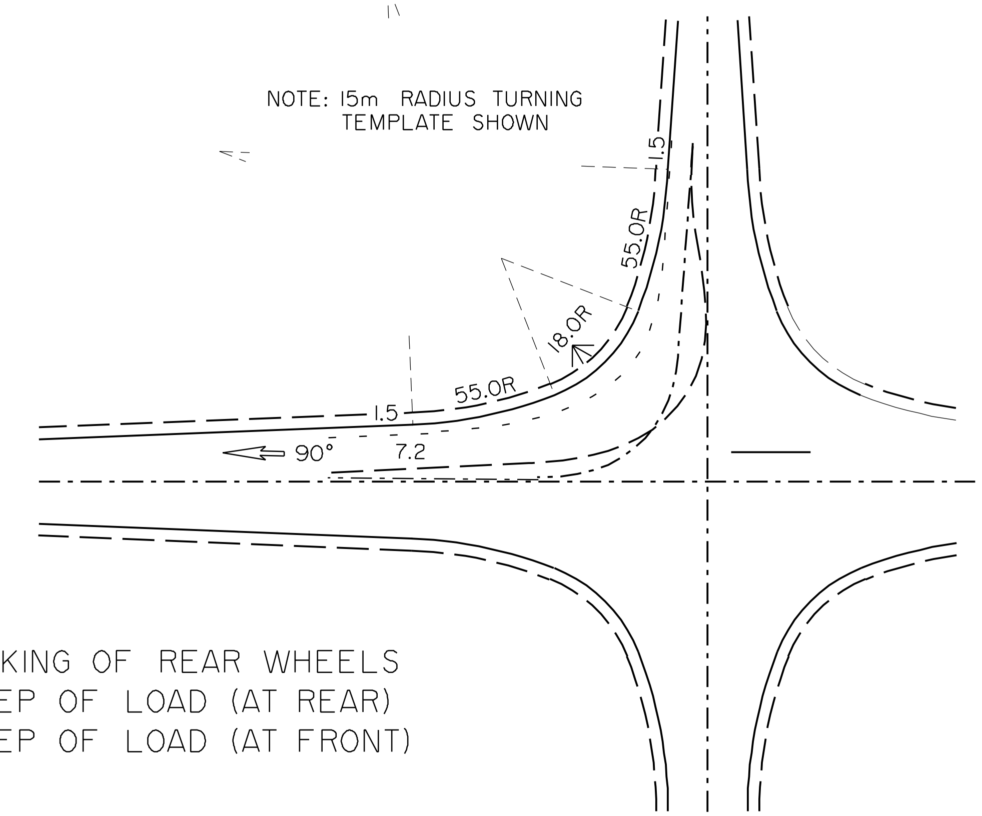
GRAPHICS FILE: debd53a.man



TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

The template used for design of this intersection is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck-Trailer configurations used in Alberta.





LEGEND:

- - TRACKING OF REAR WHEELS
—- SWEEP OF LOAD (AT REAR)
—·- SWEEP OF LOAD (AT FRONT)

Note 1: The sight distance requirement for this intersection is based on 22 seconds (ie. 20 seconds for left turn plus 2 seconds for perception/reaction time). This computes to 672m for a 110 km/h design speed. The sight distance requirement for a crossing maneourvre is 580m, based on 19 seconds (17 + 2 seconds) and a 110km/h design speed. Adjustments should be made where required for different design speeds, roadway widths, skew angles, or steep gradients. The sight distance available should be measured based on an eye height of 2.1m and an object height of 1.3m.

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

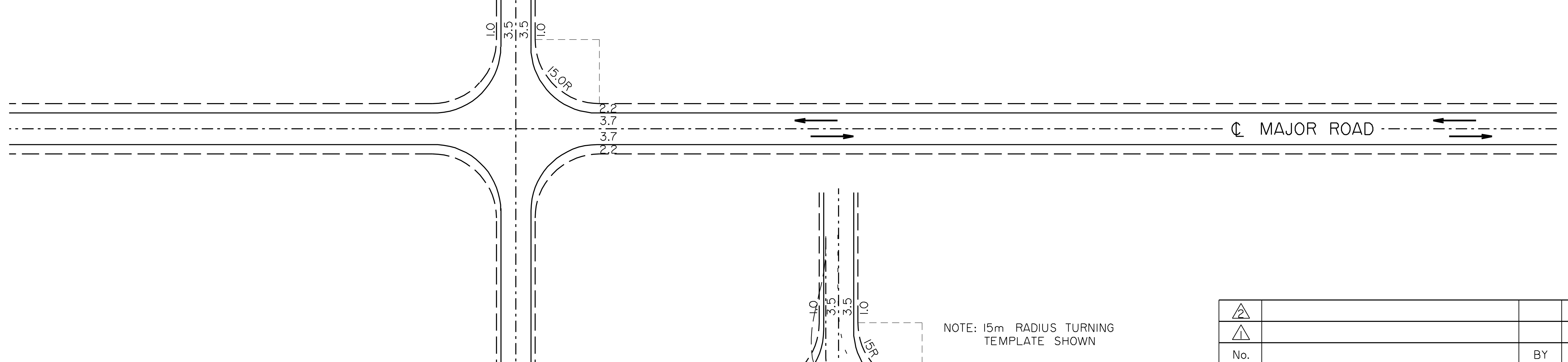
FIGURE D-5.3b

Date: APRIL 1995

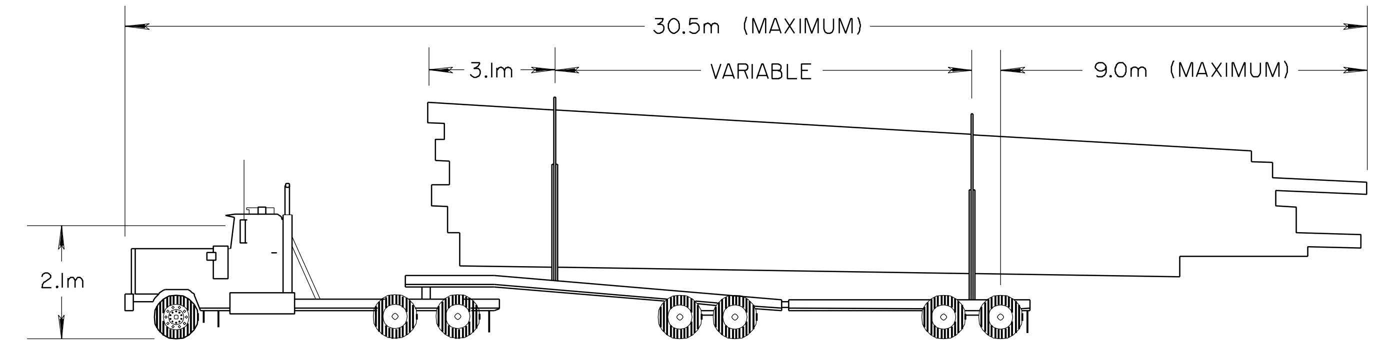
LOG HAUL INTERSECTION TYPE I (RIGHT TURN FROM MINOR ROAD)

Prepared By: Cgk	Checked By: B.K	Scale: N.T.S.	PAGE D-67

GRAPHICS FILE: debd53b.man

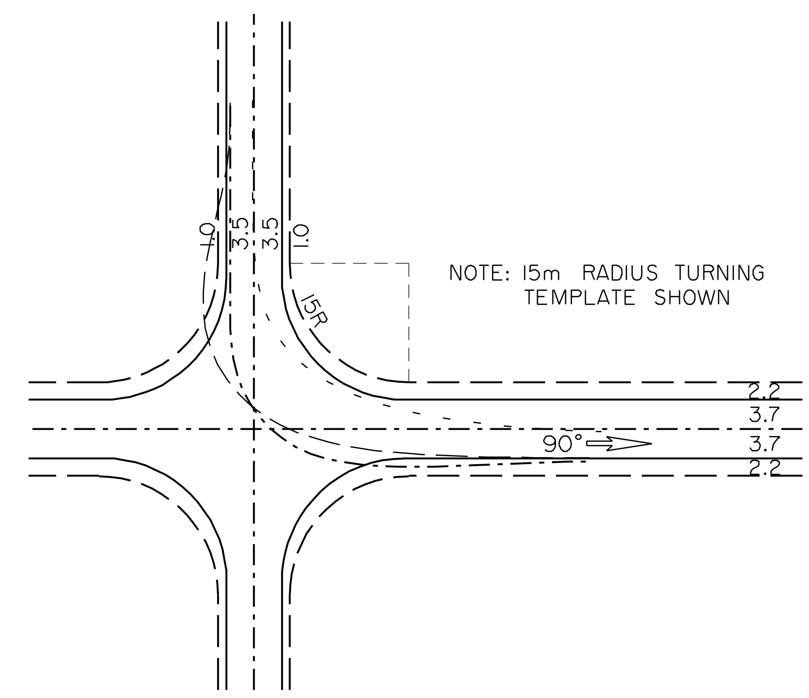


Note 1: The sight distance requirement for this intersection is based on 24 seconds (ie. 22 seconds for left turn plus 2 seconds for perception/reaction time). This computes to 733m for a 110 km/h design speed. The sight distance requirement for a crossing maneouvre is 550m, based on 18 seconds (16 + 2 seconds) and a 110km/h design speed. Adjustments should be made where required for different design speeds, roadway widths, skew angles, or steep gradients. The sight distance available should be measured based on an eye height of 2.1m and an object height of 1.3m.



TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

The template used for design of this intersection is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck-Trailer configurations used in Alberta.



NOTE: 15m RADIUS TURNING TEMPLATE SHOWN

LEGEND:

- - TRACKING OF REAR WHEELS
— - SWEEP OF LOAD (AT REAR)
-·- SWEEP OF LOAD (AT FRONT)

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

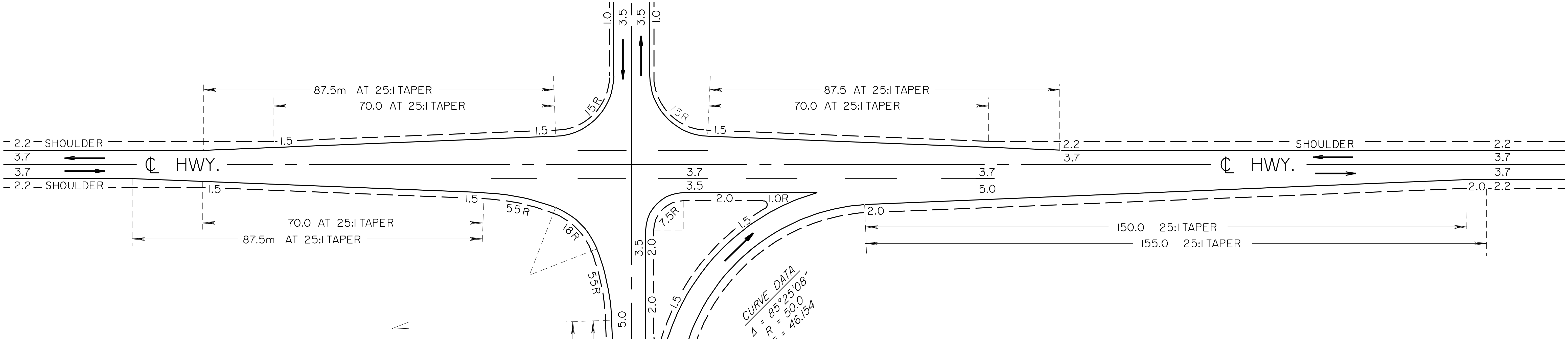
FIGURE D-5.3c

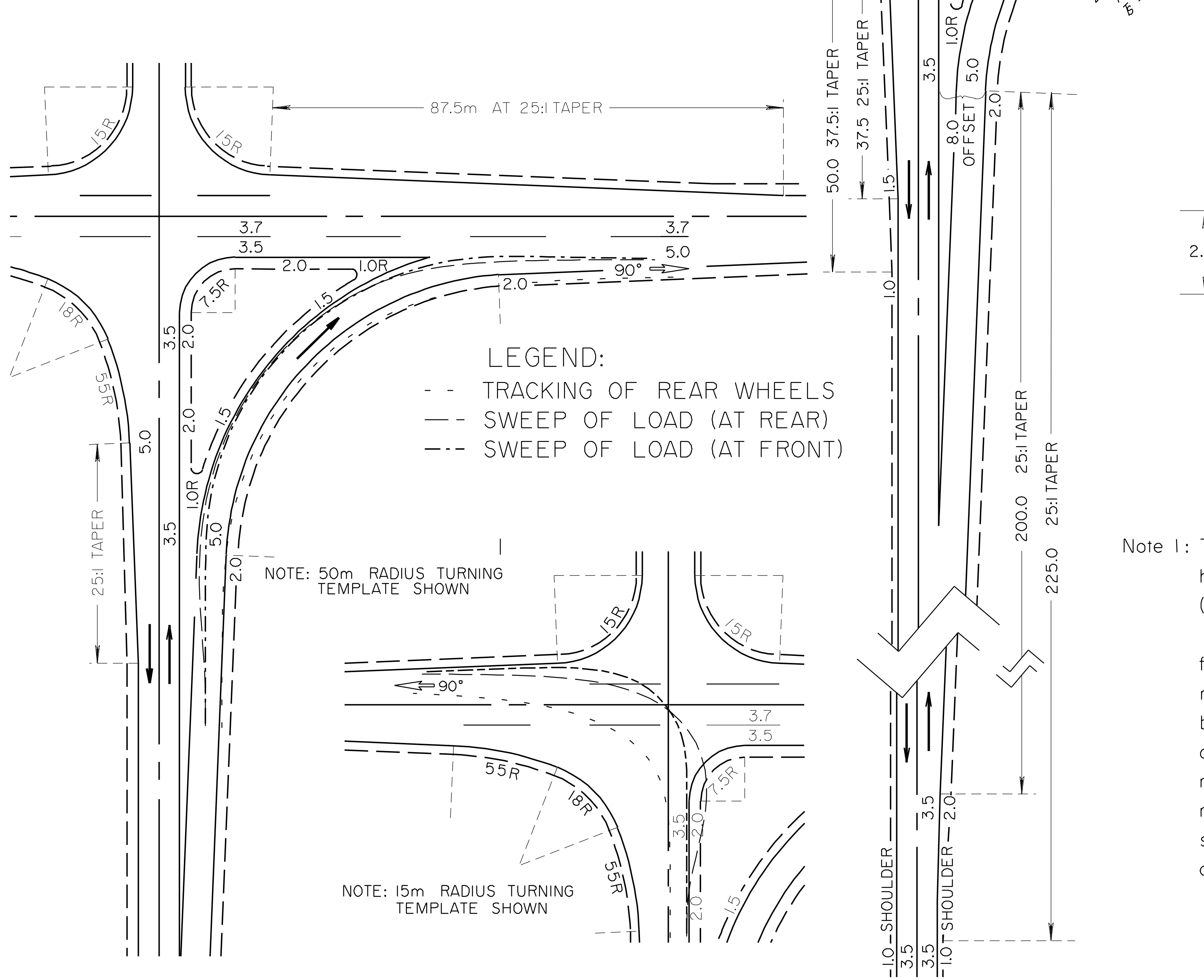
Date: APRIL 1995

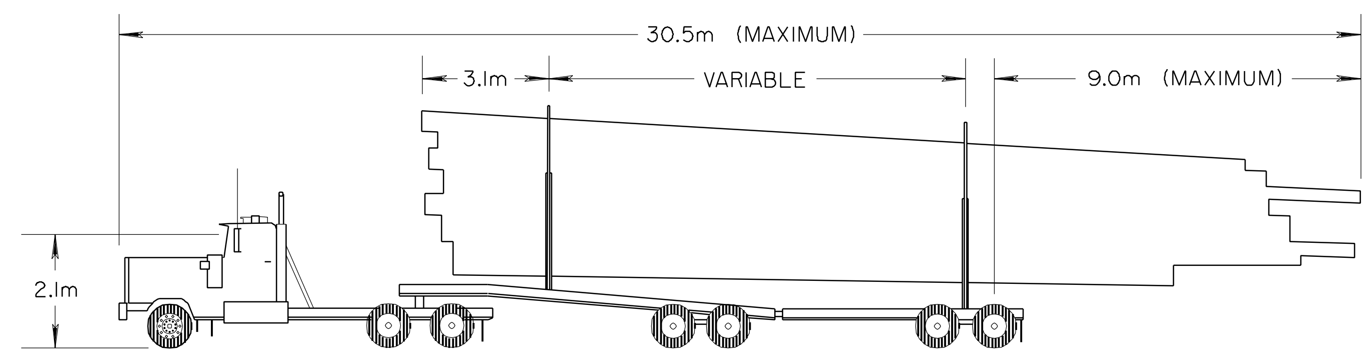
LOG HAUL INTERSECTION TYPE 2 (LEFT TURN FROM MINOR ROAD)

Prepared By: Cgk	Checked By: B.K.	Scale: N.T.S.	PAGE D-69

GRAPHICS FILE: debd53c.man







TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

The template used for design of this intersection is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck-Trailer configurations used in Alberta.

Note 1: The sight distance requirement for left turning log haul trucks at this intersection is based on 22 seconds (ie. 20 seconds for left turn plus 2 seconds for perception/reaction time). This computes to 672m for a 110km/h design speed. The sight distance requirement for a crossing manoeuvre is 596m, based on 19.5 seconds (17.5 + 2 seconds) and a 110km/h design speed. Adjustments should be made where required for different design speeds, roadway widths, skew angles, or steep gradients. The sight distance available should be measured based on an eye height of 2.1m and an object height of 1.3m.

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE D-5.3d

Date: APRIL 1995

LOG HAUL INTERSECTION TYPE 3 (LEFT OR RIGHT TURN FROM MINOR ROAD)

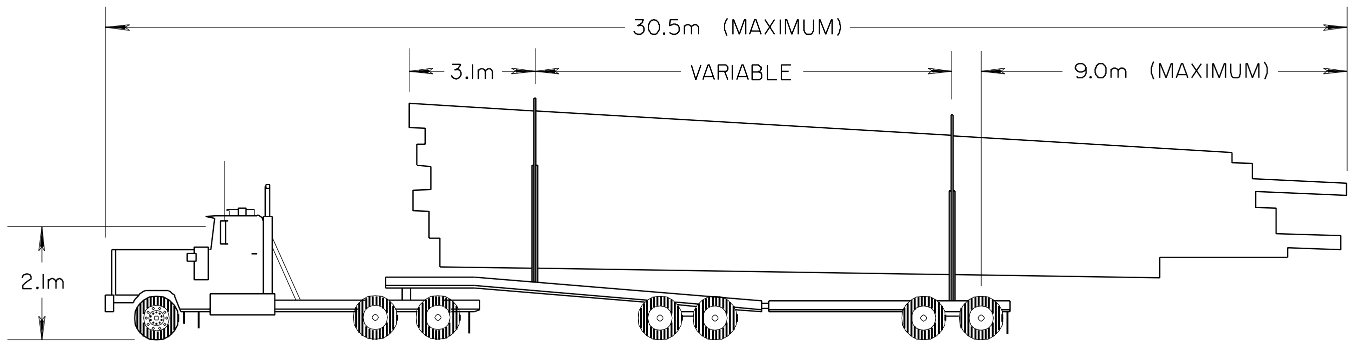
Prepared By: Cgk	Checked By: B.K.	Scale: N.T.S.	PAGE D-71

GRAPHICS FILE: debd53d.man

Note 1: The sight distance requirement for this intersection (assuming that loaded log haul trucks are only turning right from the major road) is based on a conventional WB-15 turning left from the minor road. This value is 430m for a design speed of 110 km/h . (based on 12 seconds for a left turn plus 2 seconds for perception /reaction time).

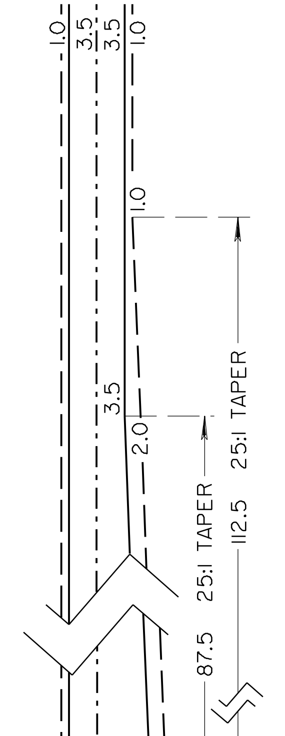
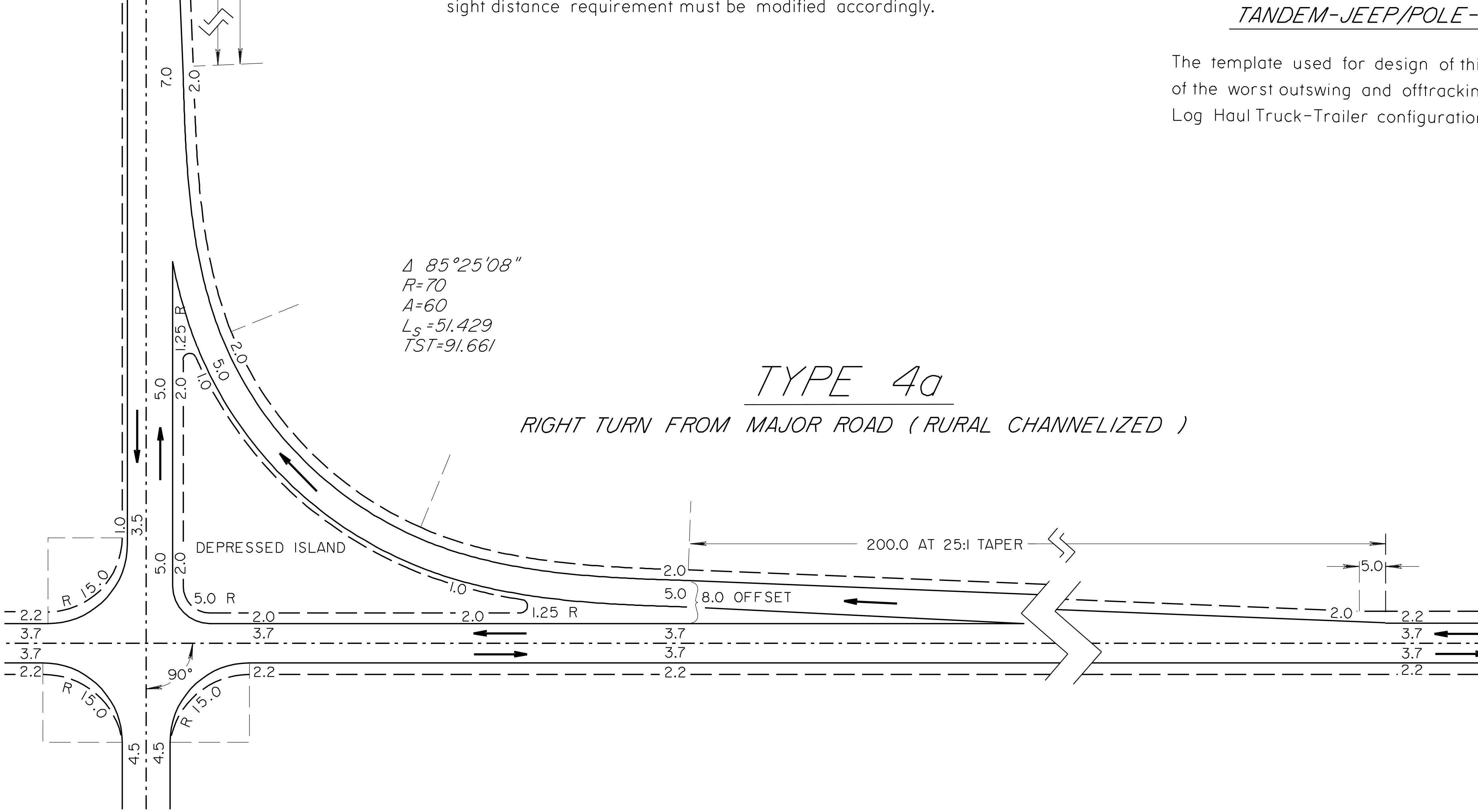
Adjustments should be made where required for different design speeds, roadway widths, skew angles, or steep gradients. The sight distance available should be measured based on an eye height of 2.1m and an object height of 1.3m.

If loaded log haul trucks are making any other turning or crossing movements at this junction, the intersection sight distance requirement must be modified accordingly.



TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

The template used for design of this intersection is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck-Trailer configurations used in Alberta.

TYPE 4a

RIGHT TURN FROM MAJOR ROAD (RURAL CHANNELIZED)

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

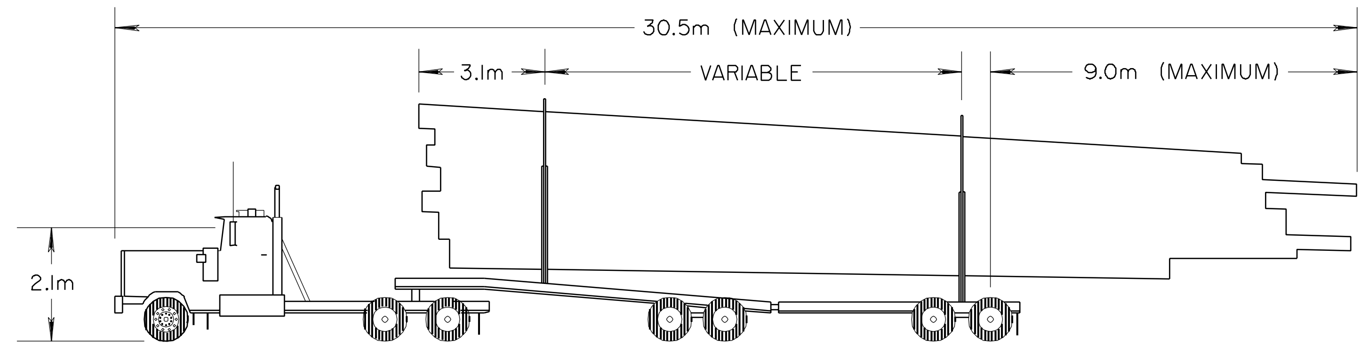
FIGURE D-5.3e

Date: APRIL 1995

LOG HAUL INTERSECTION
TYPE 4a
RIGHT TURN FROM MAJOR ROAD
(RURAL CHANNELIZED)

Prepared By: cgk	Checked By: B.K.	Scale: N.T.S.	PAGE D-73

GRAPHICS FILE: debd53e.man

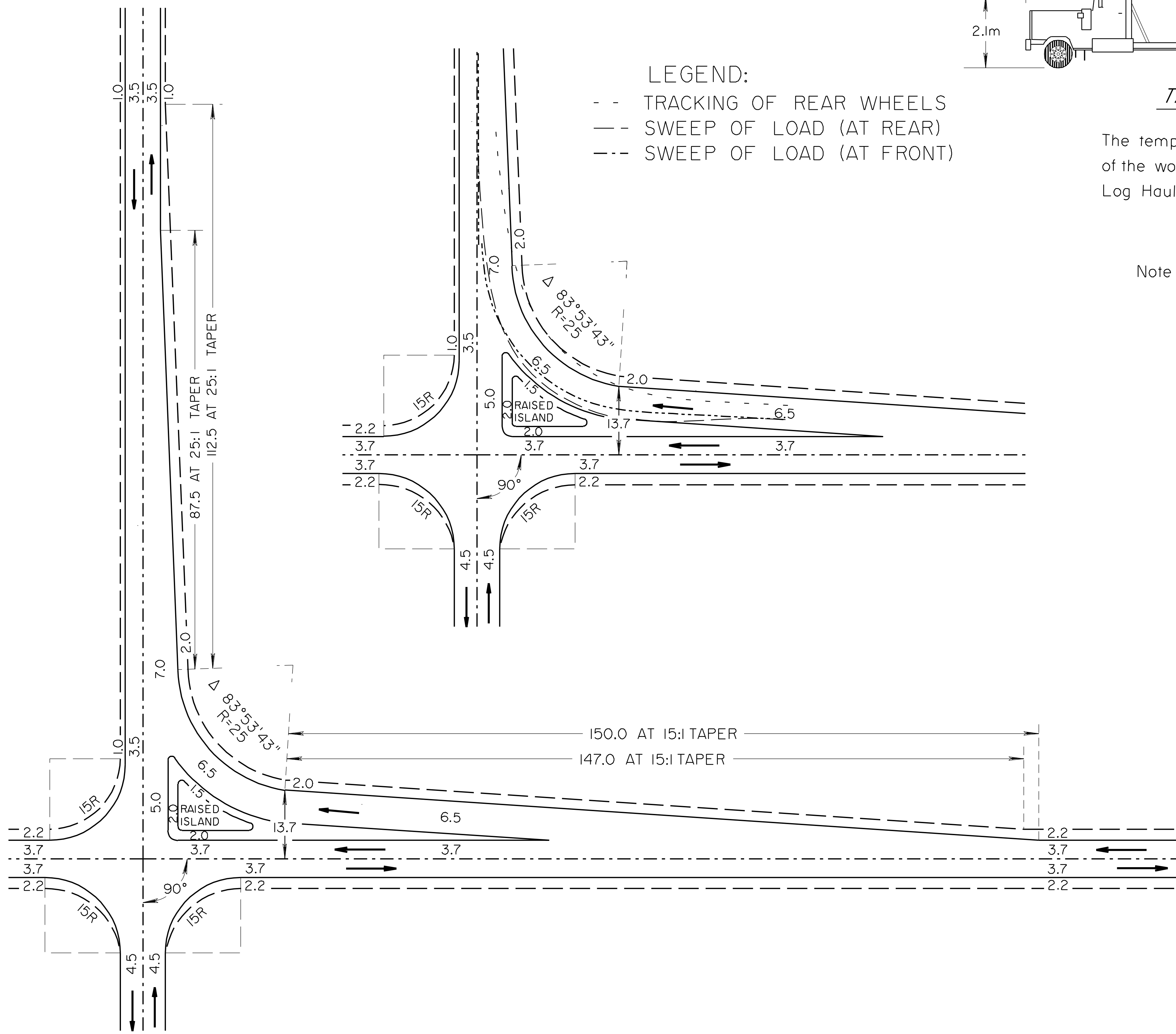


TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

The template used for design of this intersection is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck-Trailer configurations used in Alberta.

LEGEND:

- - TRACKING OF REAR WHEELS
- —- SWEEP OF LOAD (AT REAR)
- —·- SWEEP OF LOAD (AT FRONT)



Note 1: The sight distance requirement for this intersection (assuming that loaded log haul trucks are only turning right from the major road) is based on a conventional WB-15 turning left from the minor road. This value is 430m for a design speed of 110 km/h . (based on 12 seconds for a left turn plus 2 seconds for perception /reaction time).

Adjustments should be made where required for different design speeds, roadway widths, skew angles, or steep gradients. The sight distance available should be measured based on an eye height of 2.1m and an object height of 1.3m.

If loaded log haul trucks are making any other turning or crossing movements at this junction, the intersection sight distance requirement must be modified accordingly.

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE D-5.3f

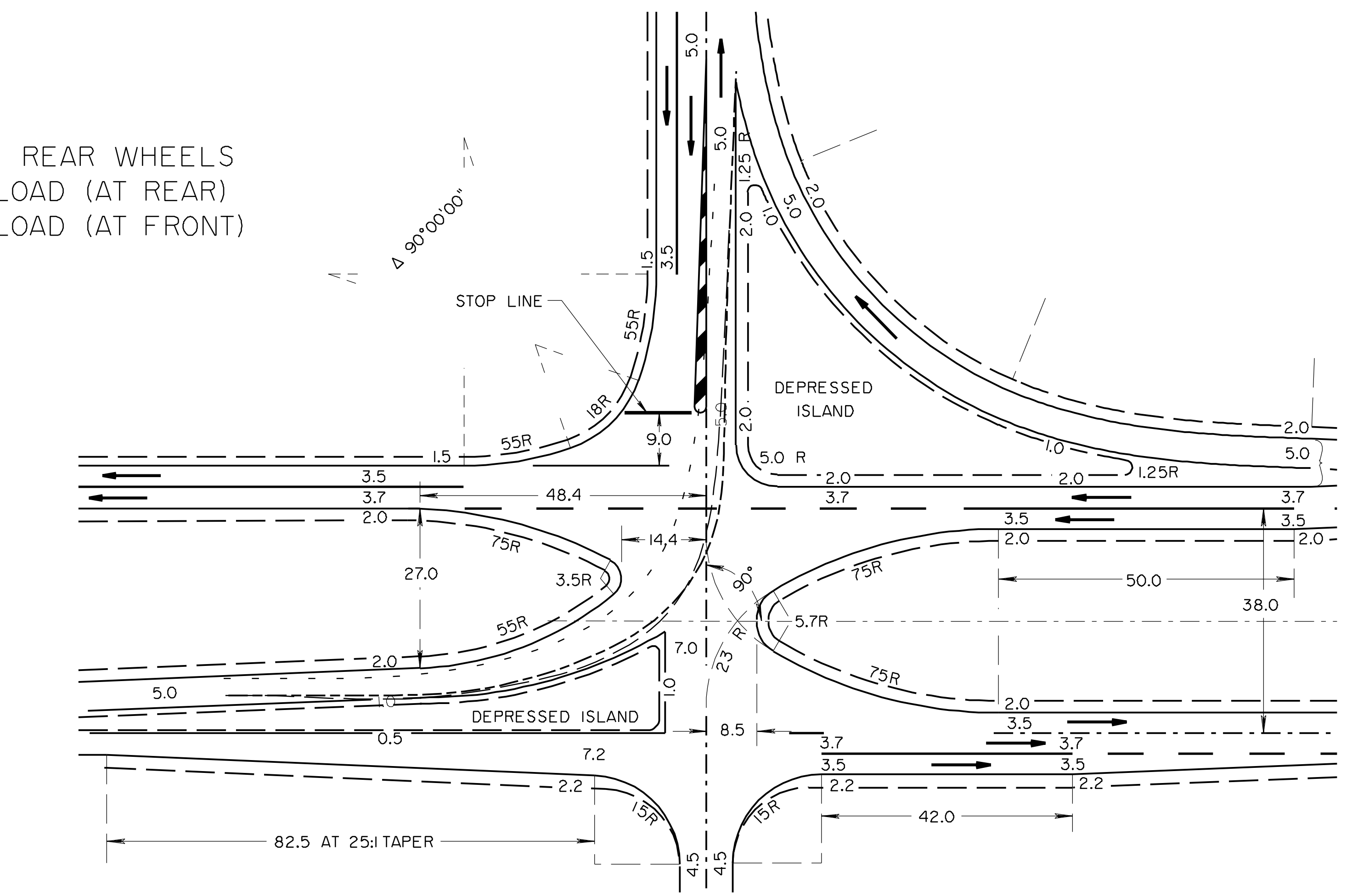
Date: APRIL 1995

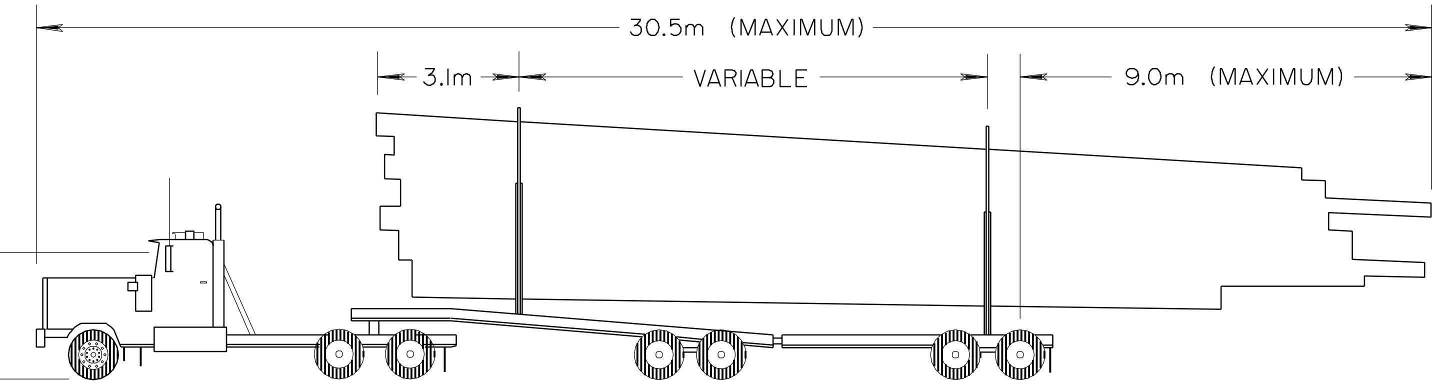
LOG HAUL INTERSECTION TYPE 4b
RIGHT TURN FROM MAJOR ROAD
(URBAN CHANNELIZED)

Prepared By: Cgk	Checked By: B.K.	Scale: N.T.S.	PAGE D-75

GRAPHICS FILE: debd53f.man

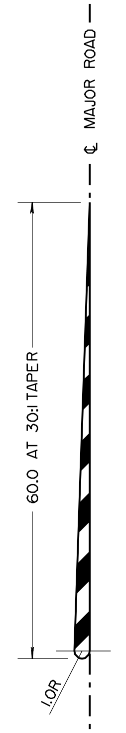
LEGEND:
- - TRACKING OF REAR WHEELS
— - SWEEP OF LOAD (AT REAR)
—·- SWEEP OF LOAD (AT FRONT)





TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

The template used for design of this intersection is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck-Trailer configurations used in Alberta.



DETAIL:
PAINTED MEDIAN

Note 1: The sight distance requirement for this intersection is based on 19 seconds (ie. 17 seconds for turning plus 2 seconds for perception/reaction time) This computes to 581m for a 110km/h design speed.

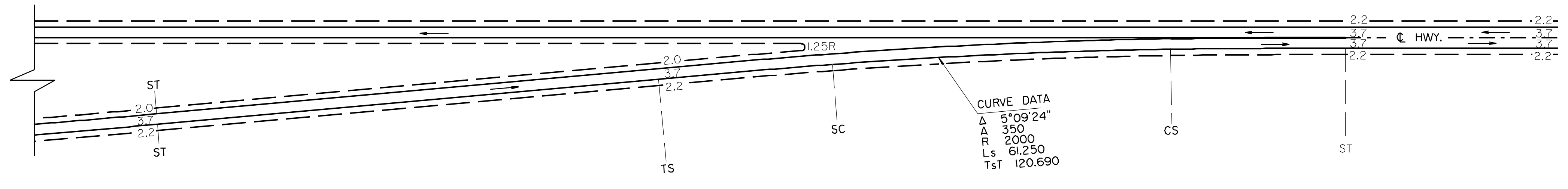
The sight distance for crossing in one manoeuvre (without stopping in the median) with a 38m centreline to centreline spacing is based on 24 seconds (22+2 seconds). This computes to 733m for a design speed of 110km/h.

Alternatively, where the centreline spacing is at least 45m, the crossing manoeuvre can be made in two steps. This reduces the sight distance requirement for crossing to 550m (based on 18 seconds at 110km/h design speed).

Adjustments should be made where required for different design speeds, roadway widths, skew angles, or steep gradients. The sight distance available should be measured based on an eye height of 2.1m and an object height of 1.3m.

NOTE: ISLAND CAN BE DEPRESSED OR AT-GRADE(PAINTED), DEPENDING ON DRAINAGE REQUIREMENTS AND LOCAL PREFERENCES. (NOTE REFERS TO LEFT TURN ISLAND ONLY)

NOTE:
38m SPACING FROM CENTRELINE TO CENTRELINE IS CHOSEN TO BE CONSISTENT WITH FUTURE TURNING REQUIREMENTS. WHERE LOADED LOG HAUL TRUCKS WILL BE HAULING DIRECTLY ACROSS THE DIVIDED HIGHWAYS i.e. FROM MINOR ROAD TO MINOR ROAD, THE SPACING SHOULD BE INCREASED TO 45m(MIN.) OR 50m(DESIRABLE) TO ALLOW A CROSSING LOG HAUL TRUCK TO TAKE REFUGE IN THE MEDIAN.



No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE D-5.3g

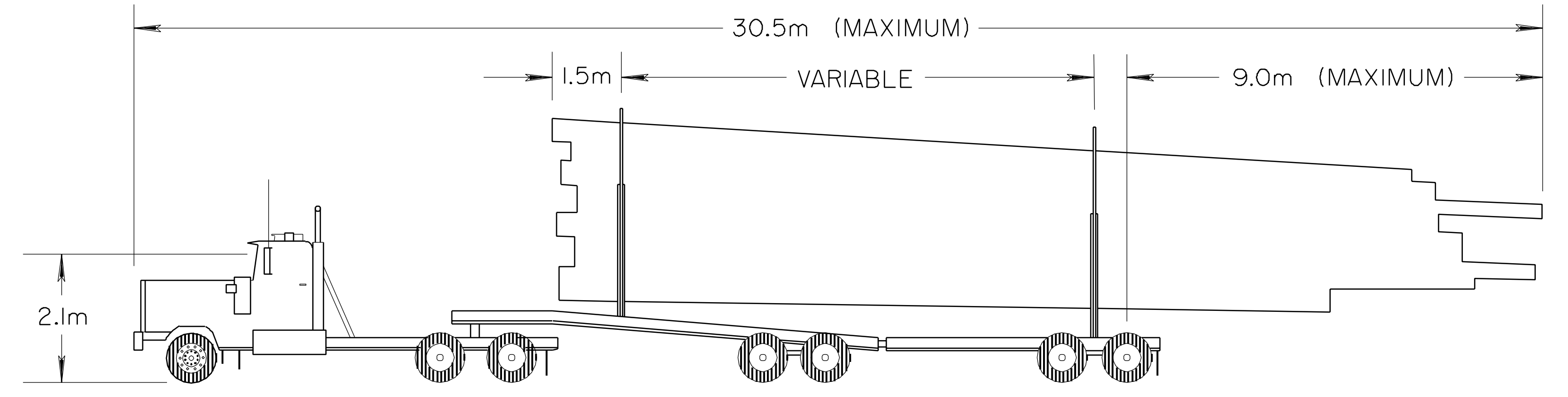
Date: APRIL 1995

LOG HAUL INTERSECTION
TYPE 5a
LEFT TURN FROM MAJOR ROAD
(RURAL DEPRESSED MEDIAN)

Prepared By: Cgk	Checked By: B.K.	Scale: N.T.S.	PAGE D-77

NOTE:

THE 1000m RADIUS AND DEFLECTION ANGLES SHOWN FOR THE MAIN ALIGNMENT ARE APPROPIATE FOR SEMI-URBAN CONDITIONS WHERE THE POSTED SPEED IS 80Km/h OR LESS. FOR HIGH SPEED ENVIRONMENTS, A 2000m RADIUS AND 3 DEGREE DEFLECTION ANGLES ARE MORE APPROPIATE.



TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

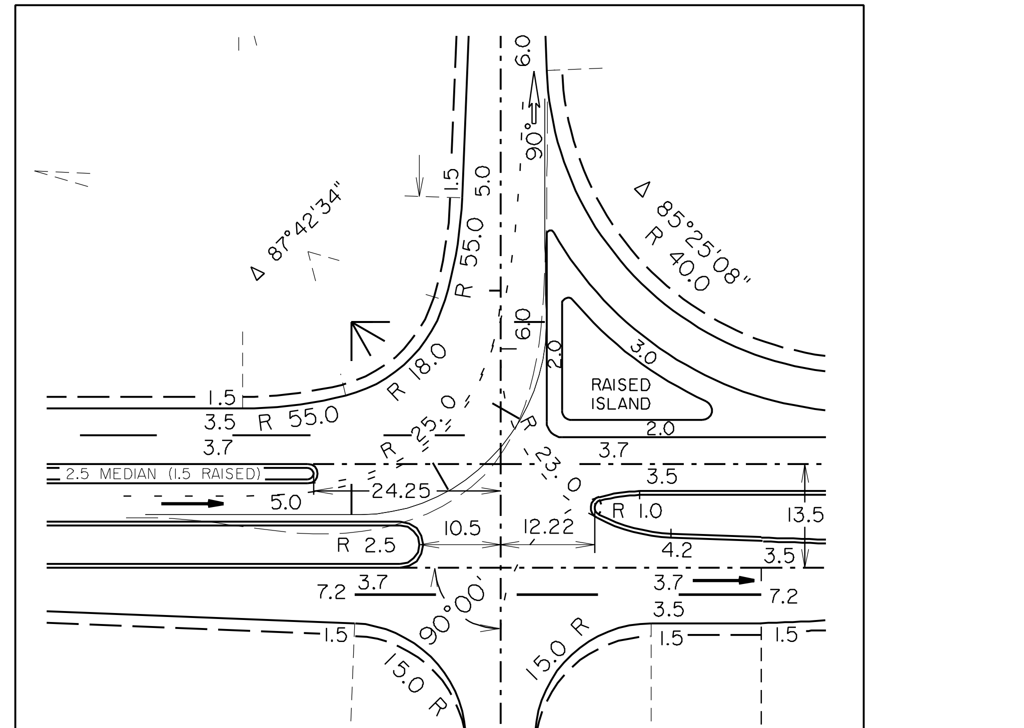
The template used for design of this intersection is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck-Trailer configurations used in Alberta.

NOTE:

1. THE MAIN ALIGNMENT RADII AS SHOWN ARE CONSIDERED SUITABLE FOR A DESIGN SPEED OF 80Km/h AND ADEQUATE FOR A DESIGN SPEED OF 100Km/h WITH NO SUPERELEVATION. IF A HIGHER DESIGN SPEED OR LOWER RADII ARE REQUIRED, THE USE OF SPIRALLED SUPERELEVATED CURVES IS SUGGESTED.

2. BARRIER CURB IS CONSIDERED UNDESIRABLE FOR DESIGN SPEEDS IN EXCESS OF 70Km/h. FOR HIGHER DESIGN SPEEDS THE SEMI-MOUNTABLE OR MOUNTABLE TYPE CURB SHOULD BE USED.

3. THE SIGHT DISTANCE REQUIREMENT FOR THIS INTERSECTION IS BASED ON 18 SECONDS. I.E. 16 SECONDS FOR LEFT TURN PLUS 2 SECONDS FOR PERCEPTION / REACTION TIME. THIS COMPUTES TO 550m FOR A 110Km/h DESIGN SPEED. ADJUSTMENTS SHOULD BE MADE WHERE REQUIRED FOR DIFFERENT DESIGN SPEEDS, ROADWAY WIDTHS SKEW ANGLES OR STEEP GRADIANTS. THE SIGHT DISTANCE AVAILABLE SHOULD BE MEASURED BASED ON AN EYE HEIGHT OF 2.1m AND AN OBJECT HEIGHT OF 1.3m.



LEGEND:
- - TRACKING OF REAR WHEELS
— - SWEEP OF LOAD (AT REAR)
— LEADING FENDER PATH

No.		BY	DATE

Alberta INFRASTRUCTURE

FIGURE D-5.3h

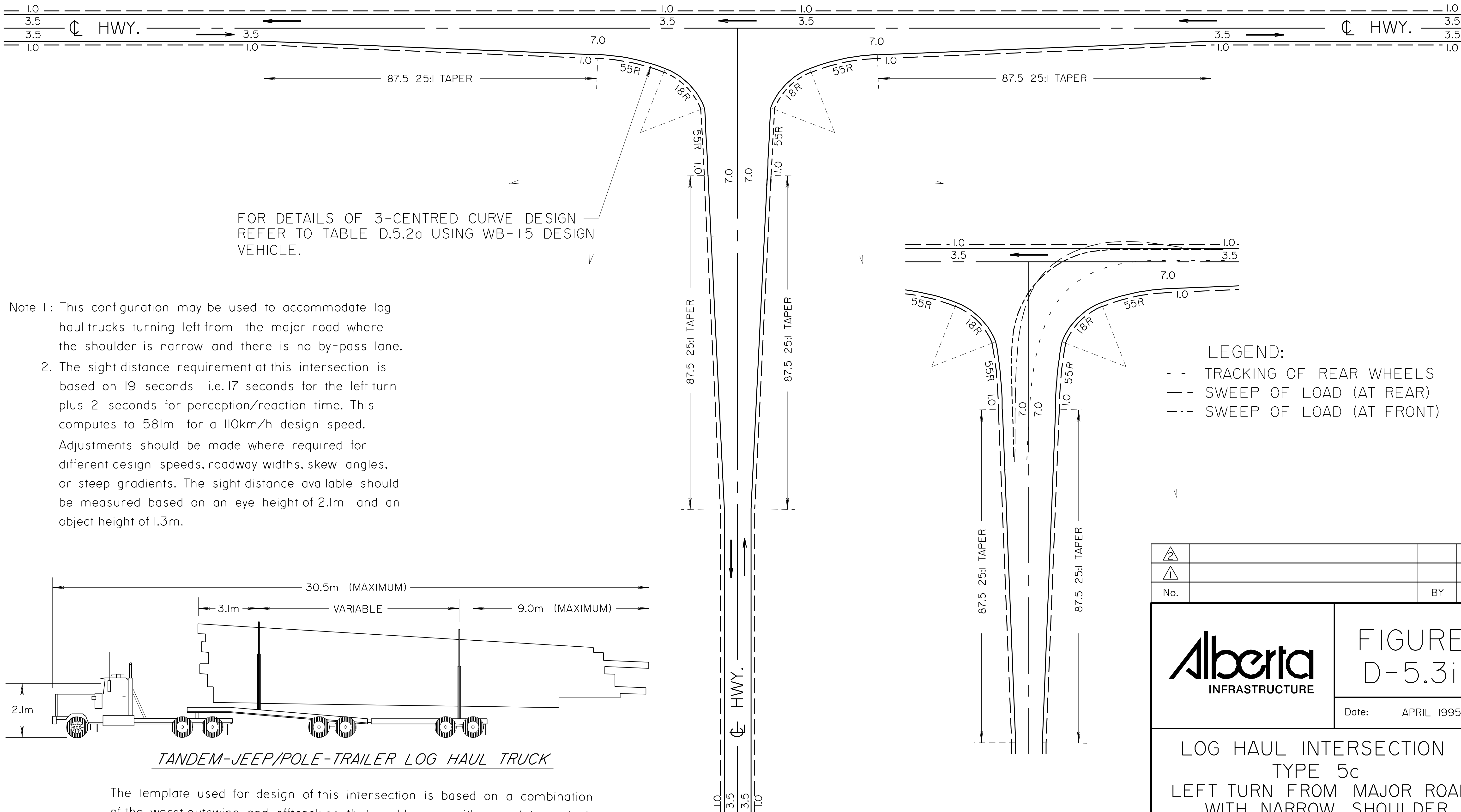
Date: APRIL 1995

LOG HAUL INTERSECTION TYPE 5b LEFT TURN FROM MAJOR ROAD (URBAN)

Prepared By: Cgk. | Checked By: B.K. | Scale: N.T.S.

GRAPHICS FILE: dedd53h.man

DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS.
ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW
FOR DEPTH OF BASE COURSE AND PAVEMENT.



LEGEND:

- - TRACKING OF REAR WHEELS
— - SWEEP OF LOAD (AT REAR)
—·- SWEEP OF LOAD (AT FRONT)

Note 1: This configuration may be used to accommodate log haul trucks turning left from the major road where the shoulder is narrow and there is no by-pass lane.

2. The sight distance requirement at this intersection is based on 19 seconds i.e. 17 seconds for the left turn plus 2 seconds for perception/reaction time. This computes to 581m for a 110km/h design speed. Adjustments should be made where required for different design speeds, roadway widths, skew angles, or steep gradients. The sight distance available should be measured based on an eye height of 2.1m and an object height of 1.3m.

TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

The template used for design of this intersection is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck-Trailer configurations used in Alberta.

GRAPHICS FILE: debd53i.man

No.		BY	DATE
2			
1			

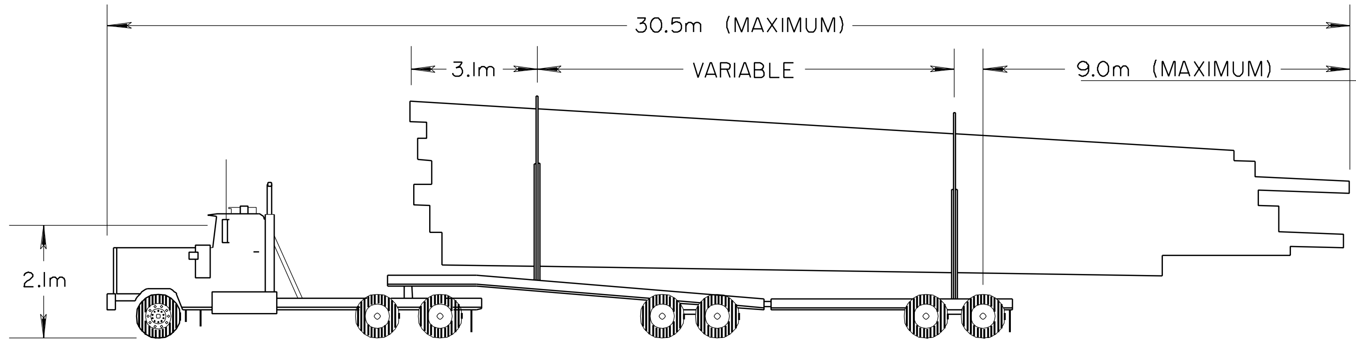
Alberta INFRASTRUCTURE

FIGURE D-5.3i

Date: APRIL 1995

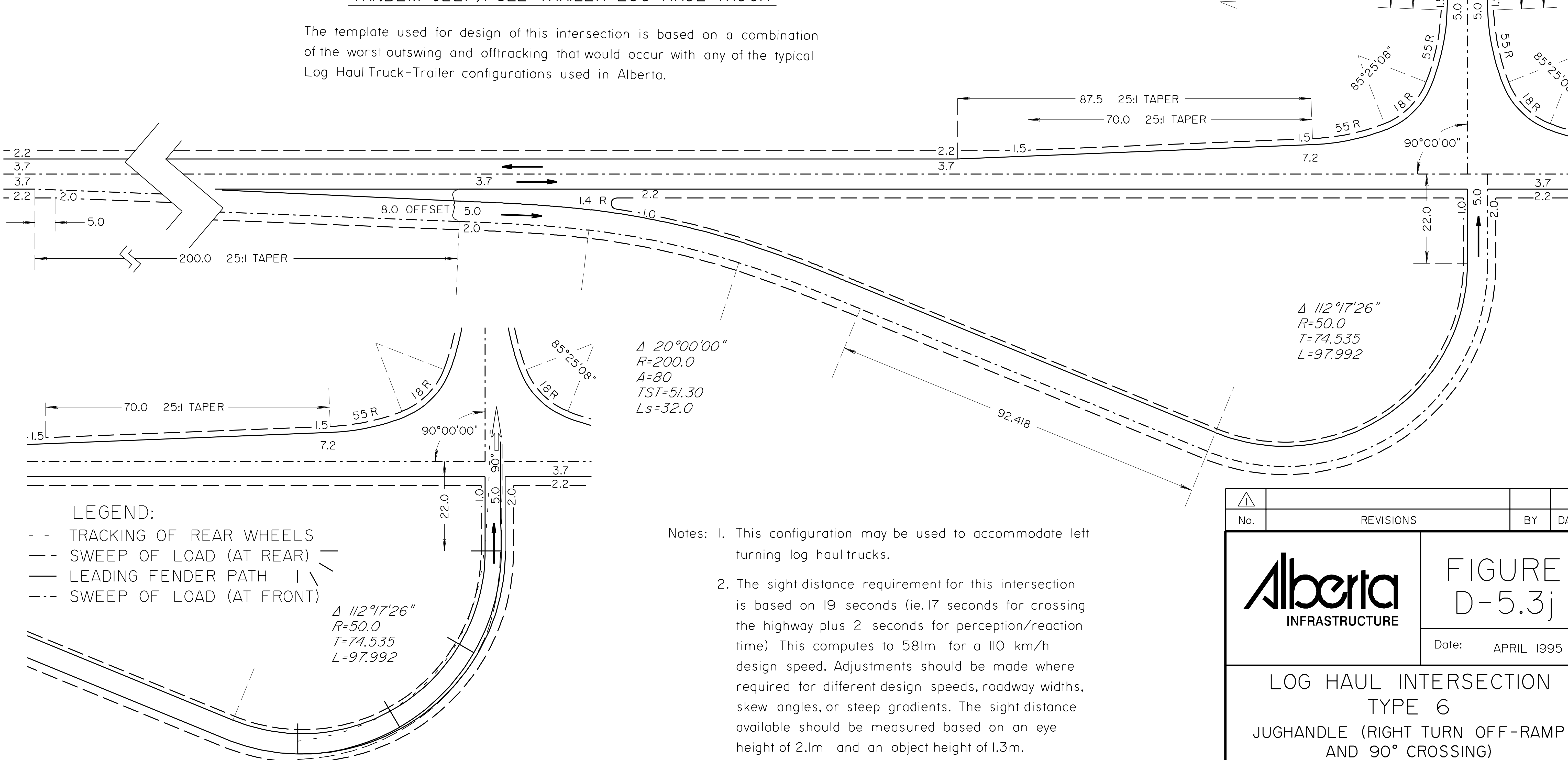
LOG HAUL INTERSECTION
TYPE 5c
LEFT TURN FROM MAJOR ROAD
WITH NARROW SHOULDER

Prepared By: Cgk.	Checked By: B.K.	Scale: N.T.S.	PAGE D-81



TANDEM-JEEP/POLE-TRAILER LOG HAUL TRUCK

The template used for design of this intersection is based on a combination of the worst outswing and offtracking that would occur with any of the typical Log Haul Truck-Trailer configurations used in Alberta.



Notes: 1. This configuration may be used to accommodate left turning log haul trucks.

2. The sight distance requirement for this intersection is based on 19 seconds (ie. 17 seconds for crossing the highway plus 2 seconds for perception/reaction time) This computes to 581m for a 110 km/h design speed. Adjustments should be made where required for different design speeds, roadway widths, skew angles, or steep gradients. The sight distance available should be measured based on an eye height of 2.1m and an object height of 1.3m.

No.	REVISIONS	BY	DATE

Alberta INFRASTRUCTURE

FIGURE D-5.3j

Date: APRIL 1995

LOG HAUL INTERSECTION TYPE 6

JUGHANDLE (RIGHT TURN OFF-RAMP AND 90° CROSSING)

Prepared By: Cgk	Checked By: B.K.	Scale: N.T.S.	PAGE D-83

GRAPHICS FILE: debd53j.man

D.5.4 Bulbing of Service Road Intersections to Accommodate Design Vehicles

Where service roads are built parallel to main (or through) highways usually in a 30m wide right of way adjacent to highway right of way, bulbing is frequently required at intersections. Bulbing allows larger vehicles to leave the service road and come to a stop at the highway intersection without blocking the intersecting road. This is normally made possible through the construction of bulbing, as shown in Figure D-5.4. The typical bulbing shown will accommodate the off-tracking of a WB-23 B-Train design vehicle. This is normally the largest vehicle that will have to be accommodated. However, if some other design vehicle is chosen, the layout may be designed and checked using the appropriate turning templates.

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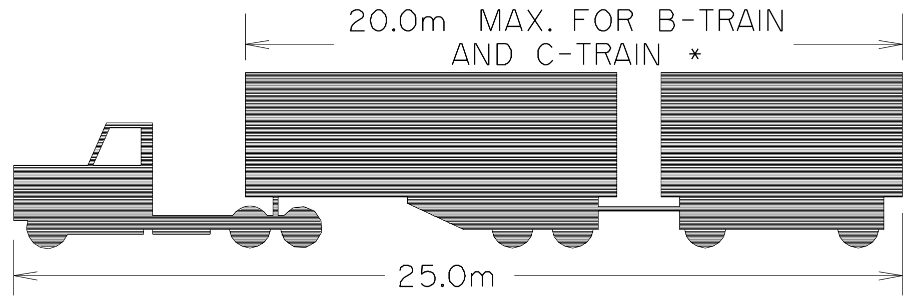
DOUBLE TRAILER COMBINATION



* MAXIMUM FOR A-TRAIN IS 18.5m IN ALBERTA

NOTES:

1. THE TYPICAL BULBING SHOWN ON THIS PLAN WILL ACCOMODATE THE OFFTRACKING OF A 25m LONG B-TRAIN TRUCK-TRAILER COMBINATION AS SHOWN IN THE SKETCH.
2. DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT, EXCEPT WHERE OTHERWISE SPECIFIED.
3. TRAFFIC FLOW ARROW

SCALE

0 10 25 50 75 100

No.		BY	DATE

Alberta INFRASTRUCTURE

FIGURE D-5.4

Date: APRIL 1995

STANDARD BULBING FOR UNDIVIDED HIGHWAY (FOR WB-23 B-TRAIN)

Prepared By: Cgk.	Checked By: B.K.	Scale: N.T.S.	PAGE D-87

Graphics File: debd54.man

D.6 INTERSECTION ELEMENTS - TWO-LANE UNDIVIDED HIGHWAYS

At-grade intersections fall into three classes, as follows:

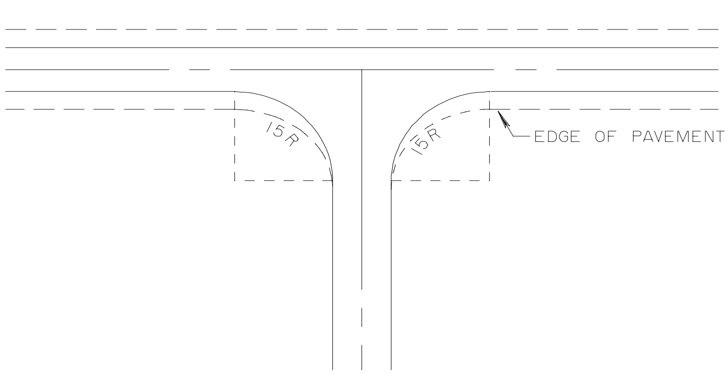
1. Simple Intersection (Type I)
2. Flared Intersection (Type II, III and IV)
3. Channelized Intersection (Type V)

D.6.1 Simple Intersection (Type I)

A simple intersection design is used where there are low turning volumes and low turning speeds. This design is most commonly used at private intersections, such as road allowances, farm or field entrances on rural highways. A simple intersection is illustrated below.

The selection of an appropriate radius of curve is dependent on the type of intersecting road, the vehicles to be accommodated and the angle of intersection. (See Table D-5.2.a.)

FIGURE D-6.1 SIMPLE INTERSECTION (TYPE I)



D.6.2 Flared Intersections with Auxiliary Lanes or Tapers (Type II, III or IV)

Flared intersections provide extra lanes and/or tapers for the movements of through or turning traffic. The introduction of auxiliary lanes, in units of 3.5m width, may be located on either side of the through lanes in the same direction of travel.

D.6.2.1 Deceleration

D.6.2.1.1 Deceleration Requirements at Undivided Highway Intersections

The deceleration length required by turning vehicles on intersection approaches depends on the assumed running speed of the approach, which is normally linked to the design speed, the grade on the approach, the manner in which deceleration occurs and the speed at which turning takes place. In the case of flared intersections it is assumed that vehicles must stop prior to turning. However, at channelized intersections, vehicles may make a right turn at the speed permitted by the controlling radius of the turning roadway. For design purposes, a deceleration rate of 0.25g (2.45m/sec^2) is assumed to occur uniformly from the assumed running speed to the turning speed. This rate is commonly considered to be the limit of comfortable braking, even though deceleration rates as high as 0.375g can be achieved on wet pavements without loss of control. The braking capability of loaded trucks generally exceeds 0.25g unless the vehicle is overloaded or has malfunctioning brakes.

In Alberta, the deceleration lengths used for design purposes have been adopted from TAC (Manual of Geometric Design Standards for Canadian Roads, 1986) for all design speeds from 60 km/h to 100 km/h. In each case, the distance required for deceleration has been determined based on a deceleration rate of 0.25g and an assumed running speed for each design speed. For design speeds of 130, 120 and 110 km/h, the 85th percentile running speeds recorded in Alberta exceed the assumed running speeds used by TAC. For this reason, the higher speeds were used. For 50 km/h, TAC does not provide a deceleration distance so a value was adopted based on interpolation and reference to the Ontario design manual.

Table D.6.2.1.1 shows the deceleration distances recommended for approaches to a stopped position based on design speed.

Table D.6.2.1.1 Deceleration Distances to Stop

Design Speed (km/h)	Deceleration Distance Recommended by TAC (1986) (m)	Alberta 85th Percentile Running Speed (km/h)	Deceleration Distance Based on 0.25g Deceleration Rate (from Alta. 85%tile running speed)	Deceleration Distance used for Design in Alberta (m)
130	215	115	208.23	215
120	200	115	208.23	210
110	185	109	187.09	190
100	170	100	157.5	170
90	150	90	127.55	150
80	130	80	100.78	130
70	110	70	77.16	110
60	90	60	56.69	90
50	-	50	39.37	70

Formulae used:

$s = ½(v+u)t$ Where a $= -0.25g = -0.25(9.81)\ m/sec^2$
$u = a(t)$ s is the deceleration distance (m)
v is the final speed (m/sec)
u is the initial speed (m/sec)
t is the deceleration time (sec)

D.6.2.1.2 Deceleration Treatment

Full provision for deceleration is only required at intersections where exclusive turning lanes are warranted, that is, Type IV and Type V only. On other intersections, because of the combination of low turning volumes and low through traffic, the occurrence of conflicts involving turning vehicles is relatively low. In this case, the cost of providing deceleration lanes cannot be justified.

On Type IV flared intersections, it is assumed that for left turns 1/2 of the taper and all of the parallel lane is available for deceleration. For right turns on Type IV intersections, it is assumed that the entire taper and all of the parallel lane is available for deceleration.

On Type V (channelized) intersections, left turn deceleration lanes may include half of the length of the reverse parabolic curves as part of the deceleration length where they are protected by a raised median. Right turn deceleration length requirements at channelized intersections are reduced based on the turning roadways controlling radius. This is described in Section D.6.3.3.

The provision of deceleration lanes on divided highway intersections is discussed in Section D.8.

D.6.2.2 Right Turn Taper

Right turn tapers are used to facilitate the movements of right turning traffic. The taper design provides the driver with a natural transition off of the through travel lane, on which vehicles can decelerate prior to turning right. In conjunction with the right turn taper, a so-called recovery taper is provided beyond the intersection. In combination, the right turn and recovery tapers provided a means for through traffic to manoeuvre around a standing left turning vehicle in the travel lane. Individually, the recovery taper facilitates the movements of traffic turning right off of the intersecting roadway, onto the through highway.

D.6.2.3 Right Turn Taper with Parallel Deceleration Lanes

If the volume of right turning vehicles is sufficient to create hazards and reduce capacity at an intersection, consideration should be given to provide a deceleration lane in the form of a taper and parallel lane. The warrant for right turn lanes is provided in Section D.7.7. The standard right turn lane design provides for vehicle deceleration and a limited storage space, which aids in keeping the through travel lanes clear of turning traffic. The length of taper and parallel lane varies with design speed (as related to deceleration rates) and grade on the main highway (see Figures D-7j, D-7k, D-7l and D-7m and Table D.6.2.6). It is assumed for design purposes that deceleration can occur over the full length of taper and parallel lane. As with the right turn taper design, a recovery taper is provided beyond the intersection. It is rarely necessary to provide an acceleration lane for vehicles turning right off the intersecting road, unless warranted by special circumstances. Generally the recovery area and taper are adequate to provide for the right turn movement off the intersecting road.

D.6.2.4 Standard Left Turn Lanes

Left turn lanes are required when conflicts between through and left turning traffic cause congestion or create collision hazards at intersections. On two-lane highways, the left turn lane is created through the introduction of a third or by-pass lane, on the right or outside of the original through lanes (see Figures D-7j, D-7k and D-7l).

The length of the parallel portion of the left turn lane is dependent on the design speed on the major highway. Figures D-7j, D-7k and D-7l give design lengths for standard left turn and bypass lanes on two-lane undivided highways for T and four-leg intersections. Figure D-7k provides a layout for cases where an exclusive left turn lane is warranted for one movement only. Figure D-7l provides a layout for cases where exclusive left turn lanes are warranted for two movements. These lengths provide for vehicle deceleration to a stopped position with a built in fixed storage length (see Table D.7.6b), and do not account for additional storage requirements, the effect of trucks on storage lengths, or the effect of grade on deceleration lengths. See Figures D-7.6-1a through D-7.6-7d and Tables D.7.6a and D.6.2.6, respectively. Where these above mentioned factors affect design lengths, the required changes are always applied to the parallel section of the deceleration lane. In determining design lengths, deceleration is assumed to begin halfway along the taper from the introduction of the lane taper.

D.6.2.5 Bypass Lanes

Bypass lanes, used in conjunction with standard left turn lanes, carry through traffic past standing left turning vehicles. Bypass lane length is based on the length of the left turning lane, which varies with left turning volumes, highway grade and design speed. A taper ratio of 40:1 for design speeds of 50 km/h to 80 km/h and 60:1 for higher design speeds, is used in transitioning into and out of the bypass lane.

D.6.2.6 Effect of Grade on Parallel Deceleration Lanes

Lengths of deceleration lanes are affected by grade. That is, deceleration distances are longer on downgrades and shorter on upgrades. For highway grades greater than two percent, the length of the deceleration lane should be multiplied by one of the factors shown in Table D.6.2.6 below:

Table D.6.2.6 Ratio of Length on Grade to Length on Level

Speed (km/h)	Grade (%)	Upgrade Ratio	Downgrade Ratio
all speeds	2 to 3	0.95	1.10
	3 to 4	0.90	1.20
	4 to 5	0.85	1.30
	5 to 6	0.80	1.35

D.6.3 Channelized Intersections

Channelization occurs when traffic is directed into definite paths through the use of islands. Channelization is normally applied to higher volume intersections, especially those that warrant both left and right exclusive turn lanes. The channelization serves to separate the streams of traffic, reduce the pavement width at the crossing and simplify the operation of the intersection. Channelization is also applied to intersections having large paved areas, such as those with large corner radii and those at oblique angle crossings.

The following principles should be adhered to in the design of a channelized intersection:

1. The proper traffic channels should seem natural and convenient to drivers and pedestrians.

2. There should be only one well defined vehicle path to a destination. This eliminates the need for driver selection of travel path.

3. Channelization should be clearly visible. It should not be introduced where sight distance is limited. When an island must be located near a high point in the roadway profile, or near the beginning of a horizontal curve, the approach end of the island

must be extended so that it will be obvious to the approaching drivers.

4. The main (or through) traffic flow should be favored. When curved alignment is unavoidable at intersections, the highway with the heavier traffic volumes and higher speed should have the flatter curvature.

5. Conflicts should be separated enabling drivers and pedestrians, at each conflict point, to make only one decision at a time.

6. The number of islands should be reduced to a practical minimum, to avoid confusion.

7. Islands should be large enough to be effective. Islands that are too small are ineffective as a method of guidance and often present problems in maintenance. The type of fill to be used for raised islands depends on local preference, aesthetic and maintenance considerations. Small islands should generally be asphalt fill or concrete fill to ensure low maintenance. Earth fill, to be seeded with grass, is generally only used on very large islands, or long medians, that exceed 6m in width. Where median width is reduced to allow provision of turning lanes, usually to 2.5m, a low maintenance fill (concrete or asphalt) is generally used instead of grass due to difficulty of grass cutting. A painted island may be used where the area between turning lane and through lanes is less than 6m^2. Generally, a raised pork chop island may be used for areas not less than 6m^2 in area. For pedestrian accommodation at least 10m^2 is preferred. Where the island is large enough to allow drainage of the central area, a depressed island is preferred, especially in rural areas.

8. The approach end treatment and delineation of islands should be consistent with the design speed of the roadway.

9. In a high speed rural environment, the use of raised median islands is not appropriate, due to the potential hazard to high speed traffic and the likelihood of snow drifting in the vicinity of the curb. Snowdrifts at raised medians or islands, in a rural setting, result in much higher maintenance costs because of the need to use special heavy equipment (loaders) to remove the snow. Depressed islands, as shown on Figure D-6.3.1a, are preferred in rural situations. In lower speed suburban or urban environments, the use of semi-mountable type curbs to provide raised islands and medians is permitted. (See Figure D-6.3.1b.) Although semi-mountable curbs are generally preferred (over barrier curbs) for all arterial roadways, barrier curb is permitted for design speeds of 70 km/h and less. However, barrier curb should not be used in combination with a rigid barrier system.

10. Where raised islands or medians are used, illumination is generally required for safety.

D.6.3.1 Islands

An island is a defined area between traffic lanes for control of vehicle movements or for pedestrian refuge. Islands may be delineated by a variety of alternative treatments, depending on size, location and function.

Directional

Directional islands control and direct traffic movements and should guide the driver into the proper travel path for his intended route. Directional islands are generally of a triangular shape when separating right turning traffic from through traffic. For rural highway design, where there is sufficient space for large radius intersection curves, the directional island consists of a non-paved, depressed area, formed by pavement edges and delineated by reflectorized guide posts. This type of island treatment is desirable since snow removal operations can be effected efficiently. Directional islands should be designed both individually and from the standpoint of comprehensive treatment of the intersection.

Divisional

Divisional islands are introduced at intersections, usually on approach legs, to separate streams of traffic travelling in the same direction. These islands are of particular advantage in controlling left turns at skewed intersections and at locations where separate travel path is provided for right turning traffic. When a roadway is widened to include a divisional island, it should be done in such a manner that the proper travel paths are unmistakably evident to drivers. The alignment should require no appreciable conscious effort in vehicle steering. Where the highway is on tangent, reverse curve alignment is necessary to introduce divisional islands. A raised median on an approach leg may be regarded as a divisional island in the vicinity of the intersection.

Refuge

Refuge or pedestrian islands are used to protect and aid pedestrians crossing a highway or for loading or unloading transit riders. In congested areas, refuge islands also expedite vehicular traffic by permitting vehicles to proceed without waiting for pedestrians to cross the entire roadway. Refuge islands vary in relation to pedestrian volumes and needs, the widths of crosswalks, intersection layout and design constraints such as available right of way. The general principles for island design also apply to refuge islands except that barrier curbs are used. Curb cuts are used where crosswalks go through refuge islands.

In studying the need for refuge islands, consideration should be given to the width of pavement, proximity of traffic signals, right and left turning movements at intersections, sight distance and any other factors which might have a bearing on the proposed installation. No refuge or loading island should be placed where it will be separated by fewer than two traffic lanes from an adjacent curb, edge of pavement or other island.

FIGURE D-6.3.1a DIRECTIONAL ISLANDS

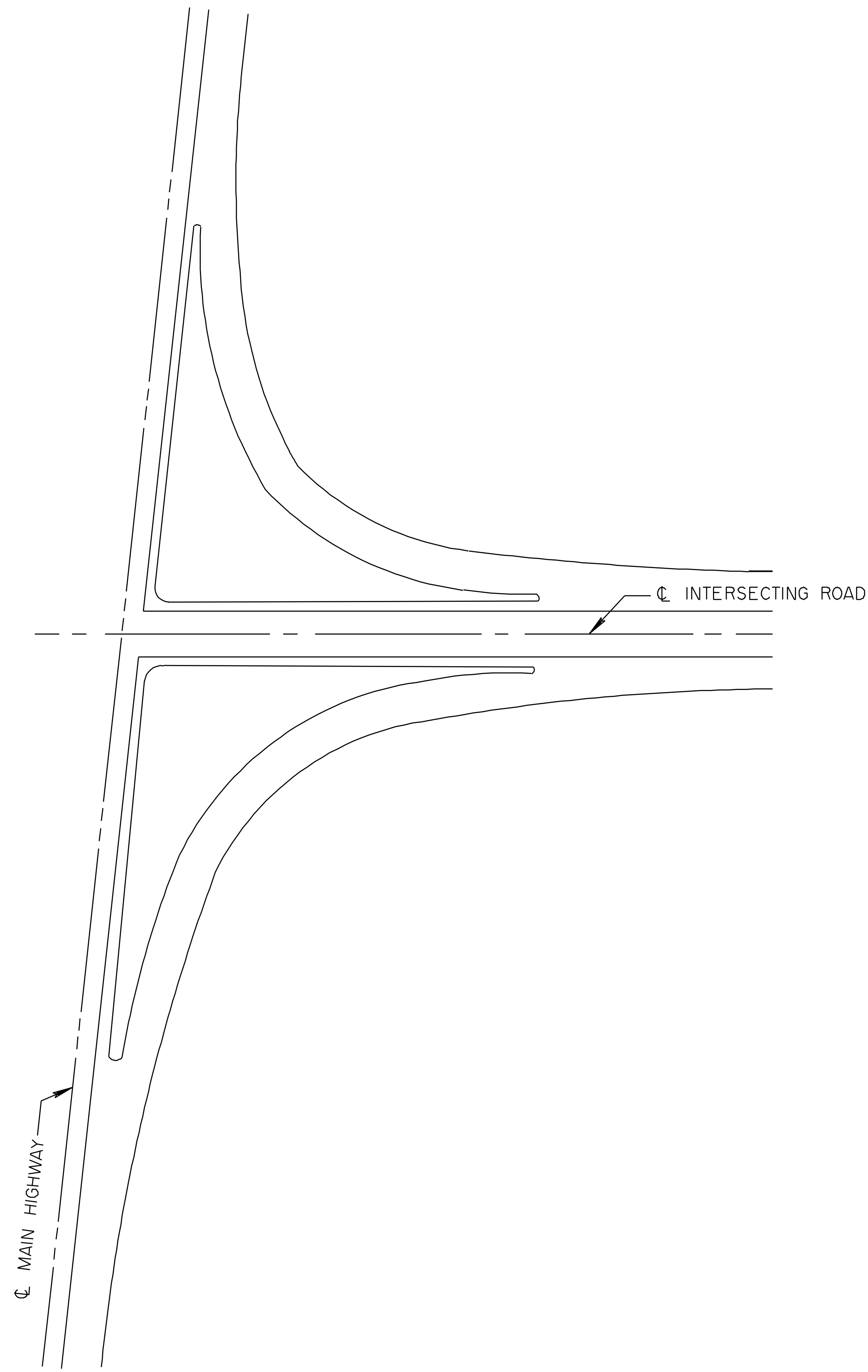


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FIGURE D-6.3.1b DIVISIONAL ISLANDS

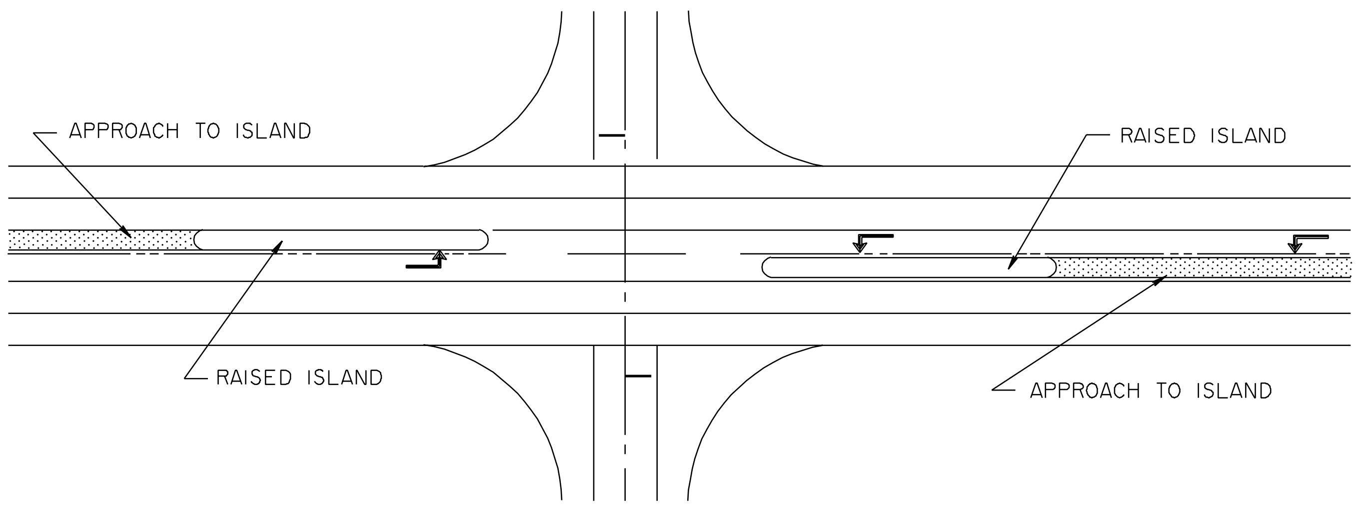
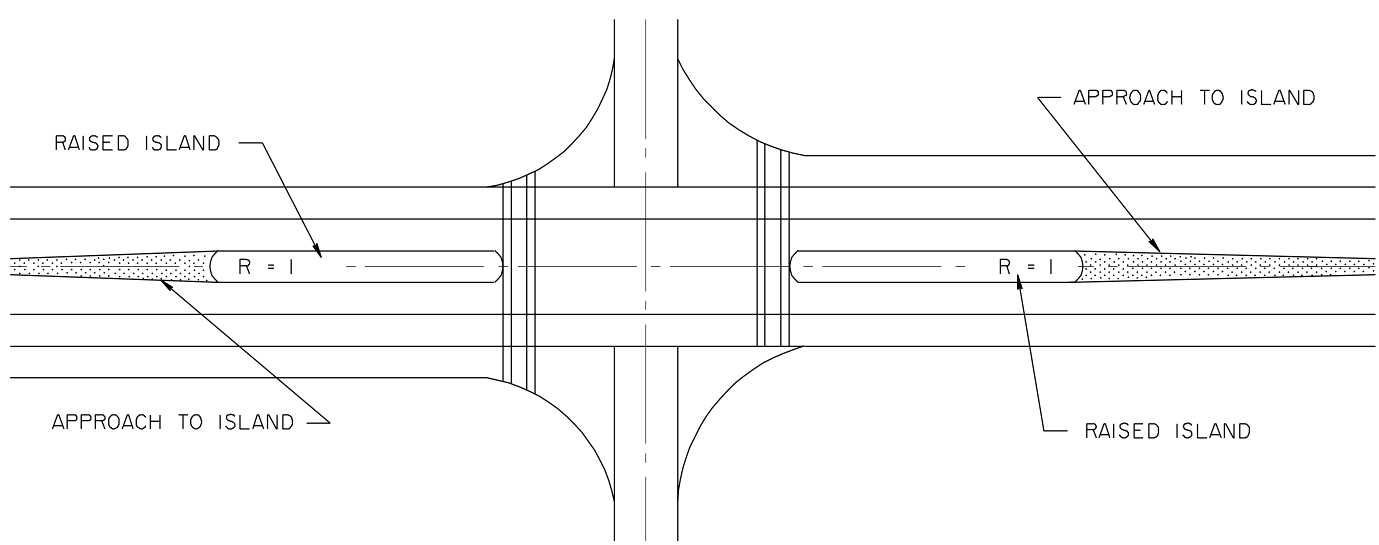


FIGURE D-6.3.1c REFUGE ISLANDS



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D.6.3.2 Turning Roadway Widths

Pavement widths of turning roadways depend jointly upon the dimension of the design vehicle and the radius of the turning roadway. Selection of the vehicle for design is based upon the size and frequency of vehicle types. For general design use, the pavements usually must accommodate more than one type of vehicle. Combinations of separate design vehicles become the practical design guide for intersection pavements.

Widths shown in Table D.6.3.2 Case II C should be used for general design purposes. These allow the SU design vehicle to pass another stalled SU design vehicle at a low speed and with restricted clearance. However, where a larger design vehicle such as WB-21 will be using a turning roadway or ramp on a regular basis, the facility should accommodate their turning paths for the Case I condition as a minimum. The widths required by a WB-21, which is the largest semi-trailer combination that can travel on Alberta highways without a special permit, are shown in Table D.6.3.2.

The widths in Table D.6.3.2 ignore the effect of insufficient superelevation and of surfaces with low frictional resistance. These tend to cause the rears of vehicles travelling at other than low speeds to swing outwards, developing the necessary slip angles.

Table D.6.3.2 Design Widths for Turning Roadways at Rural Intersections

Minimum Pavement Width (m)										
R radius on inner edge of pavement (m)	**Case I one-lane, one-way operation no provision for passing**				**Case II one-lane, one-way operation with provision for passing a stalled vehicle**			**Case III two-lane operation either one-way or two-way**		
design traffic condition vehicle accommodation type	**A (P)**	**B (SU)**	**C (WB-12)**	**D (WB-21)**	**A (P-P)**	**B (P-SU)**	**C (SU-SU)**	**A (P-SU)**	**B (SU-SU)**	**C (WB-12-WB-12)**
15	5.4	5.4	7.0	9.1	7.0	7.6	**8.8**	9.4	11.0	13.1
25	4.8	5.2	5.8	7.8	6.4	6.8	**8.1**	8.7	9.8	11.4
35	4.5	5.0	5.4	7.1	6.0	6.6	**7.5**	8.4	9.4	10.4
45	4.2	4.8	5.2	6.6	5.8	6.4	**7.3**	8.2	9.0	10.0
60	4.2	4.8	5.0	6.0	5.8	6.4	**7.2**	8.2	8.8	9.4
80	4.0	4.8	5.0	5.7	5.8	6.2	**7.0**	8.0	8.6	9.4
100	4.0	4.8	5.0	5.4	5.5	6.2	**6.8**	8.0	8.5	9.0
125	4.0	4.6	4.8	5.2	5.5	6.0	**6.8**	8.0	8.4	8.8
150	3.7	4.6	4.6	5.1	5.5	6.0	**6.7**	7.8	8.4	8.8
tangent	3.7	4.6	4.6	5.1	5.2	5.8	**6.4**	7.6	8.2	8.2
	Width Adjustment for Edge of Pavement Treatment									
mountable curb	none				none			none		
barrier curb										
one side	add 0.25m				none			add 0.25m		
two sides	add 0.5m				add 0.25m			add 0.5m		

Note:
1. The combination of vehicle accommodation type letters, such as P-SU for Case II, means the pavement width allows a P design vehicle to slowly pass by a stalled SU design truck or vice versa.
2. Case II C is generally used in Alberta.

D.6.3.3 Deceleration Lanes for Turning Roadways

Deceleration lanes, in conjunction with turning roadways on at-grade intersections, take the form of a taper or taper and parallel deceleration lane design. The parallel lane is introduced by an 87.5m at 25:1 taper for design speeds up to 110 km/h and 140m at 40:1 taper for design speeds of 120 km/h or more. This taper develops a full 3.5m lane width with a 1.5m shoulder. The length of parallel deceleration lane is based on three factors in combination:

1. The speed at which drivers manoeuvre onto the deceleration lane
2. The controlling curve radius' speed
3. The manner in which deceleration takes place.

Table 1 in Figure D-6.3.3 gives deceleration lengths for turning roadways based on these factors. Table 2 in Figure D-6.3.3 shows adjustment factors to be used when deceleration occurs on grade.

A detailed description of the method of calculating deceleration requirements is discussed in Section D.6.2.1.1.

D.6.3.4 Acceleration Lanes on Turning Roadways

Acceleration lanes, in conjunction with turning roadways on at-grade intersections, take the form of parallel lane and/or taper design. The length of the acceleration lane is based on three factors in combination:

1. The speed at which drivers merge with the through traffic
2. The speed at which drivers enter the acceleration lane, and
3. The manner of accelerating.

The taper design which merges the turning traffic with through traffic is a constant 210m at 60:1. Table 1 on Figure D-6.3.4 gives acceleration lengths for turning roadways based on these factors. Table 2 shows adjustment factors to be used when acceleration occurs on grade.

FIGURE D-6.3.3 DECELERATION LENGTHS ON TURNING ROADWAYS

DESIGN LENGTHS FOR DECELERATION LANES
(FOR GRADES OF 2% OR LESS)

DESIGN SPEED OF TURNING ROADWAY (km/h)		STOP CONDITION	25	30	40	50	60
MIN. RADIUS OF CURVE (m)			20	30	55	90	130
MIN. SPIRAL PARAMETER			-	-	50	65	85
			3 CENTRE CURVE	3 CENTRE CURVE	SPIRAL CURVE	SPIRAL CURVE	SPIRAL CURVE
HIGHWAY DESIGN SPEED (km/h)	LENGTH OF TAPER (m)	TOTAL LENGTH OF DECELERATION LANE INCLUDING TAPER (m)					
50	87.5 AT 25:1	70	87.5	87.5	87.5	87.5	87.5
60	87.5 AT 25:1	90	87.5	87.5	87.5	87.5	87.5
70	87.5 AT 25:1	110	87.5	87.5	87.5	87.5	87.5
80	87.5 AT 25:1	130	95	90	87.5	87.5	87.5
90	87.5 AT 25:1	150	125	120	110	95	87.5
100	87.5 AT 25:1	170	150	145	140	120	110
110	87.5 AT 25:1	190	180	175	165	150	135
120	140 AT 40:1	210	200	195	185	170	155
130	140 AT 40:1	215	205	200	190	175	160

TABLE No. 1

RATIO OF LENGTH OF DECELERATION
LANES ON GRADE TO LENGTH ON LEVEL

km/h	PERCENT	UPGRADES ALL SPEEDS	DOWNGRADES ALL SPEEDS
ALL SPEEDS	2 to 3	0.95	1.1
	3 to 4	0.9	1.2
	4 to 5	0.85	1.3
	5 to 6	0.8	1.35

TABLE No. 2

NO DECELERATION LANE, INCLUDING TAPER, SHOULD BE LESS THAN 122m. SEE NOTE BELOW.

NOTES:

1. MINIMUM LENGTH OF DECELERATION LANES ON GRADES OF LESS THAN 2% ARE SHOWN IN TABLE No. 1 FOR DIFFERENT DESIGN SPEEDS. TO OBTAIN MINIMUM LENGTH OF DECELERATION LANES ON GRADES IN EXCESS OF 2%, MULTIPLY THE LENGTH SHOWN IN TABLE No. 1 BY THE APPROPRIATE RATIO FROM TABLE No. 2. LENGTHS SHOWN ABOVE THE HEAVY LINE IN TABLE No. 1 ARE TO BE USED ONLY FOR MUTIPLICATION PURPOSES WHEN USING THE RATIO FROM TABLE No. 2. NO DECELERATION LANE, INCLUDING TAPER, SHOULD BE LESS THAN 122m.

2. THE VALUES FOR DECELERATION LANE LENGTH SHOWN IN THIS TABLE ARE BASED ON A COMFORTABLE DECELERATION RATE OF 1/4 GRAVITY (2.5m/sec²), FROM THE 85th PERCENTILE RUNNING SPEED ON THE HIGHWAY TO THE DESIGN SPEED ON THE TURNING ROADWAY. VALUES ARE ROUNDED UP FOR DESIGN PURPOSES.

$$S = \frac{v^2 - u^2}{2a}$$

S = deceleration distance (m)
a = deceleration rate (m/sec²)
v = initial speed (m/sec)
u = final speed (m/sec)

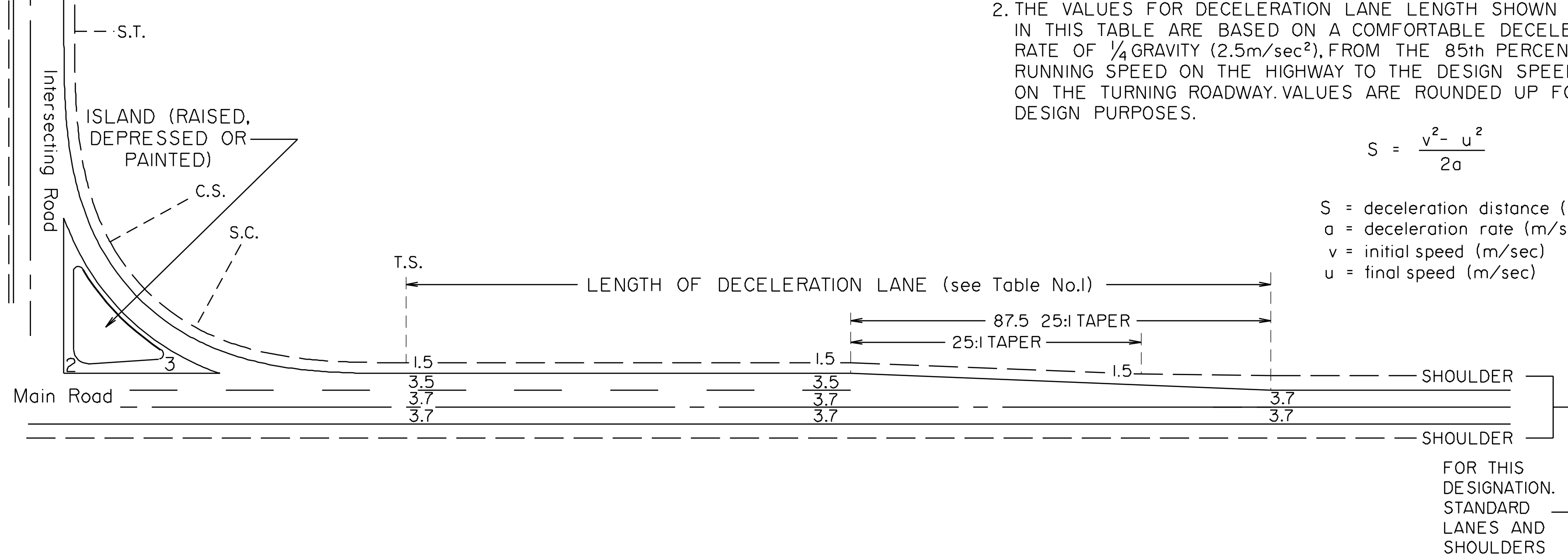


FIGURE D-6.3.4 ACCELERATION LENGTHS ON TURNING ROADWAYS

DESIGN SPEED OF TURNING ROADWAY (km/h)		STOP CONDITION	25	30	40	50	60
MIN. RADIUS OF CURVE (m)			20	30	55	90	130
MIN. SPIRAL PARAMETER			-	-	50	65	85
HIGHWAY DESIGN SPEED (km/h)	LENGTH OF TAPER (m)	TOTAL LENGTH OF ACCELERATION LANE INCLUDING TAPER (m)					
50	210.0 AT 60:1	-	50	45	25	-	- **
60	210.0 AT 60:1	-	85	80	60	30	-
70	210.0 AT 60:1	-	125	120	100	70	35
80	210.0 AT 60:1	-	175	170	150	120	80
90	210.0 AT 60:1	-	240	230	210	180	140
100	210.0 AT 60:1	-	315	305	285	255	215
110	210.0 AT 60:1	-	405	390	370	340	300
120	210.0 AT 60:1	-	505	495	475	445	405
130	210.0 AT 60:1	-	510	500	480	450	410

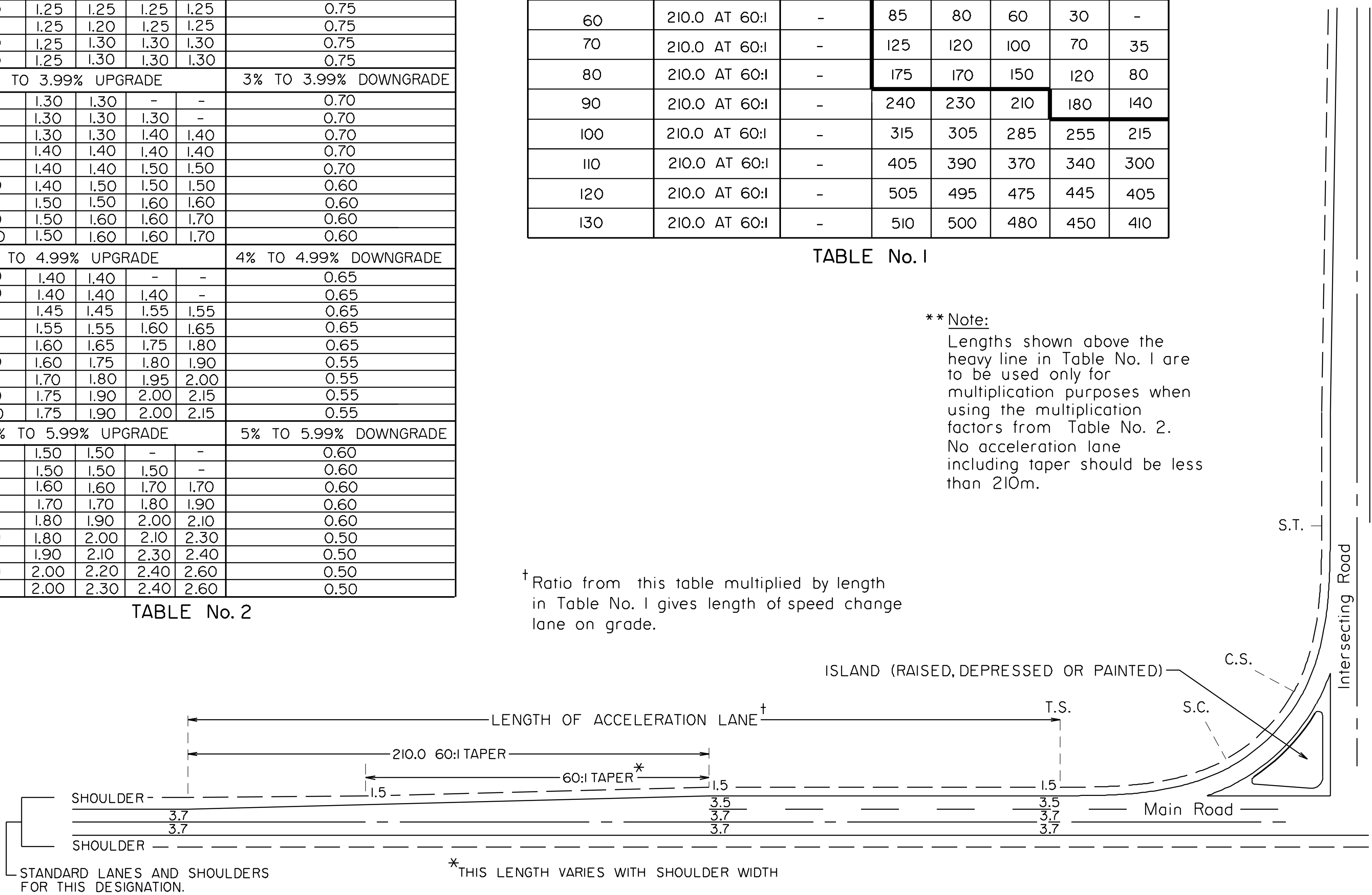
TABLE No. 1

** Note:
Lengths shown above the heavy line in Table No. 1 are to be used only for multiplication purposes when using the multiplication factors from Table No. 2.
No acceleration lane including taper should be less than 210m.

HIGHWAY DESIGN SPEED (km/h)	† RATIO OF LENGTH ON GRADE TO LENGTH ON LEVEL				
	DESIGN SPEED OF TURNING ROADWAY CURVE (km/h)				
	30	40	50	60	ALL SPEEDS
2% TO 2.99% UPGRADE					2% TO 2.99% DOWNGRADE
50	1.20	1.20	-	-	0.75
60	1.20	1.20	1.20	-	0.75
70	1.20	1.20	1.25	1.25	0.75
80	1.20	1.25	1.25	1.25	0.75
90	1.20	1.25	1.25	1.25	0.75
100	1.25	1.25	1.25	1.25	0.75
110	1.25	1.20	1.25	1.25	0.75
120	1.25	1.30	1.30	1.30	0.75
130	1.25	1.30	1.30	1.30	0.75
3% TO 3.99% UPGRADE					3% TO 3.99% DOWNGRADE
50	1.30	1.30	-	-	0.70
60	1.30	1.30	1.30	-	0.70
70	1.30	1.30	1.40	1.40	0.70
80	1.40	1.40	1.40	1.40	0.70
90	1.40	1.40	1.50	1.50	0.70
100	1.40	1.50	1.50	1.50	0.60
110	1.50	1.50	1.60	1.60	0.60
120	1.50	1.60	1.60	1.70	0.60
130	1.50	1.60	1.60	1.70	0.60
4% TO 4.99% UPGRADE					4% TO 4.99% DOWNGRADE
50	1.40	1.40	-	-	0.65
60	1.40	1.40	1.40	-	0.65
70	1.45	1.45	1.55	1.55	0.65
80	1.55	1.55	1.60	1.65	0.65
90	1.60	1.65	1.75	1.80	0.65
100	1.60	1.75	1.80	1.90	0.55
110	1.70	1.80	1.95	2.00	0.55
120	1.75	1.90	2.00	2.15	0.55
130	1.75	1.90	2.00	2.15	0.55
5% TO 5.99% UPGRADE					5% TO 5.99% DOWNGRADE
50	1.50	1.50	-	-	0.60
60	1.50	1.50	1.50	-	0.60
70	1.60	1.60	1.70	1.70	0.60
80	1.70	1.70	1.80	1.90	0.60
90	1.80	1.90	2.00	2.10	0.60
100	1.80	2.00	2.10	2.30	0.50
110	1.90	2.10	2.30	2.40	0.50
120	2.00	2.20	2.40	2.60	0.50
130	2.00	2.30	2.40	2.60	0.50

TABLE No. 2

† Ratio from this table multiplied by length in Table No. 1 gives length of speed change lane on grade.



D.6.3.5 Curvature for Turning Roadways

Drivers turning at intersections at grade naturally follow transitional travel paths just as they do at higher speeds on the open highway. If facilities are not provided for driving in this natural manner, many drivers will deviate from the intended path and develop their own transition, sometimes to the extent of encroachment on other lanes, or on the shoulder. Provision for natural travel paths is best effected by the use of spiral transition curves.

Lengths of spirals for use at intersections are determined in the same manner as for open highways. On intersection curves, lengths of spirals may be shorter than on the open highway curves because drivers accept a more rapid change in direction of travel under intersection conditions. Minimum radii and spiral requirements for curves at intersections are shown in Table 1 of Figures D-6.3.3 and D-6.3.4.

D.6.3.6 Typical Layouts for Channelized Intersections

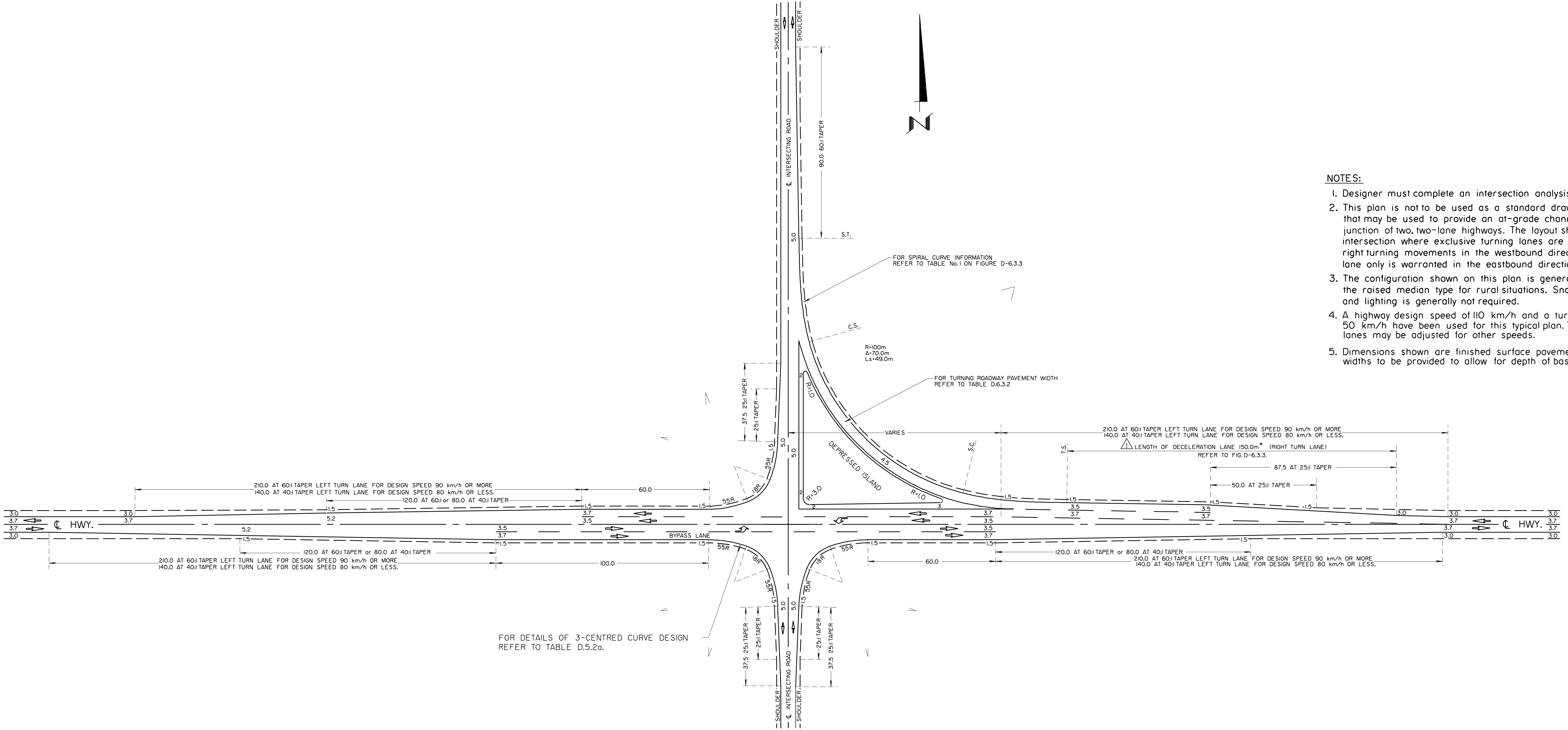
Examples of typical channelized intersection layouts for rural and semi-urban environments are shown in Figure D-6.3.6a and D-6.3.6b, respectively.

It is worth noting that the main difference between Figures D-6.3.6a and D-6.3.6b is that D-6.3.6a (recommended for rural settings) has no raised features and Figure D-6.3.6b (urban or semi-urban environments) has raised islands and medians. The use of raised structures above the pavement surface is not desirable in a rural setting because of:

- Potential snowdrifting, which results in less safe roads and higher snow-removal costs
- The need for special lighting and/or flashing lights to identify the beginning of the raised structure
- Possibly a need for a lower posted speed in the vicinity of the intersection because of the potential hazard presented by the curb.

Snow removal costs are higher because of the presence of more snow and the need for specialized equipment used for its removal (that is, a loader instead of a truck mounted snowplough used elsewhere on the highway system). When the additional costs for illumination and flashing lights, and the lower level of service resulting from the lower posted speed are included, the Figure D-6.3.6a typical intersection is considered far more suitable than Figure D-6.3.6b for a rural environment.

To summarize, raised medians and islands should be avoided, where possible, on high speed rural highways. Raised islands and medians are generally used only where necessary, due to physical constraints; for example, at the intersecting road junction on interchanges, where right-of-way is severely restricted or in urban fringe areas.



NOTES:

1. Designer must complete an intersection analysis to justify this treatment.
2. This plan is not to be used as a standard drawing. This is a typical layout that may be used to provide an at-grade channelized intersection at the junction of two, two-lane highways. The layout shown here is suitable for an intersection where exclusive turning lanes are warranted for both left and right turning movements in the westbound direction. An exclusive left turn lane only is warranted in the eastbound direction.
3. The configuration shown on this plan is generally more appropriate than the raised median type for rural situations. Snowdrifting is not a problem and lighting is generally not required.
4. A highway design speed of 110 km/h and a turning roadway design speed of 50 km/h have been used for this typical plan. Taper rates and auxiliary lanes may be adjusted for other speeds.
5. Dimensions shown are finished surface pavement widths. Additional subgrade widths to be provided to allow for depth of base course and pavement.

No.		BY	DATE
2			
1	RT. TURN DECEL. LANE TAPER CHANGED	R.M.	05/96

Alberta INFRASTRUCTURE

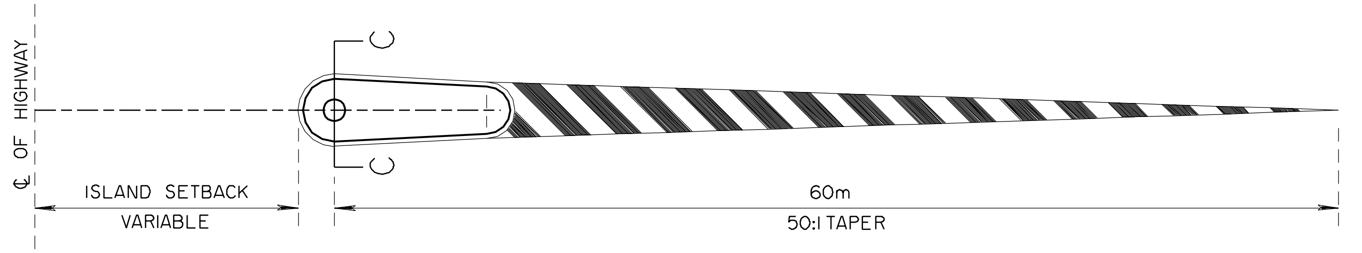
FIGURE D-6.3.6a

Date: APRIL 1995

INTERSECTION TREATMENT TYPE V(b) TYPICAL CHANNELIZED INTERSECTION (RURAL) (TWO-LANE HIGHWAY)

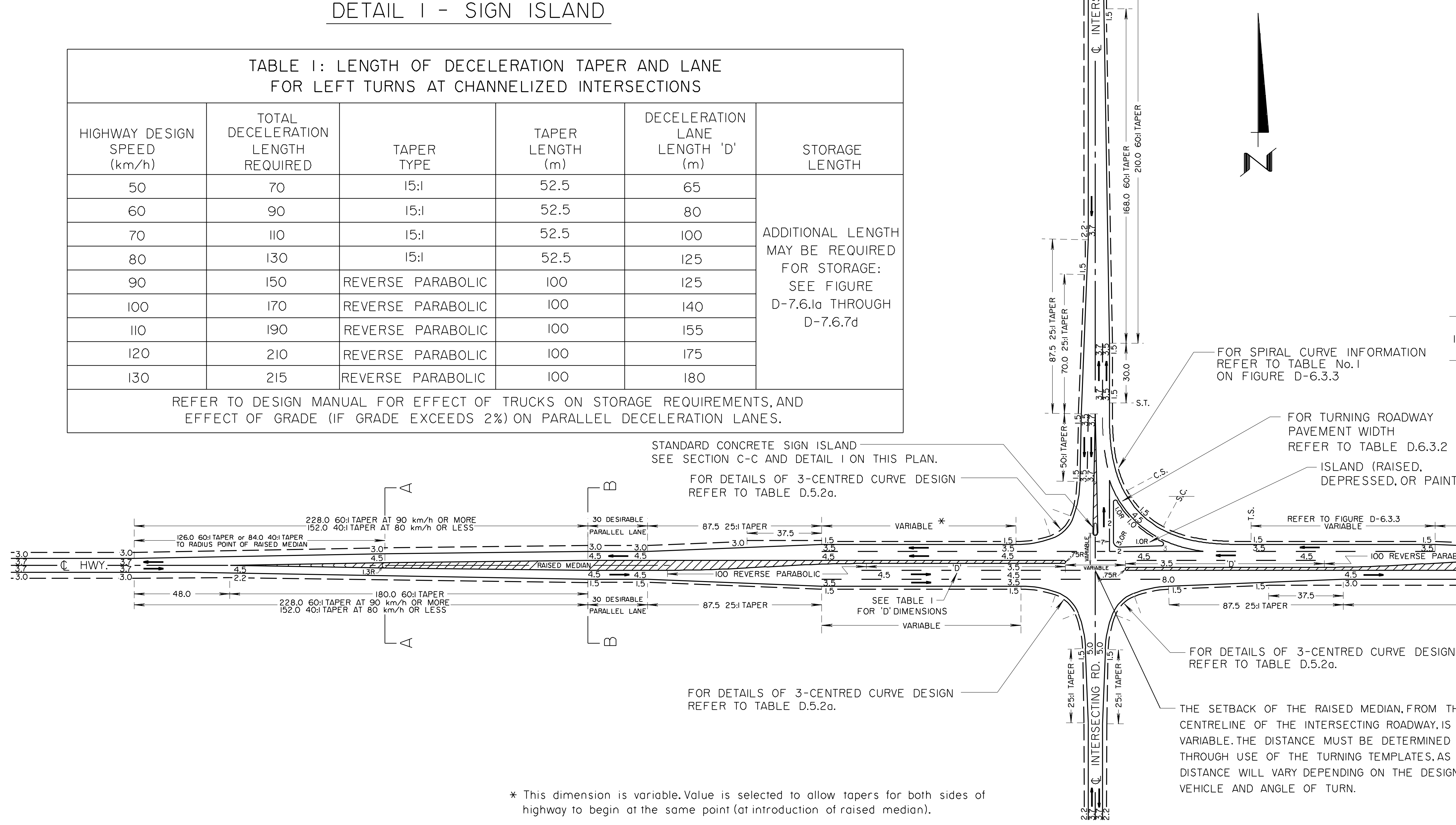
Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

Graphics File: debd636a.man



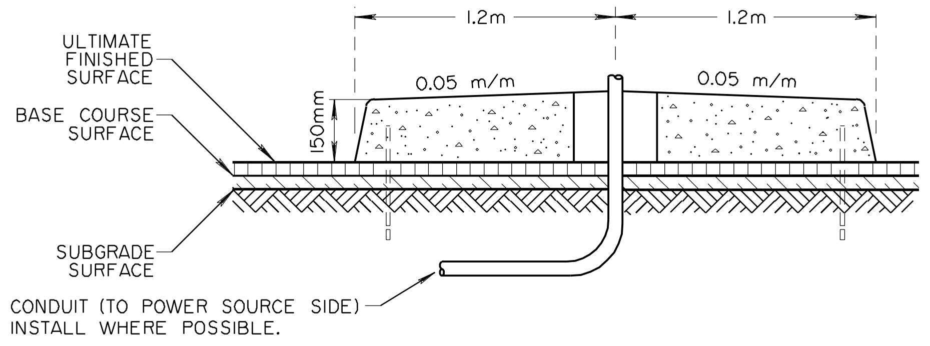
DETAIL I - SIGN ISLAND

TABLE I: LENGTH OF DECELERATION TAPER AND LANE FOR LEFT TURNS AT CHANNELIZED INTERSECTIONS					
HIGHWAY DESIGN SPEED (km/h)	TOTAL DECELERATION LENGTH REQUIRED	TAPER TYPE	TAPER LENGTH (m)	DECELERATION LANE LENGTH 'D' (m)	STORAGE LENGTH
50	70	15:1	52.5	65	ADDITIONAL LENGTH MAY BE REQUIRED FOR STORAGE: SEE FIGURE D-7.6.1a THROUGH D-7.6.7d
60	90	15:1	52.5	80	
70	110	15:1	52.5	100	
80	130	15:1	52.5	125	
90	150	REVERSE PARABOLIC	100	125	
100	170	REVERSE PARABOLIC	100	140	
110	190	REVERSE PARABOLIC	100	155	
120	210	REVERSE PARABOLIC	100	175	
130	215	REVERSE PARABOLIC	100	180	
REFER TO DESIGN MANUAL FOR EFFECT OF TRUCKS ON STORAGE REQUIREMENTS, AND EFFECT OF GRADE (IF GRADE EXCEEDS 2%) ON PARALLEL DECELERATION LANES.					

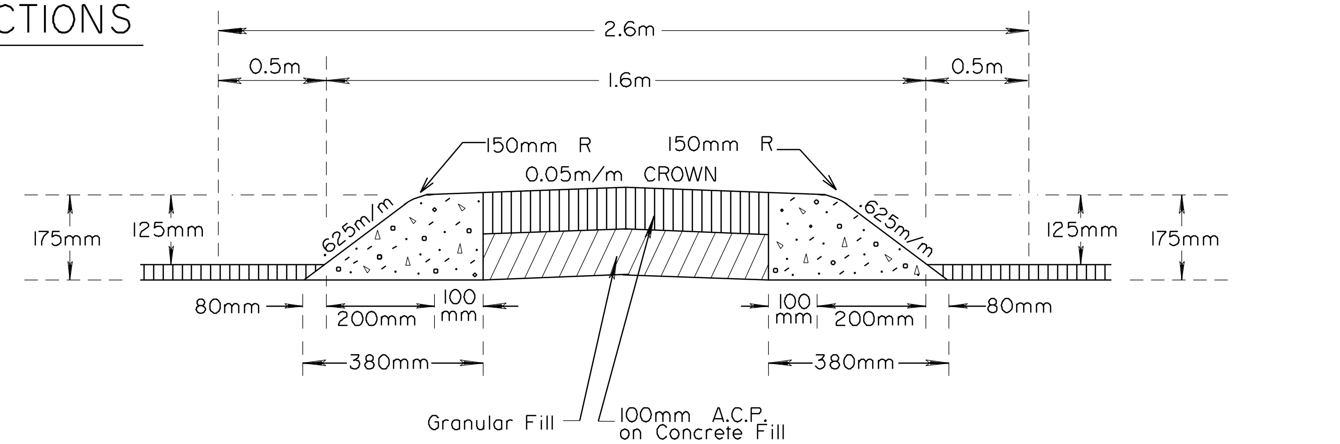


* This dimension is variable. Value is selected to allow tapers for both sides of highway to begin at the same point (at introduction of raised median).

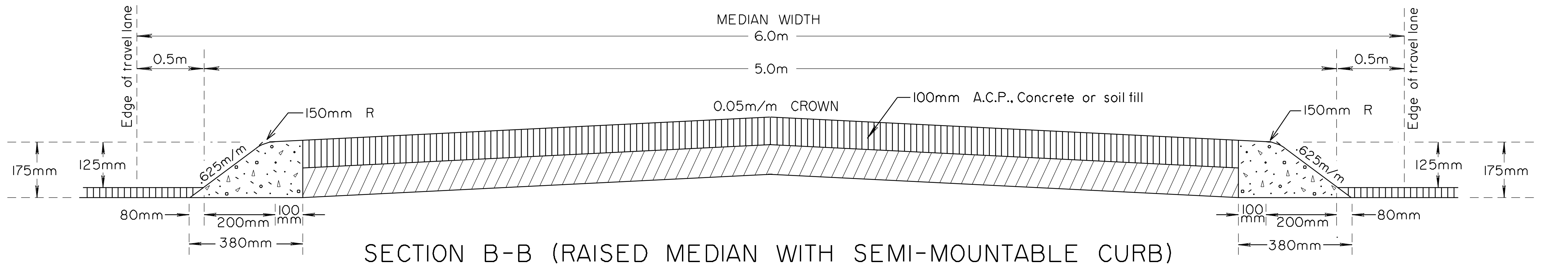
TYPICAL CROSS-SECTIONS



SECTION C-C (SIGN ISLAND)



SECTION A-A (RAISED MEDIAN WITH SEMI-MOUNTABLE CURB)



SECTION B-B (RAISED MEDIAN WITH SEMI-MOUNTABLE CURB)

NOTES:

1. Designer must complete an intersection analysis to justify this treatment.
2. This plan is not to be used as a standard drawing. This is a typical layout that may be used to provide an at-grade channelized intersection at the junction of two two-lane highways. The layout shown here is suitable for an intersection where exclusive turning lanes are warranted for both the left and right turning movements in the westbound direction. An exclusive left turn lane only is warranted in the eastbound direction.
3. This layout (because it includes raised medians and raised islands) is not as desirable for rural situations as the Type V(b) layout. The islands may cause some snow drifting, and lighting is generally required.
4. Taper ratio depends on design speed.

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FIGURE D-6.3.6b

Date: APRIL 1995

TYPICAL CHANNELIZED INTERSECTION TYPE V(c) SEMI-URBAN (RAISED ISLANDS AND MEDIANS) TWO-LANE HIGHWAY

Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

Graphics File: debd636b.man

D.6.4 Superelevation at Intersection Turning Roadways

D.6.4.1 Application of Superelevation on Turning Roadways

In general, the factors which control the maximum rates of superelevation on open highways, as discussed in Chapter B, apply to turning roadways at channelized intersections. It is desirable to provide as much superelevation as practical on intersection curves, particularly where the intersection curve is sharp and on a downgrade. Unfortunately, the practical difficulty of attaining superelevation without abrupt cross-slope change at turning roadway terminals, due primarily to sharp curvature and short lengths of turning roadway, often prevents the development of a desirable rate of superelevation. This fact has been recognized in use of low rates of superelevation for sharp curvature in the development of minimum radii for a given intersection design. (See Table D.6.4.1.)

The rate of cross-slope change on intersection curves, as on open highways, should vary with design speed. As the design speed is reduced, the length over which a change in superelevation can be made is reduced. Design values for rates of change in cross-slope are shown in Table D.6.4.1. The change in superelevation rate may be varied up to 25 percent above or below the values shown in Table D.6.4.1. Lower rates are applicable to wide pavements and the higher rates to the narrow pavements.

Table D.6.4.1 Design Values for Rate of Change of Cross-Slope for Turning Roadways

Design Speed (km/h)	25 and 30	40	50	55 and more
change in rate of superelevation				
m / m / 40m length	0.10	0.09	0.08	0.07
m / m / 10m length	0.03	0.022	0.020	0.016

D.6.4.2 Crossover Crown Line at Turning Roadways

The design control at the crossover crown line (not to be confused with the crown line normally provided at the centreline of a pavement) is the algebraic difference in cross-slope rates of the two adjacent pavements. Where both pavements slope down and away from the crossover crown line, the algebraic difference is the sum of their cross-slope rates. Where they slope in the same direction, it is the difference in their cross-slope rates.

Too great a difference in cross-slope may cause vehicles travelling over the crossover crown line, the ridge forming between the through pavement and the auxiliary pavement, to sway with possible hazard. When vehicles, particularly high bodied trucks, cross the crown line at other than low speeds and at an angle of about 10 to 40 degrees, the body throw may make vehicle control difficult and could result in an overturning.

Table D.6.4.2 gives the maximum algebraic difference in the cross slope rate between adjacent pavements for an acceptable crown line.

Table D.6.4.2 Maximum Algebraic Difference in Pavement Cross-Slope at Turning Roadways

Design Speed of Exit or Entrance Curve (km/h)	Maximum Algebraic Difference in Cross-Slope at Crossover Crown Line (m/m)
up to 30	0.06
30 to 50	0.05
50 and over	0.04

D.7 INTERSECTION TREATMENT - TWO-LANE UNDIVIDED HIGHWAYS

D.7.1 Introduction

The typical intersection treatment plans for two-lane undivided highways which follow (Figures D-7a through D-7m), do not show dimensions for lane width and shoulder width, but include tables giving those dimensions based on the highway design designation. On Type III treatments, the taper ratios are dependent on design speed. On Type IV treatments, the auxiliary lane lengths and taper ratios are dependent on design speed. For this reason, the Type III and IV plans provide tables which give the appropriate lane and taper lengths. Therefore, the typical plans that follow provide all of the intersection layout information required for design of two-lane undivided intersection treatments for all design designations and design speeds in a rural environment. For tendering and construction purposes a similar set of standard drawings are available from the CB-6 Manual which give exact taper lengths and shoulder widths for various design designations.

It should be clearly understood that these intersection treatment plans are typical and are not intended to be applicable to all intersection situations. Rather, these treatments illustrate the normal design that is applied when such roads intersect. In situations where high turning volumes are present on one or more of the intersection legs, a specialized design may be required.

The terms main (or through) and intersecting road are used to indicate the relative importance of the intersecting roadway, rather than their specific characteristics as a public road, town access road, etc.

D.7.2 Definition of Terms

The following are definitions of terms used in conjunction with the typical intersection plans:

- Main road refers to the through roadway, which generally is uncontrolled (free-flow) at the intersection.

- Intersecting road refers to any roadway which has a stop or yield control at the intersection.

- Channelized intersection refers to intersections that use islands to guide traffic into definite paths (for example, raised islands outlined by curbs or non-paved areas formed by the pavement edges, possibly supplemented by delineators on posts or other guide posts).

- Flared intersection refers to a four-leg intersection that uses tapers and/or auxiliary lanes (acceleration-deceleration) to direct the movements of turning traffic.

- Flared T intersection refers to a three-leg intersection that uses tapers and/or auxiliary lanes (acceleration-deceleration) to direct the movements of turning traffic.

- Simple T intersection refers to a three-leg intersection used in conjunction with road allowances, farm entrances or private accesses, where there are no tapers or auxiliary lanes.

D.7.3 Provision for Intersection Treatment

Normally, intersection improvement occurs in conjunction with the upgrading of an existing facility, through grading, base course or overlay operations. During these operations, intersection treatments are generally provided when the following types of main (or through) roads intersect:

- Primary and secondary highways

- Primary highways and town access roads

- Primary highways and park roads.

The type of intersection treatment selected for these intersections is primarily based on traffic volumes of both roadways and turning movements. Detailed procedures, warrants and guidelines are provided in the following sections.

Intersection treatment may also be provided at an intersecting road where traffic analysis has shown that improvement is warranted. The following types of intersections generally require analysis to determine the type of treatment required:

- Primary highways and intersecting roads

- Intersection of two secondary highways

- Secondary highways and intersecting roads.

If an intersection is collision prone, geometric improvement may be warranted to address any deficiencies that exist on the existing intersection. These improvements will normally be undertaken after a geometric assessment. Geometric improvements to existing paved intersections, if required, are normally made at the time of pavement rehabilitation or when a main (or through) grading project is in progress in the vicinity of the intersection.

D.7.4 Design Procedure

An intersection analysis procedure form (Table D.7.4) has been developed to guide the designer through the methodical data collection and analysis process required for intersection design. The procedure form is broken into four sections: data collection, functional characteristics, geometric characteristics and other characteristics. The following is a guide to filling in the procedure form.

Data Collection

The designer should initially fill in the basic data related to location, traffic volume, design speed and posted speed and then make a preliminary assessment of the type of treatment required based on that data. The preliminary assessment should be made based on Figure D-7.4 which has been developed for this purpose. The volumes to be used on Figure D-7.4 are the design volumes for the main (or through) and intersecting road, projected for the design year. This is generally 20 years after the year of construction. However, the current year may be used in assessing the suitability of an existing intersection for current traffic. This projection should be made based on historical traffic growth data for the highways in question or, if not available, an average growth rate of 2.5 percent per annum (not compounded) may be assumed.

Following the preliminary assessment, a designer may refer to Figure D-7.5 (a schematic diagram showing the standard at-grade intersection treatments). The detailed plans are shown in Figures D-7a through D-7m.

The preliminary assessment will also tell the designer the degree of analysis needed.

Functional Characteristics

Functional characteristics include the following:

Part 1

- Collision Analysis: This will indicate if an existing intersection is collision prone (had three similar type crashes in the previous five years), and what types of collisions are occurring.
- Access Requirements: Check of the need for access within the intersection plan area for developments such as service stations and private lots.
- Access Control: Check if an access can be physically accommodated within the intersection plan area.
- Future Development: Identify possible future land development within the vicinity which could become a heavy traffic generator.
- Type of Turning Vehicles: Identify design vehicle (WBl5, special log haul truck, etc.) for the intersection.
- Percentage of Trucks: Check for high percentages of truck or traffic volumes. Large volumes could warrant high standard acceleration and deceleration lanes. This information comes from Traffic Volume Breakdown Reports.

Part II Specific information for main or intersecting road with daily traffic volumes greater than 1800

- Turning Movement Diagram: Obtain turning movement diagrams for existing intersections. Four diagrams can be requested: Current AADT, Current Design Hour Volume (DHV), 20-year AADT and 20-year DHV. Diagrams are usually required when Type III intersection treatment or higher is needed.
- Warrant for Exclusive Left Turn Lane: Use Section D.7.6 for left turn lanes.
- Warrant for Exclusive Right Turn Lane: Use right turn warrant, Section D.7.7.
- Any proposed improvement to other highways that would impact the traffic movement at this intersection: Check for impact of surfacing or resurfacing of a nearby highway or realignment of

another highway. These changes could potentially increase or decrease traffic volumes at this intersection. Review the department’s Five Year Construction Program.

Geometric Characteristics

Geometric characteristics needed for intersection analysis are:

- Intersection Sight Distance: Indicate existing intersection sight distances on all approaches for all relevant design vehicles and compare to the required intersection sight distances. (See Section D.4.)

- Decision Sight Distance: Check for requirement at complex intersections where there is the possibility for error in information reception, decision making or control actions (particularly for channelized intersections). See Section D.4.5.

- Skew Angle: Identify angle intersecting road makes with main road. Desirable angle is 90 degrees, minimum is 70 degrees.

- Intersection on Horizontal Curve and Superelevation Rate: Avoid intersection on curve if possible. Check for sight distance and turning ability. For new construction projects, horizontal curve radius should not be less than the minimum value shown for the design speed on the inset table for Table B.3.6a. For geometric improvements on existing paved roads, designers should refer to design guidelines for 3R/4R projects in Chapter G.

- Profile of main and intersecting roads: On Type IV and Type V intersections, adjustments to deceleration and acceleration lane lengths may be necessary for grade effect. Refer to Table D.6.2.6.

Other Characteristics

Other characteristics needed to evaluate an intersection are:

- Utility Impact: Check for existing utilities within the intersection area which would need main (or through) expenditures to relocate or adjust. Revisions may be needed to the design to minimize the utility impact.

- Right of Way Impact: Decide if additional right of way will be required for the intersection treatment and, if so, consider cost significance in terms of intersection treatment cost.

- Warrant for Future Signalization: Signalization may be required if there are any of the following problems: accident prone rating, abnormal left turn volumes or pedestrian hazards, insufficient sight distance, delay problems or unsafe gaps. Check the need for signalization using the Department's current warrant.

- Warrant for Illumination: May be warranted at an intersection within two kilometres of an access for an urban development of over 300 population. Check the need for illumination using the Department's current guidelines.

The designer determines an appropriate treatment for a new or existing intersection by assessing functional and geometric characteristics and possible utility and right-of-way impact. In most cases where the geometric characteristics and collision history are satisfactory, the designer is expected to select a standardized intersection plan based on project volumes. For intersections where functional and geometric characteristics are adequate but the intersection is identified as accident prone, an intersection treatment may be warranted to alleviate operational concerns. In some special situations, intersection treatment is dictated by oversized or special vehicles such as logging trucks. This will require a special design.

The intersection analysis procedure form serves as a checklist and summary of data and analysis findings. The final intersection design is primarily based on the functional geometric and operational information listed here.

TABLE D.7.4

PROJECT: ______________________

INTERSECTION ANALYSIS PROCEDURE

Intersection at ____
Main (or through) Road Classification ________________ Intersecting Road Classification ____________
Main (or through) Road AADT/ASDT/AWDT Current _______ (Year ____)Future ________ (design year ____)
Intersecting Road AADT/ASDT/AWDT Current _______ (Year ____)Future ________ (design year ____)
Design Speed ____________________ Posted Speed ______________________________
Type of Treatment (preliminary assessment)____________________________________
(refer to Figure D-7.4, Traffic Volume Warrant Chart for At-Grade Intersection Treatment)

FUNCTIONAL CHARACTERISTICS

PART I (General Information for all treatment types)
Collision Analysis ____
Access Requirements____
Access Control ____
Future Development____
Type of Vehicles for Design _______________________________________
Percentage of Trucks ____

PART II (Specific Information for main (or through) and intersecting road with daily traffic volumes greater than 1800)
Turning Movement Diagram_______________________________________
Warrant for Exclusive Left Turn Lane______________________________
Warrant for Exclusive Right Turn Lane_____________________________
Any Proposed Improvement to Other Highways that would impact the traffic movement at this intersection (evaluate network)? ____

GEOMETRIC CHARACTERISTICS

Intersection Sight Distances

	Available		*Required
	left (m)	**right(m)**	**(m)**
WB21			
WB15			
SU			
P			
Other			

*Adjust length for gradient if necessary (see Table D.6.2.6)

Decision Sight Distance:____
Skew Angle: ____
Intersection on Horizontal Curve Yes ______ No______ If yes, superelevation rate = ___________ m/m
Profile grade of Main Road_________________% Intersecting Roadway____________________%

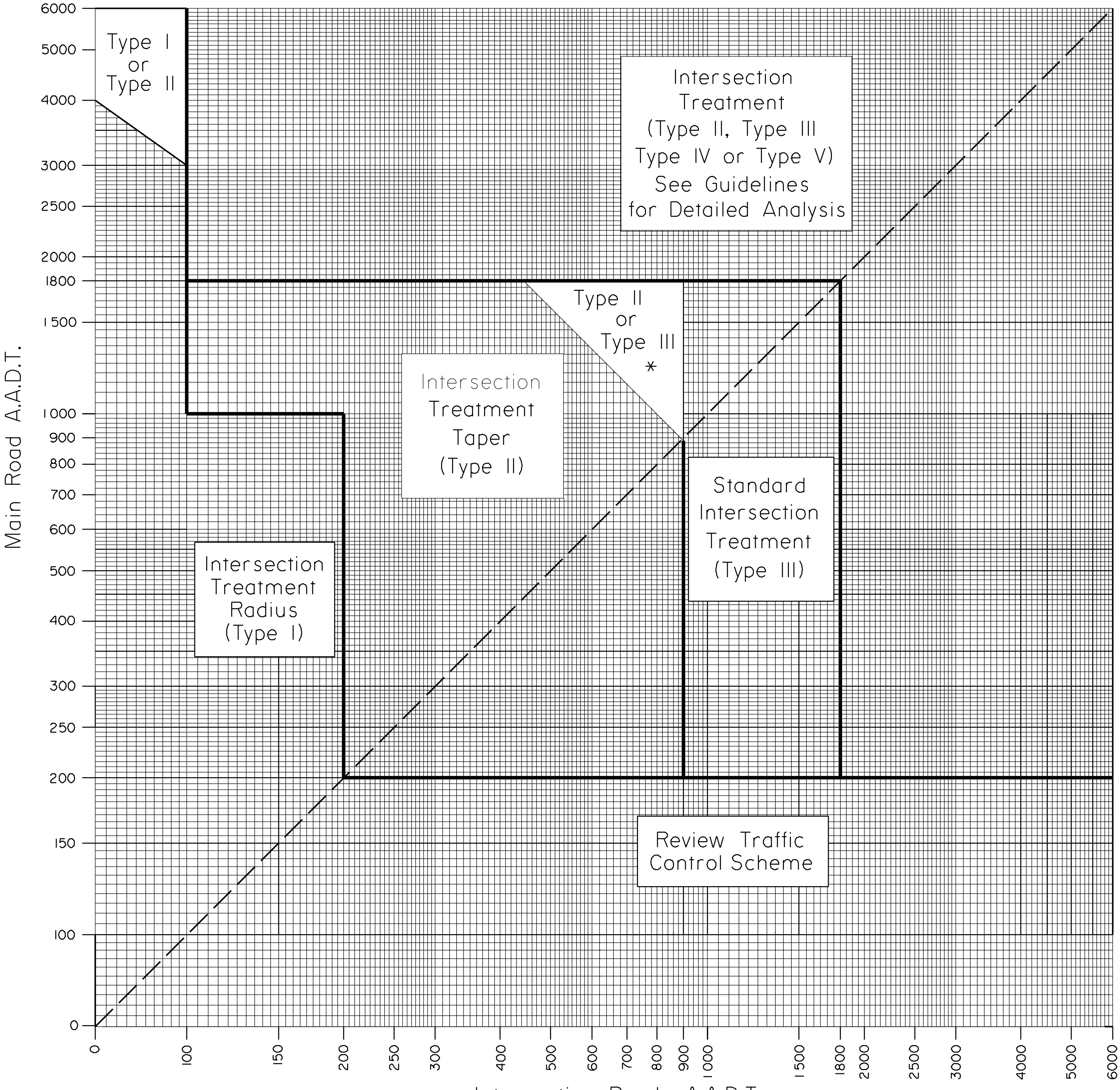
OTHER CHARACTERISTICS

Utility Impact____
Right-of-Way Impact____
Warrant for Future Signalization___________________________________
(Check with Traffic Operations Branch if necessary)
Warrant for Illumination ____
(Check with Traffic Operations Branch if necessary)
Recommendation of Type of Intersection Treatment based on Functional, Geometric and Other Characteristics:

____

Designer: ____________________Date:______________
Approved:____________________Date:______________

FIGURE D-7.4 TRAFFIC VOLUME WARRANT CHART FOR AT-GRADE INTERSECTION TREATMENT ON TWO-LANE RURAL HIGHWAYS (DESIGN SPEEDS 100, 110, 120 km/h)



Notes:

1. If main road, or intersecting road, is <100 AADT provide Type I Intersection Treatment (15m radius), except as shown for the higher volume main roads on this chart (Type I or II zone) where engineering judgement may be used to select the appropriate treatment.
2. If main road is >4000 AADT Review Access Management
   - — — If Intersecting Road AADT is > Main Road AADT: Review Traffic Control Scheme
3. Use projected traffic volumes for design
   Sloping line is defined by Main Road AADT x Intersecting Road AADT = 800,000

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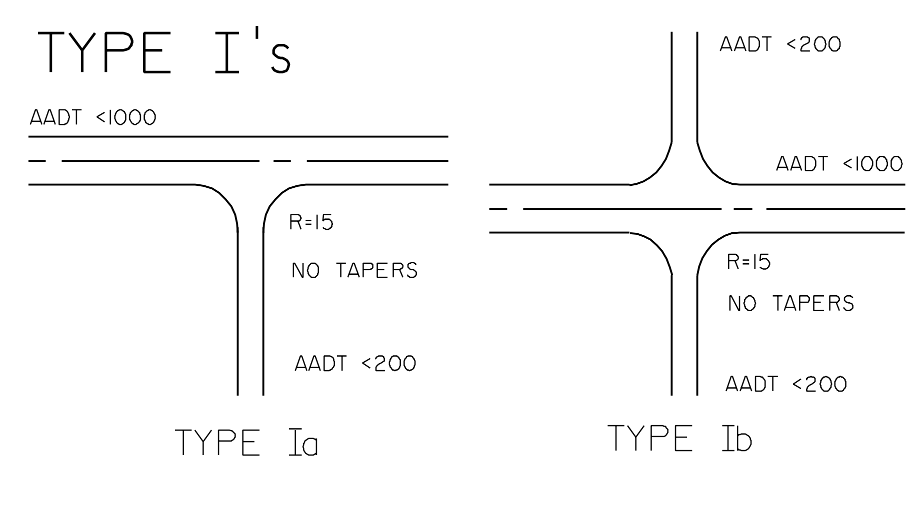

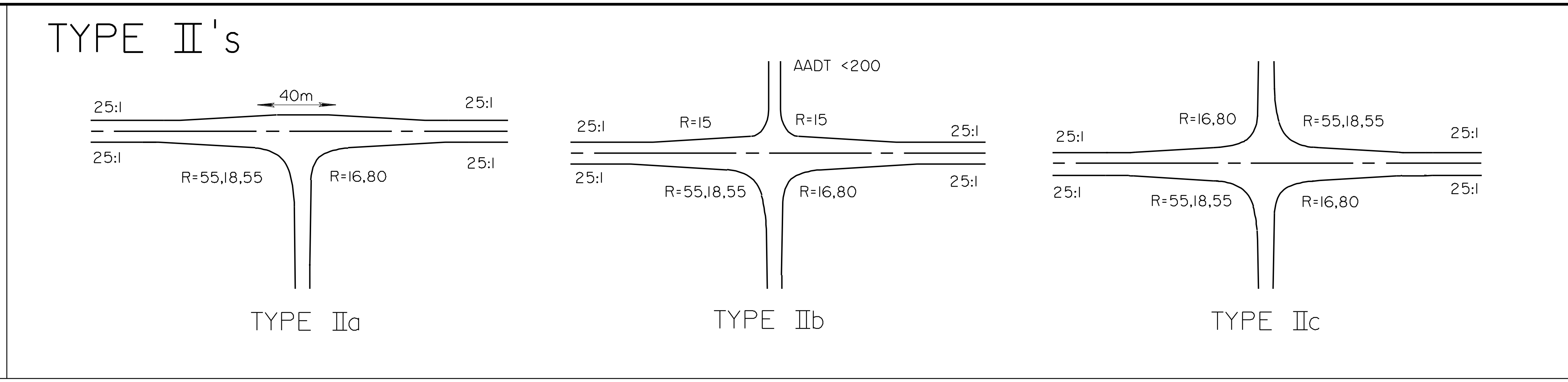

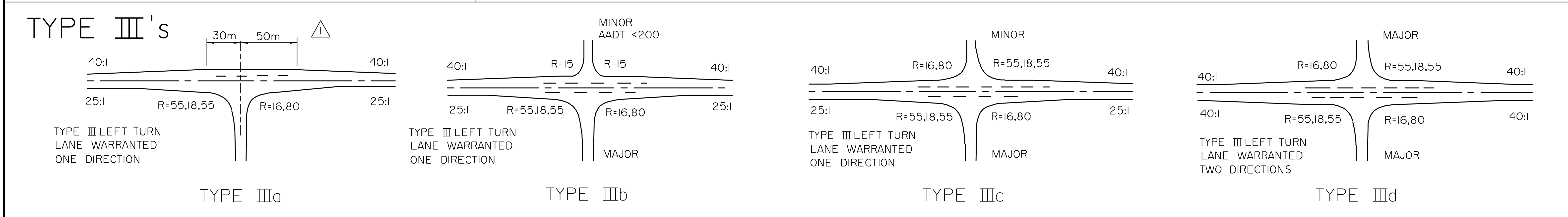

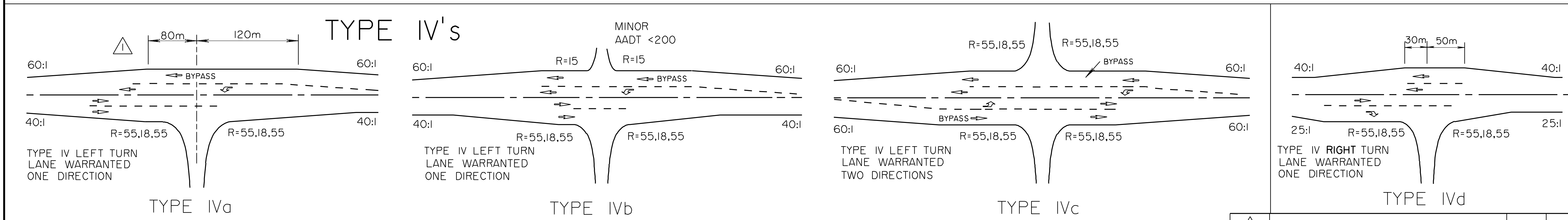

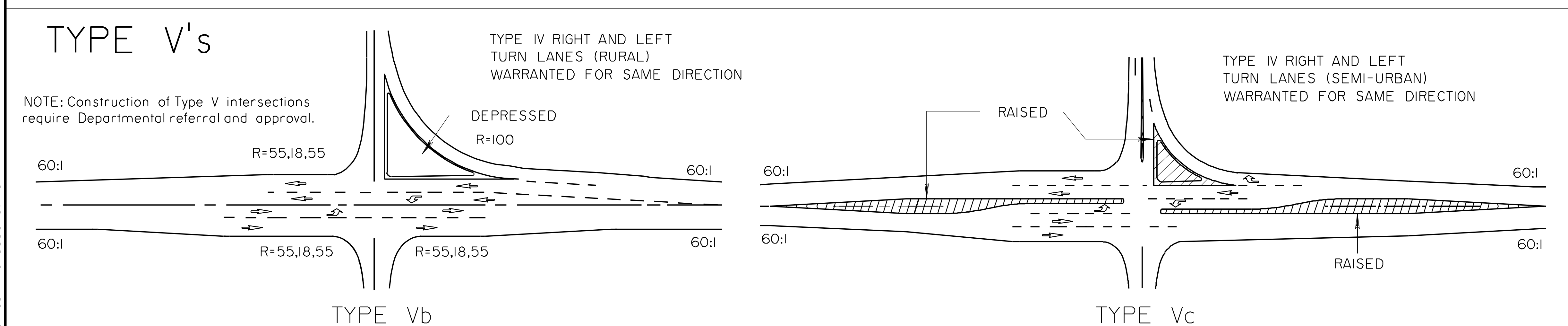

NOTES:

1. This is not a pavement marking drawing.
2. This figure depicts the typical layouts used for at-grade intersections. Detailed design considerations may dictate some minor alterations for particular intersections. The tapers shown here are typical for a 110 km/h design speed on the main highway.

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FIGURE D-7.5

Date: APRIL 1995

STANDARD AT-GRADE INTERSECTION LAYOUTS FOR TWO-LANE HIGHWAYS

Prepared By: LT	Checked By: B.K.	Scale: N.T.S.	PAGE D-III

Graphics File: debd75.man

D.7.5 Traffic Volume Warrant for Various Treatments

Figure D-7.5 provides a basic outline of the type of intersection treatment required based on the daily traffic volume on the main (or through) and intersecting roads. For many intersections (especially where the volume on main (or through) and/or intersecting road is low) the appropriate type of treatment may be chosen based on reference to this figure alone. In other cases, a more detailed analysis, including consideration of design hourly volumes and turning movements will need to be considered.

Figure D-7.5 is divided into five zones, each defining the type of intersection treatment needed. Some discussion on the reasons for defining those zones, as shown, and some additional guidelines for selection of intersection type in the detailed analysis zone follow:

Type I and Type II Zones

These zones are characterized by relatively light traffic volumes on the intersecting roads. Vehicle delay, or potential conflicts caused by turning vehicles, is expected to be relatively rare because of low turning volumes and/or large gaps between vehicles on the main road. Provision of an adequate turning radius (Type I treatment) or taper (Type II treatment) is sufficient for turning vehicle operation.

Type I intersections are generally appropriate in all cases where the intersecting road AADT is less than 100, unless the main road exceeds 3500 approximately (see Figure D-7.5). Type I is generally also appropriate for an intersecting road AADT up to 200, if the main road AADT is less than 1000.

The maximum volume boundary line stipulated for the Type II zone is a main (or through) road daily traffic volume of 1800. This volume was chosen for two reasons. The first is that with 1800 vehicles or greater on the main (or through) road, any intersections with intersecting roads exceeding 200 vehicles may require an exclusive left turn lane as defined by the department's left turn warrant in Section D.7.6. Secondly, at a volume of 1800, the highway level of service in the design hour drops from LOS A to LOS B on a design designation of RAU-211.8-110, assuming typical Alberta traffic and geometric conditions.

The maximum volume for an intersecting road is 900, at which volume the level of service for left turning vehicles on the intersecting road at the intersection drops from LOS A to LOS B.

The level-of-service calculations mentioned above are based on the Highway Capacity Manual (HCM) methods. Chapter 8 (two-lane highways) is used for the main (or through) road and Chapter 10 (unsignalized intersections) is used to determine the level of service on the intersecting road at an intersection.

Type II or III Zone

In this zone either Type II or Type III treatment is applicable. The designer may use the guidelines for detailed analysis to select the treatment type. The sloping line for this zone is based on a cross product of 800,000 between main (or through) road and intersecting road daily traffic volumes.

Type III Zone

Type III intersection treatment is the department's standard flared intersection with provision for simultaneous through and left turn movements, but with no storage or deceleration provision. This treatment can handle moderate traffic volumes on both the main (or through) and intersecting roads. The flared intersection ensures that the main (or through) road through traffic has little or no delay when lead vehicles are turning left or right.

The top boundary of the rectangular zone is at a main (or through) road daily volume of 1800, as with the Type II zone. The same rationale for this line applies for both zones. The maximum daily volume on the intersecting road is 1800. Again, at this volume, the level of service for a RAU-211.8-110 standard highway is reduced from LOS A to LOS B based on typical Alberta two-lane highway geometric and traffic conditions. This volume also marks the change from intersection LOS B to LOS C on the intersecting road, assuming high turning movements.

Review Traffic Control Scheme Zone

This zone is situated at the bottom of the graph. In this area, the volumes on the intersecting road are greater than on the main (or through) road. For the most part, this type of arrangement is illogical and a review of the traffic control scheme should be undertaken.

A dashed line is also shown on the graph. The area below the dashed line indicates the condition where the intersecting road volume is greater than the main (or through) road volume. In this case, the traffic control scheme should also be reviewed.

Detailed Analysis for Types II, III, IV or V Zones

Detailed analysis is required whenever the design AADT exceeds 1800 on the main road and 100 on the intersecting road design. A detailed analysis of the intersection must be done in order to assess the intersection treatment required. The different treatments that may be used are the tapered intersection (Type II), the standard flared intersection (Type III), the standard intersection with auxiliary lanes (Type IV) and the channelized intersection (Type V). Detailed analysis consists of compiling information and checking all of the items as shown on the intersection analysis form (Table D.7.4). When selecting the appropriate intersection treatment, the following analysis and guidelines should be used:

Analysis

1. Obtain detailed traffic information including AADT, traffic composition, traffic growth and turning movement diagram.

2. Calculate design AADT values for each roadway using existing AADT, projected annual growth and design life. If information is not available for the particular highway, the design AADT is frequently assumed to be 150 percent of existing AADT. This is based on an annual growth rate of 2.5 percent and a 20-year design life.

3. Reduce design AADT values for all movements to design hour volumes (DHV) using the appropriate design hourly volume factor K Value (DHV=KxAADT) for that highway segment (control section) as compiled by Planning Services Branch in 1990 or later. Where information is not available for the particular highway, a K value of 0.15 is frequently used.

4. Check for warrant for exclusive left turn lane as defined in Section D.7.6. Check both directions of travel on main (or through) road using the direction split as compiled by former Technical Services, Planning Branch. Where information is not available for the particular highway, a 55:45 or 50:50 directional split is frequently assumed for the design hour.

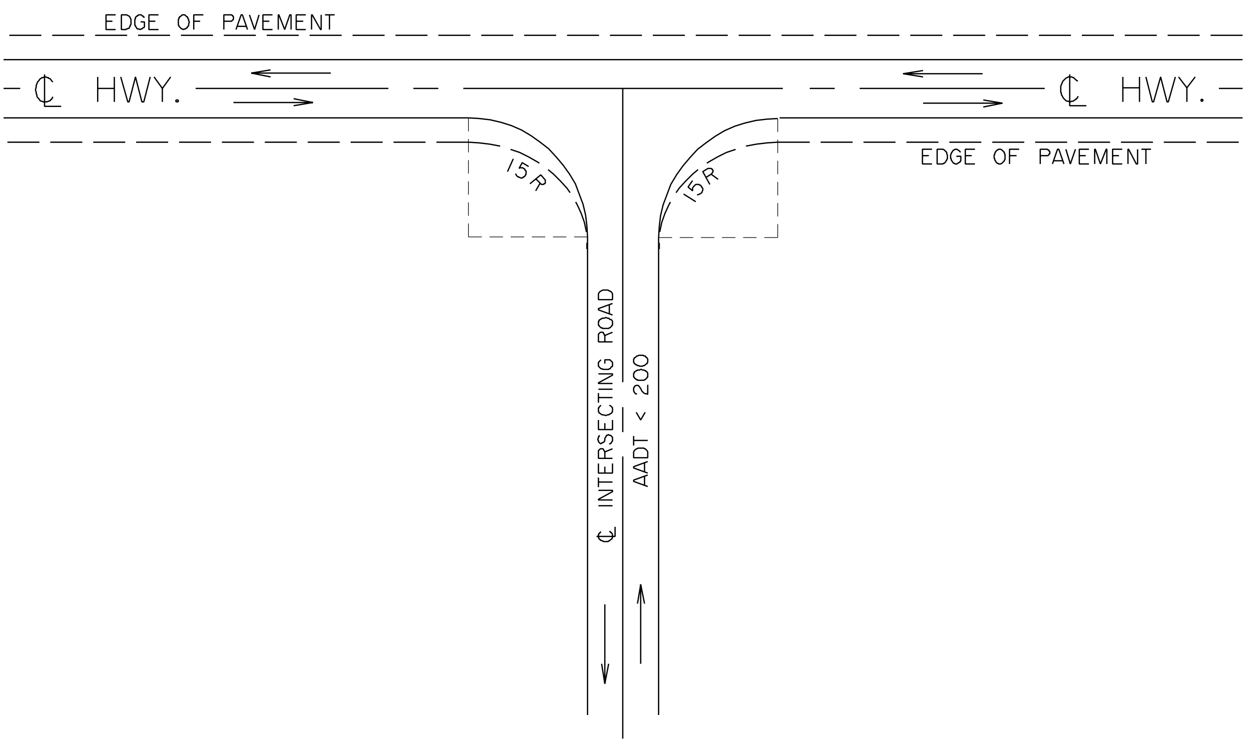
The result of the detailed analysis, as shown in Section D.7.6, will indicate if a Type II, III or IV treatment is warranted based on the percentage of left turns, design hour volume, directional split and design speed. The analysis must be undertaken for both directions of travel on the main (or through) road in order to select the appropriate treatment. For example, Type IVb has an exclusive left turn lane for one direction only, while Type IVc has exclusive left turn lanes for both directions.

To check the need for an exclusive right turn lane, the warrant in Section D.7.7 should be used. Type IVd is applicable where there is a satisfied warrant for an exclusive right turn lane but no exclusive left turn lane.

If both a left and right turn lane is warranted in the same direction, a Type V treatment is required. Generally, in rural highway conditions, the Type Vb design is preferred because it does not include any structures raised above the pavement surface. Raised islands, curbs and raised medians, which are included in Type Vc configuration, can cause snow drifting, are hazardous to errant vehicles and always require illumination. Where right of way is not available or an urban or semi-urban design is desirable, Type Vc may be used.

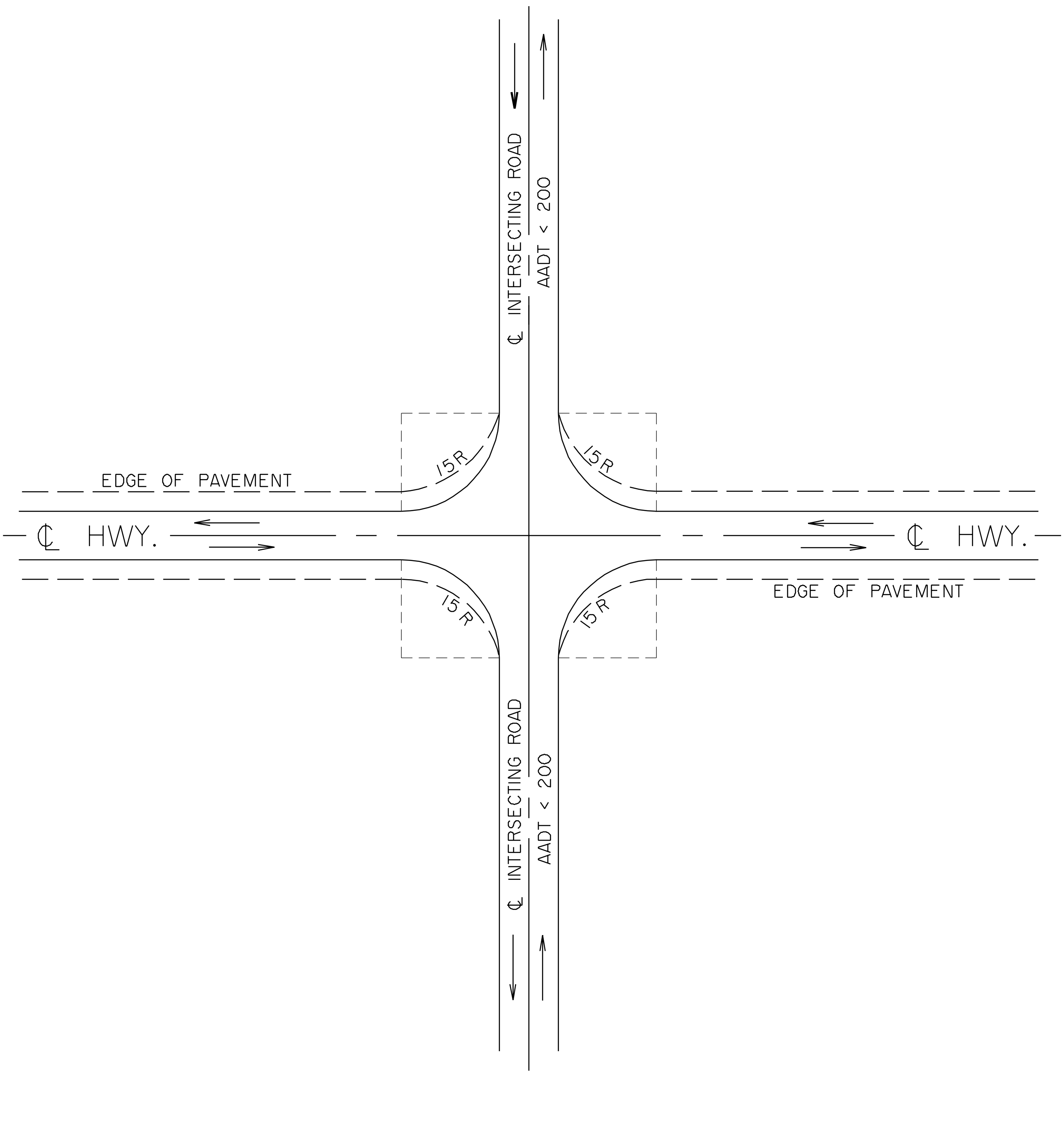
Figure D-7.5 does not cover intersections of roadways with AADT exceeding 6000. This is because twinning the highway may be a consideration for roadways of this volume (see Section A.9 - Guidelines for Twinning Based on Level of Service). Even where twinning is not going to take place, the overall access management of the highway should be considered before intersection treatments are built on any highways with AADT exceeding 4000.

FIGURE D-7a INTERSECTION TREATMENT (TYPE Ia)
(Two-Lane Highway)



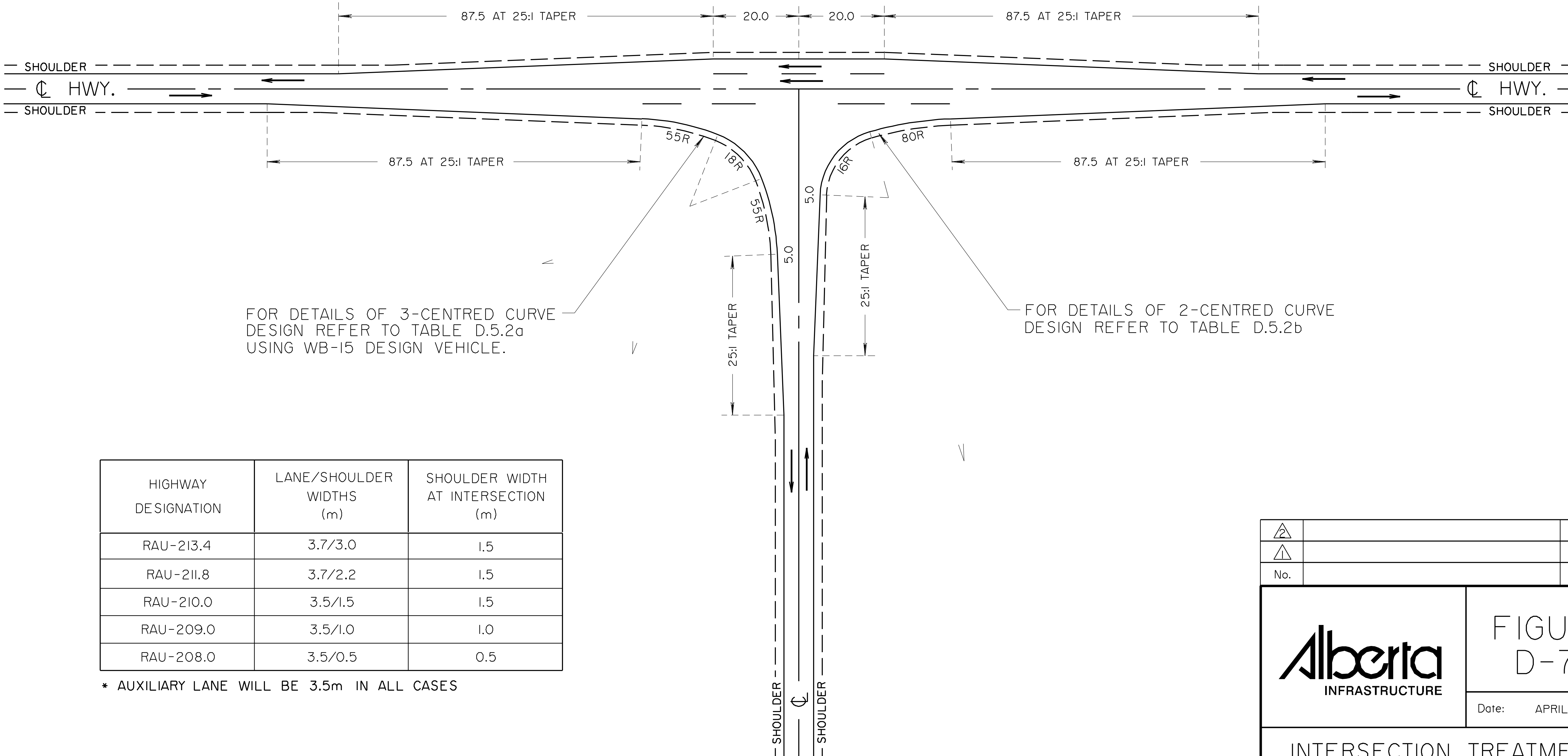
NOTE: ALL DIMENSIONS SHOWN ARE FOR FINISHED PAVEMENT SURFACES. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.

FIGURE D-7b INTERSECTION TREATMENT (TYPE Ib)
(Two-Lane Highway)



NOTE: DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF

NOTES: DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.



HIGHWAY DESIGNATION	LANE/SHOULDER WIDTHS (m)	SHOULDER WIDTH AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5

* AUXILIARY LANE WILL BE 3.5m IN ALL CASES

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FIGURE D-7c

Date: APRIL 1995

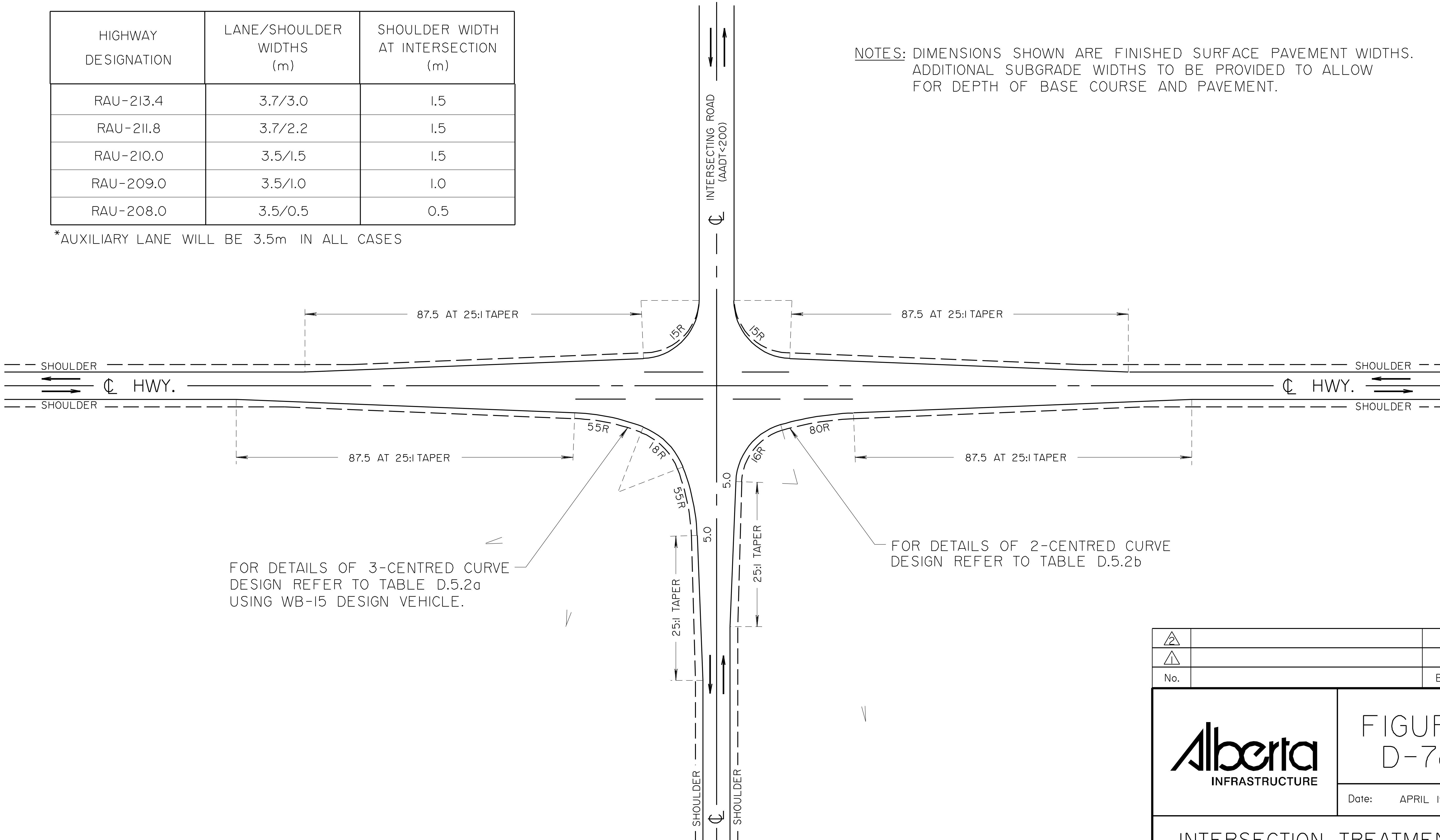
INTERSECTION TREATMENT (TYPE IIa) (TWO-LANE HIGHWAY)

Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

HIGHWAY DESIGNATION	LANE/SHOULDER WIDTHS (m)	SHOULDER WIDTH AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5

*AUXILIARY LANE WILL BE 3.5m IN ALL CASES

NOTES: DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.



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Alberta INFRASTRUCTURE

FIGURE D-7d

Date: APRIL 1995

INTERSECTION TREATMENT (TYPE IIb) (TWO-LANE HIGHWAY)

Prepared By: Cgk | Checked By: B.K. | Scale: N.T.S.

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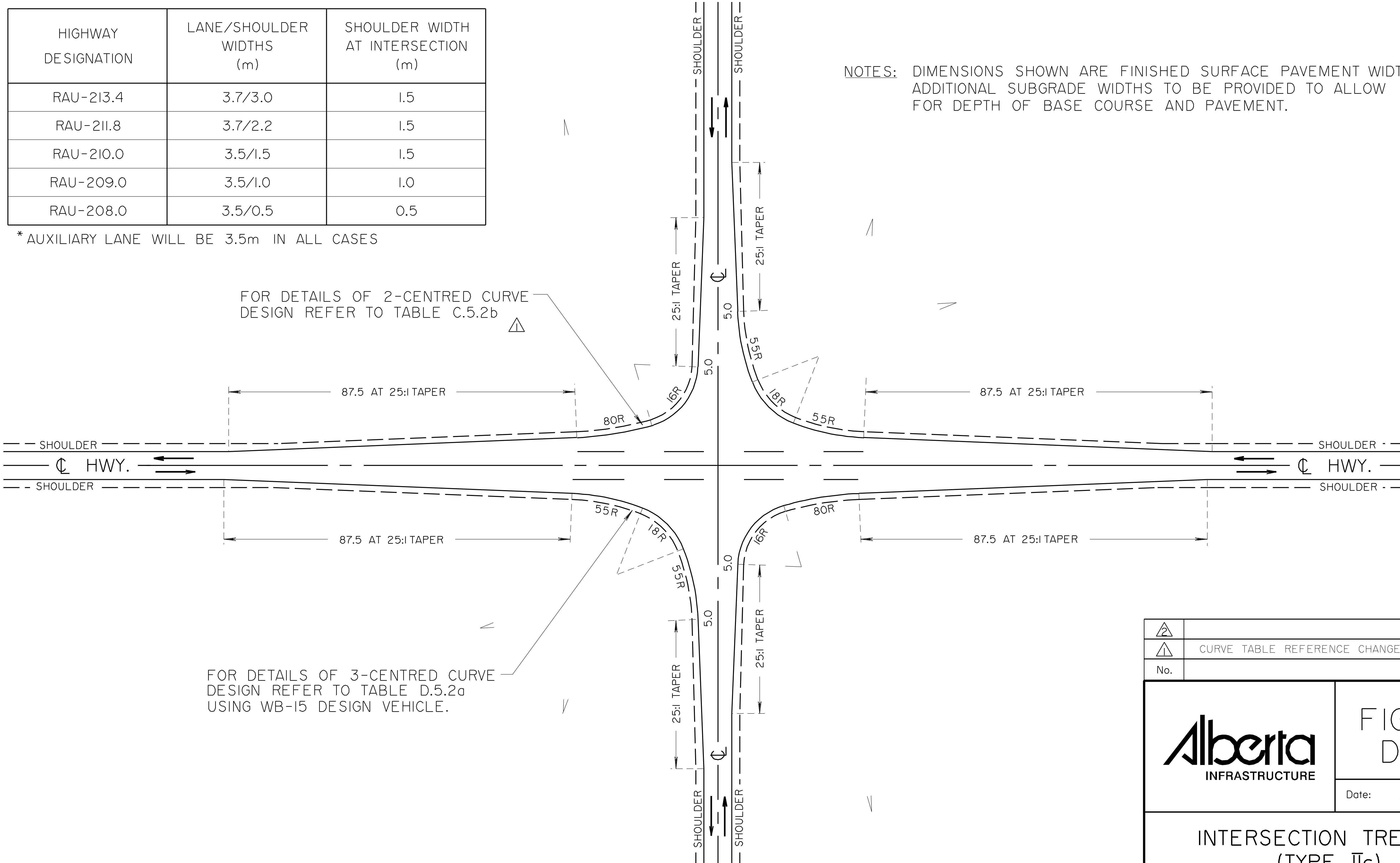
HIGHWAY DESIGNATION	LANE/SHOULDER WIDTHS (m)	SHOULDER WIDTH AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5

*AUXILIARY LANE WILL BE 3.5m IN ALL CASES

NOTES: DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.



No.		BY	DATE
2			
1	CURVE TABLE REFERENCE CHANGED	R.M.	05/96

Alberta INFRASTRUCTURE

FIGURE D-7e

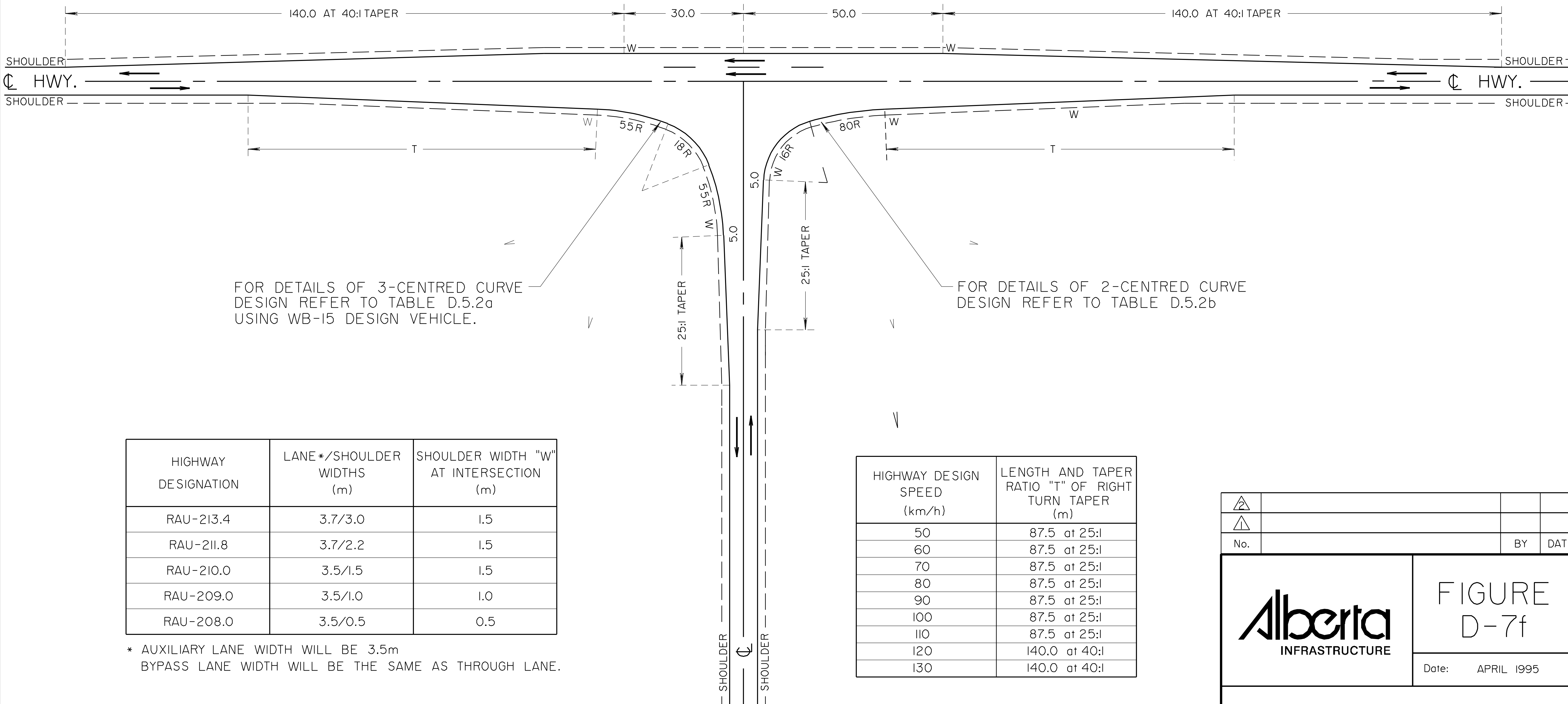
Date: APRIL 1995

INTERSECTION TREATMENT (TYPE IIc) (TWO-LANE HIGHWAY)

Prepared By: Cgk | Checked By: B.K. | Scale: N.T.S.

Graphics File: debd7e.man

NOTE 1: DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS.
ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW
FOR DEPTH OF BASE COURSE AND PAVEMENT.



HIGHWAY DESIGNATION	LANE*/SHOULDER WIDTHS (m)	SHOULDER WIDTH "W" AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5

* AUXILIARY LANE WIDTH WILL BE 3.5m
BYPASS LANE WIDTH WILL BE THE SAME AS THROUGH LANE.

HIGHWAY DESIGN SPEED (km/h)	LENGTH AND TAPER RATIO "T" OF RIGHT TURN TAPER (m)
50	87.5 at 25:1
60	87.5 at 25:1
70	87.5 at 25:1
80	87.5 at 25:1
90	87.5 at 25:1
100	87.5 at 25:1
110	87.5 at 25:1
120	140.0 at 40:1
130	140.0 at 40:1

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE D-7f

Date: APRIL 1995

INTERSECTION TREATMENT
(TYPE IIIa)
(TWO- LANE HIGHWAY)

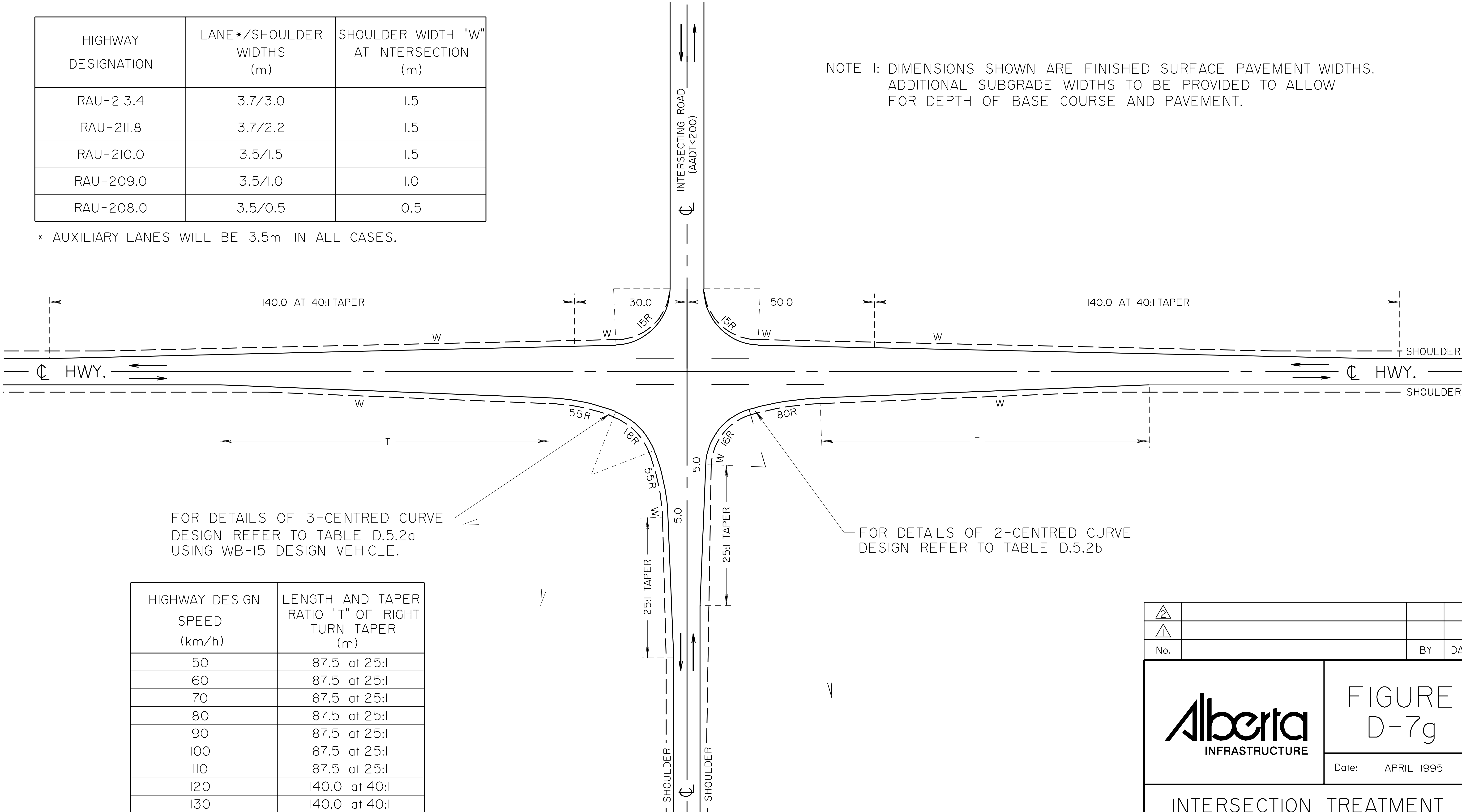
Prepared By: Cgk	Checked By: B.K.	Scale: N.T.S.	PAGE D-123

Graphics File: debd7f.man

HIGHWAY DESIGNATION	LANE*/SHOULDER WIDTHS (m)	SHOULDER WIDTH "W" AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5

* AUXILIARY LANES WILL BE 3.5m IN ALL CASES.

NOTE 1: DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.



FOR DETAILS OF 3-CENTRED CURVE DESIGN REFER TO TABLE D.5.2a USING WB-15 DESIGN VEHICLE.

FOR DETAILS OF 2-CENTRED CURVE DESIGN REFER TO TABLE D.5.2b

HIGHWAY DESIGN SPEED (km/h)	LENGTH AND TAPER RATIO "T" OF RIGHT TURN TAPER (m)
50	87.5 at 25:1
60	87.5 at 25:1
70	87.5 at 25:1
80	87.5 at 25:1
90	87.5 at 25:1
100	87.5 at 25:1
110	87.5 at 25:1
120	140.0 at 40:1
130	140.0 at 40:1

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE D-7g

Date: APRIL 1995

INTERSECTION TREATMENT TYPE IIIb (TWO-LANE HIGHWAY)

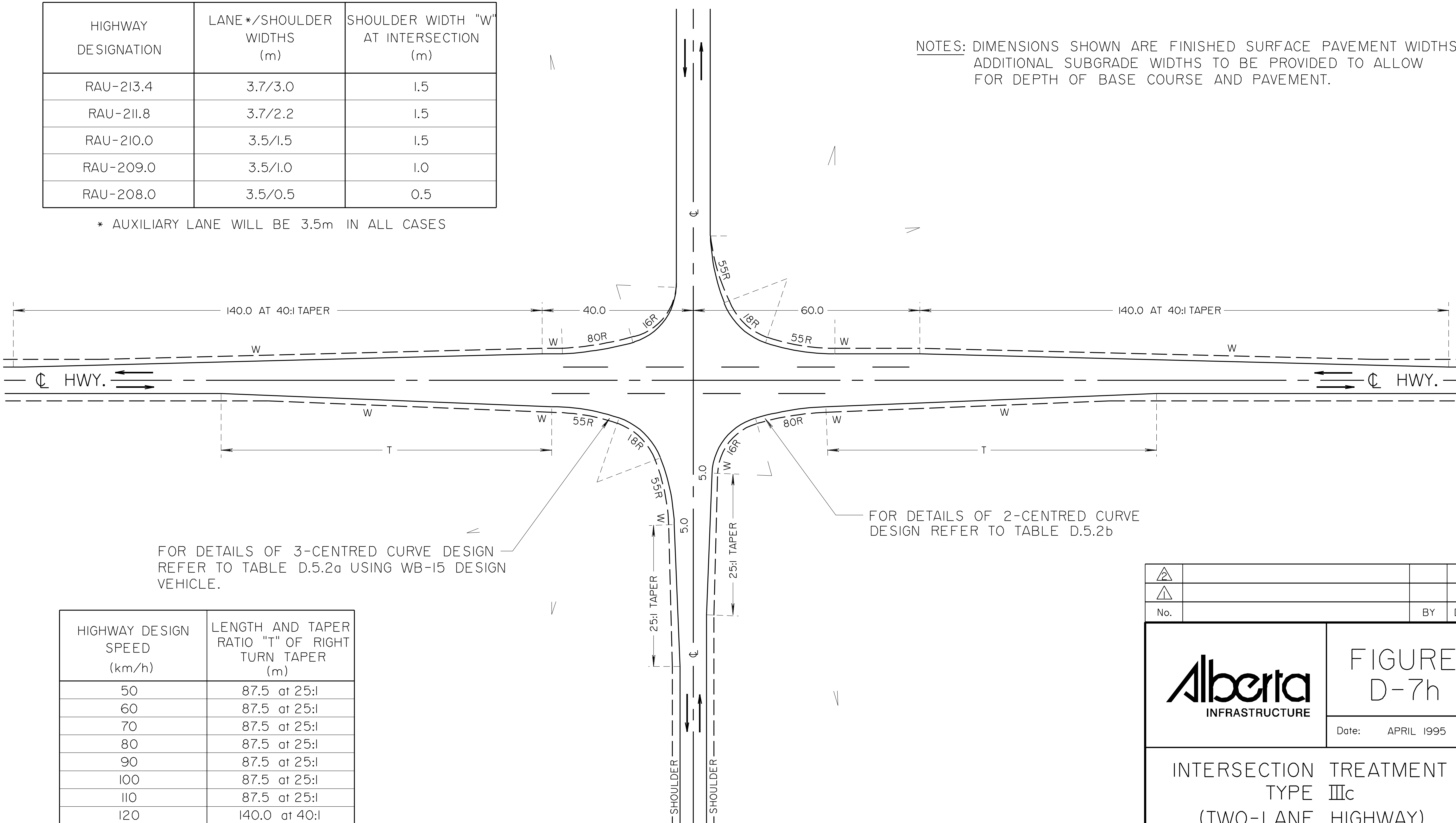
Prepared By: Cgk | Checked By: B.K. | Scale: N.T.S.

Graphics File: debd7g.man

HIGHWAY DESIGNATION	LANE*/SHOULDER WIDTHS (m)	SHOULDER WIDTH "W" AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5

* AUXILIARY LANE WILL BE 3.5m IN ALL CASES

NOTES: DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.



HIGHWAY DESIGN SPEED (km/h)	LENGTH AND TAPER RATIO "T" OF RIGHT TURN TAPER (m)
50	87.5 at 25:1
60	87.5 at 25:1
70	87.5 at 25:1
80	87.5 at 25:1
90	87.5 at 25:1
100	87.5 at 25:1
110	87.5 at 25:1
120	140.0 at 40:1
130	140.0 at 40:1

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE D-7h

Date: APRIL 1995

INTERSECTION TREATMENT TYPE IIIc (TWO-LANE HIGHWAY)

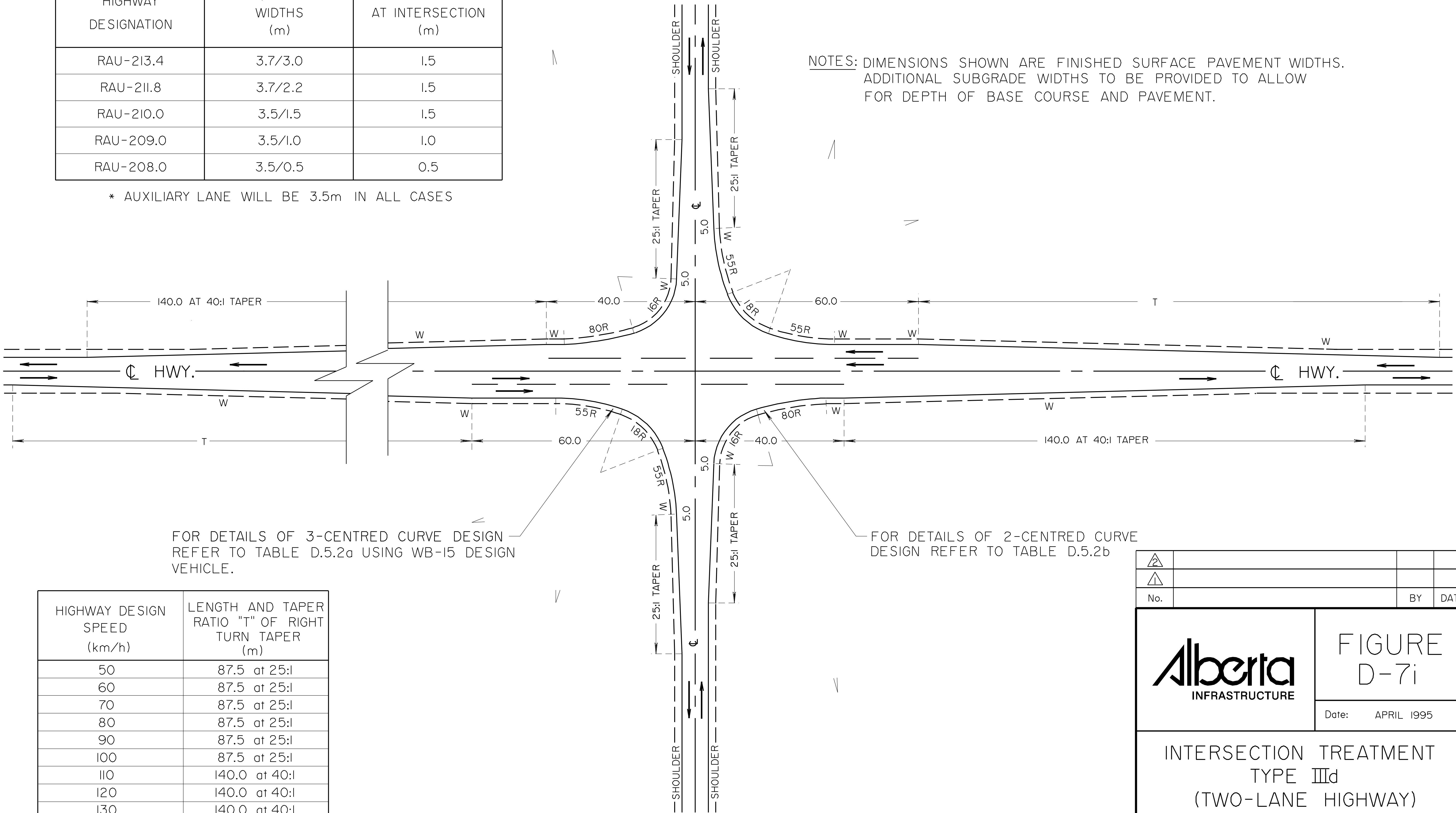
Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

Graphics File: TIGSFSO\REB\MANUAL\CHAPTERS\CHAP-D\DEBD7H.MAN

HIGHWAY DESIGNATION	LANE*/SHOULDER WIDTHS (m)	SHOULDER WIDTH "W" AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5

* AUXILIARY LANE WILL BE 3.5m IN ALL CASES

NOTES: DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.



FOR DETAILS OF 3-CENTRED CURVE DESIGN REFER TO TABLE D.5.2a USING WB-15 DESIGN VEHICLE.

FOR DETAILS OF 2-CENTRED CURVE DESIGN REFER TO TABLE D.5.2b

HIGHWAY DESIGN SPEED (km/h)	LENGTH AND TAPER RATIO "T" OF RIGHT TURN TAPER (m)
50	87.5 at 25:1
60	87.5 at 25:1
70	87.5 at 25:1
80	87.5 at 25:1
90	87.5 at 25:1
100	87.5 at 25:1
110	140.0 at 40:1
120	140.0 at 40:1
130	140.0 at 40:1

Graphics File: debd7i.man

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE D-7i

Date: APRIL 1995

INTERSECTION TREATMENT TYPE IIId (TWO-LANE HIGHWAY)

Prepared By: Cgk | Checked By: B.K. | Scale: N.T.S.

TABLE 1

HIGHWAY DESIGNATION	LANE*/SHOULDER WIDTHS (m)	SHOULDER WIDTH "W" AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5

* AUXILIARY LANE WILL BE 3.5m
BYPASS LANE WIDTH WILL BE THE SAME AS THROUGH LANE.

NOTES
1. DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.
2. THE DESIGNER MUST COMPLETE "INTERSECTION ANALYSIS" PROCEDURE TO JUSTIFY THE TYPE IV TREATMENT.
i.e. exclusive left turn lane must be warranted for the movement shown +

TABLE 2: LEFT TURN LANE

HIGHWAY DESIGN SPEED km/h	LENGTH AND TAPER RATIO "TB" OF BYPASS LANE (m)	PARALLEL DECELERATION LANE "P2" ** (m)	LENGTH AVAILABLE FOR DECELERATION ½ TAPER+LANE	DECELERATION LENGTH REQUIRED BASED ON DESIGN SPEED	STORAGE LENGTH PROVIDED BY STANDARD TREATMENT
50	140 at 40:1	20	90	70	20
60	140 at 40:1	35	105	90	15
70	140 at 40:1	55	125	110	15
80	140 at 40:1	80	150	130	20
90	210 at 60:1	70	175	150	25
100	210 at 60:1	85	190	170	20
110	210 at 60:1	100	205	190	15
120	210 at 60:1	120	225	210	15
130	210 at 60:1	125	230	215	15

TABLE 3: RIGHT TURN LANE

HIGHWAY DESIGN SPEED (km/h)	LENGTH AND TAPER RATIO "TR" OF RIGHT TURN TAPER (m)	LENGTH OF PARALLEL LANE "PI" ** (m)		LENGTH AVAILABLE FOR DECELERATION: LANE + TAPER	DECELERATION LENGTH REQUIRED BASED ON DESIGN SPEED	STORAGE LENGTH PROVIDED BY STANDARD TREATMENT
		RIGHT TURN LANE NOT + WARRANTED	RIGHT TURN LANE + WARRANTED			
50	87.5 at 25:1	0	0	87.5	70	17.5
60	87.5 at 25:1	0	10	97.5	90	7.5
70	87.5 at 25:1	0	35	122.5	110	12.5
80	87.5 at 25:1	10	50	137.5	130	7.5
90	87.5 at 25:1	10	65	152.5	150	2.5
100	87.5 at 25:1	10	85	172.5	170	2.5
110	140.0 at 40:1	20	100	240	190	50
120	140.0 at 40:1	20	100	240	210	30
130	140.0 at 40:1	30	110	250	215	35

** ADJUST PARALLEL LANE LENGTH FOR GRADE EFFECT.
⊗ SEE RIGHT TURN LANE REQUIREMENTS IN SECTION D.7.7.

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE D-7j

Date: APRIL 1995

INTERSECTION TREATMENT
TYPE IVa
(TWO-LANE HIGHWAY)

Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S. | PAGE D-131

Graphics File: deb d7j.man

TABLE 3: RIGHT TURN LANE

HIGHWAY DESIGN SPEED (km/h)	LENGTH AND TAPER RATIO "TR" OF RIGHT TURN TAPER (m)	LENGTH OF PARALLEL LANE "PI" ** (m)		LENGTH AVAILABLE FOR DECELERATION: LANE + TAPER	DECELERATION LENGTH REQUIRED BASED ON DESIGN SPEED	STORAGE LENGTH PROVIDED BY STANDARD TREATMENT
		RIGHT TURN LANE NOT + WARRANTED	RIGHT TURN LANE + WARRANTED			
50	87.5 at 25:1	0	0	87.5	70	17.5
60	87.5 at 25:1	0	10	97.5	90	7.5
70	87.5 at 25:1	0	35	122.5	110	12.5
80	87.5 at 25:1	10	50	137.5	130	7.5
90	87.5 at 25:1	10	65	152.5	150	2.5
100	87.5 at 25:1	10	85	172.5	170	2.5
110	140.0 at 40:1	20	100	240 ⚠	190	50
120	140.0 at 40:1	20	100	240	210	30
130	140.0 at 40:1	30	110	250	215	35

** ADJUST PARALLEL LANE LENGTH FOR GRADE EFFECT.
\+ SEE RIGHT TURN LANE REQUIREMENTS IN SECTION D.7.7

TABLE 2: LEFT TURN LANE

HIGHWAY DESIGN SPEED km/h	LENGTH AND TAPER RATIO "TB" OF BYPASS LANE (m)	PARALLEL DECELERATION LANE "P2" ** (m)	LENGTH AVAILABLE FOR DECELERATION ½ TAPER+LANE	DECELERATION LENGTH REQUIRED BASED ON DESIGN SPEED	STORAGE LENGTH PROVIDED BY STANDARD TREATMENT
50	140 at 40:1	20	90	70	20
60	140 at 40:1	35	105	90	15
70	140 at 40:1	55	125	110	15
80	140 at 40:1	80	150	130	20
90	210 at 60:1	70	175	150	25
100	210 at 60:1	85	190	170	20
110	210 at 60:1	100	205	190	15
120	210 at 60:1	120	225	210	15
130	210 at 60:1	125	230	215	15

TABLE 1

HIGHWAY DESIGNATION	LANE*/SHOULDER WIDTHS (m)	SHOULDER WIDTH "W" AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5
RAU-207.0	3.5/0	0

* AUXILIARY LANE WILL BE 3.5m
BYPASS LANE WIDTH WILL BE THE SAME AS THROUGH LANE.

NOTES:

1. DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.
2. THE DESIGNER MUST COMPLETE "INTERSECTION ANALYSIS" PROCEDURE TO JUSTIFY TYPE IV TREATMENT.
That is, exclusive left turn lane must be warranted for the movement shown ⊗

No.		BY	DATE
2			
1	TABLE 3: CHANGED DECEL LANE TAPER	R.M.	05/96

Alberta INFRASTRUCTURE

FIGURE D-7k

Date: APRIL 1995

INTERSECTION TREATMENT TYPE IVb (TWO-LANE HIGHWAY)

Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

Graphics File: debd7k.man

TABLE 2: LEFT TURN LANE

HIGHWAY DESIGN SPEED km/h	LENGTH AND TAPER RATIO "TB" OF BYPASS LANE (m)	PARALLEL DECELERATION LANE "P2" ** (m)	LENGTH AVAILABLE FOR DECELERATION ½ TAPER+LANE	DECELERATION LENGTH REQUIRED BASED ON DESIGN SPEED	STORAGE LENGTH PROVIDED BY STANDARD TREATMENT
50	140 at 40:1	20	90	70	20
60	140 at 40:1	35	105	90	15
70	140 at 40:1	55	125	110	15
80	140 at 40:1	80	150	130	20
90	210 at 60:1	70	175	150	25
100	210 at 60:1	85	190	170	20
110	210 at 60:1	100	205	190	15
120	210 at 60:1	120	225	210	15
130	210 at 60:1	125	230	215	15

TABLE 1

HIGHWAY DESIGNATION	LANE*/SHOULDER WIDTHS (m)	SHOULDER WIDTH "W" AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5
RAU-207.0	3.5/0	0

* AUXILIARY LANE WILL BE 3.5m
BYPASS LANE WIDTH WILL BE THE SAME AS THROUGH LANE.

NOTES:

1. DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.
2. THE DESIGNER MUST COMPLETE "INTERSECTION ANALYSIS" PROCEDURE TO JUSTIFY TYPE IV TREATMENT.
   i.e. exclusive left turn lane must be warranted for the two movements shown ⊗

No.		BY	DATE
2			
1	REMOVED TABLE 3, REV TAPER NOTE	BK	8- 99

Alberta INFRASTRUCTURE

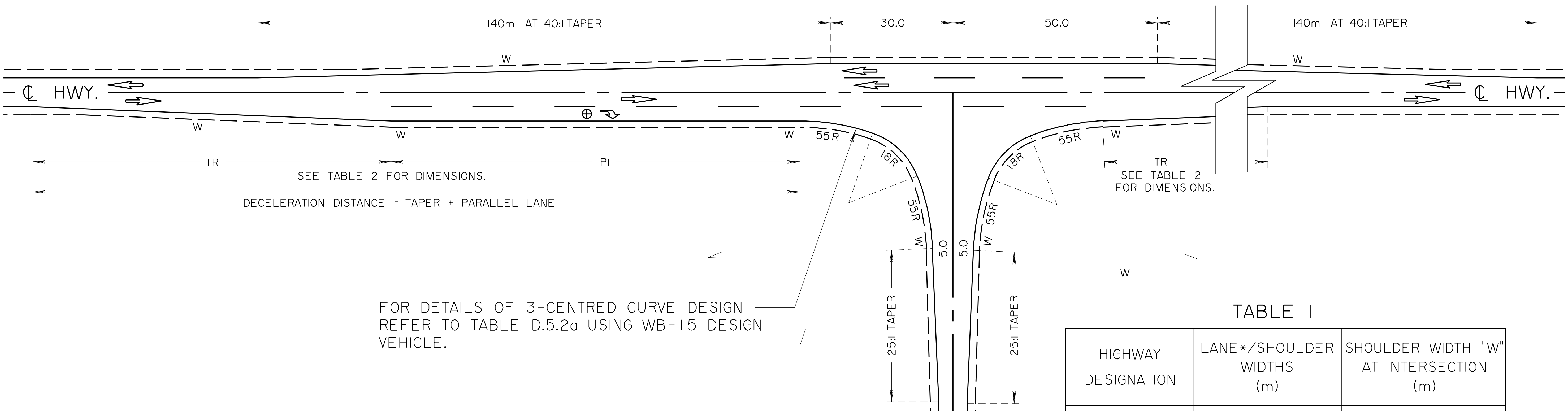
FIGURE D-71

Date: OCTOBER 1994

INTERSECTION TREATMENT
TYPE IVc
(TWO-LANE HIGHWAY)

Prepared By: Cgk | Checked By: | Scale: N.T.S. | PAGE D-135

Graphics File:del+200,22|cb623m71.dgn



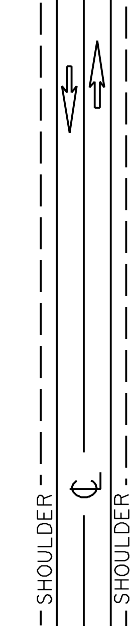


TABLE 1

HIGHWAY DESIGNATION	LANE*/SHOULDER WIDTHS (m)	SHOULDER WIDTH "W" AT INTERSECTION (m)
RAU-213.4	3.7/3.0	1.5
RAU-211.8	3.7/2.2	1.5
RAU-210.0	3.5/1.5	1.5
RAU-209.0	3.5/1.0	1.0
RAU-208.0	3.5/0.5	0.5

* AUXILIARY LANE WILL BE 3.5m
BYPASS LANE WIDTH WILL BE THE SAME AS THROUGH LANE.

TABLE 2 ⚠

HIGHWAY DESIGN SPEED (km/h)	LENGTH AND TAPER RATIO "TR" OF RIGHT TURN TAPER (m)	LENGTH OF PARALLEL LANE "PI" ** (m)	LENGTH AVAILABLE FOR DECELERATION: LANE + TAPER	DECELERATION LENGTH REQUIRED BASED ON DESIGN SPEED	STORAGE LENGTH PROVIDED BY STANDARD TREATMENT
50	87.5 at 25:1	N.A.	87.5	70	17.5
60	87.5 at 25:1	10	97.5	90	7.5
70	87.5 at 25:1	35	122.5	110	12.5
80	87.5 at 25:1	50	137.5	130	7.5
90	87.5 at 25:1	65	152.5	150	2.5
100	87.5 at 25:1	85	172.5	170	2.5
110	140.0 at 40:1	100	240	190	50
120	140.0 at 40:1	100	240	210	30
130	140.0 at 40:1	110	250	215	35

** ADJUST PARALLEL LANE LENGTH FOR GRADE EFFECT.

NOTES

1. DIMENSIONS SHOWN ARE FINISHED SURFACE PAVEMENT WIDTHS. ADDITIONAL SUBGRADE WIDTHS TO BE PROVIDED TO ALLOW FOR DEPTH OF BASE COURSE AND PAVEMENT.
2. THE DESIGNER MUST COMPLETE "INTERSECTION ANALYSIS" PROCEDURE TO JUSTIFY THE TYPE IV TREATMENT.
   i.e. exclusive right turn lane must be warranted for the movement shown ⊕

No.		BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE D-7m

Date: APRIL 1995

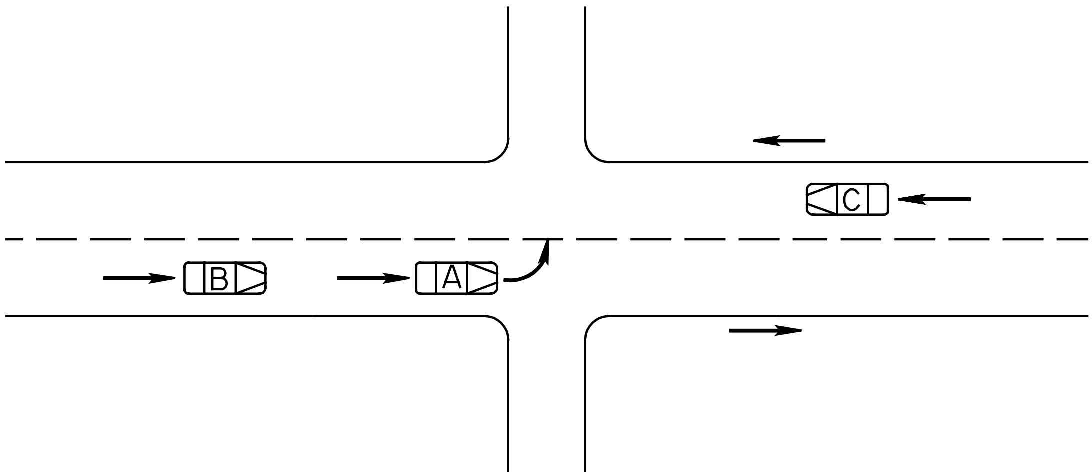
INTERSECTION TREATMENT TYPE IVd
EXCLUSIVE RIGHT TURN TREATMENT WARRANTED (TWO-LANE HIGHWAY)

Prepared By: Cgk | Checked By: B.K. | Scale: N.T.S.

GRAPHICS FILE: debd7m.man

D.7.6 Warrant for Left Turn Lane

FIGURE D-7.6 UNSIGNALIZED AT-GRADE INTERSECTION



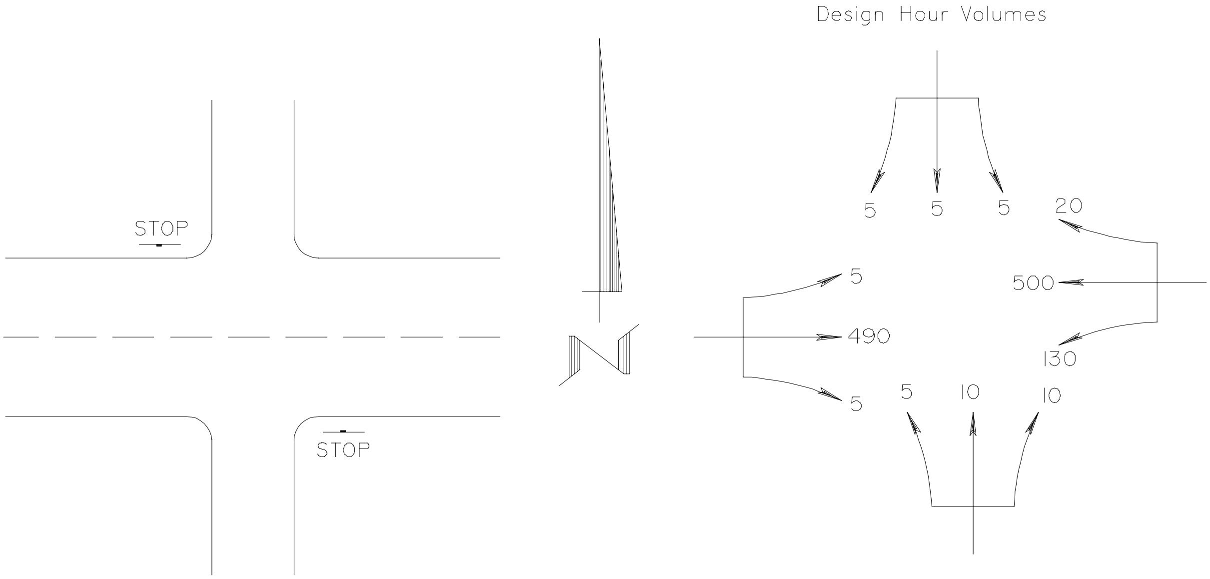
When making a left turn at the intersection illustrated above, Vehicle A may be delayed by a vehicle or vehicles in the opposing stream (Vehicle C). Through vehicles in the advancing stream (Vehicle B) following a left turning vehicle may be delayed by, or exposed to collision with Vehicle A. (In this case, the left turning vehicle is considered to make his turn from the advancing lane to the side road, across the opposing lane.) The interference caused by standing left turning vehicles in the through advancing traffic can reduce capacity and create a safety hazard. The amount of interference is dependent on opposing volumes, advancing volumes and the number of left turning vehicles.

The addition of a left turn lane with the required storage space will eliminate this interference. Figures D-7.6-1a through D-7.6-7d, based on a vehicle operating at the design speed indicated, show the conditions where left turn lanes and storage lengths should be added or where traffic signals are to be considered. When traffic signals are warranted, storage lengths are dependent on the cycle length of the installation and these charts should NOT be used to determine the storage lane lengths. Where operating speeds are such that vehicle speed differs from the design speed used for other highway elements, the actual operating speed may be used in lieu of the design speed.

Where the percentage of trucks in the left turning volume is high or where grades are in excess of two percent, additional lengths should be added to the chart values (see Tables D.7.6a and D.6.2.6). All additional lengths are to be added to the parallel left turn lane length.

Example of Chart Use

Given: Two-Lane Highway
Design Speed = 110 km / h
Percent of Trucks in $V\ell$ = 15%



A left turn lane with suitable storage space is being considered for left turning vehicles on the East approach.

$V\ell$	=	130 v.p.h.		(Number of Left Turning Vehicles Per Hour in the Advancing Volume)
Va	=	500 + 20 + 130	= 650 v.p.h.	(Advancing Volume)
L	=	$V\ell$ / Va = 130 / 650	= 20%	(Proportion of Left Turns in Va)
Vo	=	490 + 5 + 5	= 500 v.p.h.	(Opposing Volume)

Entering chart with
Vo = 500 v.p.h.
Va = 650 v.p.h.
L = 20%

We find from Figure D-7.6-7b that a left turn lane is warranted and the required additional storage space is 35m. Since 15 percent of $V\ell$ are trucks, from Table D.7.6a, the additional storage requirements due to trucks is 10m. Therefore, a left turn is warranted for this direction and standard intersection Type IVb (Figure D-7k) should be used. An additional storage length of 45m (35m due to volume plus 10m due to trucks) should be added to the left turn lane.

The standard Type IV treatment has 15 m of storage built in due to the design speed, taper and parallel lane (see Table D.7.6b). Therefore the additional storage necessary is 30 m i.e. 45 m – 15 m.

Table D.7.6a Additional Storage Length Requirements for Trucks on Type IVa, IVb, and IVc At-Grade Intersections

Additional Storage Length, S (m) *	% Trucks in Left Turning Volume						
	10%	15%	20%	25%	30%	40%	50%
	ADDITIONAL STORAGE LENGTH REQUIREMENTS FOR TRUCKS, St (m)						
<15	0	0	0	0	0	0	0
15	10	10	10	10	10	15	15
25	10	10	10	10	15	15	15
30	10	10	10	15	15	15	25
40	10	10	15	15	15	25	25
50	10	15	15	15	25	30	30
>50	15	15	20	25	30	40	50

Notes:

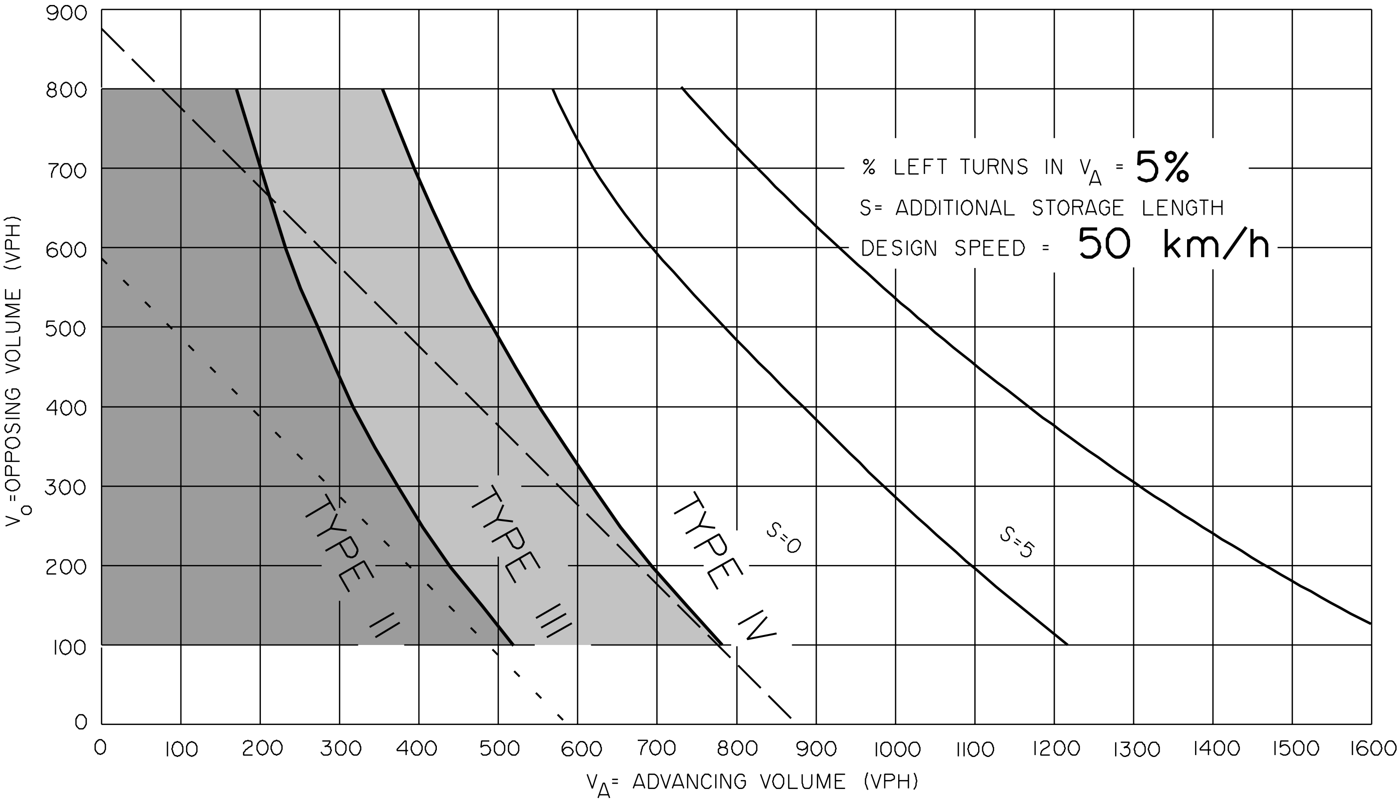
1. * S value from the appropriate Figure (D-7.6-1a through D-7.6-7d).
2. The values shown are to be provided in addition to the standard storage and the S value; that is: total storage = standard storage + S + St (from Table D.7.6a).

Designers may notice that the additional storage length requirement(s) shown on the warrant charts (Figures D-7.6-1a through D-7.6-7d) are relatively small, even for high volumes of advancing and opposing traffic. This is because there is some storage provided by the standard treatment as shown in Table D.7.6b below:

Table D.7.6b Standard Design Lengths for Parallel Deceleration Lanesfor Left Turn on Type IVa, IVb and IVc Standard Intersection Treatments on Undivided Highways

Highway Design Speed (km/h)	Taper Length (m) and Ratio	Parallel Lane Length (m)	Length (m) Available for Deceleration (Lane + 1/2 Taper)	Deceleration Length Required (m)	Storage Length Provided by Standard Treatment (m)
50	140 at 40:1	20	90	70	20
60	140 at 40:1	35	105	90	15
70	140 at 40:1	55	125	110	15
80	140 at 40:1	80	150	130	20
90	210 at 60:1	70	175	150	25
100	210 at 60:1	85	190	170	20
110	210 at 60:1	100	205	190	15
120	210 at 60:1	120	225	210	15
130	210 at 60:1	125	230	215	15

FIGURE D-7.6-Ia WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 50 KM/H, LEFT TURN 5%, 10%



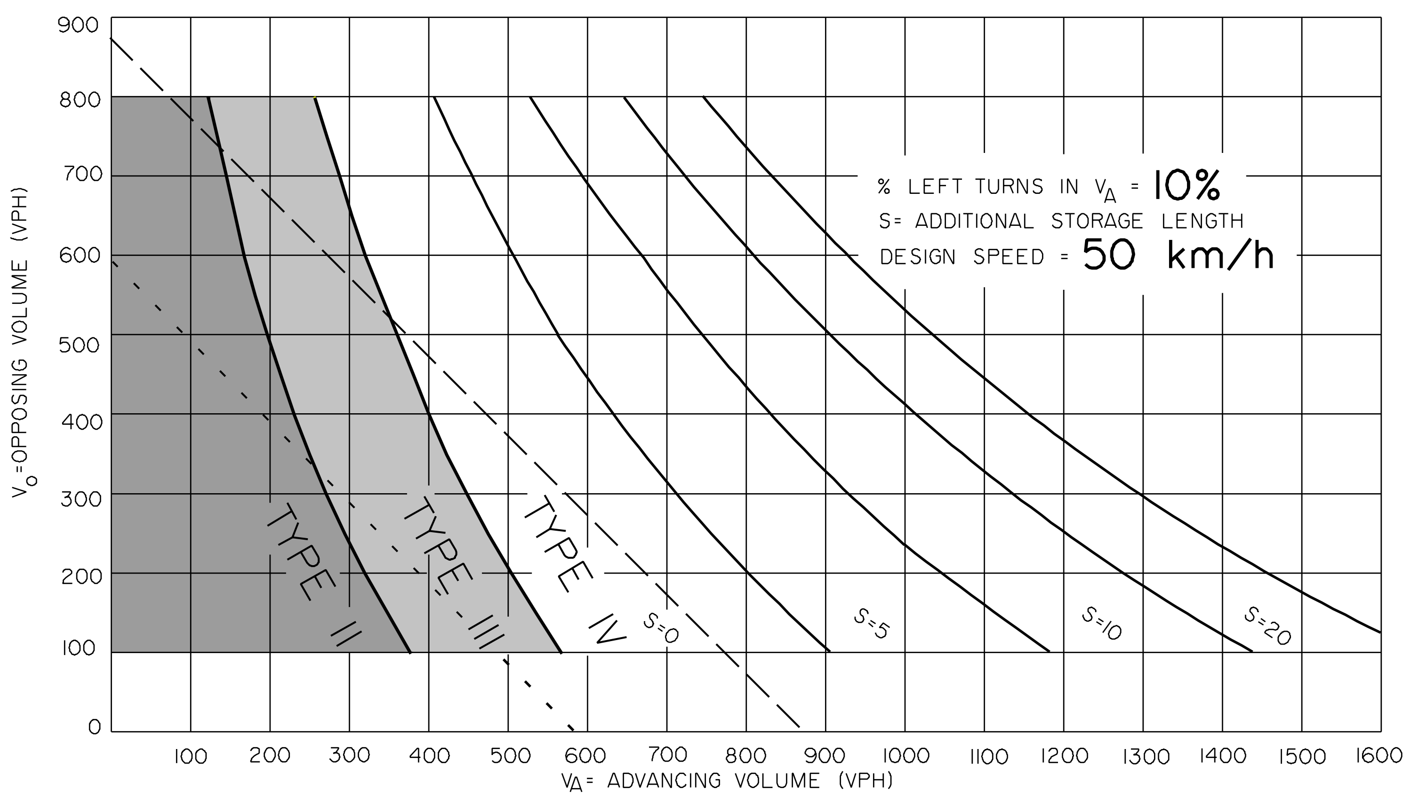
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

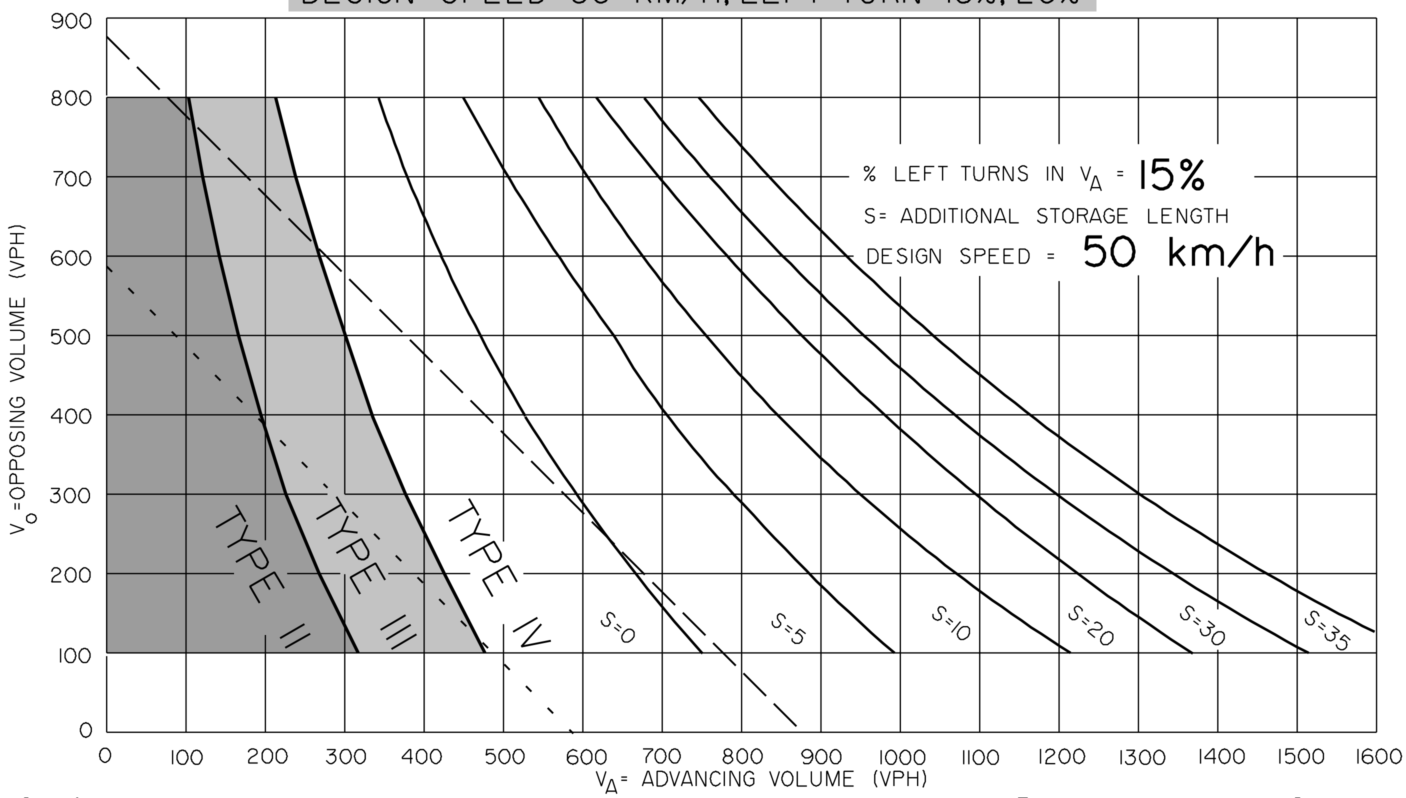
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd76la.man

FIGURE D-7.6-Ib WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 50 KM/H, LEFT TURN 15%, 20%



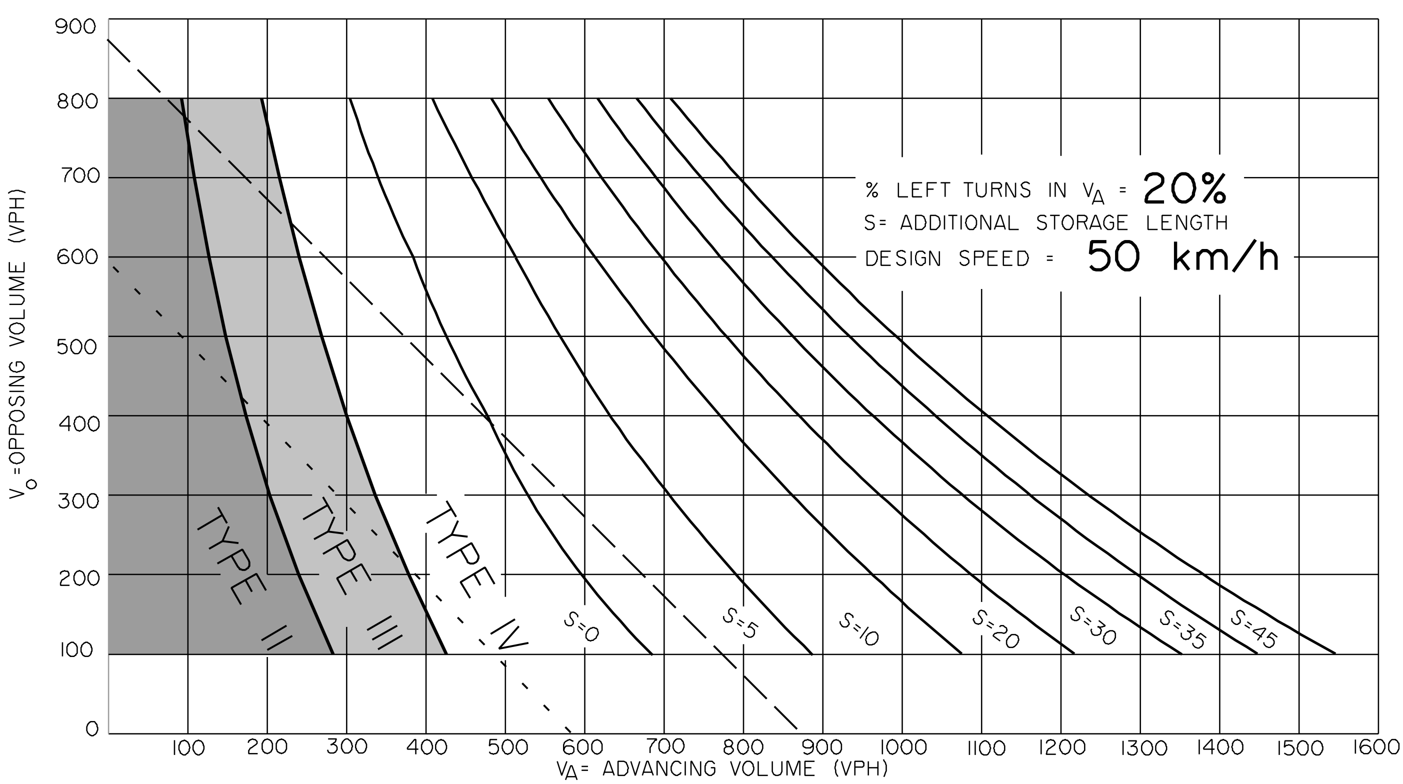
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

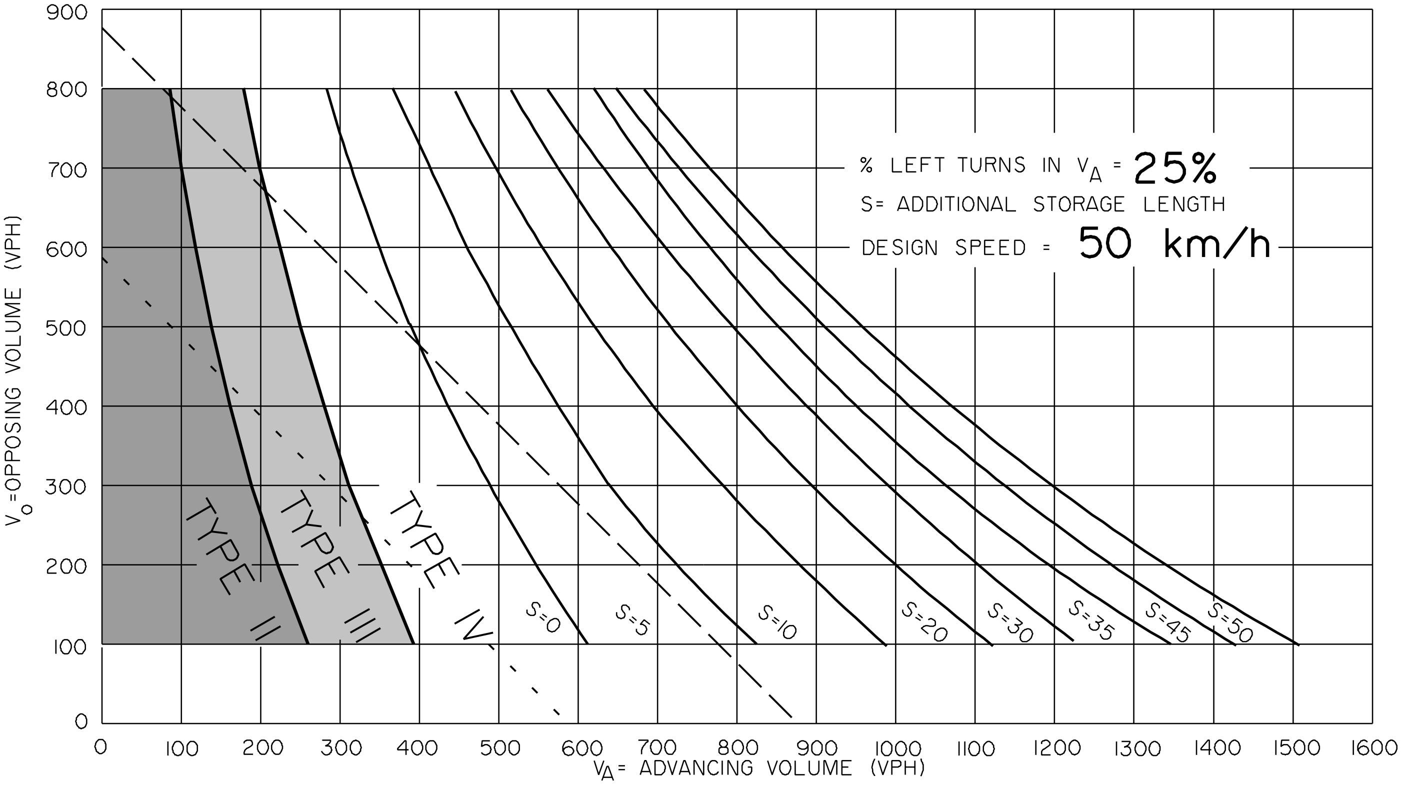
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd76la.man

FIGURE D-7.6-Ic WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 50 KM/H, LEFT TURN 25%, 30%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

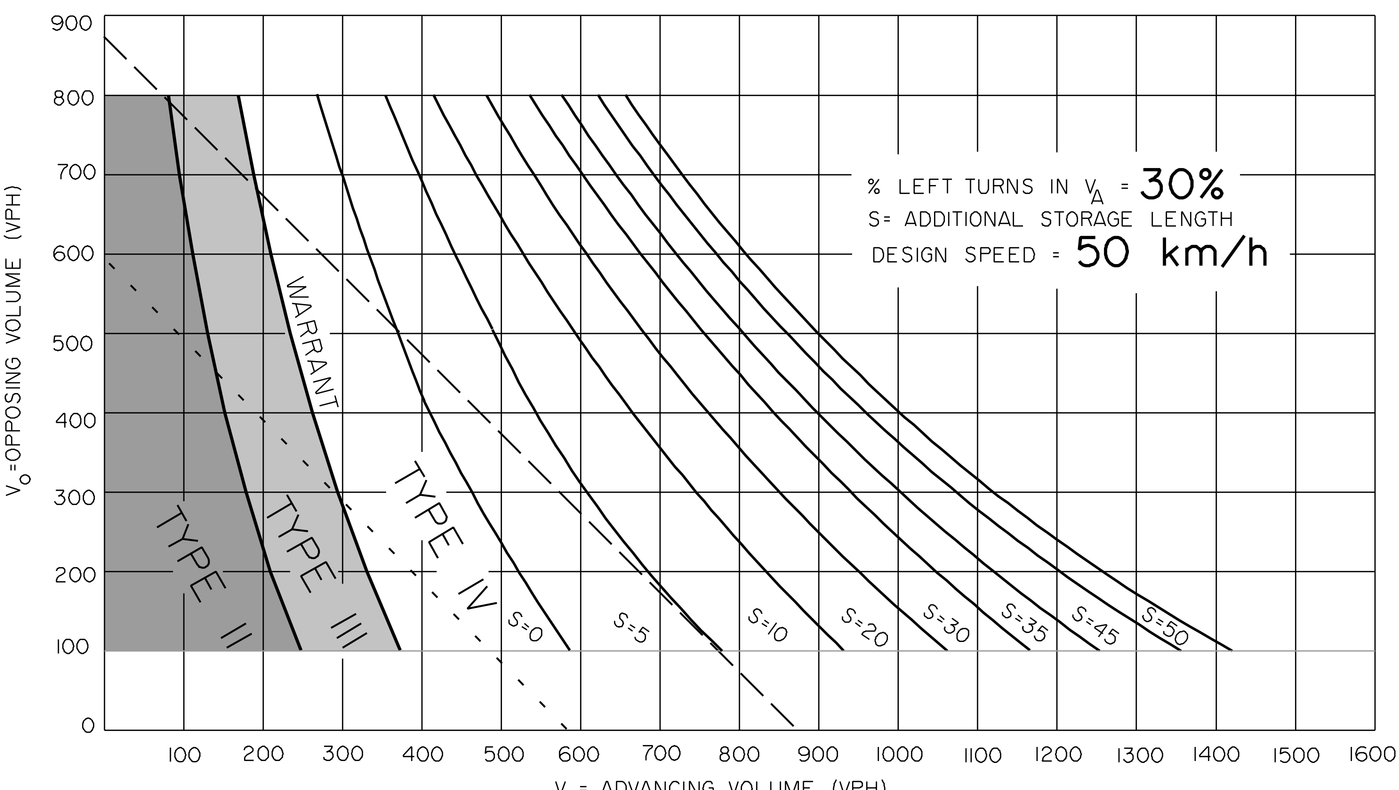
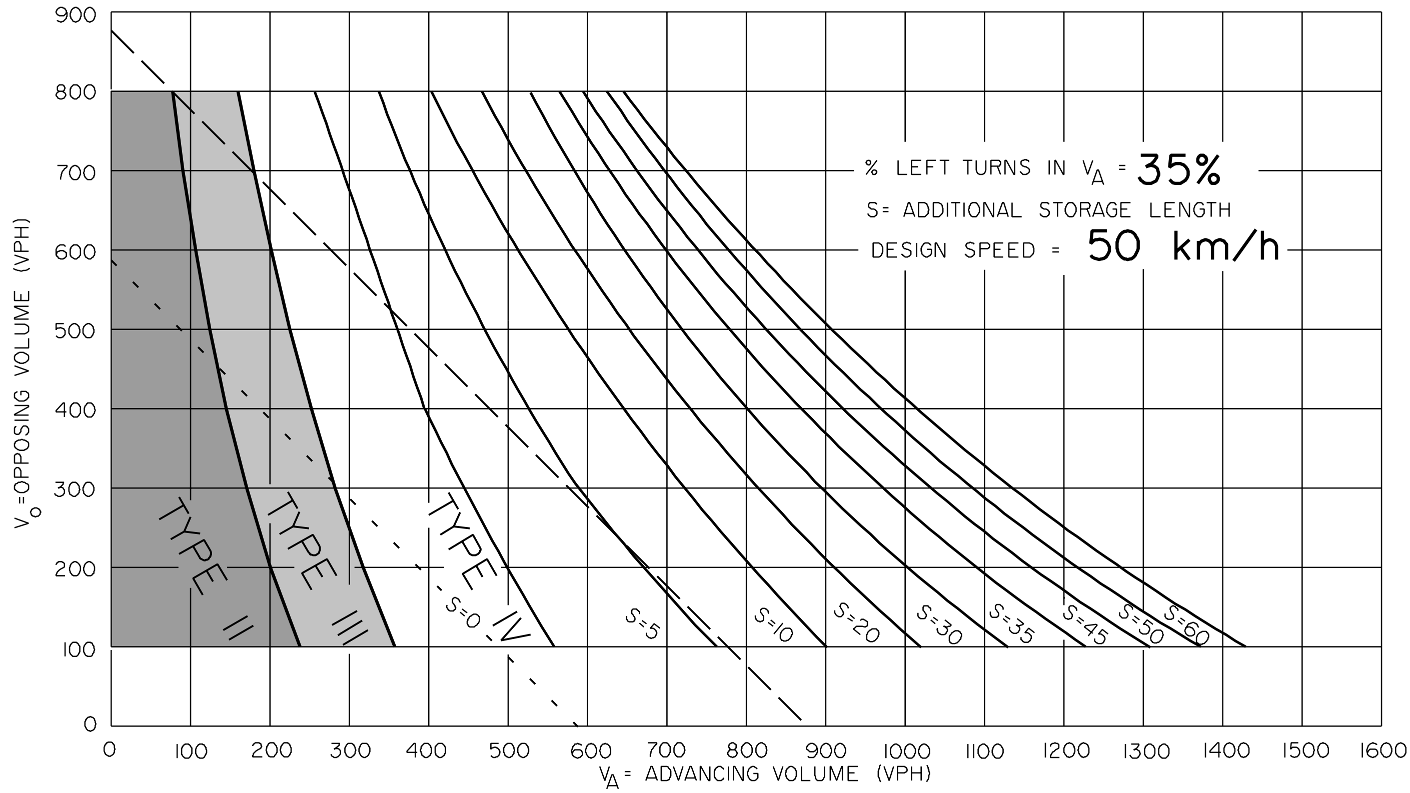


FIGURE D-7.6-Id WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 50 KM/H, LEFT TURN 35%, 40%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

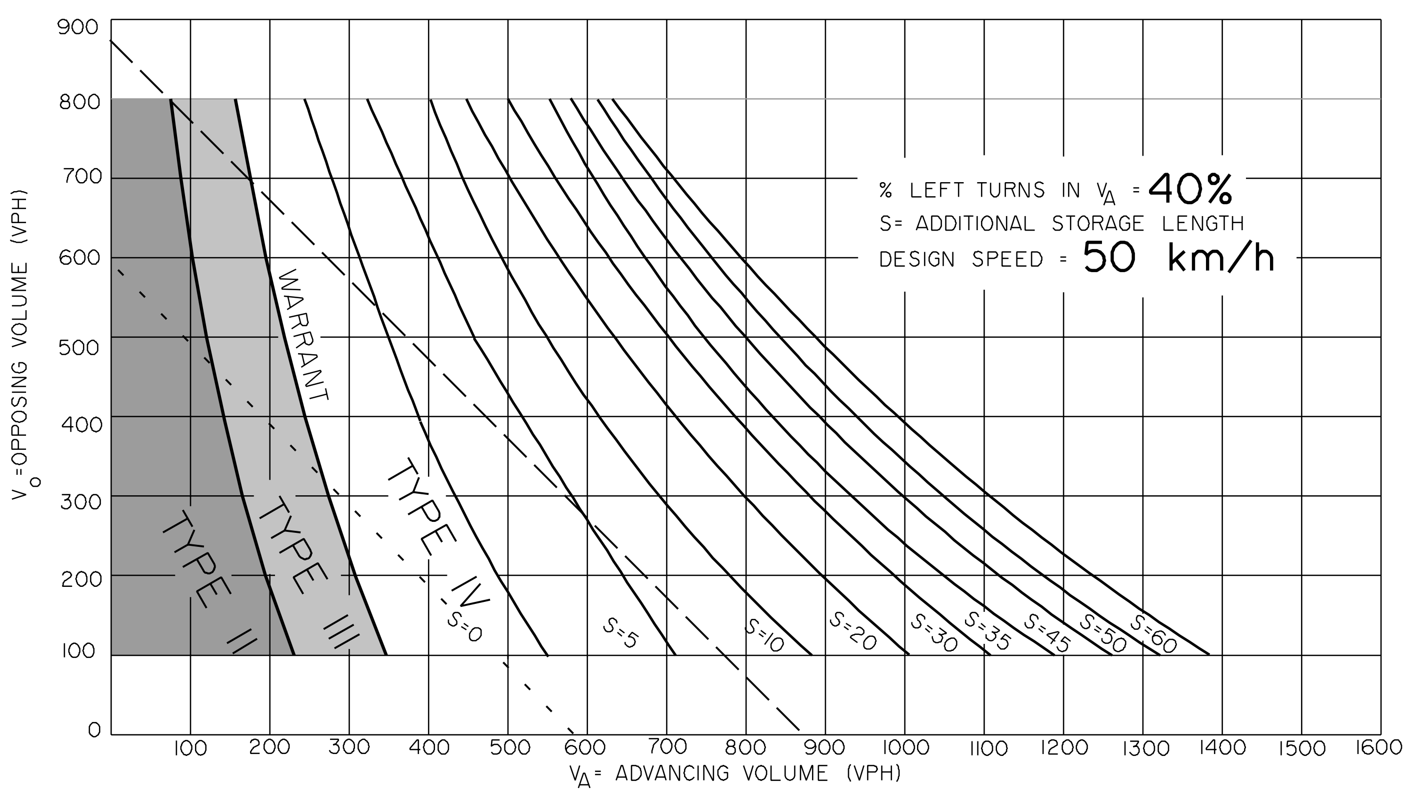
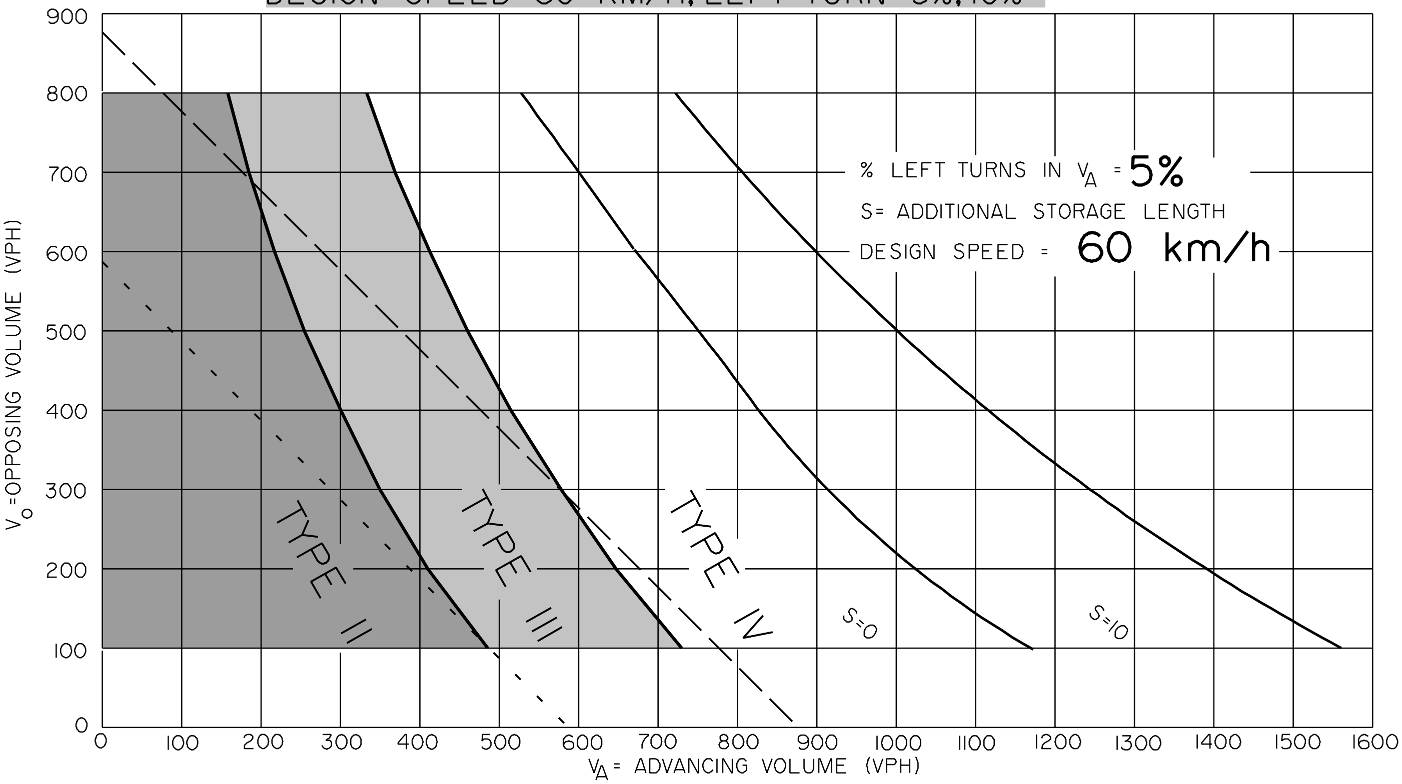


FIGURE D-7.6-2a WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 60 KM/H, LEFT TURN 5%, 10%



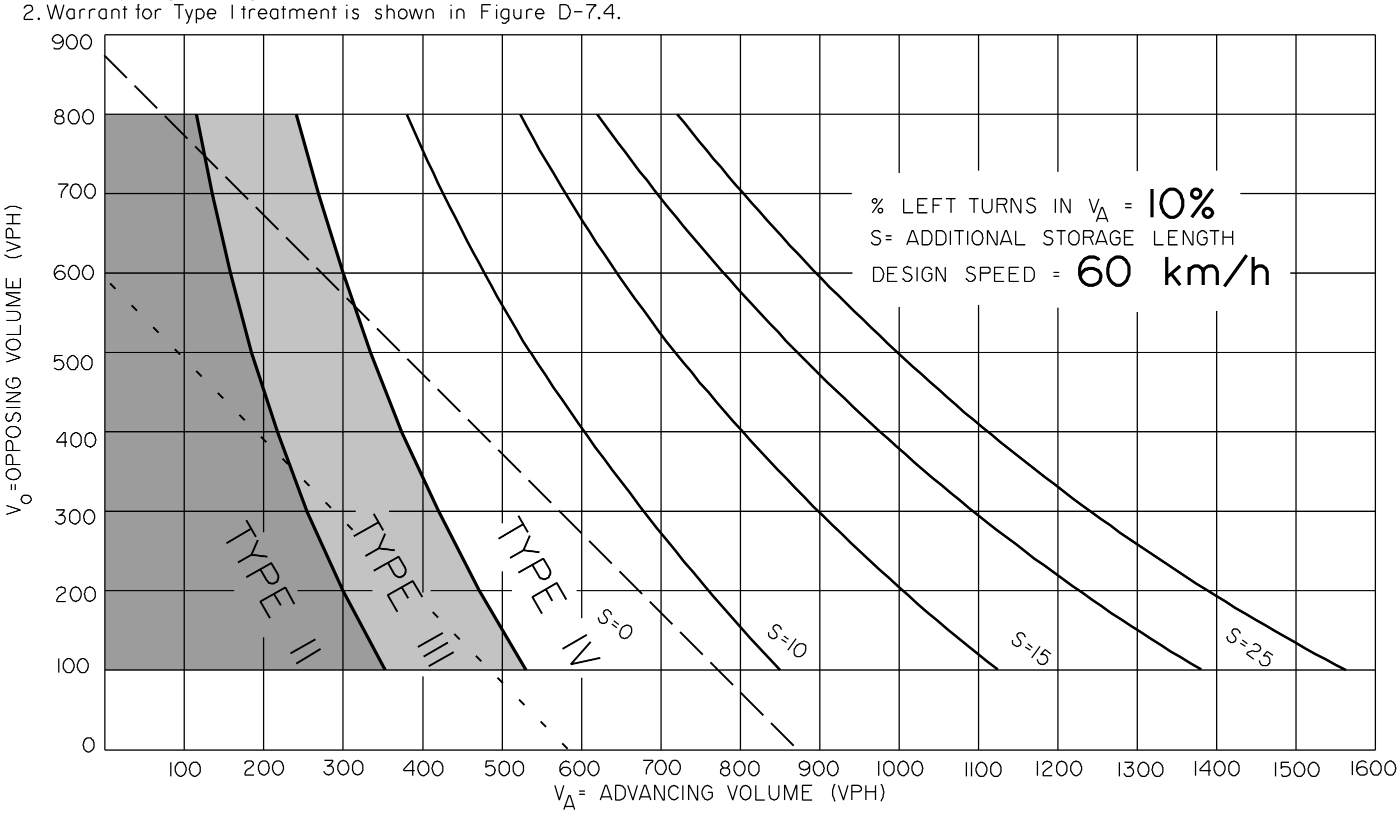
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

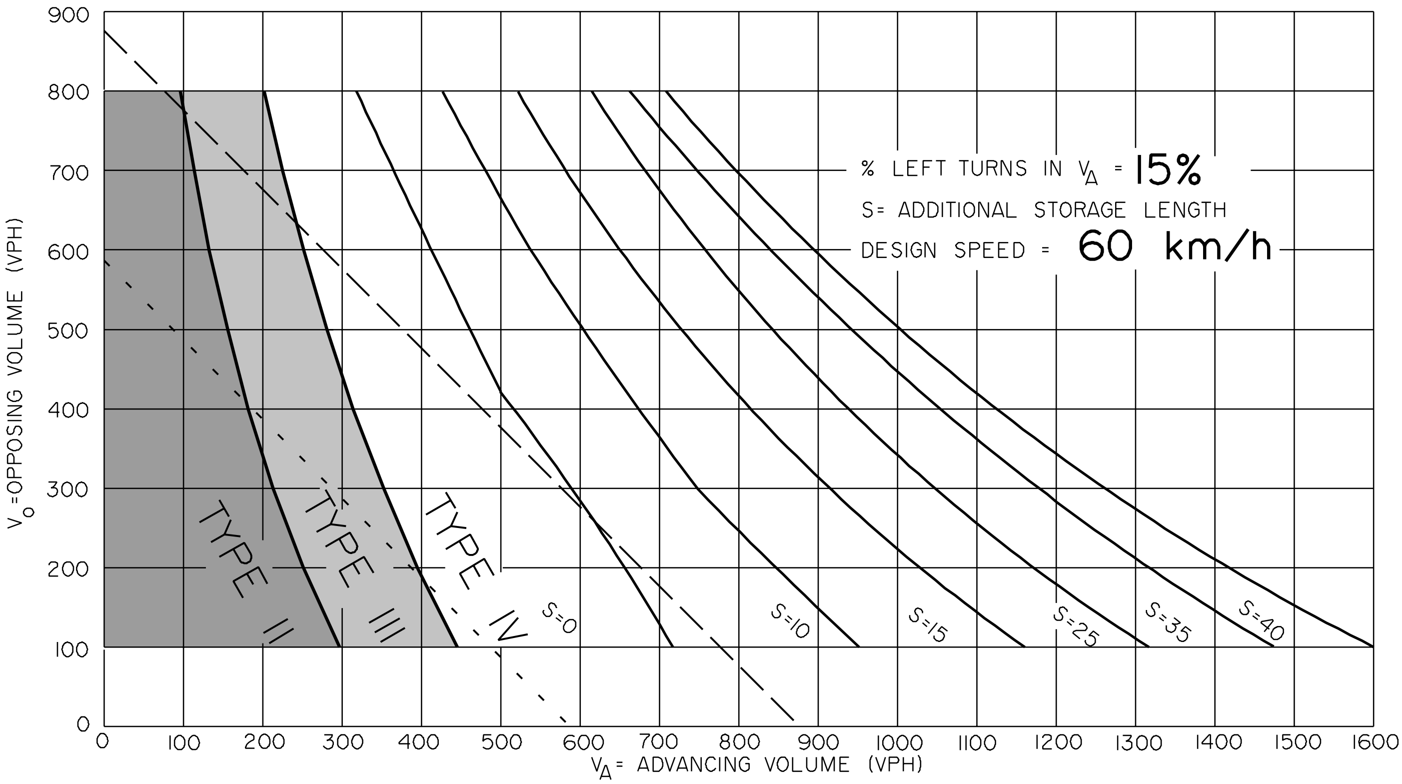
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd762a.man

FIGURE D-7.6-2b WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 60 KM/H, LEFT TURN 15%, 20%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

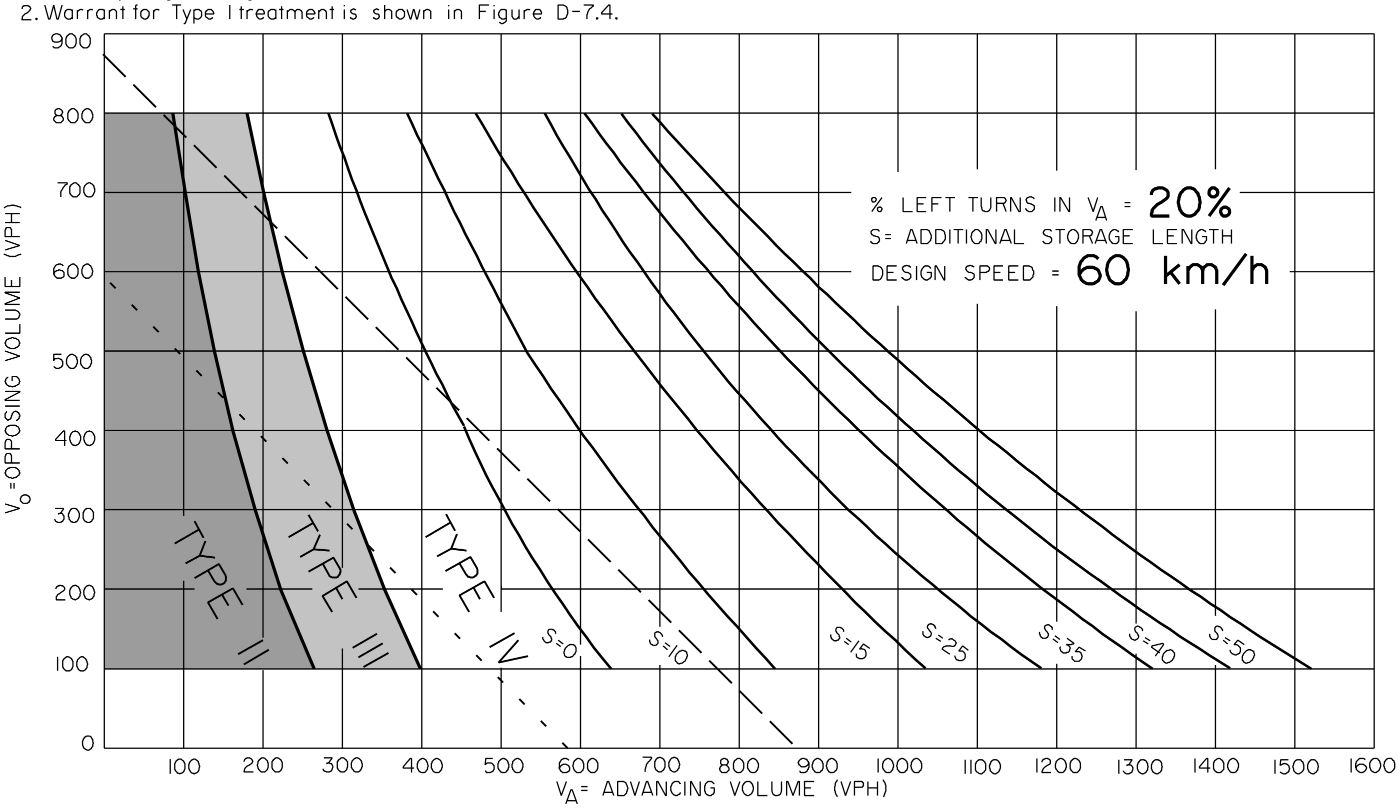
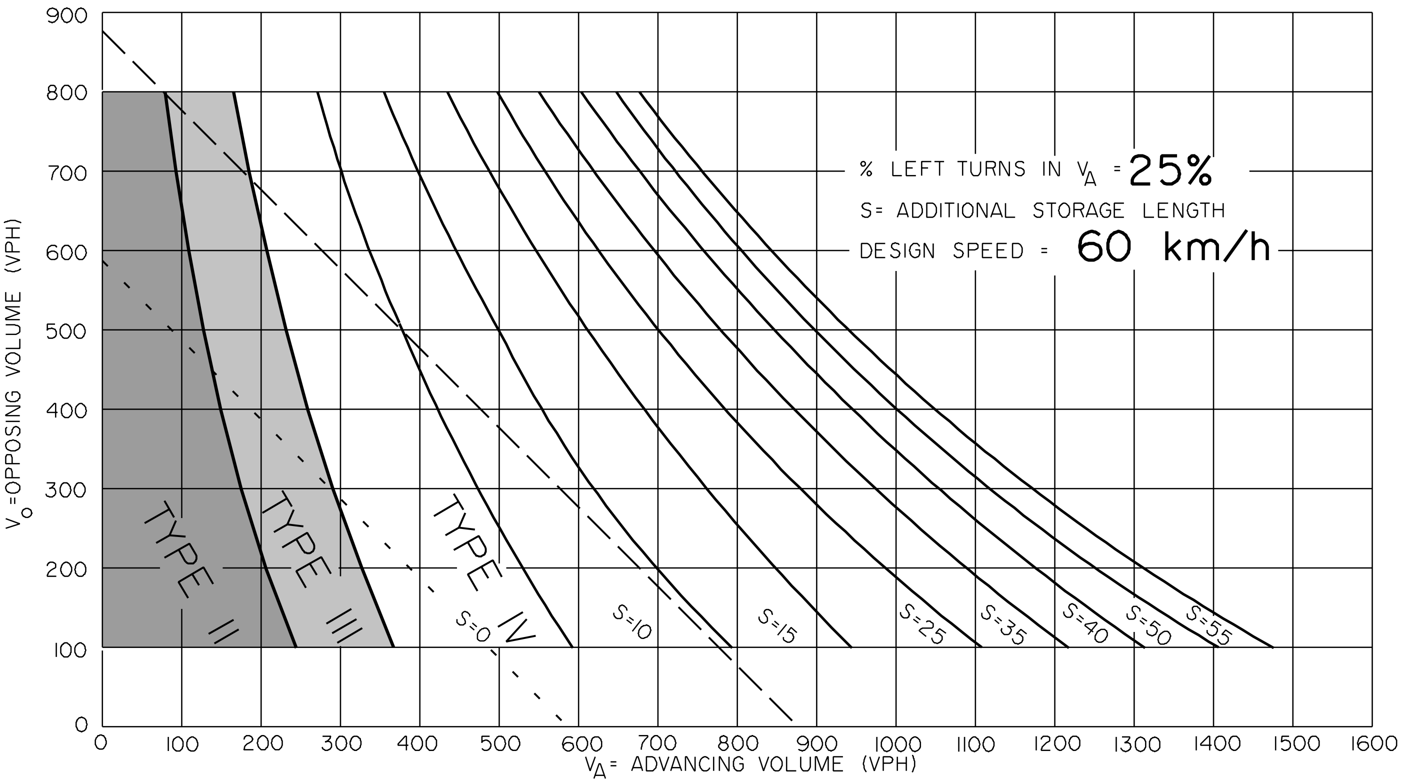


FIGURE D-7.6-2c WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 60 KM/H, LEFT TURN 25%, 30%



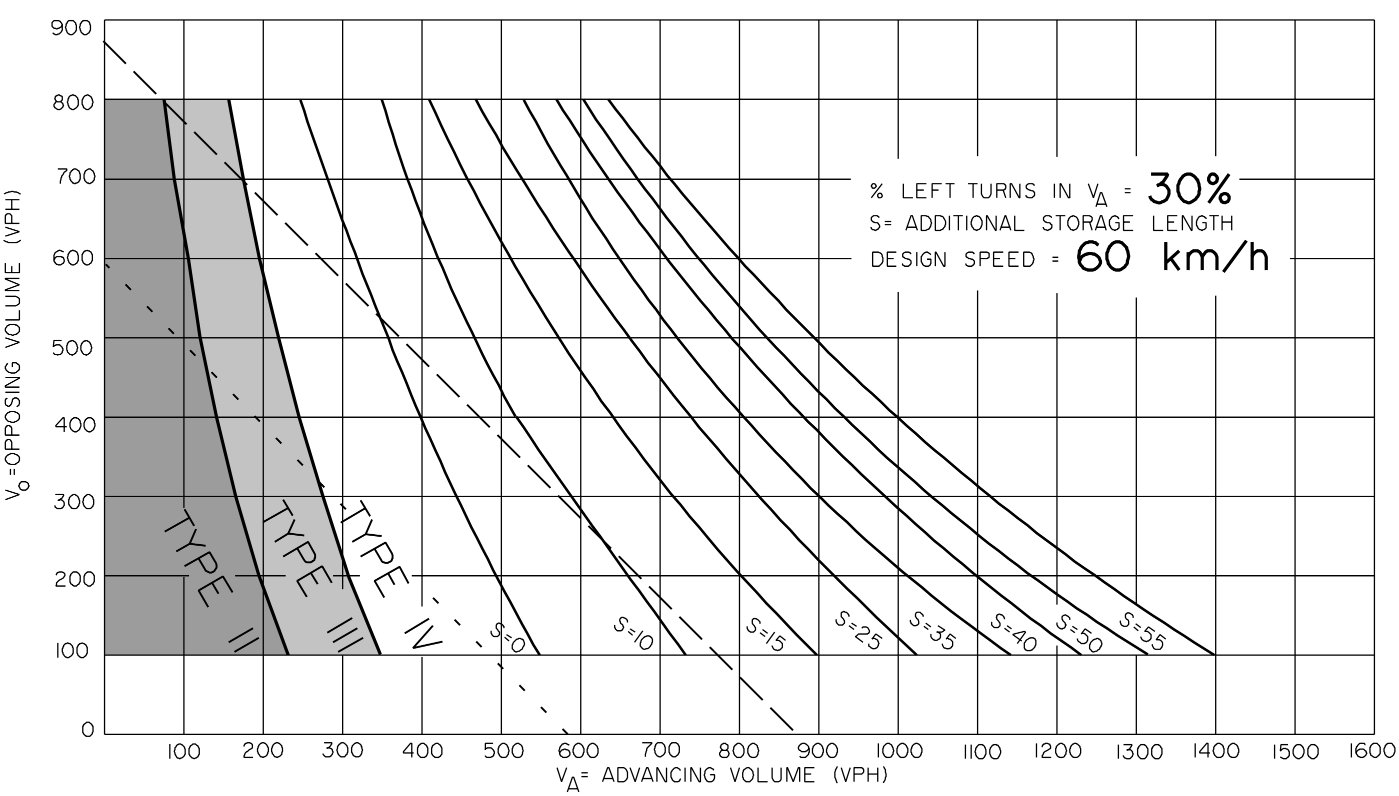
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

—— —— —— Traffic signals may be warranted in "free flow" urban areas.

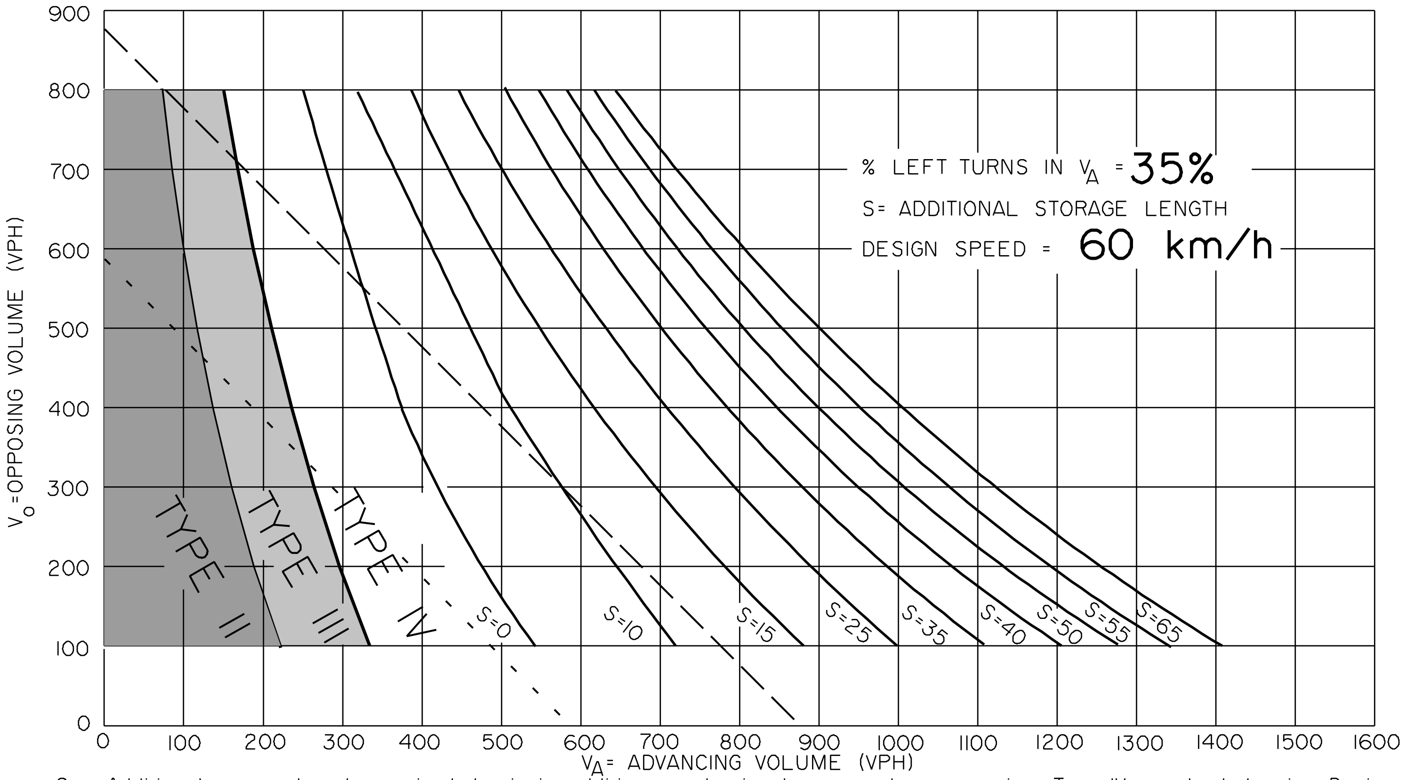
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd762a.man

FIGURE D-7.6-2d WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 60 KM/H, LEFT TURN 35%, 40%



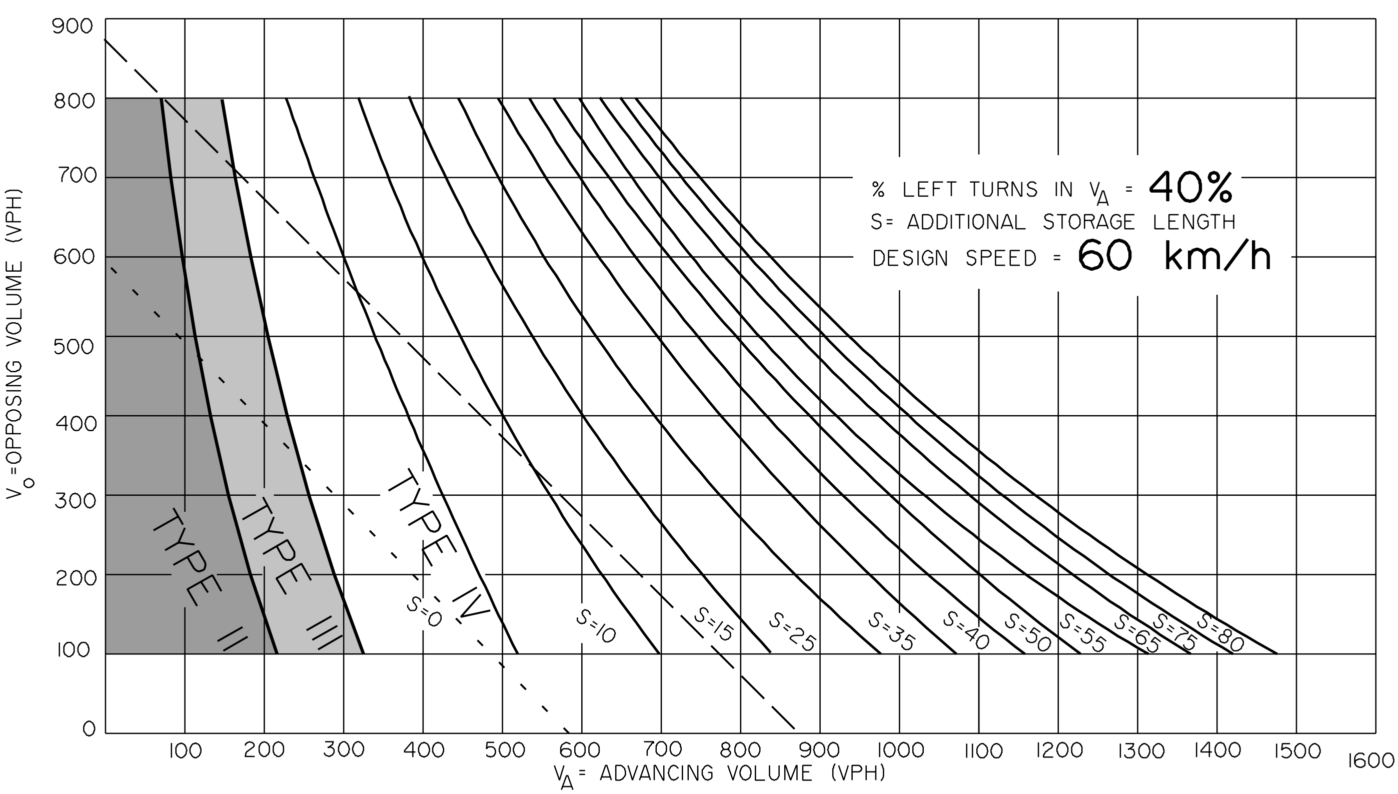
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

—— —— —— Traffic signals may be warranted in "free flow" urban areas.

Notes:

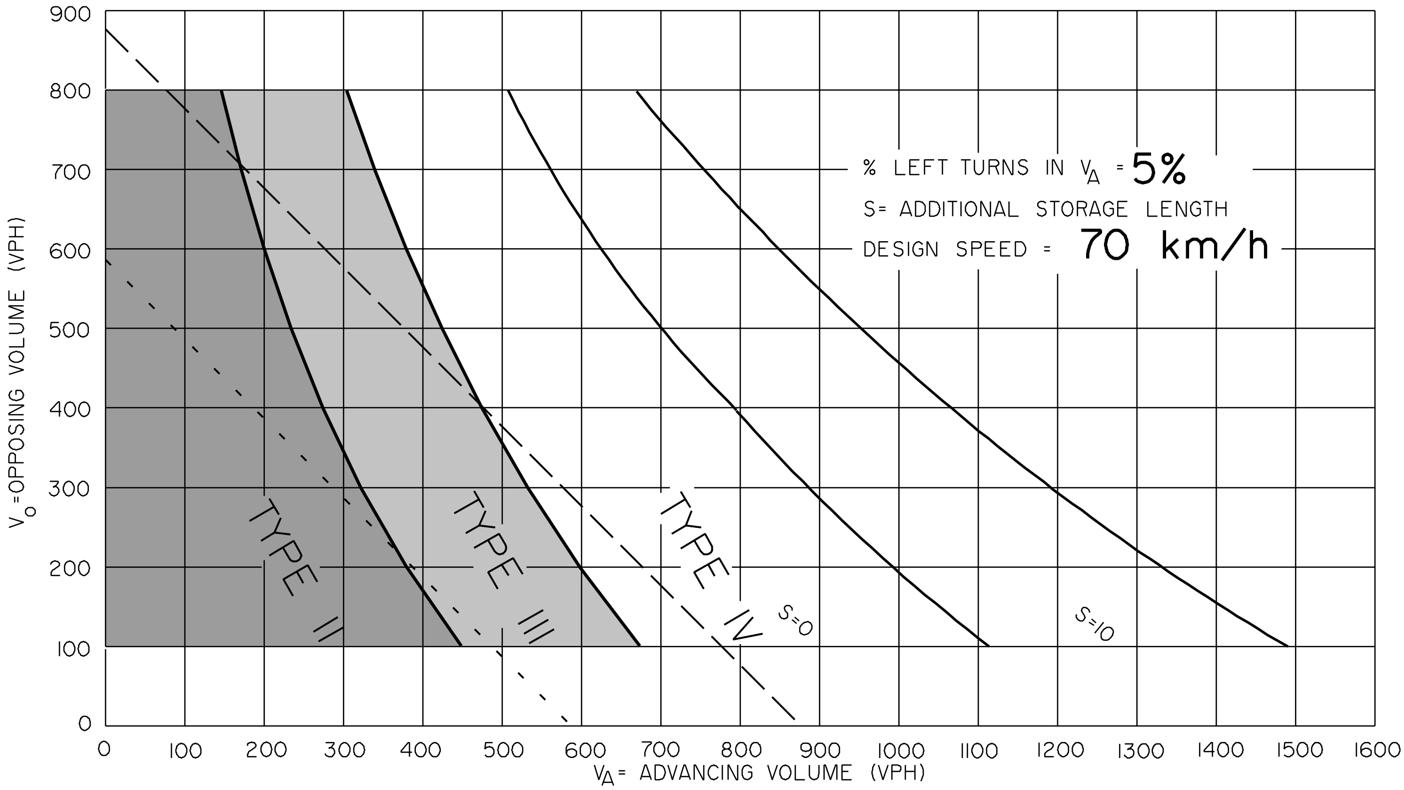
1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd762a.man

FIGURE D-7.6-3a WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS

DESIGN SPEED 70 KM/H, LEFT TURN 5%, 10%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

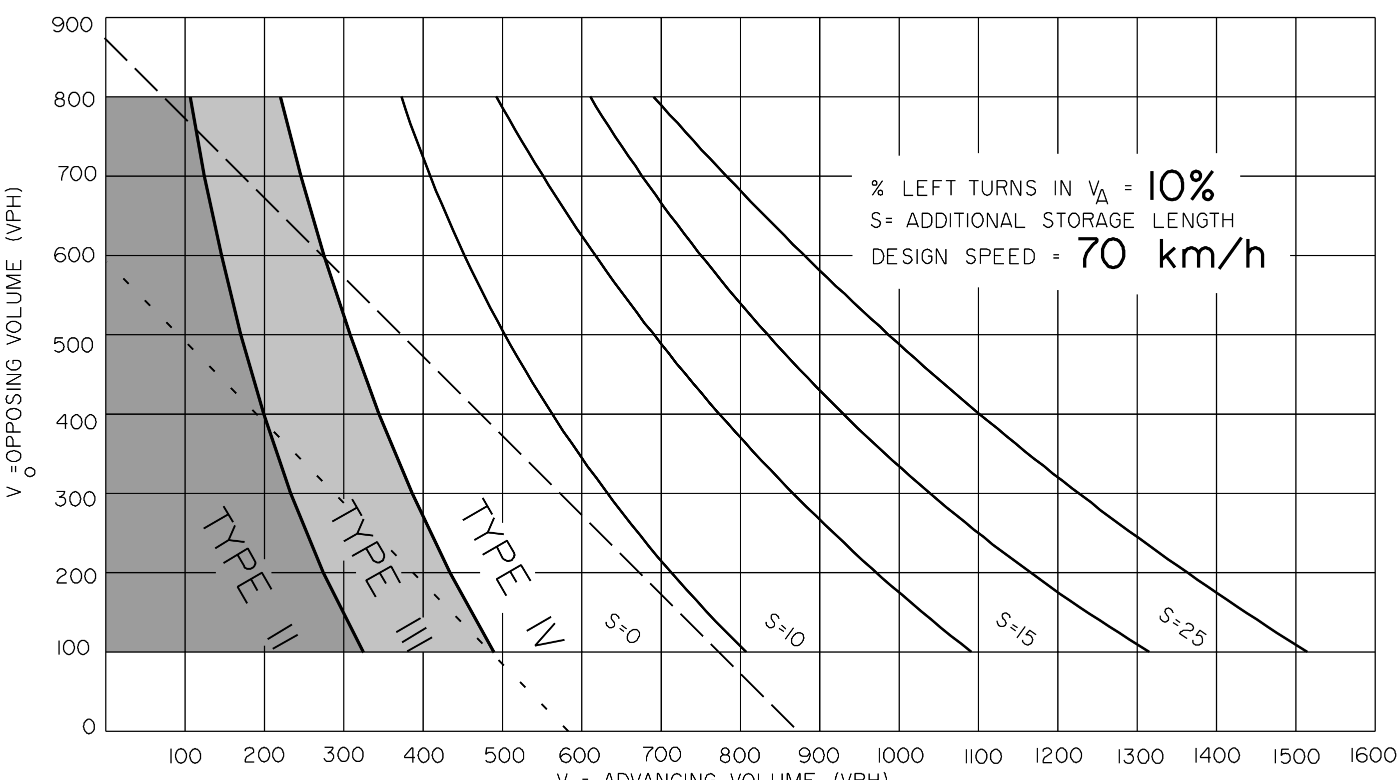
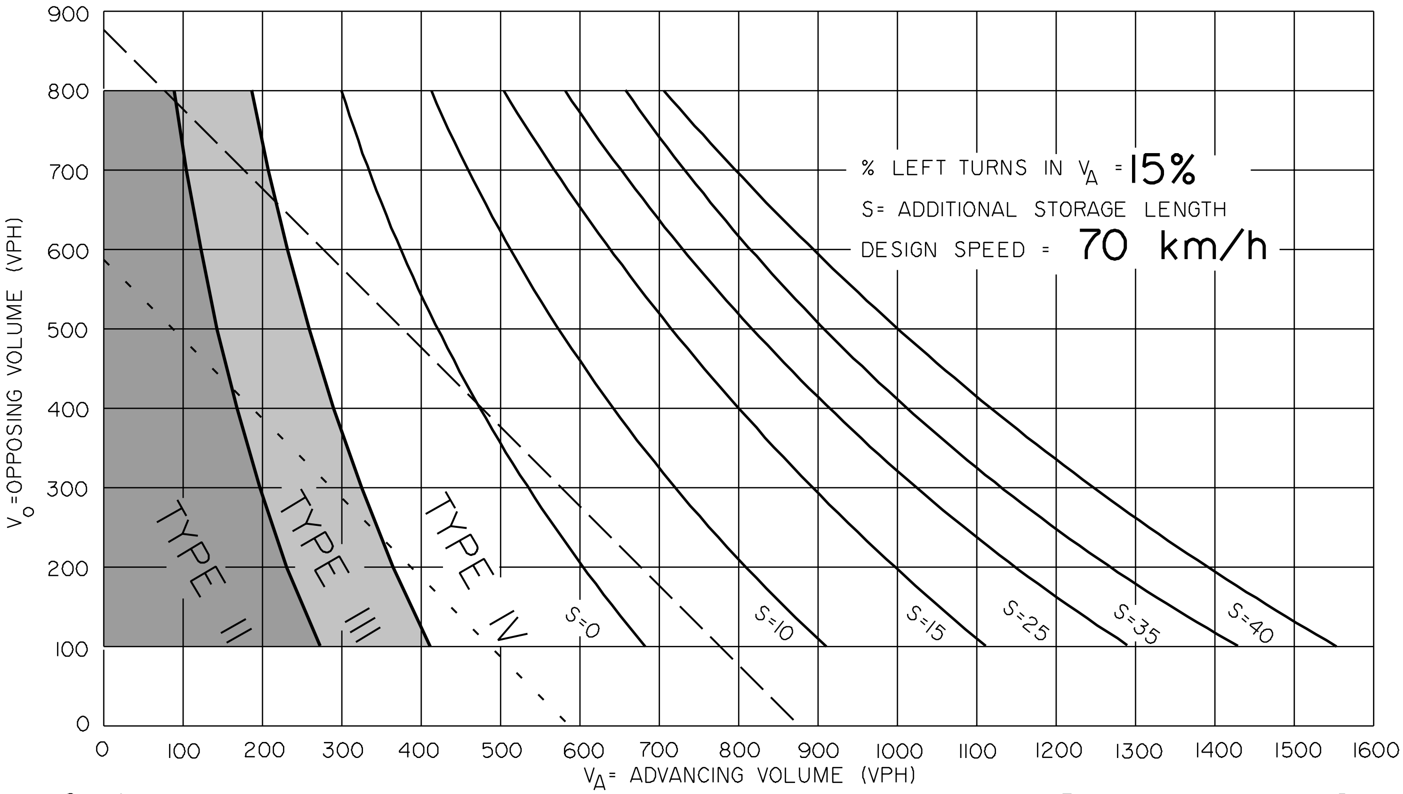


FIGURE D-7.6-3b WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 70 KM/H, LEFT TURN 15%, 20%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

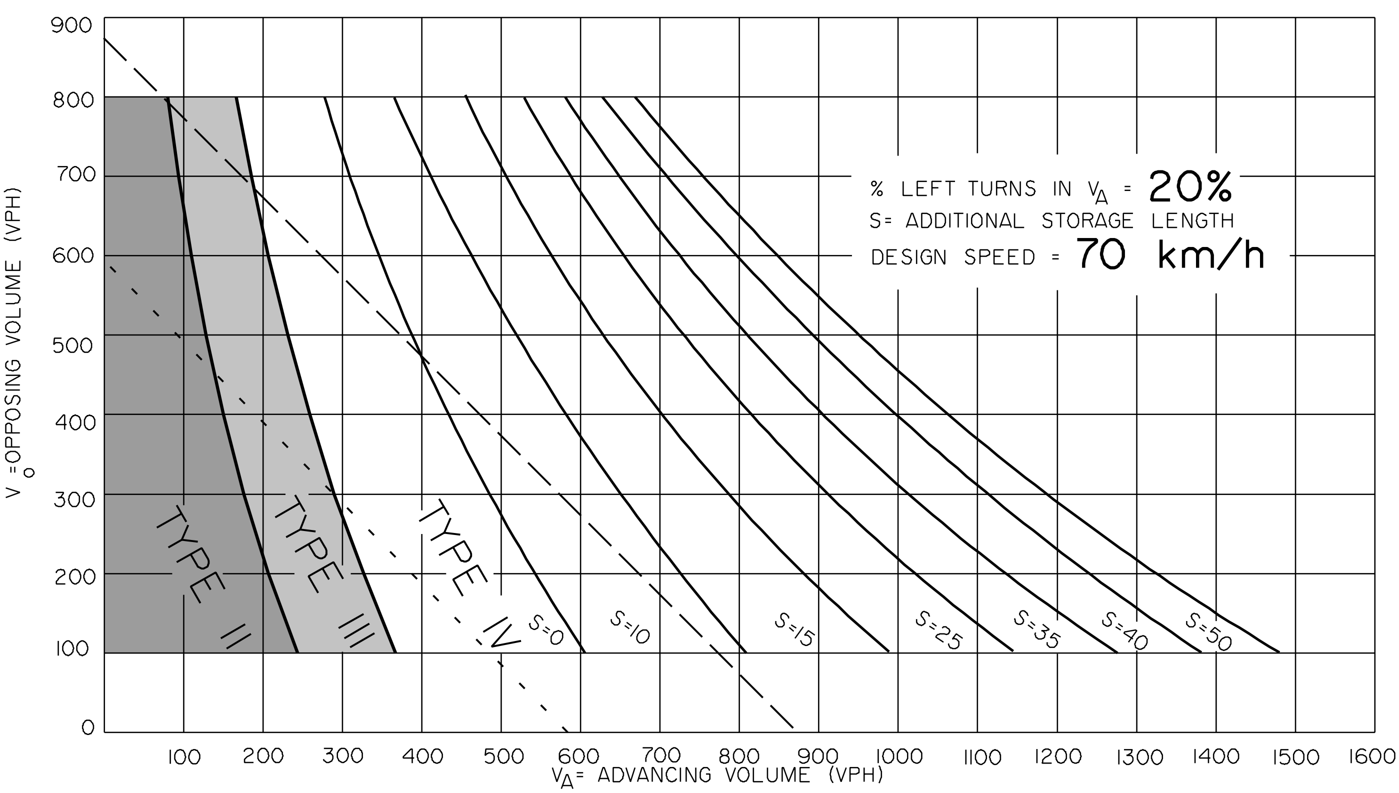
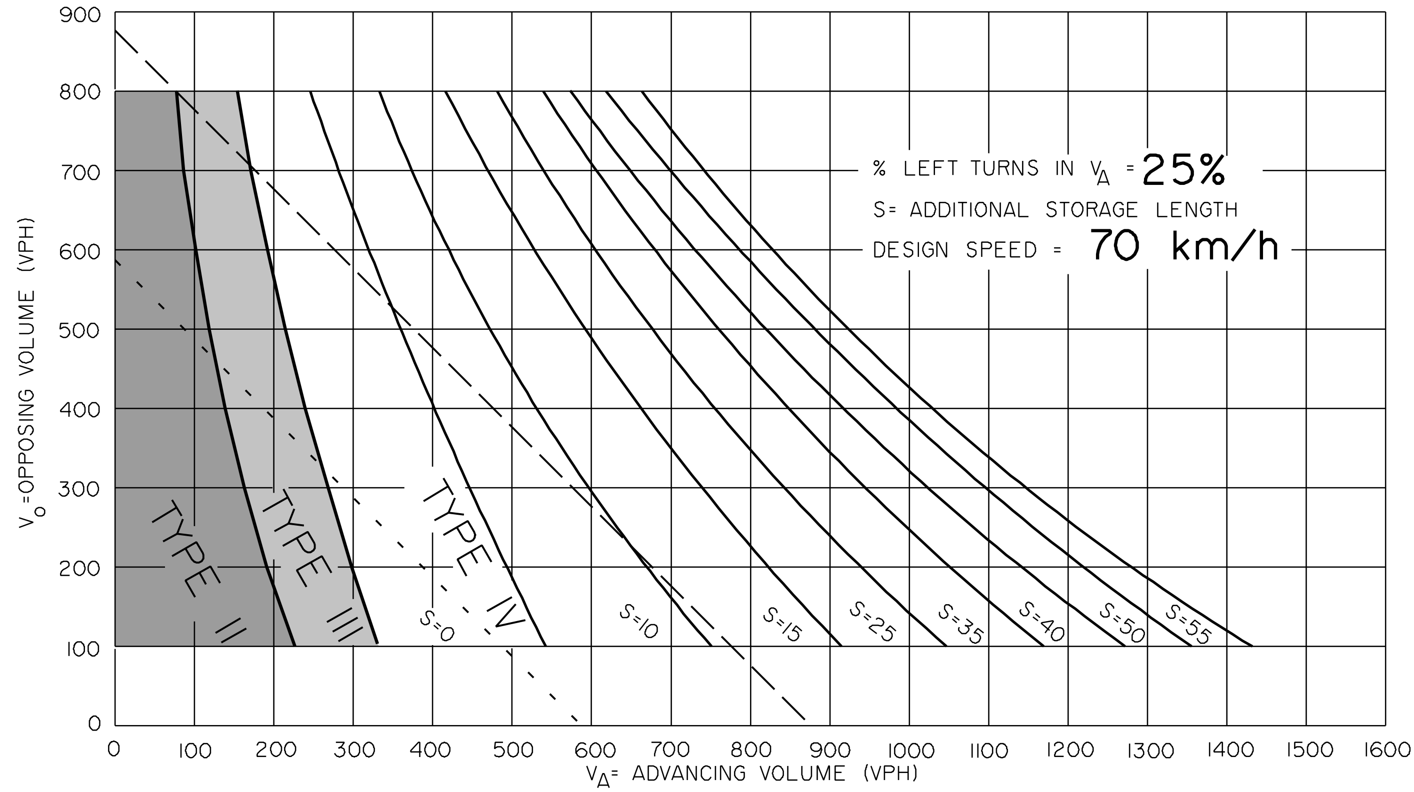


FIGURE D-7.6-3c WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 70 KM/H, LEFT TURN 25%, 30%



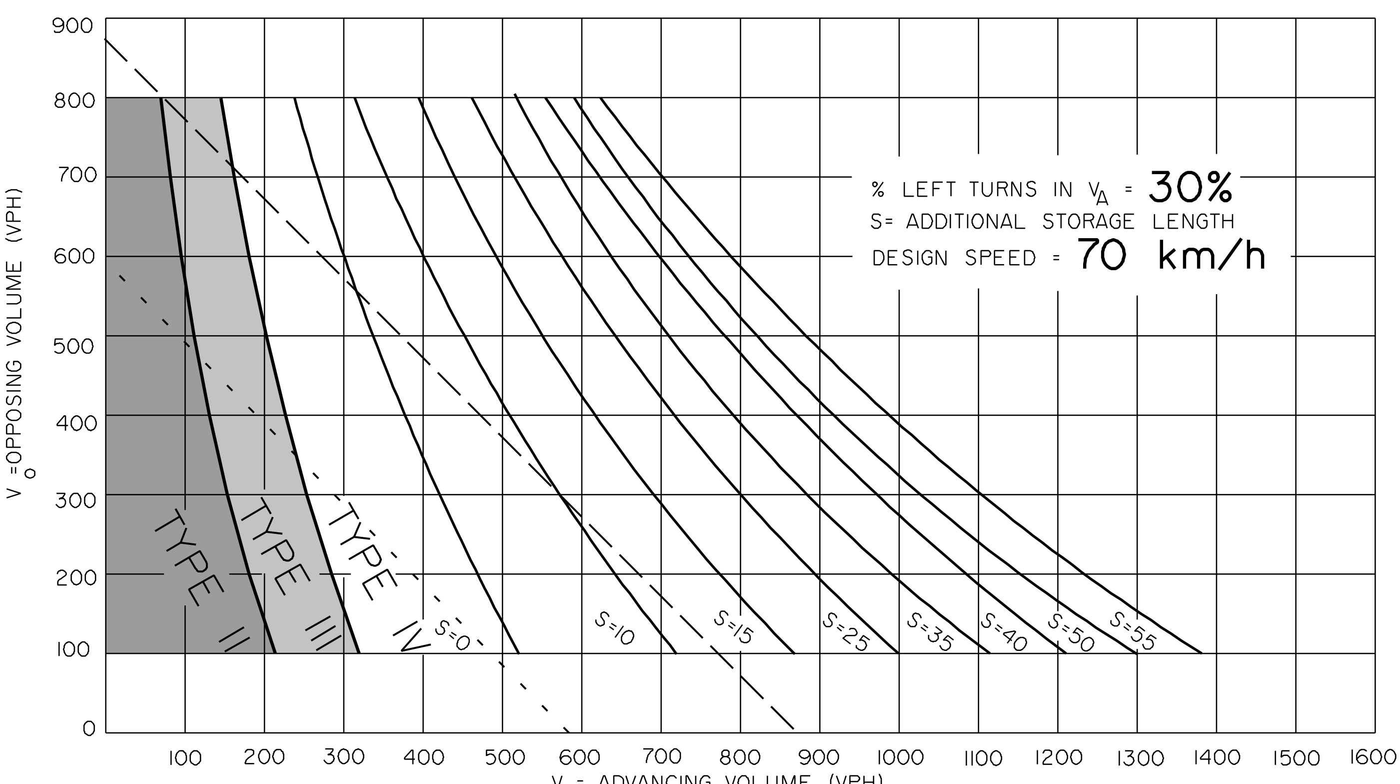
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

\- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

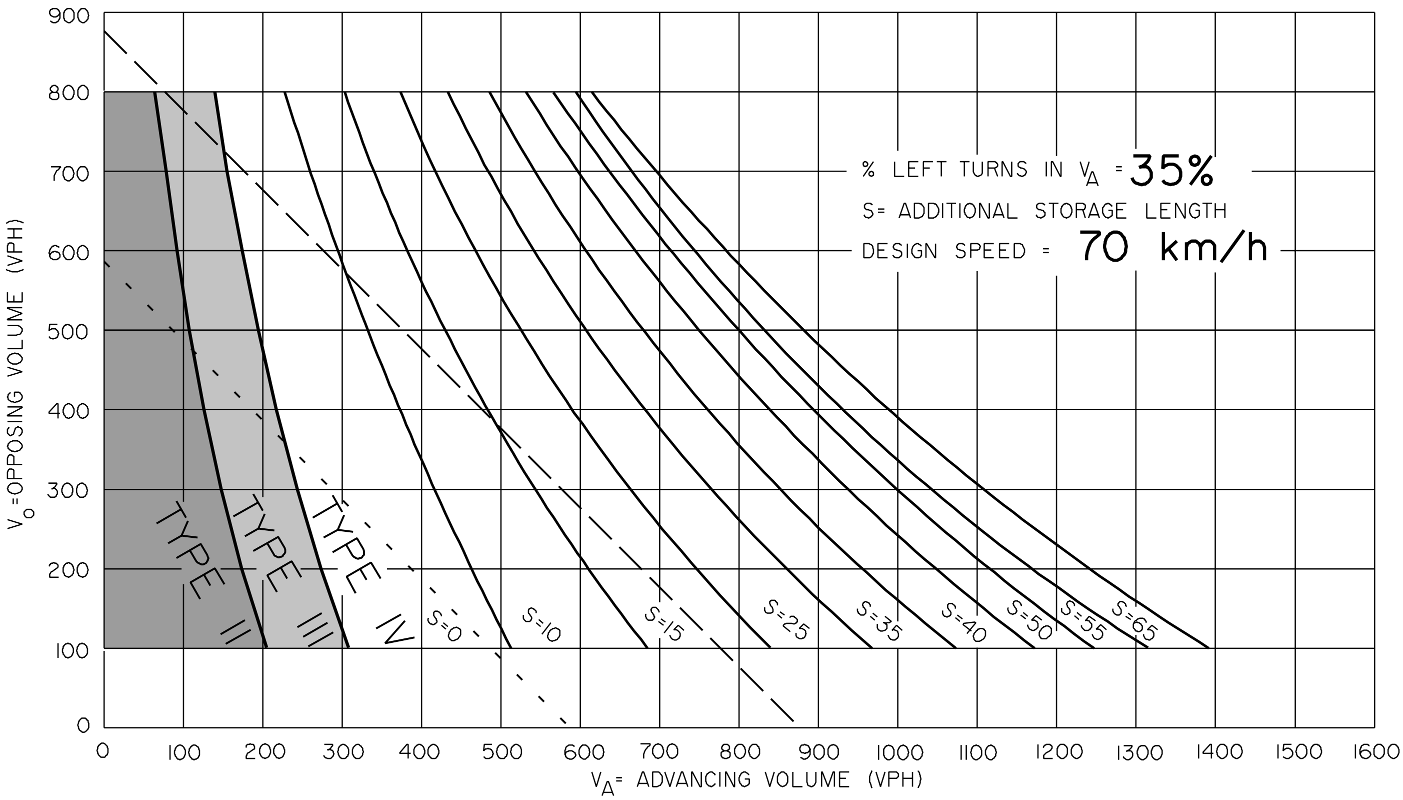
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd763a.man

FIGURE D-7.6-3d WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 70 KM/H, LEFT TURN 35%, 40%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

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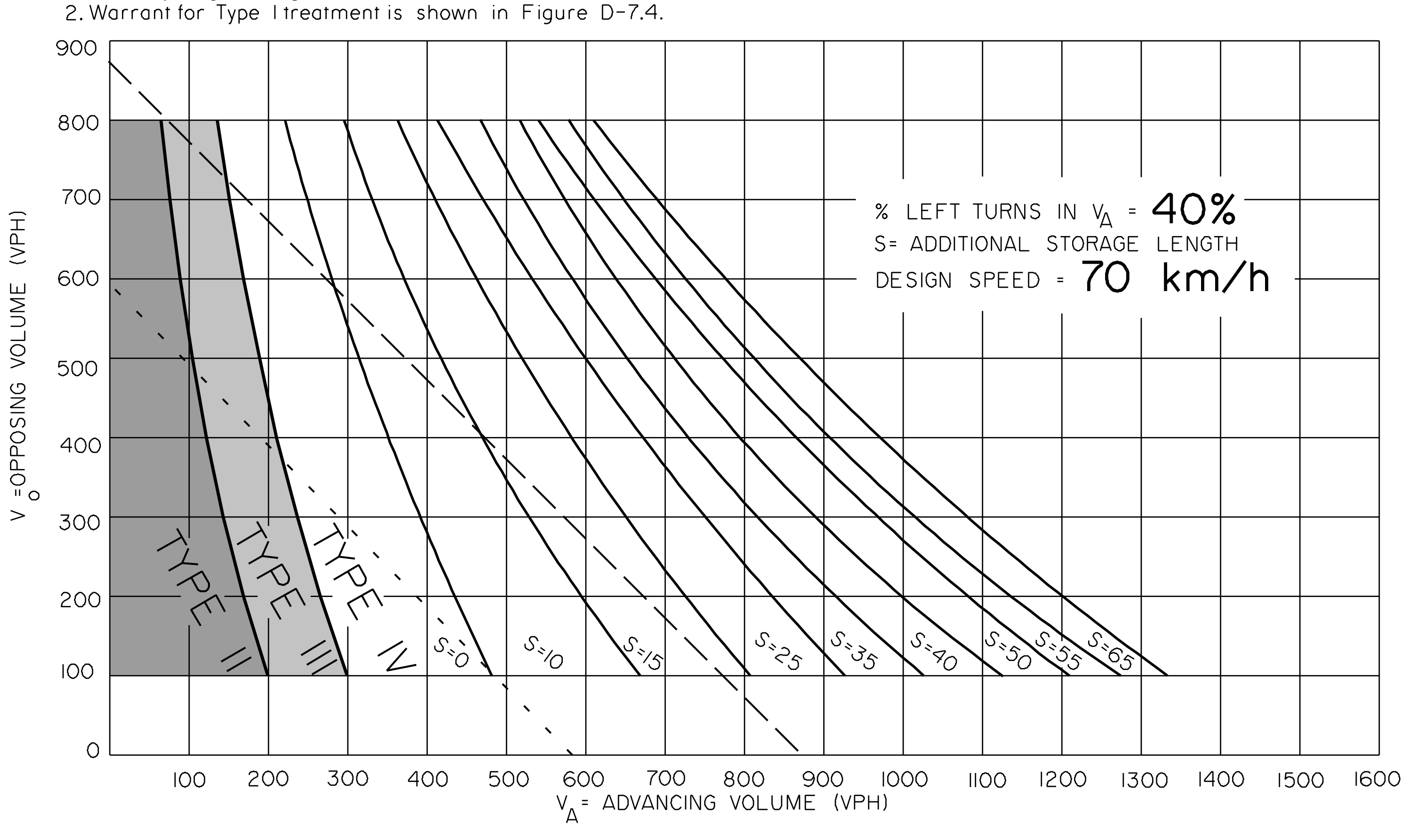
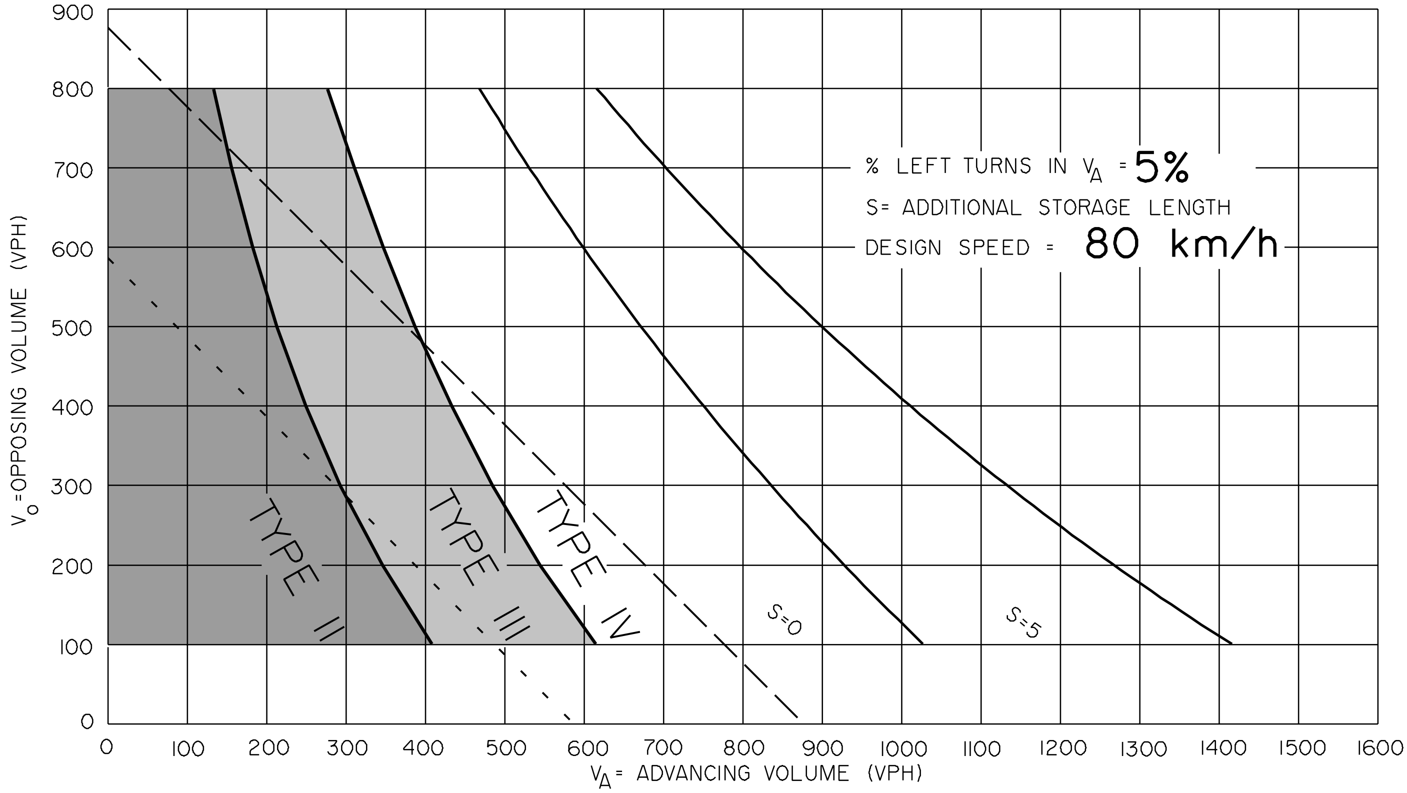
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd763a.man

FIGURE D-7.6-4a WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 80 KM/H, LEFT TURN 5%, 10%



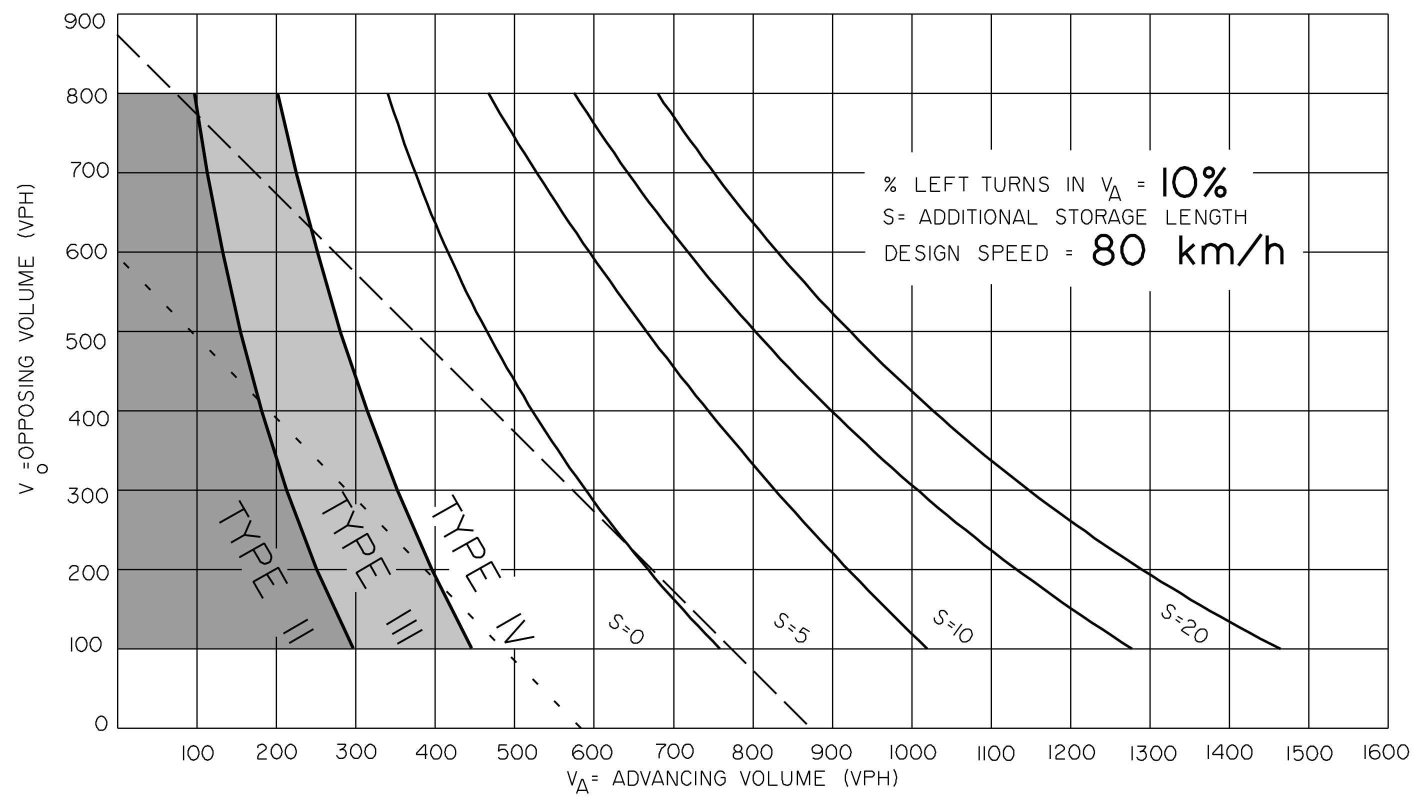
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

—— —— —— Traffic signals may be warranted in "free flow" urban areas.

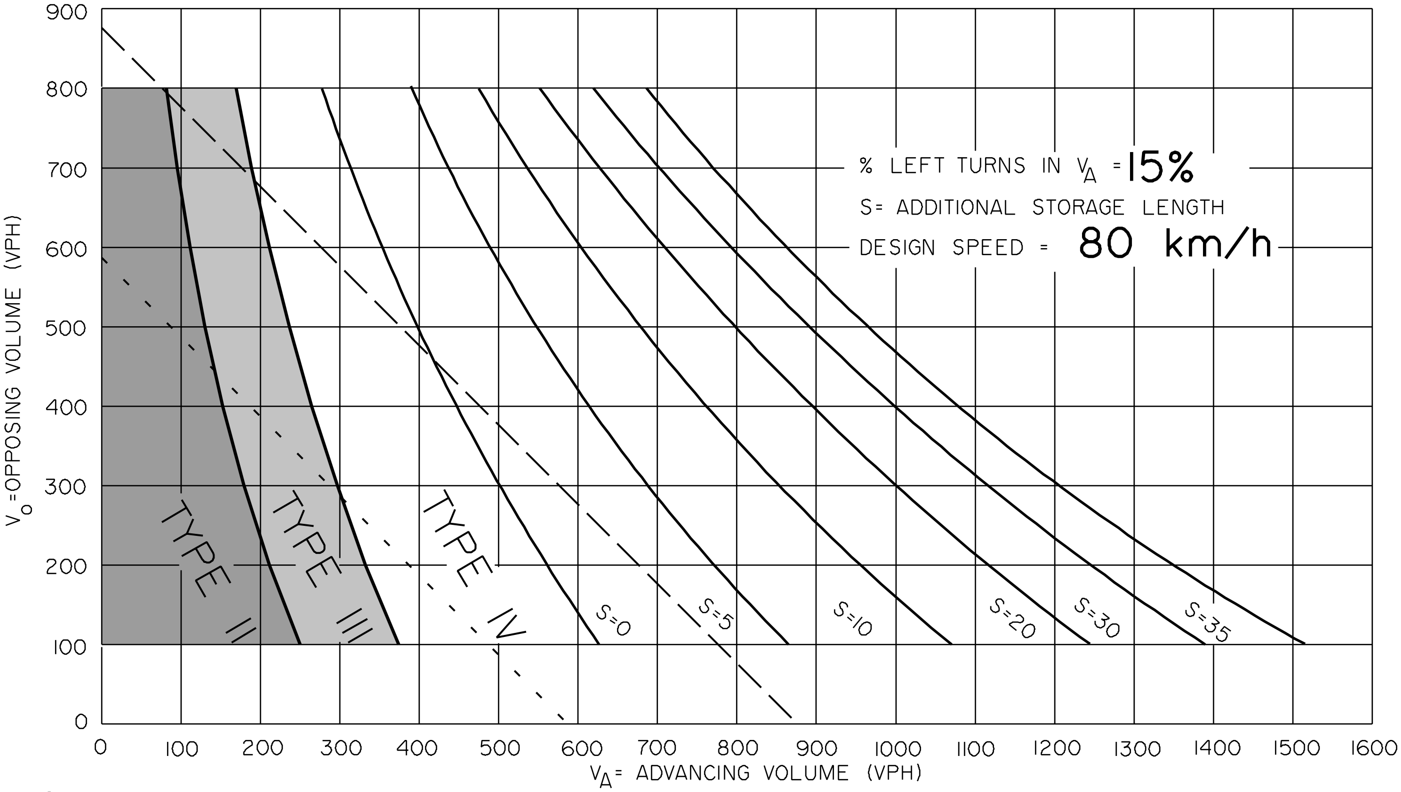
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd764a.man

FIGURE D-7.6-4b WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 80 KM/H, LEFT TURN 15%, 20%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

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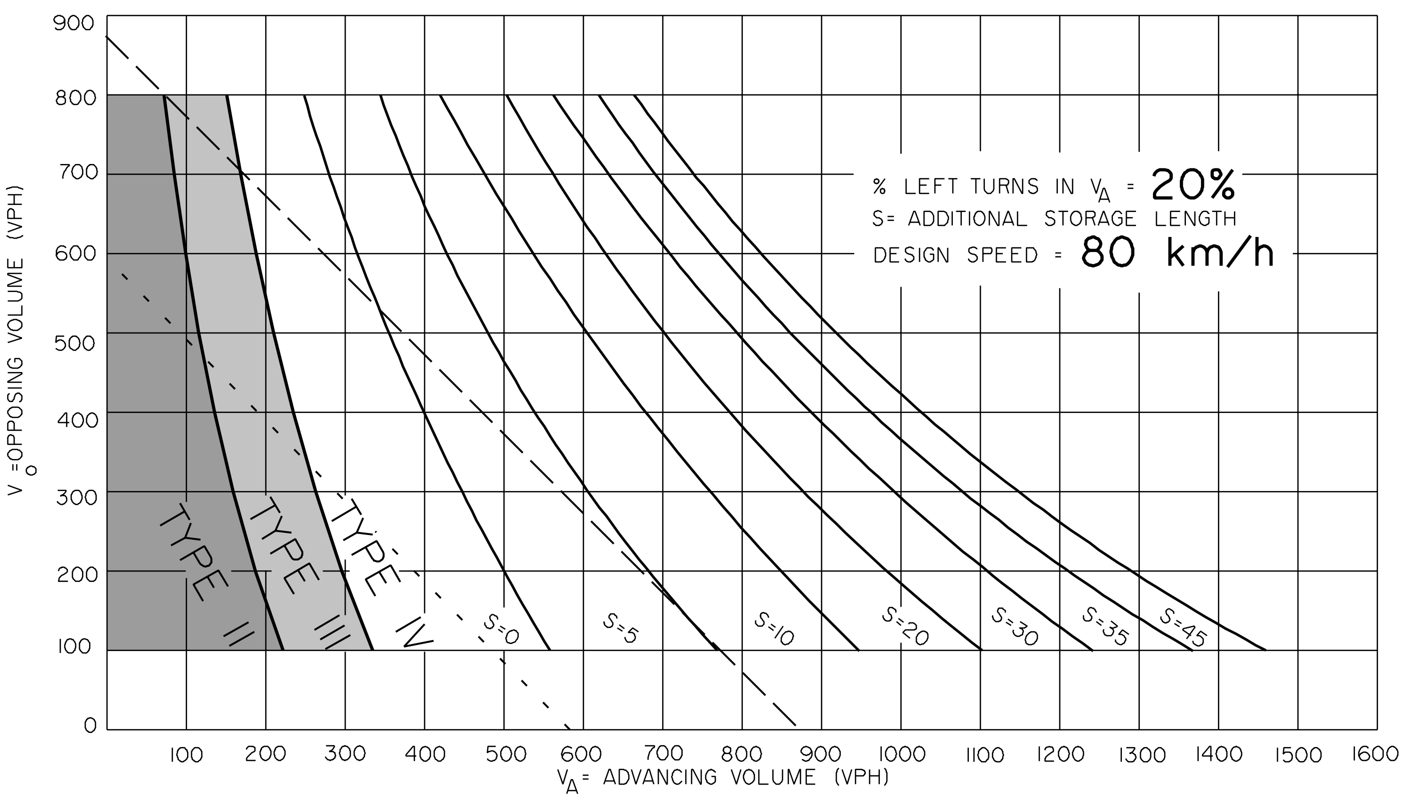
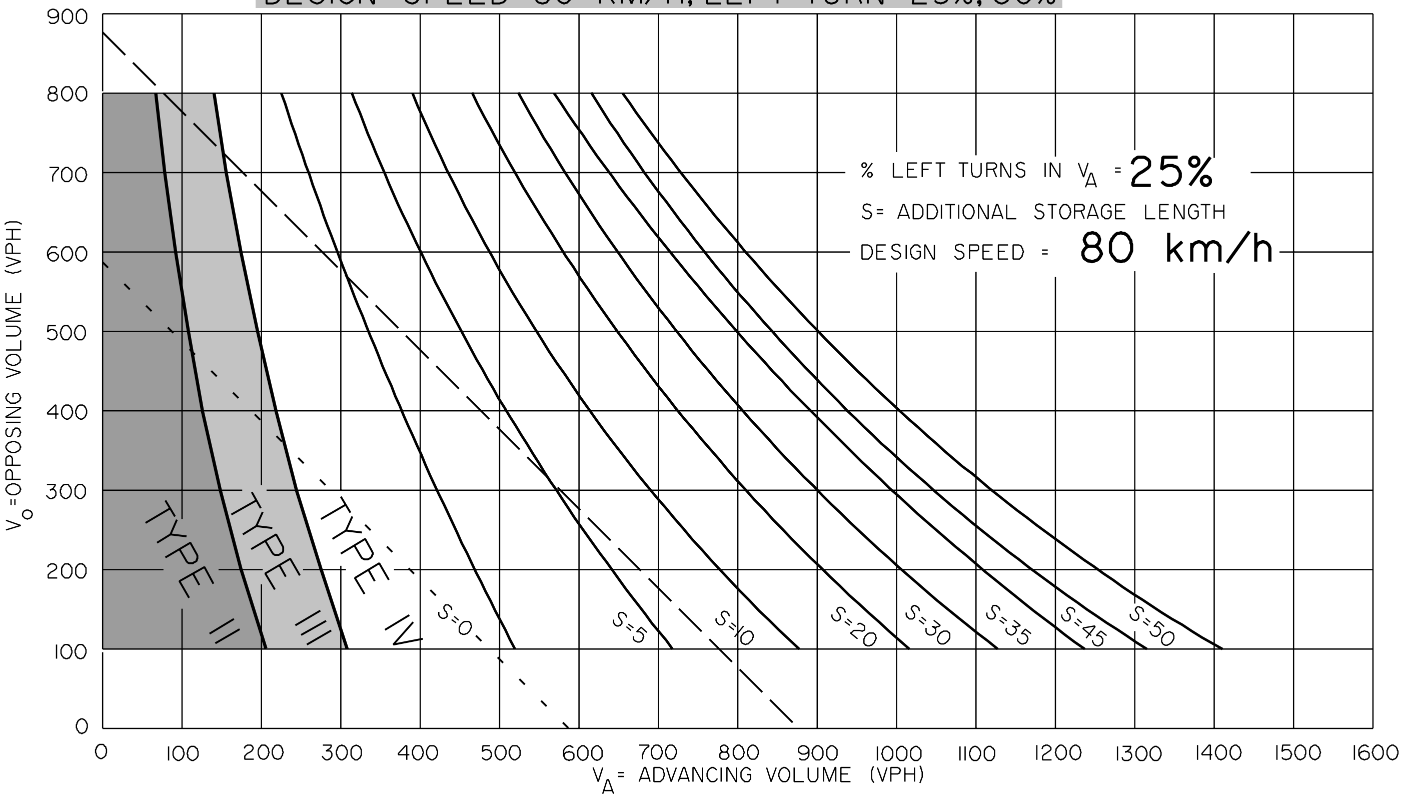
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd764a.man

FIGURE D-7.6-4c WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS
DESIGN SPEED 80 KM/H, LEFT TURN 25%, 30%



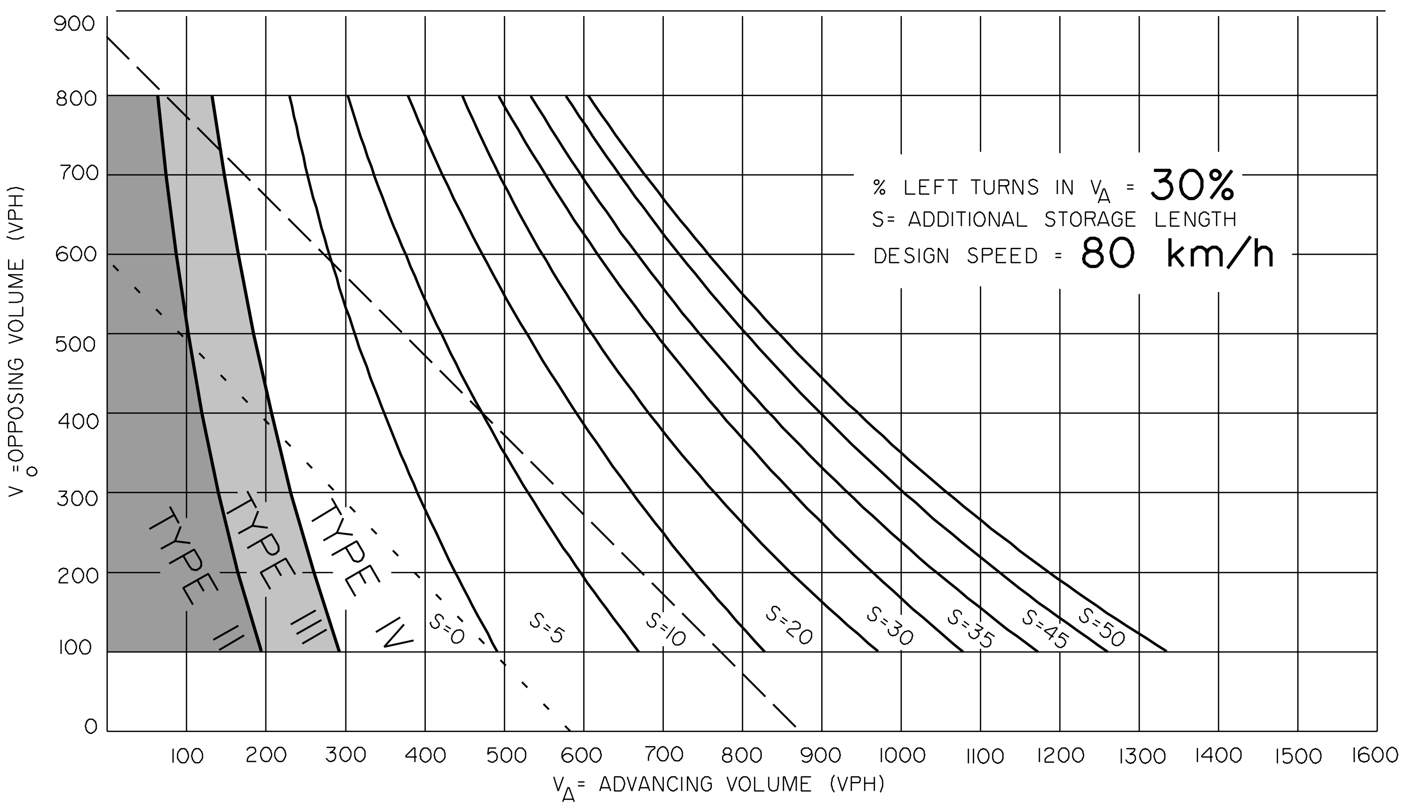
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

—— —— —— Traffic signals may be warranted in "free flow" urban areas.

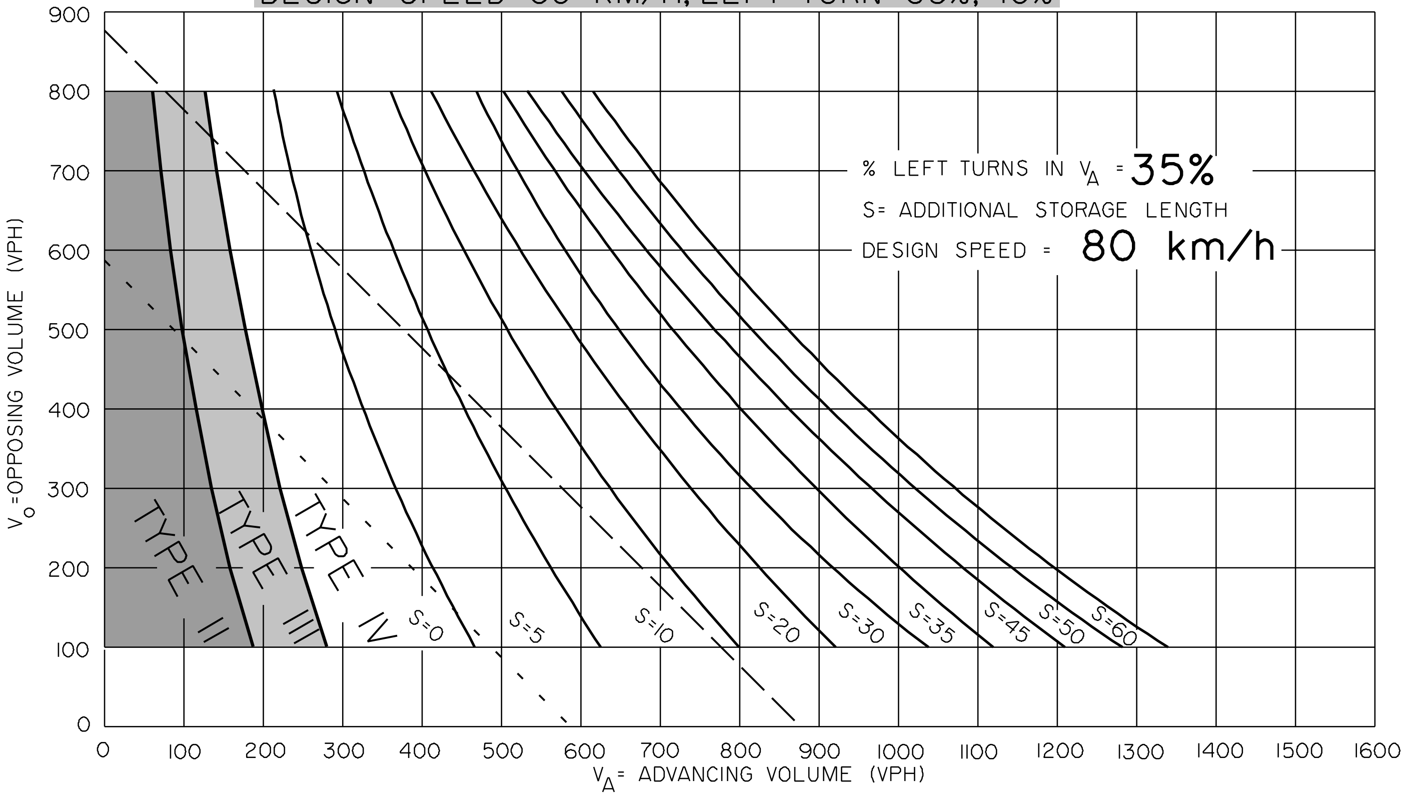
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd764a.man

FIGURE D-7.6-4d WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 80 KM/H, LEFT TURN 35%, 40%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

\- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

—— —— —— Traffic signals may be warranted in "free flow" urban areas.

Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

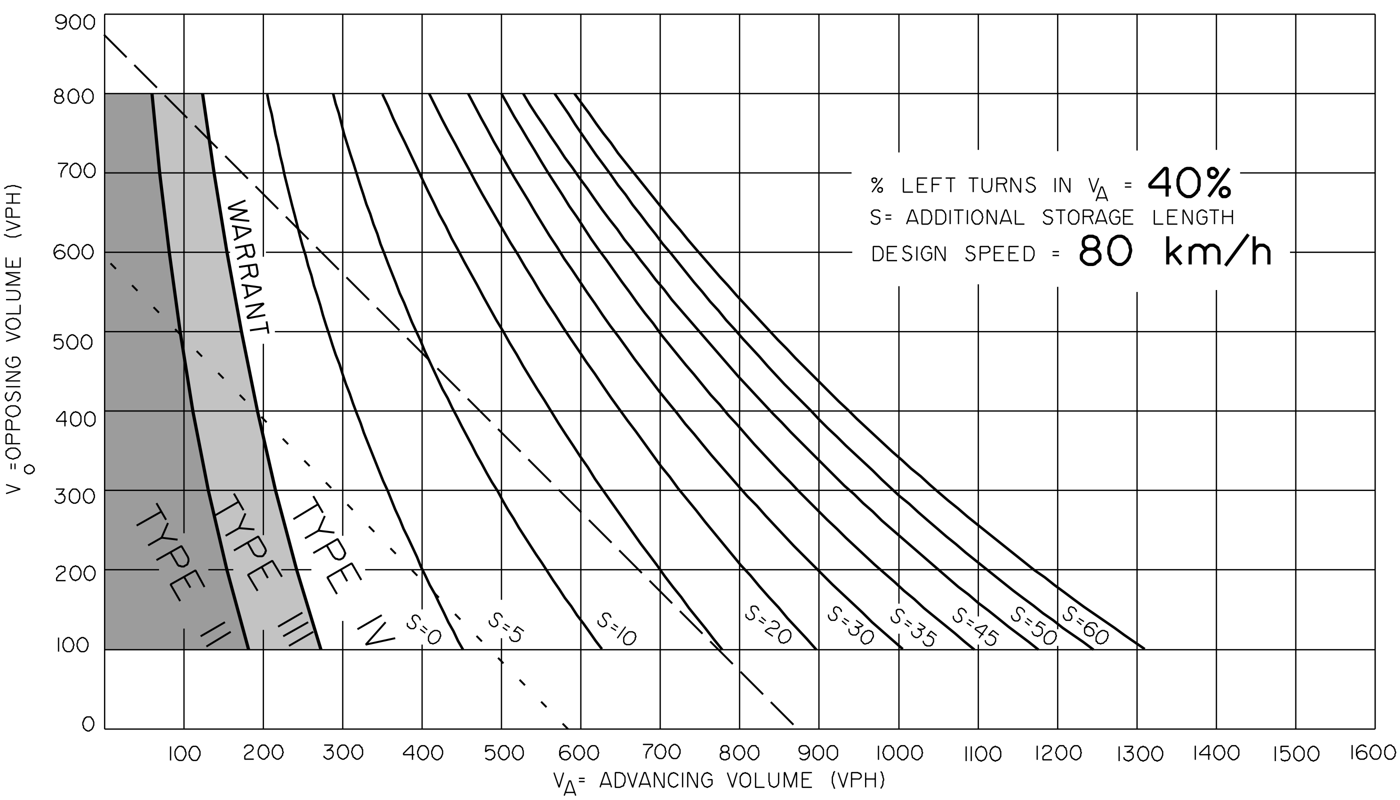
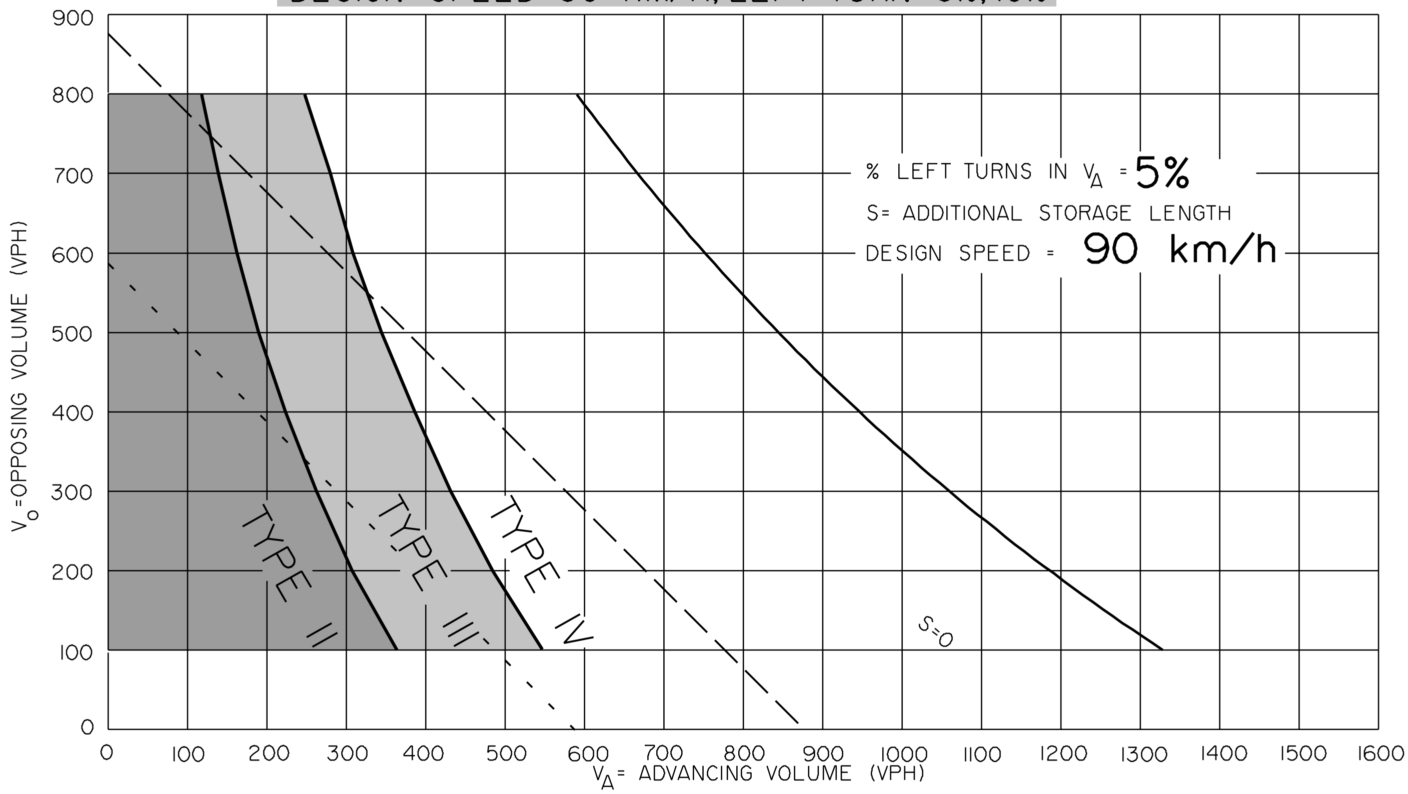


FIGURE D-7.6-5a WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS

DESIGN SPEED 90 KM/H, LEFT TURN 5%, 10%



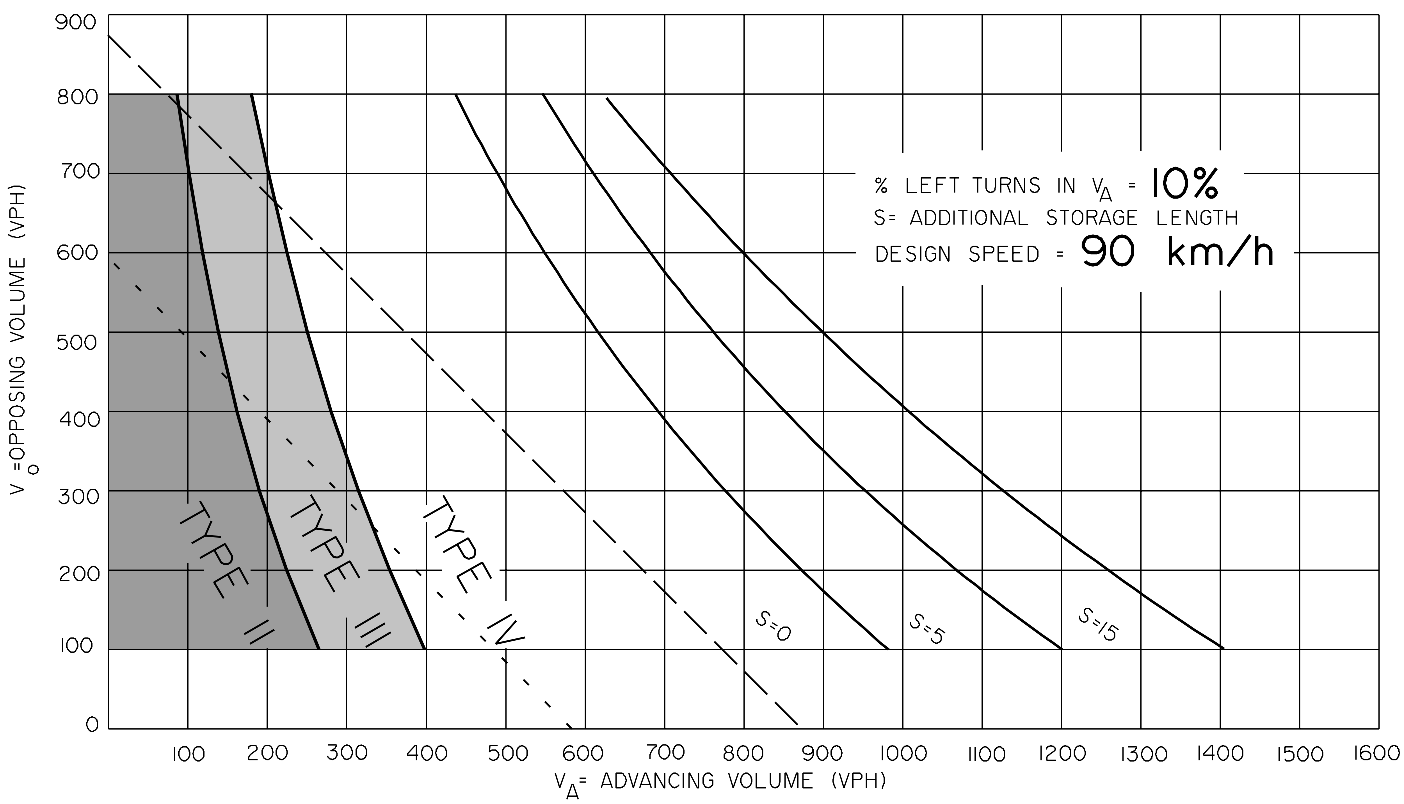
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

—— —— —— Traffic signals may be warranted in "free flow" urban areas.

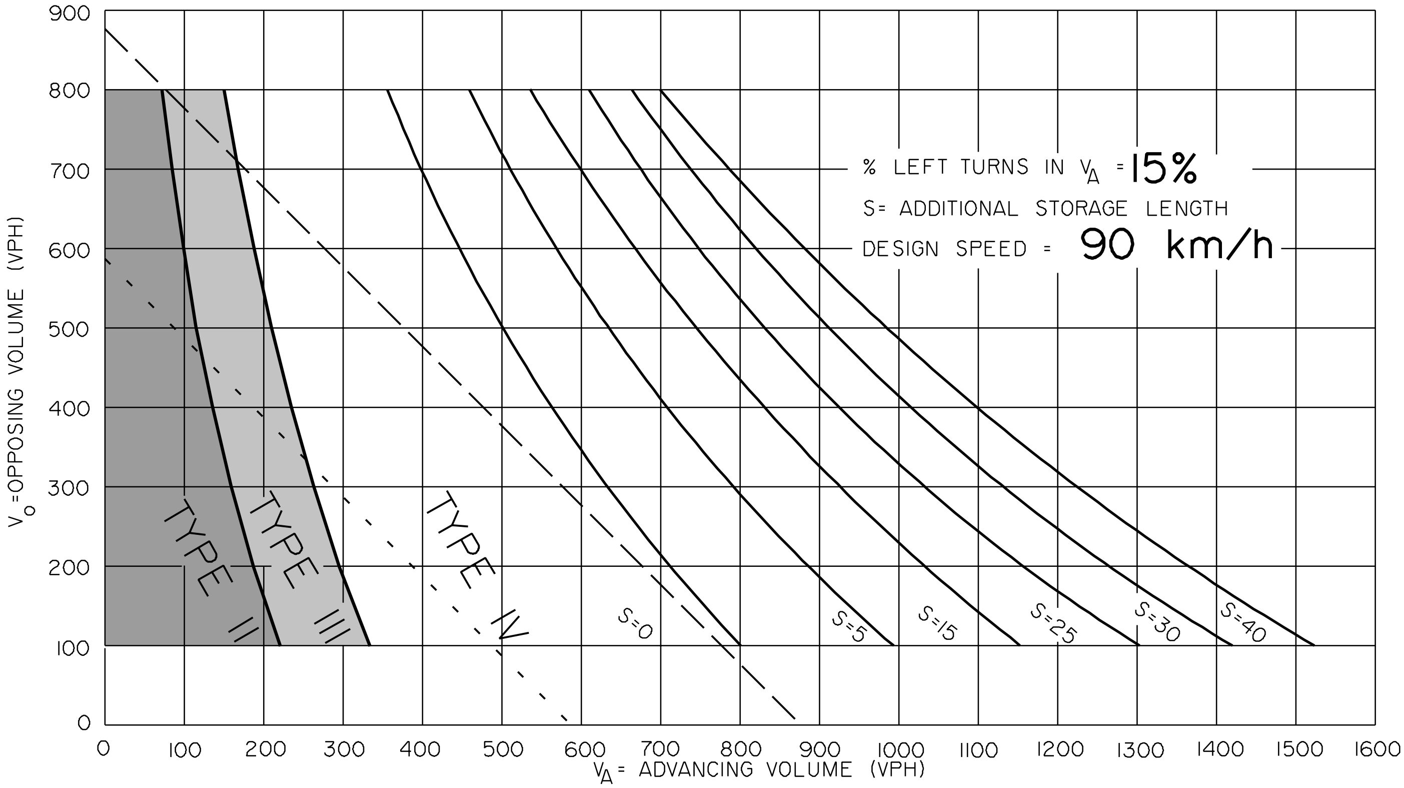
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: DEI:[200,221]debd765a.man

FIGURE D-7.6-5b WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 90 KM/H, LEFT TURN 15%, 20%



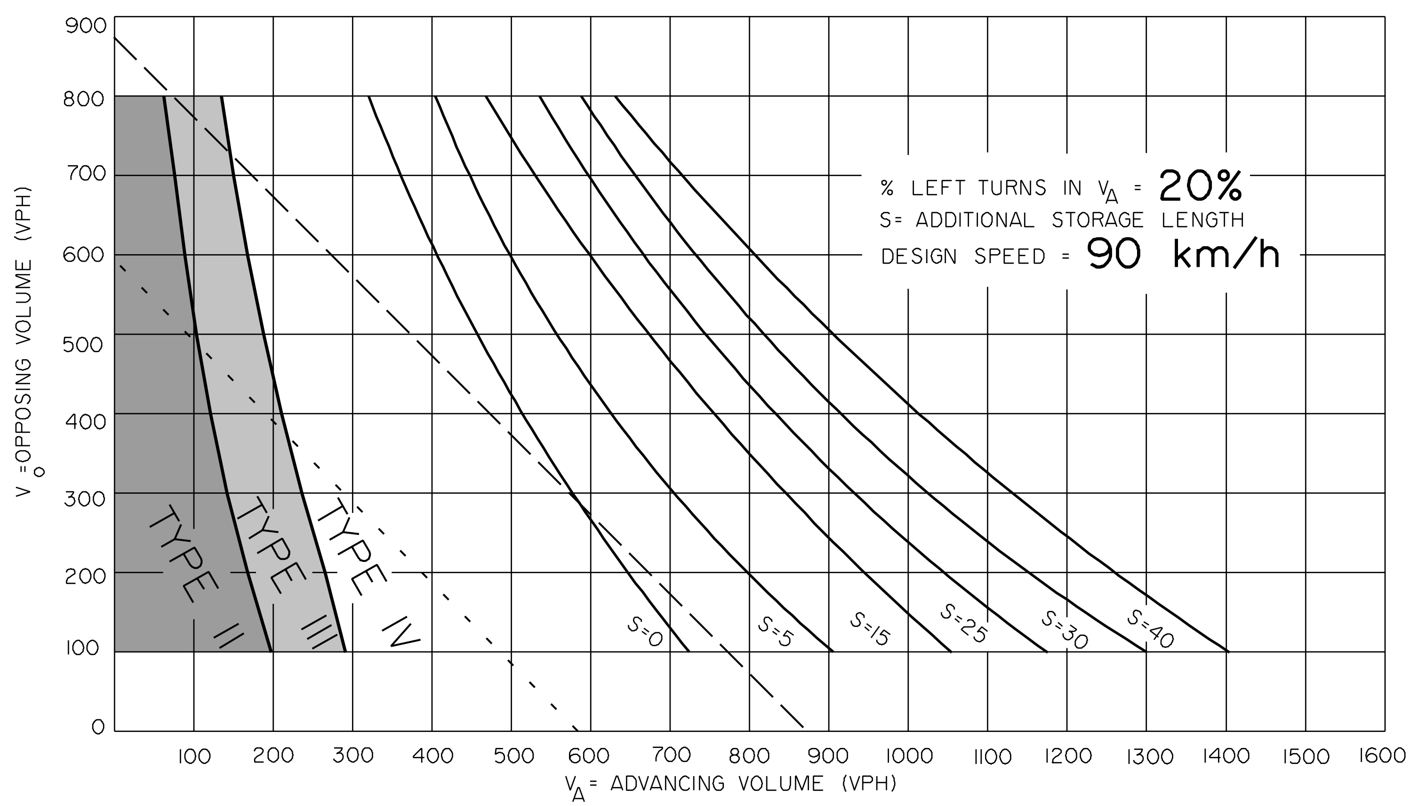
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designer should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

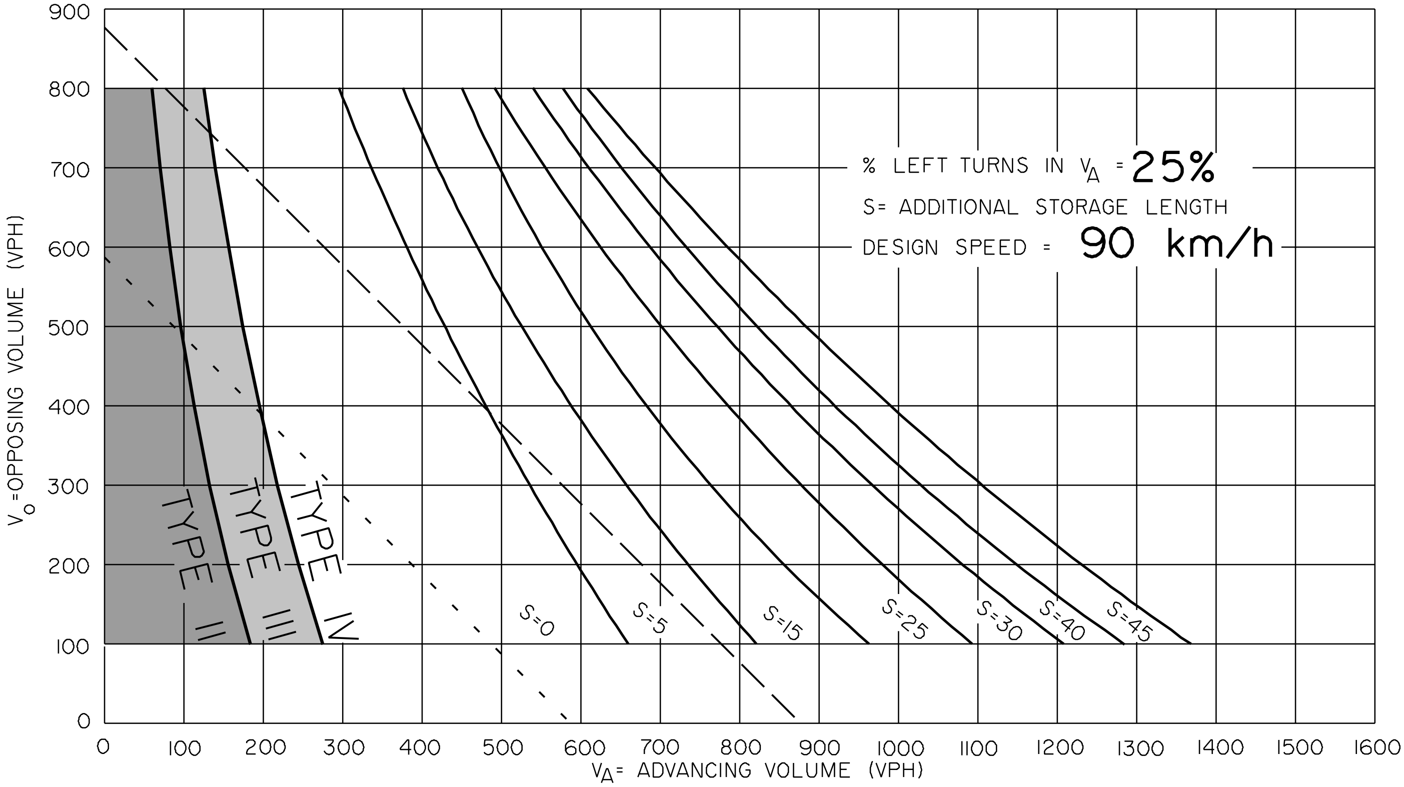
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: DEI:[200,221]debd765a.man

FIGURE D-7.6-5c WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 90 KM/H, LEFT TURN 25%, 30%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

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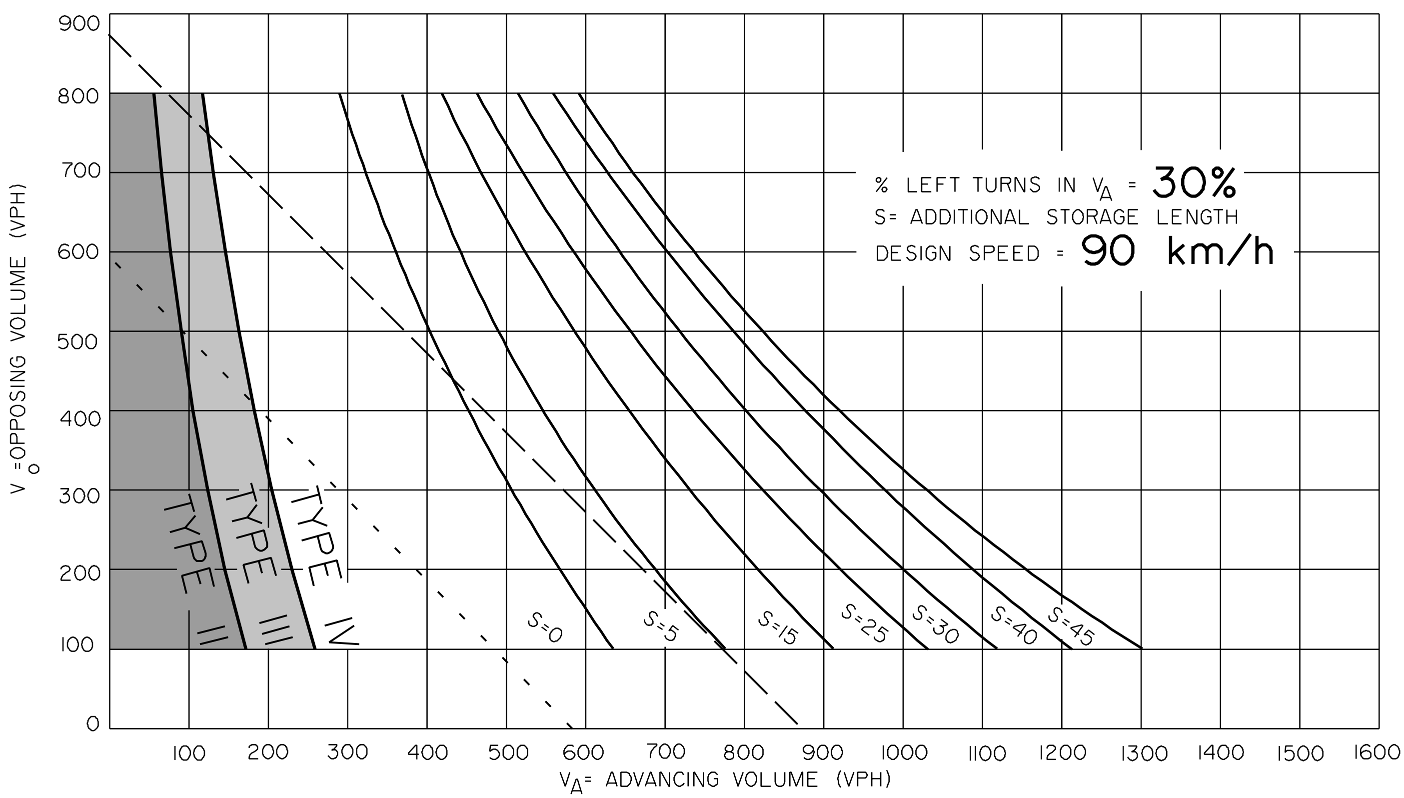
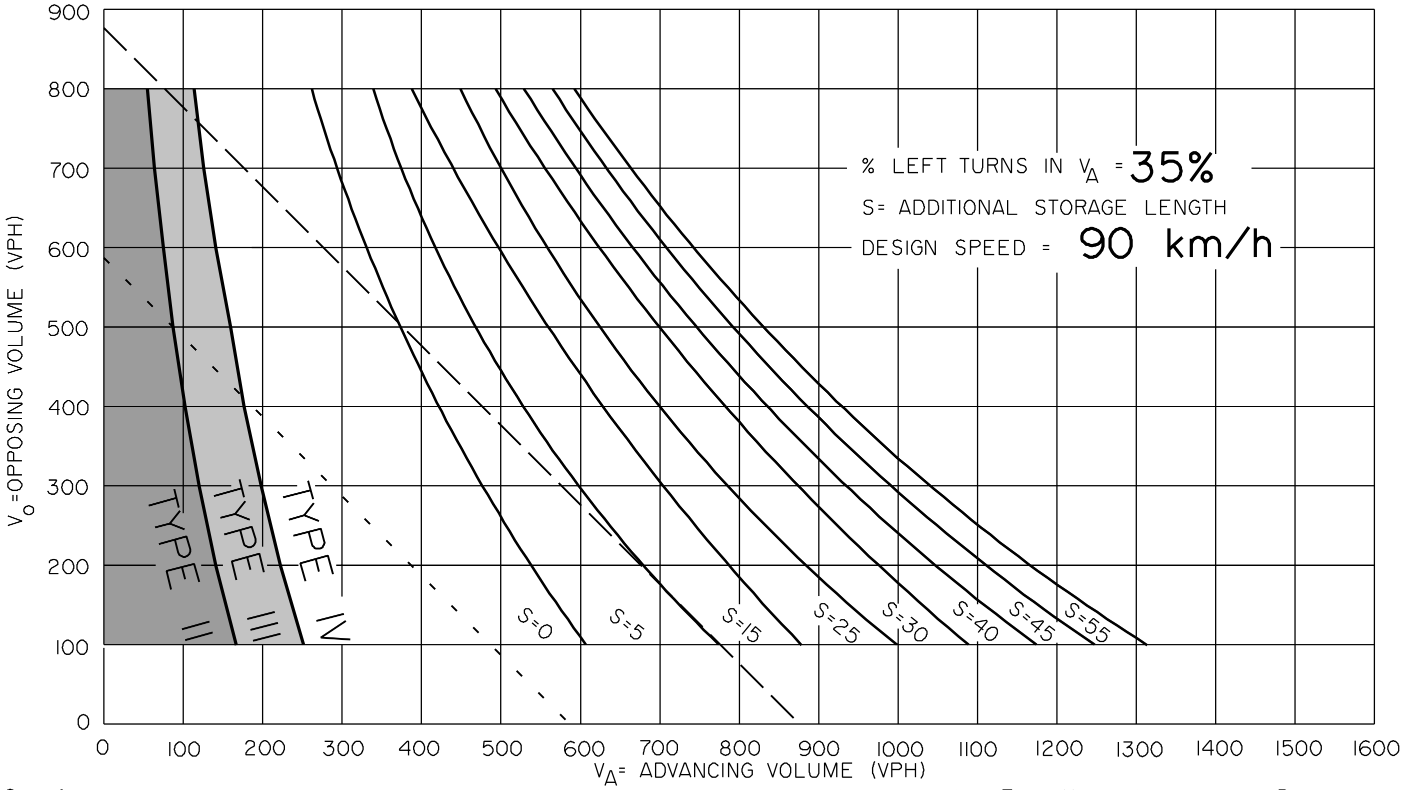
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: DEI:[200,221]debd765a.man

FIGURE D-7.6-5d WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 90 KM/H, LEFT TURN 35%, 40%



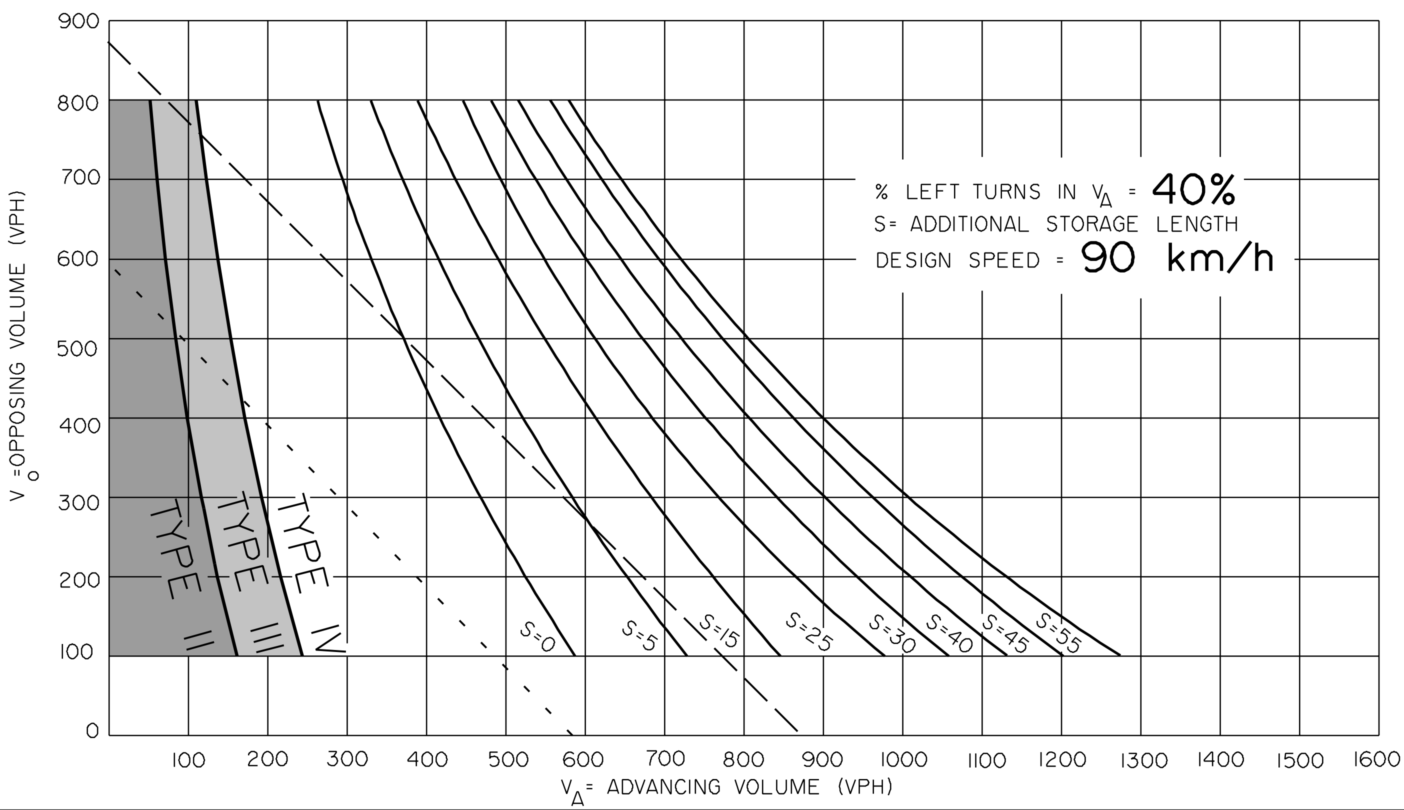
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

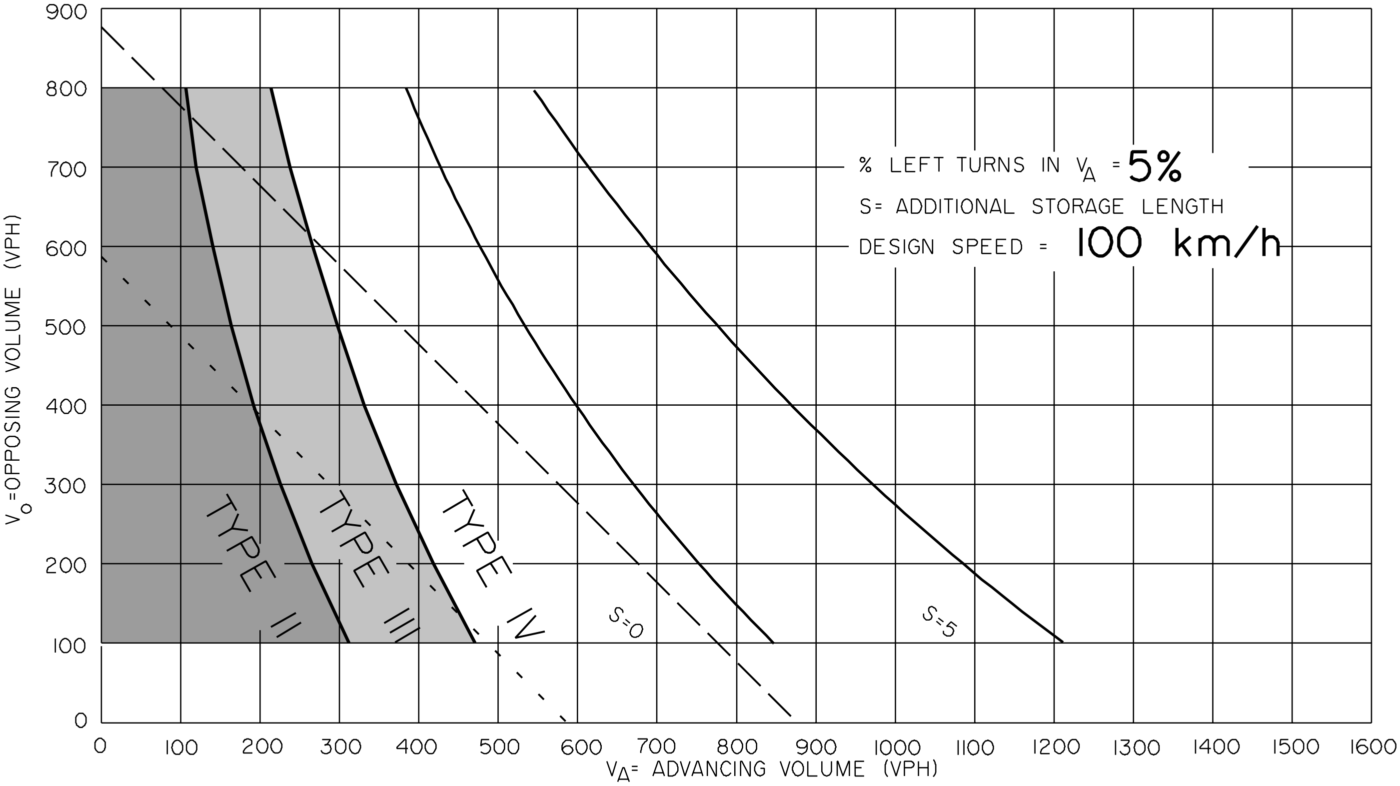
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: DEI:[200,221]debd765a.man

FIGURE D-7.6-6a WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 100 KM/H, LEFT TURN 5%, 10%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:

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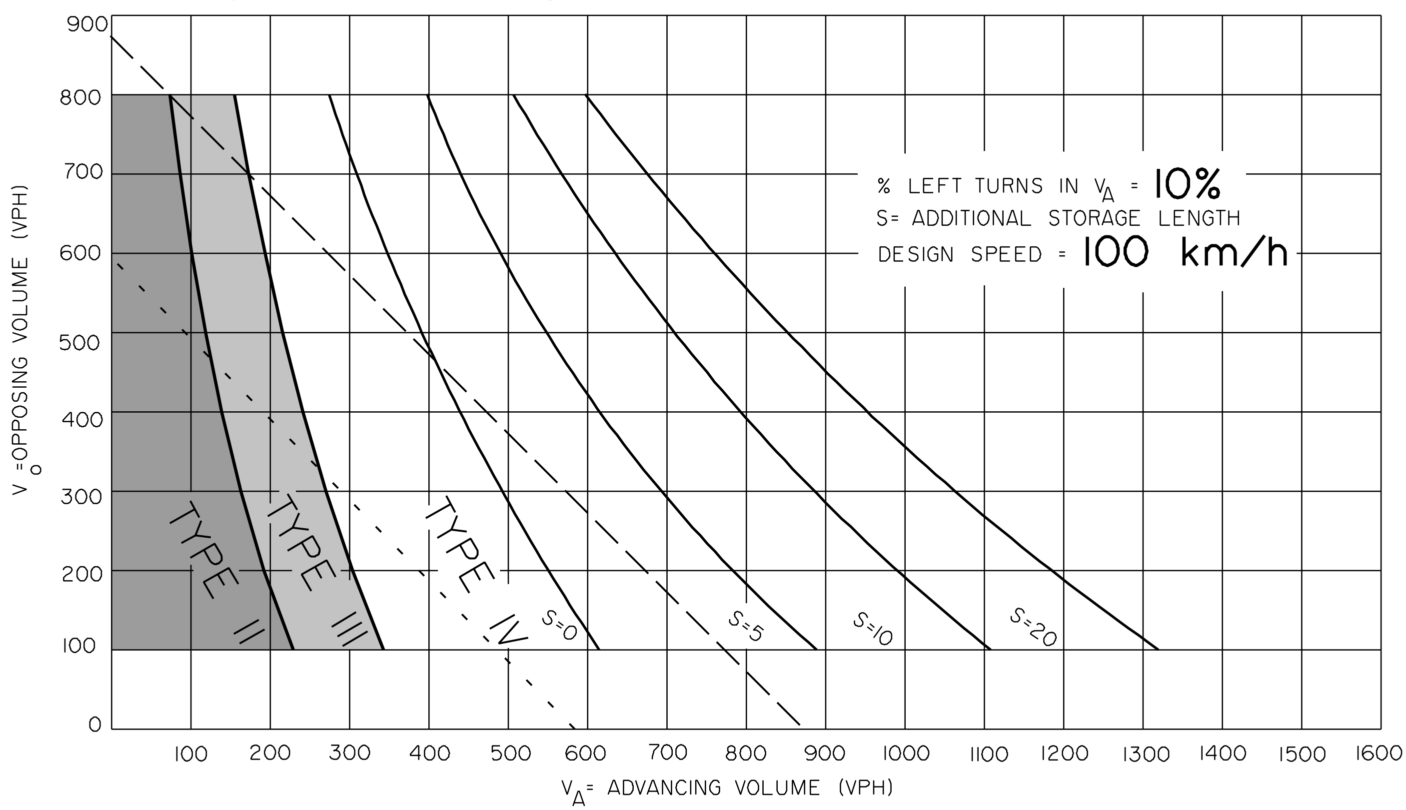
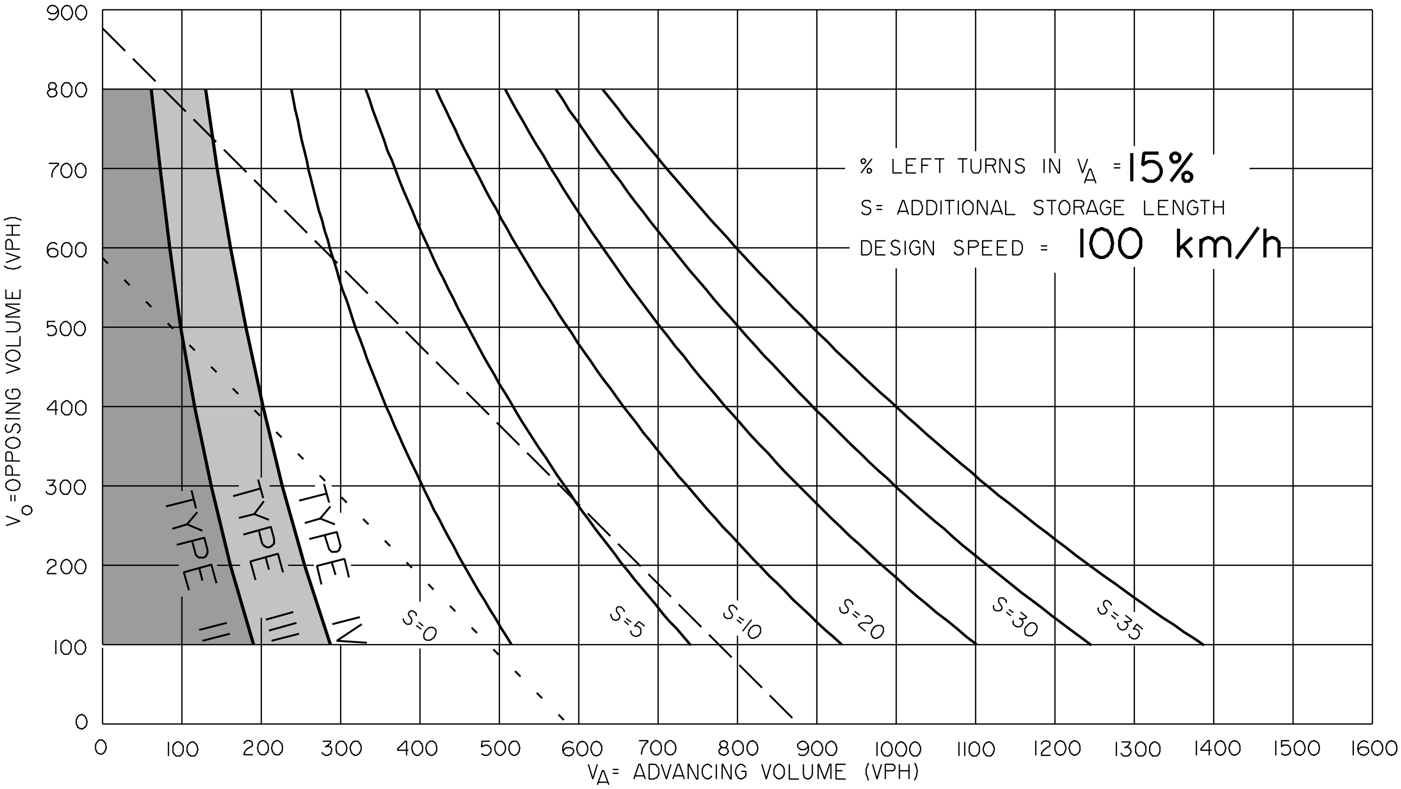
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd766a.man

FIGURE D-7.6-6b WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 100 KM/H, LEFT TURN 15%, 20%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:

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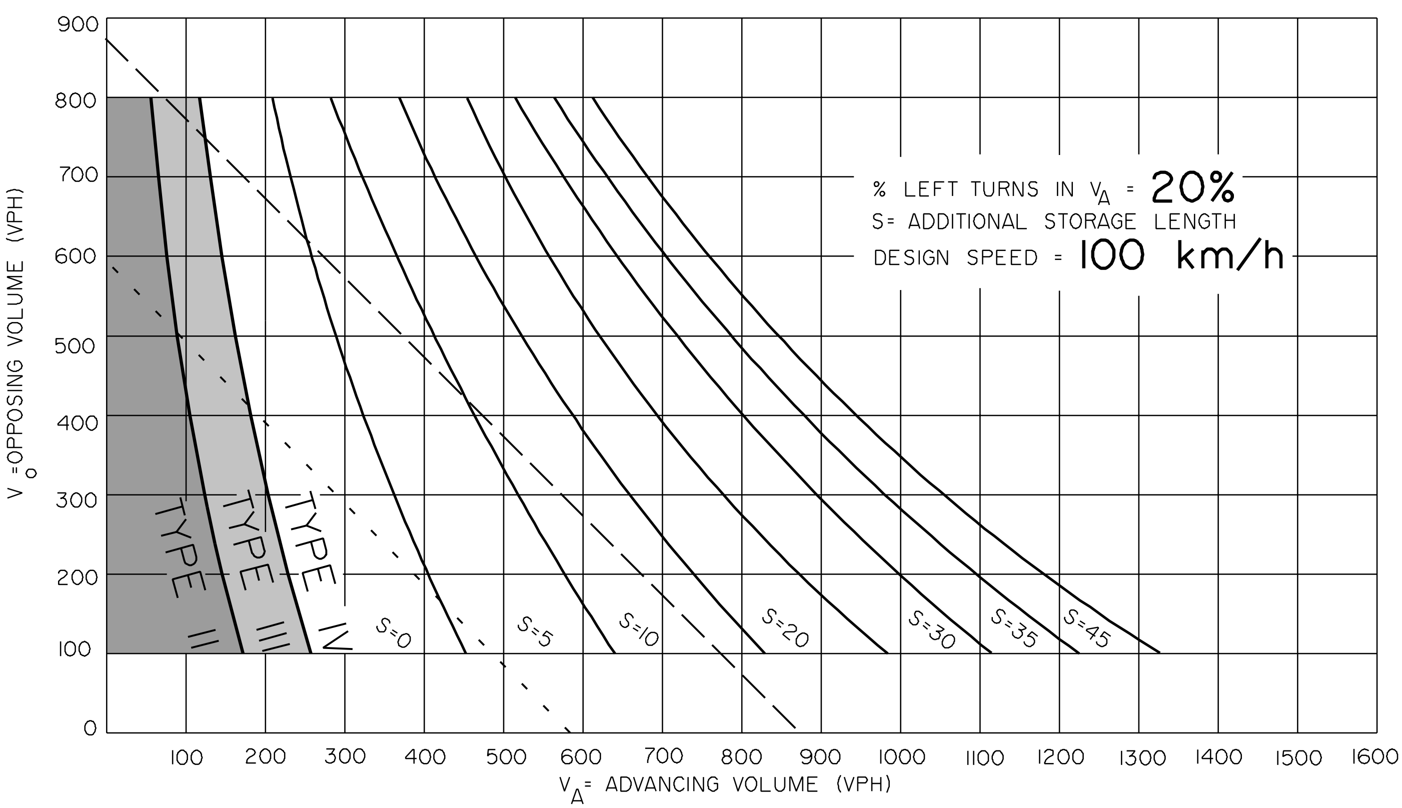
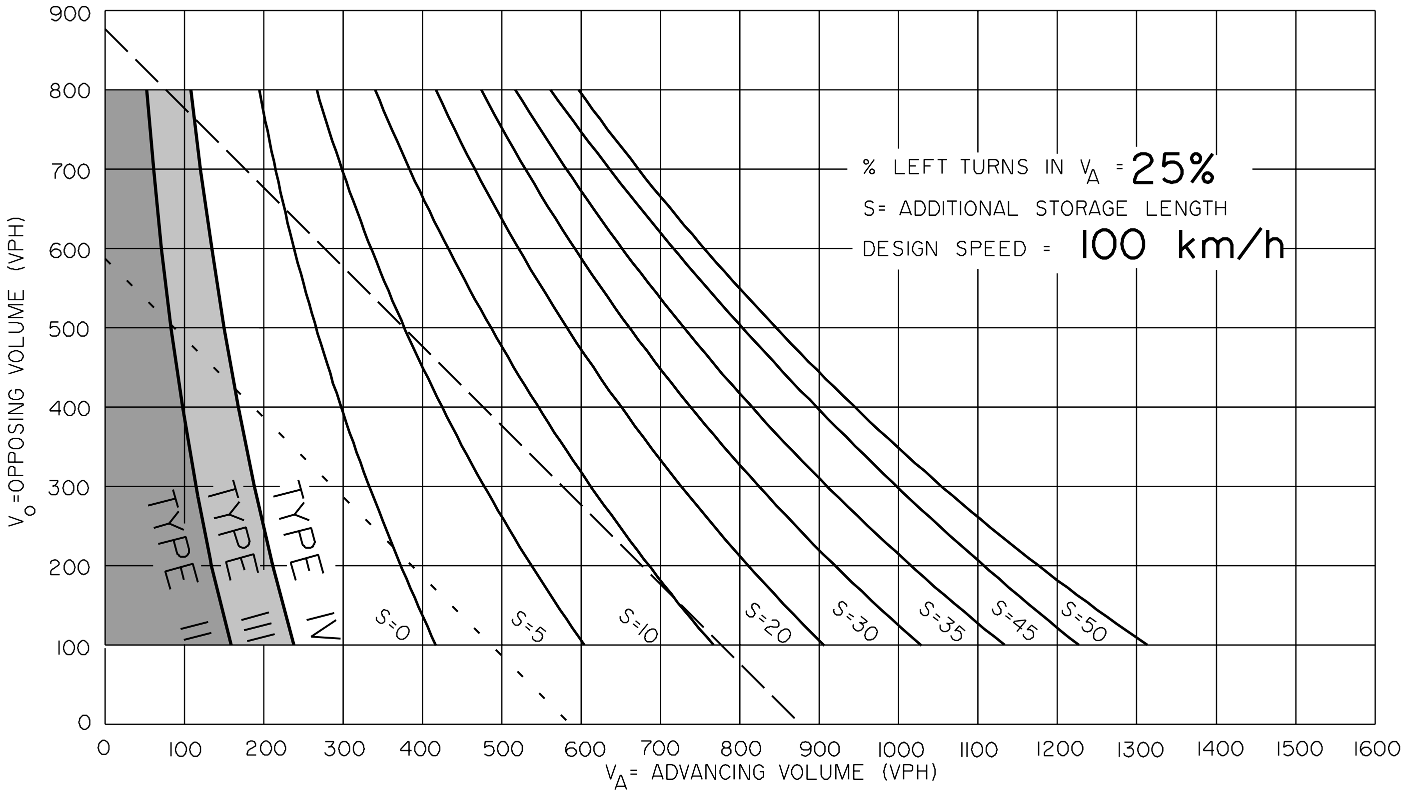
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd766a.man

FIGURE D-7.6-6c WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 100 KM/H, LEFT TURN 25%, 30%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

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Notes:

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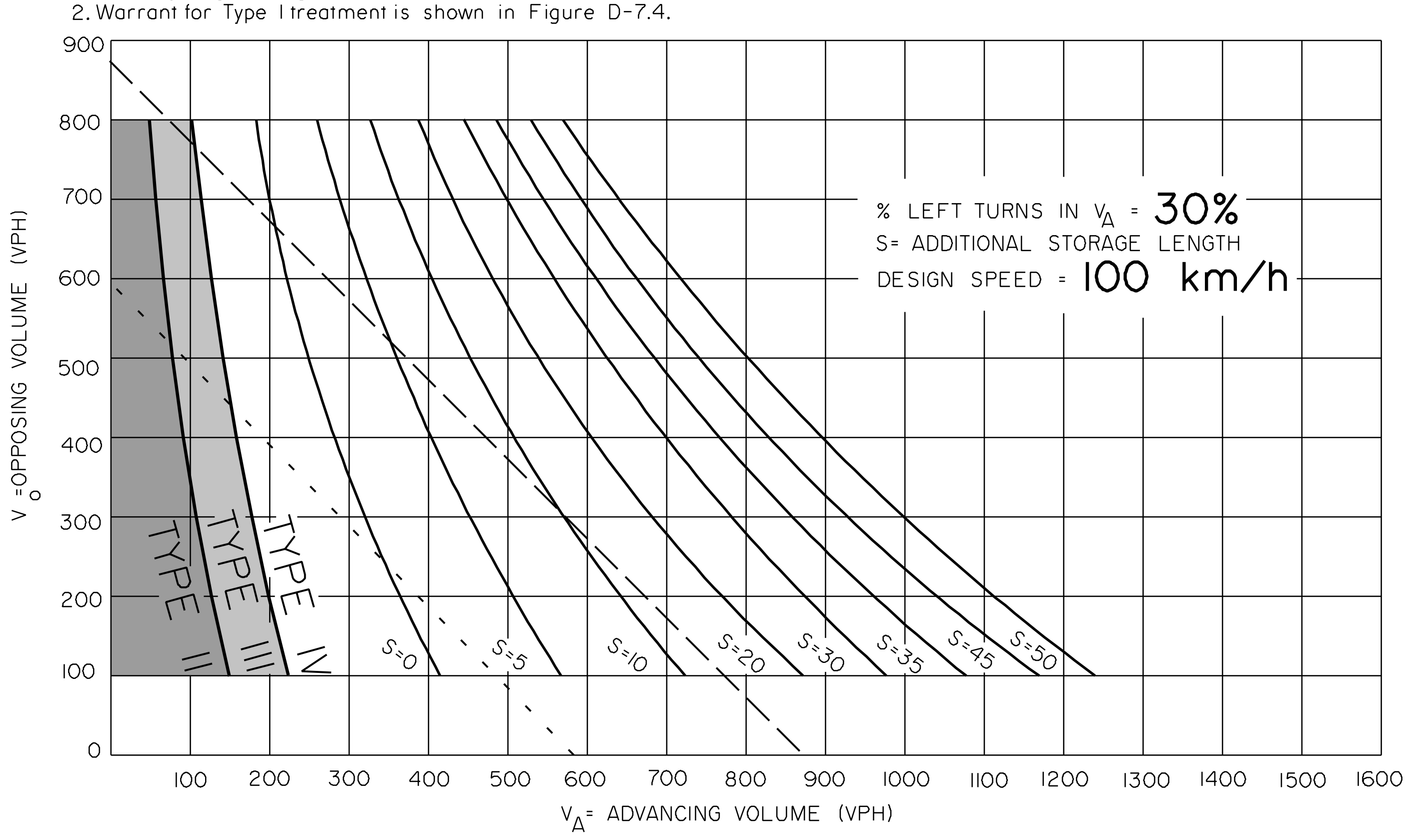
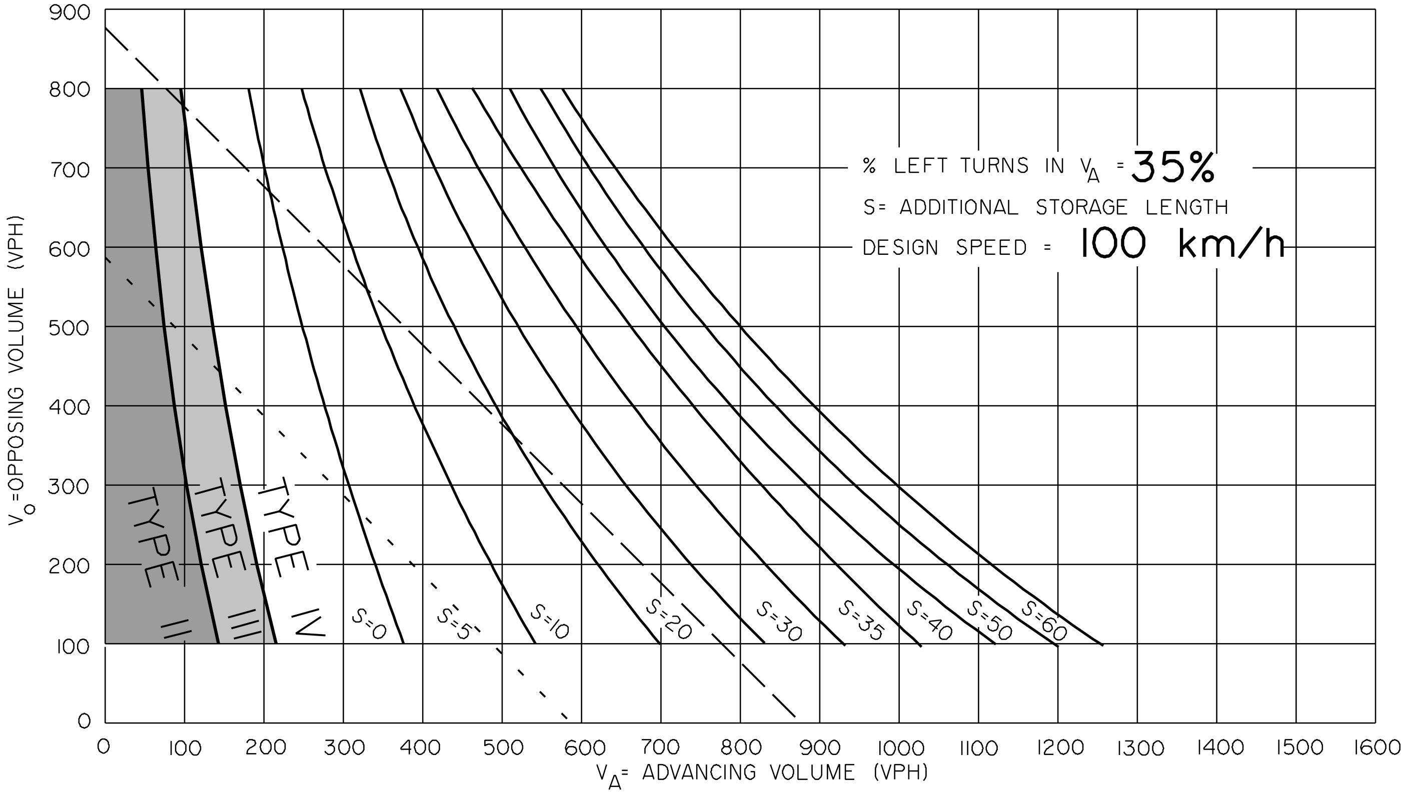
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd766a.man

FIGURE D-7.6-6d WARRANTS FOR LEFT TURN TREATMENT AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 100 KM/H, LEFT TURN 35%, 40%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

\- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:

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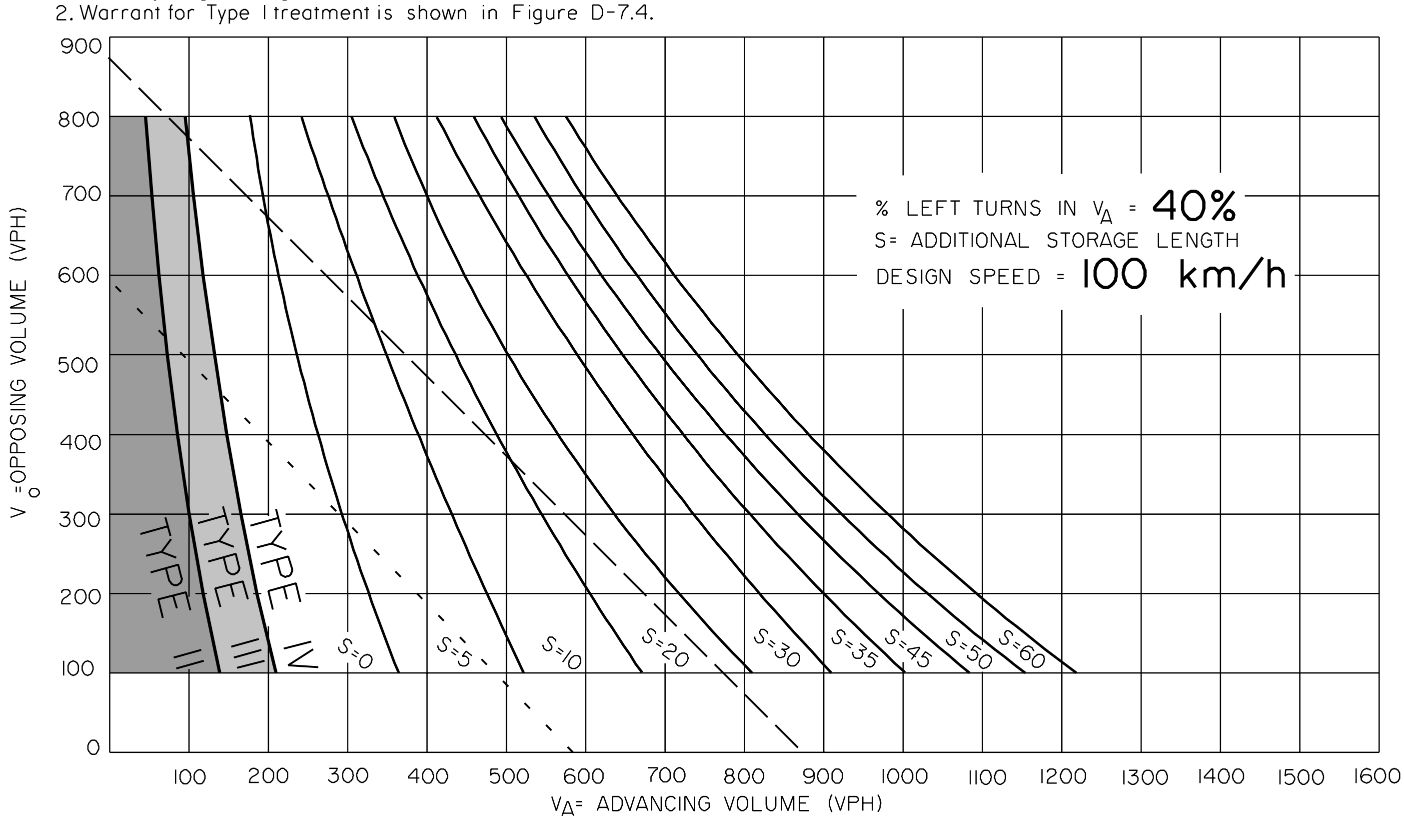
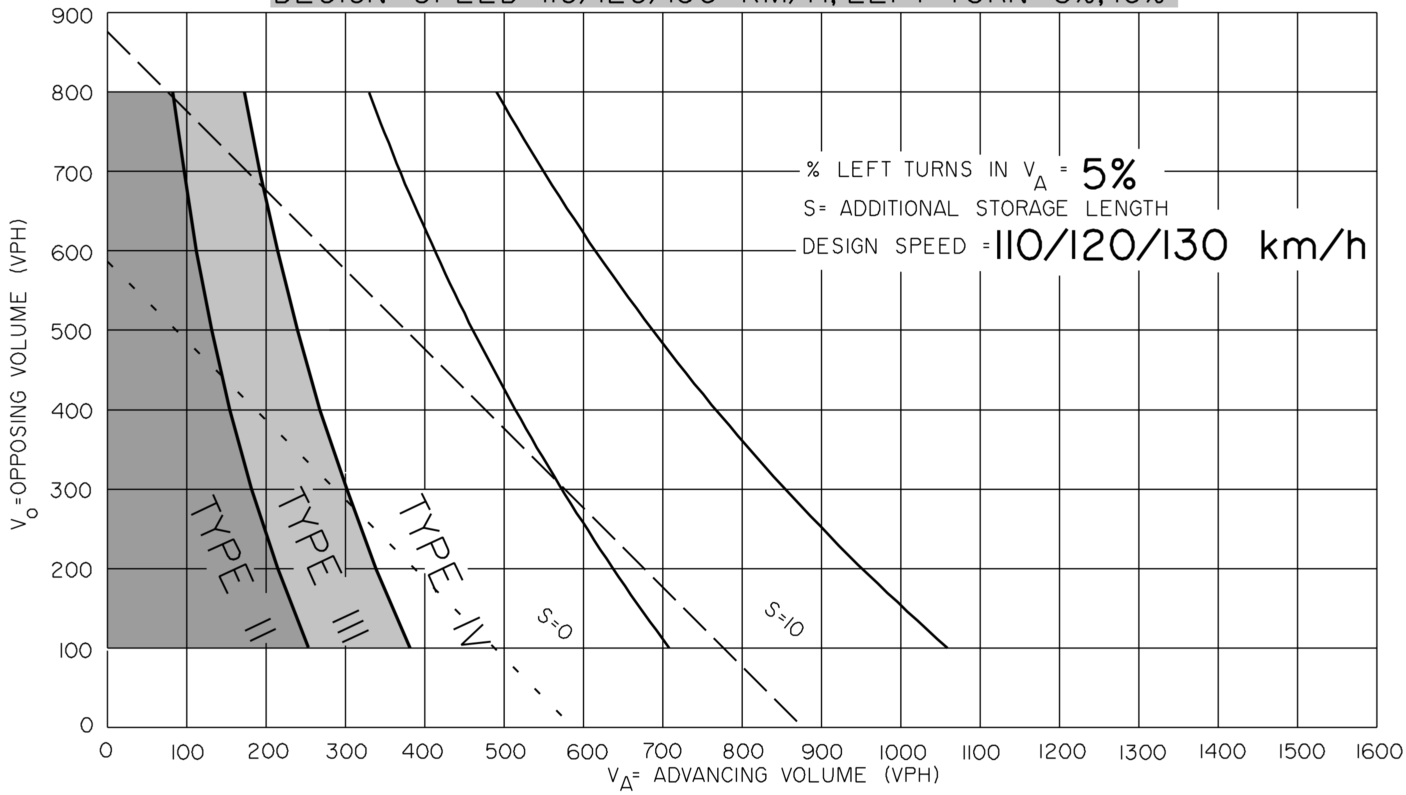
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd766a.man

FIGURE D-7.6-7a WARRANTS FOR LEFT TURN LANES AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 110/120/130 KM/H, LEFT TURN 5%, 10%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

—— —— —— Traffic signals may be warranted in "free flow" urban areas.

Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.

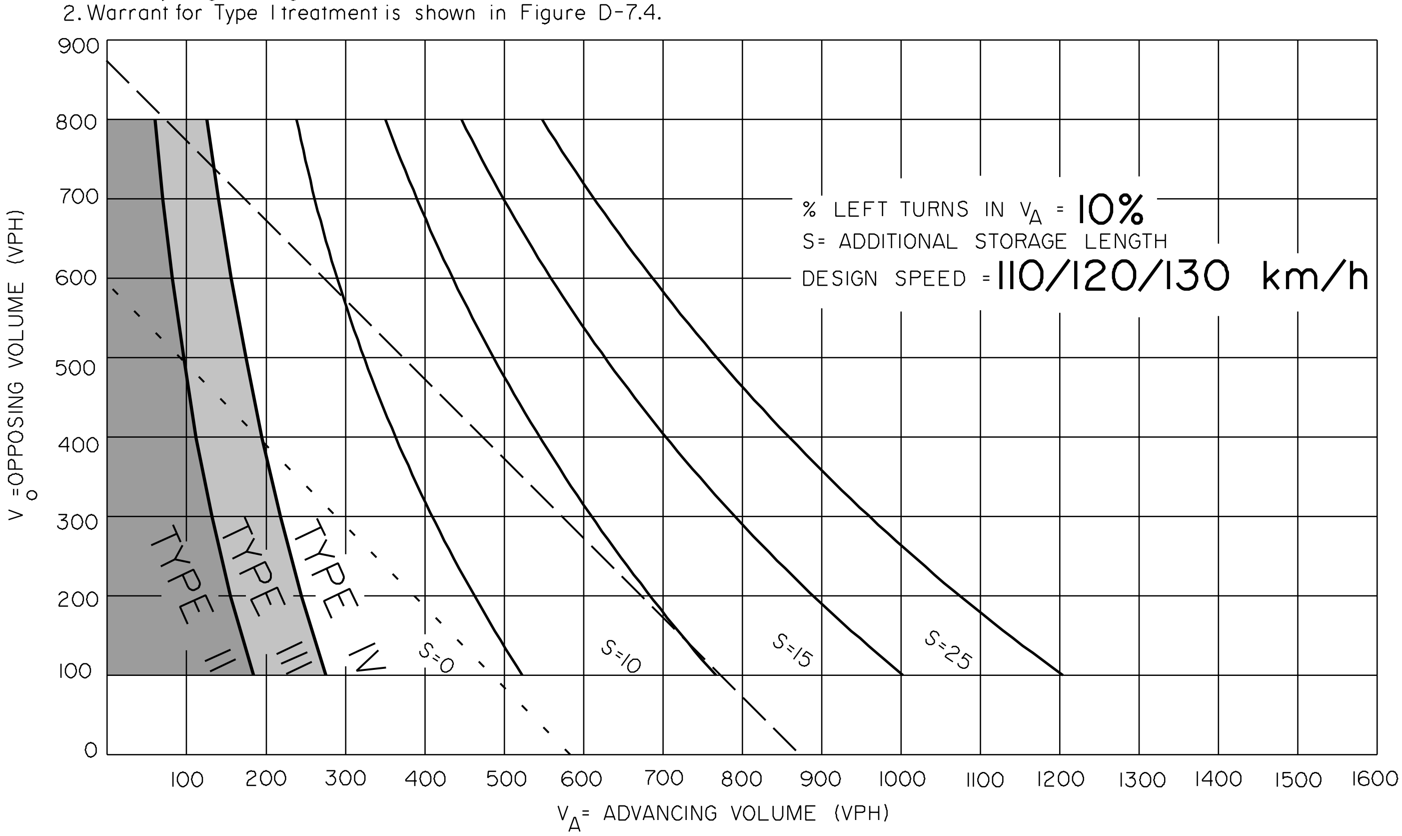
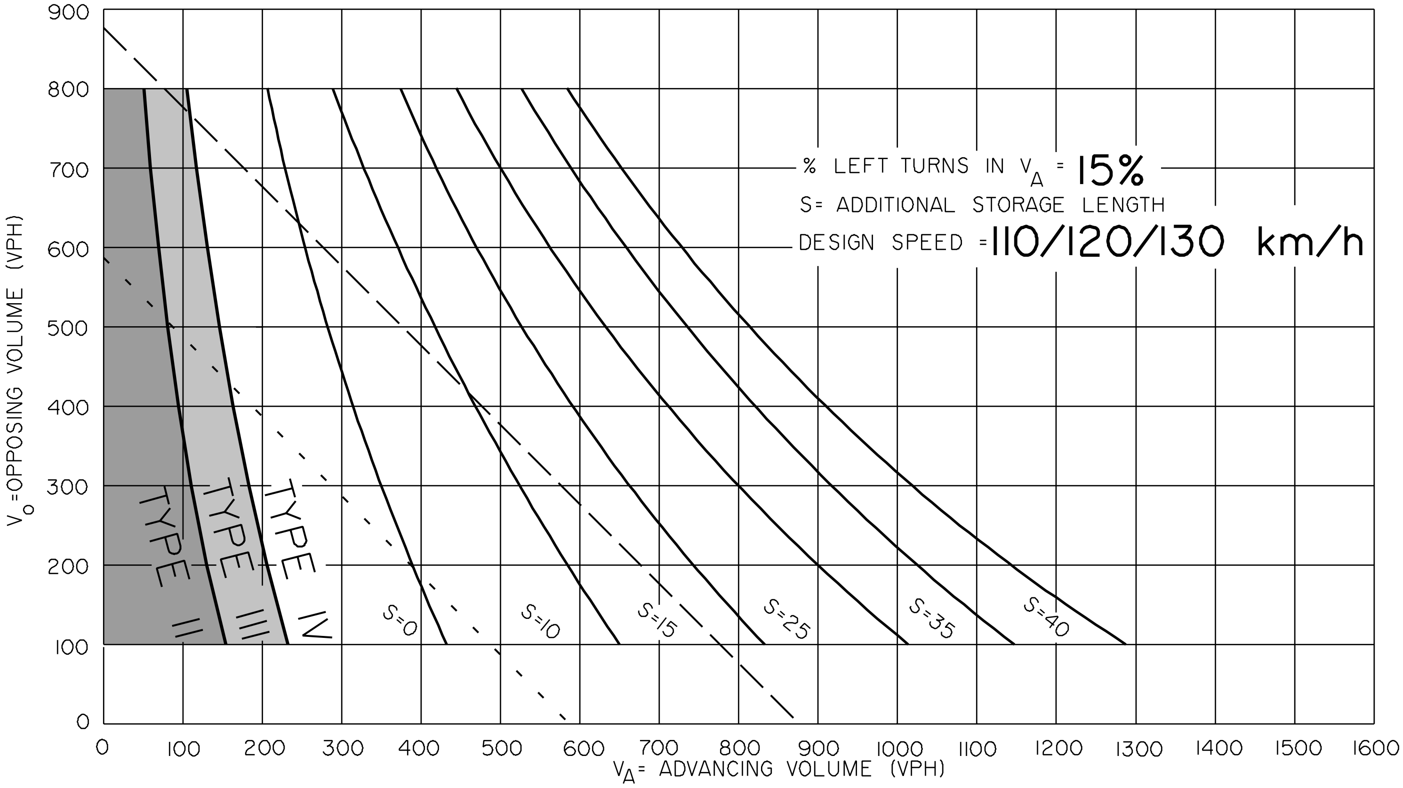


FIGURE D-7.6-7b WARRANTS FOR LEFT TURN LANES AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 110/120/130 KM/H, LEFT TURN 15%, 20%



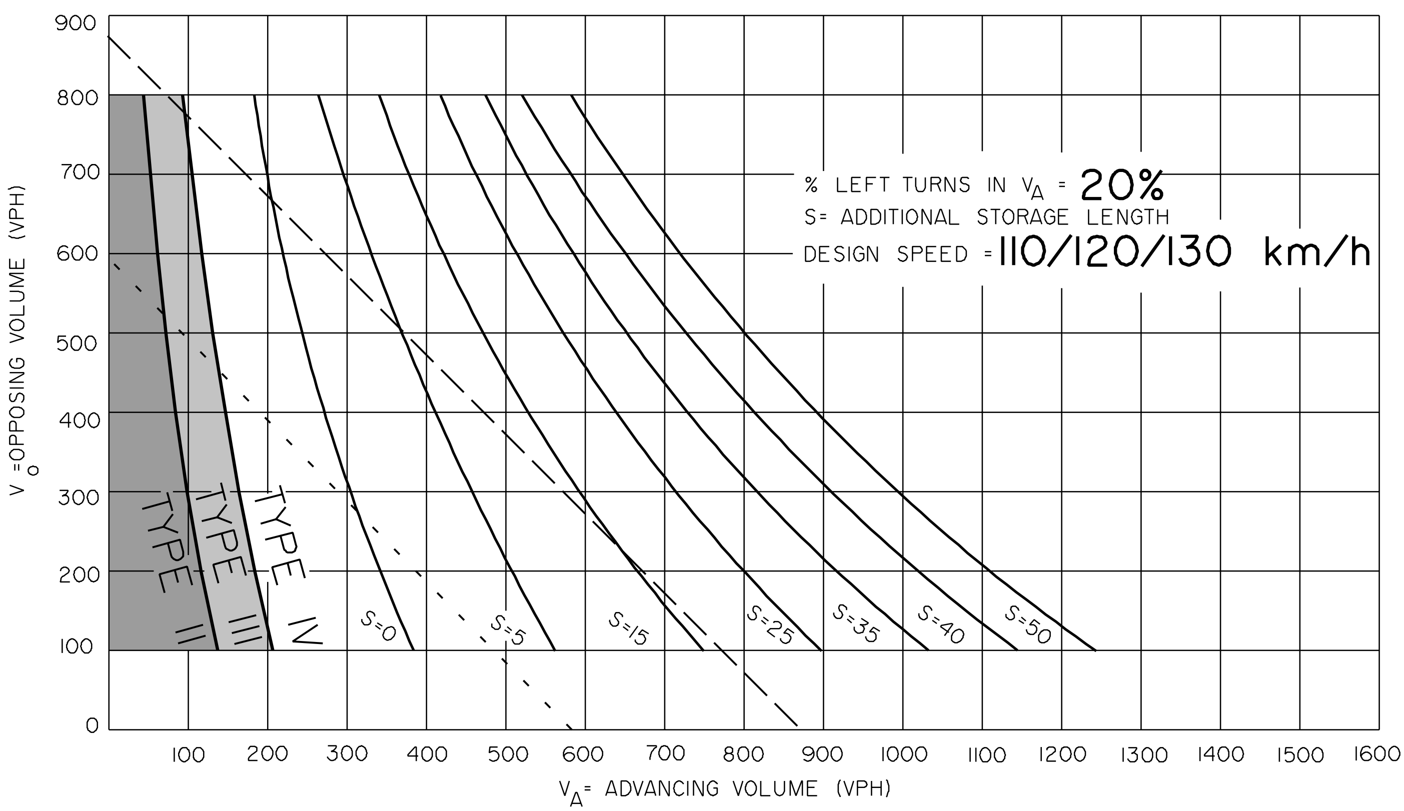
S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

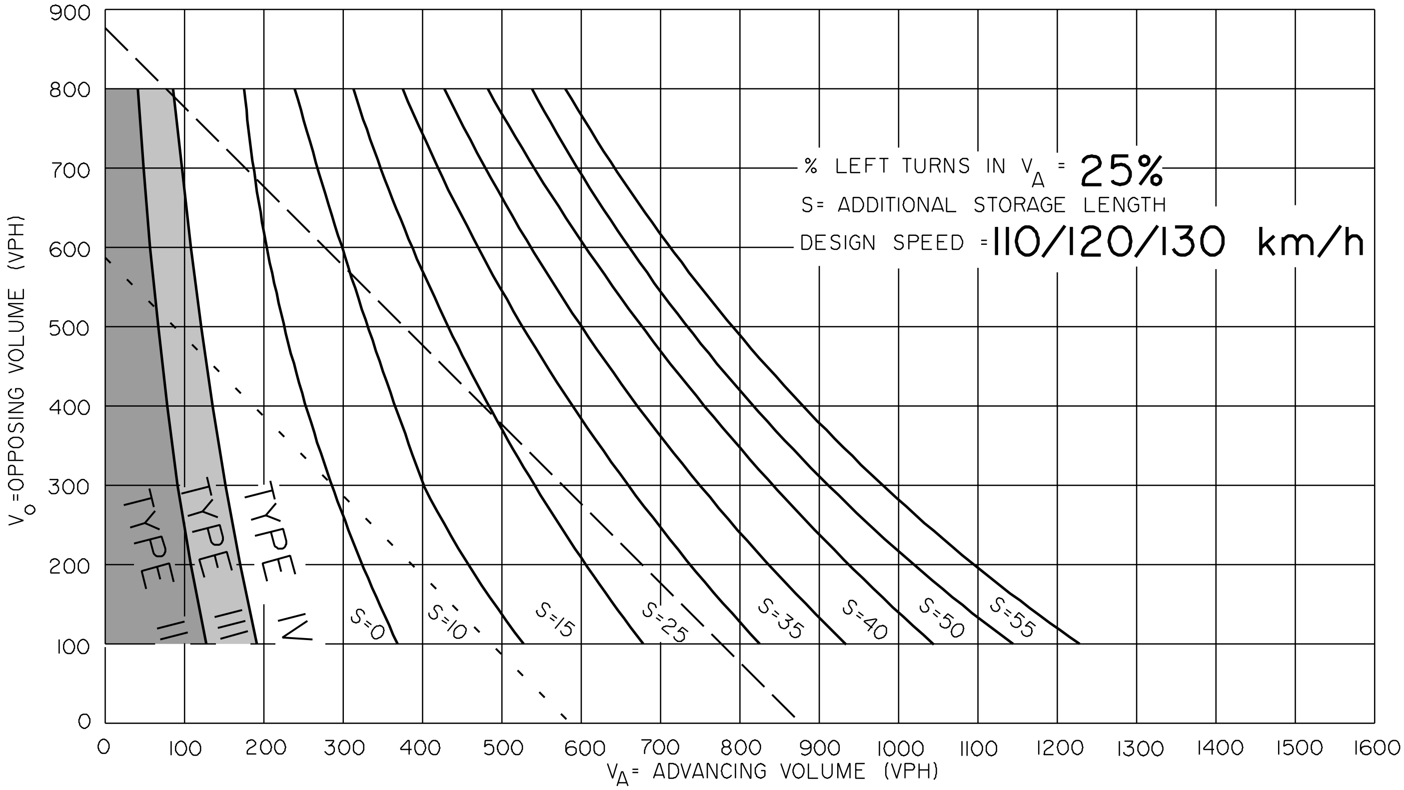
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd767a.man

FIGURE D-7.6-7c WARRANTS FOR LEFT TURN LANES AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 110/120/130 KM/H, LEFT TURN 25%, 30%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

— — — Traffic signals may be warranted in "free flow" urban areas.

Notes:

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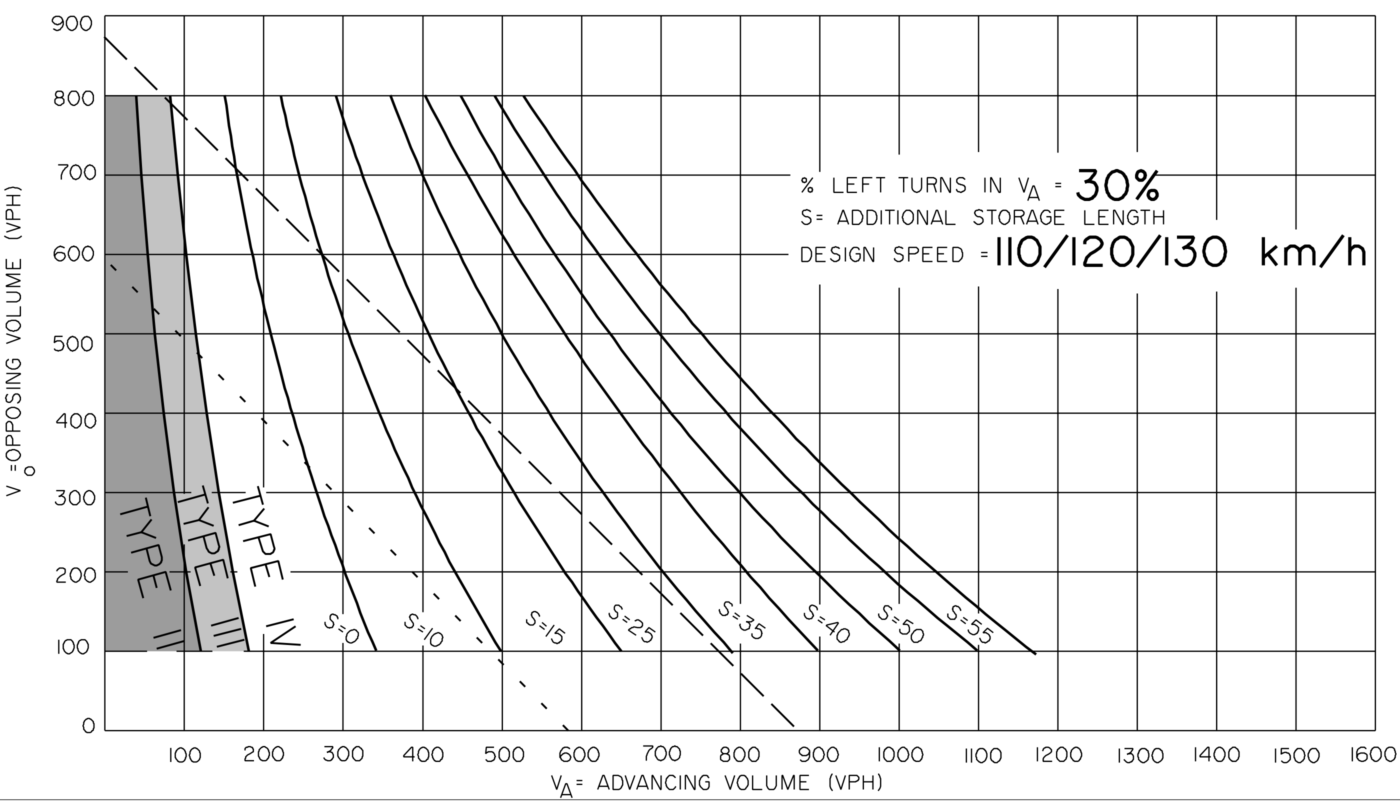
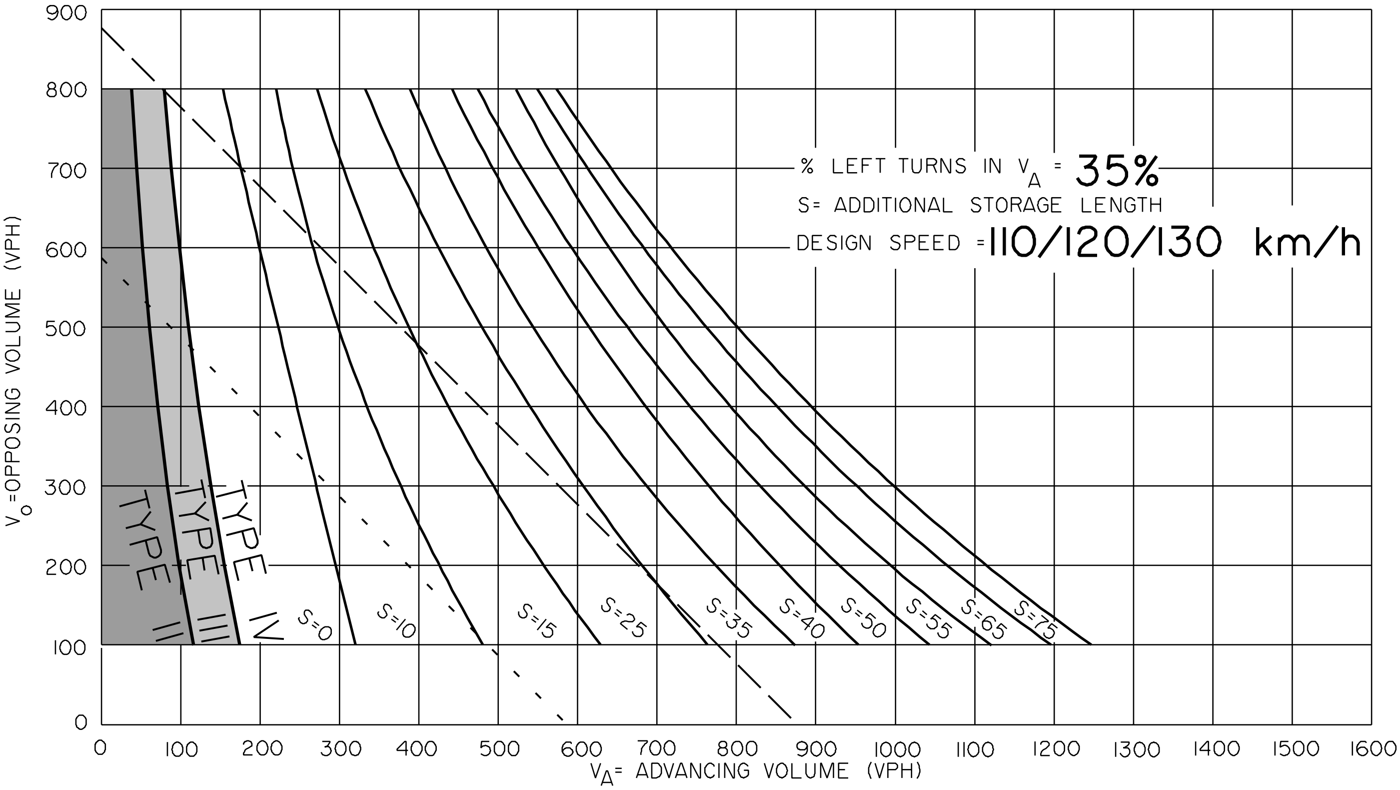
2. Warrant for Type I treatment is shown in Figure D-7.4.



GRAPHICS FILE: debd767a.man

FIGURE D-7.6-7d WARRANTS FOR LEFT TURN LANES AND STORAGE REQUIREMENTS FOR TWO-LANE HIGHWAYS DESIGN SPEED 110/120/130 KM/H, LEFT TURN 35%, 40%



S = Additional storage length required, that is, in addition to what is shown on the appropriate Type IV standard drawing. Designers should check additional storage requirements for trucks, also see Table D.7.6a.

- - - - Traffic signals may be warranted in rural areas, or urban areas, with restricted flow.

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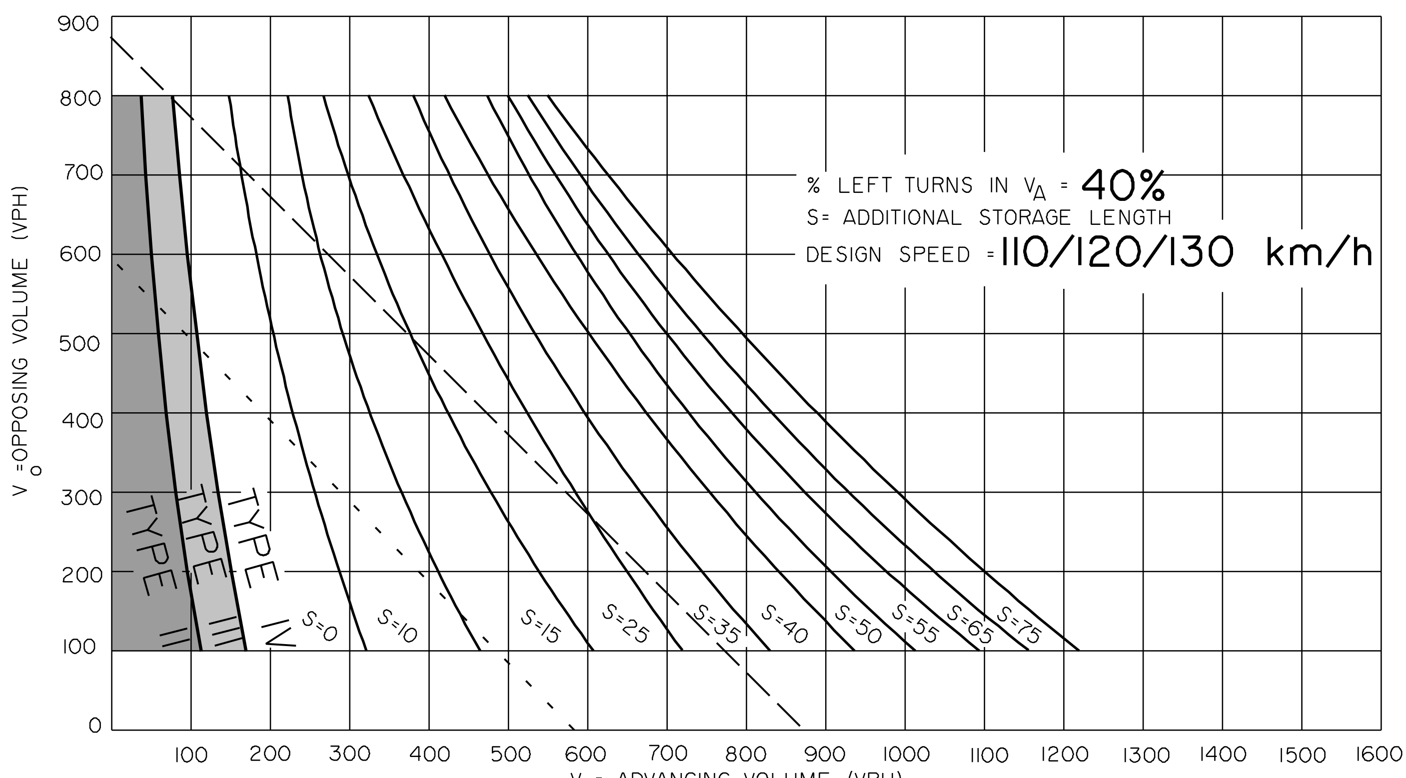
Notes:

1. The traffic signal warrant lines are provided for reference only. For detailed analysis of the requirements for signals, contact Roadway Engineering Branch.
2. Warrant for Type I treatment is shown in Figure D-7.4.



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D.7.6.1 Rationale for Left Turn Warrants

The Ministry of Transportation of Ontario developed a rational method of determining left turn lane warrants and storage requirements. (See Ministry of Transportation, Ontario, Canada, Report #RR122, January, 1967.) The Ontario design manual is based on this method. The Alberta Infrastructure warrant is also based on this method, with some differences described below.

The Ontario warrants are based on a certain level of confidence, or probability, that any vehicle in the advancing stream of traffic in the design hour will not arrive at the intersection when another vehicle, travelling in the same direction, is stopped waiting to make a left turn. Because of the potential hazard associated with having to stop on an unsignalized rural highway intersection, and because this hazard increases with increased design speed, the warrant is based on the level of confidence of having a clear roadway. A higher level of confidence is provided for higher design speeds.

The Alberta warrant differs from the Ontario warrant in three ways:

1. The level of confidence, provided to ensure that through vehicles will not have to stop, is higher in Alberta than Ontario.

2. When a Type IV exclusive left turn lane is warranted, some storage is also provided in Alberta, and

3. When the warrant is not met, but 70 percent of the advancing and opposing volume required for the warrant is present, a less extensive and less costly Type III treatment is suggested in Alberta. For lower volumes, the Type II treatment is suggested.

4. The Ontario warrant was based on a design hour which was likely the 30th highest hour. Alberta's design hour is now based on the 100th highest hour however designers are asked to check that operations will be satisfactory at other hours also.

The Ontario warrant, as presented in 1967, was based on the following relationship between design speed, operating speed and the following probabilities:

Design Speed (m.p.h.)	Assumed Operating Speed (m.p.h.)	Maximum Allowable Probability of an Arrival Behind a Left Turning Vehicle
50	40	0.020
60	50	0.015
70	60	0.010

The current Alberta warrant, as presented in the charts in this manual, is based on the probabilities indicated in Table D.7.6.1.

When a left turn lane is warranted in Alberta, a standard Type IV treatment is provided as a minimum. The Type IV treatment includes a built-in allowance for storage which varies with design speed. (See Table D.7.6b.) Consequently, it is not necessary to provide as much additional storage in the Alberta warrant. The built-in storage amount is the difference between the length available for deceleration (parallel lane plus one-half of the taper) and the required deceleration length, based on a deceleration rate of 0.25g. For this reason, the storage S values shown on the Alberta warrant charts are lower than the values shown on the Ontario charts by an amount equal to the built-in storage length. Similarly, Table D.7.6a, which shows additional storage length requirements for trucks, has also been modified.

Table D.7.6.1 Warrant Probabilities

Design Speed (km/h)	Assumed 85th Percentile Running Speed (km/h)	Maximum Allowable Probability of an Arrival Behind a Left Turning Vehicle	
		Soft Conversion	Hard Conversion
130/120/110	110	0.005	0.0058
100	100	0.010	0.0089
90	90	-	0.0120
80	80	0.015	0.0151
70	70	-	0.0182
60	60	-	0.0214
50	50	-	0.0245

* Note: The odd numbers are generated due to a hard conversion from imperial units (for design speed) to metric. The odd numbers are used to produce warrant graphs which, if interpolated, would correspond exactly with the imperial graphs. The values used for 50, 60, 70 and 90 km/h are extrapolated. The current Ontario manual uses the same probabilities for each design speed as Alberta.

D.7.7 Warrant for Right Turn Lane

To warrant an exclusive right turn lane at a two-lane highway intersection in Alberta, the following three conditions must all be met:

1. Main (or through) road AADT ≥ 1800
2. Intersecting road AADT ≥ 900, and
3. Right turn daily traffic volume ≥ 360 for the movement in question.

If an exclusive right turn lane is warranted, the standard layout shown on Type IVd (Figure D-7m) should be used. Adjustment to the length of parallel lane may be required if the gradient on the main (or through) highway exceeds two percent. Refer to Table D.6.2.6.

D.7.8 Warrant for Channelization

A channelized intersection may be warranted at intersections that have high through traffic volumes (above 4000 AADT) and one or more predominant turning movements. The need for channelized treatment is site specific. However, where both left and right turn lanes are required, this is usually a good candidate for channelization. The use of channelization is suggested in this case for two reasons:

1. A six-lane flared intersection is very wide, requires additional time for crossing and can be confusing for drivers on the intersecting road.
2. With large numbers of turning movements, there could be excessive delay for vehicles on the intersecting road, which could be reduced considerably by construction of a right turn roadway.

The designer should use the principles in the design of a channelized interseciton as described in Section D.6.3.

Examples of typical channelized intersection layouts for rural and semi-urban environments are shown in Figures D-6.3.6a and D-6.3.6b, respectively.

D.8 INTERSECTION ELEMENTS - MULTI-LANE DIVIDED HIGHWAYS

D.8.1 Right Turn Taper

At minor intersections on multi-lane divided highways, the movements of right turning traffic are accommodated through a taper design followed by a simple curve, generally 15m in radius. If right turning volumes are anticipated to be low, a parallel deceleration lane design is not warranted.

On new construction or grade widening, an 87.5m, 25:1 lane taper and a 50.0m, 25:1 shoulder taper is used, resulting in 3.5m of turning lane width with a 1.5m shoulder at the beginning of the simple curve. Beyond the intersection, an identical taper design is provided to facilitate the movements of traffic turning right off the intersecting roadway onto the through highway. For twinning projects on existing highways, a 3.0m turning lane width with a 0.3m shoulder at the beginning of the simple curve should be provided — if sufficient shoulder width is available. This is accomplished by means of pavement markings on the existing highway's shoulder, with no subgrade widening. Where additional shoulder width is available the turning lane width can be increased to 3.5m.

D.8.2 Right Turn Taper with Parallel Deceleration Lane

At main (or through) intersections on multi-lane divided highways, the movements of right turning traffic may be accommodated (if warranted) through a taper and parallel deceleration lane. On new construction or grade widening, a 140m, 40:1 lane taper and a 30m, 40:1 shoulder taper is used. This results in a 3.5m parallel deceleration lane width with a 1.5m shoulder. The length of the parallel deceleration lane varies with design speed (see Table D.8.4). This combination of taper and parallel lane allows for comfortable deceleration to a stopped position, if necessary, with provision for a limited storage space. This is based on the assumption that deceleration can take place over the length of taper and parallel lane. This is a reasonable assumption where the level of service of the divided highway is high, that is, level of service A. However, where the level of service is less than A, the parallel lane length may be increased so that all of the deceleration can take place on the auxiliary lane. On a typical rural four-lane divided highway in Alberta, the level of service is usually A in the design hour unless the AADT exceeds 17,000.

For effect of grade on parallel deceleration lanes, see Table D.6.2.6. Beyond the intersection, a similar parallel lane and taper design is provided to facilitate the movements of traffic turning right off of the main (or through) intersecting roadway onto the through highway. Adjustment to the parallel acceleration lane length may be required for effect of grade (see Table No. 2, Figure D-6.3.4). In the case of a twinning project on existing roadways, a 3.0m parallel acceleration/deceleration lane with a 0.3m shoulder may be provided. This is done through pavement markings on the existing roadway with no subgrade widening — if the existing shoulder is sufficiently wide.

Refer to Section D.8.7 for warrants for right turn lanes on four lane divided highways.

D.8.3 Left Turn Taper

When a minor intersection occurs on a multi-lane divided highway, a full median lane width may not be warranted because of the lower anticipated turning volumes. On new construction or grade widening, a 87.5m, 25:1 lane taper and a 50.0m, 25:1 shoulder taper is used. This results in a 3.5m turning roadway width with a 0.5m shoulder. This additional width allows left turning vehicles to stop clear of the through traffic lanes, prior to making the left turn. In the case of a twinning project on existing highways, a 3.0m turning lane with a 0.3m shoulder may be provided. This is done through pavement markings on the existing highway's shoulder with no subgrade widening — if the existing shoulder is sufficiently wide.

D.8.4 Left Turn Taper with Parallel Deceleration Lane

A left turn lane with parallel deceleration lane may be provided if warranted at main (or through) intersections on multi-lane divided highways. The median lane is introduced with a 140m, 40:1 taper for design speeds of 100 km/h or higher, or on a 87.5m, 25:1 taper for lower speeds. This results in a 3.5m parallel deceleration lane width with a 0.5m shoulder. The length of the parallel deceleration lane varies with the design speed. (See Table D.8.4.) This combination of taper and parallel lane allows for comfortable deceleration to a stopped position. It also makes provision for a limited storage space, assuming that deceleration can take place over the entire taper and parallel lane. This assumption is reasonable for a level of service of A, that is, AADT <17,000 approximately. However, for lower service levels, it is desirable to provide additional parallel lane length so that all of the deceleration can occur in the auxiliary lane.

Adjustments to the parallel deceleration lane length may be required for additional storage, effect of trucks on storage requirements, and effect of grade on parallel deceleration lanes. (See Figure D-8.6 and Tables D.7.6a and D.6.2.6.) Beyond the intersection, a bullet-nose transition is provided to facilitate the movements, including off-tracking, of traffic turning left from the intersecting roadway onto the main (through) highway.

Generally, a parallel acceleration lane on the median side is not provided because this encourages drivers to accelerate up to highway speed, and then attempt to merge to the right. High speed merges to the right can be difficult to perform especially for larger vehicles and trucks which may have limited rear visibility. The presence of vehicles merging to the right is also very disconcerting for through traffic because it is contrary to the normal speed profile on divided highways, where the slower vehicles are generally on the right.

The absence of a parallel acceleration lane on the median side (along with a wide median which can provide refuge for the design vehicle) is intended to force the vehicle turning left from the intersecting road, to wait for a gap in the traffic before entering the divided highway (preferably in the right-hand lane).

D.8.4.1 Left Turn Tapers with Raised Medians

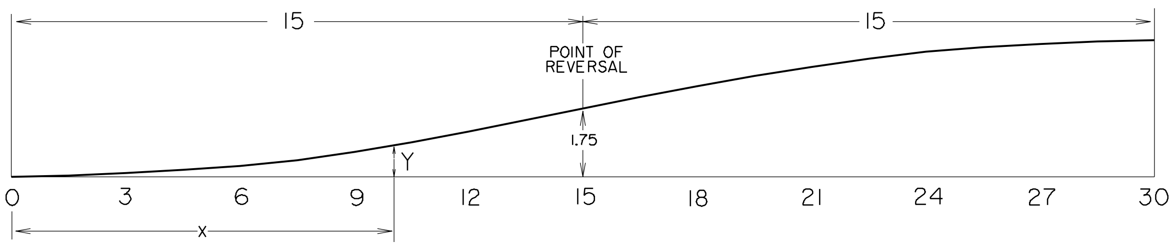
In cases where the left edge of the median lane is curbed, it is preferable to design the taper with reverse parabolic curves. Figure D-8.4.1 shows an example of a 30m reverse parabolic flare. This can be used as a guide for setting up the curb alignment for any specified length of curbed median taper.

Table D.8.4 Standard Design Lengths for Parallel Deceleration Lanes on Multi-Lane Divided Highways

Highway Design Speed (km/h)	Taper Length (m) and Ratio	Parallel Lane Length (m)	Length Available for Deceleration Lane Taper (m)	Deceleration Length Required (m)	Storage Length Provided by Standard Treatment
50	87.5 at 25:1	30	117.5	70	47.5
60	87.5 at 25:1	40	127.5	90	37.5
70	87.5 at 25:1	60	147.5	110	37.5
80	87.5 at 25:1	70	157.5	130	27.5
90	87.5 at 25:1	80	167.5	150	17.5
100	140 at 40:1	90	230	170	60
110	140 at 40:1	100	240	190	50
120	140 at 40:1	100	240	210	30
130	140 at 40:1	110	250	215	35

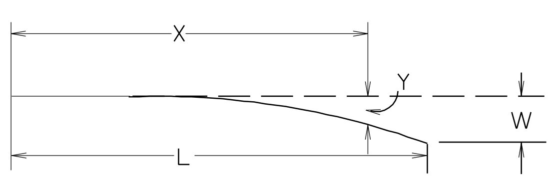
FIGURE D-8.4.1 REVERSE PARABOLIC CURB FLARES

OFFSETS FROM TANGENT FOR 30m REVERSE PARABOLIC FLARE
(SAMPLE CALCULATION)
FOR 3.5 LEFT TURN BAY



TANGENT DISTANCE "X"	DISTANCE FOR CALCULATION	$Y_1 = \frac{1.75\ X^2}{15^2}$ ORDINATE	QUANTITY TO SUBTRACT Y_1 ORDINATE FROM	OFFSET DISTANCE "Y"
0	0.0	0.0	-	0.0
3	3	0.07	-	0.07
6	6	0.28	-	0.28
9	9	0.63	-	0.63
12	12	1.12	-	1.12
15	15	1.75	-	1.75
18	12	1.12	3.5	2.38
21	9	0.63	3.5	2.87
24	6	0.28	3.5	3.22
27	3	0.07	3.5	3.43
30	0	0	3.5	3.5

DERIVATION



L= LENGTH OF PARABOLA
W= MAXIMUM OFFSET
X= TANGENT DISTANCE
Y= OFFSET FROM TANGENT

$$Y = \frac{WX^2}{L^2}$$

(NOTE THAT THIS APPLIES TO SINGLE PARABOLA ONLY)

D.8.5 Median Openings on Multi-Lane Divided Highways

The design of median openings on multi-lane divided highways is dependent on median width and turning requirements of the design vehicle. The WB-23 (25m long Super B-Train) is normally selected as the design vehicle. The shapes generally used for median openings are as follows:

- Semi-Circular median openings where median widths are narrow (up to 5m). The median opening takes the form of a semi-circular end design.
- Bullet Nose median openings formed by two symmetrical portions of control radius arcs (representative of the rear wheel path of the WB-23 design vehicle), and a small radius to round the nose. The bullet nose design closely fits the path of the inner wheel, results in less intersection pavement, and has a shorter length of opening than the semi-circular end. This design permits simultaneous left turn movements for trucks from each direction on the highway, as well as turns from the intersecting road. (See Figure D-8.5.1a.)
- Flat Nose median openings for wide medians (25m or more) with the ends flattened in shape and parallel to the intersecting roadway. This design has operational advantages over the bullet nose design, such as permitting the WB-23 design vehicles to stop off the through pavement, while waiting for an opening, and to pass each other when turning. Vehicles crossing the highway relate easier to the flat nosed opening and to the through lanes of the highway. Drivers stopped in the median opening have a greater sense of security regarding the front and rear of their vehicles. (See Figure D-8.5.1b.)

The median is defined as the area between the lanes of traffic travelling in opposite directions on a divided highway. Median width is the perpendicular distance from edge of driving lane to edge of driving lane (opposing directions).

The flat nose design is preferred at wide median intersections which are signalized. It forces vehicles to stay in the correct lane, while making left turns. This keeps the path clear for intersecting road crossings. The flat nose design also requires less pavement than the bullet nose for medians of 25m or more, and is less costly to build. On skewed intersections with a wide median, the flat nose design is again preferred because it requires much less pavement area than a bullet nose design.

The following guidelines are generally used to select the shape of the median opening on divided highways:

1. Semi-circular: median widths up to 5m.

2. Flat nose:
   - Condition 1 - Median width is 25m or more <u>and</u> either the warrants for left turn lane are not satisfied (Figure D-8.6) or the intersection will be signalized,

   <u>or,</u>
   - Condition 2 - Median width exceeds 31m.

3. Bullet nose: All openings where semi-circular or flat nose cannot be used.

The design details for a bullet nose median opening are shown in Figure D-8.5.1a. The design details for a flat nose median opening are shown in Figure D-8.5.1b.

D.8.5.1 Design of Bullet Nose Median

In Figure D-8.5.1a, greater than minimum control radii are used with a bullet nose design. Advantages in using large control radii include better vehicle control, reduction in paved area and an improved appearance, as compared to semi-circular median ends.

The design controls for bullet nose median openings are the three radii R_C, R1, and R2. R_C is the control radius for the sharpest portion of the turn, R1 defines the turnout curve at the median edge and R2 is the radius of the tip.

The two control radii used for the tables in Figure D-8.5.1a (that is, R_C=20m and R_C=25m) are representative median and maximum radii which describe the tracking of the outer front wheel of the WB-23 design vehicle. Selection of control radii for the bullet nose design is determined based on turning volumes. Generally, control radius R_C=25m should be used at all main (or through) intersections on four-lane divided highways; that is, divided highways intersected by two-lane primary or secondary highways or town access roads. At minor intersections on four-lane divided highways intersected by road allowances, private accesses, and farm entrances, control radius R_C=20m should be used.

FIGURE D-8.5.1a DESIGN FOR BULLET NOSE MEDIANS

FORMULAE FOR BULLET NOSE

(TO BE USED ONLY WHERE THE CROSS-ROAD INTERSECTS THE HIGHWAY AT 90°)

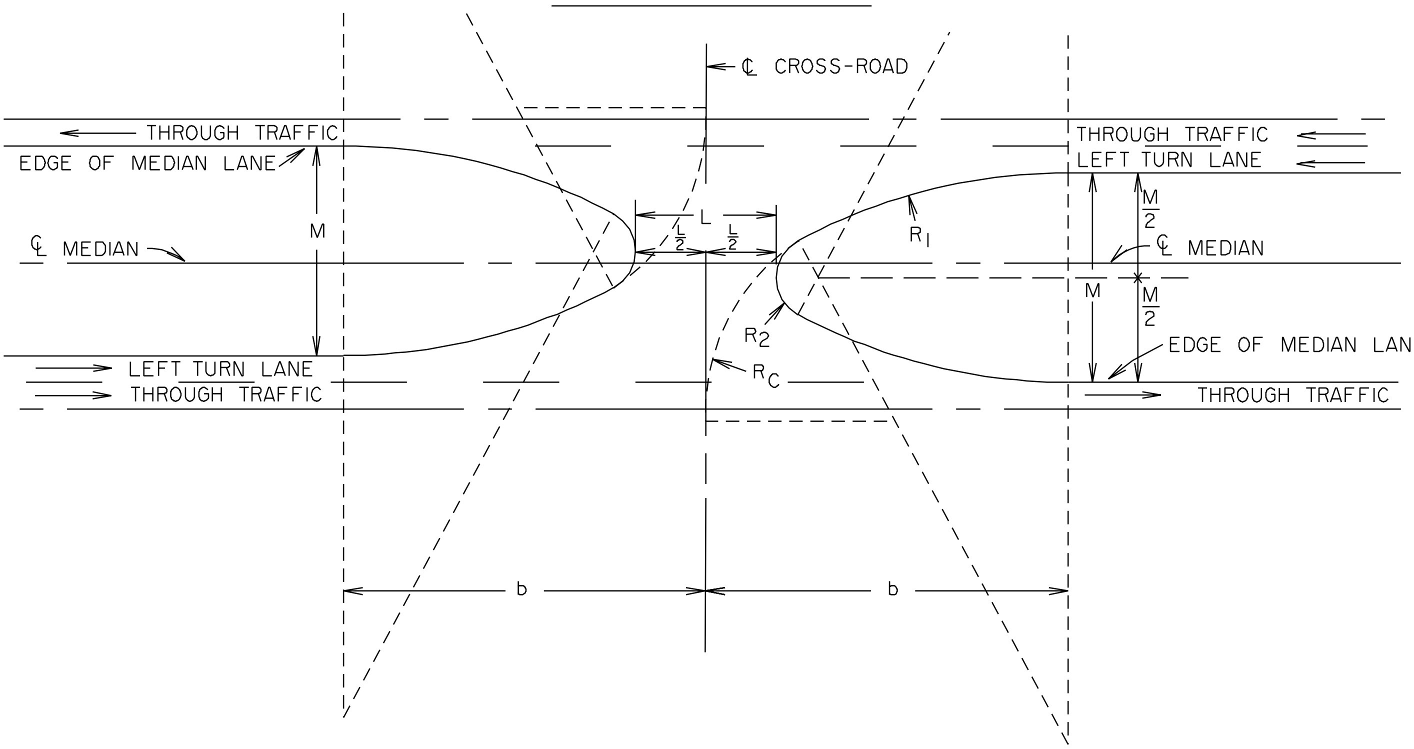
$$R_2 = \frac{M}{5}, \qquad K = \sqrt{(R_1 - R_2)^2 - \left(R_1 - \frac{M}{2}\right)^2}$$

$$b = R_C + \frac{K\,(R_1 - R_C)}{R_1 - R_2} \quad \text{or} \quad b = \frac{L}{2} + R_2 + K$$

$$L = 2(b - K - R_2)$$

$$R_C = \frac{b(R_1 - R_2) - K \times R_1}{R_1 - R_2 - K}$$

TYPICAL BULLET NOSE



CONTROL RADIUS R_C=20 (Minor Intersections)

℄ TO ℄ SPACING (m)	M WIDTH OF MEDIAN (m)	R_1=25		R_1=45		R_1=75	
		L	b	L	b	L	b
22	9.10	19.24	22.35	23.64	28.75	—	—
22	9.60	18.67	22.42	23.16	28.99	—	—
22	12.60	15.56	22.78	20.54	30.31	—	—
30	19.10	—	—	15.89	32.72	19.64	41.62
30	19.60	—	—	15.43	33.01	19.35	41.90
30	22.60	—	—	13.81	33.85	17.71	43.54
38	27.10	—	—	—	—	15.48	45.80
38	27.60	—	—	—	—	15.25	46.04
38	30.60	—	—	—	—	13.91	47.43

Control Radius R_C=20m is suitable for the medium turning templates of the WB-23 (25m long Super B-train) design vehicle and all shorter truck-trailer combinations.

CONTROL RADIUS R_C=25 (Major Intersections)

℄ TO ℄ SPACING (m)	M WIDTH OF MEDIAN (m)	R_1=25		R_1=45		R_1=75	
		L	b	L	b	L	b
20	9.10	24.53	25	30.14	34.00	—	—
20	9.60	23.83	25	29.57	32.19	—	—
20	12.60	20.01	25	26.42	33.25	—	—
30	19.10	—	—	20.81	35.18	25.71	44.65
30	19.60	—	—	20.23	35.41	25.37	44.91
30	22.60	—	—	18.27	36.08	23.43	46.40
38	27.10	—	—	—	—	20.79	48.45
38	27.60	—	—	—	—	20.52	48.67
38	30.60	—	—	—	—	18.93	49.94

Control Radius R_C=25m is suitable for the maximum turning template of the WB-23 (25m long Super B-train) design vehicle and all shorter truck-trailer combinations.

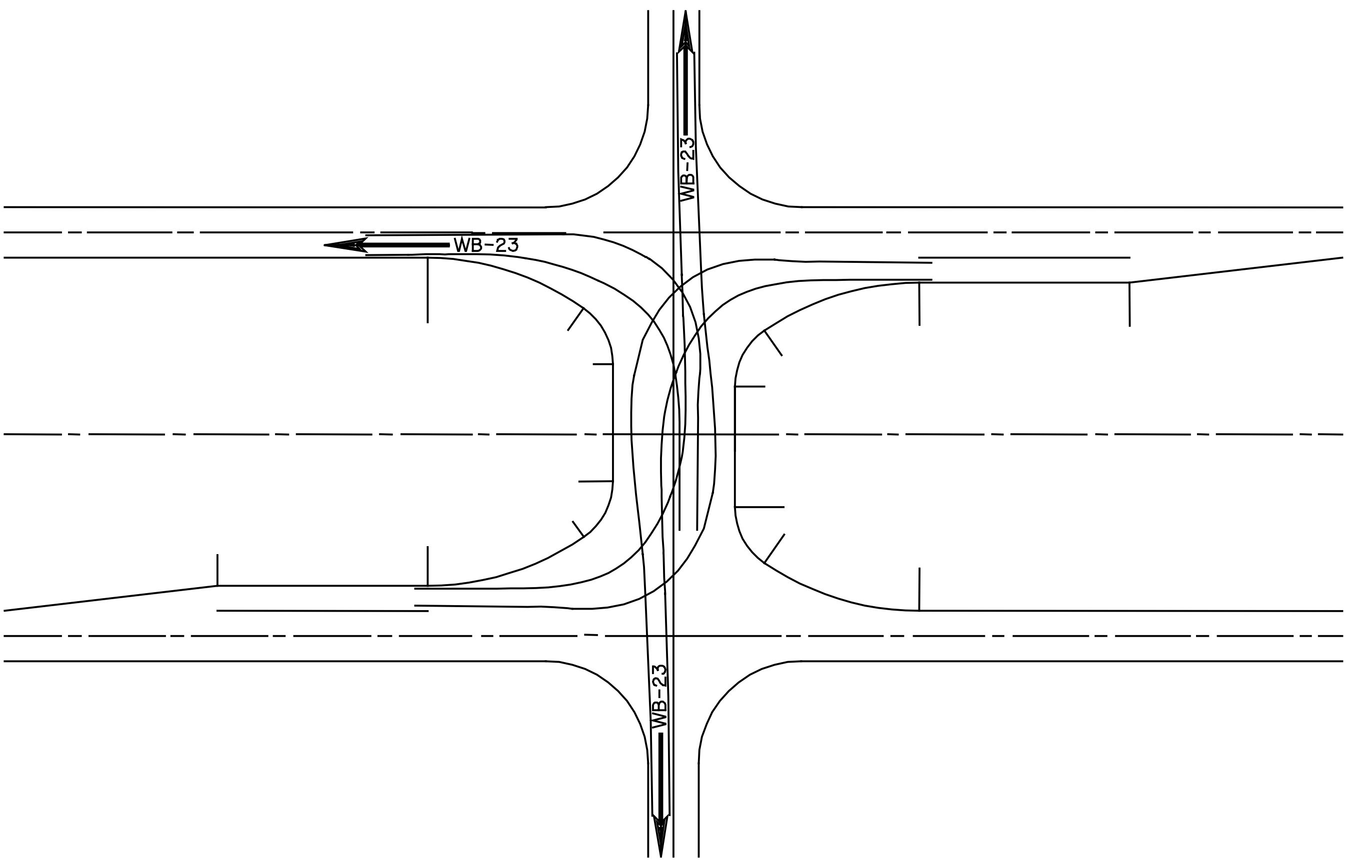
GRAPHICS FILE: debd85l.man

The R_1 values shown in the tables, 25, 45 and 75m, represent the minimum radii for turning speeds of 30, 40 and 50 km/h, respectively. This does not suggest that vehicles actually turn at these speeds, but these radii provide the driver with a turning path easily followed at those speeds with good road surface conditions. In fact, most vehicles must slow down considerably at the sharpest portion of the turn, or may stop, awaiting a gap in oncoming traffic. For design, R_1=75m is the desirable radius to be used. However, when dealing with narrow median widths (that is, 13m or less), the desirable R_1 value produces median openings that are too large to be practical. In such cases, lower R_1 values may be used (R_1=25m or R_1=45m).

Radius R_2 can vary considerably, but it is pleasing in proportion and appearance when it is about one-fifth of the median width.

Once the design parameters have been chosen for the median opening, the workability of the layout should in all cases be verified through the application of the appropriate vehicle turning templates.

FIGURE D-8.5.1b TYPICAL LAYOUT OF FLAT-NOSE MEDIAN OPENING



NOTE: PAVEMENT LAYOUT IS TO BE DESIGNED TO ACCOMMODATE VEHICLE TURNING TEMPLATE. THE RADII MAY BE SELECTED INITIALLY BASED ON TYPICAL 3-CENTRE CURVE LAYOUTS. THE LAYOUTS SHOULD BE CHECKED BY TRIAL AND ERROR USING TEMPLATES FOR ALL DESIGN VEHICLES THAT NEED TO BE ACCOMMODATED. THE 'MEDIUM' TURNING TEMPLATE IS GENERALLY APPROPRIATE FOR HIGHWAY INTERSECTIONS.

D.8.5.2 Effect of Skew on Median Openings

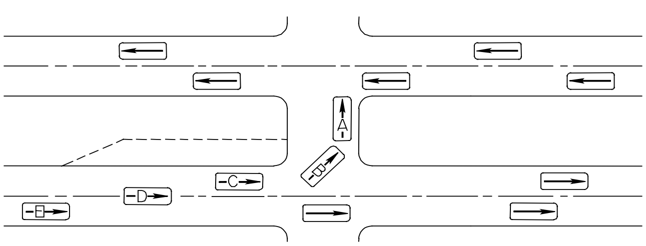
When a road intersects a divided highway on skew, the median end should be located by use of the control radius within the acute angle quadrants. Trials of several alternative opening designs are made, with the use of vehicle turning templates, to determine the most practical one for the particular skew condition. An appropriate design vehicle should be selected for the intersection in question. The medium or minimum WB-15 turning template may be used for minor intersections involving road allowances, minor roads, etc. However, the WB-23 maximum template should be used on main (or through) intersections with main (or through) turning movements.

On projects where this situation arises, the design details for the median should be investigated on an individual basis. For each intersection occurring on skew, an applicable median end design will be shown along with the intersection treatment plan.

D.8.6 Warrants for Left Turn Lanes on Four-Lane Divided Highways

In Figure D-8.6a, an unsignalized at-grade intersection on a four-lane divided highway is illustrated. In this figure, the median width is sufficient to provide refuge for one left turning vehicle.

FIGURE D-8.6a UNSIGNALIZED AT-GRADE INTERSECTION ON FOUR LANE DIVIDED HIGHWAY

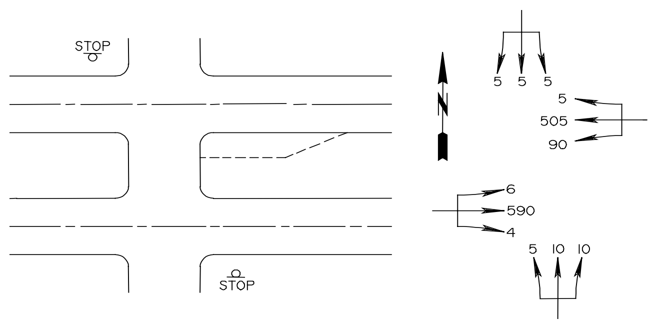


In making a left turn at the intersection as illustrated above, Vehicle A is protected from the through traffic by the median. If, however, Vehicle B arrives at the intersection before Vehicle A has made the left turn, and both vehicles must wait for a suitable gap in the opposing volume, Vehicle B will be exposed to collisions with vehicles in the advancing through traffic. That is, Vehicle D in the inside lane may attempt to move to the outside lane, risking collisions with Vehicles C and E. The interference caused by the standing left turning vehicles can reduce capacity and create a safety hazard.

A left turn lane with sufficient storage space, as shown by the dashed line in Figure D-8.6a, would improve the safety and operational characteristics of the intersection by reducing vehicle conflicts.

Figure D-8.6b shows an example of a left turn lane warrant on a four-lane divided highway.

FIGURE D-8.6B EXAMPLE SHOWING LEFT TURN LANE WARRANT ON A FOUR LANE DIVIDED HIGHWAY



A left turn lane with suitable storage space is being considered for left turning vehicles on the east approach.

V_l = 90 v.p.h.
V_o = 590 + 6 + 4 = 600 v.p.h.

Using Figure D-8.6c with V_o = 600 v.p.h.
V_l = 90 v.p.h.

A left turn lane is warranted and the required storage space is 25m. From Table D.7.6a, since 20 percent of V_l are trucks, additional storage requirements due to trucks is 10m. Therefore, a left turn lane is warranted and storage space requirements = 25 + 10 = 35m. Table D.8.4 shows the standard design lengths for parallel deceleration lanes. It also shows that the standard left turn lane for a 120 km/h design speed provides 30m of storage. Therefore, an additional five metres of parallel storage lane is required.

The warrants for left turn lanes and storage requirements for four-lane divided highways are shown in Figure D-8.6c.

D.8.7 Warrants for Right Turn Lanes on Four-Lane Divided Highways

As a general guideline for the provision of a right turn lane (complete with allowance for deceleration), it is suggested that the right turn volume be ≥ 360 vehicle/day for the movement in question. This is consistent with the warrant for an exclusive right turn lane on a two-lane undivided highway. While it is acknowledged that a slow right-turning vehicle will not cause as much delay on a four-lane highway as on a two-lane highway (in general), the adoption of a warrant at this level can be supported. The reasons include driver expectation of a high level of service on divided facilities, and higher running speeds and higher volumes on divided facilities.

The design lengths for parallel deceleration lanes to be provided, when right turn lanes are warranted, are shown in Table D.8.4. It should be noted that storage is generally not required with right turn lanes, as there should be no delay for right turning vehicles exiting the highway.

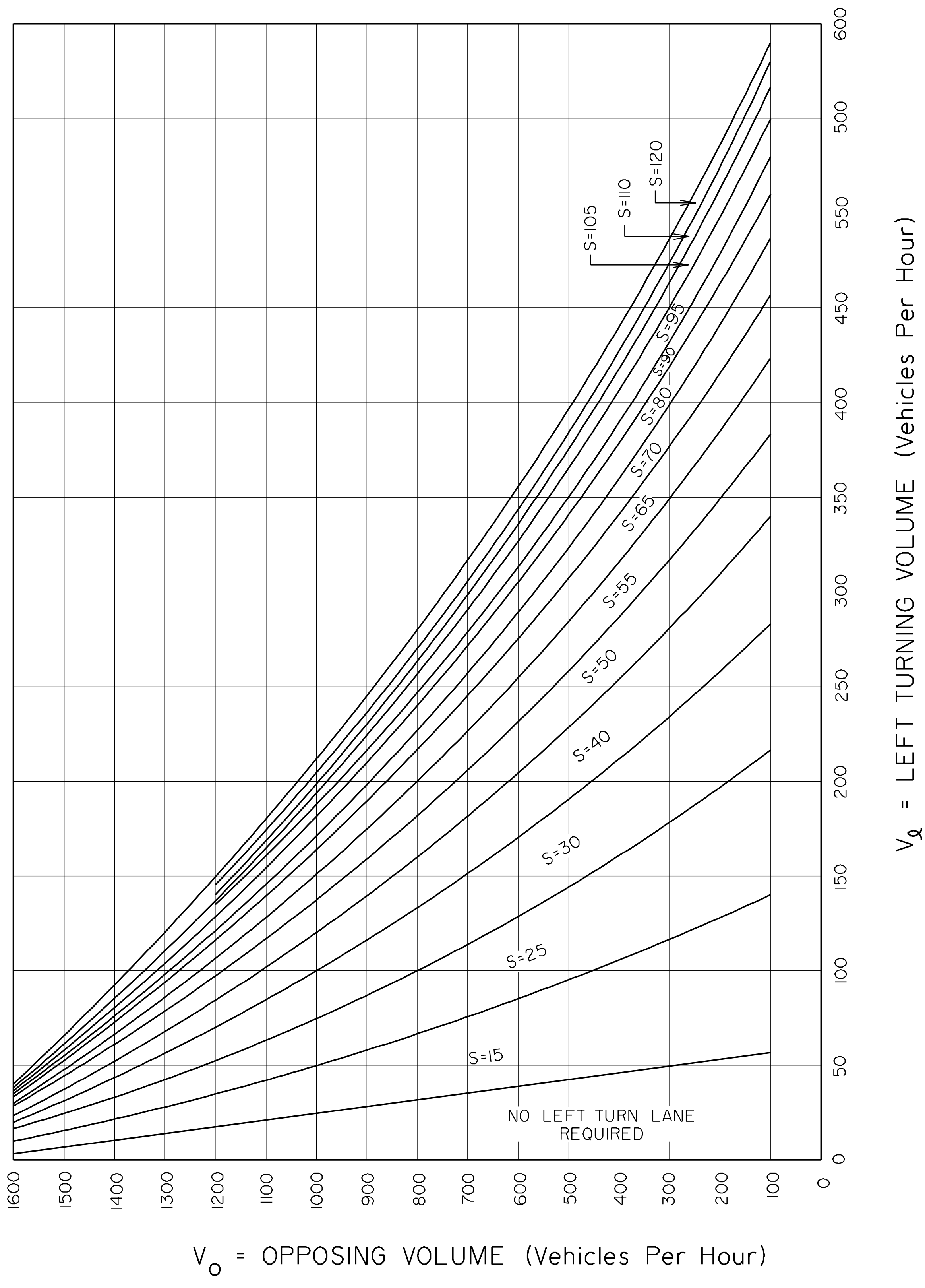
D.8.8 Transitions for Median Widening

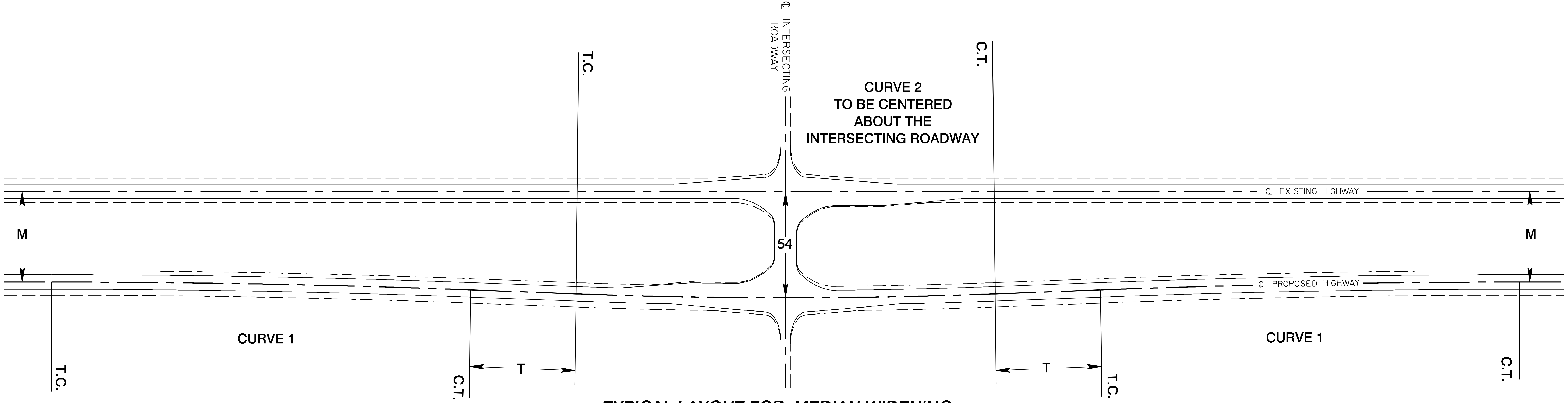
When the median requires widening at an intersection to provide adequate storage length for longer design vehicles to cross a divided highway, smooth transitions should be designed to tie the roadway from its normal centreline-to-centreline spacing (before the intersection) to the maximum (at the intersection) and back to the normal (after the intersection). Designers are encouraged to use three simple curves of large radii on the transitions. See Figure D-8.8 for typical transitions with suggested transition alignments for various scenarios.

The two outer curves are usually identical. The middle curve is in the opposite direction and should be centred about the centreline of the intersecting roadway. Although superelevation is not required, adjacent curves should be separated by a short tangent (100 m or greater depending on the amount of widening) to ensure a smooth transition between curves. Increased widening can be achieved using longer tangents.

For new construction projects, the radius for each of the two outer curves may be double that of the middle curve to allow a smooth initial transitioning on a longer curve. In the case of rehabilitation projects, the radii of the two outer curves may be reduced to minimize the disturbance to the existing roadway as shown on Figure D-8.8.

FIGURE D-8.6c WARRANTS FOR LEFT TURN LANES AND STORAGE REQUIREMENTS FOR FOUR-LANE DIVIDED HIGHWAYS





TYPICAL LAYOUT FOR MEDIAN WIDENING
N.T.S.

SUGGESTED TRANSITION ALIGNMENT DATA FOR MEDIAN WIDENING

CASE	M (℄ to ℄ SPACING)	CURVE 1	T	CURVE 2
8m MEDIAN WIDENING	46m	Δ= 01° 08' 41" R= 20000m ST= 199.780m Lc= 399.547m	100.520m	Δ= 02° 17' 21" R= 10000m ST= 199.800m Lc= 399.547m
16m MEDIAN WIDENING (MINIMUM ALIGNMENT) SUGGESTED FOR REHABILITATION PROJECTS	38m	Δ= 01° 55' 09" R= 12000m ST= 200.985m Lc= 401.933m	109.307m	Δ= 03° 50' 17" R= 10000m ST= 335.070m Lc= 669.889m
16m MEDIAN WIDENING (DESIRABLE ALIGNMENT) SUGGESTED FOR NEW TWINNING PROJECTS	38m	Δ= 01° 25' 55" R= 20000m ST= 249.934m Lc= 499.827m	265.390m	Δ= 02° 51' 50" R= 10000m ST= 249.974m Lc= 499.849m

NOTES:

INTERSECTION LAYOUT IS TO BE DESIGNED TO ACCOMMODATE THE APPROPRIATE VEHICLE TURNING TEMPLATE.
SEE FIGURES D-8.5.1a, AND D-8.5.1b AND FIGURES D-9.1a to d-9.1f FOR DESIGN AND LAYOUT OF MEDIAN OPENINGS.

No.	REVISED	BY	DATE
2			
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Alberta INFRASTRUCTURE

FIGURE D-8.8

Date: JUNE 1998

TYPICAL TRANSITIONS FOR MEDIAN WIDENING AT INTERSECTIONS FOR FOUR-LANE DIVIDED HIGHWAYS

Prepared By: T.N.	Checked By: B.K.	Scale: N.T.S.	PAGE D-181

Graphics File: debd92.man

D.9 INTERSECTION TREATMENT - MULTI-LANE DIVIDED HIGHWAYS

D.9.1 Introduction

Figures D-9.1a through D-9.1f illustrate typical intersection treatments for multi-lane divided highways. For reasons of simplicity, the main alignment in all cases is represented by an RAD-412.4 facility. The intersecting roadways are labelled as either main (through) or minor to assist the designer. However, the choice of treatment type should be made based on the warrant for left and right turn lanes, engineering judgement and a study of the turning movements and vehicle types using the intersection. Values for variable acceleration-deceleration lengths, based on design speeds, are tabulated where applicable.

Since many of our multi-lane divided highway facilities are the result of twinning operations, a modified intersection treatment on the existing highway may be required. In many cases, the existing two-lane undivided highway (which is to be twinned to provide a four-lane divided highway) was originally designed in imperial units. Since metric intersection design increases the requirement on the finished pavement width, in most cases the existing roadway subgrade would have to be widened at narrow isolated areas. This measure would accommodate the normal metric design standard for turning lanes. To avoid this costly and disruptive operation, the requirement for turning lanes and shoulders has been reduced somewhat to accommodate the intersection elements on the existing pavement through pavement markings only, with no subgrade widening. This modified treatment provides a 3.0m turning lane with a 0.3m shoulder. This criteria is noted on each of the typical intersection treatment plans. Where this criteria cannot be met on the existing pavement, and turning lanes are warranted, grade widening must take place. A 3.5m turning lane with a 0.5m shoulder (left side) or 1.5m (right side) shoulder must also be built.

As with the typical two-lane undivided intersection treatment plans, it should be clearly understood that these plans are typical and are not intended to be applicable to all intersection situations. Rather, these treatments illustrate the standard design treatment that is applied when these particular intersection elements (for example, right turn lane, left turn lane) are warranted. Each treatment should be undertaken as a specialized design to ensure that the appropriate auxiliary lanes, tapers and median openings are provided for the volume, design speed, skew angle and design vehicle. The availability of intersection sight distance for each design vehicle, based on the movements permitted and the median width, must also be checked. Because of the number of possible design vehicles and movements and the impact of various median widths, the intersection sight distance requirement must be calculated from first principles as outlined in Section D.4. This must be compared to the sight distance availability as measured in the field (preferably) or from the design drawings.

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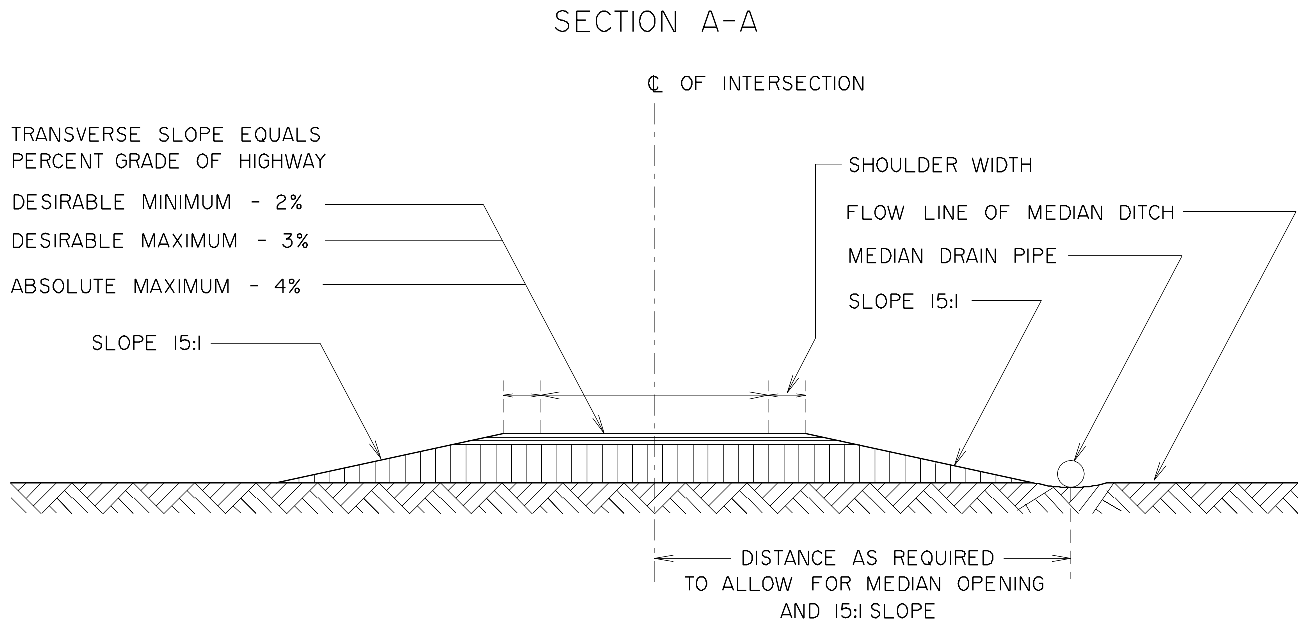
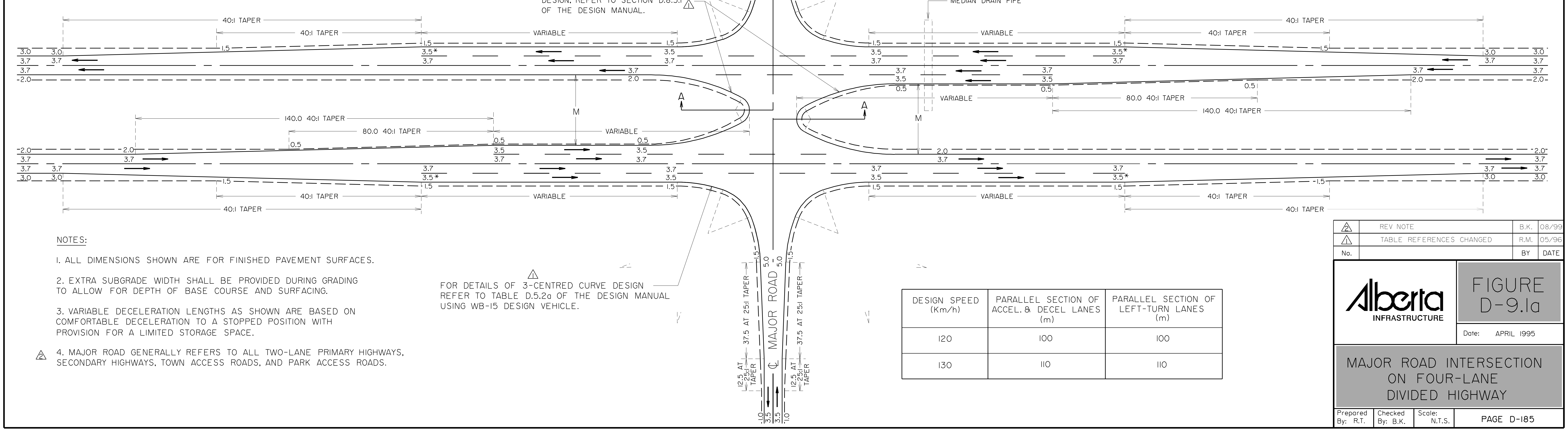
* TURNING LANES

ON NEW CONSTRUCTION OR GRADE WIDENING, A 3.5m TURNING LANE WITH 1.5m SHOULDER IS TO BE PROVIDED ON THE RIGHT HAND SIDE. A 3.5 m TURNING LANE WITH 0.5 m SHOULDER IS TO BE PROVIDED FOR THE LEFT HAND (MEDIAN) SIDE.

ON EXISTING ROADWAYS IF A SUFFICIENT SHOULDER WIDTH IS AVAILABLE A MINIMUM 3.0m TURNING LANE WITH A MINIMUM 0.3m SHOULDER MAY BE PROVIDED BY MEANS OF PAVEMENT MARKINGS. WHERE ADDITIONAL SHOULDER WIDTH IS AVAILABLE THE TURNING LANE WIDTH CAN BE INCREASED TO 3.5m.





NOTES:

1. ALL DIMENSIONS SHOWN ARE FOR FINISHED PAVEMENT SURFACES.

2. EXTRA SUBGRADE WIDTH SHALL BE PROVIDED DURING GRADING TO ALLOW FOR DEPTH OF BASE COURSE AND SURFACING.

3. VARIABLE DECELERATION LENGTHS AS SHOWN ARE BASED ON COMFORTABLE DECELERATION TO A STOPPED POSITION WITH PROVISION FOR A LIMITED STORAGE SPACE.

2 4. MAJOR ROAD GENERALLY REFERS TO ALL TWO-LANE PRIMARY HIGHWAYS, SECONDARY HIGHWAYS, TOWN ACCESS ROADS, AND PARK ACCESS ROADS.

DESIGN SPEED (Km/h)	PARALLEL SECTION OF ACCEL. & DECEL LANES (m)	PARALLEL SECTION OF LEFT-TURN LANES (m)
120	100	100
130	110	110

No.		BY	DATE
2	REV NOTE	B.K.	08/99
1	TABLE REFERENCES CHANGED	R.M.	05/96

Alberta INFRASTRUCTURE

FIGURE D-9.1a

Date: APRIL 1995

MAJOR ROAD INTERSECTION ON FOUR-LANE DIVIDED HIGHWAY

Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

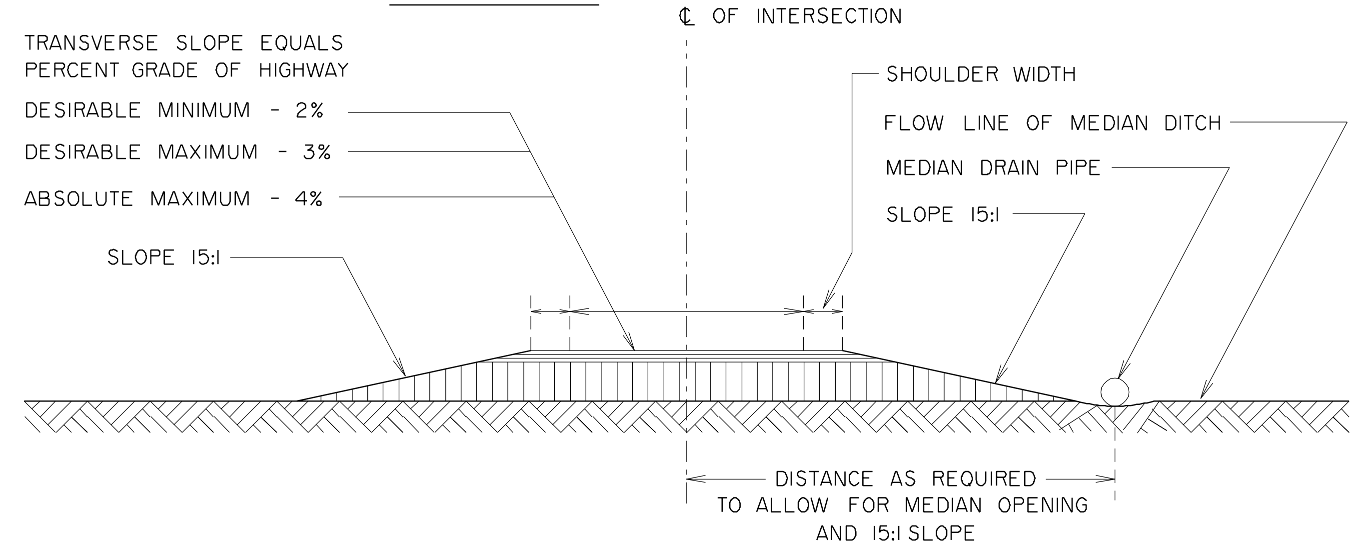
Graphics File: debd91a.man

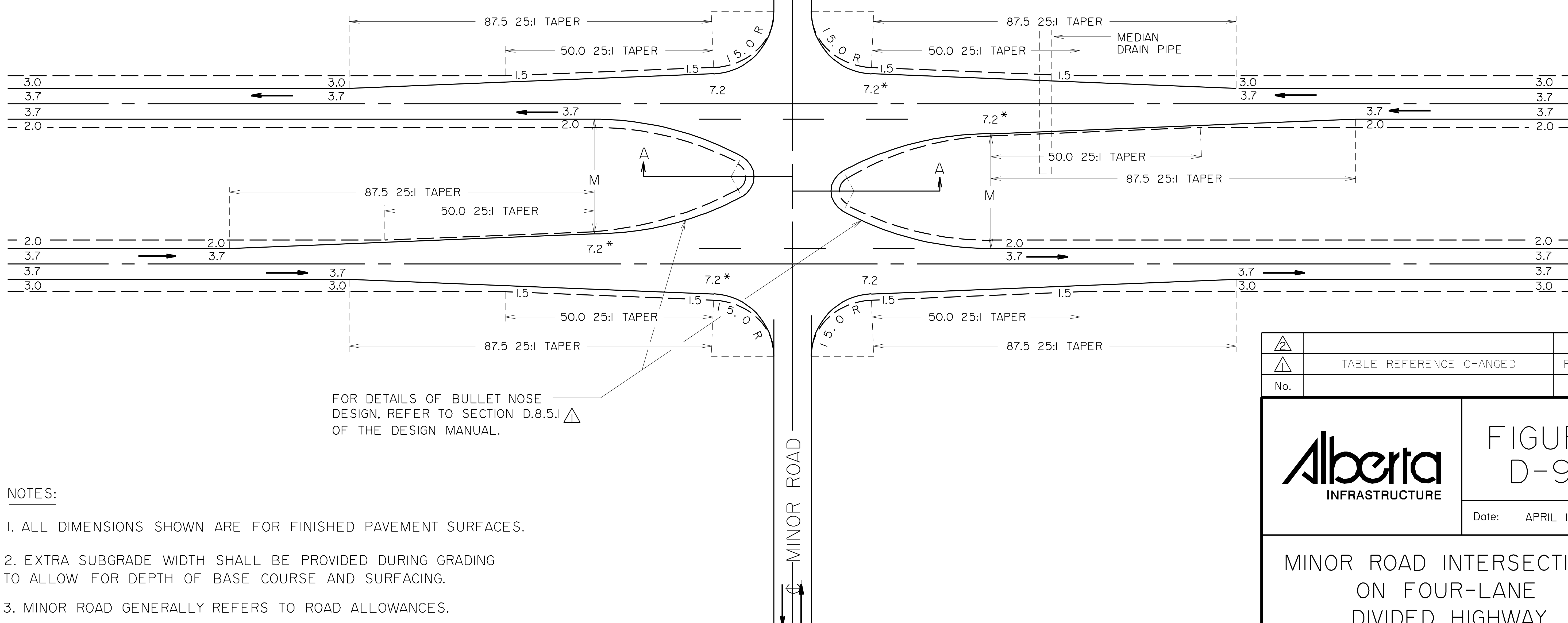
* TURNING LANES:

ON NEW CONSTRUCTION OR GRADE WIDENING, A 3.5m TURNING LANE WITH 1.5m SHOULDER IS TO BE PROVIDED ON THE RIGHT HAND SIDE. A 3.5 m TURNING LANE WITH 0.5 m SHOULDER IS TO BE PROVIDED FOR THE LEFT HAND (MEDIAN) SIDE.

ON EXISTING ROADWAYS IF A SUFFICIENT SHOULDER WIDTH IS AVAILABLE A MINIMUM 3.0m TURNING LANE WITH A MINIMUM 0.3m SHOULDER MAY BE PROVIDED BY MEANS OF PAVEMENT MARKINGS. WHERE ADDITIONAL SHOULDER WIDTH IS AVAILABLE THE TURNING LANE WIDTH CAN BE INCREASED TO 3.5m.

SECTION A-A





NOTES:

1. ALL DIMENSIONS SHOWN ARE FOR FINISHED PAVEMENT SURFACES.
2. EXTRA SUBGRADE WIDTH SHALL BE PROVIDED DURING GRADING TO ALLOW FOR DEPTH OF BASE COURSE AND SURFACING.
3. MINOR ROAD GENERALLY REFERS TO ROAD ALLOWANCES.

No.		BY	DATE
2			
1	TABLE REFERENCE CHANGED	R.M.	05/96

Alberta INFRASTRUCTURE

FIGURE D-9.1b

Date: APRIL 1995

MINOR ROAD INTERSECTION ON FOUR-LANE DIVIDED HIGHWAY

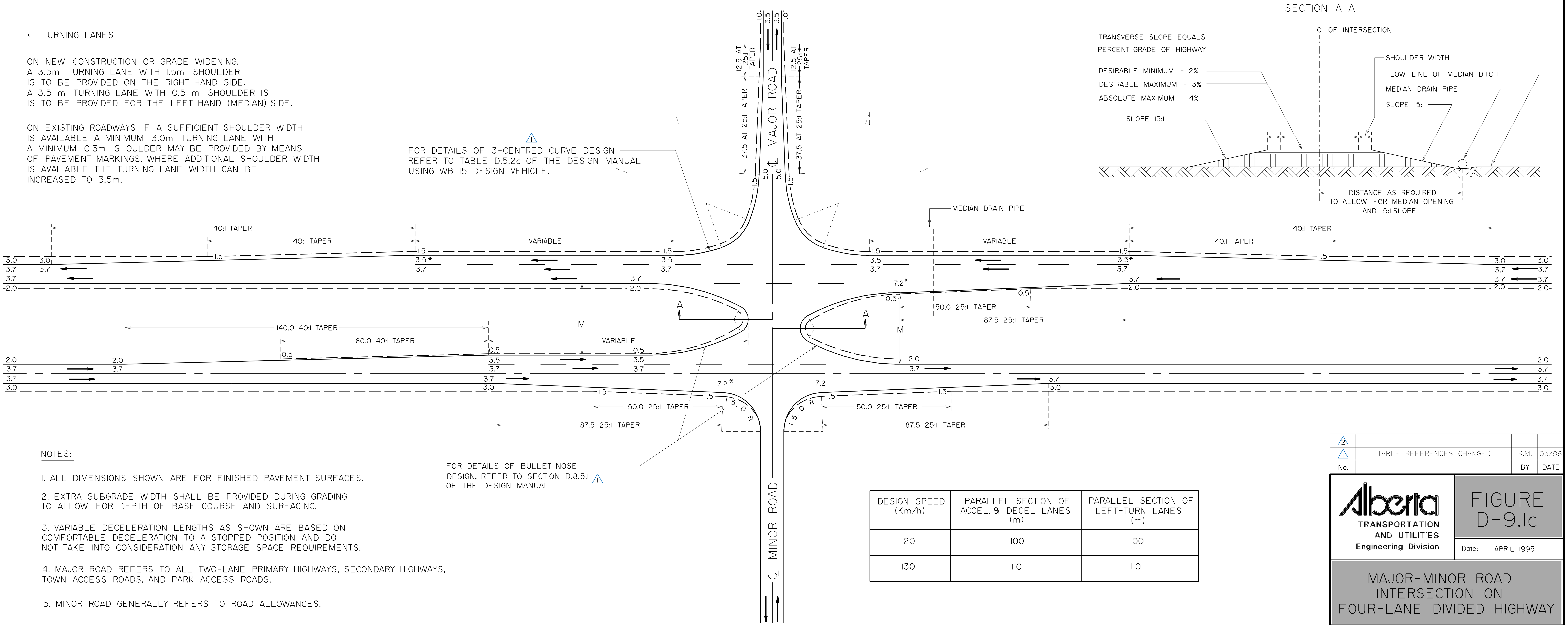
Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE D-187

Graphics File: debd9lb.man

* TURNING LANES

ON NEW CONSTRUCTION OR GRADE WIDENING, A 3.5m TURNING LANE WITH 1.5m SHOULDER IS TO BE PROVIDED ON THE RIGHT HAND SIDE. A 3.5 m TURNING LANE WITH 0.5 m SHOULDER IS IS TO BE PROVIDED FOR THE LEFT HAND (MEDIAN) SIDE.

ON EXISTING ROADWAYS IF A SUFFICIENT SHOULDER WIDTH IS AVAILABLE A MINIMUM 3.0m TURNING LANE WITH A MINIMUM 0.3m SHOULDER MAY BE PROVIDED BY MEANS OF PAVEMENT MARKINGS. WHERE ADDITIONAL SHOULDER WIDTH IS AVAILABLE THE TURNING LANE WIDTH CAN BE INCREASED TO 3.5m.



NOTES:

1. ALL DIMENSIONS SHOWN ARE FOR FINISHED PAVEMENT SURFACES.

2. EXTRA SUBGRADE WIDTH SHALL BE PROVIDED DURING GRADING TO ALLOW FOR DEPTH OF BASE COURSE AND SURFACING.

3. VARIABLE DECELERATION LENGTHS AS SHOWN ARE BASED ON COMFORTABLE DECELERATION TO A STOPPED POSITION AND DO NOT TAKE INTO CONSIDERATION ANY STORAGE SPACE REQUIREMENTS.

4. MAJOR ROAD REFERS TO ALL TWO-LANE PRIMARY HIGHWAYS, SECONDARY HIGHWAYS, TOWN ACCESS ROADS, AND PARK ACCESS ROADS.

5. MINOR ROAD GENERALLY REFERS TO ROAD ALLOWANCES.

DESIGN SPEED (Km/h)	PARALLEL SECTION OF ACCEL. & DECEL LANES (m)	PARALLEL SECTION OF LEFT-TURN LANES (m)
120	100	100
130	110	110

No.		BY	DATE
2			
1	TABLE REFERENCES CHANGED	R.M.	05/96

Alberta TRANSPORTATION AND UTILITIES Engineering Division

FIGURE D-9.1c

Date: APRIL 1995

MAJOR-MINOR ROAD INTERSECTION ON FOUR-LANE DIVIDED HIGHWAY

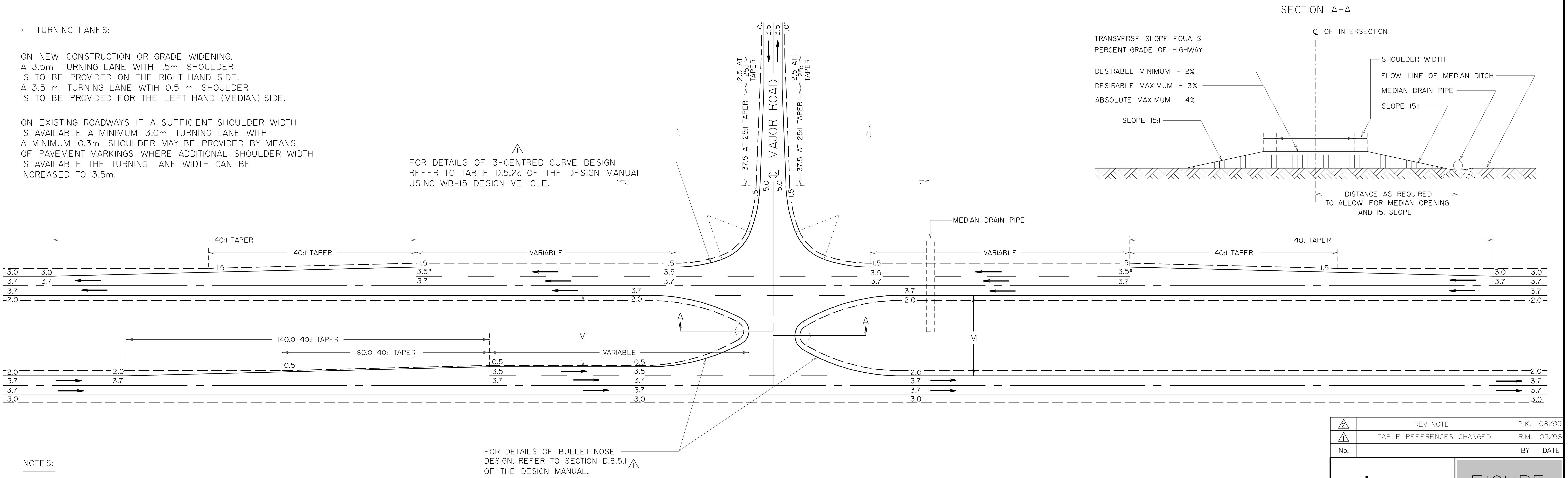
Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

Graphics File: debd91c.man

* TURNING LANES:

ON NEW CONSTRUCTION OR GRADE WIDENING, A 3.5m TURNING LANE WITH 1.5m SHOULDER IS TO BE PROVIDED ON THE RIGHT HAND SIDE. A 3.5 m TURNING LANE WTIH 0.5 m SHOULDER IS TO BE PROVIDED FOR THE LEFT HAND (MEDIAN) SIDE.

ON EXISTING ROADWAYS IF A SUFFICIENT SHOULDER WIDTH IS AVAILABLE A MINIMUM 3.0m TURNING LANE WITH A MINIMUM 0.3m SHOULDER MAY BE PROVIDED BY MEANS OF PAVEMENT MARKINGS. WHERE ADDITIONAL SHOULDER WIDTH IS AVAILABLE THE TURNING LANE WIDTH CAN BE INCREASED TO 3.5m.



NOTES:

1. ALL DIMENSIONS SHOWN ARE FOR FINISHED PAVEMENT SURFACES.

2. EXTRA SUBGRADE WIDTH SHALL BE PROVIDED DURING GRADING TO ALLOW FOR DEPTH OF BASE COURSE AND SURFACING.

3. VARIABLE DECELERATION LENGTHS AS SHOWN ARE BASED ON COMFORTABLE DECELERATION TO A STOPPED POSITION AND DO NOT TAKE INTO CONSIDERATION ANY STORAGE SPACE REQUIREMENTS.

4. MAJOR GENERALLY ROAD REFERS TO ALL TWO-LANE PRIMARY HIGHWAYS, SECONDARY HIGHWAYS, TOWN ACCESS ROADS, AND PARK ACCESS ROADS.

DESIGN SPEED (Km/h)	PARALLEL SECTION OF ACCEL. & DECEL LANES (m)	PARALLEL SECTION OF LEFT-TURN LANES (m)
120	100	100
130	110	110

No.	REV NOTE	BY	DATE
2	REV NOTE	B.K.	08/99
1	TABLE REFERENCES CHANGED	R.M.	05/96

Alberta INFRASTRUCTURE

FIGURE D-9.1d

Date: APRIL 1995

MAJOR "T" INTERSECTION ON FOUR-LANE DIVIDED HIGHWAY

Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

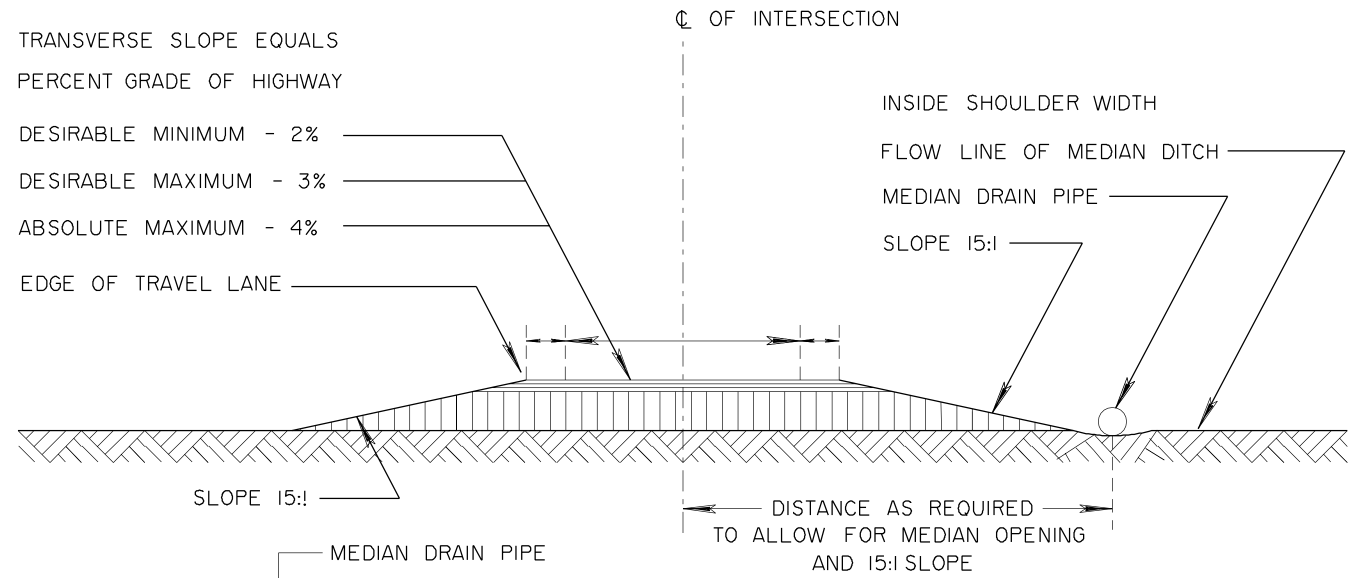
Graphics File: debd91d.man

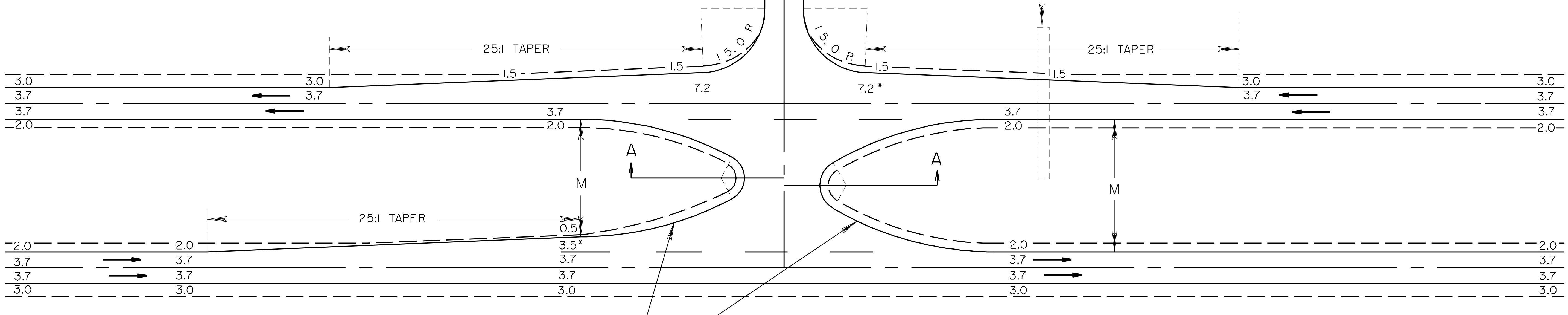
* TURNING LANES:

ON NEW CONSTRUCTION OR GRADE WIDENING, A 3.5m TURNING LANE WITH 1.5m SHOULDER IS TO BE PROVIDED ON THE RIGHT HAND SIDE. A 3.5 m TURNING LANE WITH 0.5 m SHOULDER IS TO BE PROVIDED FOR THE LEFT HAND (MEDIAN) SIDE.

ON EXISTING ROADWAYS IF A SUFFICIENT SHOULDER WIDTH IS AVAILABLE A MINIMUM 3.0m TURNING LANE WITH A MINIMUM 0.3m SHOULDER MAY BE PROVIDED BY MEANS OF PAVEMENT MARKINGS. WHERE ADDITIONAL SHOULDER WIDTH IS AVAILABLE THE TURNING LANE WIDTH CAN BE INCREASED TO 3.5m.

SECTION A-A





NOTES:

1. ALL DIMENSIONS SHOWN ARE FOR FINISHED PAVEMENT SURFACES.

2. EXTRA SUBGRADE WIDTH SHALL BE PROVIDED DURING GRADING TO ALLOW FOR DEPTH OF BASE COURSE AND SURFACING.

3. MAJOR ROAD GENERALLY REFERS TO ALL TWO-LANE HIGHWAYS, SECONDARY HIGHWAYS, TOWN ACCESS ROADS, AND PARK ACCESS ROADS.

No.		BY	DATE
2	REV NOTE	B.K.	08/99
1	TABLE REFERENCE CHANGED	R.M.	05/96

Alberta INFRASTRUCTURE

FIGURE D-9.1e

Date: APRIL 1995

MINOR "T" INTERSECTION ON FOUR-LANE DIVIDED HIGHWAY

Prepared By: LT	Checked By: B.K.	Scale: N.T.S.	PAGE D-193

GRAPHICS FILE: debd91e.man

NOTES:

1. The purpose of this plan is to show the typical layout of a rural frontage service road intersection with a major road or minor road adjacent to a four lane divided highway at-grade intersection.

2. To use this plan the engineer or designer must identify which quadrants contain intersections of service roads and major or minor roads. The engineer must ensure that the appropriate layout is used in each quadrant as required.

NOTE:
- THE RADII SHOWN FOR THE 2-CENTRED CURVE FOR SERVICE ROAD INTERSECTIONS ON MAJOR ROADWAYS ARE BASED ON THE MEDIUM TURNING TEMPLATE FOR THE WB-15 DESIGN VEHICLE.
- THE STANDARD SHOWN IN THIS QUADRANT IS TO BE USED IN ALL QUADRANTS OF THE INTERSECTION WHERE A SERVICE ROAD INTERSECTS A MAJOR ROAD.
- THE RADII SHOWN FOR THE 2-CENTRED COMPOUND CURVE (i.e. 16.0m and 30.0m) ARE DEPENDANT ON THE SPACING BETWEEN CENTRELINE OF SERVICE ROAD AND CENTRELINE OF ADJACENT ROADWAY. WHERE THE SPACING IS NOT 46.0m AS SHOWN THE RADII REQUIRED MUST BE DETERMINED USING THE APPROPRIATE VEHICLE TURNING TEMPLATES.

Design Speed km/h	Parallel Section of Accel. & Decel. Lanes (m)	Parallel Section of Left Turn Lanes (m)
120	100	100
130	110	110

NOTES:

1. ALL DIMENSIONS SHOWN ARE FOR FINISHED PAVEMENT SURFACES.

2. EXTRA SUBGRADE WIDTH SHALL BE PROVIDED DURING GRADING TO ALLOW FOR DEPTH OF BASE COURSE AND SURFACING.

3. VARIABLE DECELERATION LENGTHS AS SHOWN ARE BASED ON COMFORTABLE DECELERATION TO A STOPPED POSITION AND DO NOT TAKE INTO CONSIDERATION ANY STORAGE SPACE REQUIREMENTS.

4. MAJOR ROAD REFERS TO ALL TWO-LANE PRIMARY HIGHWAYS, SECONDARY HIGHWAYS, TOWN ACCESS ROADS AND PARK ACCESS ROADS.

5. MINOR ROAD GENERALLY REFERS TO A LOCAL ROAD WHICH MAY BE LOCATED WITHIN A STATUTORY ROAD ALLOWANCE.

FOR DETAILS OF BULLET NOSE DESIGN, REFER TO SECTION D.8.5.1 OF THE DESIGN MANUAL.

FOR BULBING DETAILS TO ACCOMMODATE TRUCK TRAILER TRAFFIC ON THE SERVICE ROAD REFER TO FIGURE D-5-4.

NOTE:
- THE RADII SHOWN FOR SERVICE ROAD INTERSECTIONS ON MINOR ROADS ARE BASED ON THE MEDIUM TURNING TEMPLATE FOR THE BI2R (HIGHWAY BUS) AND SU-9 (SINGLE UNIT TRUCK OR BUS) DESIGN VEHICLES.
- THE STANDARD SHOWN IN THIS QUADRANT IS TO BE USED IN ALL QUADRANTS OF THE INTERSECTION WHERE A SERVICE ROAD INTERSECTS A MINOR ROAD.

• TURNING LANES:

ON NEW CONSTRUCTION OR GRADE WIDENING, A 3.5m TURNING LANE WITH 1.5m SHOULDER IS TO BE PROVIDED ON THE RIGHT HAND SIDE. A 3.5 m TURNING LANE WITH 0.5 m SHOULDER IS TO BE PROVIDED FOR THE LEFT HAND (MEDIAN) SIDE.

ON EXISTING ROADWAYS IF A SUFFICIENT SHOULDER WIDTH IS AVAILABLE A MINIMUM 3.0m TURNING LANE WITH A MINIMUM 0.3m SHOULDER MAY BE PROVIDED BY MEANS OF PAVEMENT MARKINGS. WHERE ADDITIONAL SHOULDER WIDTH IS AVAILABLE THE TURNING LANE WIDTH CAN BE INCREASED TO 3.5m.

No.		BY	DATE
2			
1	TABLE REFERENCE CHANGED	R.M.	05/96

Alberta INFRASTRUCTURE

FIGURE D-9.1f

Date: APRIL 1995

RURAL FRONTAGE SERVICE ROAD INTERSECTION ON FOUR-LANE DIVIDED HIGHWAYS

Prepared By: R.T. Checked By: B.K. Scale: N.T.S.

Graphics File: deb91f.man