SECTION II - PRELIMINARY PLANS

CHAPTER 1 - DESIGN GUIDELINES

CHAPTER 2 – DRAINAGE

CHAPTER 3 - RIGHT-OF-WAY

SECTION II - PRELIMINARY PLANS

CHAPTER 1 - DESIGN GUIDELINES

2-100.00 PROJECT FOLDER (See 1-100.00)

2-105.00 ROADWAY DESIGN CHECKLIST - PRELIMINARY PLANS (See 1-105.00)

2-110.00 PROJECT ACTIVITY STATUS SHEET (See 1-110.00)

2-112.00 SIZE OF FULL-SIZE PLAN AND CROSS-SECTION SHEETS (See 3-102.00 and 4-112.00)

All full size plans submitted for printing shall be 34" x 22". No size variation will be allowed.

2-115.00 IDENTIFICATION OF SUPERVISORS, DESIGNERS, AND CHECKERS ON TITLE SHEET (See 3-105.00)

List on the lower left hand corner of the project title sheet: the names of the TDOT Civil Engineering Manager 1, TDOT Design Manager 1 or TDOT Roadway Specialist Supervisor 2 in charge of the project, the name of the firm designing the project if being done by a consultant, the name of the designer and the Design Project (P.E.) number. See examples in Figures 2-1a and 2-1b.

CONSULTANT DESIGN RIGHT-OF-WAY

TDOTDESIGN MANAGER:	______________________
	(FIRM NAME)
DESIGNED BY:	______________________
	(RESPONSIBLE PERSON)
DESIGNER:	______________________
P.E. NO.:	______________________
PIN :	______________________

Figure 2-1A
Title Sheet Identification Format for Consultant Designed Right-of-Way

T.D.O.T. DESIGN RIGHT-OF-WAY

TDOT ROAD SP. SV. 2: ______________________________

DESIGNER: ______________________________

P.E. NO.: ______________________________

PIN : ______________________________

Figure 2-1B
Title Sheet Identification Format for TDOT Designed Right-of-Way

2-115.01 SPECIAL NOTES

The Special Notes shown on the lower left hand corner of the project title sheet shall read as follows:

SPECIAL NOTES

PROPOSALS MAY BE REJECTED BY THE COMMISSIONER IF ANY OF THE UNIT PRICES CONTAINED THEREIN ARE OBVIOUSLY UNBALANCED, EITHER EXCESSIVE OR BELOW THE REASONABLE COST ANALYSIS VALUE.

THIS PROJECT TO BE CONSTRUCTED UNDER THE STANDARD SPECIFICATIONS OF THE TENNESSEE DEPARTMENT OF TRANSPORTATION DATED JANUARY 1, 2015, AND ADDITIONAL SPECIFICATIONS AND SPECIAL PROVISIONS CONTAINED IN THE PLANS AND IN THE PROPOSAL CONTRACT.

Figure 2-2
Title Sheet Special Notes Format

2-115.05 EQUATION BLOCKS ON TITLE SHEET (See 4-115.20)

The format for the Equation Block (if needed) is as shown in Figure 2-3.

If no Equation Block is needed it shall be so noted "NO EQUATIONS".

EQUATIONS	
DESCRIPTION	**NET EFFECT ON NUMERATION**
STA. xx + xx BK. = STA. xx + xx AH.	+ xx.xx
STA. xx + xx BK. = STA. xx + xx AH.	- xx.xx
TOTAL	± xx.xx

Figure 2-3
Equation Block Format

2-115.10 EXCLUSIONS ON TITLE SHEET (See 4-115.25)

If there are exclusions on the project, these shall be noted as follows:

EXCLUSION STA. XX+XXX TO STA. XX+XXX
NET EFFECT ON ENUMERATION $\pm$ XX.XXX

If there is more than one exclusion, a block shall be drawn similar to the Equation Block.

If there are no exclusions, the sheet shall be noted "NO EXCLUSIONS".

2-115.15 TRAFFIC BLOCK ON TITLE SHEET

The format for the Traffic Block is as shown in Figure 2-4. The first line of data is current year and the other lines are design year.

TRAFFIC DATA	
ADT (20XX)	xxxx
ADT (20XX)	xxxx
DHV (20XX)	xxxx
D	xx - xx
T (ADT)	xx %
T (DHV)	xx %
V	xx mph

Figure 2-4
Traffic Block Format

2-115.20 PROJECT DESCRIPTIONS

Project descriptions on the title sheet and in all correspondence shall be in sequence as follows:

1. FAI number (if an Interstate)
2. State route number (if a State route)
3. U.S. route number (if a U.S. route)
4. Local road name
5. Project limits (from and to)

Typical descriptions are shown in Figures 2-5A and 2-5B.

S.R. 6 (U.S. 16, THOMASVILLE ROAD)
FROM: 0.5 MILES SOUTH OF BANANA TOWN
TO: 1.3 MILES NORTH OF TURTLEDOVE CREEK

Figure 2-5A
Typical Title Sheet Project Description

S.R. 6 (U.S. 16, THOMASVILLE ROAD)
BRIDGE AND APPROACHES OVER TURTLEDOVE CREEK @ L.M. 2.45

Figure 2-5B
Typical Title Sheet Project Description

In all correspondence, remember to include project number and county name.

2-115.25 SPECIAL LOG MILE NOTE

On Interstate plans, both Interstate log miles (based on Interstate mileposts) and stations will be required when designating the beginning and ending points on all projects. To assist in determining the proper log mile, refer to the book *Log of the Interstate Highway System in Tennessee*. This reference also may be used for cross referencing the statewide Interstate log miles with the Interstate milepost miles.

On state highway plans, such as resurfacing projects, when using log miles to designate the beginning and ending points on projects, county log miles (mile posts) are to be used. To assist in determining the proper log mile, refer to the book *Log of the Interstate and State Highway System in Tennessee* for the region that the project is located.

Check with appropriate TDOT Manager for the location of a copy of these books.

2-120.00 TRAFFIC DATA FOR DESIGN

To establish a uniform and systematic method of obtaining desired traffic data for the construction year for all future projects, use the following procedure:

1. Mark a sketch (generally a print of the title sheet) to show the limits of the project and to establish the exact information desired. If crossroad volumes and/or turning movements on certain intersecting streets or roads are needed, this fact shall be clearly indicated by a sketch on the title sheet prints.

2. Designers shall submit the sketch in PDF format along with a properly filled out copy of the Request for Traffic Data form shown in Figure 2-6 to the Special Project Office of the Strategic Transportation Investments Division at the address shown on the

form. Consultants shall submit the information to the appropriate Design Manager for submittal.

Since the typical cross-section to be used is largely dependent on the anticipated traffic, it is urgent that traffic data for each newly assigned project be requested as soon as possible after beginning work on a project.

To expedite a pavement design from the Pavement Design Section, the following applicable notes shall be included under comments on the form. A copy of the completed form shall be forwarded with the pavement design request.

1. Furnish the 20xx-20xx ADL for pavement design on a (*number of lanes*) lane roadway.

2. Furnish the 20xx-20xx ADL for pavement design on a (*number of lanes*) lane roadway and the present ADT on all crossroads within the limits of the project.

NOTE: ADL (Average Daily Loading)
ADT (Average Daily Traffic)
DHV (Design Hourly Volume)
D (Directional Distribution)
T (Truck Percentage)

NOTE: For Bridge Replacement Projects, ADL are not required for ADTs of 1,000 or less and percentage trucks of 7 percent or less.

NOTE: ADTs and DHVs are not required for crossroads with ADTs of 1,000 or less.

TENNESSEE DEPARTMENT OF TRANSPORTATION
STRATEGIC TRANSPORTATION INVESTMENTS DIVISION

PROJECT NO.: ____________ ROUTE: ____________
COUNTY: ____________ CITY: ____________
PROJECT PIN NUMBER: ____________
PROJECT DESCRIPTION: ____________

DIVISION REQUESTING:

- MAINTENANCE ☐
- PLANNING ☐
- PROG. DEVELOPMENT & ADM. ☐
- PUBLIC TRANS. & AERO. ☐
- PAVEMENT DESIGN ☐
- STRUCTURES ☐
- SURVEY & DESIGN ☐
- TRAFFIC SIGNAL DESIGN ☐
- OTHER ____________ ☐

YEAR PROJECT PROGRAMMED FOR CONSTRUCTION: ____________
PROJECTED LETTING DATE: ____________

TRAFFIC ASSIGNMENT:

BASE YEAR		DESIGN YEAR					DESIGN ROADWAY % TRUCKS		DESIGN AVERAGE DAILY LOADS	
ADT	YEAR	ADT	DHV	%	YEAR	DIR.DIST.	DHV	ADT	FLEX	RIGID

REQUESTED BY: NAME ____________ DATE ________
DIVISION ____________
ADDRESS ____________

REVIEWED BY: ____________ DATE ________
TRANSPORTATION MANAGER 1
SUITE 1000, JAMES K. POLK

APPROVED BY: ____________ DATE ________
TRANSPORTATION MANAGER 2
SUITE 900, JAMES K. POLK BUILDING

COMMENTS:

DHV'S ARE NOT REQUIRED FOR SIDE ROADS LESS THAN 1000 ADT.

NOTE: FOR BRIDGE REPLACEMENT PROJECTS, ADLs ARE NOT REQUIRED FOR ADTs OF 1000 OR LESS AND PERCENTAGE OF TRUCKS OF 7% OR LESS.
SEE ATTACHMENTS FOR TURNING MOVEMENTS AND/OR OTHER DETAILS. (REV. 11/15/14)

Figure 2-6
Request for Traffic Data Form

2-125.00 VERTICAL CLEARANCES FOR NON-INTERSTATE BRIDGES

The minimum vertical clearance for all structures on all systems shall be not less than 16 feet over the entire roadway width, including the usable width of shoulder. The vertical clearance to sign trusses and pedestrian overpasses shall be 17 feet because of their lesser resistance to impacts. The vertical clearance from the deck to the cross bracing on through truss structures shall also be a minimum of 17 feet. The vertical clearance for railroad crossings from structure to top of rails shall be 23 feet.

An allowance of 6 inches shall be added to all vertical clearances to accommodate future resurfacing.

On crossings of low volume roadways where the cost of providing 16 feet of clearance might be considered unreasonable and may justify an exception, the Design and Structures Division personnel shall complete a joint cost analysis justifying a reduction in vertical clearance. This cost analysis shall be submitted to the Director of the Structures Division for approval.

2-127.00 SUBMITTAL OF PLANS FOR STRUCTURAL GRADE APPROVAL

The designer in the Structures Division shall receive all the material applicable to the drainage portion of the project as specified in Section 3.11 of the Survey Manual when receiving the survey. In addition, they shall receive all the material applicable to grade separations at highway and railroad crossings as specified in Section 3.14 or 3.15 of the Survey Manual when receiving the survey. When grade approval is requested the following material shall be placed on FileNet for use by the Structures Division.

1. Floodplain sections (stream crossing)

2. Stream profiles (stream crossing)

3. Roadway and railroad profile (see Section 1-210.00)

4. Topography

    A. See Section 3.11, 3.14 and 3.15, and the Survey Check List
        i. of the latest edition of the Survey Manual

    B. Low girder and bridge deck elevations

    C. Stations for each substructure

5. Complete set of full-size preliminary plans with prints of digital terrain model sheets at bridge locations

An email notification requesting structural grade approval should be sent to the Structures Division once the required materials are placed on FileNet. If a grade or alignment change is made on the project subsequent to the submission for grade approval, all revised information should be resubmitted to the Structures Division if the Design Manager determines it affects a structure. A copy of the email shall be placed in the project folder to document the submittal of structural grade approval request.

2-130.00 SUPERELEVATION RATES AND RUN-OFF

On all major grade and drain projects spirals will be required on horizontal curves below the heavy lines as shown on Standard Drawings RD01-SE series. For horizontal curves above the heavy lines spirals may still be used.

On isolated bridge replacement projects, intersection improvements, widening of existing roadways, etc., where use of spirals would provide no real benefit and/or cause problems in design, spirals will not be required. It will still be necessary to provide superelevation and superelevation lengths as shown on RD01-SE series.

On urban projects, note that the maximum desirable superelevation rate is 4 percent.

On rural projects, the maximum desirable superelevation rate is 8 percent.

On "BRZ" projects with design speed of 30 mph or less and with gravel or "spot" double bituminous surface treatment, a maximum superelevation rate of 6 percent may be used without a design exception being required.

Exceptions to this policy shall be identified in field review reports.

Show the superelevation rate and speed on all plans as a part of the horizontal curve data, thus: "S.E. 5.4% 70 mph". Also, show transition length on non-spiraled curves.

2-132.00 INTERSECTION SIGHT DISTANCE

The designer will ensure that intersection sight distance is provided in addition to adequate stopping sight distance at all intersections, railroad crossing without train activated warning devices and commercial drives. Refer to Standard Drawings: RD01-SD-1, RD01-SD-2, RD01-SD-3, RD01-SD-4, RD01-SD-5, RD01-SD-6, RD01-SD-7; for details.

2-135.00 THE CLEAR ZONE ROADSIDE CONCEPT

Clear zone distance (sometime referred to as clear zone, horizontal clearance to obstructions or roadside recovery area) as defined in the AASHTO *Roadside Design Guide*, other parts of this document and in other official publications shall be maintained on all projects.

2-135.05 CLEAR ZONES ON CURVED ALIGNMENTS

In Chapter 3 of the AASHTO *Roadside Design Guide* a formula is given for increase in clear zone on the outside of curves.

The clear zone on curved alignment is determined by increasing the value obtained from the *Roadside Design Guide* method for a tangent section of highway. The tangent section clear zone is increased by a curve correction factor, which is based on the degree of curvature and the design speed.

One note of caution, the designer must remember that the clear zone values (L_c) obtained are based on a constant side slope throughout the clear zone distance. In situations where the side slope changes within the calculated clear zone, the clear zone must be recalculated based on a weighted average of the side slopes.

2-136.00 LANDSCAPING

The cost of landscaping and hardscaping for the purpose of beautification should not exceed 5% of the total project estimate. **This amount should not include any landscaping or vegetation required for environmental mitigation.** In addition, items that are considered common items used in construction including but not limited to sodding slopes on urban projects; stamped concrete; and decorative facing on retaining walls, bridge columns, parapets, and pedestrian curb ramps should not be included in the 5% of the total project estimate.

On projects where substantial landscaping is proposed or the Design Manger estimates that the cost of landscaping items may exceed 5%, the Design Manager will request the Bid Analysis and & Estimating Office to verify the percentage of landscaping as a percentage of the total project using the latest estimate available.

Projects requiring landscaping and/or hardscaping due to a prior commitment where the cost of the landscaping and/ or hardscaping cost exceed 5%, the Design Manager should notify the Director of Project Development for guidance.

The local government may include additional landscaping plans at the local government's expense. In this case, the local government is responsible for notifying the design manager by the constructability field review of this intention and for providing a landscaping plan sealed and signed by a Registered Landscape Architect and the designer shall only be responsible for adding "Landscaping Plan Sheet, L1" to the plans index and adding a note to the appropriate proposed sheets:

NOTE: LANDSCAPING PLAN NOT SHOWN, SEE L SERIES SHEETS"

Landscaping shall not cause a sight distance or clear zone conflict. See the Environmental Division – Beautification Office's **Landscape Design Guidelines** for roadside landscaping details. The document may be view at:

http://www.tn.gov/tdot/article/beautification-landscape-design

2-140.00 MEDIAN OPENING SPACING

Safety and improved traffic operations dictate the need for providing roadways with medians in the State of Tennessee. The value of medians has been demonstrated many times in this state. Accident records indicate that the accident rate for non-median roadways in Tennessee is consistently higher than the accident rate for those roadways with medians. Since the number of median openings per mile has a significant effect on accident potential, it is important that such openings be held to a reasonable minimum and in the interests of equity, permitted at predetermined uniformly spaced specific locations. This procedure will provide a high degree of safety to the motoring public and also permit reasonable access to abutting property owners.

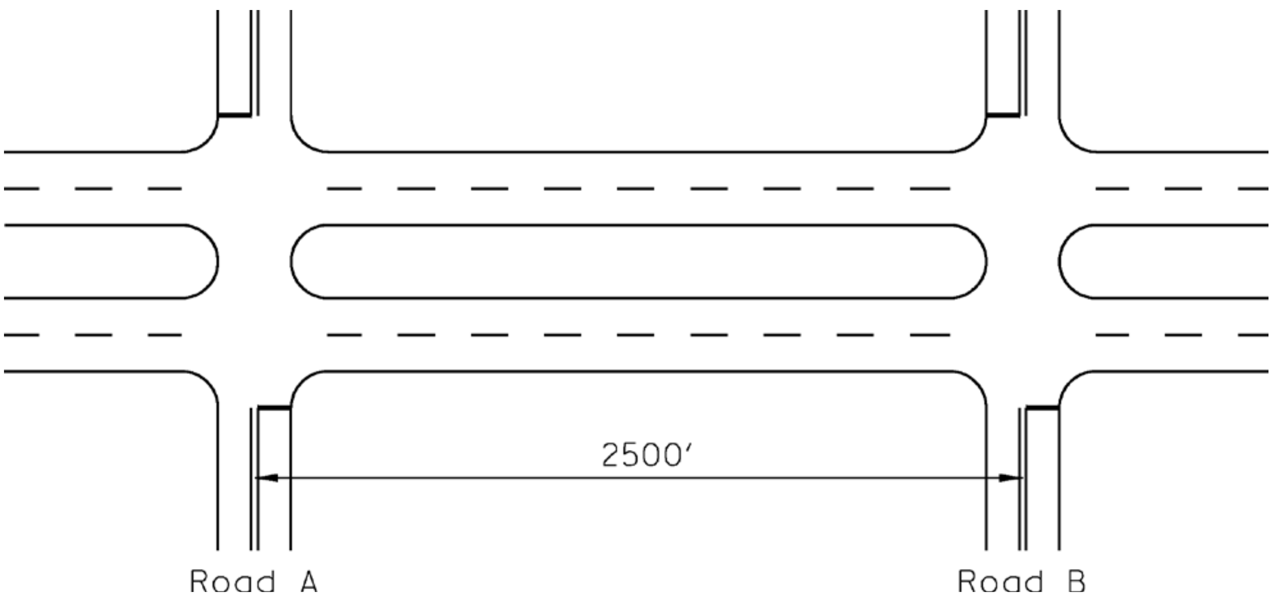
It is the policy of the Department to provide median openings at most existing city streets or county roads. It is also the policy of the Department to provide uniformly spaced openings between median openings for city streets or county roads for U-turn vehicles. The desirable uniform spacing is 1,320 feet (a range of 880 feet - 1,760 feet is acceptable) in rural areas and 660 feet (a range of 440 feet - 880 feet is acceptable) in urban areas.

Location of crossovers set by this policy shall be adjusted if safety considerations so dictate. An example is as follows: in order to minimize the potential for wrong way movements, adjustment of proposed crossover locations to align with an existing driveway shall be considered if the driveway centerline is within 75 feet of the proposed crossover centerline.

2-140.05 MEDIAN OPENING SPACING - EXAMPLE PROBLEMS

Ten example problems detailing the procedure to be used in determining the appropriate median opening spacing are as follows:

Example No. 1 Urban Section



Total distance between Road A and Road B is 2,500 feet. Since this is with an urban section of roadway, the appropriate median opening spacing would be that which most closely approximates 660 feet. It shall not, however, be less than 440 feet nor more than 880 feet.

The first step in determining the proper spacing is to divide the total distance between the intersection openings (2,500 feet) by the desirable urban spacing (660 feet). This will tell us approximate number of spaces required.

This calculates to 3 or 4 spacings (2 or 3 midblock median openings) between Road A and Road B.

The next step is to determine which condition would result in a spacing nearest 660 feet, but which is also no less than 440 feet, nor more than 880 feet. To do this, first divide the total distance between the intersection openings (2,500 feet) by the possible number of spacings (3 and 4). At the same time, check to see if the resulting distances are within the permissible range

(440 feet - 880 feet) because if the resulting distance is not within this range, discard it as an alternative.

$$\frac{2500}{3} = 833 \quad 440 < 833 < 880 \quad \textbf{OK}$$

$$\frac{2500}{4} = 625 \quad 440 < 625 < 880 \quad \textbf{OK}$$

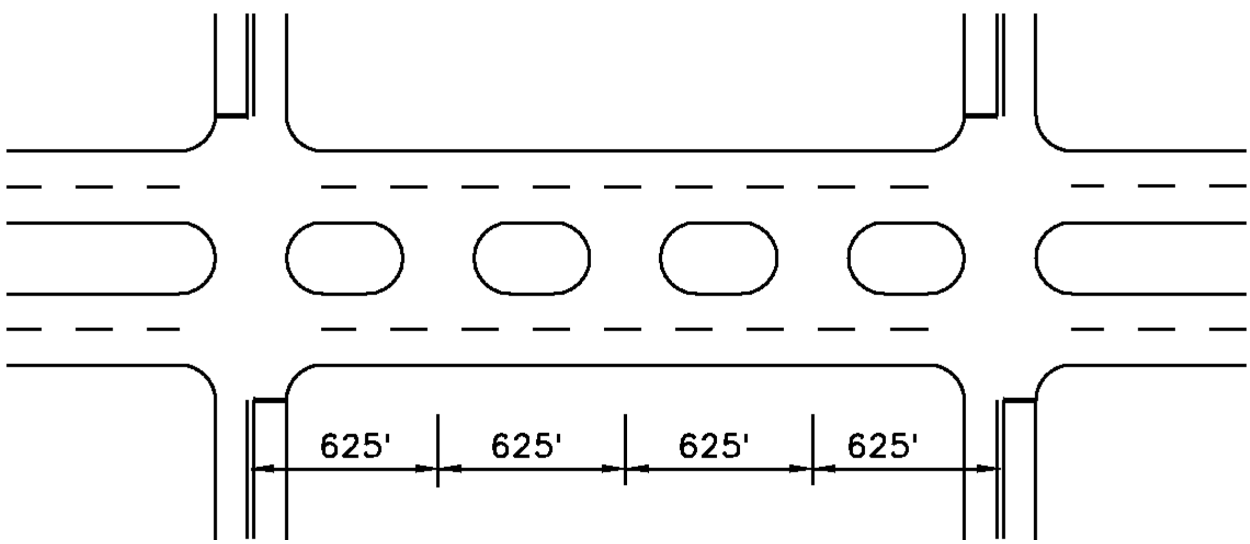
Both possible spacing (833 feet and 625 feet) are within the permissible range. Therefore, it must still be determined which is closest to 600 feet.

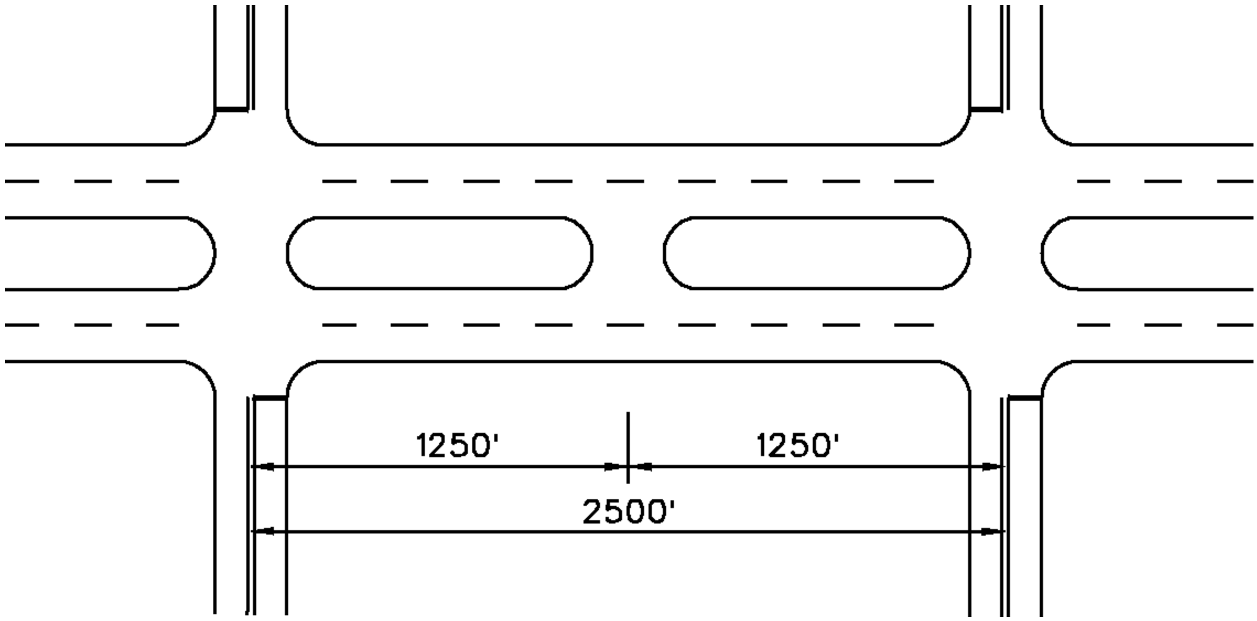
$$833 - 660 = 173$$

$$660 - 625 = 35$$

Since 35 is less than 173, the most appropriate median opening spacing between Road A and Road B would be 625 feet. This would result in 3 midblock median openings 625 feet apart.

Note that the number of midblock median openings is always one less than the number of spaces. Generally the whole number closest to the approximate number of spaces (4 for 3.75 above) will be the number of spaces which will yield the most appropriate median opening spacing (which is true in this particular example). However, this is not always the case (see Example No. 8).





Example No. 2 Rural Section

Total distance between Road A and Road B is 2,500 feet. The desirable rural spacing is 1,320 feet, but no less 880 ft, nor more than 1,760 feet.

$$\frac{2500}{1350} = 1.9$$

Therefore, there can be 1 or 2 spacings (0 or 1 midblock median openings). However, it must be determined which condition would result in a spacing nearest 1,320 feet, but which is also no less than 880 feet nor more than 1,760 feet.

$$\frac{2500}{1} = 2500 \quad 880 < 2500 > 1760 \quad \textbf{Not Acceptable}$$

$$\frac{2500}{2} = 1250 \quad 880 < 1250 < 1760 \quad \textbf{OK}$$

The only acceptable median opening spacing between Road A and Road B is 1,250 feet. Therefore, one midblock median opening shall be provided at a point 1,250 feet from each intersection.

Example No. 3 Urban Section

Total distance between intersection openings is 1,100 feet.

$$\frac{1100}{660} = 1.7$$

$$\frac{1100}{1} = 1100 \quad 440 < 1100 > 880 \quad \textbf{Not Acceptable}$$

$$\frac{1100}{2} = 550 \quad 440 < 550 < 880 \quad \textbf{OK}$$

The only acceptable spacing is 550 feet. Therefore, one midblock median opening shall be provided at a point 550 feet from each intersection.

Example No. 4 Rural Section

Total distance between intersection openings is 1,100 feet.

$$\frac{1100}{1320} = 0.8$$

$$\frac{1100}{0} = \infty \quad \infty < 1100 \quad \textbf{Not Acceptable}$$

$$\frac{1100}{1} = 1100 \quad 880 < 1100 < 1760 \quad \textbf{OK}$$

The only acceptable spacing is 1,100 feet and, therefore, no midblock median opening shall be installed.

Example No. 5 Urban Section

Total distance between intersection openings is 1,500 feet.

$$\frac{1500}{660} = 2.3$$

$$\frac{1500}{2} = 750 \quad 440 < 750 > 880 \quad \textbf{OK}$$

$$\frac{1500}{3} = 500 \quad 440 < 500 > 880 \quad \textbf{OK}$$

$$660 - 500 = 160$$

$$750 - 660 = 90$$

Since 90 feet is less than 160 feet, the most appropriate median opening spacing would be 750 feet. Therefore, 1 midblock median opening shall be installed.

Example No. 6 Rural Section

Total distance = 1,500 feet

$$\frac{1500}{1320} = 1.1$$

$$\frac{1500}{1} = 1500 \qquad 880 < 1500 < 1760 \quad \textbf{OK}$$

$$\frac{1500}{2} = 750 \qquad 750 < 880 \quad \textbf{Not Acceptable}$$

The only acceptable spacing is 1,500 feet. Therefore, no midblock opening shall be installed.

Example No. 7 Urban Section

Total distance = 5,880 feet

$$\frac{5880}{660} = 8.9$$

$$\frac{5880}{8} = 735 \qquad 440 < 735 < 880 \quad \textbf{OK}$$

$$\frac{5880}{9} = 653 \qquad 440 < 653 < 880 \quad \textbf{OK}$$

$$735 - 660 = 75$$

$$660 - 653 = 7$$

Since 7 is less than 75, the appropriate spacing is 653 feet resulting in 8 midblock median openings.

Example No. 8 Rural Section

Total distance = 5,880 feet

$$\frac{5880}{1320} = 4.5$$

$$\frac{5880}{4} = 1470 \quad 880 < 1470 < 1760 \quad \textbf{OK}$$

$$\frac{5880}{5} = 1176 \quad 880 < 1176 < 1760 \quad \textbf{OK}$$

$$1470 - 1320 = 150$$

$$1320 - 1176 = 144$$

Since 144 is less than 150, the most appropriate spacing is 1,176 feet resulting in 4 midblock median openings.

Example No. 9 Urban Section

Total distance = 5,940 feet

$$\frac{5940}{660} = 9.0$$

Therefore, the appropriate spacing would be 660 feet resulting in 8 midblock median openings.

Example No. 10 Rural Section

Total distance = 5,940 feet

$$\frac{5940}{1320} = 4.5$$

$$\frac{5940}{4} = 1485 \quad 880 < 1470 < 1760 \quad \textbf{OK}$$

$$\frac{5880}{5} = 1188 \quad 880 < 1188 < 1760 \quad \textbf{OK}$$

$$1485 - 1320 = 165$$

$$1320 - 1188 = 132$$

Since 132 is less than 165, the most appropriate median opening spacing is 1,188 feet resulting in 4 midblock median openings.

2-145.00 EXCAVATION AND UNDERCUTTING (See 4-203.00)

2-145.05 EARTHWORK BALANCES (See 2-145.10, 3-315.05 and 3-315.15)

Compute earthwork using select end areas.

2-145.07 SUBMISSION OF GRADING QUANTITIES SHEETS (See 3-315.20 and 4-203.50)

All grading quantities sheets submitted with the Construction Plans shall show the federal and/or state project numbers, route numbers and/or street names and county on each sheet. Each sheet shall be numbered to reflect both the individual sheet number as well as the total number of quantity sheets in the submission. See Figure 2-7.

This data can be added to the top of standard GEOPAK earthwork reports.

GRADING QUANTITIES SHEET

COMPUTED BY: ______________________________ SHEET _____ OF ________

CHECKED BY: ____________________ PROJECT NO.: ____________________

ROUTE NO. OR STREET: __________________ COUNTY: __________________

Figure 2-7
Grading Quantities Sheet Identification Format

2-145.10 SHRINKAGE AND SWELL FACTORS (See 2-145.05, 3-315.10, and 4-203.05)

Shrinkage and swell of earth and rock material vary with:

1. Types of material
2. Weather conditions
3. Equipment used
4. Depth of cuts and fills
5. Length of haul

Light work through wooded areas call for heavier shrinkage.

The following examples are offered as a guide:

1. <u>Light cuts and fills</u>

   1 - 2 foot cuts and fills

      Earth 30% to 50%
      Chert 20% to 30%

2 - 4 foot cuts and fills

Earth 25% to 30%
Chert 10% to 15%

4 - 6 foot cuts and fills

Earth 15% to 20%
Chert 8% to 12%

2. Heavy cuts and fills

Earth 10%
Chert 0% to 8%

3. Heavy cuts and light fills

Cuts 12 feet +, Fills 1 - 2 feet (average)

Earth 15% to 20%
Chert 5% to 10%

Cuts 12 feet +, Fills 2 - 4 feet (average)

Earth 10% to 15%
Chert 5% to 10%

4. Shale and slate

5% to 10% shrinkage; varies with type of material

5. Sandstone

0% shrinkage to 15% swell; varies with type of material and weather conditions

6. Limestone

If material is a small percentage and mixed with embankment, 0% shrinkage

Heavy cuts and fills: 15% to 20% swell

Light fills: 20% swell

Do not call for rock to be placed in fills less than 3 feet in height unless requested by the Geotechnical Engineering Section.

2-150.00 TRUCK CLIMBING LANES

It is desirable to provide a truck-climbing lane as an added lane for the upgrade direction of a highway where the grade, traffic volumes and heavy-vehicle volumes combine to degrade traffic operations from those on the approach to grade. This section discusses guidelines for determining the location of truck-climbing lanes, critical lengths of grade, design criteria for truck-climbing lanes and guidance on how to develop truck speed profiles. For additional guidance on these topics, see the AASHTO *A Policy on Geometric Design of Highways and Streets.*

2-150.01 LOCATION GUIDELINES

A truck-climbing lane may be necessary to allow a specific upgrade to operate at an acceptable level of service. The following criteria will apply:

Two-Lane Highways – On a two-lane, two-way highway, a truck-climbing lane should be considered if the following conditions are satisfied:

- The upgrade traffic flow is in excess of 200 veh/h; <u>and</u>
- The heavy-vehicle volume (i.e., trucks, buses and recreational vehicles) exceeds 20 veh/h during the design hour; <u>and</u>
- One of the following conditions exists:
  - + The critical length of grade is exceeded for the 10 mph speed reduction curve (see Figure 2-8), or
  - + The level of service (LOS) on the upgrade is E or F, or
  - + There is a reduction of two or more LOS when moving from the approach segment to the upgrade; and
- The construction costs and the construction impacts (e.g., environmental, right-of-way) are considered reasonable.

Multilane Highways – A truck-climbing lane should be considered on a multilane highway if the following conditions are satisfied:

- The directional service volume for LOS D is exceeded on the upgrade; <u>and</u>
- The directional service volume exceeds 1000 veh/h/lane; <u>and</u>
- One of the following conditions exists:
  - + The critical length of grade is exceeded for the 10 mph speed reduction curve (see Figure 2-8), or
  - + The LOS on the upgrade is E or F, or
  - + there is a reduction of one or more LOS when moving from the approach segment to the upgrade; and

- The construction costs and the construction impacts (e.g., environmental, right-of-way) are considered reasonable.

Also, truck-climbing lanes should be considered where the above criteria are not met and if there is an adverse crash experience on the upgrade related to slow-moving heavy vehicles.

2-150.02 CAPACITY ANALYSIS

See the *Highway Capacity Manual 2010* for guidance on conducting capacity analyses for climbing lanes on two-lane and multilane highways.

2-150.03 CRITICAL LENGTH OF GRADE

The critical length of grade is the maximum length of a specific upgrade on which a truck can operate without an unreasonable reduction in speed. The highway gradient, in combination with the length of the grade will determine the truck speed reduction on upgrades.

The following will apply to the critical length of grade:

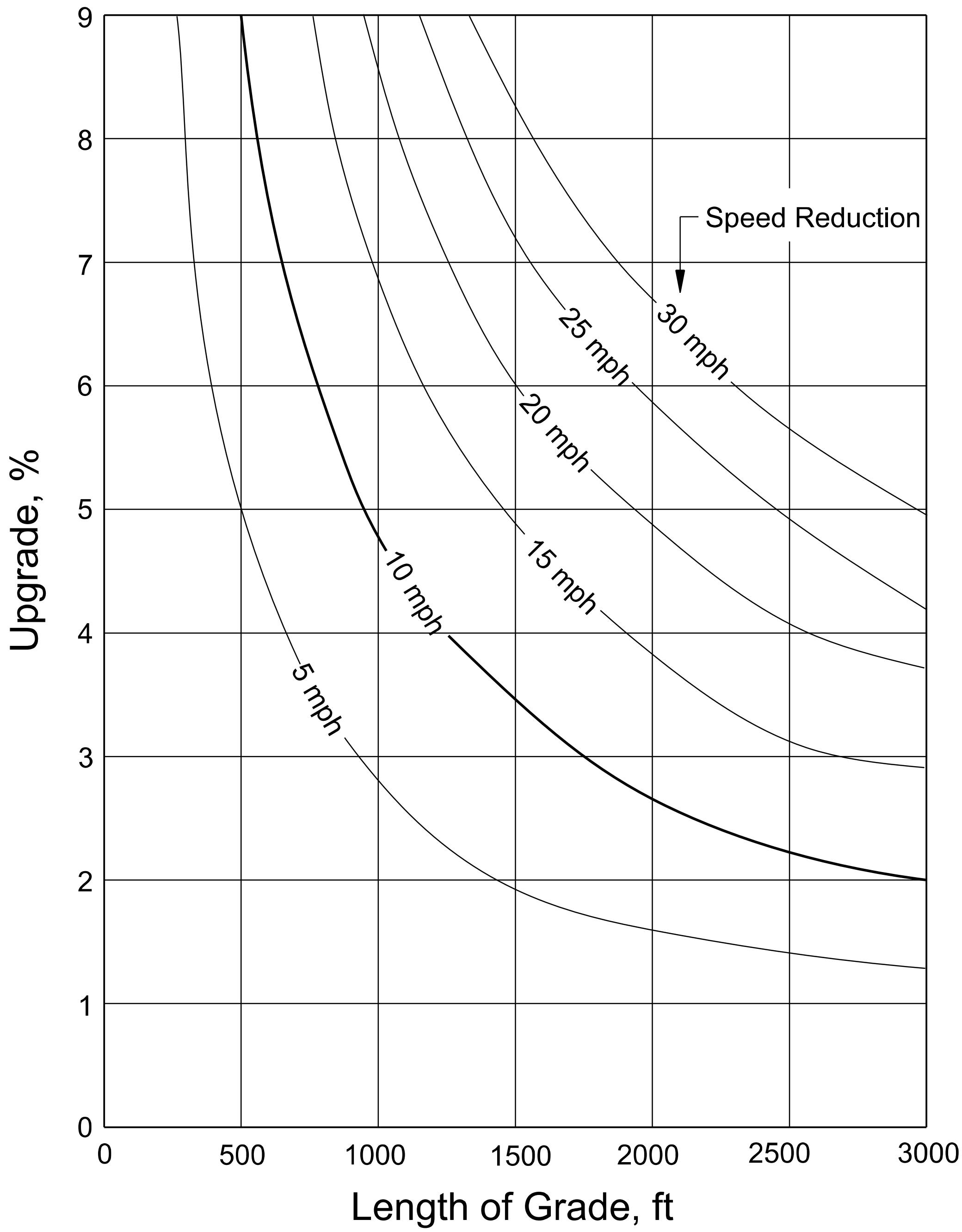
1. Design Vehicle – Figure 2-8 presents the critical length of grade for a 200 lb/hp truck. This vehicle is representative of size and type of a heavy vehicle normally used for design on main roads.

2. Criteria – Figure 2-8 provides the critical lengths of grade for a given percent grade and acceptable truck speed reduction. Although these curves are based on an initial truck speed of 70 mph, they apply to any design or posted speed. For design purposes, use the 10 mph speed reduction curve in the figure to determine if the critical length of grade is exceeded.

3. Momentum Grades – Where an upgrade is preceded by a downgrade, trucks will often increase their speed to ascend the upgrade. A speed increase of 5 mph on moderate downgrades (3%-5%) and 10 mph on steeper downgrades (6%-8%) of sufficient length are reasonable adjustments to the initial speed. This assumption allows the use of a higher speed reduction curve in Figure 2-8. However, the designer should also consider that these speed increases may not always be attainable. If traffic volumes are sufficiently high, a truck may be behind another vehicle when descending the momentum grade, thereby restricting the increase in speed. Therefore, only consider these increases in speed if the highway has a Level of Service C or better.

4. Measurement – Vertical curves are part of the length of grade. Figure 2-9 illustrates how to measure the length of grade to determine the critical length of grade using Figure 2-8.

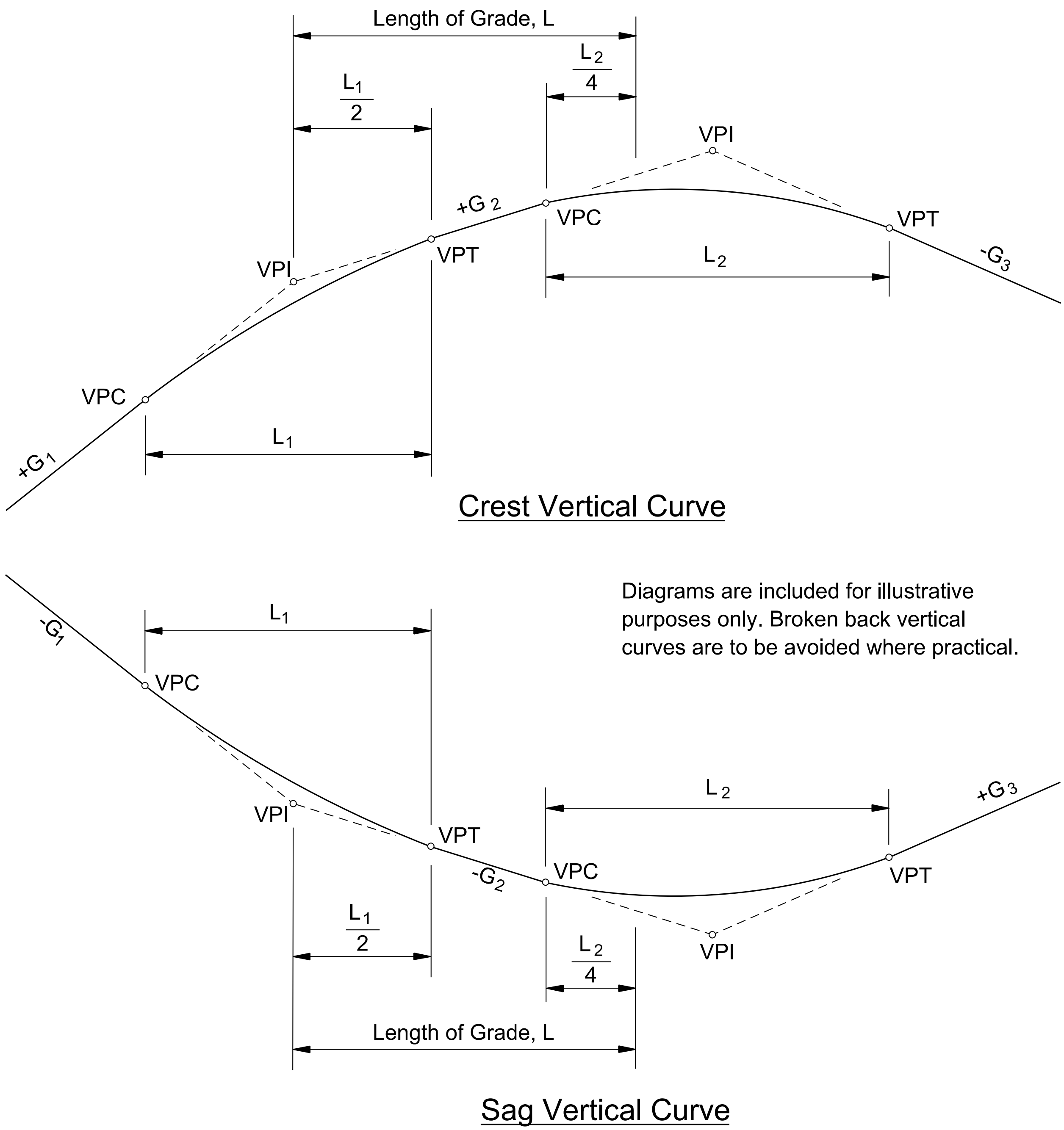
5. Application – If the critical length of grade is exceeded, flatten the grade, if practical, or evaluate the need for a truck-climbing lane. Typically, only two-lane highways have operational problems that require truck-climbing lanes.



Notes:

1. *Typically, the 10 mph curve will be used.*
2. *See examples in Section 2-150.03 for use of figure.*
3. *Figure is based on a truck with initial speed of 70 mph. However, it may be used for any design or posted speed.*
4. *This figure is based on a 200 lb/hp heavy vehicle.*
5. *Figure is from the AASHTO A Policy on Geometric Design of Highways and Streets.*

Figure 2-8
Critical Length of Grade for Design



Notes:

1. *For vertical curves where the two tangent grades are in the same direction (both upgrades or both downgrades), 50% of the curve length will be part of the length of grade.*
2. *For vertical curves where the two tangent grades are in opposite directions (one grade up and one grade down), 25% of the curve length will be part of the length of grade.*

Figure 2-9
Measurement for Length of Grade

Highway Types – The critical-length-of-grade criteria applies equally to two-lane or multilane highways, and applies equally to urban and rural facilities.

Alternative Critical Lengths of Grades – In many design situations, Figure 2-8 may not be directly applicable to the determination of the critical length of grade for one of following reasons:

The truck population for a given site may be such that a weight/power ratio is either less than or greater than the 200 lb/hp design vehicle (e.g., coal mining trucks, gravel trucks).

The truck speed at the entrance to the grade may differ from the 70 mph assumed in Figure 2-8.

The profile may not consist of a constant percent grade.

For these situations, the designer may want to consider using the software program Truck Speed Profile Model (TSPM) described in NCHRP Report 505 *Review of Truck Characteristics as Factors in Roadway Design* to determine the applicable critical length of grade. This program may be used to generate speed truck profiles for any specified truck weight/power ratio, initial truck speed and sequence of grades.

Example Problems – Examples No. 1 and No. 2 illustrate the use of Figure 2-8 to determine the critical length of grade. Example No. 3 illustrates the use of Figures 2-8 and 2-9. In the examples, the use of subscripts 1, 2, etc., indicate the successive gradients and lengths of grade on the highway segment.

Example No. 1

Given: Level Approach
$G = +4\%$
$L = 1500$ ft (length of grade)
Rural Principal Arterial

Problem: Determine if the critical length of grade is exceeded.

Solution: Figure 2-8 yields a critical length of grade of 1200 ft for a 10-mph speed reduction. The length of grade (L) exceeds this value. Therefore, flatten the grade, if practical, or evaluate the need for a truck-climbing lane.

Example No. 2

Given: Level Approach
$G_1 = +4.5\%$
$L_1 = 500$ ft
$G_2 = +2\%$
$L_2 = 700$ ft
Rural Arterial with a significant number of heavy trucks

Problem: Determine if the critical length of grade is exceeded for the combination of grades G_1 and G_2.

Solution: From Figure 2-8, G_1 yields a truck speed reduction of 5 mph. G_2 yields a speed reduction of approximately 3 mph. The total of 8 mph is less than the maximum 10 mph speed reduction. Therefore, the critical length of grade is not exceeded.

Example No. 3

Given: Figure 2-10 illustrates the vertical alignment on a low-volume, two-lane rural collector highway with no large trucks.

Problem: Determine if the critical length of grade is exceeded for G_2 or for the combination upgrade G_3 and G_4.

Solution: Use the following steps:

Step 1: Determine the length of grade using the criteria in Figure 2-9. For this example, the following calculations are used:

$$L_2 = \frac{1000}{4} + 600 + \frac{800}{4} = 825\text{ft}$$

$$L_2 = \frac{800}{4} + 700 + \frac{400}{2} = 1100\text{ft}$$

$$L_2 = \frac{400}{2} + 300 + \frac{600}{4} = 650\text{ft}$$

Step 2:. Determine the critical length of grade in both directions. Use Figure 2-8 to determine the critical length of grade.

- For trucks traveling left to right, enter into Figure 2-8 the value for G_3 (3.5%) and L_3 = 1100 ft. The speed reduction is 7.0 mph. For G_4 (2%) and L_4 = 650 ft, the speed reduction is approximately 3.5 mph. The total speed reduction on the combination upgrade G_3 and G_4 is 10.5 mph. This exceeds the maximum 10 mph speed reduction. However, on low-volume roads, one can assume a 5 mph increase in truck speed for the 3% "momentum" grade (G_2), which precedes G_3. Therefore, a speed reduction may be as high as 15 mph before concluding that the combination grade exceeds the critical length of grade. Assuming the benefits of the momentum grade, this leads to the conclusion that the critical length of grade is not exceeded.

- For trucks traveling in the opposite direction, on Figure 2-8, enter in the value for G_2 (3%) and determine the critical length of grade for the 10 mph speed reduction (i.e., 1700 ft). Because L_2 is less than 1700 ft (i.e., 825 ft), the critical length of grade for this direction is not exceeded.

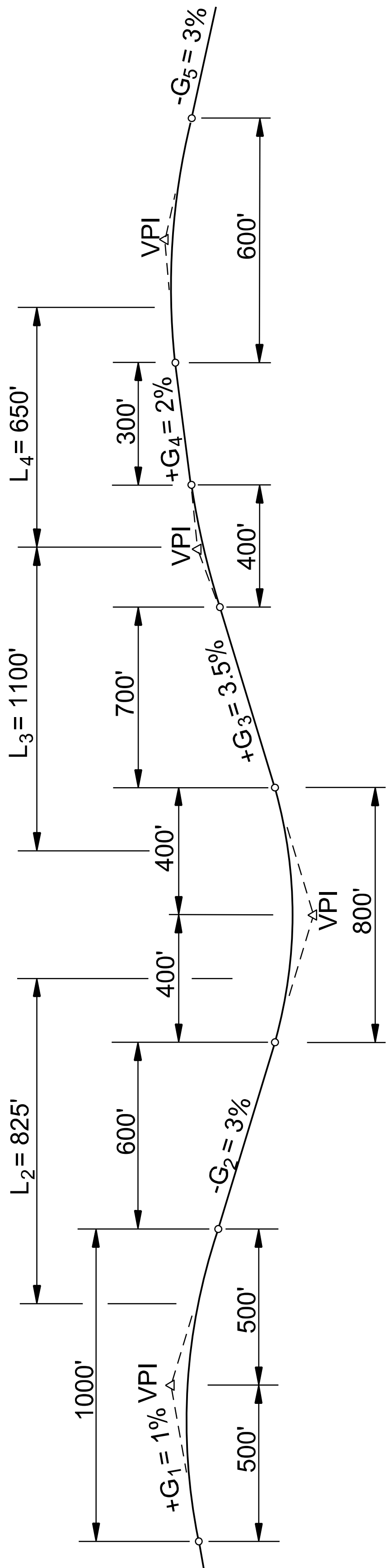


Figure 2-10
Critical Length Of Grade Calculations
(Example No. 3)

2-150.04 DESIGN GUIDELINES

Table 2-1 summarizes the design criteria for a truck-climbing lane. Also, consider the following:

1. Design Speed – For entering speeds equal to or greater than 70 mph, use 70 mph for the truck design speed. For speeds less than 70 mph, use the roadway design speed or the posted speed limit, whichever is less. Under restricted conditions, the designer may want to consider the effect a momentum grade will have on the entering speed. See Comment 3 in Section 2-150.03 for additional information on momentum grades. However, the maximum speed will be 70 mph.

2. Cross Slope – On tangent sections, the truck-climbing lane cross slope will typically be the same as that of the adjacent travel lane.

3. Superelevation – For horizontal curves, superelevate the truck-climbing lane at the same rate as the adjacent travel lane.

4. Performance Curves – Figure 2-11 presents the deceleration and acceleration rates for a 200 lb/hp truck.

5. End of Full-Width Lane – In addition to the criteria in Table 2-1, ensure that there is sufficient sight distance available to the point where the truck, RV or bus will begin to merge back into the through travel lane. At a minimum, this will be stopping sight distance. Desirably, the driver should have decision sight distance available to the roadway surface (i.e., height of object = 0.0 ft) at the end of the taper. See the AASHTO *A Policy on Geometric Design of Highways and Streets* for decision sight distance values.

   The full-lane width should be extended beyond the crest vertical curve and not ended just beyond the crest of the grade. Also, desirably the full-lane width should not end on a horizontal curve.

6. Signing and Pavement Markings – Contact the Roadway Design Office Signing Designer for signing and pavement marking guidance for truck-climbing lanes.

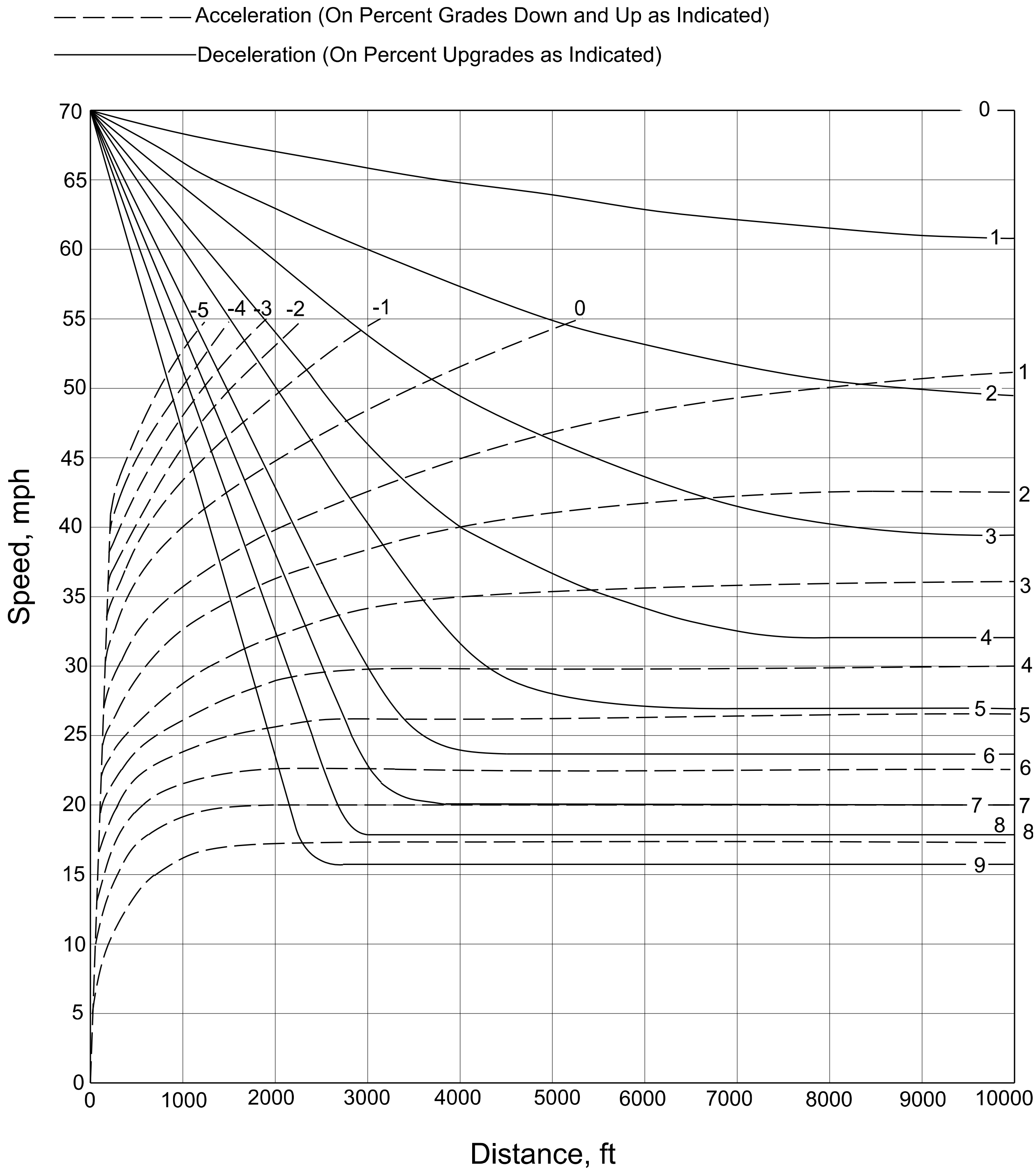
Design Element	Desirable	Minimum
Lane Width	12 ft	Width of adjacent lane
Shoulder Width	Same width as approach shoulder	Interstate: 6 ft Other Highways: 4 ft
Cross Slope on Tangent	0.02 ft/ft	0.02 ft/ft
Beginning of Full-Width Lane (1)	Location where the truck speed has been reduced to 10 mph below the posted speed limit	Location where the truck speed has been reduced to 45 mph
End of Full-Width Lane (2)	Location where truck has reached highway posted speed or 55 mph, whichever is less	Location where truck has reached 10 mph below highway posted speed limit
Entering Taper	25:1	300 ft
Exiting Taper	Interstate: 70:1 Other Highways: 600 ft	50:1
Minimum Full-Width Length	1000 ft or greater	Interstate Only: 1000 ft

Notes:

1. *Use Figure 2-11 to determine truck deceleration rates. In determining the applicable truck speed, the designer may consider the effect of momentum grades.*

2. *Use Figure 2-11 to determine truck acceleration rates. Also, see Comment 5 in Section 2-150.04.*

Table 2-1
Design Criteria for Truck-Climbing Lanes



Notes:

1. *For entering speeds equal to or greater than 70 mph, use an initial speed of 70 mph. For speeds less than 70 mph, use the design speed or posted speed limit as the initial speed.*
2. *Figure is from the AASHTO A Policy on Geometric Design of Highways and Streets*

Figure 2-11
Performance Curves for Trucks
(200 lb/hp)

2-150.05 DOWNGRADES

Truck lanes on downgrades are not typically considered. However, steep downhill grades may also have a detrimental effect on the capacity and safety of facilities with high traffic volumes and numerous heavy trucks. Although specific criteria have not been established for these conditions, trucks descending steep downgrades in low gear may produce nearly as great an effect on operations as an equivalent upgrade. The need for a truck lane for downhill traffic will be considered on a site-by-site basis.

2-150.06 TRUCK SPEED PROFILE

For highways with a single grade, the critical length of grade and deceleration and acceleration rates can be directly determined from Figure 2-11. However, most highways have a continuous series of grades. Often, it is necessary to find the impact of a series of significant grades in succession. If several different grades are present, then a speed profile may need to be developed. The following example illustrates how to construct a truck speed profile and how to use Figure 2-11.

Example No. 4

Given: Level Approach
G_1 = +3% for 800 ft (VPI to VPI)
G_2 = +5% for 3200 ft (VPI to VPI)
G_3 = -2% beyond the composite upgrade (G_1 and G_2)
V = 60 mph design speed with a 55 mph posted speed limit
Rural Principal Arterial

Problem: Using the criteria in Table 2-1 and Figure 2-11, construct a truck speed profile and determine the beginning and ending points of the full-width climbing lane.

Solution: Apply the following steps:

Step 1: Determine the truck speed on G_1 using Figure 2-11 and plot the truck speed at 200 ft increments. See Figure 2-12. Assume an initial truck speed of 55 mph. Move horizontally along the 55 mph line to the 3% deceleration curve. This is approximately 2800 ft along the horizontal axis. This is the starting point for G_1.

Distance From VPI_1 (ft)	Horizontal Distance on Figure 2-11 (ft)	Truck Speed (mph)	Comments
0	2800	55	VPI_1
200	3000	54	
400	3200	53	
600	3400	52	
800	3600	51	VPI_2

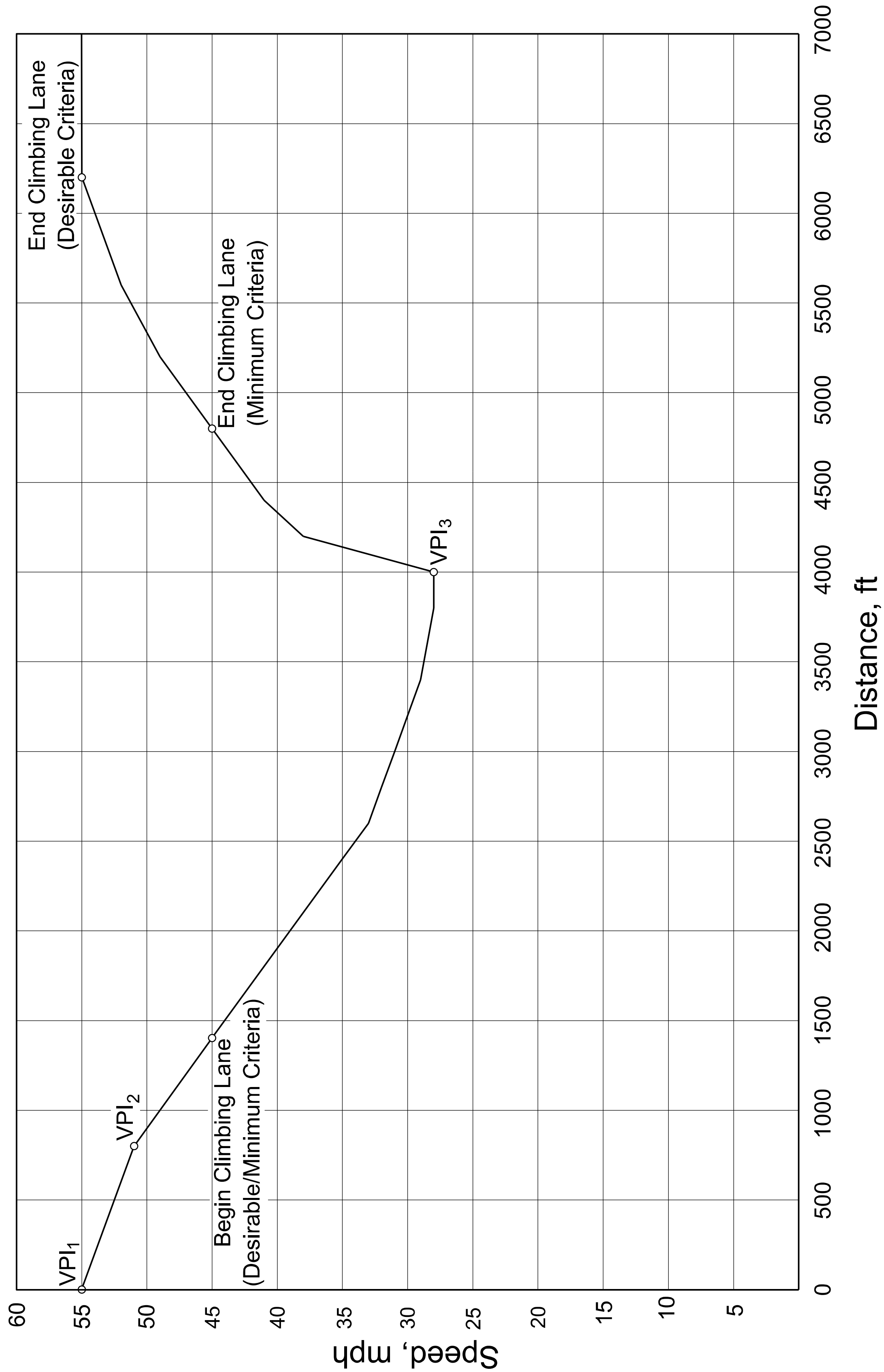


Figure 2-12
Truck Speed Profile
(Example No. 4)

Step 2: Determine the truck speed on G_2 using Figure 2-11 and plot the truck speed at 200 ft increments in Figure 2-12. From Step 1, the initial speed on G_2 is the final speed from G_1 (i.e., 51 mph). Move right horizontally along the 51 mph line to the 5% deceleration curve. This is approximately 1900 ft along the horizontal axis. This is the starting point for G_2.

Figure 2-12 Distance From VPI_1 (ft)	Horizontal Distance on Figure 2-11 (ft)	Truck Speed (mph)	Comments
800	1900	51	VPI_2
1000	2100	49	
1200	2300	47	
1400	2500	45	
1600	2700	43	
1800	2900	41	
2000	3100	39	
2200	3300	37	
2400	3500	35	
2600	3700	33	
2800	3900	32	
3000	4100	31	
3200	4300	30	
3400	4500	29	
3600	4700	29	
3800	4900	28	
4000	5100	28	VPI_3

Step 3: Determine the truck speed on G_3 using Figure 2-11 until the truck has fully accelerated to 55 mph, and plot the truck speed at 200 ft increments in Figure 2-12. The truck will have a speed of 28 mph as it enters the 2% downgrade at VPI_3. Read into Figure 2-11 at the 28 mph point on the vertical axis and move over horizontally to the -2% line. This is approximately 150 ft along the horizontal axis. This is the starting point for G_3.

Figure 2-12 Distance From VPI_1 (ft)	Horizontal Distance on Figure 2-11 (ft)	Truck Speed (mph)	Comments
4000	150	28	VPI_3
4200	350	38	
4400	550	41	
4600	750	43	
4800	950	45	
5000	1150	47	
5200	1350	49	
5400	1550	50	
5600	1750	52	
5800	1950	53	
6000	2150	54	
6200	2350	55	

Step 4: Determine the beginning and end of the full-width climbing lane. From Table 2-1, the desirable and minimum beginning of the full-width lane will be where the truck has reached a speed of 45 mph (10 mph below the posted speed). This point occurs 1400 ft. beyond VPI_1.

For ending the full-width climbing lane, the desirable criterion from Table 2-1 is where the truck speed has reached the posted speed limit (55 mph) or 6200 ft beyond the VPI_1. The minimum criterion is where the truck has reached a speed of 45 mph (10 mph below the posted speed). This occurs at 4800 ft beyond VPI_1.

2-155.00 WETLANDS BOUNDARY DESIGNATION

When the Environmental Division marks wetland boundaries in the Ecology Report, the designer will request a survey update to survey in the exact boundaries of the wetland and show the wetland boundaries on the plans.

Wetland boundaries will be shown by the symbol on Standard Drawing RD-L-1.

The wetlands number (WTL-1, etc.) shall be placed inside the boundary.

The plans shall also indicate locations where roadway outfall discharges are modified and locations where the wetland receiving flows are redirected.

The area (in square feet or acres) and volume (in cubic yards) of any wetlands impacted by the project or any right-of-way taken for wetland replacement shall be indicated on the present layout sheet. Impacts or alterations to a wetland may require an Aquatic Resources Alteration Permit (ARAP). See Section 3, Chapter 4 of these Guidelines for additional information on permit sketch requirements.

2-155.02 HAZARDOUS MATERIAL STUDY

The designer shall send an email notification requesting a hazardous materials study for all projects requiring right-of-way acquisition three weeks prior to the Preliminary Field Review (See Activity and Estimated Completion Schedule, A&E) to the Hazardous Materials (HAZMAT) Section of the Environmental Division. A copy of the email shall be placed in the project folder to document the request of a hazardous materials study.

2-155.05 BOX AND SLAB-TYPE CULVERT AND BRIDGE LENGTHS, CHANNEL CHANGES, AND WETLANDS

The following procedures and policies need to be followed in order to achieve an environmentally acceptable project as perceived by the Corps of Engineers, Environmental Protection Agency, United States Fish and Wildlife Service, Tennessee Wildlife Resources Agency, and Tennessee Department of Environment and Conservation:

1. Any project which proposes long expanses of boxes and/or channel changes on blue-line streams and/or wetlands involvement must be studied for alternate solutions: after which, a project coordination meeting between the involved TDOT Divisions must be held.

2. Where box and slab-type culverts and bridges are employed, their length shall be held to a minimum. In the case of interchanges, intermittent boxes, rather than continuous boxes, are preferred.

3. Given the choice between long runs of boxes and channel changes, channel changes are generally preferred.

4. Concrete lined channels and rock lined (rip-rapped) channels are not acceptable for channel changes on blue-line streams.

5. In streams with enough flow to support aquatic life (blue-line streams), a normal flow keyway within a channel change shall be considered if flood plain hydraulics dictate a channel larger than the natural channel is required. The normal flow keyway shall have approximately the same width (X) and height (Y) as the existing normal flow channel, as shown in Figure 2-13.

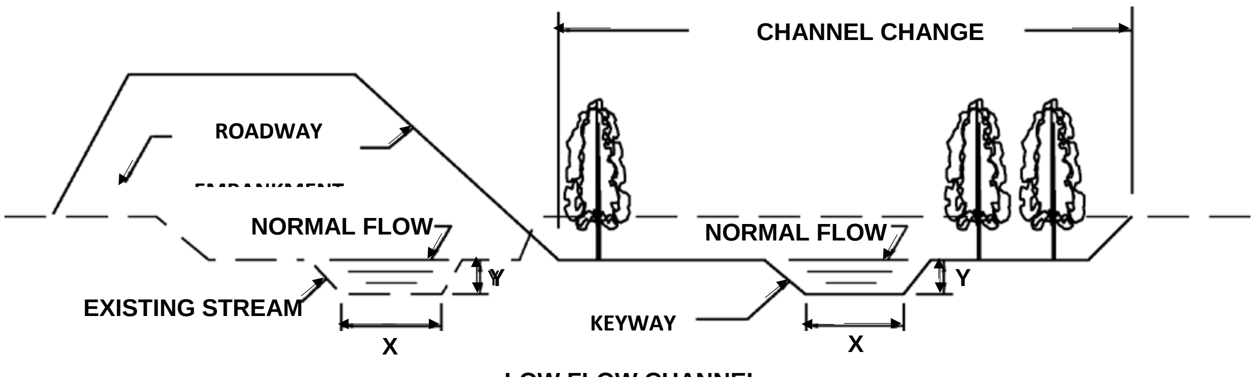


Figure 2-13
Channel Changes

6. Meanders must be included in channel changes on blue-line streams in order to maintain the natural stream length, sinuosity, and slope.

For additional information on channel changes, see Drainage Manual, Chapter 5, Section 5.05 - Guidelines and Criteria for Stream Realignments. For additional information on box and slab-type culvert and bridge lengths, see Drainage Manual, Chapter 6, Section 6.04 - Guidelines and Criteria. For additional information on Natural Stream Design, see Chapter 11 of the Drainage Manual.

2-160.00 EXTENSION OF THROUGH LANES BEYOND INTERSECTIONS AND REQUIREMENTS FOR LANE REDUCTION TRANSITION LENGTHS

Existing two-lane highways are often widened to a multi-lane section at intersections to provide additional capacity (especially at signalized locations). Also, multi-lane highways are often designed to transition down to a two-lane highway downstream from an intersection.

In order to address the resulting lane drop situation, follow the schematic shown in Figure 2-14 which shows the minimum length for the additional through lanes required to adequately sign the lane drop and minimize lane changing within the intersection. An example for computing the required transition lengths is also included with this figure.

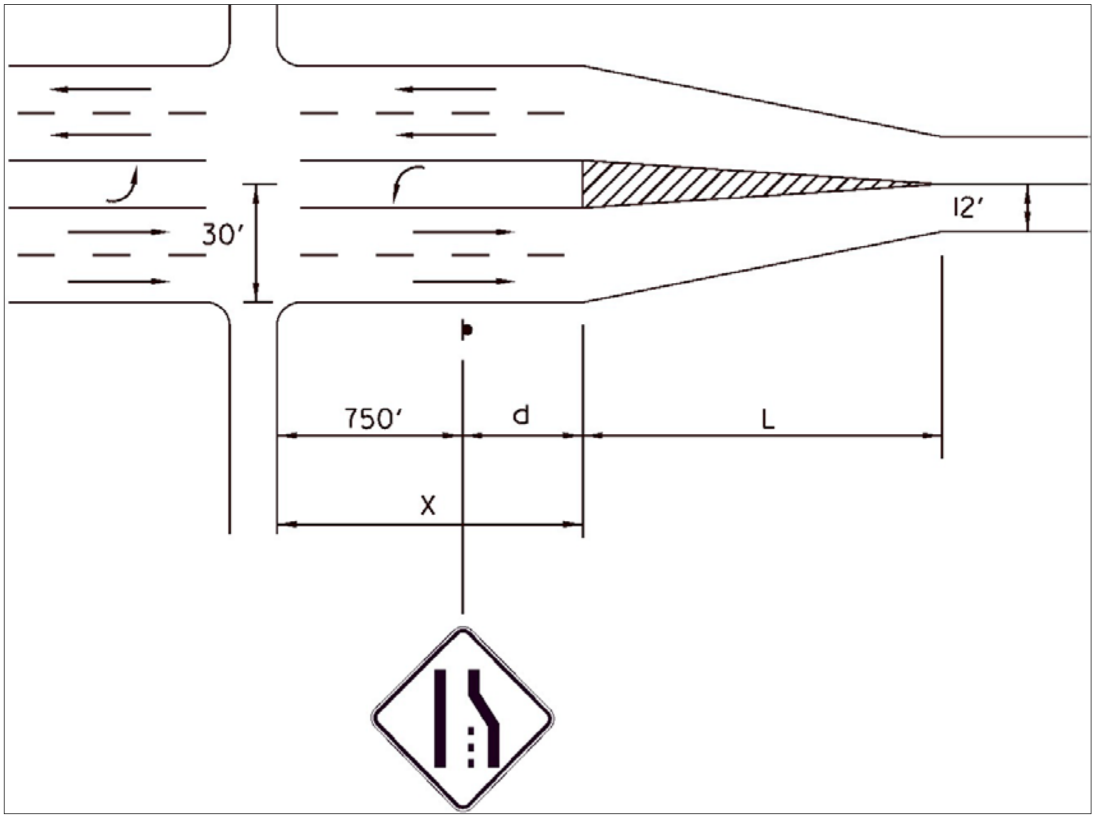


Figure 2-14
Minimum Length (X) for Lane Extensions through an Intersection With
Lane Reduction Taper (L)

750 feet- Minimum distance at which sign is not visible to traffic approaching intersection (in order to minimize lane changing within intersection).

d - As required by *M.U.T.C.D.*, Sec. 2C.05, Table 2C-4, Condition A.

L - Transition length, as required by *M.U.T.C.D.*, Sec. 3B.09, Fig. 3B-14.

Note 1- Terminating the outside lane as a right-turn lane at an intersection may be considered subject to the review and approval of the TDOT Signal Section and the Design Manager.

Note 2 - See Section 2C.42 for guidance, options, and standard use of Lane Ends Signs.

To find "d" use the following table:

Posted or 85th Percentile Speed	Advance Placement Distance[1]								
	Condition A: Speed reduction and lane changing in heavy traffic[2]	Condition B: Deceleration to the listed Advisory Speed (mph) for the Condition							
		0[3]	10[4]	20[4]	30[4]	40[4]	50[4]	60[4]	70[4]
20 mph	225 ft	100 ft[6]	N/A[5]	-	-	-	-	-	-
25 mph	325 ft	100 ft[6]	N/A[5]	N/A[5]	-	-	-	-	-
30 mph	460 ft	100 ft[6]	N/A[5]	N/A[5]	-	-	-	-	-
35 mph	565 ft	100 ft[6]	N/A[5]	N/A[5]	N/A[5]	-	-	-	-
40 mph	670 ft	125 ft	100 ft[6]	100 ft[6]	N/A[5]	-	-	-	-
45 mph	775 ft	175 ft	125 ft	100 ft[6]	100 ft[6]	N/A[5]	-	-	-
50 mph	885 ft	250 ft	200 ft	175 ft	125 ft	100 ft[6]	-	-	-
55 mph	990 ft	325 ft	275 ft	225 ft	200 ft	125 ft	N/A[5]	-	-
60 mph	1,100 ft	400 ft	350 ft	325 ft	275 ft	200 ft	100 ft[6]	-	-
65 mph	1,200 ft	475 ft	450 ft	400 ft	350 ft	275 ft	200 ft	100 ft[6]	-
70 mph	1,250 ft	550 ft	525 ft	500 ft	450 ft	375 ft	275 ft	150 ft	-
75 mph	1,350 ft	650 ft	625 ft	600 ft	550 ft	475 ft	375 ft	250 ft	100 ft[6]

Table 2-2
Guidelines for Advance Placement of Warning Signs Reference: M.U.T.C.D. 2009 Manual
(Table 2C-4 of Section 2C.05)

Notes:
[1]The distances are adjusted for a sign legibility distance of 180 ft for Condition A. The distances for Condition B have been adjusted for a sign legibility distance of 250 feet, which is appropriate for an alignment warning symbol sign.
For Conditions A and B, warning signs with less than 6-inch legend or more than four words, a minimum of 100 feet should be added to the advance placement distance to provide adequate legibility of the warning sign.

[2]Typical conditions are locations where the road user must use extra time to adjust speed and change lanes in heavy traffic because of a complex driving situation. Typical signs are Merge and Right Lane Ends. The distances are determined by providing the driver a PRT of 14.0 to 14.5 seconds for vehicle maneuvers (2005 AASHTO Policy, Exhibit 3-3, Decision Sight Distance, Avoidance Maneuver E) minus the legibility distance of 180 feet for the appropriate sign.

[3]Typical condition is the warning of a potential stop situation. Typical signs are Stop Ahead, Yield Ahead, Signal Ahead, and Intersection Warning signs. The distances are based on the 2005 AASHTO Policy, Exhibit 3-1, Stopping Sight Distance, providing a PRT of 2.5 seconds, a deceleration rate of 11.2 feet/second^2, minus the sign legibility distance of 180 feet.

[4]Typical conditions are locations where the road user must decrease speed to maneuver through the warned condition. Typical signs are Turn, Curve, Reverse Turn, or Reverse Curve. The distance is determined by providing a 2.5 second PRT, a vehicle deceleration rate of 10 feet/second^2, minus the sign legibility distance of 250 ft.

[5]No suggested distances are provided for these speeds, as the placement location is dependent on site conditions and other signing. An alignment warning sign may be placed anywhere from the point of curvature up to 100 feet in advance of the curve. However, the alignment warning sign should be installed in advance of the curve and at least 100 feet from any other signs.

[6]The minimum advance placement distance is listed as 100 feet to provide adequate spacing between signs.

EXAMPLE:

Posted speed = 55 mph

X = 750 feet + d = 750 feet + 700 feet = 1,450 feet

L = S × W (for speed 45 mph or more) = 55 × 18 = 990 feet

2-165.00 TWO-LANE ENTRANCE RAMPS ON FREEWAYS AND EXPRESSWAYS

Designers shall use the parallel design when introducing two-lane entrance ramps to freeways and expressways.

The parallel design is preferable for two reasons: (1) Past experience with the tapered design has been undesirable from an operational and safety standpoint; (2) Uniformity of design due to the fact that most two-lane entrance ramps statewide are the parallel type.

For examples of the parallel design for two-lane entrance ramps, refer to *A Policy on Geometric Design of Highways and Streets*, AASHTO, 2001, Pages 816 and 858 (Exhibits 10-52, A2 and 10-69, B).

2-170.00 GUIDELINES FOR DESIGN OF TURNING LANES

These guidelines are intended to assist the designer in designing left and right-turn lanes at intersections.

These guidelines provide information on material included in the AASHTO's *A Policy on Geometric Design of Highways and Streets*, 2001 and are an attempt to consolidate that information regarding the design of turn lanes.

The benefits of turn lanes at intersections are obvious in improved capacity and safety.

These guidelines are applicable to right and left-turn lanes, and give procedures for desirable design. Design may be limited by geometric or other constraints, but these guidelines shall be followed as closely as possible.

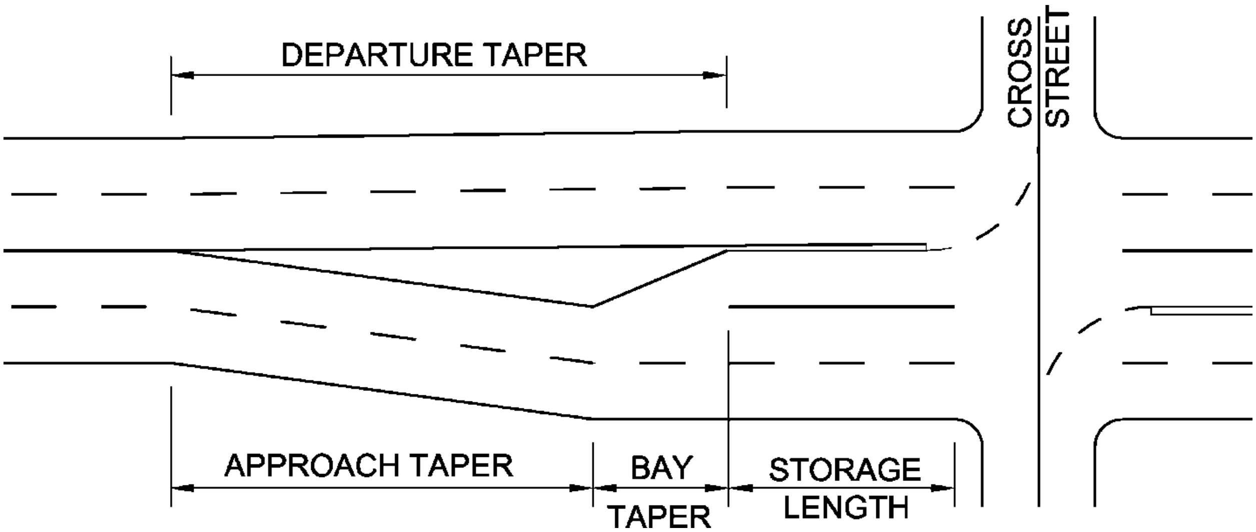


Figure 2-15
Turning Lane Terminology

1) APPROACH TAPER

(a) $L = W \times S$, Speed ≥ 45 mph

(b) $L = \frac{WS^2}{60}$, Speed < 45mph

Where L = Length of Taper in feet

W = Width of Offset in feet

S = Design Speed in miles per hour

2) BAY TAPER

$L = \frac{WS}{3}$, L, W, S as defined for approach taper above.

3) STORAGE LENGTHS

a) Unsignalized Intersections

To determine a warrant for and a required storage length, use the attached charts (Figures 2-17 through 2-20f) by M. D. Harmelink. (See also *A Policy of Geometric Design of Highways and Streets 2001*, Exhibit 9-75, page 685. This table is a condensed version of the Harmelink charts for two-lane highways.)

The first chart applies to four-lane highways, all speeds.

The remaining charts are a function of speed and the percentage of lefts in the approaching traffic, and are applicable only to two-lane highways.

Select the appropriate chart for design speed and percentage of left turns. Use the total advancing volume for the approach (left, through, and right) on the bottom axis of the chart, and the total opposing volume on the left axis of the chart.

b) Signalized Intersections

Storage lengths at signalized intersections are a function of signal timings, volumes, and saturation flow rates. Assistance in determining storage lengths can be provided by the Design Traffic Engineering Section, Signal and Lighting Office.

4) DEPARTURE TAPER

The departure taper begins at the end of the storage lane and ends at the beginning of the approach taper.

SOME SPECIAL NOTES:

i) When the left-turn volume exceeds 300 vph, a double left-turn lane shall be considered. A capacity analysis will help determine the benefit of an additional lane. If a double left is proposed, use 60% of the turn volume to determine the storage length for each lane.

ii) It is suggested in *A Policy of Geometric Design of Highways and Streets*, Chapter 9, that it is desirable to provide the appropriate deceleration distance for vehicles entering a left or right-turn lane. This distance can be considered to be the sum of the bay taper and the storage length for minimum design. From page 714, these lengths are:

Design Speed (mph)	Deceleration Length to Stop Condition for Less Than 3% Grade (ft)
30	170
40	275
45	340
50	410
55	485

Table 2-3
Approximate Total Lengths Needed for Deceleration to a Stop from Design Speed
Reference: AASHTO, A Policy on Geometric Design of Highways and Streets (2001)

Adjustments to deceleration length for grades are found on page 848, Exhibit 10-71.

Providing deceleration lengths is not normally feasible on urban facilities.

When the deceleration length is to be provided, and this length exceeds the bay taper plus storage length, the additional length shall be provided as storage and the bay taper kept constant.

iii) As suggested in the *2000 Highway Capacity Manual (HCM2000),* page 10-18, exclusive right-turn lanes shall be considered when the right-turn volume exceeds 300 vph and the adjacent thru-lane volume also exceeds 300 vphpl. A capacity analysis will also provide a measure of the benefits of a right-turn lane to the overall intersection operation.

iv) It shall be noted that at some intersections, lengths of turn lanes may be more a function of queue lengths in through lanes that might block access to turn lanes, thus reducing turn lane efficiency.

5) LOCATION OF LEFT-TURN LANES IN MEDIANS

As discussed in *A Policy of Geometric Design of Highways and Streets*, Chapter 9, it is desirable to align left-turn lanes in medians. The advantages of this placement are:

a) Better visibility of opposing through traffic as left turners look for gaps.

b) Decreased conflict between opposing left-turn vehicle paths.

c) Increased numbers of left-turn vehicles served in a given period of time. The farther left the turn lane, the shorter the crossing distance for left-turn vehicles, allowing drivers to choose shorter gaps in opposing traffic and clear the intersection. There is also an increase in capacity at signalized intersections, due to more flexibility in left-turn phasing and shorter clearance intervals.

The following guidelines apply to four-lane divided highways with a maximum median width of 48 feet. For median widths greater than 48 feet or six-lane divided highways, left-turn lanes shall be designed as usual, constructed immediately to the left of the through lanes.

The centerline of left-turn lanes shall be placed along the centerline of the median, so that opposing left-turn lanes are directly opposite each other. Excess pavement area between the turn lane and adjacent through lane shall be marked with channelization striping (see Figure 2-14).

The attached ADT criteria can be used to estimate if a traffic signal will be warranted within five years of project opening (see Table 2-4).

If the current major street ADT and minor street ADT both meet the criteria for Warrant 1 or Warrant 2, future signalization is probable and the intersection design shall provide aligned left-turn lanes.

Currently signalized intersections or those to be signalized under the project shall be designed this way.

The number of approach lanes on the major street includes only through lanes. The same is true for the minor street, except in the case of "T"-intersections. For "T"-intersections, the number of approach lanes shall include left and right-turn lanes (if present) for the stem of the "T" as the minor street.

If the major street ADT differs on each side of the intersection, an average shall be used. For the minor street, use the higher ADT on the higher volume approach.

Be aware that there may be special conditions affecting signalization or geometric design. For those unusual conditions, the Design ITS, Traffic, and Standards Office can provide assistance.

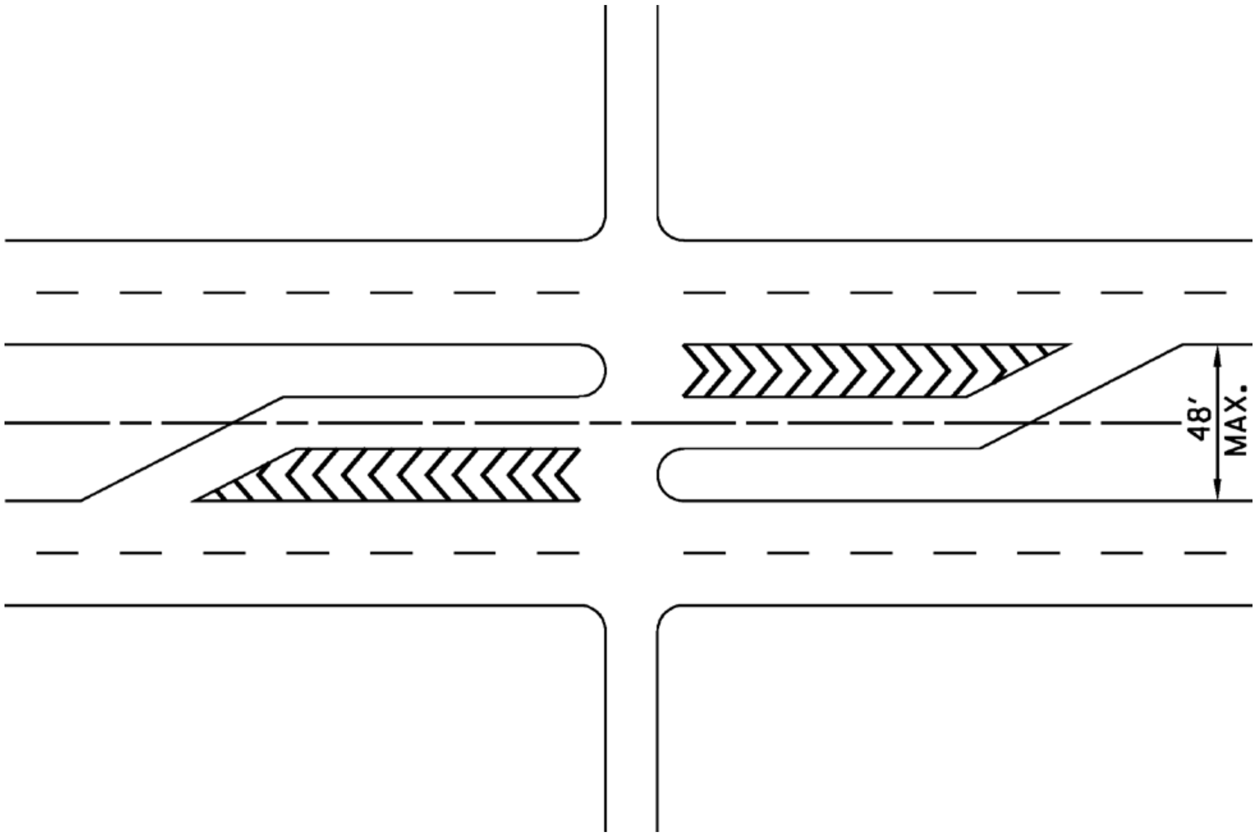


Figure 2-16
Left-Turn Lane Alignment

NUMBER OF APPROACH LANES		WARRANT 1		WARRANT 2	
Major	Minor	Major ADT	Minor ADT	Major ADT	Minor ADT
1	1	5000	3000	7500	1500
2 or more	1	6000	3000	9000	1500
2 or more	2 or more	6000	4000	9000	2000
1	2 or more	5000	4000	7500	2000

Table 2-4
Future Traffic Signal Warrants

VOLUME WARRANTS FOR LEFT - TURN STORAGE LANES AT UNSIGNALIZED GRADE INTERSECTIONS

CHART VALUE	% T_L = % TRUCKS IN V_L					
	0%	10%	20%	30%	40%	50%
75’	0	25’	25’	25’	50’	50’
100’	0	25’	25’	50’	50’	50’
125’	0	25’	25’	50’	50’	75’
150’	0	25’	50’	50’	75’	75’
175’	0	25’	50’	75’	75’	100’
200’	0	25’	50’	75’	100’	100’
250’	0	25’	50’	75’	100’	125’
300’	0	50’	75’	100’	125’	150’
350’	0	50’	75’	125’	150’	175’
400’	0	50’	100’	125’	175’	200’
450’	0	50’	100’	150’	200’	225’
500’	0	50’	100’	150’	200’	250’

Table 2-5
Storage Length to be Added to Chart Values of
Left-Turn Lane Storage Lengths

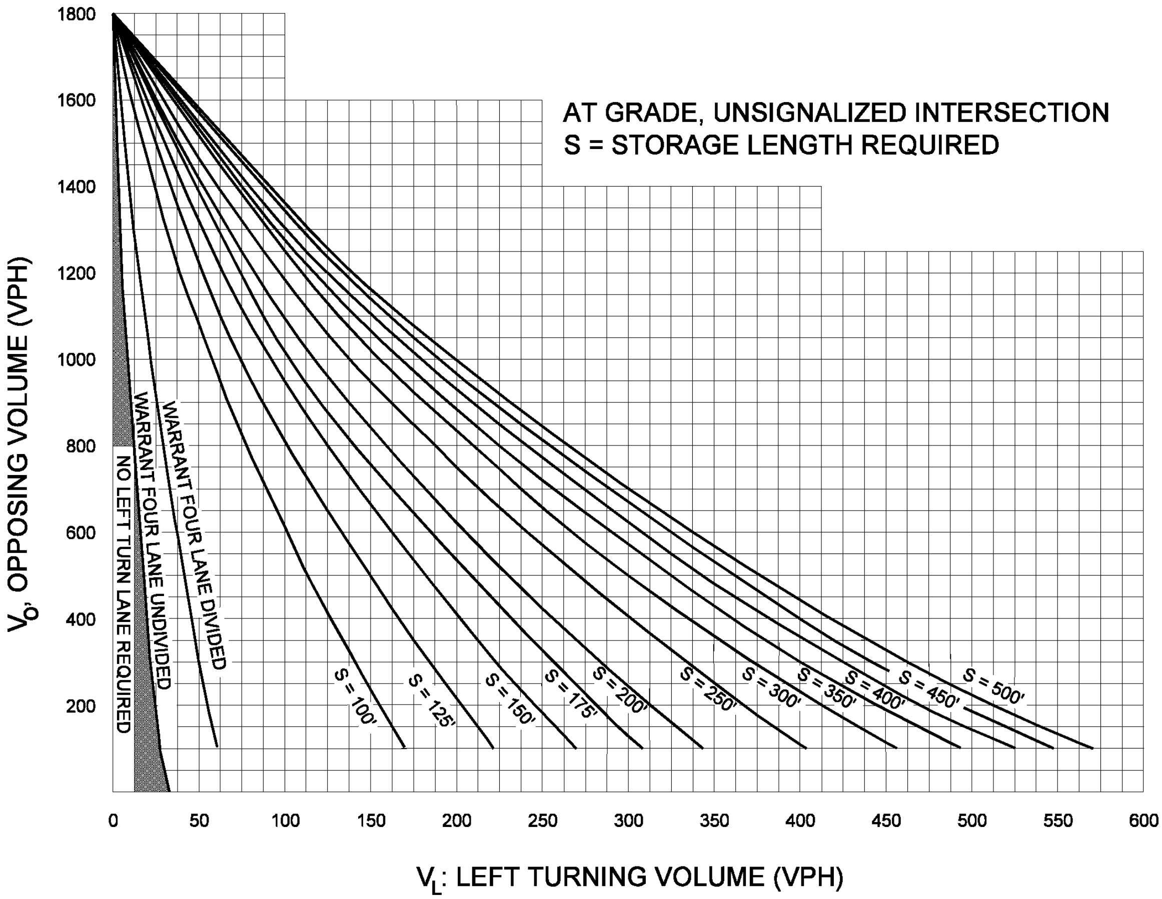


Figure 2-17
Warrant for Left-Turn Storage Lanes on Four-Lane Highways

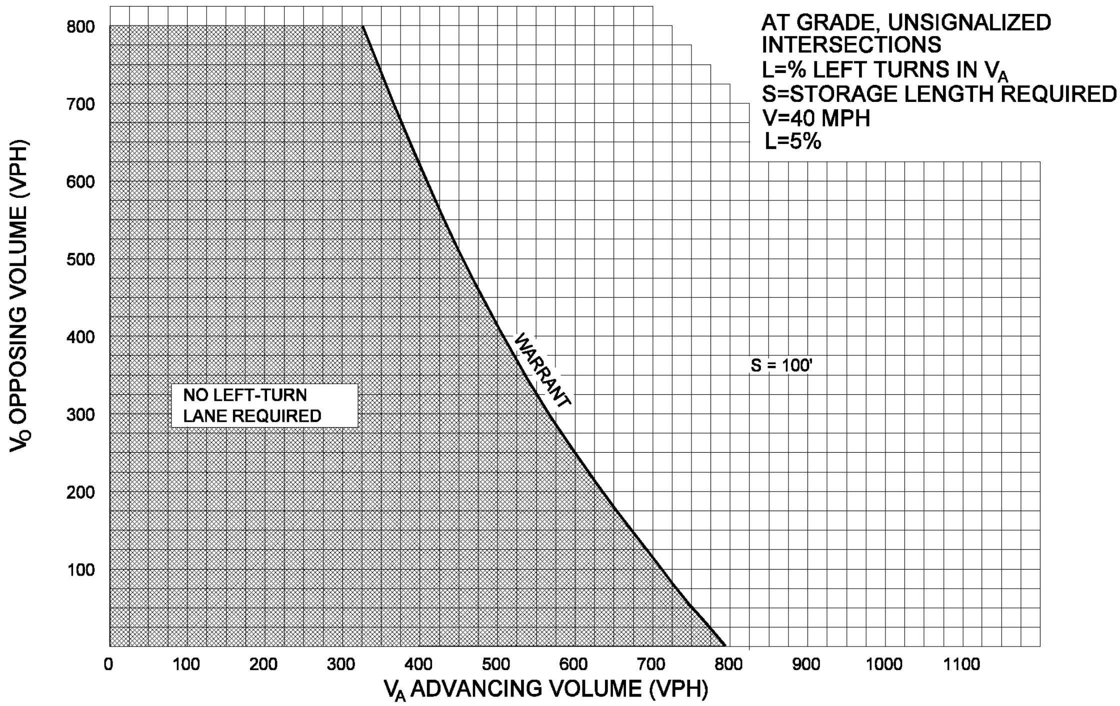


Figure 2-18A
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 40 mph and L = 5%)

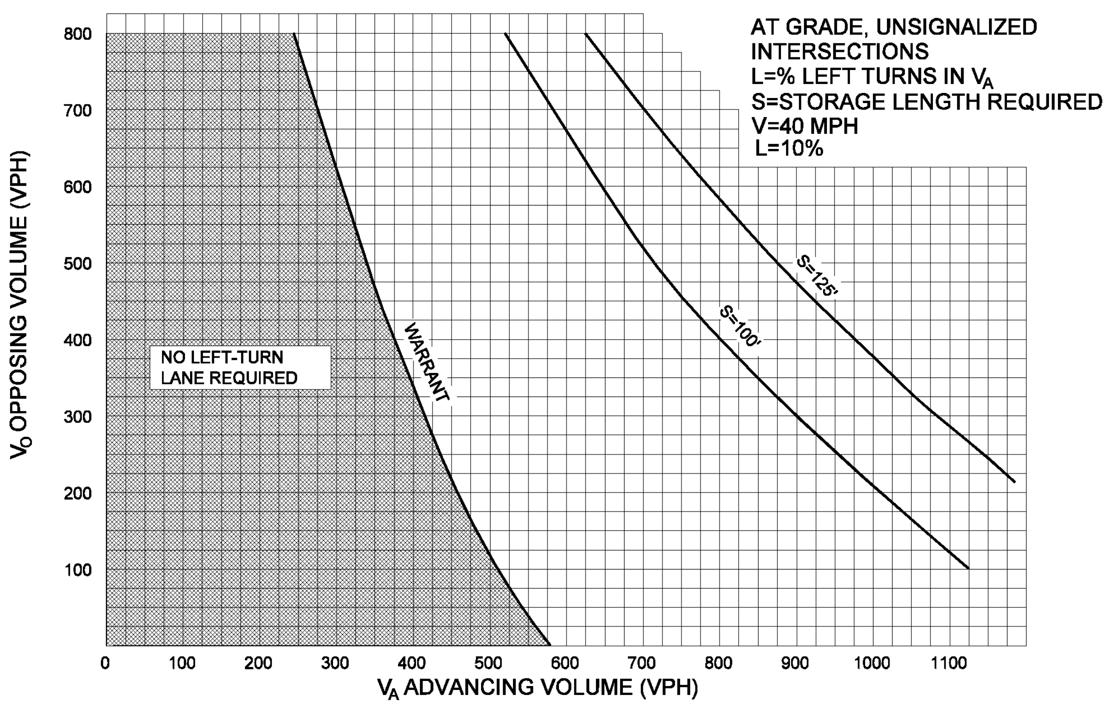


Figure 2-18B
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 40 mph and L = 10%)

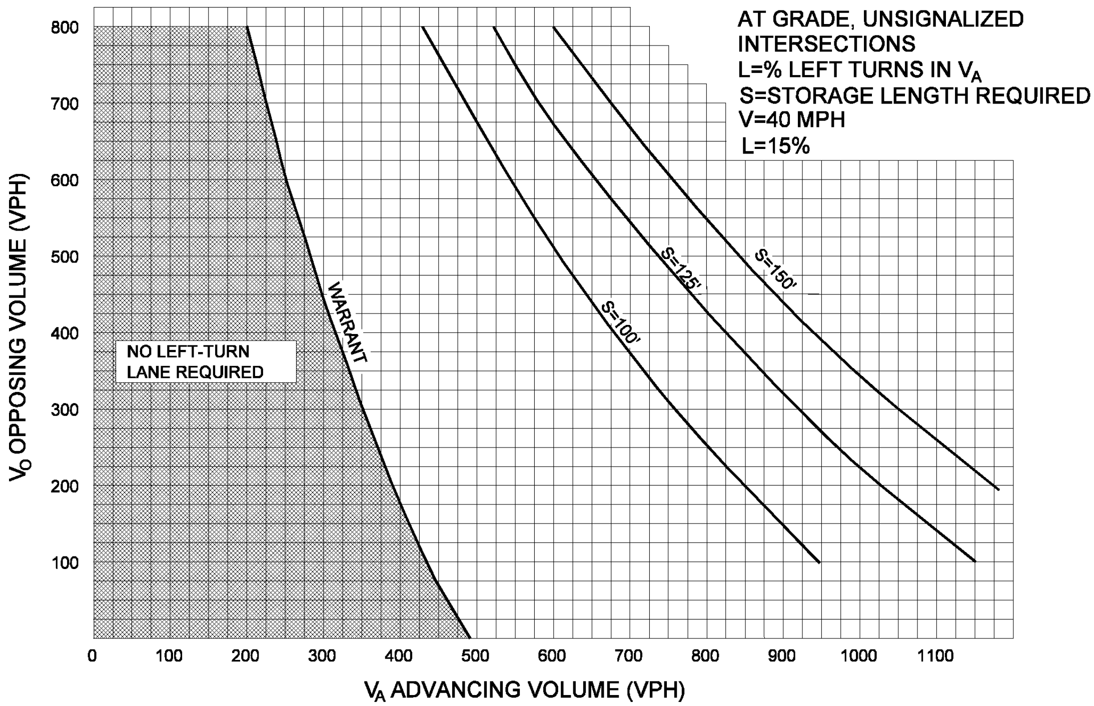


Figure 2-18C
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 40 mph and L = 15%)

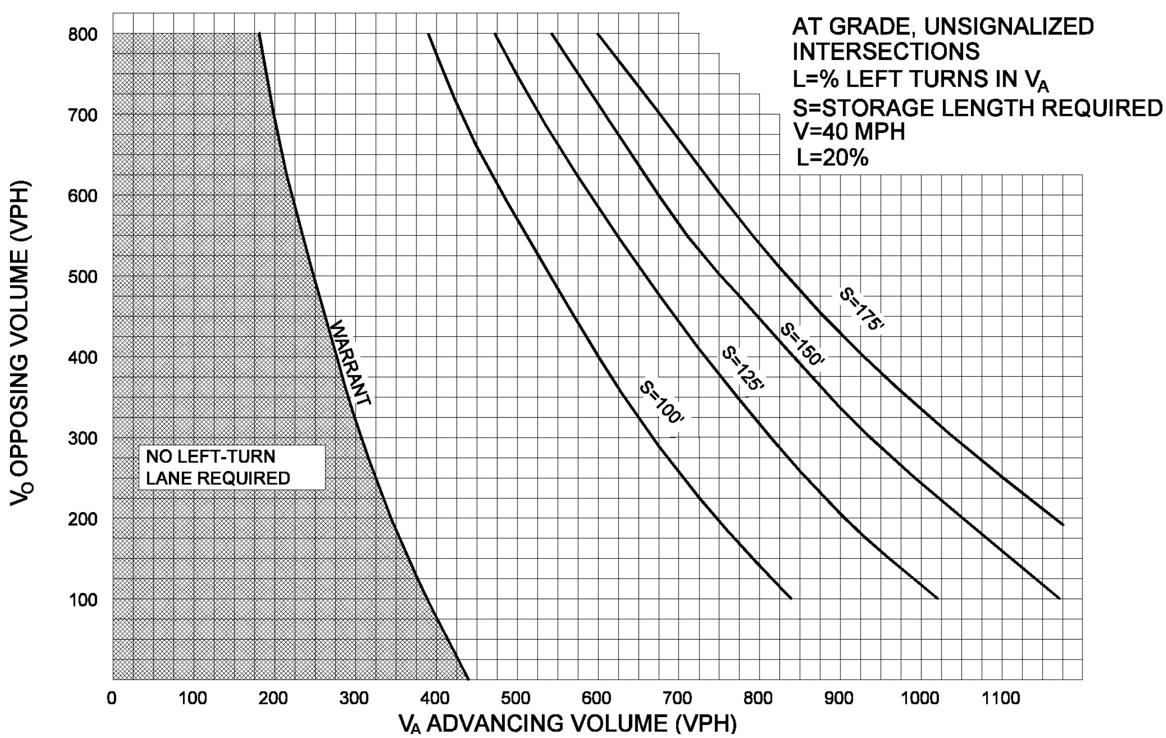


Figure 2-18D
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 40 mph and L = 20%)

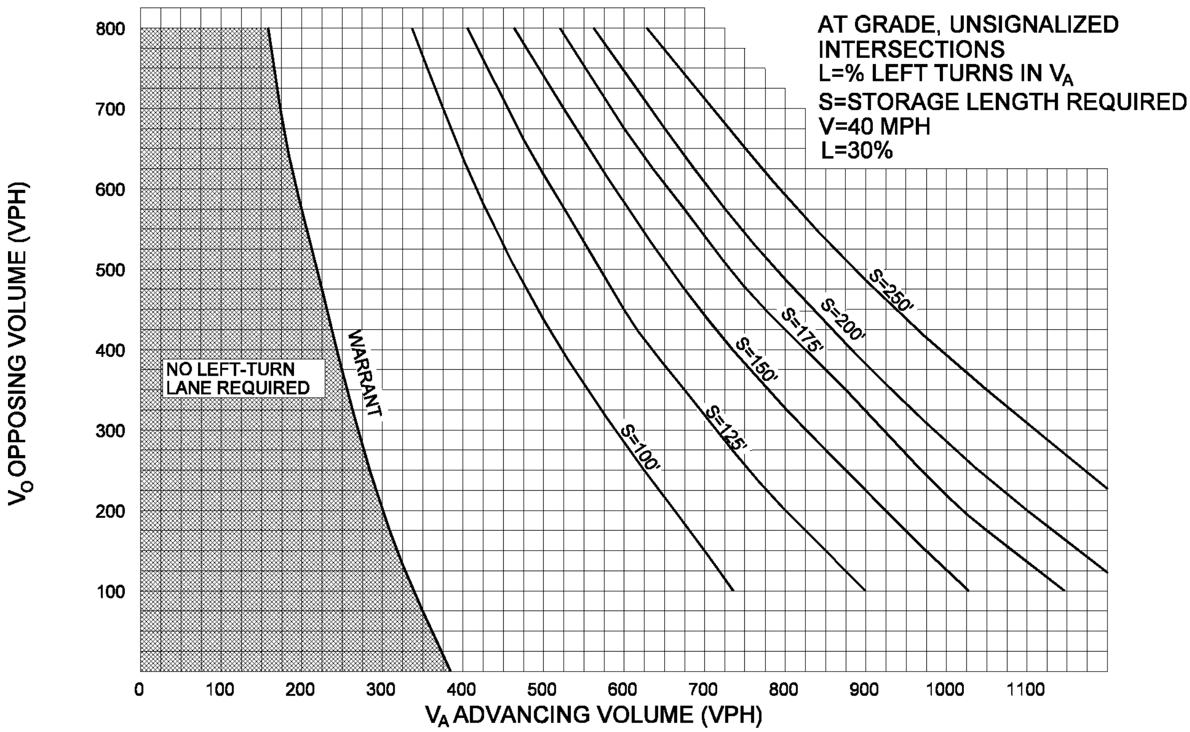


Figure 2-18E
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 40 mph and L = 30%)

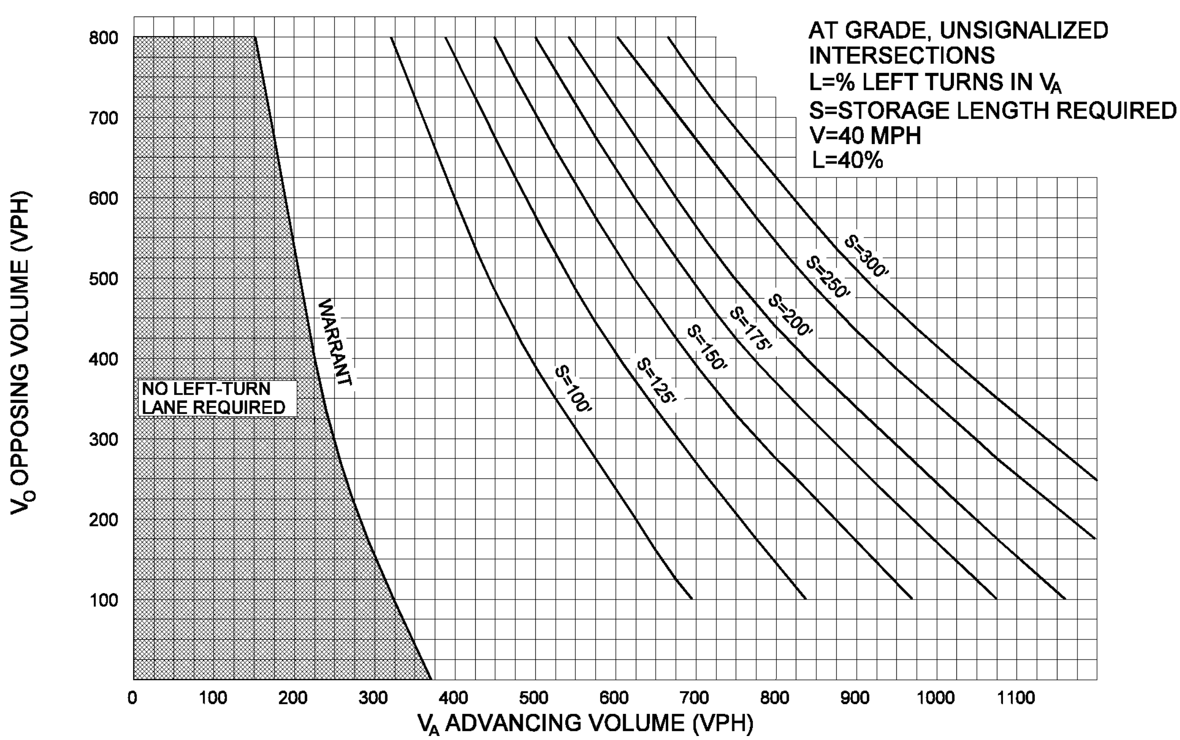


Figure 2-18F
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 40 mph and L = 40%)

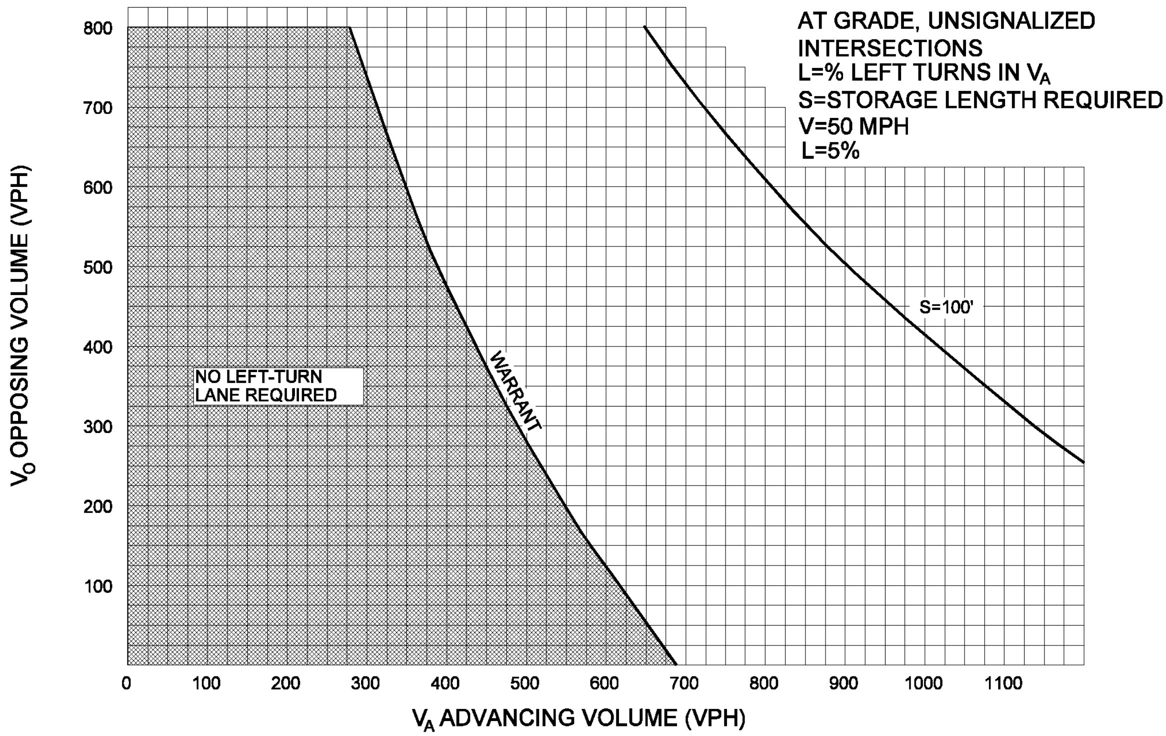


Figure 2-19A
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 50 mph and L = 5%)

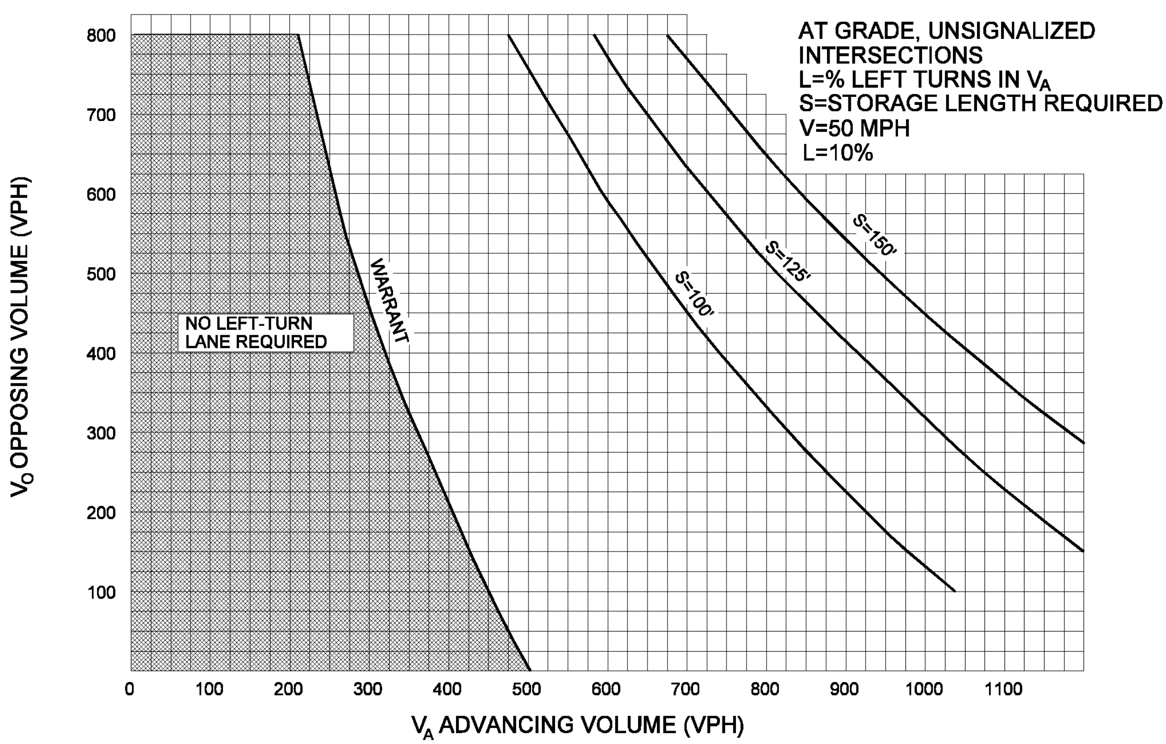


Figure 2-19B
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 50 mph and L = 10%)

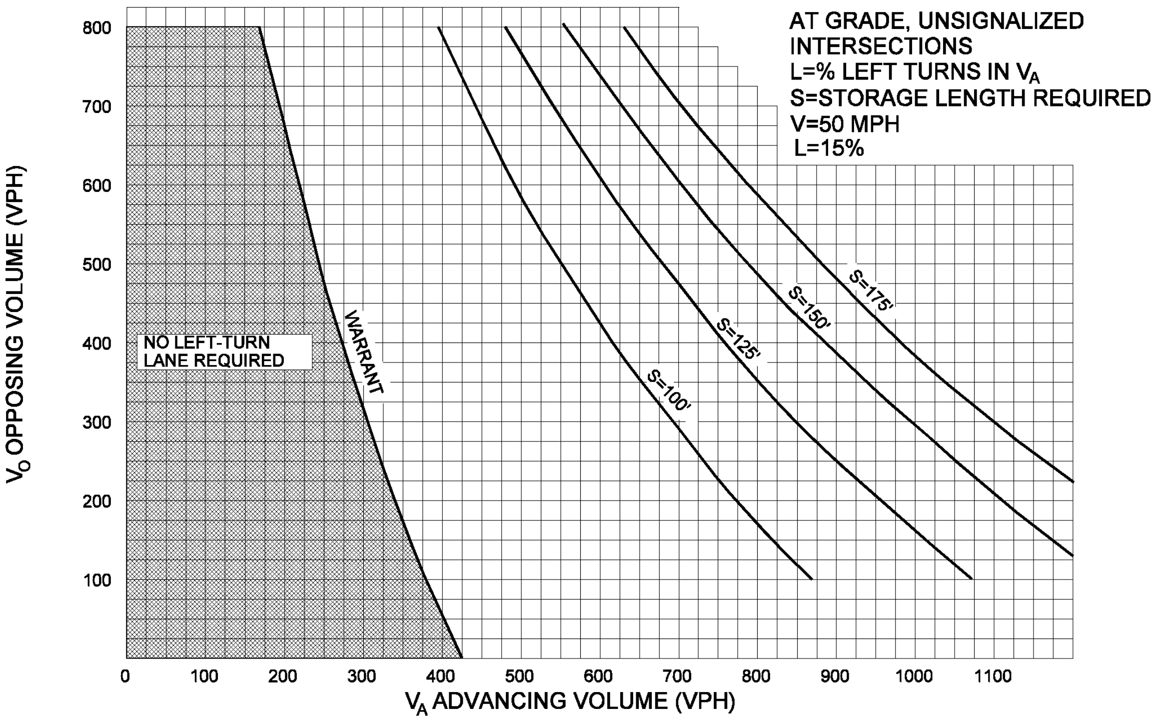


Figure 2-19C
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 50 mph and L = 15%)

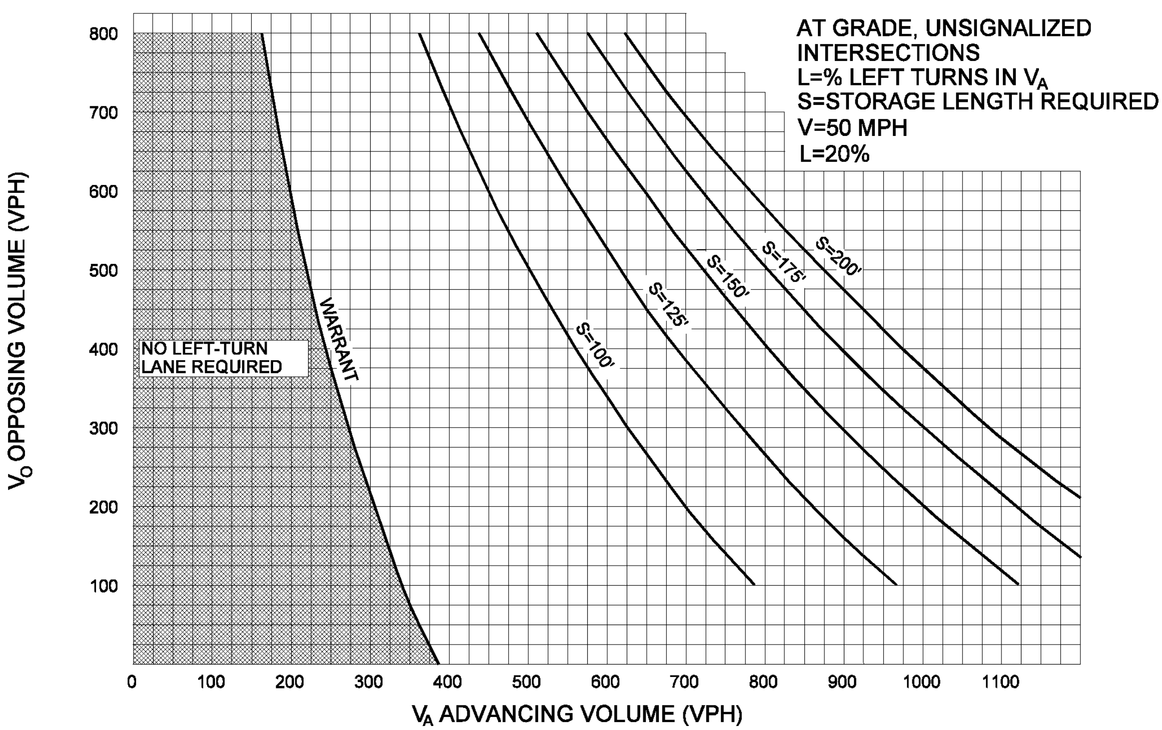


Figure 2-19D
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 50 mph and L = 20%)

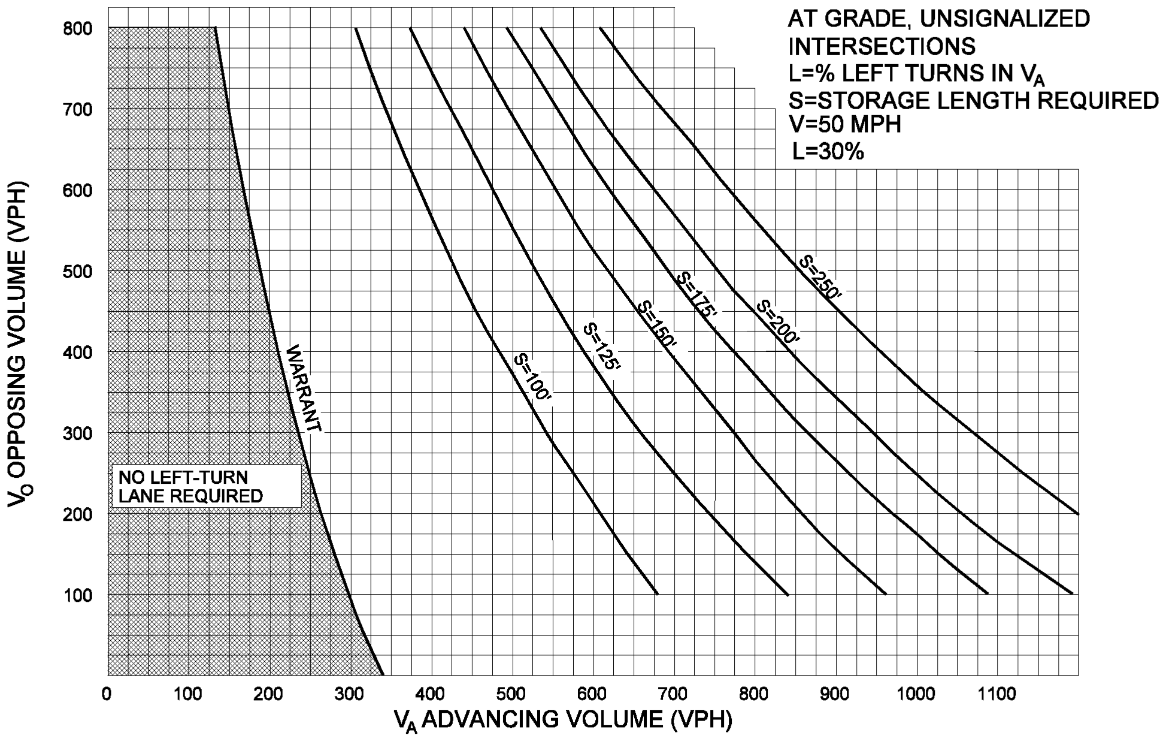


Figure 2-19E
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 50 mph and L = 30%)

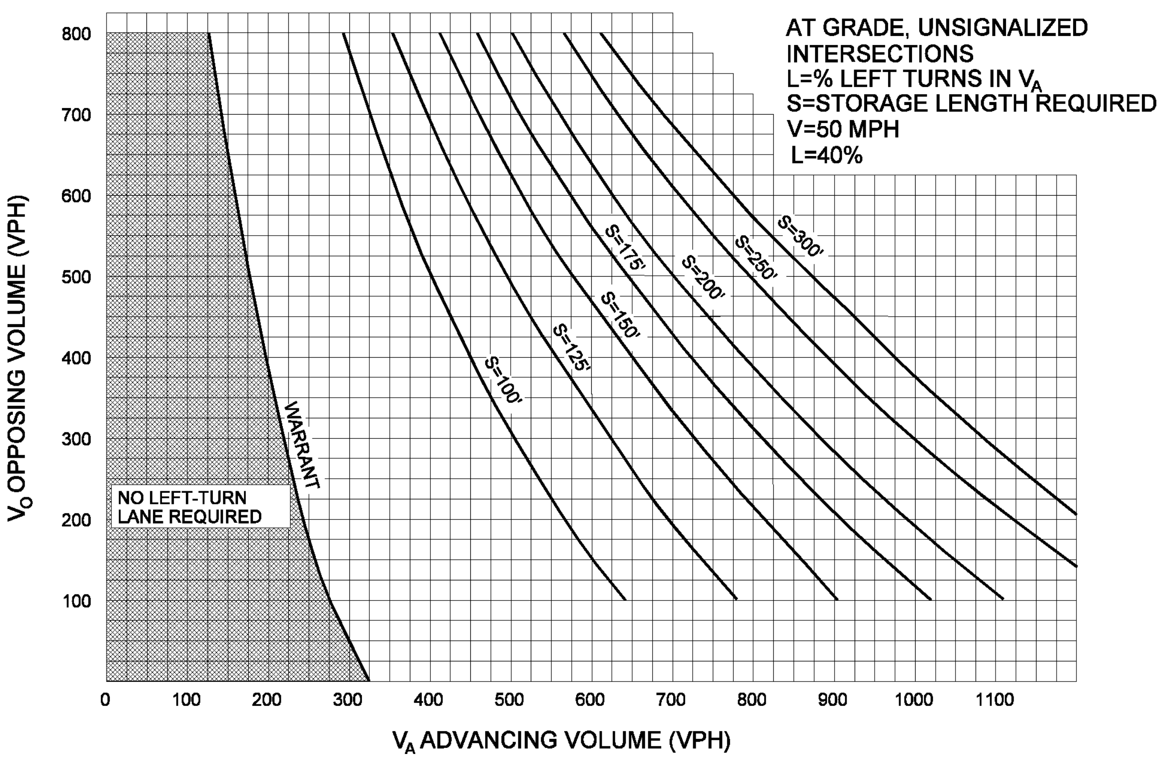


Figure 2-19F
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 50 mph and L = 40%)

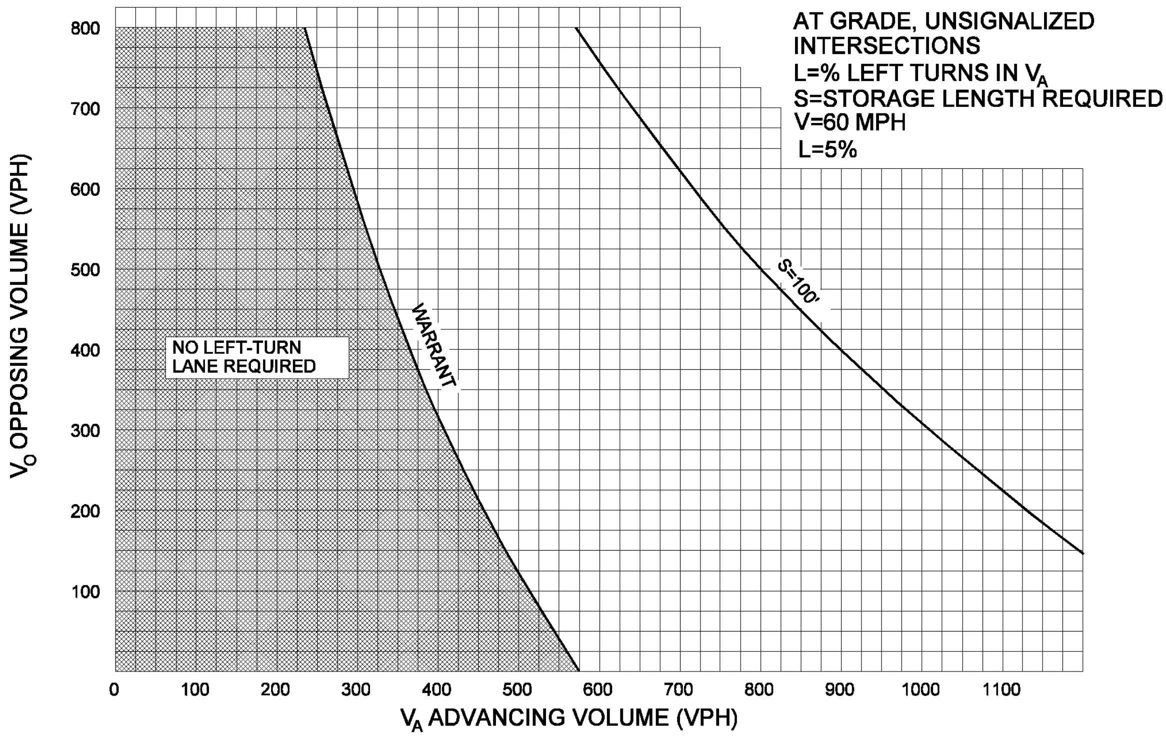


Figure 2-20A
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 60 mph and L = 5%)

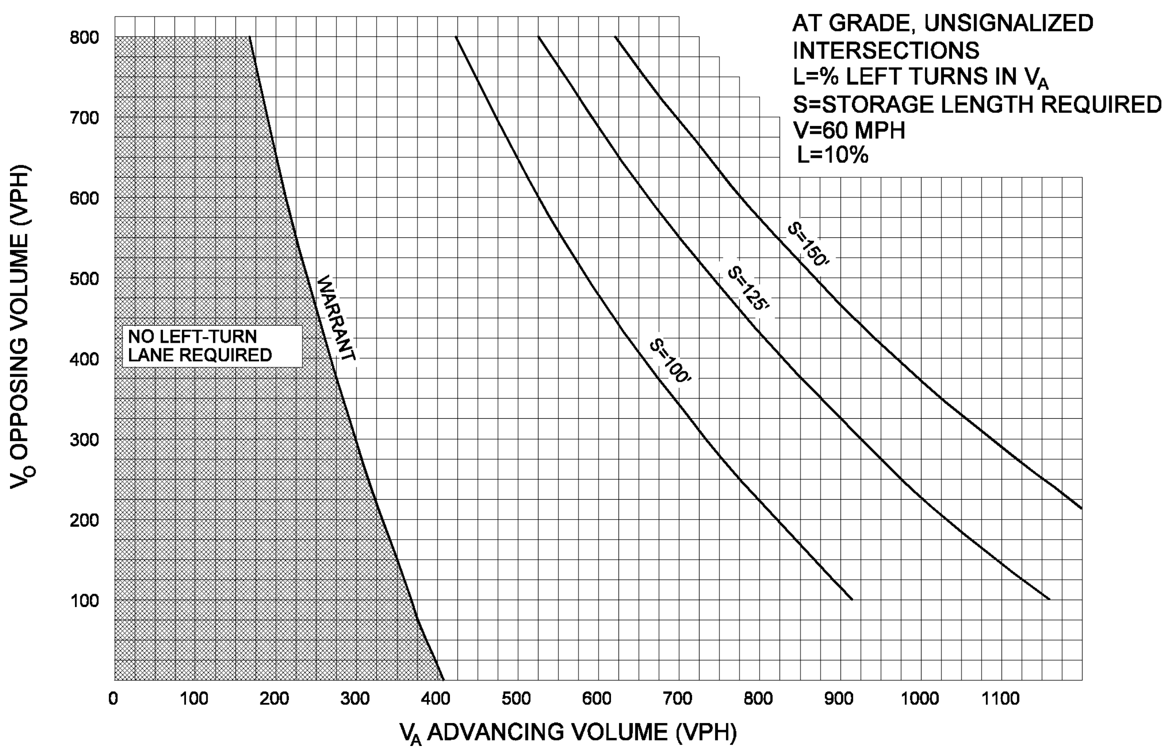


Figure 2-20B
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 60 mph and L = 10%)

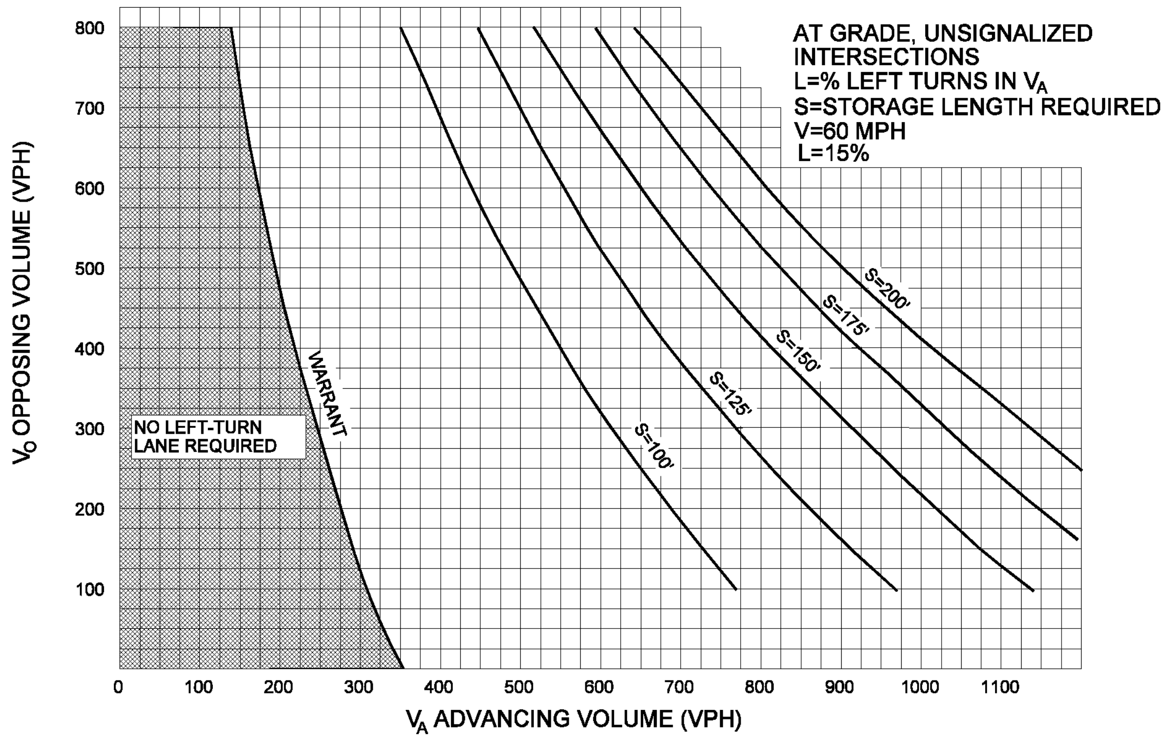


Figure 2-20C
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 60 mph and L = 15%)

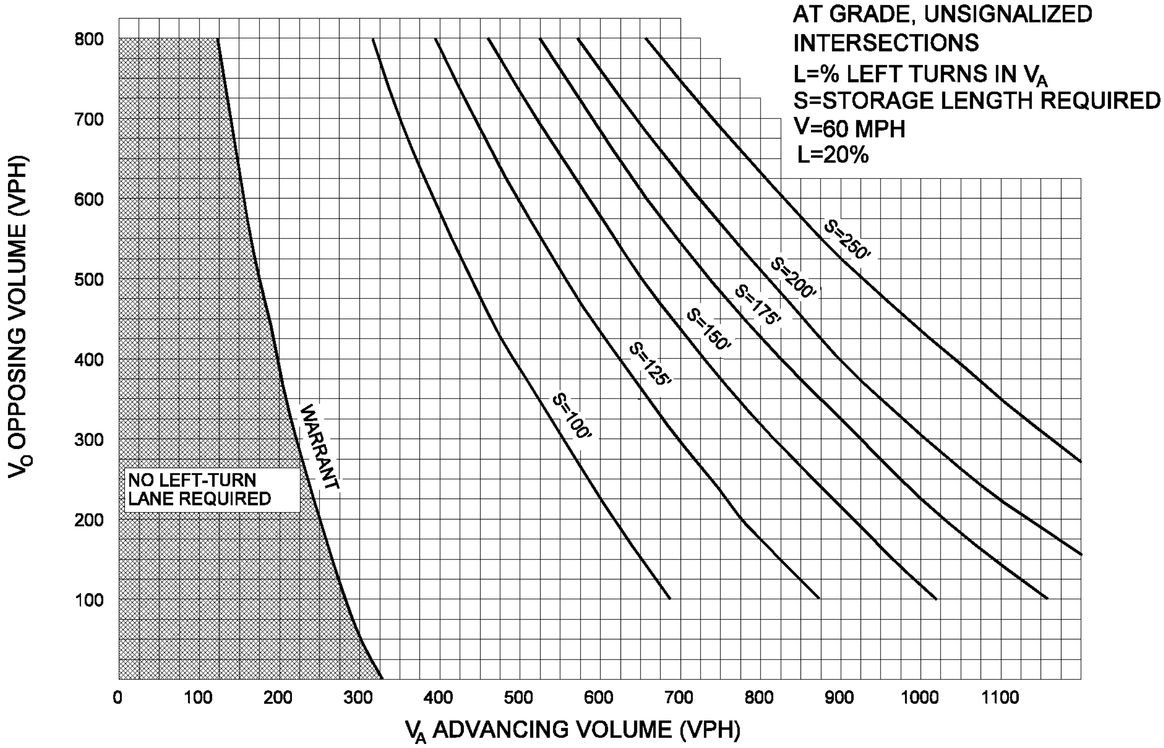


Figure 2-20D
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 60 mph and L = 20%)

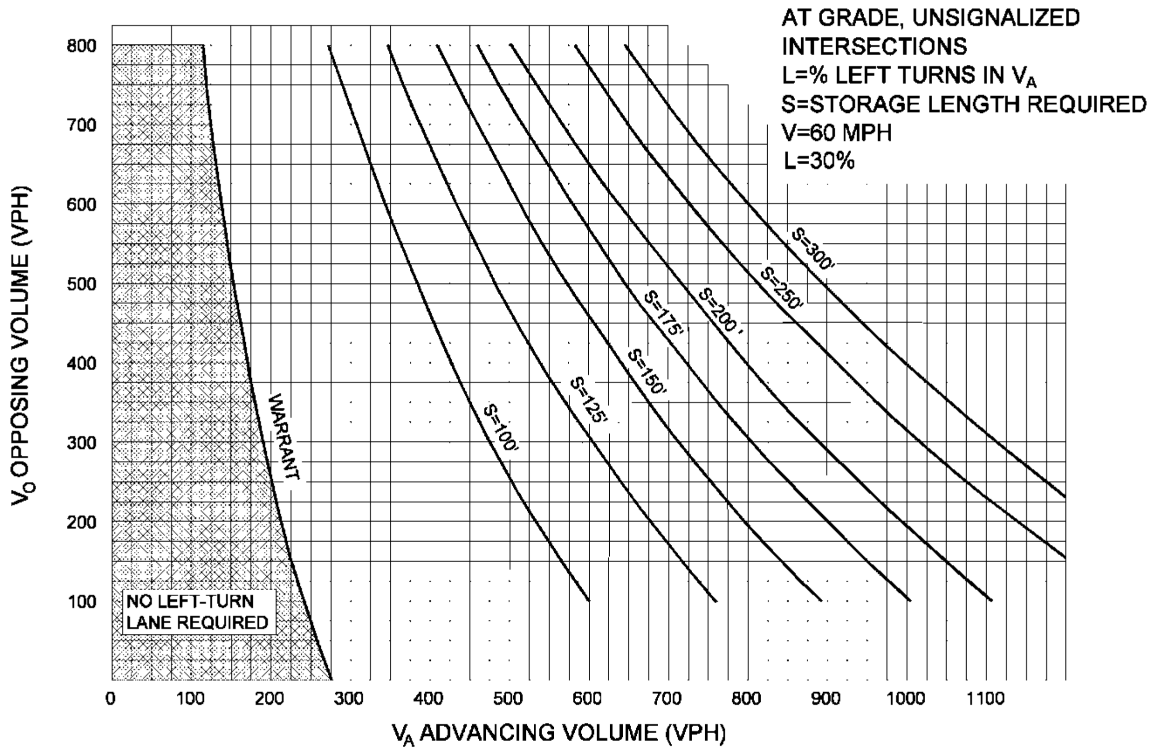


Figure 2-20E
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 60 mph and L = 30%)

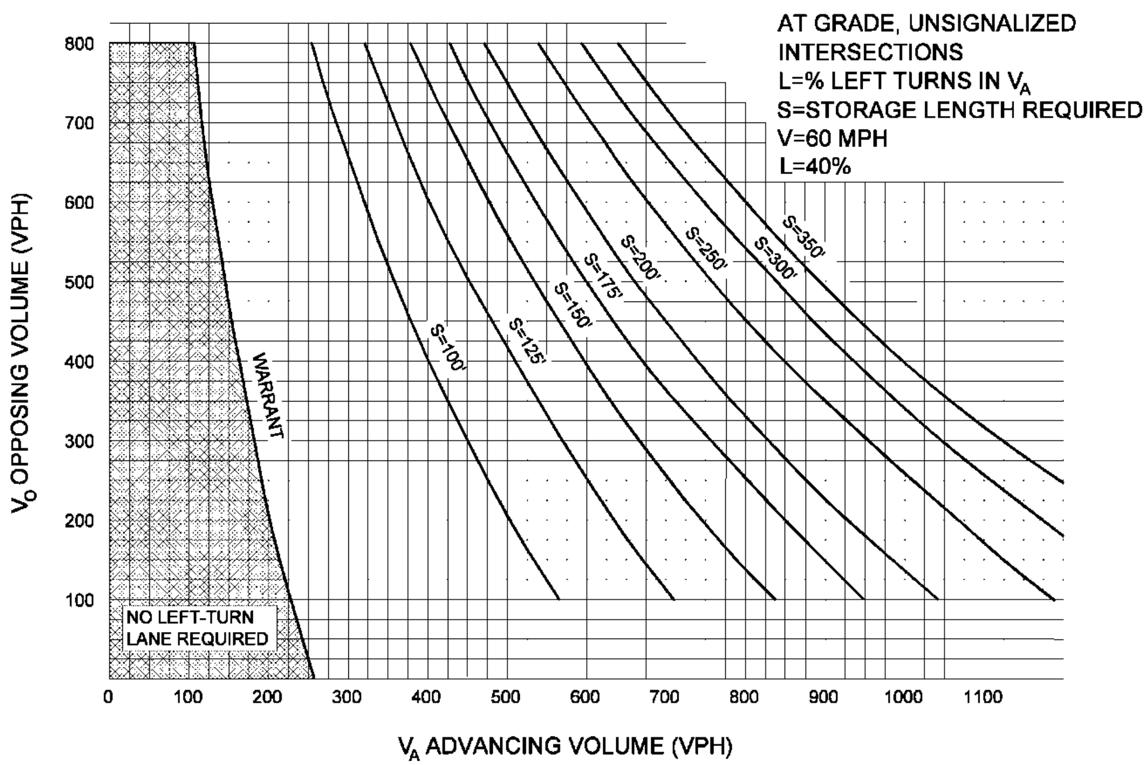


Figure 2-20F
Warrant for Left-Turn Storage Lanes on Two-Lane Highways (V = 60 mph and L = 40%)

2-175.00 RETAINING WALLS DETERMINATION PROCESS

During the development of many roadway design projects, proposing a retaining wall is necessary due to right-of-way limitations, environmental impacts, drainage issues, or the need to reduce damage to adjacent properties. During preliminary plans development the designer shall determine if a retaining wall will be required. Once the need (or possible need) for a retaining wall is determined the designer shall prepare a Retaining Wall Detail Sheet for the Structures Division to further use in developing the wall layout. The retaining wall design process shall be initiated after preliminary plans are finalized.

For all design projects that contain retaining walls or that could potentially contain retaining walls, the responsibilities of the Roadway Design Division in relation to proposing a retaining wall design shall be as follows:

A. PREPARE THE RETAINING WALL DRAWINGS

Retaining Wall Detail Sheet requirements
The information below must be shown on the proposed retaining wall typical section, layout, and profile details. (See Figure 2-21D for example)

Typical Section: The designer shall show a typical section of the retaining wall and label the following information (See Figure 2-21A for example of cut and fill section walls):

- Offset from centerline to the retaining wall.
- Existing and Proposed Right-of-way and easements
- Miscellaneous details of wall appurtenances such as traffic barriers, coping, fencing, drainage, location and configuration of signs and lighting including conduit locations, and any nearby utilities that may affect the construction of the wall.
- Any Context Sensitive Solution Design requests.

Layout: The designer shall show the proposed layout of the retaining wall relative to the roadway centerline and existing or proposed right-of-way boundary. The layout shall show the station and offsets for beginning, end and all breakpoints; right-of-way and easements, and label the distance between the wall and proposed right-of-way. (See Figure 2-21B for example)

Profile: The designer shall show a profile view of the top and bottom of the wall. The designer shall also identify the square footage of the exposed wall face (See Figure 2-21C for example).

The right side of the sheet is reserved for geotechnical and structural information. The designer shall place all three drawings on the left side of the sheet.

Roadway Plan Sheets Requirements
The information below must be added to the roadway plans. Since the detailed information for the retaining wall is shown on the "Retaining Wall Detail Sheet" less information is required to be shown on the roadway plan sheets.

Special Notes: The designer shall add the Retaining Wall Special Notes 1-4. (See Section 6-240.00)

Proposed Sheet: The designer shall show the retaining wall on the proposed sheet. Only beginning and end stations should be labeled.

Profile Sheet: The designer shall show the retaining wall elevation on the profile sheet. Only beginning and end stations should be labeled.

Cross Sections: The designer shall show the retaining wall on the cross sections. At stations where a retaining wall is present the designer shall locate and label the existing and proposed right-of-way.

FileNet Archiving
The designer shall place the following files into a compressed file and onto FileNet with the name: **nnnnnn-nn-Retainingwall.zip**

- Retaining Wall Detail Sheet (.dgn)
- Roadway plan sheets proposed, profile and cross-section showing the location of the proposed retaining wall (.tin and .gpk files).
- Survey, Proposed and Alignment Files (.dgn)

B. RETAINING WALL COST ESTIMATE

In cases when there is no alternative but to build a retaining wall (such as near historical or environmentally sensitive areas) the designer should proceed directly to the step C.

When a retaining wall is proposed to limit right-of-way acquisition only, a cost evaluation is required to evaluate the economics of the proposed wall. The designer shall fill out the Request for Cost Estimate Form (See Figure 2-21E) and email it to the Structures and Right-of-Way Divisions. The designer shall identify the amount of ROW required (including the tract numbers) for the no build option and the amount of ROW required for the retaining wall build option to assist Right-of-Way Division in preparing their estimate.

After receiving the cost estimates the designer will proceed to the next step if the retaining wall is deemed economically feasible. If the retaining wall is found to not be cost effective, the project will be designed without a retaining wall and include the larger right-of-way acquisition.

C. PROCEED WITH RETAINING WALL DESIGN

At this step, the retaining wall has been determined to be necessary. The designer will fill out the Notice to Proceed on Retaining Wall Design form letter (see Figure 2-21F) and email to Structures Division. When biological, environmental, hazardous materials, historical or archeological factors are involved it will be necessary to coordinate with the Environmental

Division to ensure that the area is properly protected and identified. The designer shall note any additional requirements on the wall in the letter (such as a barrier system incorporated into the wall).

Structures Division will communicate with the Geotechnical Section and produce a preliminary retaining wall structural design layout by the Right-of-Way Field Review including all acceptable wall types and associated ROW needs. Once preliminary structural design is received, the designer shall incorporate the information on the Retaining Wall Detail Sheet and Roadway Plans for Right-of-Way turn-in. If there is any need to revise the wall alignment , the designer shall update the plans and revise and resend the Retaining Wall Detail Sheet to Structures Division.

For the Roadway Plans prepared by consultants, the cost estimate request/notice to proceed should be prepared as described above and emailed to the Roadway Design Manager for review. Upon acceptance, the Design Manager will forward the package to the appropriate divisions.

The designer shall notify Structures Division whenever major design revisions are made that could affect the retaining wall design.

The flow chart in Figure 2-21 depicts the Roadway Design Division's responsibilities with regard to determining and proposing a retaining wall.

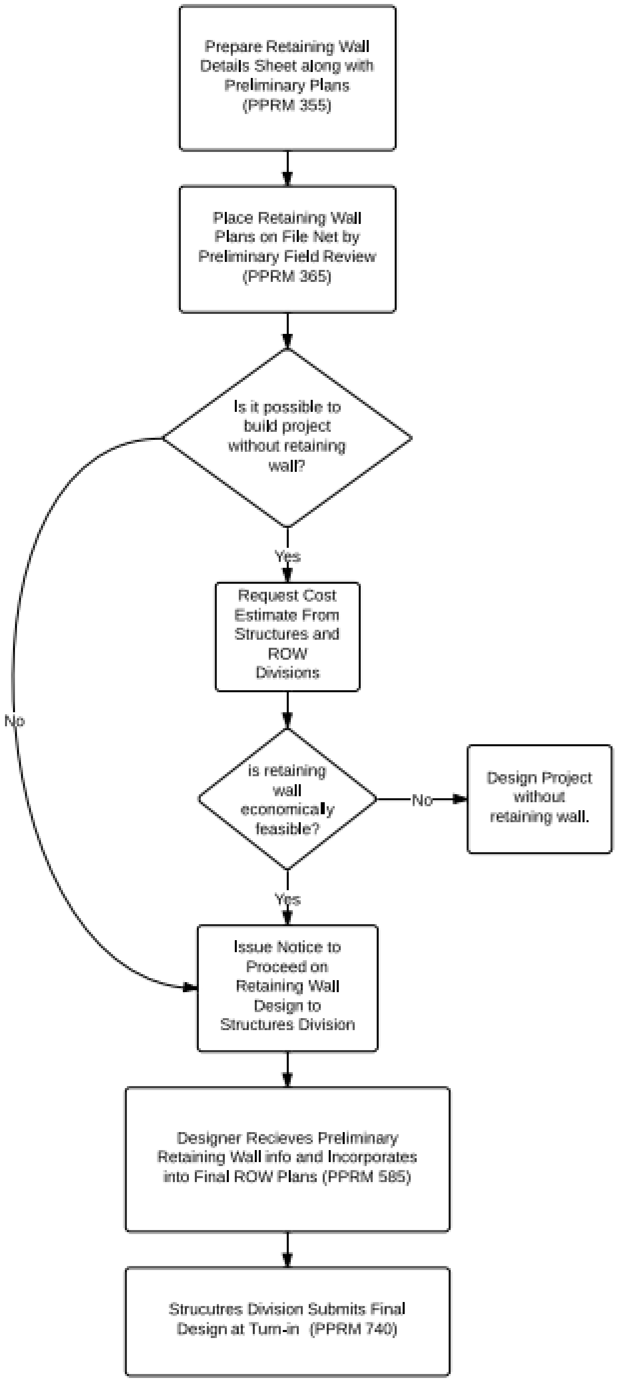


Figure 2-21
Flow Chart for Determining and Proposing a Retaining Wall

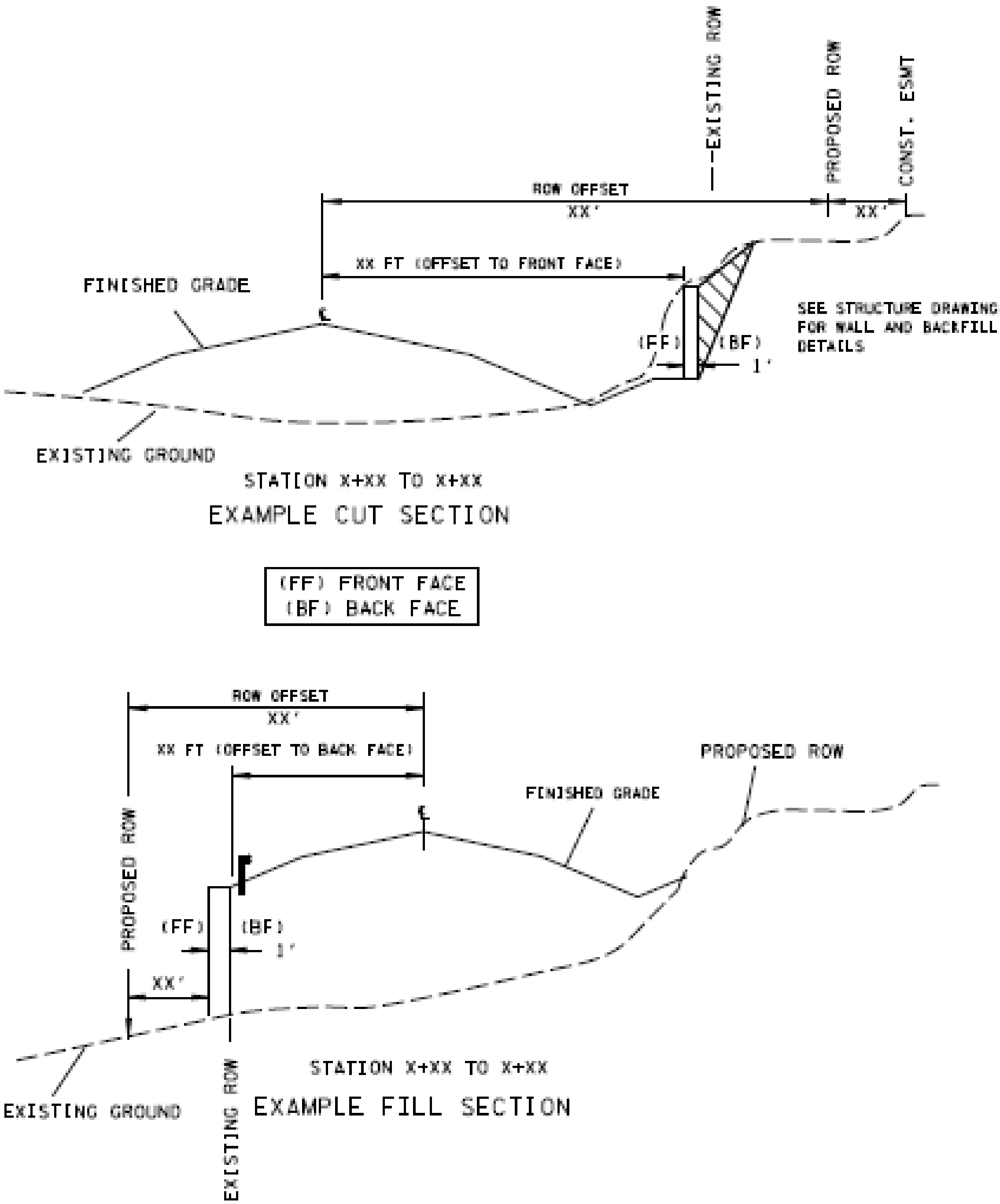
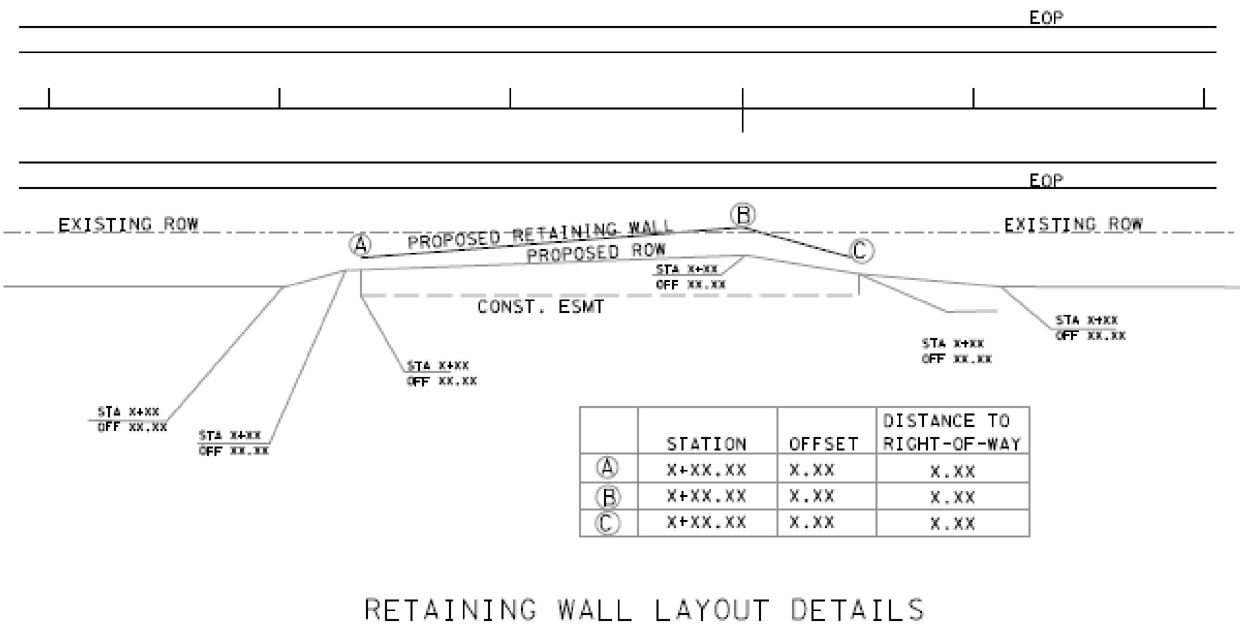


Figure 2-21A
Example of Retaining Wall Typical Sections for Cut or Fill Sections



	STATION	OFFSET	DISTANCE TO RIGHT-OF-WAY
A	X+XX.XX	X.XX	X.XX
B	X+XX.XX	X.XX	X.XX
C	X+XX.XX	X.XX	X.XX

Figure 2-21B
Example of Retaining Wall Layout Details

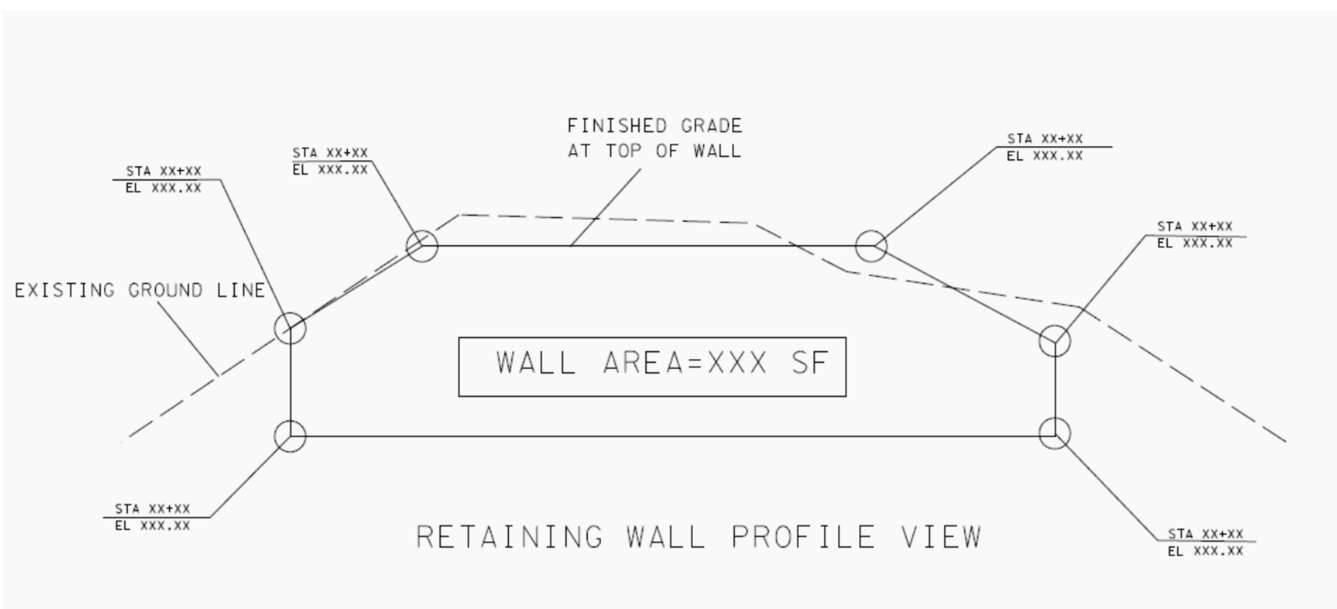


Figure 2-21C
Example Retaining Wall Profile

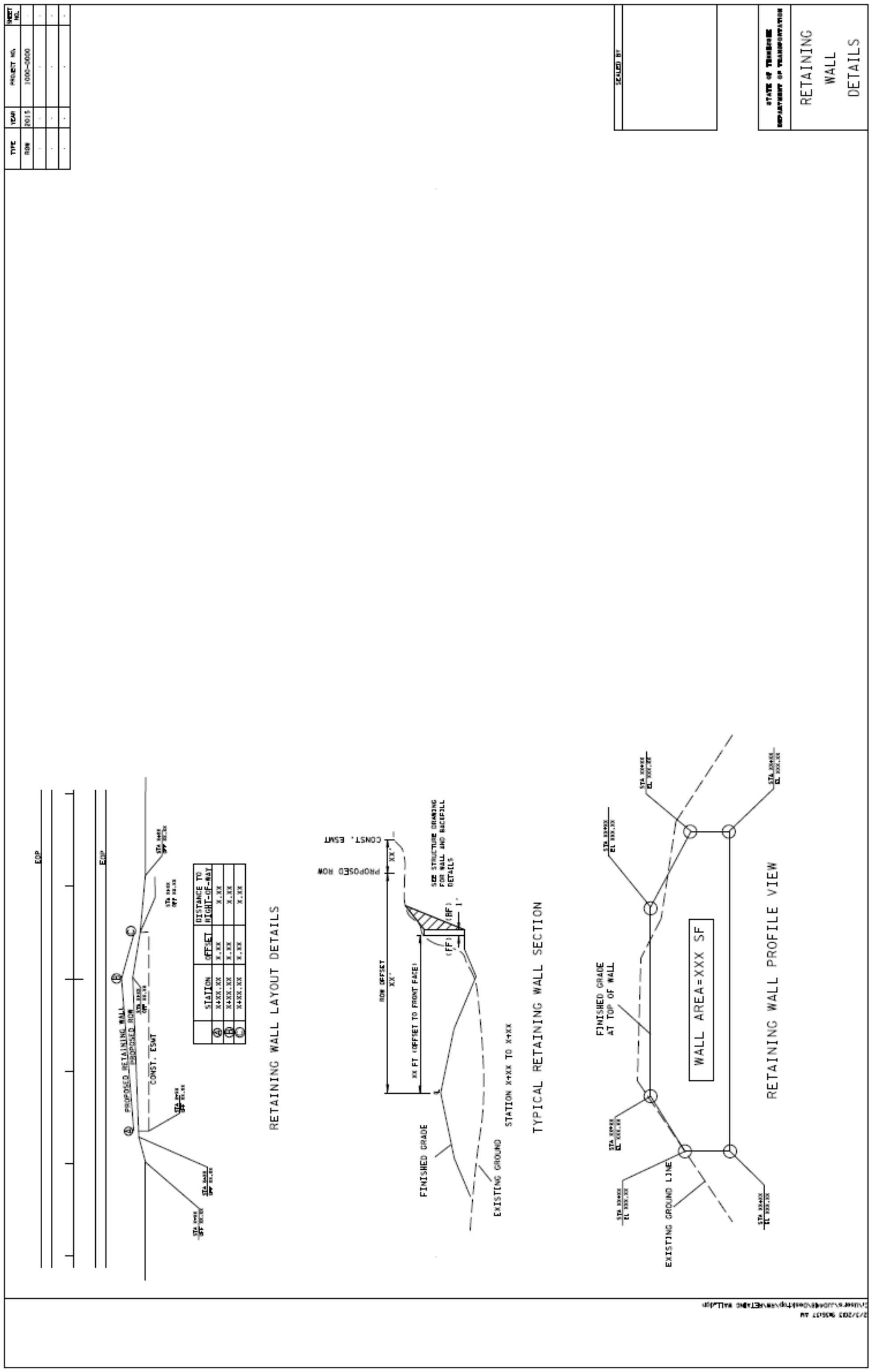


Figure 2-21D
Example Retaining Wall Detail Sheet

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
Roadway Design Division
Retaining Wall Cost Estimate

TO: Region _ Right-of-Way Division
Structures Division

FROM: Roadway Design Manager overseeing the project

DATE:

Project Number:	County:

A retaining wall has been identified for this project as a possible option for the following reasons (DESIGNER TO TYPE JUSTIFICATION HERE). However, the Department has the option to not build the wall should it prove to not be economically beneficial to do so. For this reason we are requesting a cost estimate for both the "build" and "no build" options.

Right-of-Way Division: please prepare a cost estimate of the additional right-of-way purchase(s) for the no build option and return to the design manager at your earliest convenience.

Build Option

Tract No	Approximate Additional Right-of-Way Needs (Acres)	Estimated Cost
Designer to Fill In	Designer to Fill In	
Designer to Fill In	Designer to Fill In	

No-Build Option

Tract No	Approximate Additional Right-of-Way Needs (Acres)	Estimated Cost
Designer to Fill In	Designer to Fill In	
Designer to Fill In	Designer to Fill In	

Structures Division: please provide a preliminary cost estimate for the retaining wall, and identify the amount of any additional easements required to build the proposed wall and possible alternatives and return to the design manager at your earliest convenience. Do not proceed to full design until notified by Roadway Design Division.

The Preliminary Plans (see typical section, proposed layout and profile sheets) and related files are on FileNet under the name: nnnnnn-nn-RetainingWall.zip
The proposed retaining wall(s) is located at station: XX+XX to XX+XX

Please contact me with any questions.

Figure 2-21E
Retaining Wall Cost Evaluation Request Letter

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
Roadway Design Division
Notice to Proceed with Retaining Wall Design

TO: Structures Division
Hydraulic Section (if appropriate)

FROM: Roadway Design Manager overseeing the project

DATE:

Project Number:	County:

After evaluating the cost estimates it has been determined that the retaining wall is cost effective. Please proceed with design and identify acceptable alternative wall types.

Please provide a Preliminary Retaining Wall Layout (including any acceptable wall types) to the designer by this date: (Designer to enter the date of the Right-of-Way Field Review). The retaining wall information shown on the preliminary plans is conceptual in nature, please modify or verify those details in you preliminary structural design to allow the designer to finalize right-of-way. Please note the following right-of-way restrictions in determining your design and approved alternatives: (Designer to enter all right-of-way restrictions at the wall location here)

It is the responsibility of the structural designer to coordinate with the Geotechnical Section for any soil surveys deemed necessary by the structural designer.

The Preliminary Wall Layout Drawings and related files are on filenet under the name: nnnnnn-nn-RetainingWall.zip

Please contact me with any questions.

Figure 2-21F
Notice to Proceed with Retaining Wall Design Letter

2-175.01 RETAINING WALLS PAY ITEM

Retaining walls shall be paid for by the square foot of wall face. Each individual retaining wall shall be paid for under an individual number using the following item numbers:

604-07.01	RETAINING WALL (DESCRIPTION)	PER SF
Through		
604-07.23	RETAINING WALL (DESCRIPTION)	PER SF

The designer should enter the beginning and end station of the retaining wall as the description.

2-175.02 RETAINING WALLS BARRIER SYSTEM REQUIREMENTS

The designer shall show proper barrier type associated with the acceptable wall type.

Retaining walls in fill sections will require a barrier system due to the drop off. If there is sufficient room the barrier system should be placed away from the wall. If the only option is to include the barrier as part of the wall the designer shall notify Structures Division in the Notice to Proceed with Retaining Wall Design. If the barrier system is incorporated into the retaining wall the designer shall add the following footnote to the retaining wall item number for each individual wall that the condition exists:

> “Cost of concrete barrier incorporated into the retaining wall shall be included in the cost of the retaining wall. The barrier shall be designed as TL-4 rail as defined by section 13 of the AASHTO Bridge Design Specifications.”

Retaining walls in cut sections may require a barrier system. Generally all retaining wall types inside the clear zone, except for cast-in-place reinforced concrete walls, require a concrete barrier (S-SSMB-3). If the wall is outside of the clear zone a retaining wall may not be required unless deemed appropriate by engineering judgment.

2-180.00 LOCATION OF AUTOMATIC TRAFFIC RECORDERS (ATR) AND ROADWAY WEATHER INFORMATION SYSTEMS (RWIS) ON PROJECTS

To avoid damage to Automatic Traffic Recorder (ATR) and RWIS Weather Station (RWIS) equipment that might be located within the limits of TDOT projects, the Roadway Design Division has been requested to identify equipment for ATR’s or RWIS’s located within the project limits during development of project plans. On projects developed in-house, it will be the responsibility of the designer to make this determination. On projects developed by consultants, it will be the responsibility of the TDOT Design Manager.

To determine whether an ATR is located within a project, check TRIMS using the standard query “ATR Locations” (statewide) or “ATR Locations by Region”. The county, route and log mile location for each respective ATR is listed. Please note that if you use the “ATR Locations by Region” query you must enter the correct region number under Value in the criteria window at the bottom. The query will also provide RWIS Weather Station information if a RWIS is also located at the ATR location.

If an ATR is found within a project, notify Director of Project Planning Division with a description of the proposed work in the vicinity of the ATR location. If the work Strategic Transportation Investments Division on the project is likely to affect the operation of the ATR equipment, the roadway designer will be given a list of item numbers and descriptions for inclusion in the construction plans quantity block.

To determine whether a RWIS Weather Station is located within a project, check TRIMS using the standard query “RWIS Locations”. The county, route and log mile for each RWIS location is listed statewide. The query will list stand alone RWIS sites and RWIS sites located at ATR locations.

If a RWIS is found within a project, notify the Manager of Asset Management Section of the Maintenance Division. He will determine if the equipment will be affected by the work and arrange for the equipment to be replaced or advise the designer of appropriate items to include the plans to replace the affected equipment.

If inclusion of construction items is required and the project includes any traffic signal work, notify the Manager of Design ITS, Traffic, and Standards Office in order to avoid possible duplication of construction items.

CHAPTER 2 – DRAINAGE

2-200.00 DRAINAGE MANUAL

In order to assist the designer performing drainage and hydrologic design, the Roadway Design Division has developed a Drainage Manual to provide a collection of applicable drainage criteria, policies and examples. The Manual discusses Tennessee Department of Transportation policies, practices and procedures for performing drainage design and hydraulic analyses on projects that are the responsibility of TDOT.

Designers shall use Chapters 1-11 of the Roadway Design Division's Drainage Manual for all projects designed or constructed by TDOT. These chapters include:

Chapter 1	Introduction
Chapter 2	General Drainage Policies and Practices
Chapter 3	Drainage Plan Requirements
Chapter 4	Hydrology
Chapter 5	Roadside Ditches and Streams
Chapter 6	Culverts
Chapter 7	Storm Drainage Systems
Chapter 8	Stormwater Storage Facilities
Chapter 9	Energy Dissipators
Chapter 10	Erosion Prevention and Sediment Control
Chapter 11	Natural Stream Design

Limited copies of the Manual will be distributed for internal use only. Consultants and other interested persons may download the Manual from the TDOT Internet site. The Manual can be found at:

http://www.tn.gov/tdot/topic/chief-engineer-design-drainage-manual

2-200.01 COMPUTATION OF DRAINAGE

See Chapter 4 of the Drainage Manual.

2-200.05 DRAINAGE TABLES AND CHARTS

See Chapter 4 of the Drainage Manual.

2-200.10 EXAMPLE DRAINAGE PROBLEMS

See Chapter 4 of the Drainage Manual.

CHAPTER 3 - RIGHT-OF-WAY

2-300.00 R.O.W. NOTES FOR ALL R.O.W. PROJECTS (See 3-305.00 and 6-140.00)

All the notes below, which apply, will be put on the first property map sheet or first present layout sheet of the Right-of-Way Plans.

1. It is intended that all buildings and/or portions of buildings that are within the proposed right-of-way and/or easement lines for the project, be removed in the process of right-of-way acquisition. If any such buildings or improvements are not removed in the course of right-of-way acquisition, the Design Manager, Roadway Design Division (and Design Manager, Regional Design Office, if plans are being developed in the Regional Office) is/are to be notified in sufficient time to permit having such removals designated as a part of the construction contract.

2. All ramps must conform to the Department's "Policy on Financing Construction on Public Road Intersections and Driveways on Highway Resurfacing, Reconstruction and Construction Projects on New Locations", *The Manual on Rules and Regulations for Constructing Driveways on State Highway Right-of-Way, Standard Drawing RP-R-1*, and other accepted design and safety standards.

2-300.05 R.O.W. NOTES ON PLANS REGARDING DRIVEWAYS (See 3-305.05, 3-310.00, and 6-140.00)

See Figures 2-22 through 2-24 for examples of how to show driveways on plans.

All ramp profiles (private drives, field entrances, business entrances, private and public side roads) shall be shown on the private drives and/or side road profile sheets.

All the notes below, which apply, will be put on the first property map sheet or the first present layout sheet of the Right-of-Way Plans.

1. New or Reconstruction Projects - with partial access control -

   A. Existing paved driveway per tract remainder will be replaced in-kind to a touchdown point.

   B. Where the existing driveway is unpaved and the proposed driveway exceeds 7 percent in grade, each driveway will be paved to a touchdown point or until the grade is less than 7 percent.

   C. Where the existing driveway is unpaved and the proposed driveway is less than 7 percent in grade, each driveway will be paved a shoulder width from the edge of pavement and the remainder of that driveway replaced in-kind to a touchdown point.

   D. Any necessary paving of driveways will be done during paving operations on the main roadway.

E. Tract remainders not having an existing driveway will be provided a 50-foot opening in the access control fence, and a driveway will be constructed unless access is provided from an intersecting road or based on physical conditions and/or conflicts with other design considerations which prevent an access opening. Paving of these new driveways will be in accordance with the 7 percent criteria previously mentioned for existing driveways.

2. New or Reconstruction Projects - with no access control -

A. Existing paved driveway per tract remainder will be replaced in-kind to a touchdown point.

B. Where the existing driveway is unpaved and the proposed driveway exceeds 7 percent in grade, each driveway will be paved to a touchdown point or until the grade is less than 7 percent.

C. Where the existing driveway is unpaved and the proposed driveway is less than 7 percent in grade, each driveway will be paved a shoulder width from the edge of pavement and the remainder of that driveway replaced in-kind to a touchdown point.

D. New driveways provided in the plans will be paved based on the 7 percent criteria. Those 7 percent or steeper in grade will be paved and those flatter than 7 percent will be covered with base stone.

E. Any necessary paving of driveways will be done during paving operations on the main roadway.

F. Additional driveways and field entrances other than those provided in the plans shall require a permit on a state route.

1. On projects without curb and gutter, it will be the responsibility of the owner to secure a permit and to construct additional desired driveways.

2. On projects with curb and gutter, it will be the responsibility of the owner to secure a permit. After the permit has been granted, the Department will construct the driveway or field entrance through the curb and sidewalk, provided the curb and sidewalk have not been constructed. It will be the responsibility of the property owner to construct the driveway from back of sidewalk to the touchdown point.

G. On non-state routes additional driveways and field entrances other than those provided in the plans shall require a permit only if the local agency specifies the need for that permit.

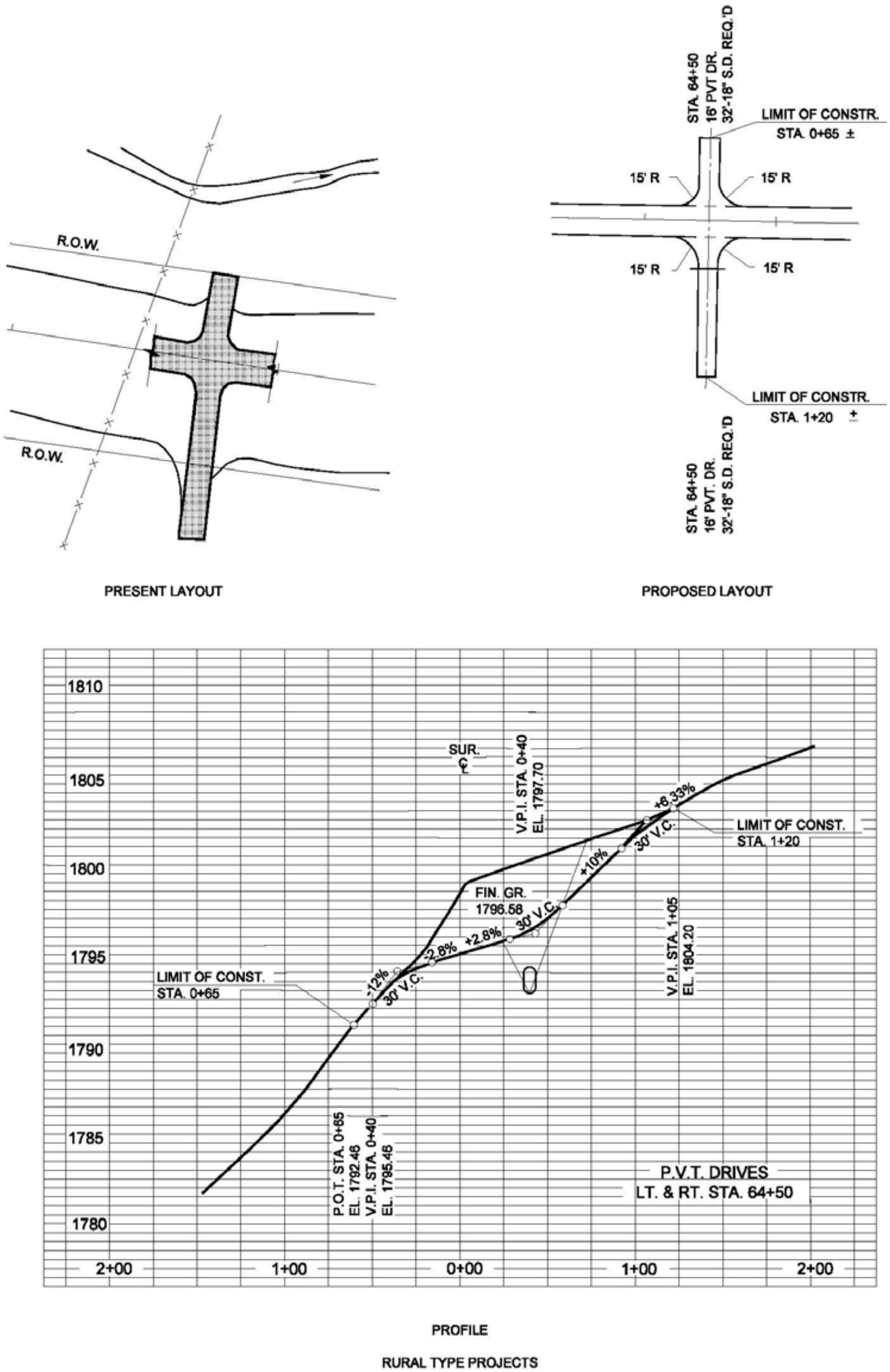


Figure 2-22
Rural Type Projects Typical Driveway Notation

Note: This figure is for layout procedure purposes only. Please refer to Manuals and Standards for design information.

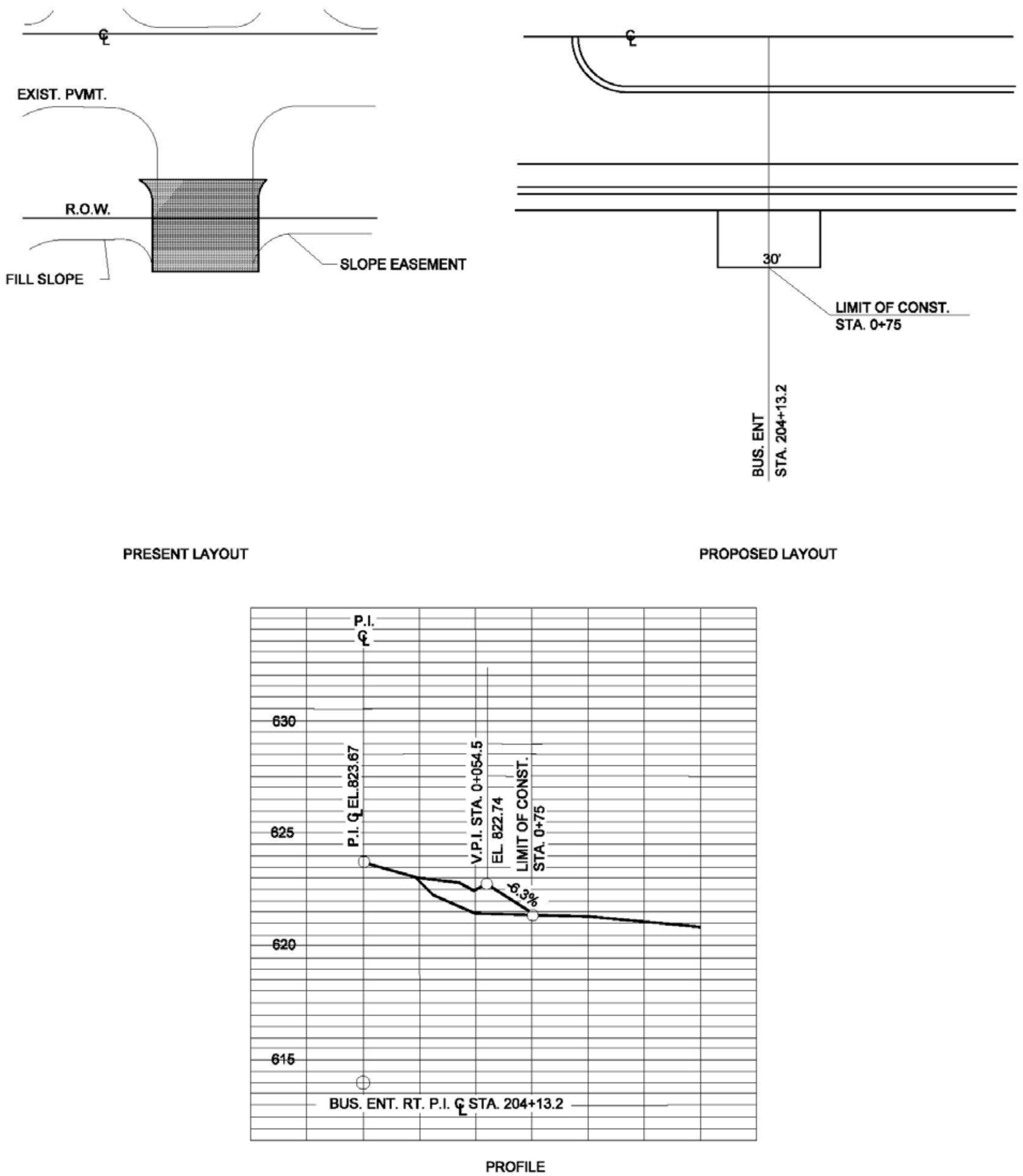


Figure 2-23
Urban Type Projects Typical Driveway Notation

Note: This figure is for layout procedure purposes only. Please refer to Manuals and Standards for design information.

BUSINESS

SURFACE – 1 ¼”

BINDER – 2”

FIELD OR RESIDENTIAL

SURFACE – 1 ½”

BINDER – NONE

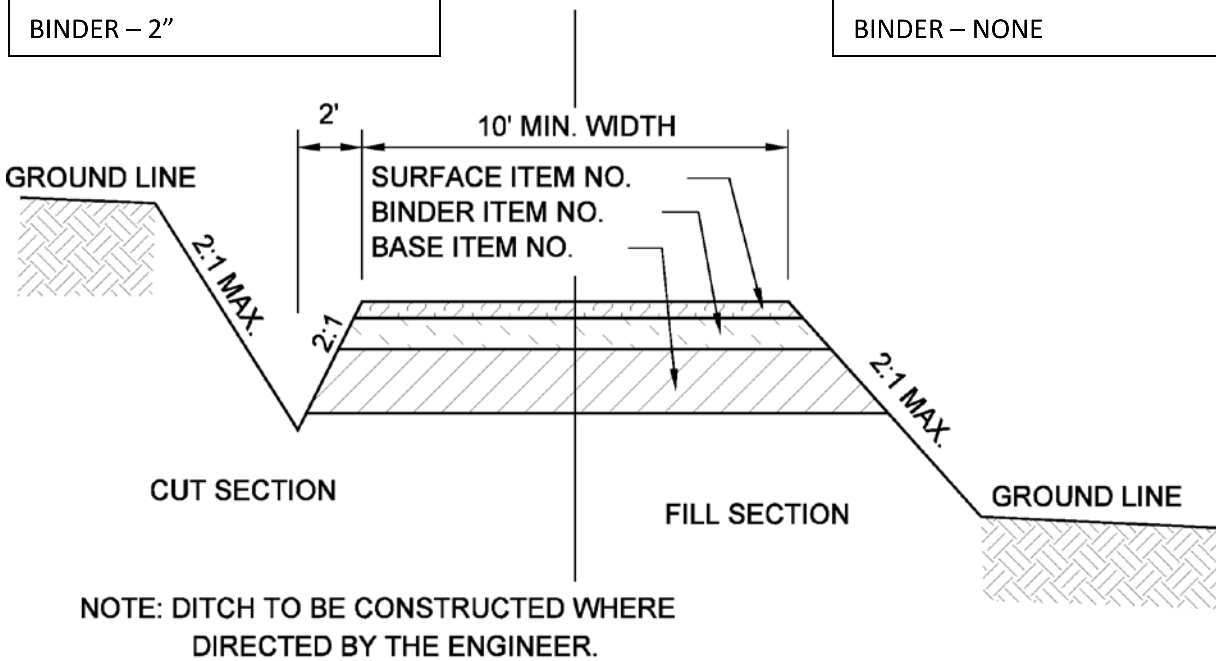


Figure 2-24
Typical Section Private Drive to Business, Field, or Residential Property

NOTES TO DESIGNERS:

1. Driveway design shall be in accordance with the State of Tennessee *Rules and Regulations for Construction of Driveways on State Highway Right-of-Way.*

2. Where surface of existing drive is concrete, substitute 6 inches of concrete for base and surface.

3. For curb and gutter sections, this typical section is to begin at the back edge of the proposed or future sidewalk. See Standard Drawings RP-D-15 and RP-D-16 for design of drives from curb line to back of sidewalk.

4. If an existing drive is greater than 10 feet, the width of the proposed drive shall be equal to the existing width; but not greater than the maximum allowable width as specified in the rules and regulations.

5. If existing drive is gravel, surfacing will be for one shoulder width. The remainder of the drive will be replaced with gravel to the touchdown point.

2-300.10 GUIDELINES FOR CONSTRUCTION AND RESURFACING OF PUBLIC ROAD INTERSECTIONS AND DRIVEWAYS ON HIGHWAY PROJECTS

I. GENERAL

This is a general guide for designers and departmental staff to use in developing project plans. Driveway installations on highway rights-of-way by individuals, firms, and corporations for each property are governed by TCA §54-5-301 through 54-5-303 and *Rules and Regulations for Construction of Driveways on State Highway Right-of-Way* (Rev. Jan. 1, 1967). Locations of driveways on new construction are also guided by the above Rules. In an effort to provide statewide uniformity, all future resurfacing, reconstruction and projects on new location shall include public road intersection and driveway construction in accordance with the provisions of this Guideline.

II. DEFINITION OF TERMS

<u>Paved Shoulder Width</u> - The width of the shoulder paved as part of the project.

<u>Paver Width</u> - The width of asphalt paving machine used on mainline paving with maximum width not to exceed 12 feet or to extend beyond right-of-way limit.

<u>Normal Right-of-Way</u> - An imaginary line which, when projected through a public road intersection, would enclose the normal slopes of the highway.

III. RESURFACING

A. Where directed by the TDOT Engineer, the Contractor shall be required to shape public side roads, business entrances, and private drives, as well as clean existing drains before placing materials. All costs are to be included in the price bid for other items of construction.

B. Resurfacing projects on roadways with shoulders and ditches (no curb or gutter):

1. All public side roads shall be paved one paver width through the intersection as a minimum. A satisfactory transition from the new pavement to the existing grade of the intersecting public road or business entrance shall be provided. Should the pavement of the intersecting public road be distressed, the resurfacing width may be increased to the normal right-of-way line.

2. Private driveways, field entrances, and business entrances will be resurfaced a paver width (lane width) as a minimum. A pavement taper to transition the new pavement shall be required, it shall be based on an additional 1 foot of width per inch depth of pavement. If the shoulder is narrow enough that the sum of the shoulder and the transition are less than a paver width (lane width), the transition shall occur within the paver width. If the sum of the shoulder and the transition is greater than a paver width (lane width), the transition shall occur outside of the paver width.

C. Resurfacing projects on roadway with urban curb and gutters

1. Public road intersections shall be resurfaced to the end of the radius. A satisfactory transition from the new pavement to the existing grade of the intersecting public road shall be provided.

2. Residential driveways and business entrances shall have a minimum width of material not less than one foot used in the transition to feather the pavement edge.

D. In all cases, the length of the pavement transition, the thickness and width of the resurfacing and any additional pavement materials shall be as directed by the TDOT Engineer.

IV. NEW OR RECONSTRUCTION

A. Facilities with Full Access Control

1. Full access control will be maintained for the entire designated project limits.

B. Facilities with Limited Access Control

1. Access will be allowed at public roads and streets only. No driveways will be permitted access to the mainline project.

C. Facilities with Partial Access Control - driveways permitted:

1. Fence Opening:

One 50-foot opening in the control access fence will be provided per tract remainder, unless access is provided from an intersecting road or based on physical conditions and/or conflicts with other design considerations, which prevent an access opening.

2. Existing Driveways:

Existing paved driveway per tract remainder will be replaced in-kind to a touchdown point.

Where the existing driveway is unpaved and the proposed driveway exceeds 7 percent in grade, each proposed driveway will be paved to a touchdown point or until the grade is less than 7 percent.

Where the existing driveway is unpaved and the proposed driveway is less than 7 percent in grade, each proposed driveway will be paved a shoulder width from the edge of pavement and the remainder of that driveway replaced in-kind to a touchdown point.

3. Requirements for field entrances and/or other driveways:

New driveways provided in the plans will be paved based on the 7 percent criteria. Those 7 percent or steeper in grade will be paved and those flatter than 7 percent will be covered with base stone.

Field entrances provided in the plans will be covered with base stone.

Normally, one field entrance or driveway, whichever is appropriate, per tract remainder will be provided except in the following circumstances:

a. In the project's preconstruction condition, there is a barrier to access such as a substantial cut, fill, ditch or curb.

b. A non-gated fence where the existing frontage is totally fenced.

c. In the project's post-construction condition, there is a substantial cut, fill, or ditch.

Also, small remainders and damage considerations are to be reviewed by the Roadway Design Division and the Right-of-Way Office to determine if a proposed driveway or field entrance is justified. The location, design and method of surfacing of the field entrance or driveway must be in accordance with the previously mentioned Rules. If the landowner does not desire a driveway, then it will not be included in the project.

4. All public roads will be paved to a touchdown point.

D. Non-Access Control Facilities

1. Existing paved driveways will be replaced in-kind to a touchdown point.

2. Where the existing driveway is unpaved and the proposed driveway exceeds 7 percent in grade, each proposed driveway will be paved to a touchdown point or until the grade is less than 7 percent.

3. Where the existing driveway is unpaved and the proposed driveway is less than 7 percent in grade, each proposed driveway will be paved a shoulder width from the edge of pavement and the remainder of that driveway replaced in-kind to a touchdown point.

4. Requirements for field entrances and/or other driveways:

   New driveways provided in the plans will be paved based on the 7 percent criteria. Those 7 percent or steeper in grade will be paved and those flatter than 7 percent will be covered with base stone.

   Field entrances provided in the plans will be covered with base stone.

   Normally, one field entrance or driveway, whichever is appropriate, per tract remainder will be provided except in the following circumstances:

   a. In the project's preconstruction condition, there is a barrier to access such as a substantial cut, fill, ditch or curb.

   b. A non-gated fence where the existing frontage is totally fenced.

   c. In the project's post construction condition, there is a substantial cut, fill, or ditch.

   Also, small remainders and damage considerations are to be reviewed by the Roadway Design Divison and Right-of-Way Office to determine if a proposed driveway or field entrance is justified. The location, design and method of surfacing of the field entrance or driveway must be in accordance with the previously mentioned Rules. Variances may be permitted due to the proximity of existing drives to property lines. No drives will be allowed in radii. If the landowner does not desire a driveway, then it will not be included in the project.

5. All public roads will be paved to a touchdown point.

To assist local governments with compliance with the Americans with Disabilities Act, it is the Department’s intent to repair or install curb ramps which meet the Americans with Disabilities Act Accessibility Guidelines whenever possible as encountered through resurfacing.

While according to TCA §54-5-202, the Department is responsible, when resurfacing or performing any maintenance work on a roadway, for work from “curb to curb”, due to the limited resources of some localities, the Department will attempt to install or repair curb ramps whenever possible and funds are available.

The local government is responsible for maintaining sidewalks, curb ramps, etc.

2-310.00 ACCESS CONTROL - CROSSROADS AT INTERCHANGES

The extent of the access control for rural highways will be 300 feet from the ramp terminal, treating each side of the crossroad independently. Thus, where the interchange ramp terminals at the crossroad are not opposite each other, the limits of access control will not be opposite; each being 300 feet from the ramp terminal which governs. For urban highways, the extent of access control shall be 100 feet.

2-315.00 TRAFFIC SIGNAL AND LIGHTING DESIGNS FOR ROADWAY PROJECTS (See 3-140.00, 3-400.05, 3-400.15, 4-145.00, 4-714.00 and 4-730.10)

The following steps are to be followed in order to assist the ITS, Traffic, and Standards Office in providing signalization and lighting designs in a timely manner as well as to allow the ITS, Traffic, and Standards Office to schedule its work efficiently.

A. When the Transportation Planning Report (TPR) indicates that signalization and/or lighting is required on a project, or if signalization and/or lighting is not included in the TPR, but there is suspicion that signals and/or lighting may be involved in a project, the ITS, Traffic, and Standards Office shall be notified by email of preliminary field review. Designers are reminded that all available design traffic data (including ADT's, DHV's, Design Speed, and traffic turning movements at all intersections) shall be included in the preliminary plans. The ITS, Traffic, and Standards Office will respond to the designer indicating where signalization is warranted, or if no signalization will be involved, give any comments pertaining to geometric improvements that will provide better operations characteristics.

B. For Right-of-Way, the designer shall notify the ITS, Traffic and Signal Design Section by email of the Right-of-Way Field Review.

   The ITS, Traffic, and Standards Office, will provide support pole and lighting pole locations and related information for the Right-of-Way Plans.

C. For Construction Plans the designer shall notify the ITS, Traffic and Standards Office by email of Construction Field Review to ensure that the latest changes will be reflected on the signal and/or lighting layout.

   The ITS, Traffic, and Standards Office, will then complete and submit final signal and/or lighting design, quantities, standard drawings, and applicable notes for Construction Plans assembly.

2-315.01 INTERSECTIONS LOCATED NEAR THE LIMITS OF CONSTRUCTION

On new construction or reconstruction projects when an intersection is located at the beginning or end limit of construction the project shall comply with the following:

A. If design of the intersection is included in the scope of the project defined by the Transportation Planning Report (TPR) the designer shall include the entire intersection (i.e. place the construction limit at a point beyond the stop bar on the far side of the intersection from the project.)
B. If design of the intersection is not included in the scope of the work defined by the TPR, the designer shall exclude the entire intersection (i.e. place the construction limit at a point no closer than the stop bar on the near side of the intersection from the project.)

C. ***In no case shall the designer place the construction limits between the stop bars of a signalized intersection.***

2-315.05 ROADWAY LIGHTING INFORMATION FOR RIGHT-OF-WAY / UTILITIES (See 3-140.00, 3-400.05, 3-400.15, 4-145.00 and 4-714.00)

When the Transportation Planning Report (TPR) indicates that lighting is required on a project, the designer shall furnish the ITS, Traffic, and Standards Office, with a set of prints and request a pole location layout. These prints shall be furnished by the designer at the "preliminary plans" stage of project development to ensure that the utility requirements will be shown on the plans for the Right-of-Way Field Review.

If there is no right-of-way acquisition required on the plans, but lighting is required, the designer shall furnish the ITS, Traffic, and Standards Office with a set of prints of the plans as soon as the present and proposed layout sheets are drawn and request the light pole locations. This is to ensure that the utility requirements will be shown on the plans for Right-of-Way plans submittal.

2-320.00 EASEMENTS - GENERAL (See 3-300.05)

The Right-of-Way Acquisition Table shall have three columns for easements. The first column shall be for Permanent Drainage Easements, the second column shall be for Slope Easements, and the third column shall be for Construction Easements.

Figure 2-25 is a model R.O.W. Acquisition Table.

Figure 2-26 demonstrates how to show various easements on the plans.

2-320.05 PERMANENT DRAINAGE EASEMENT ON PLANS (See 2-200.00)

Slope and Construction Easements shall not overlap Permanent Drainage Easements. The Permanent Drainage Easement shall extend from the Right-of-Way and have precedence over other easements.

Permanent drainage easements may be appropriate for channel changes and realignments or ditches where no ditch existed before the proposed project.

Permanent drainage easements will be required for ponding occurring outside the right-of-way, as discussed elsewhere in this document.

On urban curb and gutter roadway sections, when catch basins must be located outside the right-of-way line to eliminate ponding or when a cross drain pipe and headwalls are installed outside the right-of-way line, permanent drainage easements shall be set up for these structures. Good engineering judgment must be exercised regarding the amount of drainage easement taken.

Riprap, for the protection of proposed structures that are outside of the right-of-way, shall be located within a permanent drainage easement.

There may be isolated instances where permanent drainage easements may be required for other reasons. In these instances, the Right-of-Way Division's concurrence shall be required.

R.O.W. ACQUISITION TABLE

TRACT NO.	PROPERTY OWNERS	COUNTY RECORDS				TOTAL AREA (ACRES)			AREA TO BE ACQUIRED (ACRES)			AREA REMAINING (ACRES)		EASEMENT (ACRES)		
		TAX MAP NO.	PARCEL NO.	DEED DOCUMENT REFERENCE BK.	PAGE	LEFT	RIGHT	TOTAL	LEFT	RIGHT	TOTAL	LEFT	RIGHT	PERM. DRAINAGE	SLOPE	CONST.
1	BERT C. NICHOLSON	42	8	16	142	19.72		19.72						0.113		
2	GINGER BURCHETT	42	9	24	216		11.3	11.3						0.276		0.077
3	GLENN LADD	42	10	38	123		3.10	3.1								149 S.F.
4	IRENE S. MONK	42	11	77	289		30.01	30.01		8.993	8.993	21.017		(1) 0.630	0.035	(3) 0.461
5	ROBERT L. BRYANT	42	12	63	220	773.66		773.66	9.031		9.031	764.629		(2) 0.296	0.225	(4) 0.791
6	ZACK FARRIS	42	13	79	249									240 S.F.		0.024
ACQUISITION TOTALS (ACRES)									9.031	8.993	18.024			1.320	0.261	1.356

DISTURBED AREA

IN BETWEEN SLOPE LINES	20.136 (AC)
15 FOOT WIDE STRIP (OUTSIDE SLOPE LINES)	7.263 (AC)
TOTAL DISTURBED AREA	27.399 (AC)

(1) INCLUDES 0.375 AC. FOR WINGWALLS
(2) INCLUDES 0228 AC. FOR WINGWALLS
(3) DOES NOT INCLUDE 0.492 AC. FOR SINK HOLE REPAIR
(4) DOES NOT INCLUDE 0.261 AC. FOR SINK HOLE REPAIR. INCLUDES 0.070 AC. FOR SEDIMENT FILTER BAG.

NOTE: EASEMENT AREAS SHOULD BE SHOWN IN ACRES AND NOTED AS SUCH WHEN GREATER THEN 0.1 ACRES SQUARE FEETAREAS ACUIRED AND REMAINING SHOULD BE SHOWN IN SQUARE FEET AND NOTED AS SUCH WHEN LESS THAN 0.1 ACRES. IN URBAN PROJECTS THE PREDOMINANT UNITS FOR AREA ACQUIRED AND REMAINING SHOULD BE SHOWN IN SQUARE FEET.

Figure 2-25
Typical R.O.W. Acquisition Table

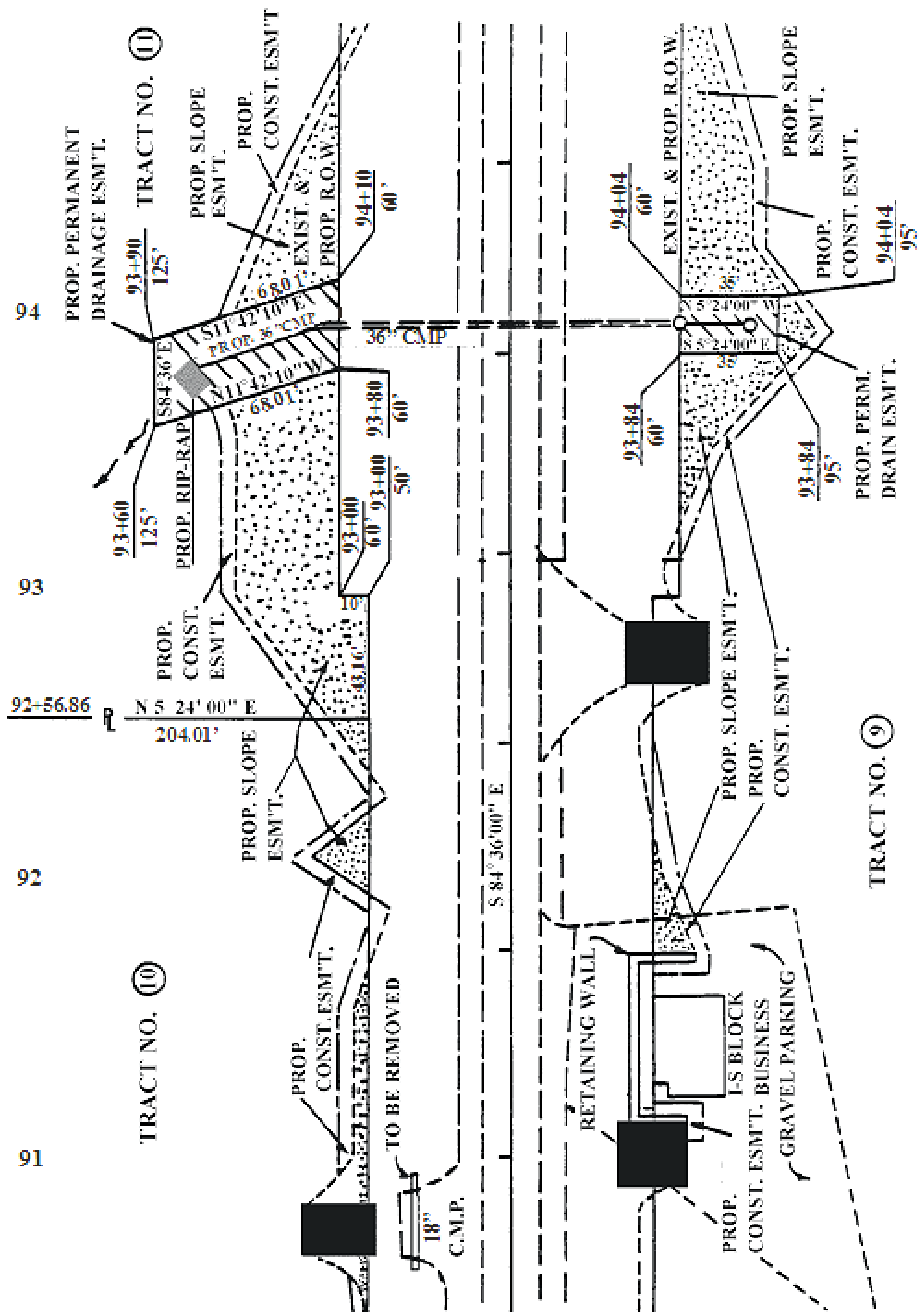


Figure 2-26
Guide for Showing Various Easements in Plans

2-320.10 SLOPE EASEMENTS

The Slope Easement column shall contain only that area outside the right-of-way, required for slopes.

2-320.15 CONSTRUCTION EASEMENTS

All easement areas that do not go in the Drainage Easement or Slope Easement columns, such as detours, some drainage ditches and channel improvements (such as widening or bank stabilization with riprap), locations where a ditch or channel already exists, sediment basins and other erosion prevention and sediment control areas, working room for retaining walls and permanent easement on railroad right-of-way, shall be placed in the construction easement column and footnoted as appropriate.

A 10-foot construction easement, for working outside slope easements, is to be shown on the plans sheet. This construction easement may be reduced or eliminated as necessary to avoid trees, buildings, etc. It may be necessary to increase the easement size to allow for pollution control structures and high fills.

2-320.20 PRELIMINARY RIGHT-OF-WAY ESTIMATE FROM PRELIMINARY FIELD REVIEW PLANS

Design will provide preliminary acquisition areas and slope easement areas to the Right-of-Way Division so that a preliminary right-of-way estimate can be developed. Design managers will be responsible for furnishing a copy of the R.O.W. Acquisition Excel File with acquisition areas and slope easement areas prior to scheduling the preliminary field review.

Designers shall calculate preliminary areas using the following procedure:

1. Calculate acquisition areas and slope easements with MicroStation's Measure Area tool using the Points or Flood methods. It is not necessary to store areas in the GEOPAK GPK file nor should time be spent defining shape elements in MicroStation for area calculations.

2. In the **R.O.W. Acquisition Excel File** provided by Survey and includes owner and tract information; enter the calculated square foot areas on the "DES IN" worksheet.

3. Make a copy of the Excel file and rename it using the State Route Number, County and Pin Number followed by the extension .xls. **Example: SR1Knox405132.00.xls**

4. Consultants shall provide the Excel file to the Design Manager. For projects developed in-house, the designer should submit the excel file to the email address listed below with a copy of the email being sent to the Design Manager.

5. Submit the Excel file via email as an attachment to Preliminary.acquistiontable@tn.gov. Subject line for email should be Preliminary Areas-State Route #, County, PIN. **Example: Preliminary Areas, SR 1, Knox County, PIN 405132.00.** A copy of the email shall be placed in the project folder to document the submittal of preliminary acquisition and slope easement areas.

2-325.00 RAILROADS (See 1-210.00, 1-210.05 and 1-210.10)

2-330.00 FIELD REVIEW PROCEDURES (See 1-120.00)

CHAPTER 4 - GUIDELINES FOR DESIGN OF ROUNDABOUTS

2-400.00 GENERAL ROUNDABOUT DESIGN PRINCIPLES

TDOT roundabout designs should consist of either a single lane or multi-lane facility for both urban and rural settings. The design of a roundabout requires balancing the needs of the existing and proposed traffic in a given location with providing intersection control that is efficient and user friendly for the traveling public. The design should provide for reduced and consistent speeds throughout the intersection. This will enhance both safety and operational performance at the intersection.

At a minimum, all TDOT roundabouts should follow these basic design principles:

- Provide a yield at all entry points
- Yield right-of-way to circulating vehicles
- Counterclockwise vehicular traffic passes to the right of the center island
- Splitter islands at all approaches providing channelized approaches
- Entry deflection required to control speed
- Maintain consistent speeds throughout
- Limit pedestrian traffic to designated locations at the approach legs
- Parking and private driveways prohibited within the circulatory roadway
- Provide proper sight distance, marking, signing, and visibility

Roundabout designs are site specific to each individual intersection and should not be considered as a template to be used at other locations. The designer should be aware that there is not an absolute design for any given site. Each proposed location will require new information and analysis and may contain site specific design issues to overcome during the project development process.

The basis for these roundabout Design Guidelines is the Federal Highway Administration's (FHWA) Report No. FHWA-RD-00-067, *Roundabouts: An Informational Guide*, dated June 2000. Available on-line, this document is widely considered the most comprehensive guide for planning and designing roundabouts; however, the designer should not consider this document as the rule book for proper design. Other supplemental information and standards of practice have been adopted for these Design Guidelines.

2-405.00 GENERAL ROUNDABOUT DESIGN CONSIDERATIONS

2-405.05 DESIGN SPEED AND DESIGN VEHICLE SELECTION FOR ROUNDABOUTS

A roundabout operates most effectively when the final design results in a desired speed reduction and a consistent speed is maintained throughout the intersection. Design speed is fundamental to attaining desired operational performance at the intersection. The design speed of a roundabout is determined from the fastest vehicle path allowed by the geometry. Geometric and other design features should be properly selected and checked to ensure speeds are appropriately reduced at the approach, entry, circulating lanes, and exit of the intersection. A combination of all design elements working together is ultimately how the final design speed will be dictated. Table 2-6 provides the recommended design speed based on the type of roundabout.

Roundabout Type	Recommended Entry Design Speed R1 (mph)
Urban Single Lane	20
Urban Multi-Lane	25
Rural Single Lane	25
Rural Multi-Lane	30

Table 2-6
Recommended Entry Design Speed (R1) for Roundabouts
Reference: FHWA, *Roundabouts: An Informational Guide, 2000*

The choice of design vehicle should be based on the type of roadway, volume and type of vehicles expected, and the intersection location. For the purpose of most TDOT designs, the AASHTO WB-62 vehicle should be used for designing roundabouts, especially those located on the state highway system, freeway or other controlled access facility ramp terminals, or industrial areas where a high percentage of truck traffic is expected. The circulatory roadway width should readily accommodate a WB-50 design vehicle without the need to track onto the truck apron; however, larger vehicles (WB-62, etc…) are expected to track onto the truck apron.

In cases where a roundabout is being located in an area with minimal truck traffic, or where the roundabout is being located on an urban collector, local road, or where community sensitive design parameters are being used for design, the WB-50 design vehicle may be used for the entire design, including the turning movements check at the truck apron. Where over-sized trucks are expected, the designer may want to consider designing the roundabout for a legal vehicle larger than the WB-62.

The design vehicle should be accommodated while maintaining a minimum 2-foot separation between the truck and the curb face. Additionally, the designer should be aware that for multi-lane roundabouts, large trucks rarely track within the circulatory lanes marked on the pavement and may utilize both lanes, or possibly both lanes *and* the truck apron, while attempting to navigate through the intersection.

2-405.10 HORIZONTAL ALIGNMENT CONSIDERATIONS FOR ROUNDABOUTS

All approaching roadway centerlines should pass near the center of the proposed circle, as close to a 90 degree angle as possible when projected across the intersection. This configuration should allow for necessary entry deflection without creating severe horizontal curvature or reduced stopping sight distance. The designer should attempt to achieve this configuration on most projects. Where this is not possible at an approach, the designer may offset an approach centerline to the left of the circle’s center. It is not recommended that any approach leg to a roundabout be offset to the right of the circle’s center. A right-of-center layout will result in the alignment entering at a greater tangential angle and may lead to higher entry speeds, greater potential for vehicle roll-over, and increased pedestrian conflicts.

Where feasible, the designer should attempt to equally space entries into the circulatory roadway. For new facilities, adjustments to the approaches in advance of the roundabout may be required. For urban roundabouts, the ability to provide equally spaced entries may not always be possible, especially when existing intersecting roadways are skewed from the mainline. When considering adjustment to approaches the proposed right-of-way cost should be factored into the final design decision. Where estimated right-of-way and construction costs are excessive, the roundabout design may be eliminated.

2-405.15 LONGITUDINAL GRADE CONSIDERATIONS FOR ROUNDABOUTS

An important factor when determining the optimum location of a roundabout is the longitudinal (profile) grade passing through the intersection. A relatively flat area with minor grade changes for drainage is preferred. The longitudinal grade through a roundabout should be limited to a maximum of 4 percent. Flatter longitudinal grades are preferred. Longitudinal grades in excess of 4 percent are not recommended due to the increased potential for load shifting within semi-trailers traversing the intersection, especially on the down-slope side of the central island, which can result in overturning of the vehicle.

Where a longitudinal grade cannot be designed less than 4 percent, the designer should consider benching the roundabout into a localized flat area and steepening the roadway approaches to the intersection. The design should accommodate for the steeper approach grades by providing adequate braking distance.

Large differences in grades through and around a roundabout can create sight distance problems; refer to the sight distance design criteria in Section 1-225.20 for more information. Roundabout sight triangles should be approximated during the preliminary design stage since they are different than for a normal intersection. Having proper sight triangles is essential to roundabout operation and performance.

2-405.20 RIGHT-OF-WAY REQUIREMENTS FOR ROUNDABOUTS

The purchase of right-of-way may be a determining factor when locating a roundabout. As compared to a traffic signal or a stop-controlled intersection, roundabouts usually require more right-of-way closer to the intersection and less right-of-way further away. Roundabouts designed in tight urban areas where building corners and/or right-of-way corners are close to the intersection may require additional right-of-way so that required sight distances are achieved. Additional right-of-way may also be required to alleviate skewed entries, accommodate multi-lane roundabouts, provide for right-turn bypass lanes, or maintain required intersection sight distances.

If there is a possibility for future expansion of a roundabout from a single lane to a multi-lane facility, the designer should consider designing the roundabout to a multi-lane standard with provisions for expanding the initial roundabout included in the design. The intersection may be opened as a single lane roundabout and then enlarged toward the central island and splitter islands at a later date. Expansion should normally be inward, so the designer should provide an adequately sized inscribed circle diameter and splitter islands if future expansion is expected.

2-405.25 CONSIDERATIONS FOR HIGH SPEED APPROACHES AND RURAL LOCATIONS FOR ROUNDABOUTS

High speed approaches and rural roundabout locations require additional attention because of the need for speed reduction of the approaching vehicles. Any approach to a roundabout with a posted speed of 45 mph or greater should be considered a high speed approach, even if the project site is located in an urban or urbanizing area. At these locations, drivers may not be anticipating a roundabout or any other type of speed interruption. Drivers should be able to discern the impending intersection configuration and react to changing operational needs. Providing sufficient entry deflection is one of the most important design parameters for roundabouts with high speed approaches.

At high speed approaches or rural locations the designer may consider additional speed reducing design elements including:

- Providing visibility of the roundabout from a greater distance.
- Adding reverse curvature at the high speed approach leg. The reverse curves should have a broad radius at the first curve, moderate at the second, and a sharp radius at the last curve before the yield line. See Section 6.5 in FHWA *Roundabouts: An Informational Guide*, for a graphical representation.
- Alignment and cross-sectional cues to alert drivers of the pending change in geometry such as longer splitter islands for additional deceleration length (see AASHTO recommendations for required braking distance), adding curb or curb and gutter to both sides of the approach, and a transition section where the shoulders narrow for the curbed section.
- Additional signs and pavement markings to supplement geometric features, landscaping features to produce a “tunneling” effect, and roadway lighting.

Standard AASHTO guidelines for island design should be followed for the splitter island designs. This includes using larger nose radii at approach corners to maximize island visibility and offsetting curb lines at the approach ends to create a funneling effect. The funneling treatment also aids in reducing speeds as vehicles approach the roundabout.

For rural locations where a roadway shoulder is being used for a bike route or for urban areas designated as a bike lane, the shoulder should not continue through the roundabout. The roadway shoulder should end approximately 100 feet prior to the yield line and a bicycle ramp should be provided to allow cyclists the option of exiting the roadway to a multi-use path around the roundabout or remaining on the roadway. Riders choosing to continue through the roundabout will be required to merge with the vehicular traffic in both position and speed. The additional lane width of the circulatory roadway should be adequate to accommodate cyclists choosing to pass through the circle. The designer should not specifically mark a shoulder or bike lane within the circulatory roadway.

2-405.30 GRADING AND DRAINAGE CONSIDERATIONS FOR ROUNDABOUTS

The optimum grading scheme for a roundabout is to slope the circulatory roadway away from the central island (i.e. the center of the central island is the highest point in the intersection). This will aid in achieving the desired visibility of the central island to the approaching motorist. The designer should accept the adverse superelevation for left turning and through vehicles in the travel lanes of the circulatory roadway.

While each location will be unique, grading a roundabout to slope away from the central island should follow these general guidelines:

- The ground slope of the central island should not exceed 6H:1V (per AASHTO *Roadside Design Guide*).
- The central island earthen area should always be raised, not depressed.
- The slope of the truck apron should not exceed 4 percent and should normally be between 2 and 3 percent, away from the central island. When the entire intersection is placed on a constant longitudinal grade, special attention should be given to ensure that the slope of the truck apron on the down-grade side of the center circle does not exceed 4 percent. Apron cross-slopes above 4 percent may lead to roll-over or load shifting within trucks.
- Roadway cross slope of the circulatory roadway should be a maximum of 2 percent sloping away from the center circle. Superelevation sloping toward the central island will normally result in increased vehicle speeds and will additionally result in the need to place stormwater inlets along the truck apron.
- The maximum grade in any direction of travel along the circulatory roadway should be 4 percent.

The designer should note that by sloping the entire intersection away from the central island, visibility is improved since the center of the circle becomes the highest point in the intersection. Sloping the roadway inward is not preferred, unless the design is for a multi-lane roundabout in which one-third of the lane width can slope inwards and two thirds can slope outwards from the central island.

Stormwater runoff should be controlled to minimize sheet flow across the roundabout. The designer should consider the vehicle wheel path traveling through the roundabout when considering placement of catch basins and inlets. The most desirable location of stormwater inlets is between the entrance and exits of the roundabout. Additional inlets in the roundabout may be required and installed above the splitter islands. Concentrated storm drainage that is directed towards a roundabout should be intercepted where practical prior to entering the circulatory roadway. The designer should not place inlets or low points within crosswalks.

Drainage for the circulatory roadway should typically be toward the exterior of the intersection; away from the central island. Inlets should be placed in the outer curb line of the roundabout, away from, and up-slope, of crosswalks. When the roundabout is placed on a roadway with a constant grade that passes completely through the intersection, the designer may be required to place an inlet adjacent to the central island. In rare cases where the central island is large enough and/or contains complex landscaping plans, the designer may consider placing an area drain within the central island to minimize runoff to the roadway.

2-410.00 GEOMETRIC DESIGN ELEMENTS FOR ROUNDABOUTS

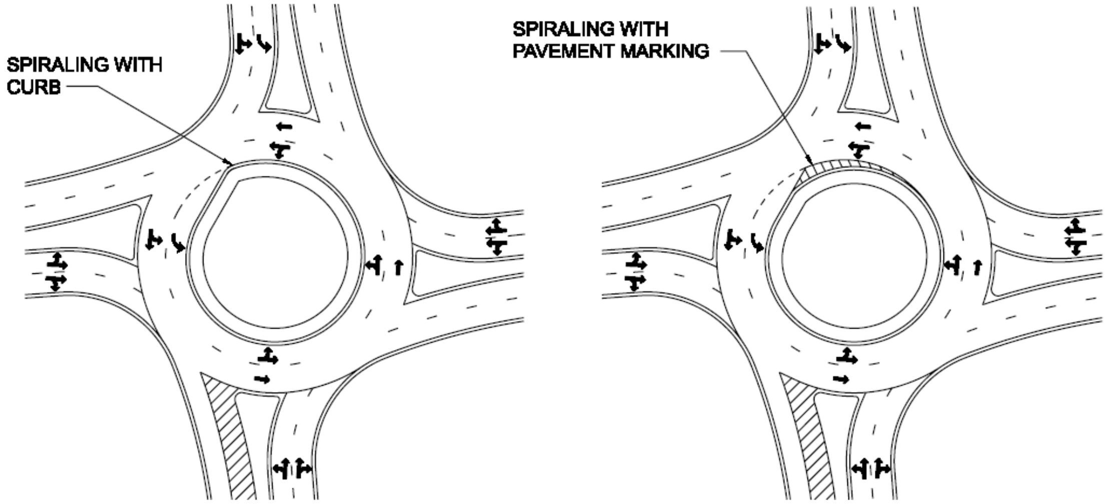
A roundabout intersection incorporates a different group of geometric elements than a traditional signal or stop controlled intersection. Roundabout design ranges should not be considered absolute. Some locations may require the designer to deviate slightly from the given design ranges on an as-needed basis. The following list of geometric features is generally considered the most basic of design elements for a simple roundabout intersection.

1. **Inscribed Circle Diameter (ICD)** is the basic diameter of the roundabout circle. The ICD is measured from curb face to curb face across the largest part of the circle. The ICD size can vary at different parts of the circle due to spirals on the inside lanes (see Figure 2-27). Larger ICDs may help to reduce circulating speeds but may also result in the need for additional right-of-way. Determining the optimal ICD size is typically an iterative process. The designer may consider making minor changes in the size of the ICD, but should also be cautioned from deviating too much from the original requirements of the roundabout traffic model. See the RD-series Standard Drawings for ICD size.

   The use of a smaller ICD may not adequately allow for the WB-62 to make a left or u-turn. Ultimately, the design vehicle selected will have a direct influence on the ICD, especially for single lane roundabouts where the ICD is most influenced by the vehicle selected. While a truck apron is required at all roundabouts, the width of the truck apron may be larger when the ICD is small.

2. **Circulatory Roadway Width** is the travelled way width of the roadway for vehicles circulating around the central island. This width is typically measured from the curb face at the central island to the edge of the gutter of the ICD. The width of the circulatory roadway is directly dependent on the entry width into the roundabout, and is typically designed to be 1.0 to 1.2 times as wide as the width of the largest entry. The circulatory roadway width does not include the mountable truck apron.

   Spirals are used to lead vehicles into their proper lane within the circulating roadway and are effective in keeping vehicles in the proper lane as they traverse the roundabout. A spiral is either a hard raised surface or painted line that develops at the central island and continues “spiraling out” until it ties into a circulating lane. Spirals should be considered for use when multiple left-turning lanes are present so that turning movements and through movements do not overlap. Figure 2-27 depicts two options for providing spirals when used in a design at a multi-lane roundabout.



Spiral with Extended Central Island (Preferred) | Spiral with Pavement Marking (Acceptable)

Figure 2-27
Spirals for Multilane Roundabouts

3. **Entry Deflection** is the curvature (deflection) of the roadway as the roadway enters the roundabout. Deflection is used as a passive speed control measure for entering vehicles and should be applied prior to the yield line. Proper and adequate entry deflection promotes reduced entry speed and speed consistency. Deflection also positions the entering vehicle so that the driver can see the circulating vehicles already in the roundabout. Entry deflection has a direct correlation with fastest path speeds, phi angle, truck turning movements, and path overlap, and will ultimately affect all aspects of a roundabout. Deflection is also critical for preventing wrong way movements at the entries.

   If the computed speed at the entry (the speed corresponding to the R1 critical path radius – see Figure 2-30) is high, the designer should consider increasing the entry deflection. To gain additional area for entry deflection, the designer can offset the roadway alignment of the approach leg to the left of the circle center. When used, a left-of-center offset is particularly beneficial to achieving desired deflection at roundabouts with small ICD's.

   Entry Width is the width of the entering travelled way as it approaches the roundabout after the flare length has ended (flare length is the distance from approach width to entry width). Entry width is the largest determinant of a roundabout's capacity and has a direct correlation to the fastest path measurement and truck turning movements. The most accurate location for measuring entry width is typically at the end of the splitter island, beginning at the intersection of the yield line and the left edge of the travel way, measured to the right edge of travel way. This measurement should be taken perpendicular to the right (exterior) gutter. Design ranges for entry width are provided on the Standard Drawings.

4. **Entry Radius** is the radius of the curve that leads vehicles into the roundabout. The entry radius is measured at the face of the outer curb line. The designer should use a

radius that is small enough to reduce vehicle speeds, but not so small that vehicle turning movements are compromised. Acceptable ranges for entry radius can be found on the Standard Drawings.

5. **Exit Width** is the width at the exit roadway from a roundabout measured from curb face to curb face. The exit width should correlate with the upstream entries and circulating roadway width to ensure that it is wide enough. The designer should ensure that the exit width provided is not too narrow for vehicles as they attempt to leave the roundabout, resulting in possible delays. In general, the exit width should be no less than the entry width and it should transition to the full width cross-section of the receiving roadway.

6. **Exit Radius** is the radius of the curve that leads a vehicle out of the roundabout. The radius is measured along the face of the outer curb line. Exit radii are generally larger than entry radii to allow for smoother exits and minimize the potential for delays; however, to ensure low speeds at the downstream crosswalk, the exit path radius should not be significantly greater than the circulatory path radius either. Ideally, the exit curve should be tangential to the circulatory roadway. Design ranges for exit radius can be found on the Standard Drawings.

7. **Approach Width:** The approach width is the width of the approach leg prior to the flare length. The approach width, or half width, is measured from edge of travel way to edge of travel way.

8. **Right-Turn Bypass Lanes (Slip Lanes):** An exclusive lane used to accommodate a high right-turn volume; whereby, allowing right-turning traffic to bypass the roundabout. See Figure 2-28 for a schematic of a typical right turn bypass lane. In areas that have a high volume of pedestrian traffic, additional attention should be given to the design of the right turn bypass lane to allow for pedestrians to have the right-of-way. The designer should consider other options for accommodating anticipated right-turn volumes prior to using a bypass lane in an urban environment due to the potential for high pedestrian volumes. However, in some cases, the need for a multilane roundabout may be eliminated by providing a right-turn bypass lane.

   For rural roundabouts, right-turn bypass lanes may be considered when their need is warranted. When used, the designer should accommodate for greater vehicle speeds in the bypass lane and an increased risk to pedestrians crossing the quadrant of the intersection where the bypass lane is to be located. The project designer should examine the present and projected pedestrian and bicycle demand at the rural location under consideration, and properly design pedestrian crossings, signalization, and signing at the bypass lane.

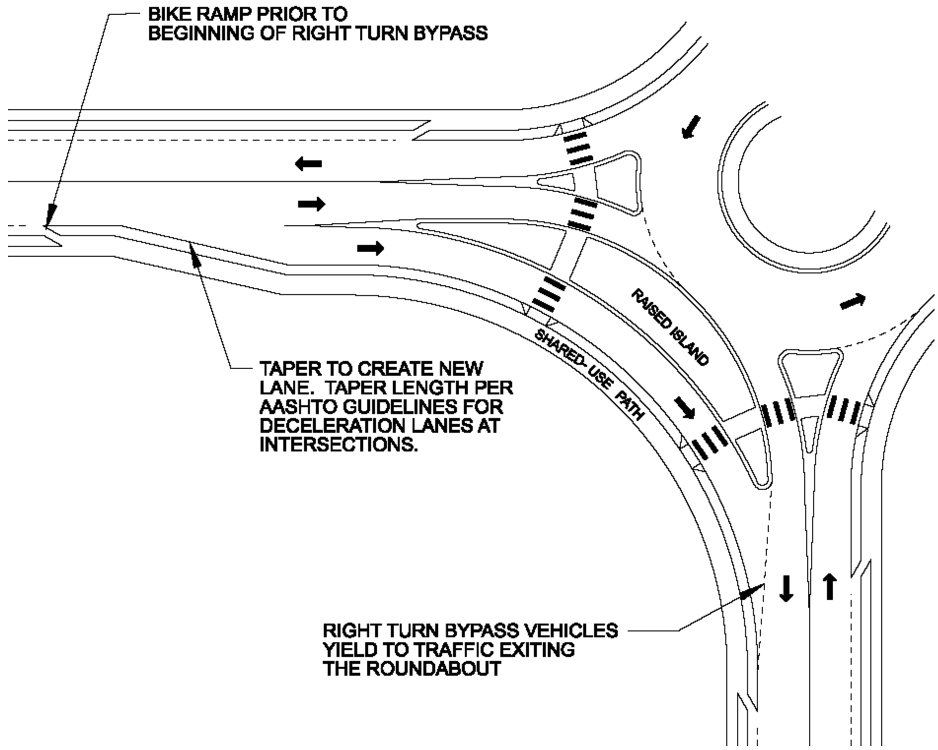


Figure 2-28
Typical Right-Turn Bypass Lane

Where a bypass lane is used, the following design criteria should be considered:

- Run a fastest path check through the bypass lane so that the bypass lane does not produce excessive speeds. Vehicle speeds in the bypass lane should be similar to those in the roundabout.
- Once a vehicle is committed to using the bypass lane, the design should not allow for access back into the circulating roadway.
- Minimizing the radius of the bypass lane may provide greater safety for crossing pedestrians; however, the design vehicle should be checked on all aspects of the bypass lane geometry.
- Traffic exiting the roundabout should be given the right-of-way over traffic exiting any bypass lanes. Providing a yield-controlled entrance onto the adjacent exit roadway from the bypass lane is required.
- In rural locations where right-of-way is available, an acceleration lane with appropriate taper rates based on AASHTO guidelines is the preferred merging method at the end of the bypass lane.
- Pedestrian crossing points should be designed per ADA guidelines in addition to the other requirements found in these roundabout guidelines.
- Proper lighting should be provided, where applicable.

Bypass lanes can potentially add a significant amount of required right-of-way area to the intersection design. The final decision to use a bypass lane should take into account pedestrian and right-of-way constraints. Proper analysis should ensure all right-turn bypass lanes have been justified prior to proceeding with a detailed design.

9. **Truck Apron:** A mountable circular concrete pad along the outer edge of the central island used to accommodate turning movements of larger vehicles. The truck apron is designed to allow the rear tires of large vehicles to traverse the apron as they are making through and left turn movements. The width of the truck apron should be in the range of 6 to 10 feet. Final truck apron design (width) should be based on truck turning analysis (design vehicle tracking) plus a recommended buffer of 2-feet in width for driver irregularity. Truck aprons should not be less than 6 feet wide.

   The truck apron shall not be flush with the traffic lanes nor merely painted on the roadway surface. Truck aprons are not intended for passenger vehicles or small trucks; therefore, a mountable curb that provides enough vertical grade difference should be used so as to appear unappealing to the driver of a smaller vehicle.

   It is preferable that the design of the truck apron provide a color or surface texture contrast from the circulatory roadway. This should normally be accomplished with an asphalt roadway and a concrete truck apron. Where the roadway surface is to be concrete, the designer may consider the use of stamped or colored concrete or brick pavers to achieve this contrast. The use of asphalt on the truck apron should be avoided.

2-420.00 ROUNDABOUT DESIGN CHECKS AND MEASUREMENTS

Roundabouts are generally considered a passive form of intersection control. Roundabouts create a situation in which drivers are expected to slow down as they enter the intersection through the use of visual cues and roadway geometry. Since a roundabout does not require a vehicle to completely stop, the design should ensure that vehicle speeds are reduced as the vehicle enters the roundabout. Vehicles entering at a slow, consistent, and controlled pace are essential to roundabout design, safety, and operation.

Design checks are measurements that are taken on various geometric elements of a roundabout to verify that the design will have sufficient entry angles, proper deflection and speed reduction, adequate area for turning movements, and adequate sight distance. Design checks are also necessary to show that the desired capacity and speed will be maintained for the types of vehicles that are expected to use the intersection. The design check process is essential to a roundabout design. Verifying the design through the use of design checks can be a tedious process, but is necessary for proper roundabout design.

The following design checks should be performed for proper roundabout design:

1. Fastest Path – The measure of a single vehicle's shortest (smoothest) path through a roundabout given the absence of any other traffic and given that the driver ignores all lane markings, traverses the entry, and travels around the central island and through the exit. In order for the designer to determine the maximum expected vehicle speeds at, and through the roundabout, fastest path measurements should be calculated. The fastest path should be measured at all approaches to a roundabout and should include path analysis for all left-turn, right-turn, and through movements at the intersection (i.e. a total of 12 measurements for a 4-leg intersection). Under certain circumstances, the critical

path may be the right-turn movement; however, in most cases it will likely be the through movement. The longest of the fastest paths is typically the left-turn movement at the intersection.

Fastest path measurements are typically taken by constructing a b-spline (polyline) curve in a CADD program. The b-spline curve (See Figure 2-29) should represent the centerline of the vehicle that is attempting to traverse the roundabout at the highest rate of speed possible while ignoring other vehicles, pedestrians, pavement markings, and signing. Three b-spline curves should be constructed for each approach into a roundabout.

When laying out a b-spline curve, the designer should use an assumed width for a vehicle of 6 feet and to maintain a minimum of 2-feet of clearance from the roadway centerline or any curb face. When constructing b-spline curves for the centerline of the vehicle path, maintain the following minimum offset distances:

- 5 ft. from face of a concrete curb (2' clearance + 3 ft to center of vehicle),
- 5 ft. from a roadway centerline, and
- 3 ft. from a painted edge line (if no curb is present).

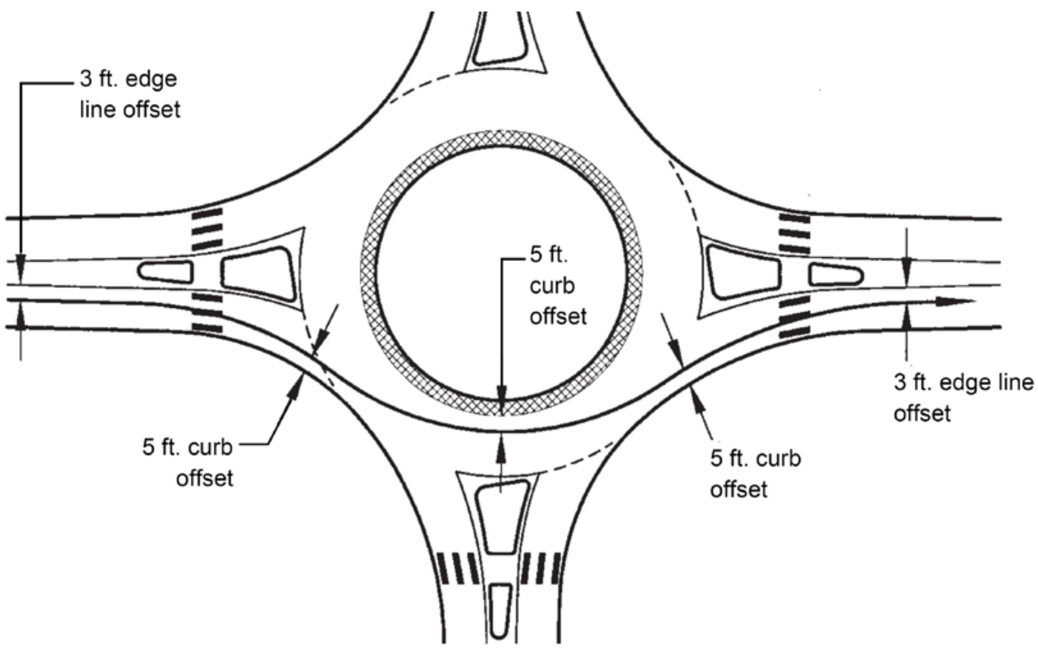


Figure 2-29
Fastest Path for Through Movement at Single Lane Roundabout
Adapted From: FHWA, *Roundabouts: An Informational Guide*

The through movement b-spline curve (as shown above in Figure 2-29) will be constructed to represent a vehicle entering a roundabout, passing to the right of the central island, and exiting the roundabout on the opposite side of the circle. The left-turn movement b-spline curve will be constructed to represent a vehicle entering a roundabout and making a left turn-around the central island. The right-turn movement b-spline curve will be constructed to represent a vehicle entering a roundabout and then making an immediate right-turn out of the roundabout. These movements are depicted in Figure 2-30.

Once the designer has constructed b-spline curves for the through, left-turn, and right-turn movements for each approach to the roundabout, corresponding speeds can be computed from each critical (minimum) path radius measured along the b-spline curve. The five critical path radii in a roundabout are:

- R1 - The minimum radius on the through movement b-spline curve, typically measured prior to the yield line, but not more than 165’ prior to yield line.
- R2 - The minimum radius on the through movement b-spline curve measured in the circulatory lanes around the central island.
- R3 - The minimum radius on the through movement b-spline curve measured at the exit to the roundabout.
- R4 - The minimum radius on the left-turn b-spline curve measured in the circulatory roadway around the central island.
- R5 - The minimum radius on the right-turn b-spline curve. Measured at the tightest point.

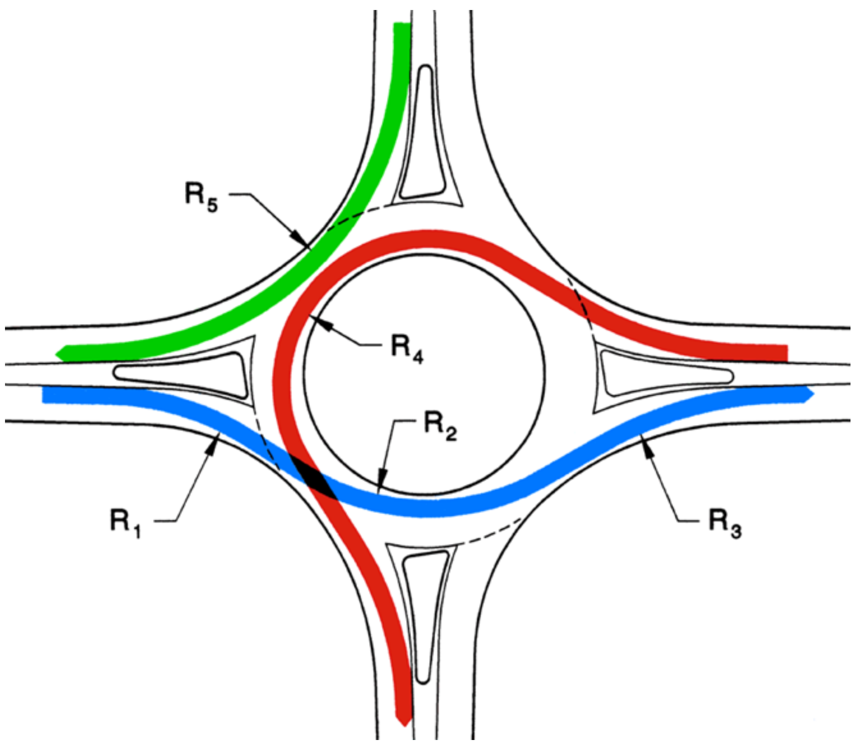


Figure 2-30
Critical Path Radii at a Roundabout
Reference: FHWA, *Roundabouts: An Informational Guide*

It should be noted that critical path radius does NOT equal curb radius. Each critical path radius should be measured in a CADD program; generally the designer can draw a new curve on top of the b-spline curve in order to measure the critical radii. Speeds should be recorded for all critical radii. Once the critical path radii are measured the designer can determine the corresponding speed associated with each critical path radius using methodology in AASHTO's *A Policy on Geometric Design of Highways and Streets*. Figure 2-31 correlates the measured radius to a computed speed using the AASHTO methodology.

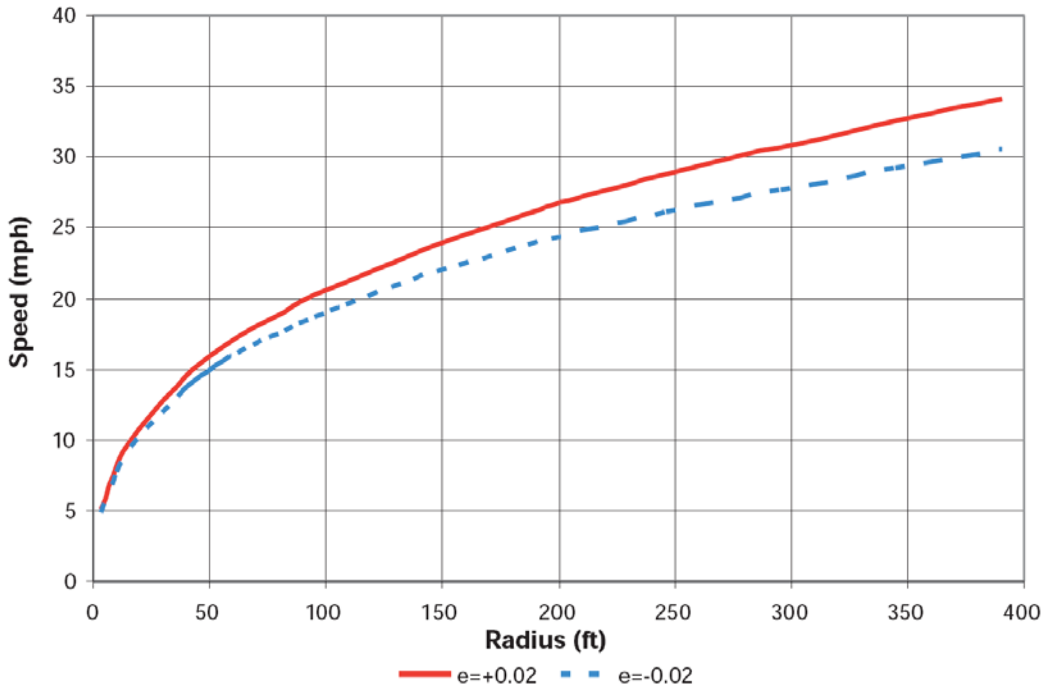


Figure 2-31
Speed-Radius Relationship
Reference: FHWA, *Roundabouts: An Informational Guide*

Figure 2-31 gives the designer an estimate of the maximum speeds through the roundabout at various locations: entrance, circulatory roadway, and exit. Use the +0.02 curve for measurements at the entry and exit (R1, R3, and R5) and use the -0.02 curve for those around the central island (R2 and R4).

Speed consistency is critical and should be checked between all fastest path measurements. The designer should attempt to minimize variations in vehicular speeds. If one path has a speed differential significantly higher than the other paths, that movement will tend to control the roundabout and the lower speed movements will be affected with longer queues. A speed differential of no more than 6 mph is preferred between all paths. Since this may not always be possible, a speed differential of 12 mph shall be considered the maximum allowable. It is preferable for R3 to be greater than R2, and R2 to be greater than R1 (i.e. the entrance has the lowest speed).

When the initial design will not produce adequate speed consistency, the designer has several options for consideration to remedy the situation. The following is a list of options that the designer may consider to correct a speed control problem:

- Adjust the size of the inscribed circle diameter a few feet, either making it smaller or larger as needed.
- Adjust the entry radius by a few feet by either making it smaller or larger.
- Re-design the entry or exit so that the entry angle changes, thus creating more or less deflection as needed.
- Move the entire circle in one direction to increase or decrease the entry deflection.
- Re-evaluate the modeling to determine if a different lane configuration will be acceptable.

Designers should be aware that any change to a geometric element will affect the previously computed roundabout design checks and all checks will need to be re-evaluated after geometric changes are made.

2. Phi Angle – The angle measured between the entering and exiting roadways or in the case of a three legged roundabout, it is the angle measured between the entering and circulatory roadway. When the angle is measured between the entering and exiting roadways, the actual phi angle is half the angle measured. In the case of an angle being measured between entering and circulatory roadways the phi angle is the angle measured.

   Phi angle is typically measured as a design check to verify that the entering roadway, in relation to the nearest exiting roadway, allows a driver to see oncoming traffic within the circle, without the driver having to turn their head in an uncomfortable position. When a driver approaches the yield line, the roundabout geometry should allow for the driver to see oncoming vehicles within the circle without having to look over their left shoulder excessively; whereby producing driver discomfort. Acceptable values for the phi angle typically range from 16 to 40 degrees.

3. Path Overlap – A critical design issue for multi-lane roundabouts occurs when the natural paths of entering and exiting vehicles in adjacent lanes overlap or cross each other. This occurs when a vehicle enters a roundabout and is directed into an adjacent lane once inside the circulatory roadway as shown in Figure 2-32. The existence of path overlap should be checked at both the entrance and exits.

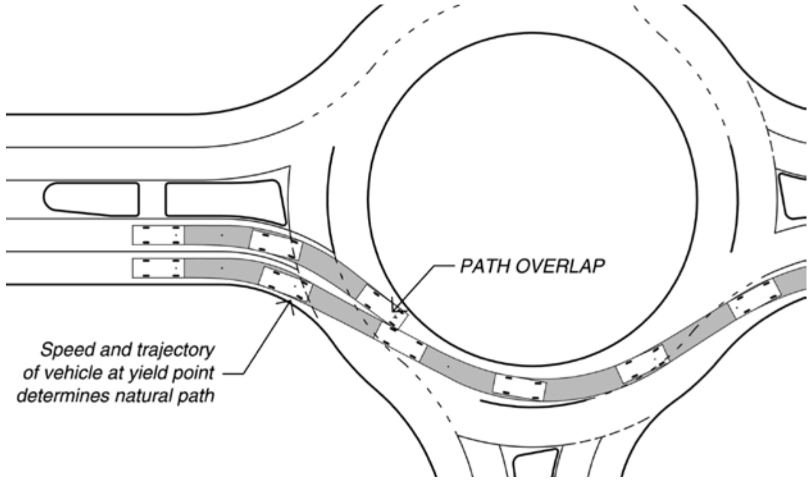


Figure 2-32
Example of Vehicle Path Overlap
Reference: KDOT, *Kansas Roundabout Guide*

Larger exit radii and/or tangential exits will aid in reducing the potential for exit path overlap. The designer can minimize the potential for entry path overlap by providing adequate entry deflection and ensuring multi-lane vehicle entry paths are properly aligned with the circulatory lanes ahead at the yield line. To accomplish this, the designer should locate the entry curve so that the projection of the inside entry lane at the yield line connects tangentially, or nearly tangentially, to the curb line ahead at the central island, as see in Figure 2-33.

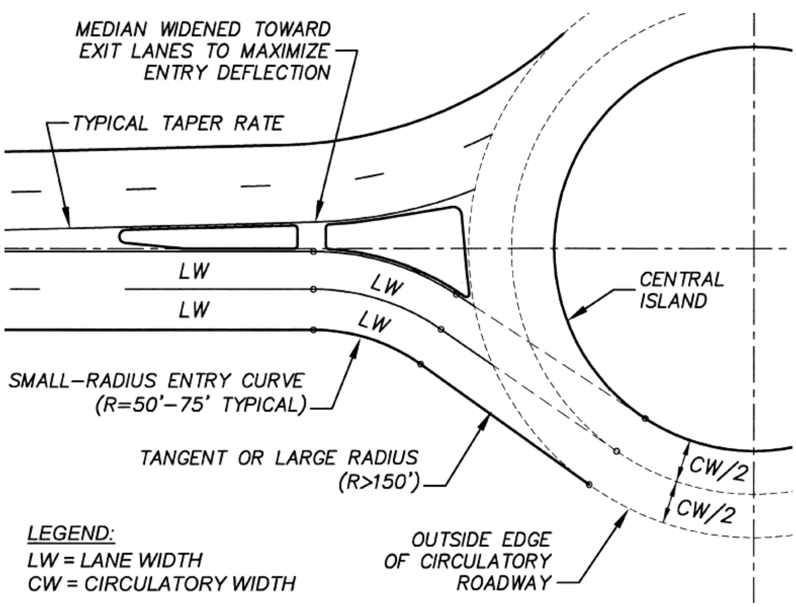


Figure 2-33
Good Path Alignment into Multi-Lane Roundabout
Reference: FHWA, *Roundabouts Technical Summary (FHWA-SA-10-006)*

Multi-lane roundabouts should be designed to minimize the potential for entry and exit path overlap which results in reduced operational performance due to unbalanced lane utilization on the approach. The designer should be particularly aware of path overlap, since it can lead to a higher rate of side-swipe collisions and may be adverse to the desired capacity of the roundabout. FHWA's *Roundabouts: An Informational Guide, 2000*; provides additional suggestions for eliminating path overlap at a multi-lane roundabout.

4. Truck Turning Movements – Truck movements should be reviewed for all roundabout designs to verify that the design vehicle can properly navigate all required turns. The right-turn movement tends to be the most challenging movement for a truck. The roundabout should be designed so that the truck tires do not track over the exterior concrete curbing or combined curb and gutter for the right-turn movement, nor over the splitter island curbing at the entry and exits. Trucks that are continuing through the roundabout or making a left turn can use the truck apron within the central island.

   TDOT roundabouts should be designed to accommodate a WB-50 vehicle within the traffic lanes, with the WB-62 design vehicle (or larger) expected to have to track over the truck apron. The truck apron at the central island will allow larger vehicles to track around the central island.

5. Stopping Sight Distance/Intersection Sight Distance – Key elements to safety and operating speed of a roundabout. There are three critical types of stopping sight distance that should be measured at roundabout intersections. Approach stopping sight distance, stopping sight distance on the circulatory roadway, and stopping sight distance to a crosswalk. These distances are normally measured to verify that there are no obstructions within the sight lines (triangles). Refer to FHWA's *Roundabouts: An Informational Guide* or the Standard Drawings for diagrams on the proper method for measuring stopping sight distance.

   When measuring intersection sight distance there are two conflicting approaches for a vehicle entering the roundabout. Intersection sight distance with the conflicting upstream entry and intersection sight distance within the circulatory roadway should be determined. Each should be checked independently and each should be measures along the expected vehicular path on the roadway, not as a straight line. While studies have shown that providing the minimum intersection sight distance may actually aid in speed reduction at some locations; for TDOT projects, speed should be controlled with geometric and other design elements, <u>not</u> by means of limiting sight distance. See Section 1-225.10 for additional speed reduction design elements.

   Stopping sight distance to crosswalks should be verified for both the entry and exit of the roundabout; especially at the exit crosswalk. NCHRP (Report 572, 2007) studies have shown that a higher percentage of drivers do not yield to pedestrians at the exit when compared to the entry. The proper design of the exit is essential to ensure adequate sight lines are provided between the driver and the pedestrian and that speeds are held to the desired amount. The designer should consider additional design features that will provide improved safety to pedestrians at crosswalks.

The roundabout design process should be considered an iterative process throughout the design. There may be several acceptable designs for a given location that will meet the desired performance objectives; however, this is rarely achieved on the first design iteration. Because of this, it is advisable that the designer prepare the preliminary layout drawings to a "sketch" level of detail. Design components are interrelated, and changing one affects others, so it is important that the designer evaluate the performance of the entire intersection design as changes are made to ensure that the individual components are compatible. If a change is made to one component of a roundabout design such as the ICD size, angle of approaches, or lane width, the designer should verify that other components of the roundabout will still meet the design criteria.

The flow chart in Figure 2-34 provides the general procedure and steps for designing a typical roundabout.

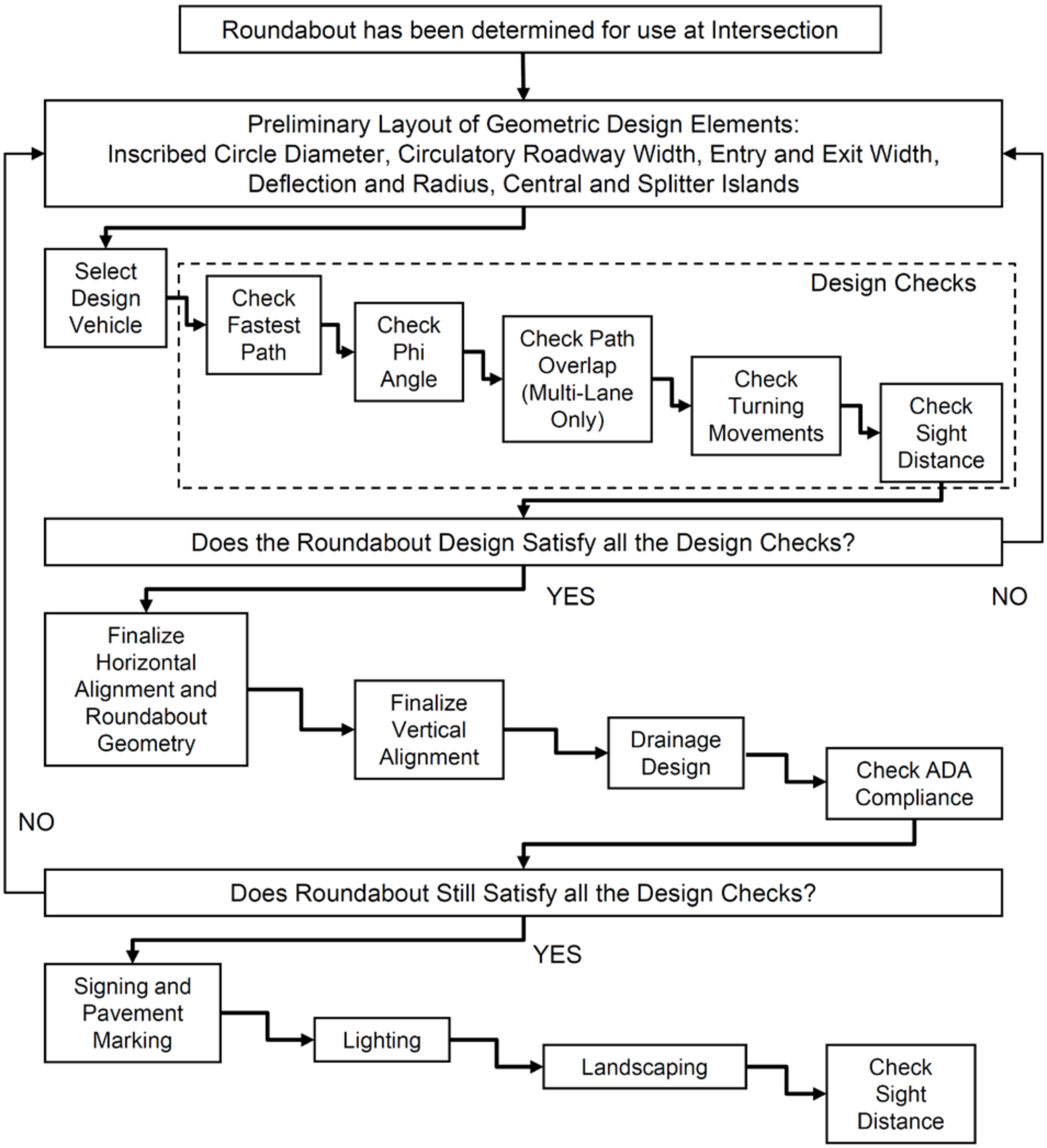


Figure 2-34
Typical Roundabout Design Procedure

2-430.00 ROADWAY DESIGN CONSIDERATIONS FOR ROUNDABOUTS

2-430.05 DETERMINING ROUNDABOUT LOCATION

For projects utilizing a roundabout for intersection control, optimum location, project goals, and system considerations should be reviewed before formal design begins. These additional design considerations should take into account existing and proposed grades, availability and cost of right-of-way, proximity to other intersections (especially signalized intersections), railroad crossings, intersecting roadway skew angles, and private driveway locations.

2-430.10 ROUNDABOUT PROXIMITY TO OTHER INTERSECTIONS

Roundabout proximity to other types of intersection control should be considered when determining a location for a roundabout. The typical spacing between intersections where one or more of the intersections is a roundabout, will generally be shorter than a series of signalized or stop controlled intersections. There is no absolute minimum distance between a roundabout and another intersection. In order to determine a satisfactory distance, a queue length evaluation should be completed prior to commencing with design. This queue length evaluation should include all queue lengths associated with the roundabout and any adjacent signalized or stop controlled intersections.

2-430.15 ACCESS MANAGEMENT AND PRIVATE DRIVEWAYS AT ROUNDABOUTS

Parking will not be allowed within the circulatory roadway of roundabouts designed by the Department. The designer should attempt to minimize or avoid locating on-street parking areas within the splitter island area or within the transition to the splitter island. For new designs, parking should be terminated a minimum of 75 feet from the yield point, which is at the entrance to the circulatory roadway.

Where driveways are present, the designer should consider methods for locating private driveways outside of the roundabout, so that a vehicle cannot take direct access to the circulatory roadway from the private property. Additionally, the designer should avoid providing private driveways anywhere within the vicinity of the splitter island. Where this is unavoidable, the driveway connection should be designed with a small raised island restricting traffic to a right-in/right-out movement, and the designer should check for proper sight distance to the left of the driveway for vehicles entering or exiting the roundabout. For most TDOT projects, driveway access between the crosswalk and yield line at the entrance (or exit) to the roundabout will not be permitted except under extraordinary circumstances.

Bus stops should be located as far away as possible from the entries and exits and should not be placed within the circulatory roadway or within the area of the splitter islands. Pedestrian crossing areas at the splitter islands should not be used for bus stop locations.

2-430.20 RAILROAD CROSSINGS AT ROUNDABOUTS

Roundabouts should not be designed at a location where the existing railroad line will pass through the center circle (or any portion) of the roundabout. The exception to this will be where an existing intersection is being reconstructed, and an existing rail line currently passes through the intersection. Even in this case, the designer should explore all options for re-locating the roundabout to a location that the rail line crosses only one leg in proximity to the roundabout. In all cases involving a project in close proximity to a railroad track, the designer should acquire a queue length evaluation to ensure that vehicles will not queue onto the active rail line. Other options to minimize the possibility of a vehicle being on the railroad track is to pre-empt the roundabout with gates or flashing beacons at all the entrances and the exit feeding to the railroad track.

2-430.25 SERIES OF ROUNDABOUTS

Roundabouts should be evaluated for installation along a corridor, because they have advantages and disadvantages over traditional signalized corridors and may provide for design flexibility in urban and developing areas. Traffic and planning studies should be evaluated before considering a corridor containing a series of roundabouts. Each roundabout in a corridor or ramp interchange should be designed as a completely new intersection, just as a designer would treat a series of signalized intersections.

Roundabouts typically tend to have a higher capacity and lower delays than a traditional signalized intersection. This leads to shorter travel times through roundabout corridors than through signalized corridors.

2-430.30 ROUNDABOUTS USED AT INTERCHANGES

Roundabouts may be considered as an acceptable design option for intersection control at interchange ramp locations. Unlike a typical stop or signal controlled interchange, roundabouts generally require less space between ramps. This may save on right-of-way costs when considering a new interchange, especially when right-of-way is constrained or when the interchange is located near a narrow structure such as an underpass or overpass. Additionally, when designing a roundabout in close proximity to an interstate or other controlled access route approved for large trucks, the WB-62 design vehicle should be used for analysis.

Sight distance should be a significant design parameter when designing tightly spaced roundabouts at interchanges. The designer should verify that bridge abutments, piers, and/or bridge railings do not interfere with sight distance requirements. A full traffic analysis should be performed before a roundabout is considered at an interchange since roundabouts will be closely spaced. Additionally, an analysis should be performed to verify that required and appropriate signing can be adequately provided and visible to motorists at both new and retrofitted interchange locations.

2-440.00 PEDESTRIAN, BICYCLE, AND ADA CONSIDERATIONS FOR ROUNDABOUTS

The number of pedestrian/vehicle conflict points is reduced when a roundabout is used for intersection control. Since a roundabout may not have pedestrian signal phases or pedestrian push-buttons, and does not require vehicles to make a complete stop, other measures should be designed to ensure drivers and pedestrians are clearly able to see each other. Proper design should produce conditions needed to allow vehicles to yield to the pedestrians and at a reduced speed.

Since a goal of any roundabout is to reduce speeds without actually stopping the vehicles, a properly designed roundabout will reduce the risk of pedestrian/vehicle collisions due to the slow speeds expected. There are design elements that may be beneficial to pedestrian safety when designing the crosswalks at a roundabout. The following general design criteria should be considered for crosswalks at roundabouts:

- Minimized crossing distance to reduce pedestrian exposure to traffic.
- Where possible, crosswalks should be designed to provide pedestrians a straight walking path across the traffic lanes (90 degrees to traffic flow preferred), including any right-turn bypass lanes. This may not apply to small single lane approaches where a straight crossing route can be provided regardless of splitter island or roadway deflection.
- To minimize out-of-direction travel for pedestrians, crosswalks should be located as close as possible to the intersection while still maintaining required queue space for vehicles. A mid-block pedestrian crossing near a roundabout is not recommended.
- At single lane roundabouts, crosswalks should typically be located one vehicle length (approximately 20 feet minimum) behind the yield line; this gives the driver at the yield line the ability to concentrate on entering the roundabout.
- For multi-lane roundabouts crosswalks may be located one vehicle length behind the yield line. A designer may need to “bend” crosswalk alignments at the splitter island, where necessary to provide 90 degree crossings at the entrance/exit lanes where possible.
- Splitter islands should be a minimum width of 6 feet at the narrow end of the island – 9.5 feet preferred. The refuge area (gap) within the splitter island should be 10’ long. Therefore the minimum dimensions for the refuge area should be 6’ x 10’. See the Standard Drawings.
- The finished grade of the pedestrian crossing (refuge) areas within the splitter islands should be at or slightly above the elevation of the adjacent pavement. The designer should avoid elevating the refuge area except the minimal amount needed for proper drainage.

Additional details for crosswalks can be found on the Standard Drawings. The Standard Drawings for handicap ramps provide details for ramps at the exterior curb cuts for crosswalks. The splitter island refuge area should be wide enough to accommodate multiple modes of pedestrian traffic including side-by-side wheelchairs, bicycles with trailers, pedestrians, and pedestrians with baby strollers.

Accommodating designs for visually impaired and disabled pedestrians should be a priority at roundabouts since those pedestrians tend to rely on audio signals more than other pedestrians. Roundabouts generally do not require audio devices for pedestrian crossings, but in special cases they may be needed at a roundabout. In addition, detectable warning surfaces should be provided at all paths, including the splitter island refuge area, leading to any traffic lane. The Roadway Design Divison’s handicap ramp Standard Drawings and roundabout Standard Drawings provide detectable warning surface details. All pedestrian facilities should be designed to comply with the latest version of the Americans with Disabilities Act.

The TDOT bicycle and pedestrian policy requires consideration be given to providing provisions for bicycles to be integrated into new construction and reconstruction of roadway projects through design features appropriate for the context and function of the transportation facility.

Bicyclists should be given a choice when approaching a roundabout of either going through the roundabout and mixing with the vehicles in the circulatory stream, or exiting the roadway prior to entering the roundabout and continuing around the roundabout on a shared-use path (sidewalk) with pedestrians. To optimize safety and the most efficient operation of the roundabout, bicyclists should be provided with shared-use paths around the perimeter of the roundabout. For the purposes of most TDOT design projects, the designer should provide bike ramps for exiting the roadway to the shared use path, and then ramps for re-entering the roadway, bicycle lane, or roadway shoulder on the opposite side of the roundabout.

The bicycle exit ramp (the ramp the bicyclist uses to exit the roadway prior to the roundabout) should be provided prior to the pedestrian crossing or at least 100' prior to the yield line, whichever of the two is greater. At the exits, a bicycle entrance ramp should be provided after a pedestrian crosswalk or 100' from the exit, whichever is greater.

Bicycle ramps should be a minimum 6' wide between the roadway and the shared-use path. This width will be large enough to accommodate a bicycle pulling a child cart, but small enough to prevent a vehicle from using it. The bicycle exit and entrance ramp should typically be placed at a 20 to 45 degree departure angle from the roadway. A perpendicular bicycle ramp is not recommended since it would require a bicyclist to stop their forward momentum as they exit (or enter) the roadway. See the Standard Drawings for details of bicycle entrance and exit ramps.

Where cyclists prefer to pass through the roundabout, the designer should treat them as a vehicle in the circulating stream. Any designated bike lanes on the approach to the roundabout should be terminated a minimum of 100 feet upstream of the yield line. This will allow the bicycle to mix with the traffic, both in lane position and speed. Specific pavement markings for bicycles should not be present within the circulatory roadway.

If the roundabout is being designed at a location where there is a designated shared-use path, the design should include those geometric features detailed on standard drawing RD-TS-8. To minimize confusion between bicycle ramps and pedestrian ramps, detectable warning surfaces should be placed at the top of the bicycle ramps rather than at the bottom as is the practice with pedestrian ramps. At rural and urban locations where current pedestrian and bicycle traffic is not significant, but expected to increase, the designer should include measures in the plans to accommodate future needs or demands. These may include:

- Rough grading the perimeter of the roundabout to accommodate future sidewalks, landscaping buffer strip, shared use paths, etc…
- Installing handicap ramps or lowered curb at logical "future" locations along perimeter curbing
- Providing cut-throughs (gaps) at the splitter islands for future crosswalks
- Obtaining adequate right-of-way to accommodate future measures including lighting

Additionally, the designer should refer to the AASHTO Guide for the Development of Bicycle Facilities, 1999.

2-450.00 SIGNING AND PAVEMENT MARKING FOR ROUNDABOUTS

The concept for signing and marking a roundabout is similar to standard intersection signing and marking. The signing and marking plan should stress proper regulatory, advanced warning, and directional guidance to provide positive guidance to the motorist. Each roundabout design will be unique, and the signing and marking plans can become complex. Signing and marking needs are different for urban and rural applications and for varying types of roundabouts.

All signing and marking plans should conform to the current edition of the *Manual on Uniform Traffic Control Devices* (MUTCD). The FHWA's *Roundabouts: An Informational Guide*, the Roadway Design Divison's *Traffic Design Manual* and the Standard Drawings may be used for additional reference or guidance for signing roundabouts and the approaches to a roundabout.

The following additional sign criteria should be considered for roundabouts over that which may be present at a normal intersection:

- Roundabout ahead signs
- Advanced diagrammatic guide signs and markings
- Yield signs on more than one approach to an intersection
- Long chevron plate typically used in the center circle
- Exit guide signs

For urban roundabouts, the design will need to balance providing adequate signing for a more familiar user of the intersection with the tendency to use too many signs. Street name signs are typically considered a necessity for urban locations. For rural applications, where higher approach speeds are expected and normal signage and geometric features will not produce the desired reduction in speed, the designer should consider the following additional measures:

- Large advanced warning signs
- Word markings on the pavement
- Speed reduction warning signs

Additional requirements for pavement markings and signs for bicycles can be found on the T-M-series Standard Drawings.

2-460.00 ROADWAY LIGHTING FOR ROUNDABOUTS

Illumination may be requested at urban and suburban roundabouts and the design should be coordinated with local officials. The lighting of rural roundabouts is recommended, but may not be necessary in all circumstances. The decision to illuminate a rural intersection should be on a case-by-case basis and will depend on factors such as availability of a power source, volume of anticipated night-time vehicular or pedestrian traffic, and available sight distance. Regardless of lighting, a roundabout intersection should be signed and marked in accordance with the *Manual on Uniform Traffic Control Devices.* The design of roundabouts can vary greatly from project to project; therefore, specific illumination guidelines and design criteria is not appropriate. When lighted, the following features and guidance should be considered by the designer for lighting a roundabout intersection:

- Roundabouts should be illuminated from the outside in towards the center circle. For vehicles approaching the intersection, this will improve the visibility of the central island and of the vehicles already in the circulating stream of the roundabout. Avoid placing light poles within the central island.
- Good illumination should be provided at the approach nose of splitter islands, all conflict areas where vehicles are entering the circulating stream, and at locations where traffic departs from the circulation to exit the roundabout.
- Pedestrian crossings and bicycle merging areas should be given special consideration. Light poles placed 10 to 30 feet in advance of a crosswalk is recommended to provide positive contrast on the pedestrians.
- Clear zone requirements from the AASHTO *Roadside Design Guide* should be considered when lighting is provided. Illumination poles or masts should not be placed within small splitter islands, on the right-hand perimeter just downstream of an exit point, or on the central island directly opposite of an entry roadway.
- In rare cases when it is desired to illuminate objects within the central island the designer should consider using ground-level lighting that shines upward and away from the nearest edge of pavement. In these cases a separate electrical disconnect should be provided for blackout protection.
- It is recommended that the approach and/or exit roadways serving the roundabout be illuminated up to 260 feet beyond the final trajectory changes at each exit, especially at rural sites where lighting is used.
- Short dark areas between a series of roundabouts or dark areas between an illuminated roundabout and an existing illuminated roadway section should be avoided.

On projects developed for the Department with proposed lighting, the designer (or consultant) should forward a set of preliminary plans to the Signal and Lighting Office to determine the need (if any) for lighting, level of illumination, and pole locations at the time of the preliminary plans submittal.

2-470.00 LANDSCAPING GUIDELINES FOR ROUNDABOUTS

Properly designed landscaping typically increases the efficiency of the roundabout and improves safety of the circulatory intersection. For urban areas, landscaping may be requested by the local entity to enhance the aesthetics of the intersection. Landscaping can improve intersection performance and safety for the following reasons:

- When used at the right and/or left of the approaches, vehicle speeds are typically reduced due to the tunneling effect perceived by motorists.
- Landscaping makes the central island more conspicuous (noticeable) to drivers; whereby indicating to the approaching driver that they cannot pass straight through the intersection.
- Properly placed landscaping obstructs the motorists view across the intersection; whereby forcing drivers to look in the standard left and right directions.
- In high pedestrian areas, landscaping will tend to channel pedestrians to designated cross-walk locations reducing unwanted pedestrian/vehicle conflict points. This is vital since roundabouts may not have pedestrian push buttons and signals.

The central island, large splitter islands, and the approaches to the intersection present opportunity for landscaping; however, the landscaping should be designed to optimize safety and operation. The designer should consider the following guidelines for developing a safe, effective, and low-maintenance landscaping plan for a roundabout:

- Maintain required stopping and intersection sight distance for the circulatory roadway around the central island. Keep the outside 6 feet of the central island (above the truck apron) free from significant landscaping features except very low-growth plants and grass (preferable) to maintain sight distance. In no case should this width be less than 6 feet; however the actual width may be greater and should be determined by computing the required circulatory roadway and intersection sight distances.
- Avoid landscaping in splitter islands except where the island is long and/or exceptionally wide. When used, the maximum height of landscaping features at maturity should not exceed 30 inches measured from the nearest pavement edge to the tallest point of the mature vegetation, including the curb height. See RD-SD-2.
- Consider low maintenance, drought resistant grasses and hearty plant material in the raised center island, larger splitter islands, and buffer strips. Minimize fixed objects (trees, large boulders, walls, etc…) in as much as possible. Avoid trees with large canopies. The central island should be considered similar to a median, with all objects being breakaway.
- Splitter islands can be hardscaped (concrete, textured concrete, brick pavers, etc…) to reduce maintenance and maintain required site distances. A hardscaping that is different from the sidewalk or shared-use path is recommended to ensure that pedestrians and bicyclist do not confuse the splitter island with a sidewalk.
- The designer should avoid placing benches, street furniture, or plaques and monuments with small text in the central island so as not to attract pedestrians to the center island.

When landscaping is requested by the local government, the designer should coordinate with the local agency for development of the landscaping plans and for specific landscaping features that may be requested at the intersection, especially for those located in urban or historic districts. Additional guidance regarding landscape design may be found in TDOT Landscape Design Manual.