Alabama Speed Management Manual

October 2015

Alabama Department of Transportation

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FOREWORD REGARDING SPEED ZONING MANUAL

This MANUAL supersedes all previous speed management and policy manuals; however, it is not intended to be a substitute for engineering judgment, knowledge, or experience. It provides information and general concepts for ALDOT and outside agencies. References to other documents are provided for awareness of the availability of other information; however, the content is the responsibility of the respective authors.

Chapter 1

Introduction

1.0 Purpose and Responsibility

1.1 Introduction and Background

1.1.1 Manual Objective

The purpose of this manual is to provide guidelines and a framework for establishing realistic and credible regulatory speed zones on the state highway system. Speed zoning aids in balancing the two primary objectives of transportation systems – mobility and safety. This balance is accomplished by establishing speed limits that are acceptable to a majority of motorists, reducing the likelihood and potential severity of crashes, and are self-enforcing. The key to determining speed limits that accomplish these objectives is conducting a comprehensive engineering and traffic investigation. This manual explores the approach and methodology required for this type of study when performed on Alabama roadways. By doing so, it provides a consistent approach in conducting speed studies on all types of roadways in the state.

This manual is intended as a guide for entities that have authority to set speed limits on a roadway. This theory and methodology is required of the Alabama Department of Transportation (ALDOT) and local governing agencies when establishing speed limits along state roadways. Additionally, it is advisable that local agencies conduct speed studies according to the procedures in this manual as the recommended practice.

PURPOSE OF MANUAL

THIS DOCUMENT COMBINES INFORMATON, GUIDANCE AND RECOMMENDED PROCEDURES THAT PROVIDES UNIFORM SPEED ZONING AND ADVISORY SPEEDS ON STATE, MUNICIPAL, AND COUNTY ROADWAYS IN ALABAMA

USERS OF MANUAL

THIS DOCUMENT IS INTENDED FOR USE BY ENTITIES WITH AUTHORITY TO SET SPEED ZONES ACCORDING TO TYPICAL ENGINEERING PRACTICE

RESPONSIBILITIES OF ENTITIES FOR SETTING SPEED ZONES ON STATE ROUTE

ALDOT MAINTENANCE – MONTGOMERY
    Review and approve region speed zoning recommendations
ALDOT REGIONS – STATEWIDE
    Conduct engineering study to establish speed zones
MUNICIPALITES – STATEWIDE
    Request REGION to conduct engineering study and or conduct it according to these procedures
COUNTIES – STATEWIDE
    Request REGION to conduct engineering study and or conduct it according to these procedures

1.1.2 Alabama Speed Policy, Laws, and Strategic Highway Safety Plan

ALABAMA SPEED POLICY

The mission statement of the Alabama Speed Policy, last updated September 3, 2008 is as follows:

"To reduce deaths, injuries and the economic cost due to speed-related crashes, through enforcement, engineering, education, emergency medical services, legislation, setting realistic and credible speed limits, research and adjudication."

The Speed Policy is based on the following problem statement:

Speeding is a significant threat to public safety and warrants priority attention.

The Policy identifies some cost-effective strategies for decreasing speed-related crashes that include:

- Targeting enforcement to locations with high numbers of speed-related fatal and injury crashes.
- Setting realistic and credible speed limits based on engineering studies.
- Understanding the problem: who speeds, where, when, and why.
- Using multi-agency, multi-disciplinary processes, assessment, techniques and technologies, including conducting multi-agency, multi-disciplinary field investigations of locations with high numbers of speed-related fatal and injury crashes.
- Providing public information and education on the risks and consequences of speeding, especially at locations with high numbers of speed-related fatal and injury crashes.
- Proposing legislation.
- Fair and consistent adjudication of speeding citations.
- Modify or reinforce speed management programs, based on the results of impact and effectiveness.

APPLICABLE ALABAMA SPEED LAWS
The basic Speed Law(s) for the State of Alabama are shown below:

Alabama State Statutes 32-5A-170 and 32-5A-171

Basic Speed Rule: No person shall drive a vehicle at a speed greater that is reasonable and prudent under the conditions and having regard to the actual and potential hazards.

Require Statutory Speed Limits:
- Urban District – 30 mph
- Unpaved road – 35 mph
- County-maintained paved road in an unincorporated area – 45 mph
- Highways (except Interstate Highways or highways with > 4 lanes) – 55 mph
- Interstate Highways (4 or more lanes) – 70 mph
- Highways with 4 or more lanes – 65 mph
- Vehicles carrying hazardous cargo – 55 mph

STRATEGIC HIGHWAY SAFETY PLAN (2nd Edition)
A Strategic Highway Safety Plan (SHSP) is a "statewide-coordinated safety plan that provides a comprehensive framework for reducing highway fatalities and serious injuries on all public roads" (Federal Highway Administration, December 2010)[1]. Alabama's SHSP 2nd Edition seeks to reduce the number of crash-related fatalities and injuries in the state by adopting the Toward Zero Deaths (TZD) approach to improving roadway safety. The American Association of State Highway and Transportation Officials (AASHTO) embraced the TZD initiative[2] to achieve its own fatality-reduction goals. The TZD approach presents the concept that, while engineering and design are important factors, drivers' decisions have the most impact on roadway safety. Therefore, a major component of SHSP 2nd Edition focuses on plans and methods to help improve the mindset and safety culture of Alabama's drivers.

The SHSP 2nd Edition states that the majority of the vehicular fatalities and injuries in the state can be ascribed to three factors: speeding, alcohol use, and lack of seatbelt use – all of which are based upon decisions of individual drivers. Efforts focused on driver education and awareness of speeding and other harmful behaviors are instrumental in helping to reduce speed-related deaths and will help change the safety culture in Alabama. The "Take Back Our Highways Campaign," which addresses speeding and drunk driving through greater enforcement, is one of the SHSP 2nd Edition's priority strategies that will continue to be promoted in the State. Properly designed speed zones and the appropriate application of design manuals and standards also play an important role in the advancement of safety.

Focus Area 2 in the SHSP 2nd Edition specifically advocates the development of a speed management program as a supporting program under infrastructure countermeasures.

[1] http://safety.fhwa.dot.gov/hsip/shsp/
[2] http://safety.fhwa.dot.gov/tzd/docs/tzd_summary_v3.pdf

SHSP 2nd Edition FOCUS AREAS

FOCUS AREA 1: Driver Behavioral Related Crashes

- Speeding
- Alcohol Use
- Lack of Seatbelt Restraint

FOCUS AREA 2: Infrastructure Countermeasures thru Engineering

- Categorically assess intersection safety issues
- Segments – Implement program to minimize departure crashes
- Segments – Maintain vehicles on road by guiding traffic movements
- Supporting Programs (Speed Management)

FOCUS AREA 3: Legislative Initiative

FOCUS AREA 4: Traffic Safety Information Systems

FOCUS AREA 5: Safety Stakeholder Community

1.1.3 Impetus for Speed Management Manual

This Speed Management Manual is a direct result of the combined focus of Alabama speed policy, speed laws, and the safety strategy of the SHSP 2nd Edition. It provides a basis to set speed limits uniformly, based on an engineering evaluation. The best process of setting speed limits uses a rational and defendable procedure to command the respect and confidence of the public, law enforcement, and legal entities.

1.2 Fact-Based and Rational Speed Limits (Prima Facie Concept)

1.2.1 Basic Speed Rule: Reasonable and Prudent

The Basic Speed Rule is outlined in Alabama State Statute § 32-5A-170[3], as is true for all states, Alabama's rule is based on the *Uniform Vehicle Code (UVC)*. The general premise behind the nationally accepted Speed Rule is that the majority of people are law-abiding citizens whose day-to-day actions are generally reasonable and prudent in nature.

Specifically, the Basic Speed Rule and Speed Limits should adhere to the Prima Facie Limits concept. That is, Prima Facie speed limits are those that "on its face" or "on the face of it", are reasonable and prudent under normal conditions. It is those individuals (i.e., statistical outliers or non-typical) who are outside of that majority that necessitate the need for laws and regulations, and enforcement is consequently directed toward their actions.

The Rule states that no person shall drive a vehicle at a speed greater than is reasonable and prudent under the conditions and shall have due regard for actual and potential hazards. Although it is not feasible to set speed limits that take into account every potential hazard that may confront a motorist, speed management can be used to make the public aware of maximum speed limits that adhere to the Basic Speed Rule under normal or preferred circumstances. It is up to drivers to adjust their speed as physical or environmental conditions arise so that reasonable and prudent

[3] http://alisondb.legislature.state.al.us/ACAS/CodeOfAlabama/1975/32-5A-170.htm

speeds are maintained at all times. As practical, drivers are notified of needed speed adjustments through advisory speed signs, intersection approach signs and other signs on horizontal or vertical alignments, regardless of the posted speed on a roadway, as the fundamental speed rule always govern.

1.2.2 Appropriate Speed Limits and Speed Management

The most effective way to increase safety for all modes of transportation is speed management, which can be broken down into four key components: engineering, education, enforcement and adjudication. Balance among the four components encourages effective and sustainable speed management; and it begins with the establishment of realistic, consistent and credible speed limits. To improve credibility, speed zones and speed limits should be established on the basis of an extensive engineering study and traffic investigation. Using sound engineering principles for speed management will make public education and outreach, enforcement, and adjudication easier to implement and more effective.

Properly applied speed zoning aids in achieving the following:

- Helps drivers adjust operating speeds to conditions.
- Makes enforcement easier and more effective by providing law enforcement officials with a reasonable indication of what constitutes an excessive speed.
- Produce fewer variations in speed ranges.
- Reduce the frequency and severity of crashes.
- Provides a more efficient flow of traffic along roadways.

1.2.3 Factors for Safe and Reasonable Speed Zones

The nationally recognized method for establishing safe and reasonable speed zones is based upon the 85th percentile speed, which is defined as the speed at or below which 85% of traffic moves along a roadway segment. It is the speed that the majority of motorists feel comfortable driving.

85th Percentile Speed
The nationally recognized method for establishing safe and reasonable speed zones is based upon the **85th percentile speed** as determined by an engineering study.

Various physical and environmental factors along and adjacent to a roadway influence a driver's perception of the safe speed at which to operate a vehicle and consequently affect the 85th percentile speed. Many variables can affect the safe operating speed of vehicles; it is not practical to consider each variable individually. Rather, these factors are compared in combination and evaluated as a whole when establishing speed zones. Some of the physical factors include: horizontal and vertical curves, hidden driveways, access density, roadside developments, width and condition of shoulders, number of lanes, lane width, pavement condition, intersections, pedestrian features, available sight distances, and nearby land uses (school zones, parks, commercial establishments, etc.). In addition to roadway features, the following factors can affect safe speeds and influence the operating speeds of motorists based on their personal roadway knowledge including a vehicle's mechanical condition and characteristics, a driver's ability, traffic volume (vehicular, bicycle and pedestrian), weather and visibility, and crash potential.

Speed limits in speed zones should be established for favorable conditions (i.e., clear weather conditions, free-flowing traffic and good visibility). It is the driver's responsibility to reduce speeds as conditions deteriorate to less favorable conditions.

1.2.4 Value of Speed Zoning Based on Engineering Studies

Regardless of how or why the need arises, posting speed limits and making speed limit adjustments through a comprehensive engineering study based on established traffic engineering practices ensures that the speed limit established will be fact-based. It will also take into account various site-specific factors such as operating speeds of free-flowing vehicles, crash history and potential, roadside development, roadway geometry, on-street parking and pedestrian activity.

In 1992, a study entitled "Comparison of Speed Zoning Procedures and their Effectiveness" was completed by the Michigan Department of Transportation. Although the study precedes this manual by two decades, the conclusions presented are still valid:

- Posting speed limits within 5 miles per hour of the 85th percentile speed has a beneficial effect, although small, on reducing total crashes but has a major beneficial effect on providing improved driver compliance.
- Posting speed limits more than 5 miles per hour below the 85th percentile speed does not reduce crashes and has an adverse effect on driver compliance.
- Speed zoning should not be used as the only corrective measure at high crash locations in lieu of other safety improvements.
- The use of radar to collect speed data appears to underestimate the 85th percentile speed by approximately 3 miles per hour[4].

1.3 Authority to Establish Speed Zones

1.3.1 Code of Alabama

Title 32, Section 5A, Article 8 of the Code of Alabama 1975 outlines provisions for speed restrictions imposed on Alabama roadways. It gives the DOT Director and the Director of Public Safety joint authority to alter a speed limit on State highways on the basis of an engineering and traffic investigation, with the approval of the Governor, up to the maximum allowed by code. It also establishes the ability of local authorities to change speed limits on roadways within their jurisdiction up to the statutory limit on the basis of an engineering and traffic investigation. If the roadway is a state roadway, Department of Transportation approval is also required. The complete excerpt from the Code of Alabama Title 32 is provided in the appendix.

[4] Procedures for Establishing Speed Zones, Texas Department of Transportation, 2011
http://onlinemanuals.txdot.gov/txdotmanuals/szn/szn.pdf

1.4 Engineering Approach to Speed Zoning

1.4.1 Important Factors Affecting Speed Zoning

The engineering approach to setting and adjusting speed limits involves a comprehensive review of pertinent roadway and traffic characteristics to determine the most appropriate operating speed. It requires the use of engineering judgment using one of two methods to determine appropriate speed. The first uses the observation and measurement of the 85th percentile speed, which can be adjusted based on infrastructure and traffic conditions. This method sets speeds according to reasonable driver behavior, but also assumes that the majority of drivers will select the safest operating speed for their environment. The second method utilizes the function of the road in conjunction with roadside development to determine the appropriate speed. It recognizes the functionality of the road is the greatest constraint on speed, so enforcement methods may be needed to offset road design qualities and driver behavior.[5]

Several factors influence the selection of an appropriate speed limit:

- Land use, roadway, and traffic characteristics to include roadway geometrics, shoulder condition, grade, alignment, and sight distance as horizontal and vertical alignment may restrict operating speeds along a short highway segment requiring the use of advisory speeds.
- Observation and measurement of vehicle speeds.
- Analysis of speed statistics.
- Crash history/potential.
- Conflicting transportation modes such as parking activity, bicycles, pedestrians, and transit vehicles in the vicinity of driveway causing highway conflicts that affect vehicle speeds due to vehicles making crossing maneuvers or turns.
- Roadway geometry variations based on setting of urban, rural, residential, or commercial
- Traffic conditions and volumes.

Principle Components of Typical Engineering Speed Studies

- Spot speed studies to determine 85th percentile speed
- Analysis of available crash data (3 years minimum, 5 years preferred)
- Speed Zone determination and design
- Re-checks of Speed Zones when appropriate

It is important that all components of the study be well documented using the appropriate forms as described in Section 3.0.

[5] FHWA-SA-12-004 - Methods and Practices for Setting Speed Limits: An Informational Report
http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa12004/fhwasa12004.pdf

1.4.2 Speed Zone Re-evaluation Criteria

1.4.2.1 Corridor Changes (Number of Lanes, Land Use, Volume Changes, etc.)

If a speed limit is determined based on roadway classification and adjacent land use, changes in these factors can change the road's purpose, requiring an updated speed limit designation. Even if this method is not used, these changes can have an important effect. A change in commercial, recreational or residential development can bring more drivers, as well as pedestrians and cyclists, and increase the number of intersecting driveways and side streets. However, the road may not be designed with these factors in mind, so the speed limit may need to be adjusted to correspond with a change in what is a reasonable and prudent speed for the corridor.

After a new change to the corridor has been implemented and traffic has had adequate time to adjust to the change, a speed study would be beneficial to reassess the 85th percentile speed. The study is conducted on an average weekday(s) during off-peak hours (free-flow conditions) under favorable weather conditions to maximize results. Reposting of the speed limit may be considered if the 85th percentile speed is substantially different than the previously posted speed limit.

1.4.2.2 Calendar Time (Effect of School Year, Seasonal Activities, etc.)

Speed zones are not regarded as permanent due to the variable nature of the conditions upon which they are founded. Performed periodic reevaluations of speed limits are made to ensure that the posted speeds are still adequate for a given corridor. Even if no obvious major changes have taken place in the area, traffic patterns could still have been altered due to unforeseen factors. According to ITE, *Survey of Speed Zoning Practices An Informational Report*, it is important to re-evaluate all speed zones every five years in urban areas or when changes are made to the roadway. In Texas, re-evaluations are performed every three to five years in urban areas and every five to ten years in rural areas. The re-check can be done by performing a spot speed check or by conducting a "trial run", which consists of driving through a zone at the speed that is posted in order to evaluate the appropriateness of the speed limit. Speed checks are performed on average weekdays during off-peak hours under favorable weather conditions. A description of spot speed checks is presented in Section 3.1.1.

Re-evaluation Schedule

According to ITE's *Survey of Speed Zoning Practices – An Informational Report*, "it is important to **reevaluate speed zones every five (5) years** in urban areas or when changes are made to the roadway."

1.5 Local Agency (City/County Government) Application

1.5.1 Speed Limit Change Initiated at Local Level

As stated previously in Section 1.3.1, the Code of Alabama grants local municipalities and counties the authority to change speed limits on non-State roadways within their jurisdiction (but not above the statutory limit) on the basis of an engineering and traffic investigation. Approval by the Alabama Department of Transportation is not required for non-State roadways. While it is not mandatory for non-State roadways, it is recommended that local officials utilize the format and criteria specified in this Speed Manual as a reference guide for performing the engineering and traffic investigation. For state roadways or extensions thereof, it is required that local officials adhere to the requirements of this document setting speed zones and obtaining approval from the Alabama Department of Transportation prior to implementation of the new or adjusted speed limit.

1.5.2 Process for Requesting Speed Study

There are two ways in which a local governing agency can obtain a speed study to establish or modify a speed zone. A City or County can request that ALDOT conduct an engineering and traffic study associated with the request, conduct the study themselves, or engage a qualified transportation consultant to perform the study on their behalf. Once the study has been completed, the request accompanied by the study results must be submitted through the ALDOT approval process as outlined in Section 4.0 of this report.

Upon approval, the City or County is responsible for preparing and passing an ordinance to formally establish the speed zone.

Chapter 2

Essential Factors in Setting Appropriate Speed Limits

2.0 Key Factors in Setting Appropriate Speed Limits

2.1 Factors Affecting Safe Speeds

Traffic volumes and driver behavior, as well as pedestrian activity, during daytime off-peak hours on an average weekday should be the controlling factors of the posted speed limit. This may cause traffic to travel at lower speeds during peak periods, but it will accommodate free-flow traffic during the majority of the day. It is important to understand the various factors that impact operating speeds as discussed in the following sections.

2.1.1 Drivers and Vehicles

Drivers possess varied levels of driving skills and experience. It is not possible to accommodate all degrees of driver ability, nor is it practical to post speeds intended for either end of the skill spectrum. Therefore, speed limits are based on the average ability of the typical driver of a passenger vehicle. Perception-reaction time is the primary measure of a driver’s competency because it is the basis for choosing approach speeds to intersections and other possible stopping situations. The vehicle is also a very important factor to consider when selecting speed limits. Vehicles vary in their capability to speed up, slow down, stop, and make turns, thus varying the time it takes to make such maneuvers. Since it is not feasible to accommodate every possible type of vehicle or every variation in passenger cars, the average characteristics of a passenger car, in terms of performance and maneuvering should be considered when determining appropriate speeds. However, these factors are inherently included when standard traffic engineering practices are applied in appropriately setting speed limits.

2.1.2 Weather

The concept of reasonable and prudent speed establishes that drivers should operate vehicles safely under all circumstances, including when hazards such as severe or abnormal weather conditions exist. The Code of Alabama allows differing speed limits to be established for "varying weather conditions" but in general speeds should be established for daylight, favorable weather, and dry pavement.

Posting of warnings should not be arbitrarily set for wet pavement conditions or any other weather hazard if done as a reactionary installation. If weather conditions are the determining factor for establishing a regulatory speed limit, then this speed limit shall be based on an engineering study.

2.2 Speed Setting By Chosen Approach (Operation or Design)

2.2.1 Operating Statutory Limits

A statutory speed limit automatically governs in the absence of a posted speed. Typical speed limits vary for different classifications of roadway types within an urban or rural setting. This type of speed limit considers the intended characteristics of roadways. Required statutory or maximum allowable speeds mentioned previously are established by the Code of the State of Alabama (Section 32) as follows:

- Urban District – 30 mph.
- Unpaved road – 35 mph.
- County maintained paved road in an unincorporated area – 45 mph.
- Highways (except Interstate Highways or highways with 4 or more lanes – 55 mph).
- Interstate Highways (4 or more lanes) – 70 mph.
- Highways with 4 or more lanes – 65 mph.
- Vehicles carrying hazardous cargo – 55 mph.

Statutory speed limits are enforced unless a different speed limit has been establish and posted using techniques in this document.

2.2.2 Design Speed

ALDOT uses the American Association of State Highway and Transportation Officials (AASHTO) definition of design speed, which is used to determine the various geometric design features of a roadway. Some of the roadway characteristics determined from design speed include:

- Minimum sight distances (intersection, stopping, etc.).
- Horizontal curve radii.
- Grade.
- Rate of vertical curvature.
- Superelevation rate.
- Acceleration/Deceleration lane lengths.
- Required roadside clearance.

Factors used in the determination of the design speed of a roadway are functional classification, topography, surrounding land use(s) and anticipated operating speed. Because selected design speeds incorporate safety factors, they do not necessarily reflect the 85th percentile speed, or the speed at which most motorists may feel comfortable traveling. In such cases, the posted speed may exceed the design speed. Critical points in the roadway such as horizontal curves may not allow for driving faster than the design speed. If the posted speed is higher than the design speed on a roadway, appropriate warning signs should be used at these critical points.

2.2.3 Inferred Design Speed

The Federal Highway Administration (FHWA) defines inferred design speed as "the maximum speed for which all critical design-speed-related criteria are met at a particular location." Generally speaking, it is the design speed for a particular feature of the roadway and not for the entire corridor. Each feature of a corridor can have a different inferred design speed because the criteria for determining the speed limit may be different for each feature.

The FHWA manual *Speed Concepts: Informational Guide* gives several examples of the determination of inferred design speeds: *"The inferred design speed for a horizontal curve may also be limited by horizontal offsets to sight obstructions on the inside of a horizontal curve. The inferred design speed for a crest vertical curve is the maximum speed for which the available stopping sight distance is not exceeded by the required stopping sight distance. The inferred design speed may also be limited by a combination of lane width and average daily traffic. The inferred design speed can be greater than, equal to, or less than the designated design speed."*

Typically, the 85th percentile speed for a corridor is the speed limit that is posted, even if the corridor contains segments or features whose inferred design speeds are lower than the 85th percentile speed. Segments or features with such inferred design speeds should be evaluated for warning signs and advisory speed plaques rather than allowing these sections to dictate the speed limit of the entire corridor.

2.2.4 Operating Speed Statistics – 85th Percentile, Median, Pace, and Mean Speeds

Using field data, four types of vehicle operating speed statistics can be determined. The mean speed is the average speed of all vehicles recorded during the collection period. The median speed is the speed at which 50% of the vehicles recorded are operating at or below. The 85th percentile speed is the speed value for which 85% of the recorded vehicles are operating at or below. It is typically viewed as the best representation of the maximum reasonable and prudent driving speed for the study corridor. The 10-mph pace is a measure of speed dispersion. It is the ten-mile-per-hour range of speeds that contains the highest number of vehicles, which indicate the extent to which vehicles are traveling at a uniform speed.

2.2.5 Operating Speed versus Posted Speed

Regulatory speed zones are only established for roadway segments where an engineering study demonstrates that the statutory speed limits are no longer applicable for the existing conditions. The posted speed limit is determined based on roadway and traffic conditions that are specific to that segment of roadway and the 85th percentile free-flowing operating speed as determined by an engineering study. Implementing posted speed limits based on sound engineering studies helps to strengthen the relationship between operating speeds and posted speeds, which in turn improves the overall safety and operations of our highway systems.

2.2.6 Regulatory Speed

Regulatory speed zones are based on a comprehensive traffic study with an understanding of the statutory or prima facie speed limits for a particular roadway. Additional factors to consider include:

- Advisory speed usage
- Geometry (Shoulder width and characteristics)
- Roadside development
- Driveway density
- Crash History

2.2.7 Posting Advisory Speed Warnings

There are situations which the posted speed limit exceeds the critical design speed. This is a situation for when advisory speed limits should be posted. Advisory speeds are typically recommended for curves, intersections, or other conditions that would require motorists to adjust their speed to less than the posted speed limit. Details of the application of advisory speed warnings are discussed further in Section 5.1.

2.3 Speed Limits and the Alabama Speed Setting Approach

2.3.1 85th Percentile

Most states and local agencies use the 85th percentile speed for free-flowing traffic as the basic factor in establishing speed limits. ALDOT embraces this strategy. Adjustments can be based on factors like crash experience, road geometry, horizontal and vertical curves, pedestrians, and land use.

2.3.2 Engineering Judgment

The final decision of determining adjustments to the 85th percentile speeds should be at the judgment of an experienced traffic engineer.

Alabama Speed Setting Approach

1. Utilize 85th Percentile Speed
2. Apply engineering judgment to considering other factors (i.e., crashes, geometrics, pedestrians, land use) for possible speed limit adjustment

Chapter 3

Speed Study Procedures

3.0 Speed Study Procedures

For the public, legal entities, and law enforcement to respect and properly observe the posted speed limits, the traffic study used to determine the posted speed limit should be conducted with sound engineering principles and judgment that are uniform and consistently applied.

3.1 Initiate Field Speed Study

The following section outlines various elements and describes specific details of a typical speed study conducted for the purpose of posting speed limits. Appendix A is a shortened version of speed study procedures and analysis techniques that is a "Field Guide", which outlines the most essential elements of a speed study. It may be used as a quick reference as compared to this document, and provides detailed descriptions, direction, and documentation of a typical speed study.

3.1.1 Speed Data Sets

Appropriate and representative speed data is needed to set effective speed limits. When performed correctly, speed checks represent the speeds that the majority of drivers feel safe driving. They are the basis for the determination of the appropriate regulatory speed to be posted.

Spot speed checks capture the behavior of random vehicles traveling at free-flow speeds. Therefore, vehicles in nonfree-flow conditions, such as those engaged in passing maneuvers, or traveling in platoons, with the exception of the lead vehicle, are not included as part of the spot speed data collection. Heavy trucks and buses are recorded separately and not included in the speed data sets.

Spot Speed Checks – Key Elements

1. Data is collected at Free-Flow Speeds (Pneumatic Tubes, Radar Gun, Hi-Star Counters, and mounted Radar)
2. Data is collected for passenger vehicles unencumbered by other vehicles (i.e., platoons)
3. Data is collected for at least 100 passenger vehicles in each direction at chosen data collection location

Sample sizes should include a minimum of **100 vehicles *in <u>each</u> direction*** (*100 + 100 = 200 Total*) at each collection station. If the minimum sample size has not been met after two hours when using radar or four hours when using pneumatic tubes, data collection can be discontinued for that segment of roadway. It is not necessary to obtain the speed of every vehicle traveling the roadway during the collection period. Vehicle speed data collection provides the optimal information when consecutive vehicles traveling along the roadway are separated by a gap of at least five seconds between vehicles. The data is usually tabulated on a vehicle spot speed study tally sheet shown in Figure 1 and is also provided in the appendix along with other blank forms.

SPOT SPEED STUDY TALLY SHEET			
LOCATION ID/STREET NAME:			
CITY:		**LANE WIDTHS**	
COUNTY:		**NO. OF LANES**	
ALDOT DIVISION:		**WEATHER**	
DAY/DATE:		**TYPE OF LAND USE**	
LOCATION:		**PAVEMENT CONDITION**	
DIRECTION(S):		**PAVEMENT CONDITION**	
TIME PERIOD	FROM: TO:	**POSTED SPEED (MPH)**	
RELEVANT REMARKS			
		NO. OF VEHICLES	
SPEED RANGE	**MID-POINT**	**DIRECTION**	**DIRECTION**
15-19	17		
20-24	22		
25-29	27		
30-34	32		
35-39	37		
40-44	42		
45-49	47		
50-54	52		
55-59	57		
60-64	62		
65-69	67		
70-74	72		
75-79	77		

Figure 1: Spot Speed Study Tally Sheet

When using speed bins covering a range of speeds (i.e., 50 mph – 54 mph), it is statistically beneficial to the analysis of the data set for each speed range to have at least 4 or 5 data points recorded per bin. This may result in the time period or number of total data points required being increased to ensure that the number of data points recorded is sufficient. Generally, automated speed counting equipment such as pneumatic road tube counters (Discussed in Section 3.2.4) can be set-up to record data which can be separated in specifically defined speed ranges or “Bins” on an hourly basis as shown in Figure 2.

Hour	<=40 MPH	41-45 MPH	46-50 MPH	51-55 MPH	56-60 MPH	61-65 MPH	66-70 MPH	71-75 MPH	76-80 MPH	81-85 MPH	86-100 MPH	101-110 MPH	> 110 MPH
00:00	6	2	14	36	118	112	47	20	4	3	3	0	0
01:00	9	6	13	36	94	69	32	12	3	3	1	0	0
02:00	9	5	9	33	84	47	20	8	2	2	0	0	1
03:00	9	5	8	28	57	65	23	5	1	1	0	1	0

Figure 2. Example of Speed Ranges or “Bins” for a Speed Study as Recorded Each Hour

When limited data is available, engineering judgment should be applied, to assess whether the data available is sufficient for true measure of free-flow speeds on the study segment. It should be reasonably assured that all elements and information represent unbiased sampling.

3.1.1.1 Time Period Selection

The appropriate time to collect speed data representative of free-flow conditions is important for an effective traffic speed study. Periods of peak hour congestion or certain seasons of the year (e.g., holiday shopping) can affect typical free-flow conditions of the roadway, resulting in data that is not acceptable in determining appropriate speed zones.

3.1.2 External Factors Affecting Data Collection

Any conditions that may affect speed should be understood prior to performing a spot speed check. This should be done by driving the length of the corridor to obtain general roadway and surrounding area characteristics. Additional trial runs are performed for each segment as described in Section 3.2.5 to identify what a typical driver experiences when traveling the corridor and what speed feels most comfortable. It is important that the weather, date, and time of day be documented for every data collection event.

Figure 3 shows example characteristics, separated into three types, which are important to observe and document because they can affect the speed of traffic:

Roadway Characteristics

- Roadway Geometry
  - Vertical/Horizontal Curvature
  - Medians
  - Grade Separation
  - Number of lanes
  - Lane widths
- Pavement Condition
- Sight Distance Restrictions
- Lighting

Traffic Characteristics

- Average Annual Daily Traffic (AADT) and Hourly Volumes
- Crash History Over a 3-year Period
- Traffic Control Devices
- Posted Speed Limit
- Pedestrian/Cyclist Activity
- Transit Activity

Area Characteristics

- Land Use
  - Adjacent Developments
  - Truck Percentages
- Driveways/Entrances
- Weather
- Time of Day
- Time of Year

Figure 3: External Factors Affecting Data Collection

After properly considering roadway, traffic, and surrounding area characteristics, there are some key elements to avoid when gathering free-flow speeds for a speed zone study.

Elements to Avoid for Free-Flow Speeds Assessments

1. Horizontal and Vertical Curves, or locations where sight distance is inadequate
2. Traffic Control or Operations that would alter speed (traffic signals, stop signs, recurrent/non-recurrent congestions , nearby construction)
3. Area Characteristics that would alter speed (interchanges nearby, rural/urban setting, commercial/residential)

Not all of this information will be applicable to every study. Additional information, such as planned roadway or land use changes, construction activities in the study area, anecdotal information on roadway characteristics or driver behavior can be obtained from local safety, planning, or law enforcement officials. Activities or conditions outside of the study area that could affect travel speed during data collection (e.g., special events, detours, etc.) should also be determined and taken into consideration when planning for field data collection efforts.

3.1.2.1 Enforcement Bias

Data collected for speed zoning purposes may be skewed if conducted in the vicinity of intensive enforcement activities or on days after the conclusion of enforcement due to driver sensitivity and awareness of the operations. Therefore, enforcement should be relaxed in the study area for several days or longer prior to the study. Along the same lines, care should be taken to ensure the radar device and any other speed detection equipment is placed as inconspicuously as possible so as not to alert drivers that they are being observed.

3.1.3 Appropriate Data Collection Area

The area to be studied is defined through the initial request for a speed zone study and can be divided into homogeneous sections for analysis once relevant corridor characteristics have been determined. If divided, the sections should show consistency in adjacent roadside development, land use, roadway characteristics, and should be typically extended 500 feet beyond the end of the study zone to capture boundary conditions.[6] A graphical representation of the study zone, such as a strip map or line diagram, should be provided with the findings of the study. This provides an overview of the area, including any features of interest and depictions of the typical driver behavior within the study corridor. Blank and example strip maps are included in Appendix G and described further in Section 4.2. The strip map should include the following information:

- Name and/or highway number
- Crossroads and cross streets
- Limits of the speed zone
- Adjoining speed zones of connecting maps

[6] FHWA-SA-12-004 – p. 39 http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa12004/fhwasa12004.pdf

- Limits of any incorporated city or town
- Names and approximate limits of the developed area of unincorporated towns
- Urban districts
- Schools and school crossings
- Traffic signals
- Important traffic generators (factories, shopping centers, stadiums)
- Ball bank readings (see Appendix F)
- Railroad crossings
- Bridges[7]

3.2 Data Collection

3.2.1 Speed Check Station

Placement of the speed check stations is important in the speed observation process. The stations should be strategically located to provide a complete understanding of speed patterns along the roadway. In urban or suburban areas, speed check stations should generally be placed at intervals not to exceed 0.25 miles. Where traffic signals are present, the stations should be located midway between signals or 0.2 mile from any signal, whichever is less. In rural areas, the spacing can exceed 0.25 miles, assuming the general speed pattern is followed for the full length of the interval chosen. In some instances, closer spacing may be necessary based on physical and traffic conditions. Speed checks should be performed for each direction of travel.

Collection sites should be far enough from intersections, driveways, highway-rail grade crossings, horizontal curves, etc., so that acceleration/deceleration does not affect measurements.

3.2.3 Assess Roadway Characteristics

An inventory of all roadway features that may have an impact on vehicles' speed—including the presence or absence of a median, the road's geometry (horizontal curves, vertical curves, superelevation, etc.), the number and width of lanes, on-street parking, sidewalks, the number of driveways, and the number of traffic signals—should be taken as part of the speed study. This inventory should be reviewed and analyzed along with the speed data that is collected.

3.2.4 Data Collection Methods (Manual-Portable Radar, Road Tube, Mounted Radar, Electronic Speed Management Equipment)

Proper equipment is essential for accurate measurement of the free flow characteristics. Two categories of collection devices are available, each with its own advantages and disadvantages in terms of installation and collection. Active devices, such as stop watches and radar guns (Figure 4), allow the collector to select free-flowing vehicles, but may influence driver behavior if the driver notices their activity being recorded. Passive devices, such as pneumatic tube counters (Figure 5) and electronic speed management equipment – Mounted Radar or tubeless counters (Figure 6 and 7), are less labor-intensive for collection efforts, but must be adjusted to only collect speeds when long gaps exist between vehicles. This will ensure that drivers are acting under free flow conditions during collection. Considering these characteristics, active devices are

[7] Procedures for Establishing Speed Zones, Manual 2012-1, TXDOT
http://onlinemanuals.txdot.gov/txdotmanuals/szn/developing_strip_maps.htm

more applicable to areas where traffic volumes are high, while passive devices are more suited to areas where traffic volumes are low.

Figure 4. Handheld Radar Example

Figure 5. Pneumatic Tube Counter Example

Figure 6. Pole-Mounted Radar

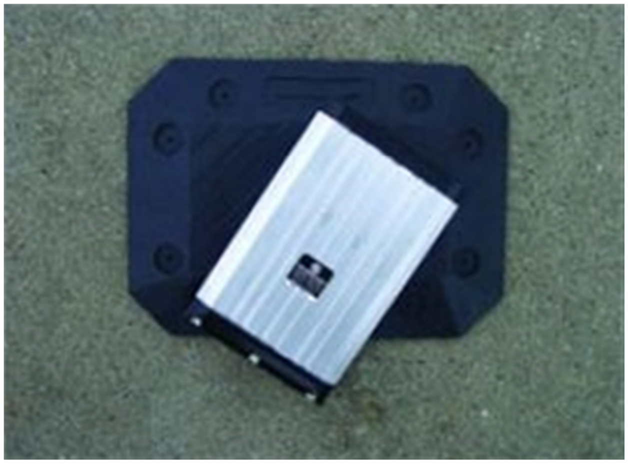

Figure 7. Electronic Tubeless Counter Example

The spot speed check should generally follow these preferred guidelines:

- Collection should occur on a weekday during off-peak hours under ideal weather conditions.
- Collection should occur in an unobtrusive, undetectable manner in order to capture normal traffic speeds without affecting driver behavior.

3.2.5 Trial Runs of Speed Zones

Trial runs are intended to ensure that spot speeds are representative of speeds throughout the corridor. At least three trial runs should be performed prior to the collection of speed data so that the driver of the trial run is not influenced by any previous understanding of normal travel speeds in the area. Trial runs can also help in locating the appropriate position of data collection sites.

There are two methods for performing trial runs. The first method utilizes the data collectors' own vehicle as the study vehicle with one person driving at a comfortably safe speed while another person records the speed at certain intervals. The second method, called the floating car method, involves following cars on the road and recording their speed through the limits of the corridor. The driver performing this test must pass as many vehicles as he or she is passed by in order to maintain the average speed of the cars on the roadway. The first method allows for an accurate capture of speed, while the second more accurately collects the behavior of drivers familiar with the road and its conditions.

Re-checks of speed zones may be performed with trial runs, as is discussed in Section 4.3.

3.3 Data Analysis and Speed Zone Design

3.3.1 Speed Data Analysis

The proper speed limit for a facility is selected primarily by data collection and analysis to determine the 85th percentile speed, along with other aspects of roadway characteristics as already mentioned. The 85th percentile speed can be easily determined by calculation or through observing data displayed graphically. Using the data set summarized in Figure 8 with exactly 100 vehicle speed observations in one direction provides a general example for determining the 85th percentile speed (*Note: 100 observation, minimum, in both directions will ultimately be necessary to determine proper posting speeds*).

Sample Size = 100 vehicles for Westbound Direction

Multiply the sample size by 0.85 to determine which data point represents the 85th Percentile Vehicle for the data set; therefore,

100 X 0.85 = 85 (**85th Vehicle's Speed**)

In Figure 8, the 85th vehicle falls somewhere within the ranges (52-54) and (55-57).

By applying the middle value of the ranges, the 85th Percentile Speed can be calculated using interpolation:

$$\frac{(High\ Midpoint\ Range - Low\ Midpoint\ Range)}{(High\ Cumulative\ \%\ Veh - Low\ Cumulative\ \%\ Veh)} = \frac{(High\ Midpoint\ Range - 85th\ \%\ Midpoint\ Range)}{(High\ Cumulative\ \%\ Veh - 85th\ \%\ Cumulative\ Veh)}$$

$$\frac{56-53}{92-81} = \frac{56-x}{92-85}$$

$$\frac{3}{11} = \frac{56-x}{7}$$

Solve for x: The 85th speed is 54.09 mph ≈ **54 MPH**

In simplest terms when using 100 vehicle speeds, the 85th percentile speed is determined by looking at the speed of the 15th vehicle down from the top speed. This is equivalent to the equation above for **85th vehicle's speed**.

Determination of the mean speed and pace speed may also be desirable from the data set. The determinations of these from the data again in Figure 8 are as follows:

Mean Speed (Average Speed) =

$$\frac{(31x1)+(35x1)+(41x4)+(44\ x10)+(47x23)+(50x22)+(53x20)+(56x11)+(59x5)+(62x3)}{100}$$

= 50.8 (51 MPH)

The pace speed is defined as the 10 mph range or window that encompasses the highest portion of observations. Therefore, the pace speed is in the range of 44 MPH to 54 MPH.

The same procedure applies for larger data sets. For example, given that the data for 200 vehicles is available, the following equation would apply:

200 vehicles x 0.85 = 170 (equates to the 170th vehicle or 30th down from the top observed vehicle speed in the data set);

Therefore, the 85th percentile speed is determined by looking for the 30th vehicle (200-170 = 30) down from the top speed recorded.

SPOT SPEED STUDY RESULTS			
LOCATION ID/STREET NAME: County Road 99			
CITY: Unincorporated Jefferson Co.		LANE WIDTHS:	12'
COUNTY:	Jefferson	NO. OF LANES:	2
ALDOT DIVISION:	3rd	WEATHER:	Clear Sunny
DAY/DATE	WED. 8-23-2013	TYPE OF LAND USE:	Rural
LOCATION	1/4 Mile West of	OBSERVER:	S. Smith
DIRECTION	NB	PAVEMENT CONDITION: DRY	
TIME	1:40PM - 2:15PM		
STREET	CR 99	POSTED SPEED (MPH)	55 MPH

SPEED RANGE	MIDPOINT	NO. of VEHICLES	% VEHICLES	CUMULATIVE % VEHICLES
19-21	20	0	0.0	0.0
22-24	23	0	0.0	0.0
25-27	26	0	0.0	0.0
28-30	29	0	0.0	0.0
31-33	32	1	1.0	1.0
34-36	35	1	1.0	2.0
37-39	38	0	0.0	2.0
40-42	41	4	4.0	6.0
43-45	44	10	10.0	16.0
46-48	47	23	23.0	39.0
49-51	50	22	22.0	61.0
52-54	53	20	20.0	81.0
55-57	56	11	11.0	92.0
58-60	59	5	5.0	97.0
61-63	62	3	3.0	100.0
64-66	65	0	0.0	100.0
67-69	68	0	0.0	100.0
70-72	71	0	0.0	100.0
		100		

RESULTS (from graph):		
Median Speed:	48	mph
85th Percentile:	54	mph
Analysis Recommended Speed Limit (***Directional***)*	**55**	**mph**

**Note: Data as recorded from the opposing direction should be gathered also and considered in combination in determining the proper speed limit for posting*

Figure 8. Example Speed Study Results

Posted speed limits are usually in increments of 5 mph, but the speed range used in determining the 85th percentile speed may depend on roadway type. For instance, a smaller speed range may be necessary for roadways with a lower design speed, where fluctuations of 3 mph may have an impact on safety. For interstate highways, a 3 mph increment may provide an excessive level of precision.

Often the 85th percentile speed can be reasonably determined from graphing the speed range vs. the cumulative percentage of vehicles travelling below that speed, as shown in Figure 9.

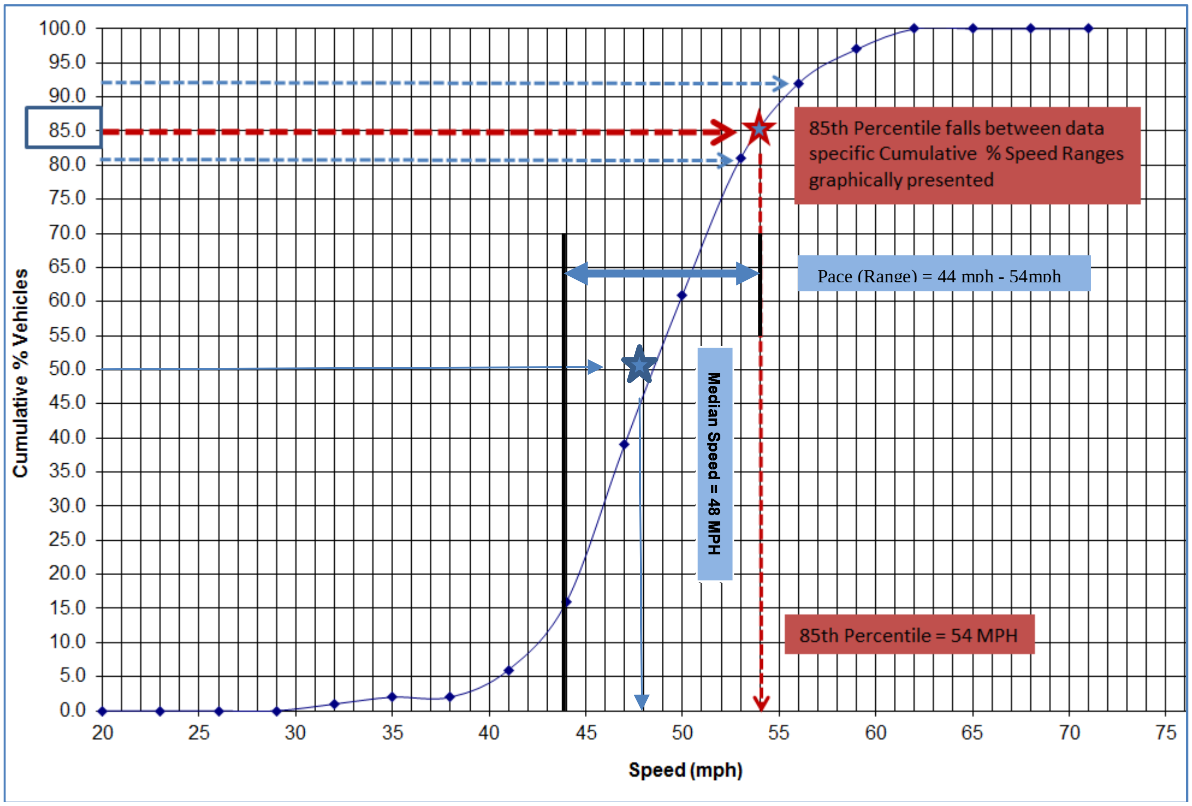

Figure 9. 85th Percentile, Median, and Pace Speeds Chart

The 2009 MUTCD states that when a speed limit is posted, it should be within 5 MPH of the 85th percentile speed. In the above example, the reasonable selection for posted speed is 55 mph. The final determination for reasonable posting of speed limit should take into account the data analysis of both directions.

A procedure to confirm analysis results is described in the following section.

3.3.2 USLIMITS2 Speed Evaluation

Expert systems have been used for more than a decade in Australia as an aid to recommend maximum posted speed limits. These early systems were known as the XLIMITS programs. FHWA solicited help from the Australian Road Research Board to develop a similar program for the United States that became known as the USLIMITS system. Changes have been made since the program was first introduced in the United States, and the most recent version is known as the USLIMITS2 system.

USLIMITS2 is a computer web-based expert tool to assist in setting reasonable, safe and consistent speed limits. It provides an objective perspective and supplemental support for speed limits determined by an engineering study. It is applicable to all roadway types – ranging from rural two-lane roadway segments and residential streets to urban freeway segments.

The program is readily accessible via the Internet on the FHWA website[8]. Anyone with an internet connection and a web browser version developed in 2003 or later can utilize it.

The USLIMITS2 program may be used to determine posted speed limits. The output from USLIMITS2 can be printed, and saved in a Microsoft Word file or in a Microsoft Excel file. If used in the determination of a speed limit, the printout of the Word or Excel file shall be submitted along with the other necessary paperwork and engineering study documentation. The Word or Excel file printout must include all input variables and the recommended speed limit for each roadway segment. The USLIMITS2 analysis would be considered supplemental to the primary speed limit assessment.

Currently the program does not address statutory speed limits, temporary or part-time speed limits such as posted limits for construction zones and school zones, or variable speed limits that change based on traffic, weather or other conditions. Characteristics of the location should be considered in ultimately determining proper posting of speed limit. USLIMITS2 should only be used to support or complement other speed limit studies and is not meant for use as a standalone evaluation.

3.4 Crash Data Review

Nationwide, speeding is a factor in about one-third of all traffic-related fatalities; speed-related crashes involving injuries cost society approximately $40.4 billion annually[9]. Even if speeding itself is not the direct cause of a crash, it certainly affects the severity of the crash.

Studying the crash history of a roadway helps determine reasonable and safe speeds for a roadway segment. Crash trends may signify locations that have a disproportionately high crash rate that should be considered when determining the speed limit for the roadway. Crash trends may also indicate the need for advisory speeds and signage for certain localized geometric or environmental conditions.

Crash data should be obtained from the Alabama Department of Transportation Critical Analysis and Reporting Environment (CARE) database for the most recent three-year period, at a minimum, with a five-year period being preferred if available. The CARE database developed for ALDOT by the University of Alabama archives details about crashes and fatalities on the Alabama roadway network. A request for this information can be made through the Safety Section of ALDOT's Transportation Planning and Modal Programs Bureau.

3.5 Implementation

3.5.1 Sign Installation

Once an appropriate speed limit has been approved, appropriate signage needs to be installed to define the speed limit in that location. All speed zone and related signs shall be in compliance with requirements in the most current edition of the MUTCD. Along state roadways, ALDOT is

[8] http://safety.fhwa.dot.gov/uslimits/

[9] National Highway Traffic Safety Administration, Traffic Safety Facts, 2011 Data http://www-nrd.nhtsa.dot.gov/Pubs/811751.pdf

responsible for sign installation and maintenance. For city and county roadways, sign installation and maintenance is the responsibility of the local governing authority for the roadway.

Section 2B.13 of the 2009 MUTCD emphasizes the importance of an engineering study as the basis for determining regulatory speed limits. It states, *"The Speed Limit (R2-1) sign shall display the limit established by law, ordinance, regulation, or as adopted by the authorized agency based on the engineering study. The speed limits displayed shall be in multiples of 5 mph. Speed Limit (R2-1) signs, indicating speed limits for which posting is required by law, shall be located at the points of change from one speed limit to another. At the downstream end of the section to which a speed limit applies, a Speed Limit sign showing the next speed limit shall be installed. Additional Speed Limit signs shall be installed beyond major intersections and at other locations where it is necessary to remind road users of the speed limit that is applicable."*

As stated, a speed limit sign is placed at the beginning of each speed zone and after any major intersection. In urban and suburban environments, R2-1 signs are placed every ½ mile. For rural roadways, R2-1 signs are placed every 2 miles. It should be noted that on divided and one-way facilities with multiple lanes, an R2-1 sign may be placed on both sides of the traveled way to improve communication with drivers based on engineering judgment, except in cases where there is no room for such installation.

Additionally, speed limit signs are posted at points of entry to the state even if there is no change in speed limit. The signs are placed as close as possible to the state line.

Based on the 2009 MUTCD, speed reduction warning signs (W3-5 or W3-5a) should be erected in advance of a speed zone where the speed limit is reduced by more than 10 miles per hour or in special circumstances where engineering judgment indicates advance notice of a speed change is needed in order for drivers to comply with the posted speed limit forthcoming. Speed reduction warning signs should always be followed by a Speed Limit (R2-1) sign erected at the beginning of the zone where the speed limit applies. As is the case with the R2-1 signs, if a W3-5 or W3-5a is used on divided and one-way facilities with multiple lanes, the signs may be erected on both sides of the traveled way based on engineering judgment, except in cases where there is no room for such installation. In cases of inaccurate interpretation of the W3-5 sign as a regulatory sign, a supplemental plaque can be used with either the message "AHEAD" (W16-9P) or stating the advance distance (W16-2P) to a regulatory speed limit sign. ALDOT's acceptable speed limit signs and plaques are shown in Figure 10. Note that in Alabama trucks may have a maximum speed limit on rural facilities of 70 mph unless circumstances related to truck safety necessitate a lower speed limit being posted. Additional guidance for appropriate signage of speed zones is provided in Appendix B as excerpted from the ITE Traffic Control Devices Manual.

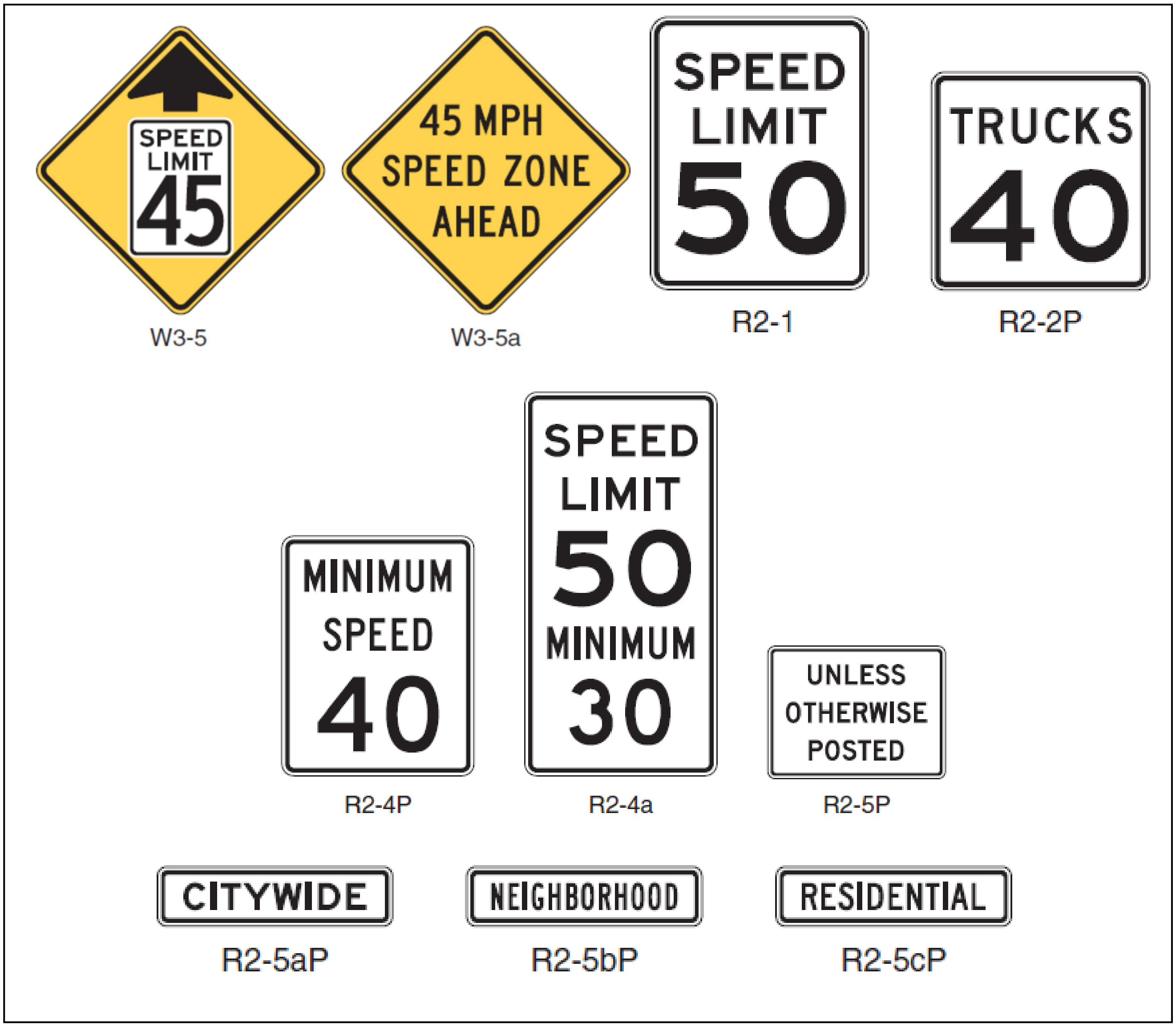

Figure 10. ALDOT's Acceptable Speed Limit Signs and Plaques

ALDOT typical sizes of speed limit signs based on its application is as follows:

Conventional Road - 30" x 36"

Expressway – 36" x 48"

Freeway – 48" x 60"

3.6 Transition Zones

A transition zone should communicate to motorists that the roadway environment is changing and vehicle speeds should change also. Other factors appropriate for a transition zone are the roadway geometry and adjacent land use. High speed rural roads transitioning into built-up urban areas should be analyzed for possible use of advance warning per this manual, while other methods can be used to ensure that vehicle speeds are lowered and maintained. The goal is that the speed reduction of approaching vehicles be accomplished prior to entering the built-up area, as shown in Figure 11. In Alabama, not more than six alterations to the posted speed limit can occur within a one mile long roadway segment. Additionally, the difference between adjacent limits shall not be more than 10 miles per hour represented similarly in Figure 11. More discussion on speed modification options for a transition zone is provided with Chapter 6.

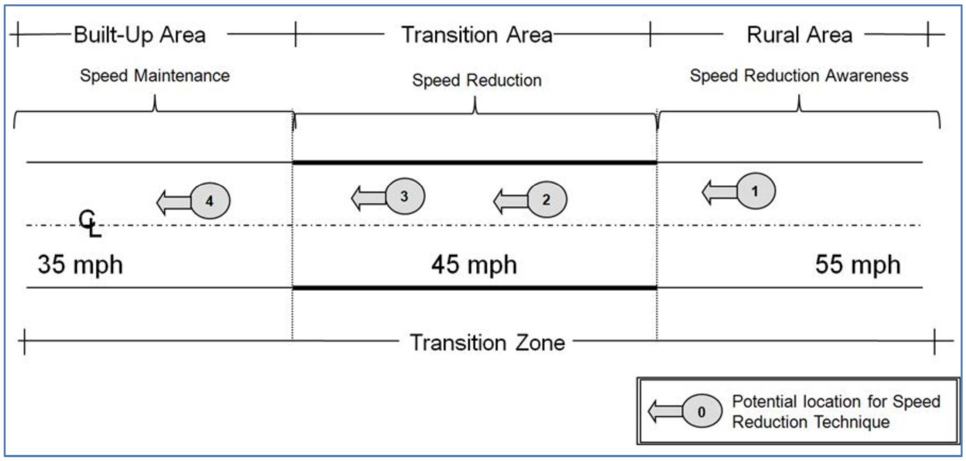

Figure 11. Transition Zone Concept (Transition Zone Design – Kentucky Transportation Center 2013)

Chapter 4

Speed Study Approvals

4.0 Approvals

4.1 Submitting a Speed Study

To establish speed zones and to properly post speed limits, a comprehensive engineering study is required. The study should identify the safe, reasonable, and self-enforcing speed for posting along a segment under ideal conditions. The 85th percentile speed is the standard to identify the speed at which a majority of reasonable and prudent motorists will travel a roadway. Accordingly, a motorist's selection of an operating speed should be self-adjusted for conditions other than ideal, such as weather conditions, driver visibility, extreme traffic conditions, personal abilities, or experience.

4.1.1 Study of Field Conditions and Speed Zone Associated Elements

Whether data is gathered by a local municipality, county, or an ALDOT Region, there are multiple field elements that should be summarized in preparation for a speed zoning request and installation. The following items outline the various field data required:

1. Measurable roadway features (horizontal/vertical curvature, roadway surface conditions, and photography of applicable traffic control for segments of interest).
2. Traffic characteristics (traffic volumes, crash history analysis, bicycle and pedestrian activity).
3. Adjacent lane uses (driveways, nearby schools or recreational activity areas).
4. Homogenous segments for conducting spot speed study.
    a. Speed check stations are strategically located to reflect likely locations for variations in 85th percentile speed. Trial runs (see section 4.1.2) are performed to further validate chosen locations of speed check stations.
    b. Strip map (see section 3.1.3 and Appendix G)
5. Vehicle Operating Speed Information (85th percentile spot speed summaries, Trial Run information).
    a. Summary data by direction (i.e, Field Tally Sheets)
    b. Speed Statistics (85th percentile speed number)

c. Trial Run data sheets

4.1.2 Trial Runs Assessment

Trial runs aid in determining appropriate speed check stations. Additionally, trial runs aid an analyst in understanding what vehicle data speed patterns to expect during data collection. This early information is a particularly useful data check when the radar gun data collection method is used. Trial runs by different analyst(s) are beneficial to account for variations in driving style, experience, and understanding of the driving environment.

4.1.3 Speed Limit Recommendations and Zone Length

Speed zones should be as long as possible along a homogenous segment of a roadway – while still considering the existence and impact of horizontal and/or vertical curvature, as well as locations where vehicles would enter and exit the facility at intersections and driveways. For rural locations, the length of a speed zone should be generally at least one-half mile long. Speed zones leading into urban, residential, or congested areas should be at least 0.2 miles in length or longer based on homogenous segments.

4.1.4 Checklist for Comprehensive Speed Study

Items Needed in a Comprehensive Speed Study

- Information on roadway environment, physical features, condition and traffic characteristics shown as a corridor line diagram or strip map
- Observation and measurement of vehicle speeds (100 vehicles – each direction) under ideal weather and free-flow conditions
- Prepare speed frequency distribution table
- Analyze vehicle speeds to determine 85th percentile and upper limit of 10 mph Pace Speed
- Conduct average Test Run Speeds with passenger vehicle for confirmation
- Summary of crash history
- Additional information on unusual conditions not readily apparent

In general the documentation of a speed study will have three (3) elements:

1. A memo with discussion of the roadway characteristics, the 85th percentile speed, crash data, other conditions of which to be aware, and a recommendation for a speed limit.
2. A strip map (discussed next) is a schematic plan of the roadway that graphically indicates the observed speed measurement data set, available crash information, and pertinent roadway characteristics possibly impacting speed measurements.
3. Approval of the speed limit change and justification.

4.2 Strip Map Summary

Another useful tool for summarizing corridor characteristics and speed profiles is a “Strip Map”, but this is not a requirement in speed study submittals. A Strip Map example is shown in Figures 12-A and 12-B, and will typically include the following items:

1. Roadway name(s), limits of the proposed speed zones, and location along the route.
2. Number and width of lanes.
3. Average daily traffic volume.
4. Crash information.
5. Plotted 85th percentile speed and pace speed as recorded in the field.

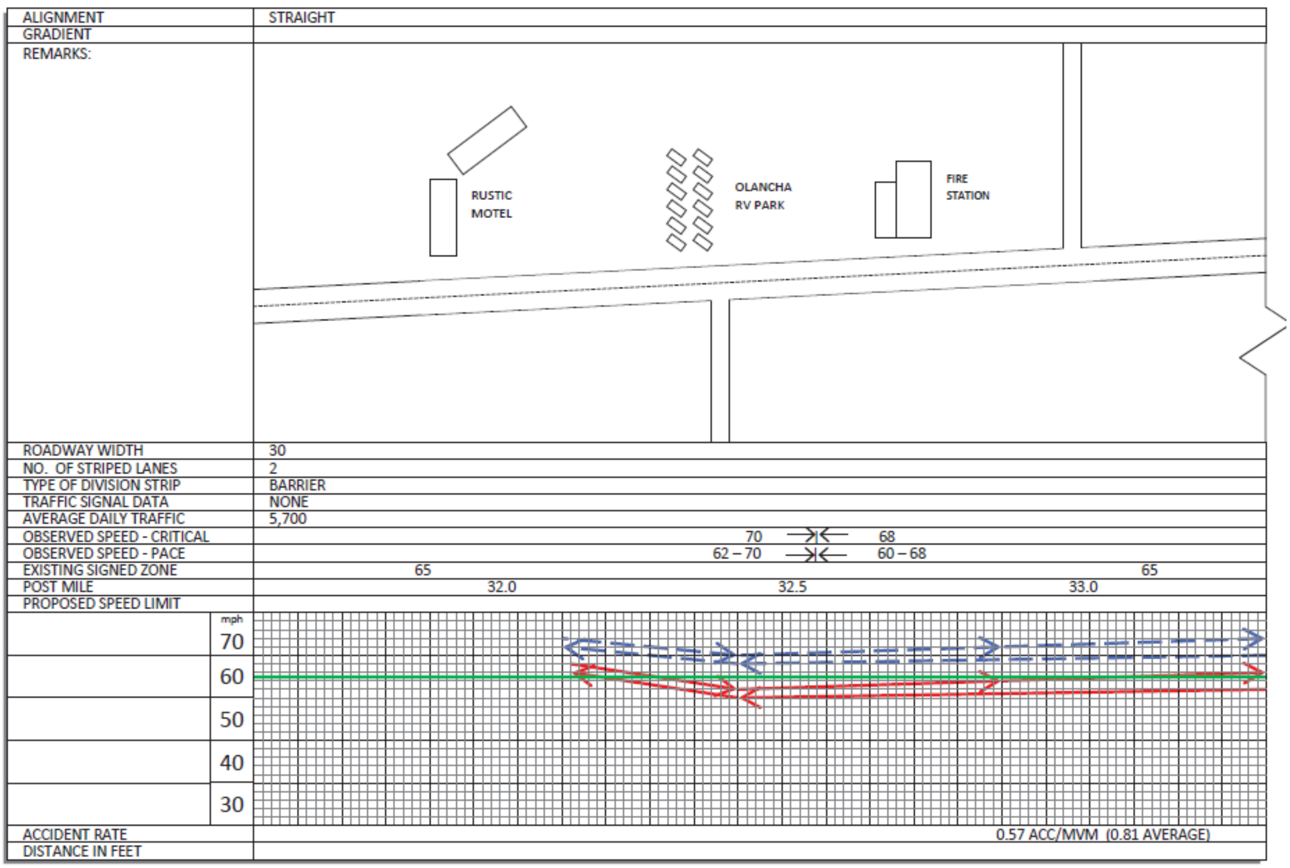

Figure 12-A. Example Strip Map: Left Side – 11 X 17 (Caltrans)

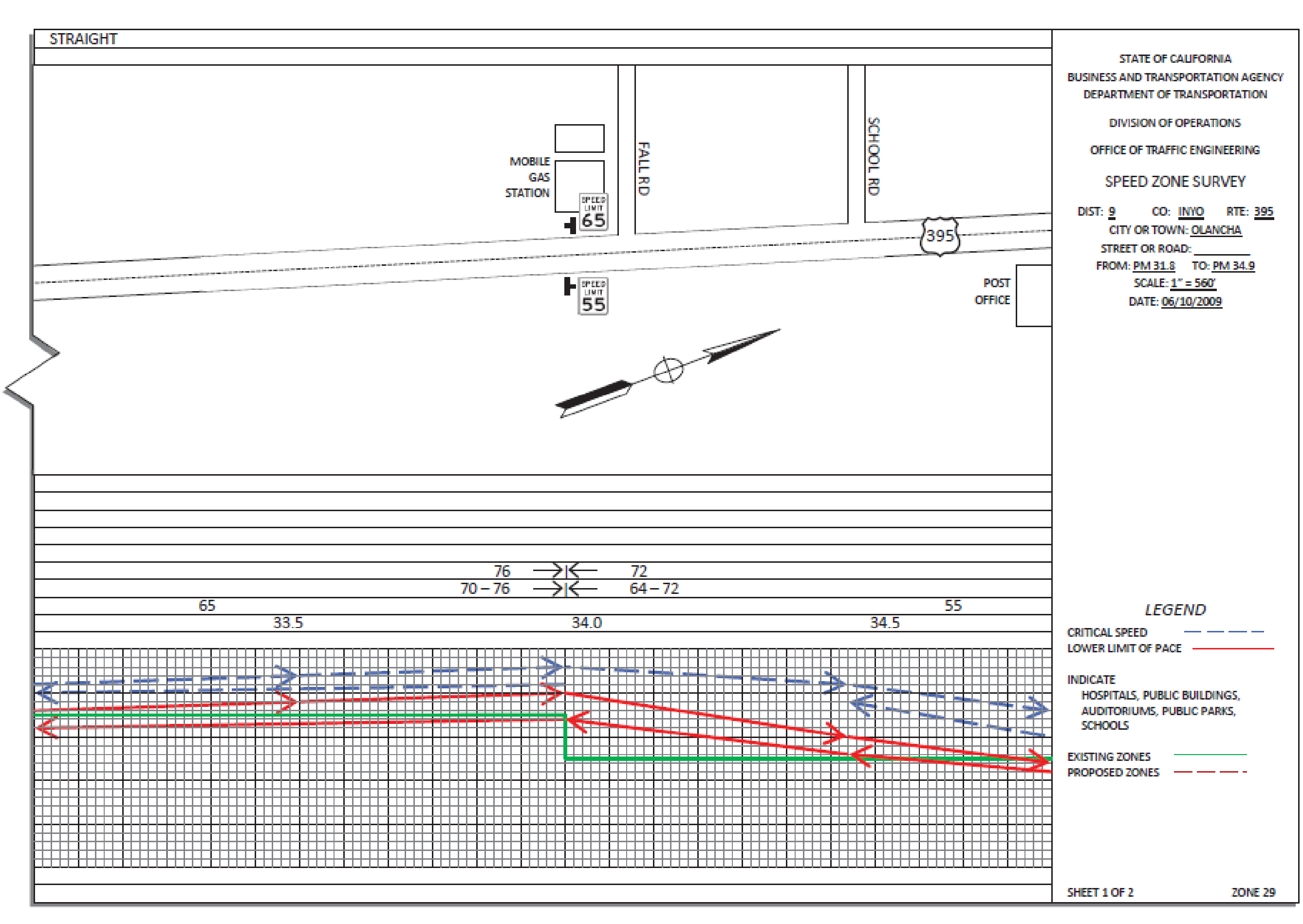

Figure 12-B. Example Strip Map: Right Side – 11 X 17 (Caltrans)

4.3 Approval Routing

It is the responsibility of the Project Engineer, to prepare the Speed Study Report once data is gathered and analyzed. The speed study routing sequence will be though the following offices for approval and consensus.

1. ALDOT Region Engineer
2. ALDOT Office of Safety Operations
3. ALDOT State Maintenance Engineer

Ultimately, approval of speed zone studies for state maintained roadways will be required by the State Maintenance Engineer.

4.4 Reassessment with Trial Runs

It is important to reassess speed zones after the signs have been in place for one or two years to determine the zone's effectiveness and to evaluate any speed pattern changes. Before and after crash data is compared to assess effectiveness.

After the first year and the initial reassessment, periodic re-checks of all speed zones are desirable at intervals of three to five years for urban areas and five to ten years for rural areas. These periodic re-checks should be in addition to any reassessments brought about by roadway changes or new developments.

It is acceptable for all reassessments at the first year milestone and beyond, to be done by performing trial runs along the roadway segments where speed limits have been set. Re-checking at reasonably homogeneous segments is also an acceptable reassessment method. If these re-checks or the trial run indicates a need for adjustment, then re-checks should be performed at every speed check station along the segment in question. Revisions should also be made to the strip map and it should be resubmitted.

Chapter 5

Other Speed Zone Types

5.0 Other Speed Zone Types

5.1 Advisory Zones with Speed Plaques

Engineering judgment or traffic studies sometimes show the maximum legal speeds or posted regulatory speed limits are no longer applicable when certain conditions exist. In the presence of such conditions, advisory speed zones with speed plaques should be established through the use of proper signage to warn drivers of the recommended, maximum, safe, comfortable speed that conditions allow. The advisory zone may be a location within a regulatory speed zone requiring speed advisory signs, which the current MUTCD shows as typical black lettering on yellow background. In a work zone area, black lettering on orange background is required. The Advisory Speed plaque (Figure 13) may be used to supplement any warning sign to advise drivers of both the condition and the maximum speed at which the roadway can be traversed safely and comfortably.

When advisory speed signing is necessary, placing them to close to speed limit signs may confuse drivers. The minimum allowed distance between adjacent signs in this case is 100 feet. Additionally, a regulatory speed limit sign should not be placed within the advisory speed zone. The advisory speed should not be posted at a higher value than that of the regulatory speed zone in which it occurs. The FHWA recommends that advisory speeds should be determined by engineering study and based on free-flow conditions. Additionally, each speed zone should be reevaluated when conditions change.

There are several engineering practices that can be used to determine advisory speeds for horizontal curves, including the accelerometer method, the direct method, the Global Positioning System (GPS) method, the design method, and the ball-bank indicator method. The use of an electronic or traditional ball-bank indicator is ALDOT's preferred assessment method for horizontal curves.

The latest edition of the MUTCD provides a great deal of guidance related to the use and placement of advisory speed signs. Several tables in the document are devoted to determining the need for and location of advisory speed and other warning signs. MUTCD Table 2C-4 shows the placement distances for warning signs from a given condition based on the advisory speed for that condition. MUTCD Table 2C-5 shows the need for horizontal alignment signs, including Advisory Speed plaques (W13-1P), Exit Speed

(W13-2), and Ramp Speed (W13-3) signs shown in Figure 13. These requirements and recommendations are based on the difference between the posted regulatory speed limit and the advisory speed for the horizontal curve (or other condition).

An example for field placement of the type of signs shown in Figure 13 is available as MUTCD Figure 2C-3. It should be noted that each ramp may have varying geometric design or operation which would require engineering judgment as to the correct application of a ramp warning speed sign or a combination of warning speed signs.

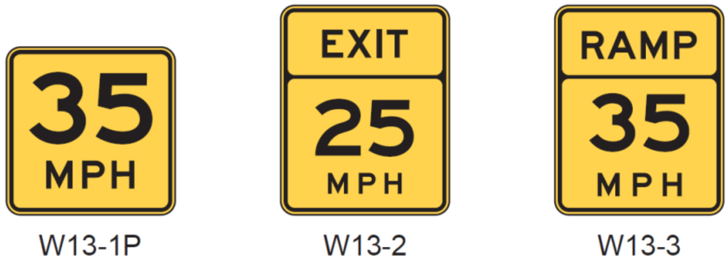

Figure 13. Advisory Speed Signs and Plaques

5.2 Work Zone Speed Limit

The engineering studies that are performed to determine regulatory speed limits are not required to determine work zone speeds. The assessment and documentation for determining work zones are different because of the dynamic nature of construction phases, utility work or other conditions requiring temporary speed limits. Speed limits should be determined based on engineering judgment of a reasonable speed based on the field conditions.

Work Zone Conditions to Consider

1. Type and duration of construction work (also consider equipment crossing)
2. Understanding of the traffic control plan and consideration of drivers' perception traveling through the work zone
3. Traffic volumes
4. Roadway geometry and/or detour geometry
5. Work activity area (vehicles and workers) in relation to the travel way

The MUTCD contains guidance on work zone speed zones, including stopping sight distances (Table 6C-2) and worker safety considerations (Section 6D.03). Speed zoning may either be advisory or regulatory, depending on the conditions of each specific work zone. Once construction is complete, construction speed zones are immediately annulled and should be removed without delay.

Work zone speeds may only be required in certain segments of the work zone where specific conditions, activities, or restrictive features of the travel way are occurring. A lower speed for the construction zone may be justified when personnel or equipment does not have physical separation from moving traffic. The reduced speed limit should be stepped down in advance of the construction activity area.

5.2.1 Regulatory

Regulatory speed limits should be installed throughout a work zone whenever possible, and in sections where speed control is essential and law enforcement officials are not available to enforce speeds. Portable changeable message sings may also be used to display speed limits that vary depending on operation conditions. To prevent unnecessary traffic delays, the regulatory signs should be taken down or covered during any time periods when they are not needed.

5.2.2 Advisory

Under certain situations it is suitable to use Advisory Speed plaques (W13-1P) for a construction zone (or for certain sections of the zone) instead of regulatory Speed Limit signs (R2-1). The advisory speed may differ throughout the work zone in order to accommodate various conditions; the speeds may also be modified during the course of the project as conditions change. The plaques should supplement construction warning signs throughout the work zone to advise drivers of safe speeds for each given section.

All construction speed zones, whether regulatory or advisory, should be applied only in the areas where work is actually being performed and not throughout the entire project limits. As a general rule, reduced speed zoning should be kept to a minimum, and traffic control plans should allow for existing regulatory speeds to be used as much as possible. However, engineering judgment should be applied according to the nature of the project and any other factors that may have an impact on the safety of the public and construction personnel as already mentioned. If during the course of the project there are times when the reduced speed limits are not necessary, the speed limit signs should be moved to the edge of the right-of-way, or turned to face away from traffic so drives are not confused, or covered completely. If they are covered, there is a possibility that the sign assembly may be difficult to see at night; delineation may be used so they are not completely obscured.

5.3 School Speed Zones

During time when children are going to and from school, speed limits may be reduced for segments of roadways that are adjacent to schools or from which schools are visible. It is especially important to assess the speed limit over a segment of highway that contains a school crossing.

School Zone Conditions to Consider

1. Potential for school pedestrian activity (School type, location, and age of children)
2. Traffic volumes, length of crossing, and presence of crossing patrols where there is street crossing activity
3. Nearby traffic operations and traffic control

A School Speed Limit assembly (MUTCD signs S4-3P, R2-1, and S4-1P) or a School Speed Limit sign (S5-1) must be used to specify the beginning of the speed zone. In most situations, the reduced speed limit should only be in use from approximately 30 minutes before the school opens until 30 minutes after classes begin in the morning, and a similar time period is used when school dismisses in the afternoon (unless otherwise specified by the local municipality).

A local municipality may specify the speed limit for a school zone. However, a school speed limit on a state roadway should not be more than 15 miles per hour below the normally posted regulatory speed limit for the roadway. This is important on higher speed roadways as the appropriate methodology for reducing speed limits in increments of 10 mph for adjacent limits, as discussed in Section 3.6, is impractical for school speed zoning and traffic operation. The use of a buffer zone, as discussed in the following section, may be advisable in situations where the roadway is posted with a speed limit within a range of 55 mph to 65 mph.

5.3.1 Buffer Zones

An example situation where a buffer zone would be required is a corridor adjacent to a school with a posted regulatory speed of 65 miles per hour. A transition speed zone of 55 miles per hour should be applied outside the 40 miles per hour zone for both the approach and the departure. This transition speed zone should be 0.2 miles or greater on each end of the school zone. In some situations, it is appropriate to allow the buffer zone speed reduction to operate only during the same time periods that the school zone speed limit is in effect. This scenario is preferable because drivers are more likely to comply with speed reductions that are not unnecessarily enforced 24 hours a day. Flashing school speed limit sign assemblies, as shown in Figure 14, can be used to accomplish this. However, some situations may not allow for buffer zones to operate in this fashion, so school zones should be evaluated on a case-by-case basis using engineering judgment.

Standards and guidance for the placement of all school zone signage can be found in Part 7 of the 2009 MUTCD.

Figure 14. Flashing School Speed Limit Sign

5.4 Incident Management Speed Zones

Crashes and other incidents and circumstances may require temporary traffic control measures that may include speed limit reduction. These situations should be evaluated on a case-by-case basis to determine the most appropriate speed limit using engineering judgment by appropriate agency representatives. For post-incident management conditions, engineering judgment will determine the posted speed limit appropriate that is a function of the average speed of the traffic traveling through the affected corridor. Variable speed limits displayed with changeable message signs are the most effective way to achieve a temporary speed reduction.

5.5 Automated Speed Zone Enforcement

Automated Speed Enforcement uses Radar with digital camera systems and computer software to determine whether a speed violation has occurred. Information regarding the vehicle is recorded for violating vehicles including the license plate data and possibly a digital photograph of the vehicle's driver. Deployment of automated speed zone enforcement is often supplemental to traditional methods.

There are occasions when automated speed zone enforcement is preferred over other methods. The lack of a safe location along a route to conduct traditional stops often prevents typical speed enforcement by agencies, but would be possible with automated speed enforcement. Additionally, automated speed zone enforcement provides the option of continuously conducting speed enforcement over a longer time period; particularly for locations known for having speeding motorists or locations with a history of crashes related to speeding.

Chapter 6

Speed Modification Options

6.0 Speed Modification Options

6.1 Engineering Measures

Two types of speeding-related safety issues exist: excessive speeds due to driver behavior and inappropriate speeds related to drivers' response to the built environment. Crashes that result from excessive speeds are the domain of enforcement. Engineers can influence safety through the built environment. Roads can be designed to encourage drivers to travel at safe speeds, thus reducing the likelihood and severity of speed-related crashes. The modification of geometric elements such as horizontal and vertical curves, lane widths, number of lanes, and shoulder widths are ways to affect motorists' operating speed.

Within the built environment, we can influence drivers' responses. Some common methods of influence include: setting appropriate speed limits, communicating appropriate speeds through the use of traffic control devices, and ensuring that roadway design and traffic control elements support appropriate and safe speeds. The following discussion reflects information and guidance from NCHRP Report 500, Volume 23: A Guide for Reducing Speeding-Related Crashes[10].

6.1.1 Appropriate Speed Limits

Speed limits should be set appropriately to account for roadway design, traffic, and environment. If speed limits are in conflict with what would be expected for a particular roadway, drivers will be less likely to obey the limits and possibly other traffic signs as well. Speed limits should communicate what a driver expects from the surrounding environment and circumstances of the roadway, thereby encouraging respect for the posted limits.

Using the 85th percentile speed as the basis for setting speed limits gives the best likelihood that drivers will be traveling at or below the speed. Additionally, it encourages motorists to travel at the same speed as other vehicles, which promotes increased roadway safety.

[10] http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v23.pdf

Communicating appropriate speeds on a facility through the use of traffic control devices such as signing (permanent, variable, or warning speeds) or pavement markings inherently conveys speeds at which a reasonable driver can safely navigate a roadway. That is, the roadway infrastructure and environment together should provide cues to motorists as to a safe speed on a facility.

6.1.2 Variable Speed Limits

Under certain conditions, drivers may need to be encouraged to temporarily drive more slowly through a roadway segment by using speed limit variations on changeable message signs. Weather situations, roadway incidents, or special traffic operations (i.e., fog, snow, traffic crashes) are scenarios that benefit from having variable speed limit infrastructure.

Field detection equipment to determine current speeds, volumes, and weather conditions is beneficial to proper use of variable speed limits. The display of a variable speed limit may be automatically determined based on field conditions or programmed for a specific field condition – such as a work zone or detour. Law enforcement officials should be visible in a corridor to encourage compliance with variable speed limits that operate outside of normal traffic operations. An example of a variable speed limit sign is shown in Figure 15.

Figure 15. Variable Speed Limit Sign

6.1.3 Speed Feedback Displays

Speed display signs are an element of intelligent transportation systems that exist to provide drivers with up-to-date information about their speed and the current speed limit. These types of signs are especially applicable in work zones, but can also be used in any areas where speed control is an issue. The two main types of speed displays are Variable Speed Limit signs (VSL) (Figure 15) and Speed Feedback displays (Figure 16). Speed Feedback signs display the posted speed limit and also detect and display each driver's current speed as he drives past. The purpose of these signs is to make drivers aware of their speed and encourage them to slow down if they are driving over the posted limit. This application can reduce average travel speeds up to 10 mph.

Figure 16. Speed Feedback Display

6.1.4 Proper Installation of Speed Limit Signage

A speed limit cannot be communicated effectively without proper signage. The visibility, condition, and placement of speed limit signs are important to the effectiveness of the signs. Signs that cannot readily be seen and understood can create safety hazards for motorists.

Sign placement has two important aspects – location and frequency. Consistency in location helps drivers know when they can expect to see a speed limit sign. These signs should not be spaced so far apart that drivers begin to believe that the limit no longer applies, nor should they be so far apart that drivers entering from side streets have to a travel a significant distance before encountering a sign. The spacing should be consistent with the number of access points along a corridor. The more access points, the more signs will be needed in order to inform drivers entering the roadway. Speed limit signs should be placed after every major intersection, and spaced appropriately throughout the rest of the corridor. In some urban areas it may be appropriate to place a speed limit sign after each intersection at which traffic enters the roadway.

6.2 Infrastructure Speed Modification Measures

6.2.1 Self-Enforcing Roads for Reducing Speeds

The concept of self-enforcing roads is more widespread in European countries than it is in the United States. Self-enforcing roads use design and aesthetics to convey the intended speed limit. The approach of roadway designers in the United States has typically been to rely on signage to inform the driver of safe speeds and to use wider roadways to aid in safety; however, this is considered by some to convey conflicting messages to the driver. The driver should receive a consistent message from the roadway, the signage, and the surroundings. If the roadway appears as though it can be driven at a higher speed than that which is posted, drivers may be likely to ignore the posted limits and drive at the highest speed they perceive as safe. This type of reaction to speed limit signs may be dangerous, as speeds which drivers think are appropriate may not always be safe and may lead to crashes. Self-enforcing road designs capitalize on this aspect of driver behavior and seek to design roads so that the driver will be more likely to choose a safe speed. The goals of this type of design include correct interpretation of the messages conveyed, reduction of driver mistakes, and minimization of the impact of mistakes when they do occur. Roads designed in this way should still be subject to a speed study and should be marked with the speed limit determined by the study.

6.2.2 Pavement Textures and Perceptual Pavement Markings

The uses of in-pavement textures (i.e., rumble strips) or perceptual pavement markings can modify a motorist's speed. Typical deployment of these measures is associated with entrances to residential areas, approaches to horizontal curves, approaches to intersections, or proximity to schools or work zones.

Rumble strips are in-pavement measures that produce a vibration when driven over. Vibrations in the vehicle and a loud noise are produced when vehicle tires come in contact with the strips, warning the driver of a lane departure, an upcoming speed zone or any other kind of approaching situation. They can be placed either along the shoulder, along the centerline, or across the width of the travel lane. These three types of rumble strips accomplish different purposes and are chosen based on the roadway characteristics that are present.

- Shoulder Rumble Strips and Edgeline Rumble Strips (Figure 17)
  These strips warn drivers they have drifted from their lane and are an effective countermeasure to prevent run of the road collisions. They are commonly used on roads with narrow shoulders or steep side-slopes.

Figure 17. Shoulder Rumble Strips (Left) and Edgeline Rumble Strips (Right)

- Centerline Rumble Strips (Figure 18)
  Centerline rumble strips help prevent head-on collisions and opposite-direction sideswipes. The usual application is on two-lane, two-way roadways where vehicles are crossing centerlines.

Figure 18. Centerline Rumble Strips

- Transverse Rumble Strips (Figure 19)
  These strips stretch across the width of the travel lane and are typically placed before situations in which drivers will need to slow down or possibly stop. Applications include transitions to lower speed zones, intersection approaches, ramps, work zones, toll plazas, and severe horizontal curves.

Figure 19. Transverse Rumble Strips

6.2.2 On-Pavement Traffic Operations Markings

The addition of on-pavement text and symbol markings can be useful in a variety of situations where additional traffic control guidance may be needed. Within the context of speed control, this treatment may be applied to the approach of a curve, prior to the beginning of a slower speed zone, or to any other situation where it is necessary to warn drivers of the need to reduce their speed. The Texas Transportation Institute (TTI) has performed studies on the implementation of horizontal signing for curves and found that marking the desired speed on the pavement along with a curve arrow or the word CURVE causes drivers to reduce their speeds by three to ten percent.[11] One example of on-pavement text and symbol markings signing is shown in Figure 20.

[11] Texas Transportation Institute – *Field Evaluations and Driver Comprehension Studies of Horizontal Signing* http://www.ce.siue.edu/faculty/hzhou/ww/paper/2005_FIELD%20EVALUATIONS%20AND%20DRIVER%20COMPREHENSION%20studies%20of%20horizontal%20signing_report_21.pdf

Figure 20. On-Pavement Signing

For local and low volume roads, pavement speed limit marking displays may be used to supplement other traffic signing as shown in Figure 21.

Figure 21. Pavement Speed Limit Marking

6.2.3 Road and Street Designs that Affect Speed Reductions

There are various techniques, devices, and strategies to slow or reduce traffic speed and lessen the problems caused by speeding. This section discusses the reduction of lane width, road diets, and the use of raised medians, gateway entry, and roundabouts as applied to higher speed roadways.

Reducing Lane Widths

Lane reduction can be accomplished by using existing pavement and restriping the roadway to produce narrower lanes. The remaining area can be used for bicycle lanes or a buffer between pedestrian activities immediately adjacent to the roadway as shown in Figure 22. This application can reduce average travel speeds between 3-6 mph for the travel lanes.

Figure 22. Lane width reduction producing wide shoulder

Road Diet

The road diet can be accomplished by using existing pavement and restriping the roadway to reduce the number of travel lanes as shown in Figure 23. The remaining area can be used for other uses including bicycle lanes, turn lanes and intersections. This results in a perceived narrowing of the roadway.

Figure 23. Example of "Before" and "After" of a Road Diet

Center Raised Median

The application of a raised median can be effective in reducing speeds if motorists perceive that the roadway is narrower, as shown in Figure 24. The installation of a center raised median can reduce average travel speeds by 7 percent of the 85th percentile speed.

Figure 24. Raised Median Example

Roundabout

The roundabout is an alternative to the typical intersection and boasts a number of advantages. Of those, improved safety and reduced speeds are two of the most important benefits of roundabouts. There are two main types of roundabouts, radial and flared. The flared layout is ALDOT's preference on state roadways as shown in Figure 25.

Figure 25. Flared Roundabout

Gateway Treatment

Motorists approaching a rural town after traveling for miles on a high speed road may benefit from the use of a gateway treatment along the road. It draws motorists' attention to the changing character of the roadway as shown in Figures 26, 27, and 28. Elements of a gateway may include enhanced traffic signing, gateway structures, lane reductions or other pavement markings. This application can reduce average travel speeds from 5 to 10 mph.

Figure 26. Gateway Structure

Figure 27. Gateway Roadside Sign

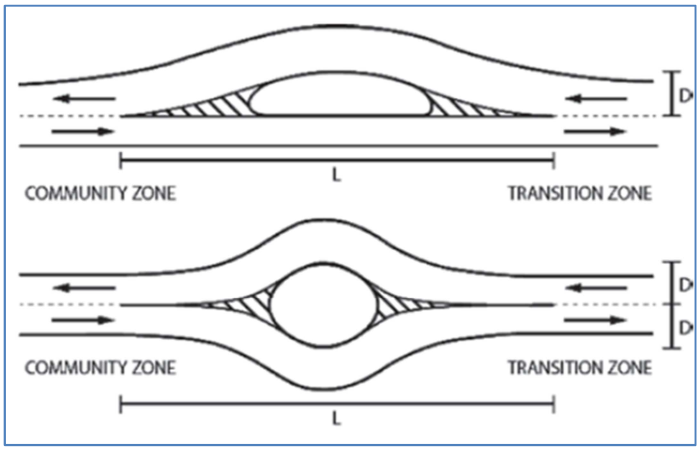

Figure 28. Gateway Travel Lane Flare-Out

6.2.3 Traffic Calming on Local and Low Speed Roads

Traffic calming measures can be used throughout entire neighborhoods, along corridor segments, at single intersections, or in the middle of a block. It is important to be sure that the roadway being considered for traffic calming measures is appropriate for such implementation. Low volumes and low speed roads are the most appropriate candidates for traffic calming. Other speed reduction strategies should be used on major roadways with high volumes and speeds as previously discussed, although some overlap for techniques for speed reduction on high speed and low speed roads may be applied to each if designed appropriately.

For low speed type roadways, a reduction in speeds and/or volumes on both neighborhood and downtown streets can be achieved with the use of traffic calming and other related countermeasures that have an element of vertical relief or horizontal shift. They are usually in the form of features added to the roadway that complement the existing conditions. Not all traffic calming features are suitable for every road, so care must be taken to ensure the measures chosen are analyzed for appropriateness for the given circumstances before implementation. Traffic should be observed after the implementation of traffic calming measures to ensure that drivers are not speeding up between features.

Traffic Calming Methods and Features
Speed Humps
Speed Tables
Roundabouts
Traffic Circles
Raised Intersections
Lane Narrowing
Intersection Realignment
Lateral Shifts

The use of traffic calming on state roads is limited to horizontal displacement measures to include:

- Intersection narrowing
- Raised medians as a lane narrowing technique

Sample standard drawings of traffic calming methods are provided in Appendix C.

Roundabouts can be effective traffic calming and speed-reducing tools; however, they may not be appropriate in all situations. The presence of pedestrians and bicycles must be considered and should be accommodated. The proposal of a roundabout should be evaluated within the context of the individual intersection and surrounding circumstances before the roundabout is installed. Typically, the roundabout has been shown to be a very safe and effective intersection treatment and should be considered when traffic calming is needed.

6.3 Driver Perceptual Countermeasures to Reduce Speed

The term "perceptual countermeasure" includes and describes both the techniques used in traffic calming and the elements of self-enforcing roads. Perceptual countermeasures work by affecting drivers' perception of speed and risk, ability to think and respond, and comfort level, as has been discussed previously. The following subsections discuss how the public can be made more aware of such countermeasures and give specific examples of how these countermeasures can be applied in particular situations.

6.3.1 Education

The public should be educated about the dangers of speeding and the countermeasures in place to encourage slower speeds. Education can help promote public support for speed management as the public becomes more aware about the consequences of speeding and the advantages of controlling speeds. The more the public is educated about the types of devices and techniques that are being used or are planned for use in their area, the more they can understand that these measures are for their benefit and the benefit of their community.

6.3.2 School Zones

School zones require special attention to ensure that vehicles are traveling at safe speeds throughout the zones. Drivers must clearly perceive that they are approaching a school zone and what speed is appropriate. This can be done through the proper placement of signage and the use of beacons, if necessary. At the beginning of and throughout the school zone, raised pavement markings, rumble strips, and/or additional signage and beacons may be used to encourage drivers to reduce their speed or to maintain their speed reduction. School zone pavement markings are shown in Figure 29.

Figure 29. School Zone Pavement Markings

6.3.3 Work Zones

Work zones often create vulnerable conditions for construction workers, road users, and pedestrians; therefore, controlling speeds through work zones is important. Speed reduction can be encouraged with a variety of perceptual countermeasures, including synchronized flashing lights, channelizing drums or pavement markings (to make lanes narrower or cause them to appear as such), raised pavement markings, transverse rumble strips, and retroreflective devices.

6.3.4 Pedestrian and Bicycling Areas

Many perceptual countermeasures that alert motorists to the possible presence of bicyclists and pedestrians and encourage reduced vehicle speeds are available for engineers and planners to consider when adding non-motorized facilities or improving existing facilities. These countermeasures include medians and pedestrian crossing islands in urban and suburban areas, pavement markings denoting bicycle and/or pedestrian crossings (Figure 30), pedestrian hybrid beacons, road diets, rectangular rapid-flashing beacons, and shared lane markings (for bicycles and cars).

Figure 30. Bicycle/Pedestrian Crossing Pavement Markings

6.4 Low-Cost Retrofit

Many of the measures mentioned in the previous sections are low-cost options that local agencies could use for speed management. Ideally, speed control would be implemented at the front end when a new corridor, neighborhood, or development is built. In many cases, existing neighborhoods can easily be retrofitted with these devices and techniques to relieve speeding issues that have arisen. Some other low-cost, retrofitting options not previously mentioned are the addition of street trees and on-street parking. Street trees, when fully grown and planted no more than 30 feet apart along the edge of a residential or urban street, can give drivers the impression that their view is impeded, making them more likely to drive at safer speeds.

Adding on-street parking can also reduce speeds on urban or residential streets. Lane widths will either be reduced or will appear reduced when parking is added, making higher speeds feel less comfortable to drivers. Seeing more pedestrians near the street and being forced to travel in close proximity to parked cars will also help drivers slow down.

6.5 High-Speed to Low-Speed Transitions

NCHRP Report 737[12] examines the high-speed to low-speed transition zones on rural highways. When approaching a settled area with a low speed limit, motorists should first be provided with warning devices and psychological measures, such as advance signing, and then be presented with physical measures (e.g. road narrowings, stepped down speed limits, etc.). This transition concept is illustrated in Figure 31. The researchers found that roundabouts and transverse pavement markings increase the rate of speed limit compliance by 15 and 20 percent, respectively.

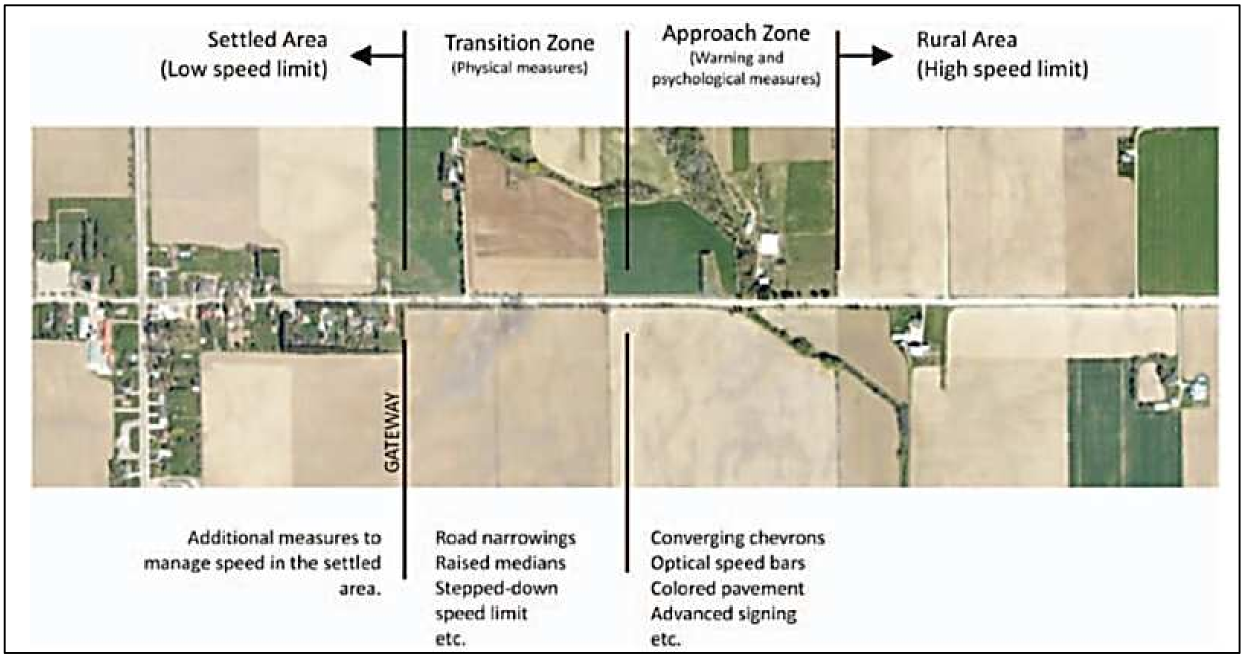

Figure 31. Transition Zone and Approach Zone Concept

[12] NCHRP Report 737: Design Guidance for High-Speed to Low-Speed Transition Zones for Rural Highways http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_737.pdf

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Appendix A – Data Collection Field Guide

Alabama Speed Management "Field Guide" For Data Collection & Analysis

October 2015

Alabama Department of Transportation

AL Speed Management "Field Guide" for Data Collection/Analysis Effective: 10/2015

Contents

List of Figures:

FOREWORD REGARDING SPEED MANAGEMENT "Field Guide"

This Field Guide supersedes all previous ALDOT speed management and speed data collection and analysis procedures. The contents of this Field Guide summarize other more comprehensive information found in the Alabama Speed Management Manual. It provides information for ALDOT and outside agencies for conducting a speed study for the purpose of identifying an appropriate speed limit for sign posting.

INTRODUCTION

The Alabama Speed Policy seeks to address speeding as a significant threat to public safety. This policy identifies cost-effective strategies for decreasing speed-related crashes, one of which includes setting realistic and credible speed limits based on engineering studies. State laws outlined in the Code of Alabama, Title 32, and the 2009 MUTCD, standardize the methodology for establishing appropriate and enforceable speed limits on travel ways. This field guide provides guidance in performing the steps for producing an accurate speed study. Information in this field guide is summarized from the Alabama Speed Management Manual, dated 2015.

The nationally recognized method for establishing safe and reasonable speed zones is based upon the 85th percentile speed which is defined as the speed at or below which 85% of traffic moves along a particular segment of roadway. This and other environmental factors described within this guide will determine the appropriate speed limit for a particular section of roadway.

SPEED STUDY – BASE ELEMENTS

A Speed Study has typical elements and items to consider for determining an appropriate posted speed limit for a corridor. A summarized listing of each step is discussed in the remainder of this field guide:

1. Collect preliminary site information
2. Determine data collection locations
3. Time of day to perform study
4. Environmental considerations
5. Equipment selection
6. Collect field data with Road Tubes, Radar Gun or Electronic (Mounted Radar or Tubeless) Counters
7. Sample size of at least 100 free-flow vehicles in each direction, if possible
8. Data documentation
9. Determine the 85th percentile speed of vehicles (Details of determining the 85th percentile is covered in Section 3.3.1 of the Alabama Speed Management Manual.)
10. Speed data analysis
11. Speed study reporting and approval

PRIOR TO FIELD DATA COLLECTION

Preliminary Site Information

Prior to determining appropriate count locations, equipment to use, and time for field data collection, an analyst needs to obtain and review the following information if available:

1. Road inventory information
   a. Name and highway number of route to be zoned
   b. Crossroads and cross streets
   c. Limits of speed zone
   d. Schools and school crossings
   e. Traffic Signal locations
   f. Railroad crossing locations
   g. Bridge locations
2. Crash history via the CARE database (3 to 5 years of data)
3. Critical traffic control devices (traffic signals or other devices that affect vehicle speeds) or traffic generators (factory entrances, schools, subdivisions, or shopping centers) in the vicinity of the subject location.
4. Previous traffic studies in the area and citizen complaints
5. Geometric information that would affect speeds (such as restricted ROW or sight distance obstructions)
6. Recent video log, if available, may aide in determining best location for speed observer doing study

Data Collection Locations

A sufficient number of speed data collection locations give a more comprehensive understanding of traffic speeds throughout a speed study section. When evaluating the locations for a speed study, the analyst should consider the following:

1. Data collection should be done in a safe location while being as unnoticeable to motorists as possible, avoiding influencing the data gathered. Data collection locations should have varied traffic characteristics, environment/land use, or geometric characteristics.
2. Boundaries should also be considered that identify locations of special need (i.e. transitional zones to urban and rural segments) where substantial changes in speed will likely occur. Boundaries may also be defined as a change in the roadways character as perceived from motorists.

Additional information regarding transitional zones may be found in the Alabama Speed Management Manual, Section 6.5.

Time of Day

Traffic speeds on a roadway section may vary at different times of the day. For instance, during peak times of the day congestion will likely reduce vehicle speeds. Samples of vehicle speeds may be needed during different times of the day to determine when free-flow speeds occur, which are used to set appropriate speed limits. Additionally, it is critical to ensure that data collection reflects typical operating conditions and is not influenced by special traffic circumstances such as that related to schools, factories, parks, other recreational activities, or inclement weather.

Environmental Considerations

The general road environment and adjacent land use of a facility will affect motorists travel speeds on a roadway facility. Items that should be considered include:

1. Roadside Development (e.g., shopping centers, factories, and subdivisions)
2. Roadway Geometrics
3. Pedestrian Activity
4. Truck Activity
5. Roadway environment difference by direction (entering or leaving urban area, nearby horizontal curvature, substantial grade changes or changes in number of lanes).

Equipment Selection

The equipment to be used is based on the type of data desired. Typically pneumatic tube counters, electronic tubeless counter, handheld radar, or mounted radar are used to collect speed data.

1. Pneumatic tubes – Pneumatic tube counters or "machine counters" use two tubes placed across a roadway facility at a specified distance apart shown in Figure 1. These measure speed by determining the time between axles crossing each tube.

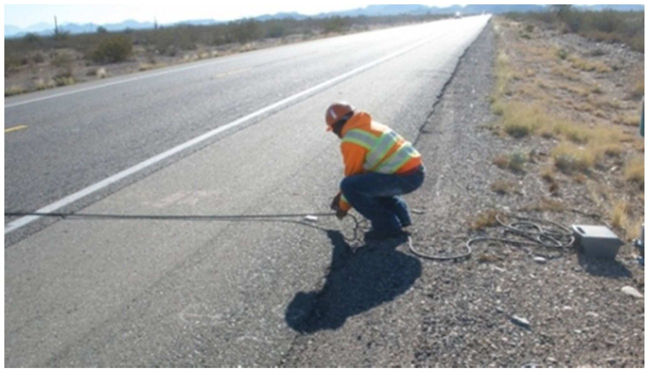


Figure 1. Pneumatic Road Tube Counter Installation

Other details that should be considered when conducting a speed study using pneumatic road tubes include:

a. Speed Bins - The equipment can be set up to record data which can be separated into specifically defined speed ranges or "Bins" on an hourly basis.

Hour	<=40 MPH	41-45 MPH	46-50 MPH	51-55 MPH	56-60 MPH	61-65 MPH	66-70 MPH	71-75 MPH	76-80 MPH	81-85 MPH	86-100 MPH	101-110 MPH	> 110 MPH
00:00	6	2	14	36	118	112	47	20	4	3	3	0	0
01:00	9	6	13	36	94	69	32	12	3	3	1	0	0
02:00	9	5	9	33	84	47	20	8	2	2	0	0	1
03:00	9	5	8	28	57	65	23	5	1	1	0	1	0

b. Setup - Tubes are placed across travel lanes, ideally under low speed or low volume conditions, parallel to each other.

c. Sample Size – All vehicles in the traffic stream are recorded. An analyst should determine when data recorded as an "outlier" should be omitted. Outliers are data recorded as low or high speed vehicles captured in a lowest or highest range speed bin. These data points do not represent an accurate picture of reasonable free-flow traffic. Accordingly, outliers should not be considered when evaluating the 85th percentile speed.

2. Radar – A hand held radar unit operates using the Doppler shift principle to determine the vehicle speeds. Speeds can be recorded for both directions of a roadway if a suitable data observation location can be found shown in Figure 2.

Figure 2. Hand-held Radar Application

This data collection methodology is subject to the following considerations:

a. Radar accuracy – The accuracy of a radar unit is subject to error depending on the angle at which it is held with respect to the roadway. Angles between 0 degrees and 15 degrees are optimal. Angles greater than 15 degrees can result in speed data errors of 2 MPH. For the most accurate speed readings, the hand-held radar must be placed in the line of travel of the target where the vehicles are moving directly toward or away from the radar. (i.e., "0" degrees). Again, slight angles (<15 degrees) are acceptable. Large angles (>15 degrees) will yield erroneous data collection speeds.
b. Accounting for bias – Different analysts may have different opinions as to which vehicles are traveling at free-flow speeds. Defining and documenting characteristics of vehicles operating at free-flow speeds at the particular data collection location is beneficial for later data analysis.
c. Distance from approaching vehicle affects the speed data collection – Reading of vehicle speeds at long distance introduces the possibility that the radar unit is displaying information for an

incorrect vehicle (i.e., large trucks or vehicles following closely), other than the intended reading as taken from a free-flow vehicle. Although there is not a recommended distance between observation point and the approaching vehicle, the ideal location is one in which the radar gun is aimed straight on and hidden from the approaching vehicle and at a reasonable distance to record speed measurements.

d. Sample size – The typical sample size when collecting speed data using a hand-held unit is 100 vehicles (each free-flow) in each direction. For low-volume roads, a smaller sample size likely would be allowable when data collection has occurred over a reasonable time period (e.g. 1 or 2 hours with 2 hours or more being preferred)

3. If electronic equipment (Mounted Radar or electronic tubeless counters) is utilized for data collection (Figures 3 and 4, respectively), data analysis can be simplified using equipment specific software. These methods are similar to pneumatic tubes in that the data set is often very large. Items to address include determining the desirable times for installation, determining the appropriate speed bins for analysis, and identifying the data outliers not used in calculating the 85th percentile speeds. Field installation should be according to manufacturer's instruction.

Figure 3. Pole-Mounted Radar Installation

4. Verification of readings using floating car technique – In addition to collecting speed data using pneumatic tubes, handheld radar, mounted radar, or tubeless counters, it is advisable that an analyst drive the subject roadway to assess reasonable speeds that will likely be recorded for

other vehicles. Engineering judgment should be applied to determine reasonable speeds given the roadside environment, horizontal and vertical curvature, and the roadway surface.

Figure 4. Electronic Tubeless Counter

FIELD PROCEDURES

Area Assessment

A data collector/field analyst should note the following just prior to collecting data:

- ☐ General environment (urban, rural, commercial, residential)
- ☐ Roadway condition
- ☐ Proximity to driveways
- ☐ Proximity of roadway curvature (vertical or horizontal curves that may affect data)
- ☐ Location of speed limit signs or other traffic control that would affect speeds
- ☐ Availability of passing zones and location
- ☐ Nearby special traffic generators (schools, industry)

Data Collector Deployment

One of following data collection methodologies may be chosen:

Pneumatic Tubes Method

Consider placing traffic tubes during periods of low traffic volumes. Distance between tubes should be according to manufacturer's recommendations. The bin categories can be defined by the analysts in terms of number of bins required, and the range of speeds collected, within each bin as previously described in the equipment selection section.

The pneumatic road tube method is normally used for longer data collection time periods as compared to other methods. With this method, tubes are place in the travel lanes and are connected to recorders located at the side of the road. These "machine" counters are capable of storing large amounts of individual vehicle data which can be downloaded to a computer either in the field or back at the office.

When preparing for a speed study using **pneumatic road tubes**, the following checklist is advisable as minimum items to address:

- ☐ Field Guide
- ☐ Obtain equipment (Counter Machine, tubes, PK nails, Hammer, Tape Measure)

- ☐ Camera
- ☐ Read equipment users' manual
- ☐ Obtain safety vest
- ☐ Select time and day
- ☐ Select proper deployment location
- ☐ Data collection forms, as needed

A pneumatic road tube speed study includes four key steps:

1. Perform necessary office preparations
    a. Identify the speed study goals and considerations
        i. Written description of the issue
        ii. Map of posted speed limits in the area
    b. Identify factors in the vicinity of the study that could affect data gathered including nearby driveways, excessive multi-axle trucks or other factors that could cause erroneous double or triple counting of vehicles.
    c. Identify factors that could limit pneumatic tubes recognizing an axle hit. This includes vehicles in adjacent lanes sitting on tube at an intersection preventing the pulse of air from reaching the counter machine.
    d. Identify factors that result in tubes easily becoming unfastened or broken including excessive breaking/slowing of passing vehicles where the tube is deployed, or hot/soft new asphalt that could cause the PK nails to dislodge. When practical, field check tubes to ensure proper installation is maintained throughout the data collection period.
2. Deploy and calibrate data collection equipment
    a. Tubes should be located outside the influence area of roadway elements affecting the data, including nearby intersections, major access points, or locations of recent law enforcement activity related to speed limit enforcement.
    b. Spacing of the pneumatic tubes should be per manufacture supplied user's manual.
3. Field check data accuracy
    a. Accuracy of the equipment in measuring speeds of the traffic stream should be checked with a test

vehicle or with a stopwatch timing of vehicle travel time recorded over a measured test distance.

4. Generate frequency distribution table and determine speed percentiles from data collection. Identify the 50th and 85th speed percentiles and the pace speed.

<u>Handheld Radar Method</u>

The radar data collection methodology can be impacted by the angle of the radar gun with respect to the roadway direction of travel. Therefore, it is important that the radar beam is no more than 15 degrees from approaching vehicles. This threshold produces results that are within 2 mph of the actual vehicle speed. Radar capabilities vary depending on manufacturer and price point. Be aware of specific set-up and calibration of your particular unit. Test samples using test vehicle to ensure proper calibration.

A data collector should ensure recording of vehicles speeds is done under free flow conditions. Large vehicles or fast vehicles can skew results, creating outlier data. Truck data recorded in terms of percentage should reflect that of a facility's typical percent trucks, if known.

A handheld radar instrument is commonly used for measuring speeds at spot locations. It is most often handheld, but may be mounted in a vehicle, or mounted on a tripod. The effective measuring distance is typically in the range of up to 200 to 300 feet and requires a clear line-of-sight for operation by a single observer.

Vehicles of different sizes can affect radar readings as large vehicles return a strong signal. The presence of large vehicles in the traffic stream may inhibit an observer from correctly identifying which vehicle's speed is being detected by the instrument.

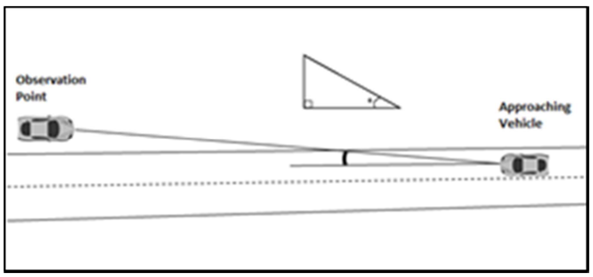
When preparing for a speed study using **hand-held radar equipment**, the following <u>checklist</u> is advisable as minimum items to address:

- □ Field Guide
- □ Obtain hand-held radar
- □ Camera

- ☐ Reads manufacturer’s instruction for operation
- ☐ Safety Vest
- ☐ Data collection forms
- ☐ Select time and day
- ☐ Ensure police radar enforcement not occurring in vicinity

A hand-held radar speed study includes four key steps:

1. Select proper location and placement for radar
    a. The radar unit should be concealed from the view of motorists
    b. As close to “straight on” readings of approaching departing vehicles provides most accurate data readings from the equipment



2. Determine an appropriate selection strategy
    a. Readings of every vehicle is not necessary as data collection from particular vehicle types will dictate data collection strategy
    b. A reading of the first vehicle in a platoon of vehicles is appropriate for recording
    c. When assessing general speed trends within an area or for the purpose of setting speed limits, off-peak travel period measures are most appropriate as this is the time free-flow traffic most often occurs
    d. Use random sampling (i.e., record data for every 4th passenger car observed)
3. Record observations of radar speed on study form
    a. Document speeds of 100 vehicles in each direction, if roadway volumes allow

b. Observer should document the date, location, posted speed, weather conditions, and start and end time of data collection

4. Generate frequency distribution table and determine speed percentiles from data collection. Identify the 50th and 85th speed percentiles and the pace speed.

Electronic Equipment (Pole Mounted Radar or Tubeless Counter)

The analysts should follow manufacturer instructions for field installation of portable traffic data collectors that do not require external sensors (i.e., loops or tubes).

The side-fire radar speed data collection method detects, tracts, and identifies speed of passing vehicles through radar detection zones. The equipment observes vehicles passing through a virtual detection zone to measure and record all vehicle speeds for the selected time period for data collection.

For the tubeless counter speed data collection method, obtain data by a sensor placed on the pavement surface and centered within the travel lane. Data is recorded as vehicles pass over the equipment causing a change in the magnetic field that gets converted to speed data.

When preparing for a speed study using the **Pole Mounted Radar** or **Tubeless equipment**, the following checklist is advisable as minimum items to address:

- ☐ Field Guide
- ☐ Obtain device
- ☐ Camera
- ☐ Reads manufacturer’s instruction for operation
- ☐ Obtain safety vest
- ☐ Select time and day
- ☐ Select proper deployment location
- ☐ Data collection forms, as needed

A Pole-Mounted Radar or electronic tubeless counter speed study includes three key steps:

1. Perform necessary office preparations
    a. Identify the speed study goals and considerations
        i. Written description of the issue
        ii. Map of posted speed limits in the area
    b. Identify factors in the vicinity of the study that could affect data gathered including nearby driveways or other factors that could cause erroneous double or triple counting
2. Select proper location and placement for equipment deployment.
3. Generate frequency distribution table and determine speed percentiles from data collection. Identify the 50th and 85th speed percentiles and the pace speed.

DATA DOCUMENTATION

The following items are most important in documenting study conditions and results:

1. Time of Study
    a. Record Start Time
    b. End Time
    c. If study interrupted, document reason

2. Surrounding environment
    a. Existing posted speed zone
    b. Information about nearby development and impact on prevailing speeds
    c. Weather and Road Condition
    d. Data Collection Forms – Figures 5 and 6 show a sample tally sheet for use in recording results for hand-held radar and results with large data sets, respectively. When pneumatic tube counter machines, pole mounted radar, or electronic tubeless counters are used the outputs from the machines themselves will be sufficient.

Date: MM/DD/YY Name: Location: Speed Limit:					Start Time: End Time: Down Time: Weather: Clear		
Speed	Passenger Vehicles		Buses		Trucks		Total
	Record	No.	Record	No.	Record	No.	
15							
16							
17							
18							
19							
20							
21	II	2					2
22					I	1	1
23	I	1			II	2	3
24	IIII	4					4
25	I	1					1
26	III	3					3
27	II	2			I	1	3
28	II	2					2
29	~~IIII~~	5	II	2			7
30	II	2			I	1	3
31	III	3					3
32	~~IIII~~	5					5
33	III	3					3
34	III	3	I	1	I	1	5
35	~~IIII~~ I	6			II	2	8
36	~~IIII~~ I	6					6
37	~~IIII~~ I	6			II	2	8
38	IIII	4					4
39	~~IIII~~ I	6					6
40	IIII	4					4
41	~~IIII~~	5			II	2	7
42	III	3					3
43	II	2					2
44	IIII	4					4
45	II	2					2
46							
47	I	1					1
48							
49							
50							
Total							100

Figure 5. Example Radar Spot Speed Study Form

SPOT SPEED STUDY TALLY SHEET			
LOCATION ID/STREET NAME:			
CITY:		LANE WIDTHS	
COUNTY:		NO. OF LANES	
ALDOT DIVISION:		WEATHER	
DAY/DATE:		TYPE OF LAND USE	
LOCATION:		OBSERVER	
DIRECTION(S):		PAVEMENT CONDITION	
TIME PERIOD	FROM: TO:	POSTED SPEED (MPH)	
RELEVANT REMARKS			

		NO. OF VEHICLES	
SPEED RANGE	MID-POINT	DIRECTION	DIRECTION
15-19	17		
20-24	22		
25-29	27		
30-34	32		
35-39	37		
40-44	42		
45-49	47		
50-54	52		
55-59	57		
60-64	62		
65-69	67		
70-74	72		
75-79	77		

Figure 6. Example Study Tally Sheet w/ Speed Bins/Ranges

When using speed bins covering a range of speeds (i.e., 50 mph – 54 mph), it is statistically beneficial to the analysis of the data set for each speed range to have at least 4 or 5 data points recorded per bin. This may result in increasing the time period or number of total data points to ensure that the number of data points recorded is sufficient. Generally, automated speed counting equipment such as pneumatic road tube counters can be set-up to record data which can be separated in specifically defined speed ranges or "Bins" on an hourly basis. Note that a chosen speed range for speed bins may be a single value, similar to that shown previously in Figure 5.

Statistical Analysis and Summarizing

After speed data has been collected, statistical analyses can be performed on the collected data. The most common value used as a major factor in determining the appropriate speed limit for a highway is **the 85th percentile speed** which is used in combination with median speed and pace speed. Typically, the **median speed** and **pace speed** is used in assessment of roadway speed characteristics. Each of these important factors are defined below:

85th Percentile Speed: This is the speed at or below which 85 percent of traffic from the data collected is traveling.

Median Speed: This is the speed represented by the middle value of all data points (50th percentile) of data speeds when assembled in ascending order. In Figure 7, the median speed is 48 mph.

Pace Speed: Defined as the 10 mph range or window that encompasses the highest portion of observations.

Other speed data statistical analysis values which may be beneficial in a study include:

Mode Speed: Defined as the most frequently observed speed.

Mean Speed: Defined as the average value of all speeds observed.

Figure 7 shows an example of the 85th percentile, median, and pace speeds determination using a graph of the speed range vs. the cumulative percentage of vehicles traveling below that speed for a directional 100 vehicle speed set. This is known as a speed distribution curve, with the table shown as Figure 7 representing the speed data sheet for this data set.

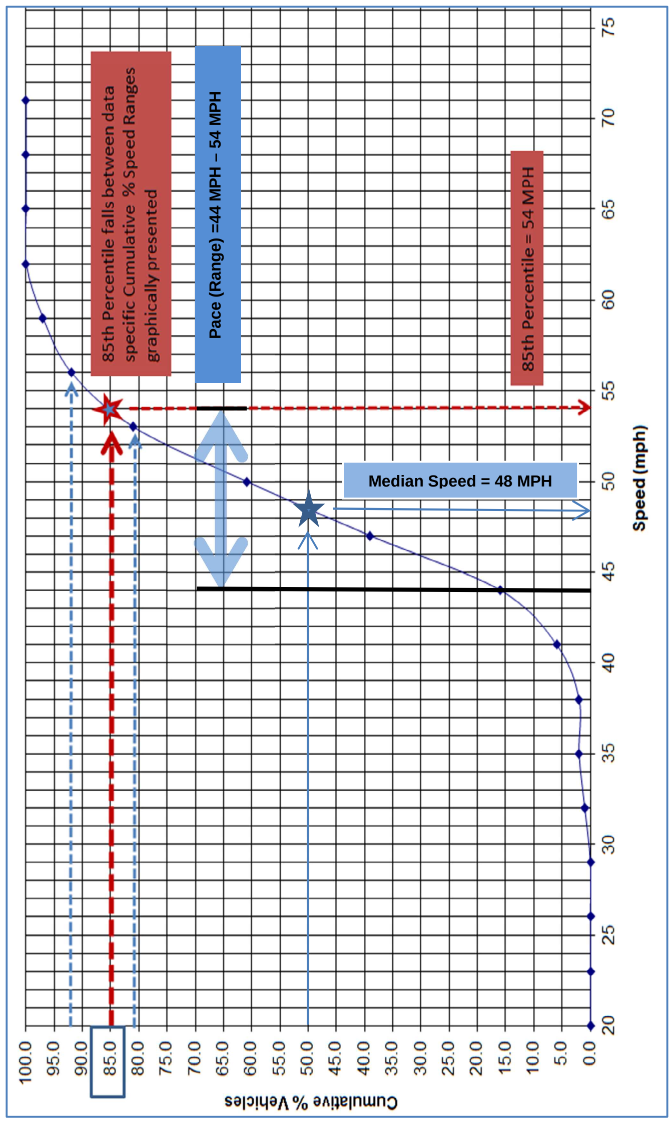


Figure 7. Graphical Representation-85th, Median, Pace

SPOT SPEED STUDY RESULTS				
LOCATION ID/STREET NAME: County Road 99				
CITY: Unincorporated Jefferson Co.			LANE WIDTHS:	12'
COUNTY:	Jefferson		NO. OF LANES:	2
ALDOT DIVISION:	3rd		WEATHER:	Clear Sunny
DAY/DATE	WED. 8-23-2013		TYPE OF LAND USE:	Rural
LOCATION	1/4 Mile West of		OBSERVER:	S. Smith
DIRECTION	NB		PAVEMENT CONDITION: DRY	
TIME	1:40PM - 2:15PM			
STREET	CR 99		POSTED SPEED (MPH)	55 MPH

SPEED RANGE	MIDPOINT	NO. of VEHICLES	% VEHICLES	CUMULATIVE % VEHICLES
19-21	20	0	0.0	0.0
22-24	23	0	0.0	0.0
25-27	26	0	0.0	0.0
28-30	29	0	0.0	0.0
31-33	32	1	1.0	1.0
34-36	35	1	1.0	2.0
37-39	38	0	0.0	2.0
40-42	41	4	4.0	6.0
43-45	44	10	10.0	16.0
46-48	47	23	23.0	39.0
49-51	50	22	22.0	61.0
52-54	53	20	20.0	81.0
55-57	56	11	11.0	92.0
58-60	59	5	5.0	97.0
61-63	62	3	3.0	100.0
64-66	65	0	0.0	100.0
67-69	68	0	0.0	100.0
70-72	71	0	0.0	100.0
		100		

RESULTS (from graph):	
Median Speed:	48 mph
85th Percentile:	54 mph
Analysis Recommended Speed Limit (***Directional***)*	**55 mph**

**Note: Data as recorded from the opposing direction should be gathered also and considered in combination in determining the proper speed limit for posting*

Figure 8. Example of Summarized Speed Study Results

Figure 8 is a speed tally sheet with data summarized with speed ranges. A simpler determination of 85th percentile, median value, and pace speed can be plotted from the speed tally sheet when data is recorded for each individual possible speed reading.

Another tool for summarizing the speed and corridor data collected is the Speed Profile and/or Strip Map shown as Figures 9 and 10. A Strip Map will typically include the following items:

- Roadway name(s), limits of the proposed speed zones, and location along the route
- Number and width of lanes
- Average daily traffic volume
- Crash information

- Plotted 85th percentile speed and pace speed as recorded in the field

Additional detail for utilizing a Strip Map Summary is provided in Section 4.2 of the Alabama Speed Management Manual.

Calculation of Speed Data Statistics

The proper speed limit for a roadway is primarily selected by data collection and analysis to determine the 85th percentile speed, along with other aspects of roadway characteristics as already mentioned. The 85th percentile speed can be easily determined by calculation or through observing data as displayed graphically.

Using the data set summarized in Figure 8 of exactly 100 vehicle speed observations in one direction, the 85th percentile speed for the northbound direction can be calculated. *Note:* A minimum 100 observations for each directions would ultimately be necessary to determine the proper speed limit posting for each direction along a corridor segment.

Refer back to data from Figure 8:

Sample Size = 100 vehicles for Northbound Direction

Multiply the sample size by 0.85 to determine which data point represents the 85th Percentile Vehicle for the data set; therefore,

100 X 0.85 = 85 (**85th Vehicle's Speed**)

In the above, the 85th vehicle falls somewhere within the ranges (52-54) and (55-57).

By applying the middle value of the ranges, the 85th Percentile Speed can be calculated using interpolation:

$(56-53)/(92-81)=(56-x)/(92-85)$

$3/11 = (56-x)/7$

Solve for x: The 85th speed is 54.09 mph ≈ 54 MPH

Further details of this calculation are provided in Section 3.3 of the Alabama Speed Management Manual.

Consider the following to expand the determination of 85th percentile speeds for larger data sets:

In simplest terms when using 100 vehicle speeds, the 85th percentile speed is determined by looking at the speed of the 15th vehicle down from the top speed. This is equivalent to the equation above for 85th vehicle's speed. If data for 200 vehicles is available, the following equation would then apply:

200 x 0.85 = 170; therefore, the 85th percentile speed is determined by looking for the 30th vehicle (200-170 = 30) down from the top speed recorded. This same premise can be applied to larger and larger data sets.

Determination of the mean speed and pace speed may also be desirable from the data set. The determinations of these from the data again in Table 7 are as follows:

Mean Speed (Average Speed) =

$$\frac{(31x1)+(35x1)+(41x4)+(44\ x10)+(47x23)+(50x22)+(53x20)+(56x11)+(59x5)+(62x3)}{100}$$

$$= 50.8\ (51\ MPH)$$

Again, the pace speed is defined as the 10 mph range or window that contains the highest number of observations. Therefore, the pace speed is in the range of 44 MPH to 54 MPH.

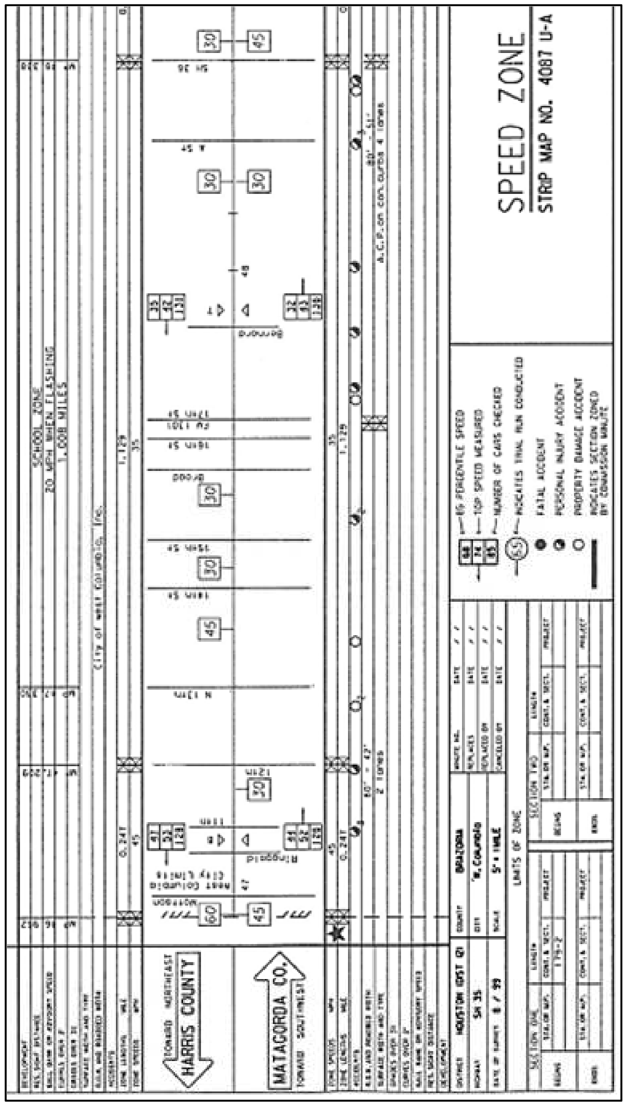


Figure 9. Example Strip Map w/ Crash Info. (TX)

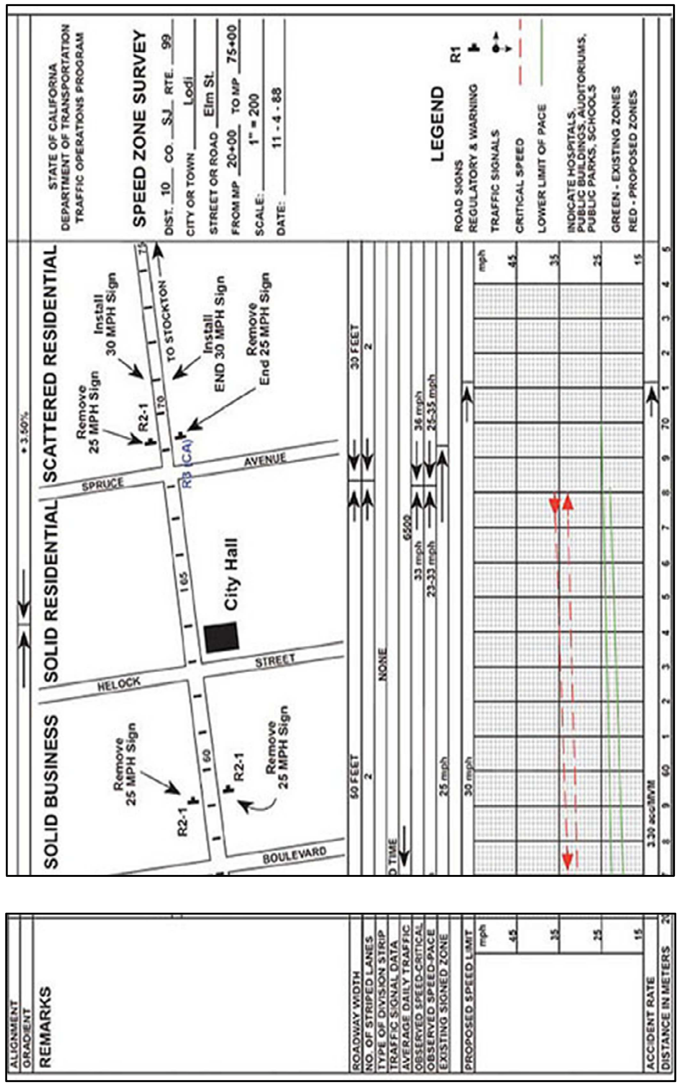


Figure 10. Example Strip Map w/ Speed Profile (CA)

SPEED STUDY REPORTING AND APPROVAL

A Speed Study Report should be prepared once the data has been received and analyzed. The report provides documentation of the findings and recommendation for speed zoning. A uniform report ensures that all appropriate information is provided. Although not all areas will be addressed in every report, sufficient detail is necessary for a complete understanding of the data gathered and recommendations. The following topic areas should be addressed in a Speed Study Report:

1. Introduction
2. Study Location and Limits
3. Roadway Physical Characteristics
4. Traffic Data and Summary Statistics
5. Crash History (Recent 3 years. Minimum, 5 years Preferred)
6. Supporting Traffic Engineering Studies, if available
    a. Pedestrian Studies
    b. School Zone Studies
    c. Special traffic volume or truck studies
    d. Old/historical speed studies
7. Conclusions and Recommendations - Summarize the most important issues and items for consideration from the study. Clearly define the recommended speed limit(s), location and the associated speed zone length. The study document will normally be between two- five pages in length. Any detailed analysis should be added as appendices in the report.

The speed study should be routed though the following steps for approval and consensus.

ALDOT Region Engineer
ALDOT Office of Safety Operations
ALDOT State Maintenance Engineer

Ultimately, approval of speed zone studies for state maintained roadways will be required by the State Maintenance Engineer.

Appendix B – Speed Signing Guidance

The following guidance regarding speed limit signage is as excerpted from the 2009 MUTCD and the 2009 Traffic Control Devices Handbook as published from the Institute of Transportation Engineers (ITE).

Section 2B.13 Speed Limit Sign (R2-1)

Standard:

01 **Speed zones (other than statutory speed limits) shall only be established on the basis of an engineering study that has been performed in accordance with traffic engineering practices. The engineering study shall include an analysis of the current speed distribution of free-flowing vehicles.**

02 **The Speed Limit (R2-1) sign (see Figure 2B-3) shall display the limit established by law, ordinance, regulation, or as adopted by the authorized agency based on the engineering study. The speed limits displayed shall be in multiples of 5 mph.**

03 **Speed Limit (R2-1) signs, indicating speed limits for which posting is required by law, shall be located at the points of change from one speed limit to another.**

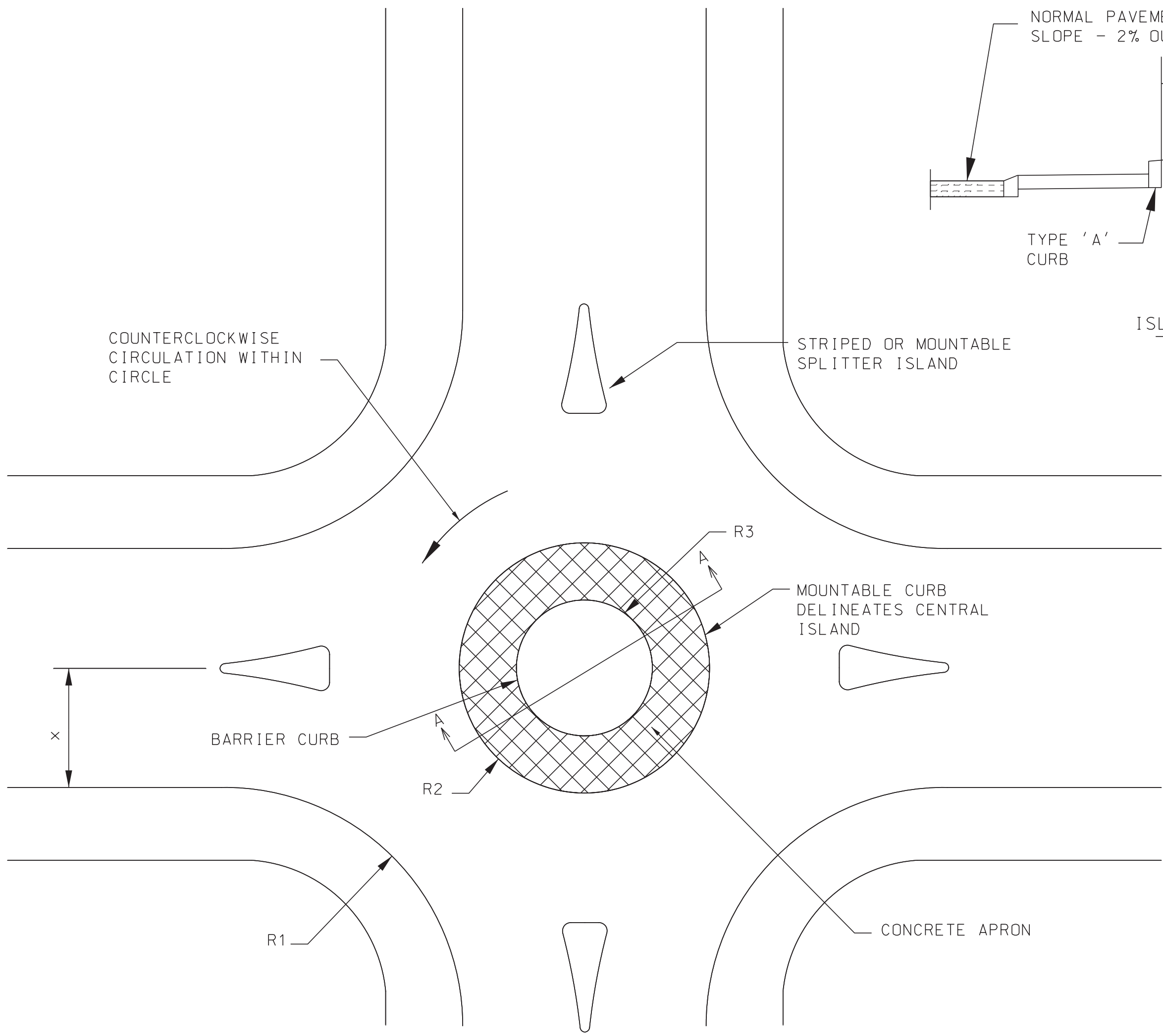
04 **At the downstream end of the section to which a speed limit applies, a Speed Limit sign showing the next speed limit shall be installed. Additional Speed Limit signs shall be installed beyond major intersections and at other locations where it is necessary to remind road users of the speed limit that is applicable.**

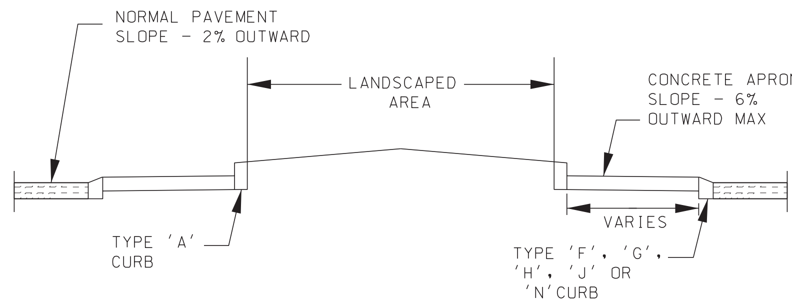
05 **Speed Limit signs indicating the statutory speed limits shall be installed at entrances to the State and, where appropriate, at jurisdictional boundaries in urban areas.**

Section 2B.15 of the MUTCD (2009) requires that Speed Limit signs (R2-1) be erected at the point where a change occurs in established speed limitations. Although no specific spacing or interval for Speed Limit signing is included, the MUTCD further states that signs be posted beyond major intersections as at other locations where it may be necessary to remind motorists of the established limits. These signs should not be erected until speed limits are officially approved and authorized by the controlling jurisdiction.

Appendix C – Sample Standard Drawings of Traffic Calming Methods

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO





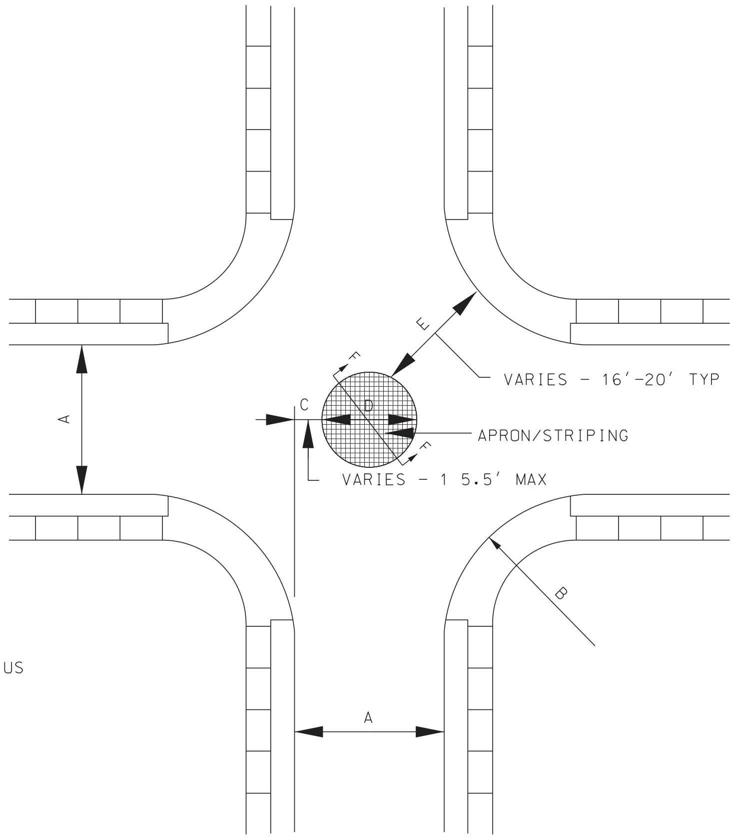
ISLAND SECTION A - A

NTS

X	R1	R2	R3
16′	15′	12′	7′
	20′	18′	7′
	25′	20′	7′
14′	15′	10′	5′
	20′	11′	5′
	25′	12′	5′
12′	15′	6′	3′
	20′	8′	3′
	25′	9′	3′

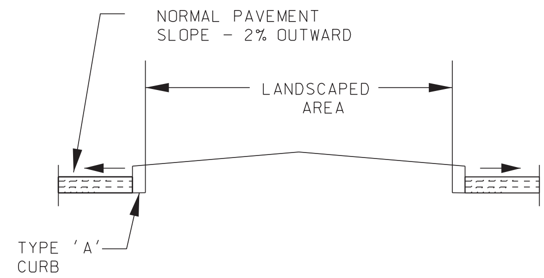
RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				NEIGHBORHOOD TRAFFIC CIRCLE	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



LEGEND
A STREET WIDTH
B CURB RETURN RADIUS
C OFF-SET
D CIRCLE DIAMETER
E OPENING WIDTH

PLAN VIEW
NTS



ISLAND SECTION F - F
NTS

"A" STREET WIDTH (FEET)	"B" CURB RADIUS (FEET)	"C" OFFSET DISTANCE (FEET)	"D" CIRCLE DIAMETER (FEET)	"E" OPENING WIDTH (FEET)
22	<14	RECONSTRUCT CURBS		
	15	5.5	11	16
	20	4.5	13	18
	25	4.0	15	19
24	<12	RECONSTRUCT CURBS		
	15	5.0	14	17
	20	4.5	15	18
	25	3.5	17	20
30	10	5.5	19	16
	15	5.0	20	17
	20	4.0	22	19
	25	3.0	24	20
32	10	5.5	21	16
	15	4.5	23	18
	20	4.0	24	19
	25	2.5	27	20

THE OPTIMAL RELATIONSHIP BETWEEN OFFSET DISTANCE AND OPENING WIDTH IS:

5.5 FEET MAX	16 FEET MIN
5	17
4.5	18
4	19
3.5 OR LESS	20

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				MINI TRAFFIC CIRCLE	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

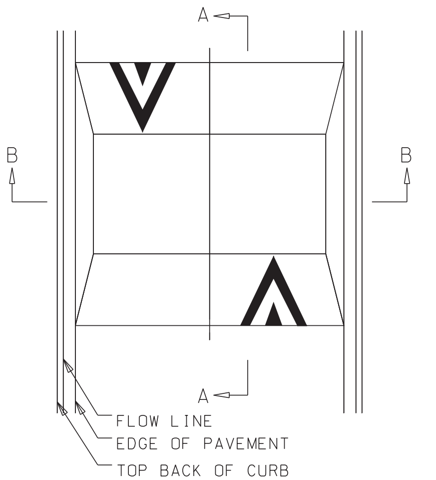
"A" STREET WIDTH (FEET)	"B" CURB RADIUS (FEET)	"C" OFFSET DISTANCE (FEET)	"D" CIRCLE DIAMETER (FEET)	"E" OPENING WIDTH (FEET)
22	℞14	RECONSTRUCT CURBS		
	15	5.5	11	16
	20	4.5	13	18
	25	4.0	15	19
24	℞12	RECONSTRUCT CURBS		
	15	5.0	14	17
	20	4.5	15	18
	25	3.5	17	20
30	10	5.5	19	16
	15	5.0	20	17
	20	4.0	22	19
	25	3.0	24	20
32	10	5.5	21	16
	15	4.5	23	18
	20	4.0	24	19
	25	2.5	27	20

THE OPTIMAL RELATIONSHIP BETWEEN OFFSET DISTANCE AND OPENING WIDTH IS:

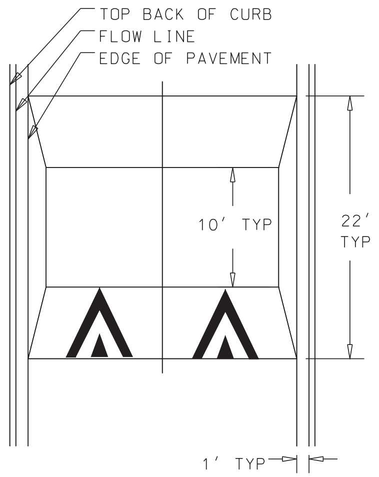
5.5 FEET MAX	16 FEET MIN.
5	17
4.5	18
4	19
3.5 OR LESS	20

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				CENTER ISLAND DIMENSIONS FOR MINITRAFFIC CIRCLE	

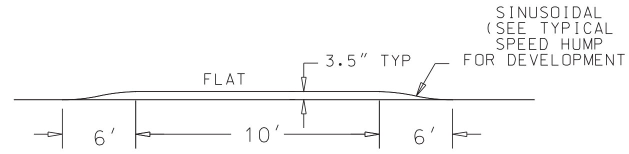
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



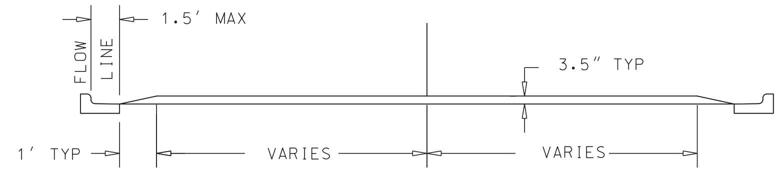
TWO-WAY STREET



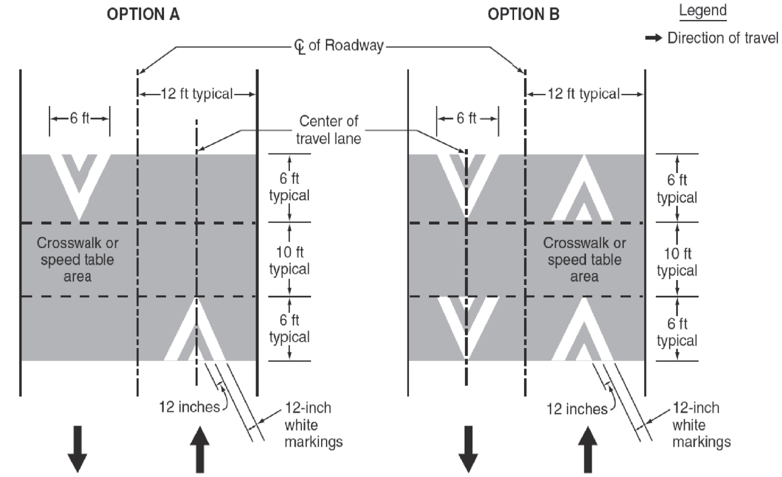
ONE-WAY STREET



SECTION A-A



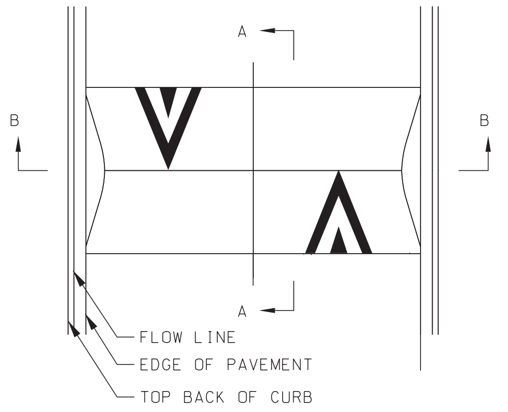
SECTION B-B



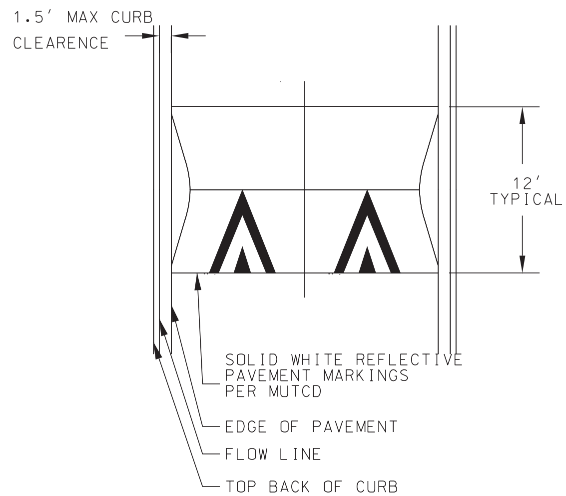
Note: Optional crosswalk lines are not shown in this figure

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				SPEED TABLE	

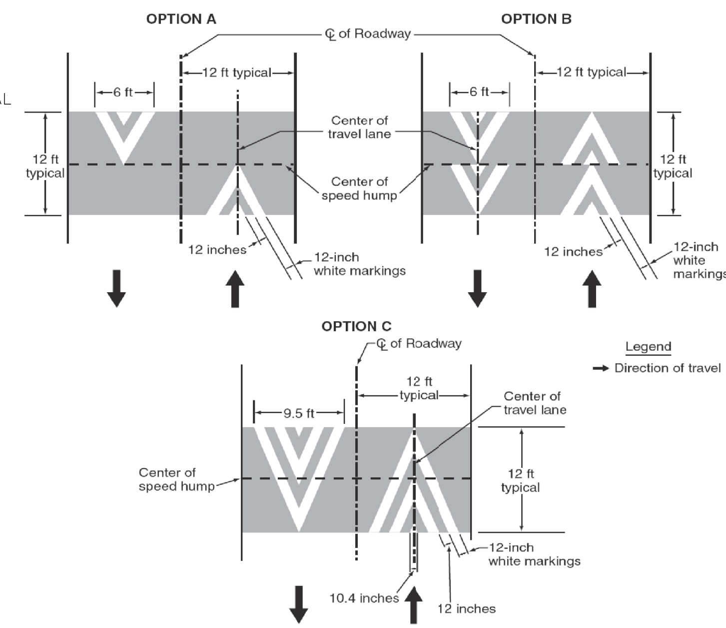
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

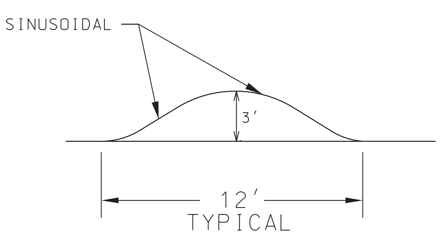


TWO-WAY STREET

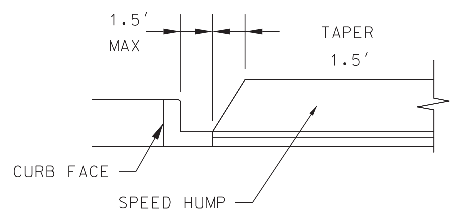


ONE-WAY STREET





SECTION A-A



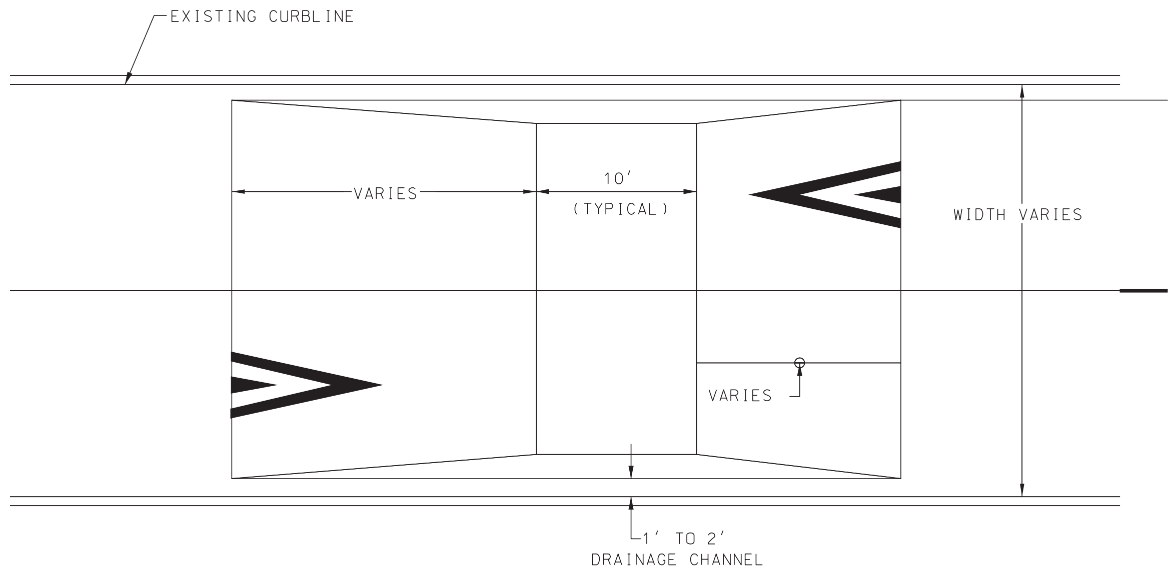
SECTION B-B

SINUSOIDAL SPEED HUMP DEVELOPMENT

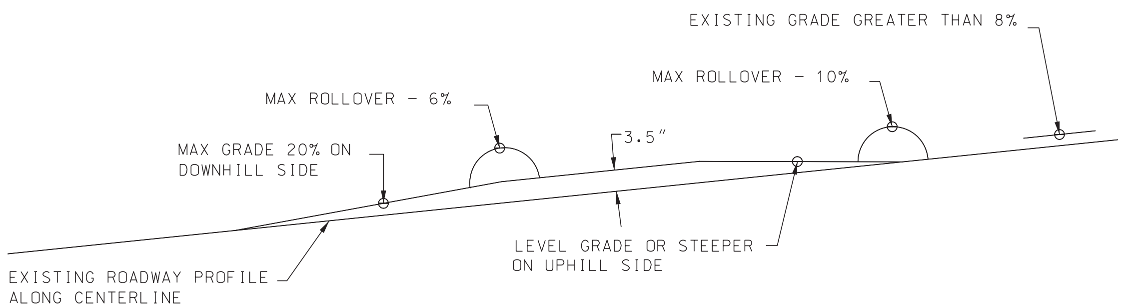
DISTANCE (FT)(L)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
FINISHED HEIGHT (IN)(H)	0.00	0.48	0.92	1.31	1.67	1.98	2.25	2.48	2.67	2.81	2.92	2.98	3.00

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N.T.S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				TYPICAL SPEED HUMP	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



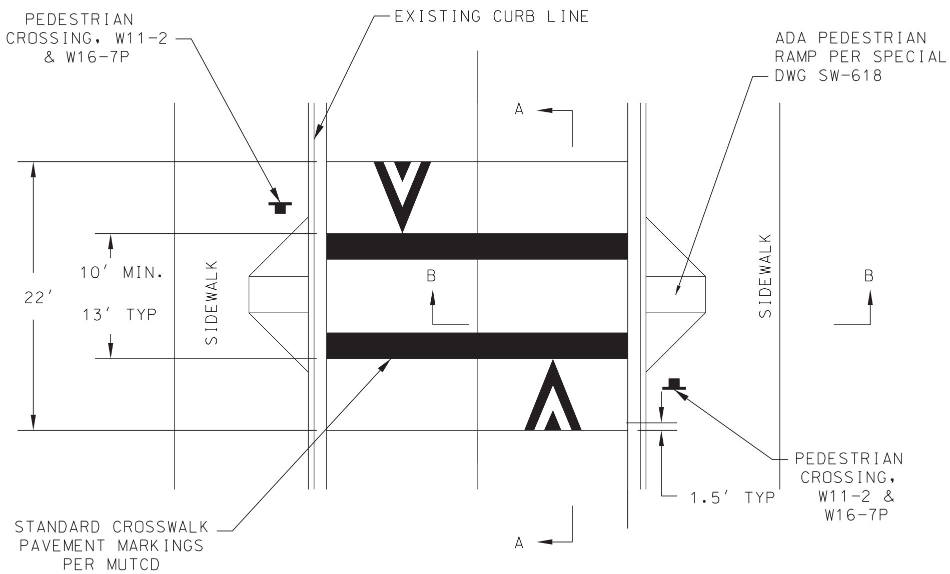
PLAN VIEW

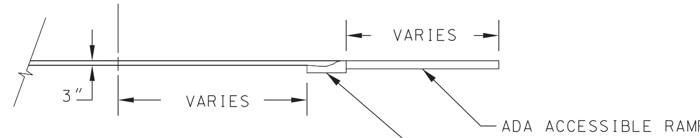


VERTICAL PROFILE MODIFIED TO BE EFFECTIVE
ON AN INCLINE WITH A GRADIENT EXCEEDING 8%
PAVEMENT MARKINGS PER MUTCD

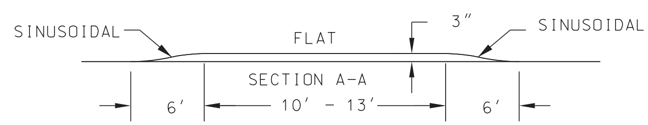
PROFILE VIEW

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				SPEED HUMP ON GRADE	

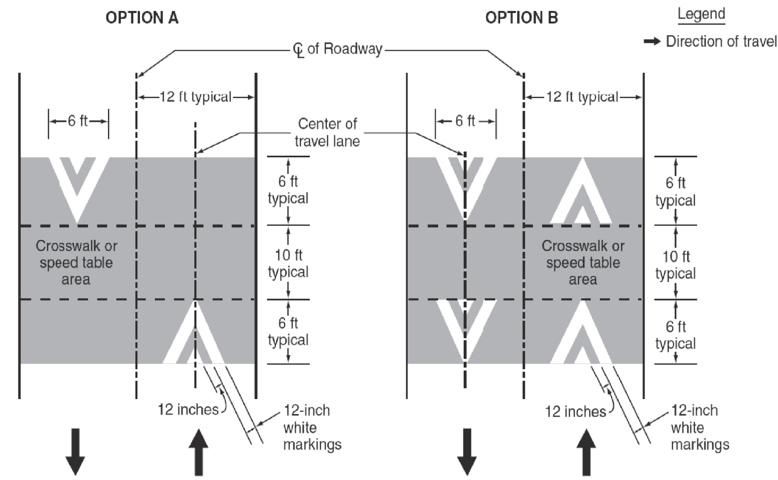




SECTION B-B



SECTION A-A



Note: Optional crosswalk lines are not shown in this figure

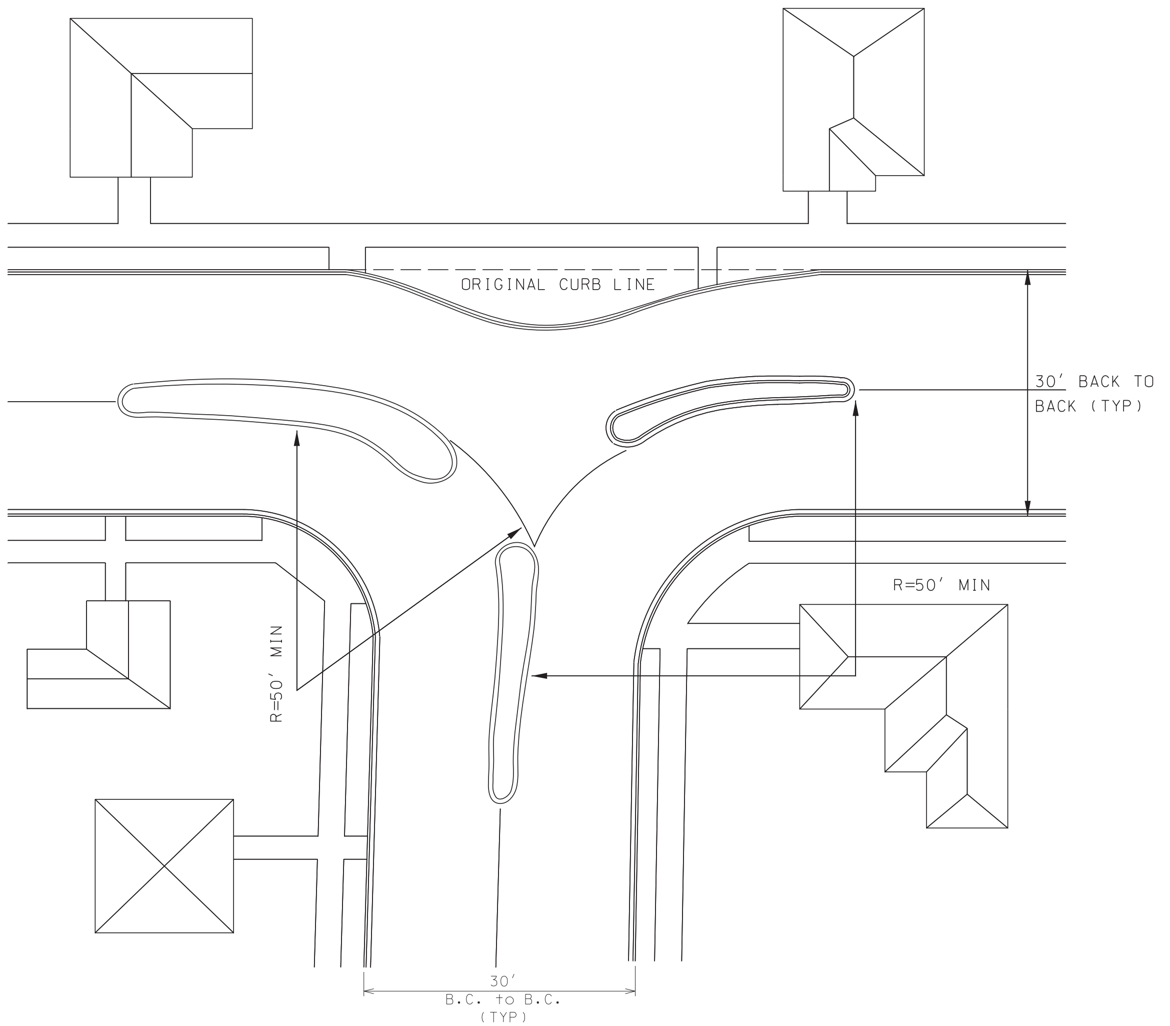
STORM DRAIN INLETS ARE REQUIRED ON THE UP HILL SIDE OF A RAISED CROSSWALK.

SINUSOIDAL SPEED HUMP DEVELOPMENT

DISTANCE (FT)	0.00	0.41	0.82	1.23	1.64	2.05	2.46	2.87	3.28	3.69	4.10	4.51	4.92	5.33	5.74	6.15	6.55
FINISHED HEIGHT (IN)	0.00	0.04	0.12	0.26	0.47	0.71	0.98	1.26	1.57	1.89	2.17	2.44	2.68	2.87	3.03	3.11	3.15

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				RAISED CROSSWALK	

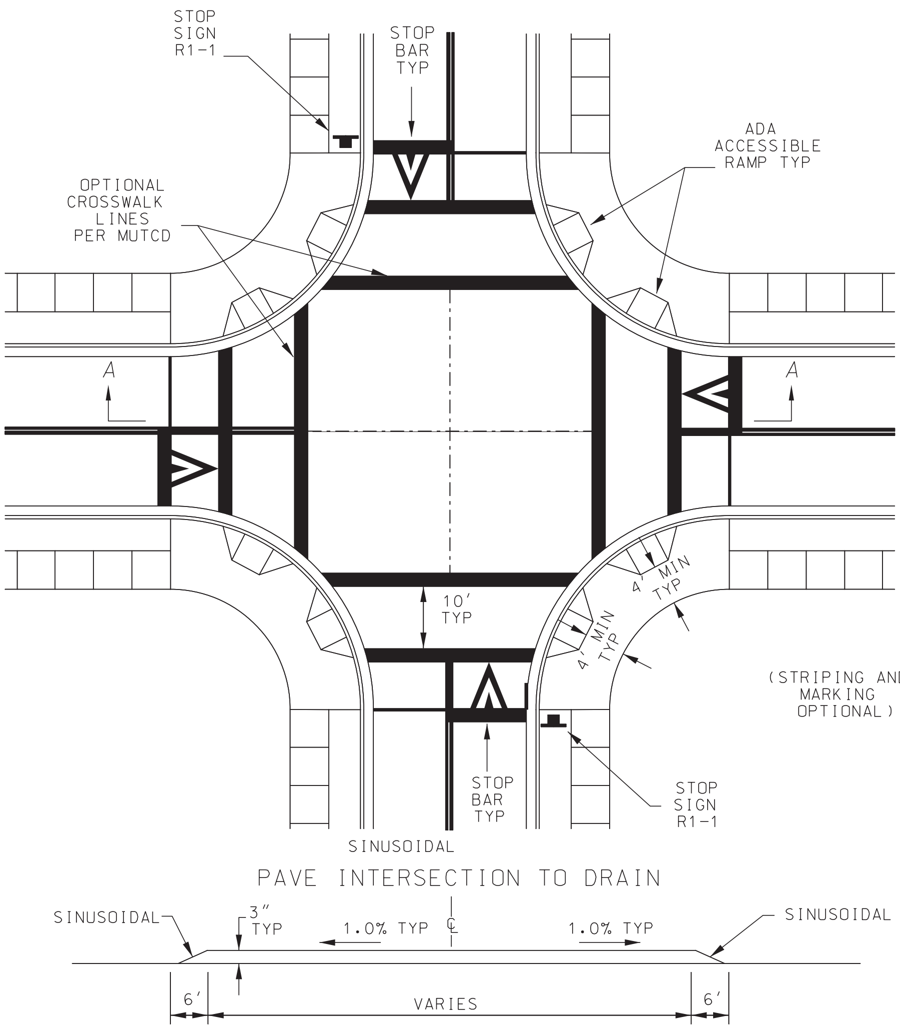
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



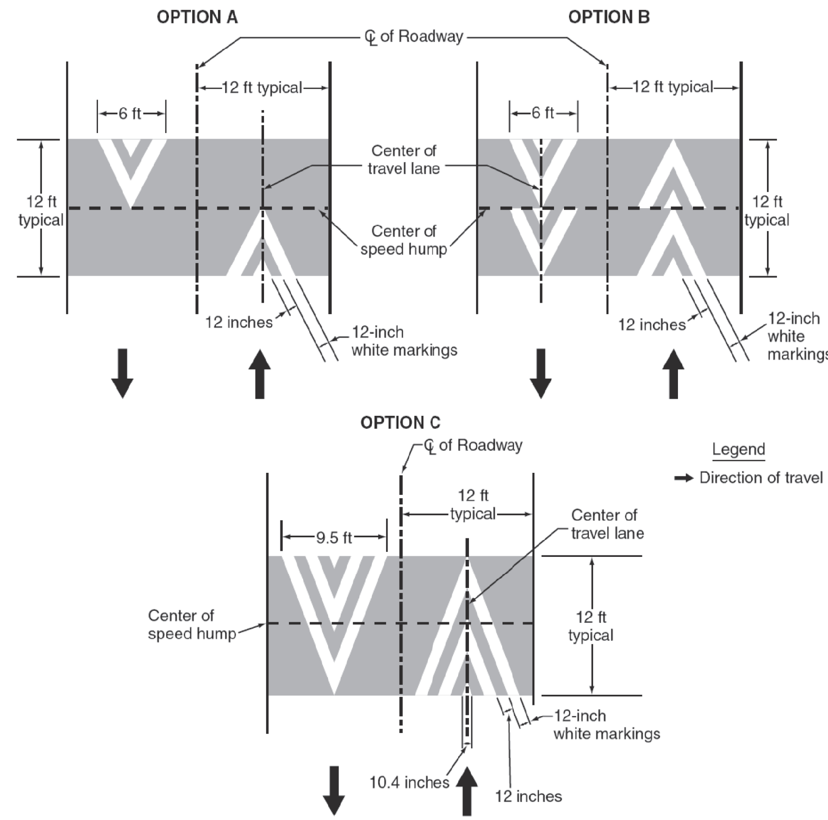
NOTE: STOP OR YIELD SIGNS TO BE USED AS APPROPRIATE

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				MODIFIED INTERSECTION	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

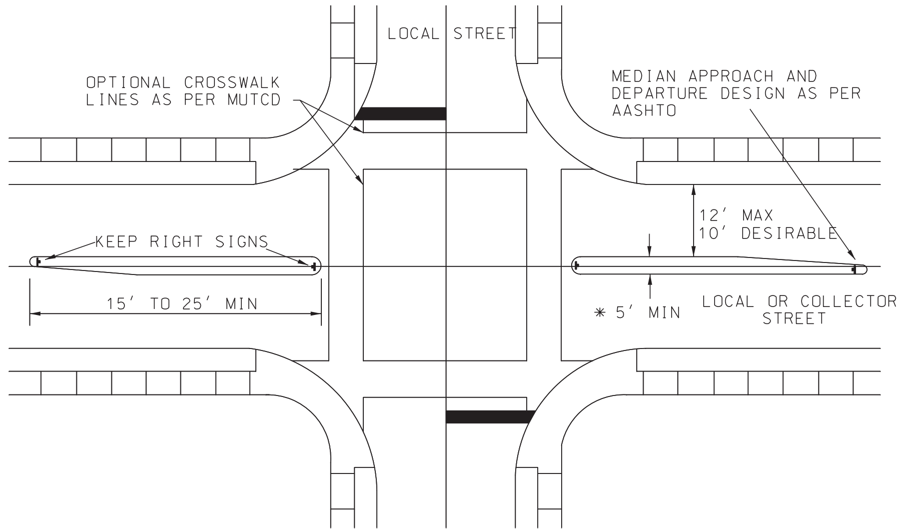


SECTION A-A



RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N.T.S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				RAISED INTERSECTION	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

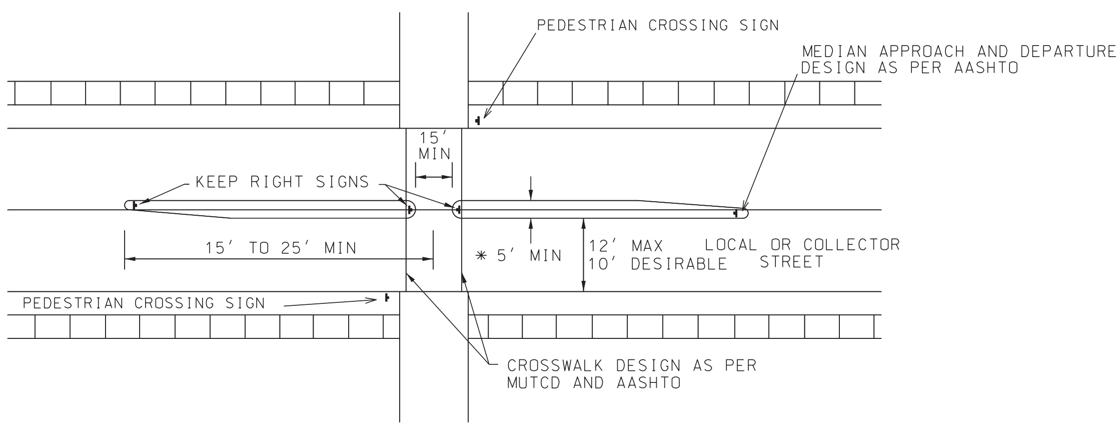


LOCAL STREET INTERSECTION

∗ TRAFFIC CHANNELIZATION DEVICES OR MOUNTABLE RAISED CURB MAY BE ALTERNATELY USED.

THE MAXIMUM LENGTH OF THE MEDIAN ISLAND IS AFFECTED BY ADJACENT DRIVEWAY AND INTERSECTION LOCATIONS.

ADDITIONAL PARKING PROHIBITED SIGNS MAY BE REQUIRED.

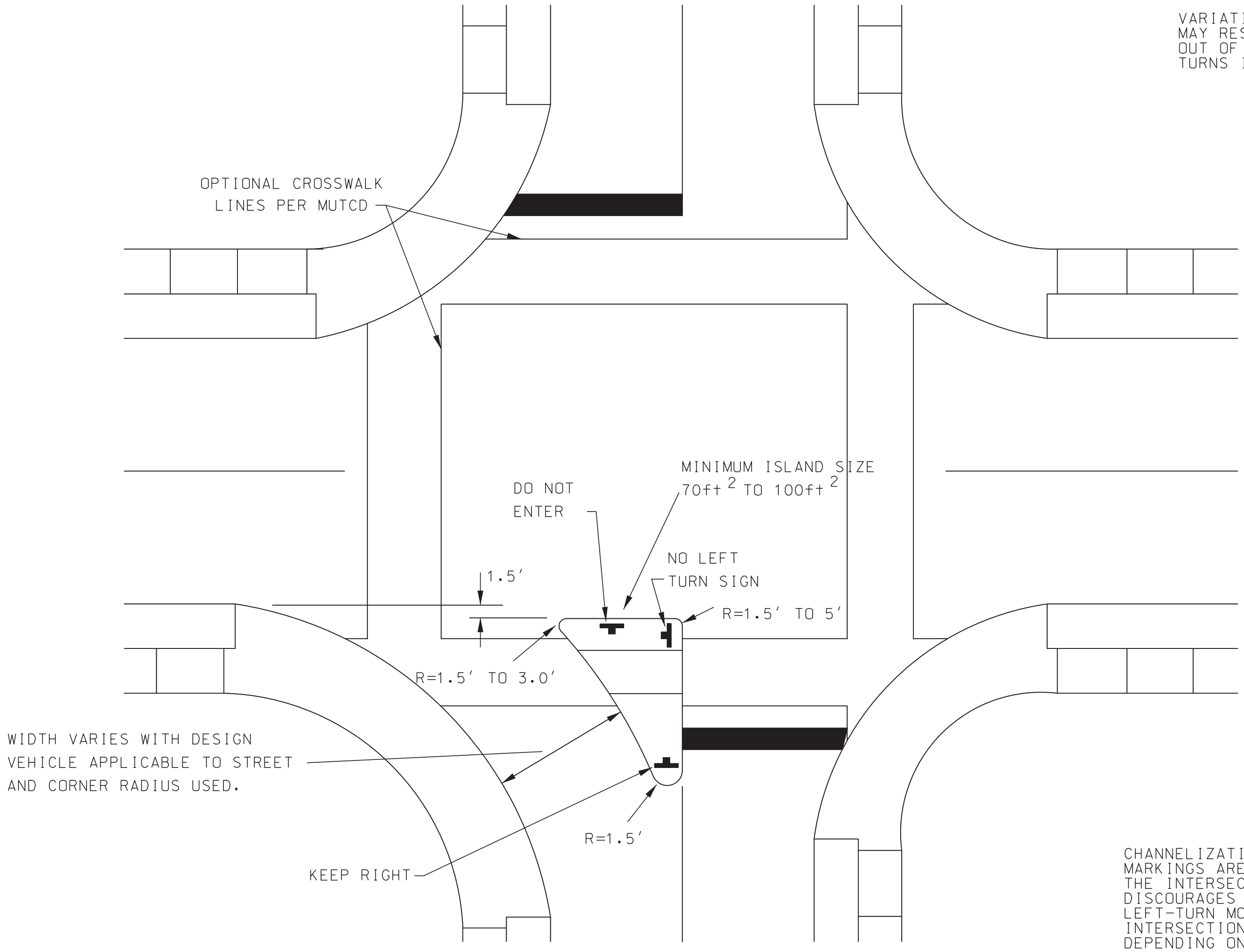


MID-BLOCK CROSSWALK

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				RAISED MEDIAN ISLAND	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

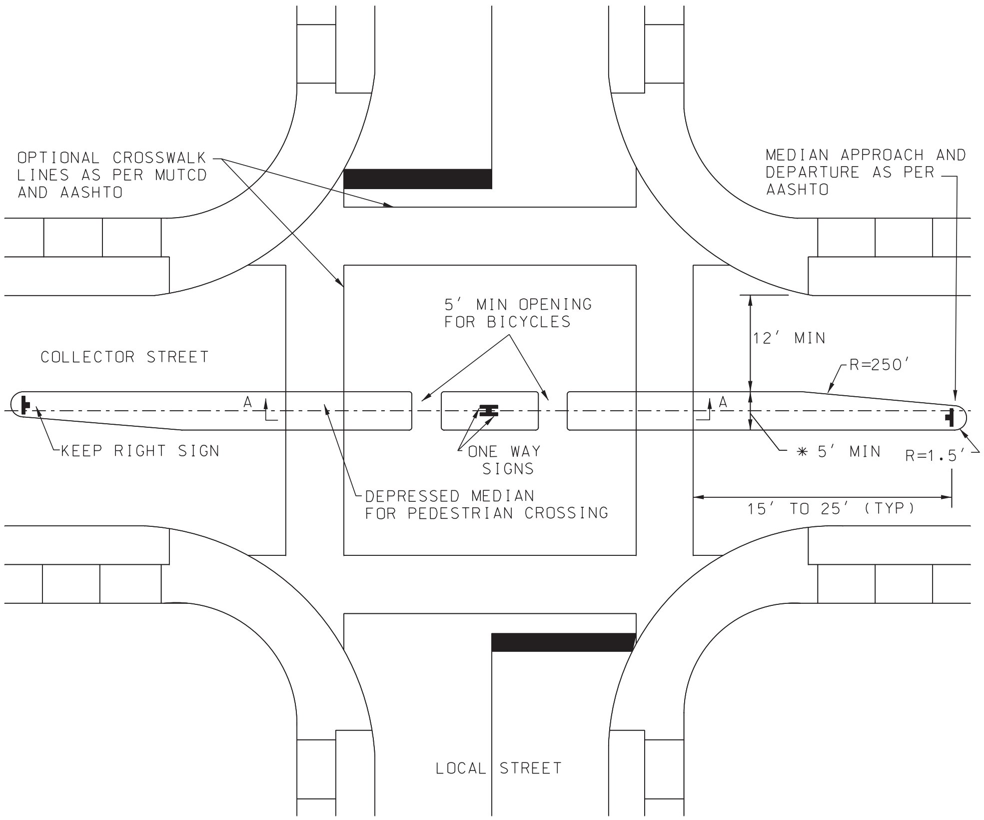
VARIATIONS OF THIS CONCEPT MAY RESTRICT LEFT/RIGHT TURNS OUT OF SIDE ROAD, OR LEFT/RIGHT TURNS INTO SIDE ROAD.



CHANNELIZATION AS PER MUTCD
MARKINGS ARE OPTIONAL
THE INTERSECTION CHANNELIZATION ILLUSTRATED DISCOURAGES THROUGH MOVEMENT AND LEFT-TURN MOVEMENTS ONTO ONE LEG OF THE INTERSECTION. A RANGE OF ALTERNATIVES EXIST DEPENDING ON THE CURB RADIUS USED AND WHETHER LARGE VEHICLES NEED TO BE ACCOMMODATED THROUGH THE CHANNELIZED AREA.

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				INTERSECTION CHANNELIZATION	

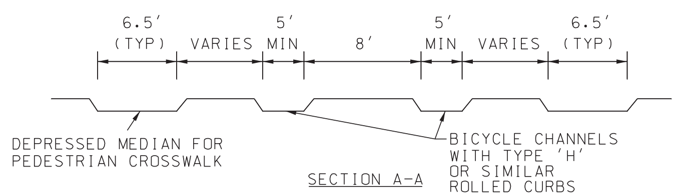
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



✱ TRAFFIC CHANNELIZATION DEVICES OR MOUNTABLE RAISED CURB MAY BE ALTERNATELY USED.

BICYCLE OPENINGS ARE OPTIONAL.

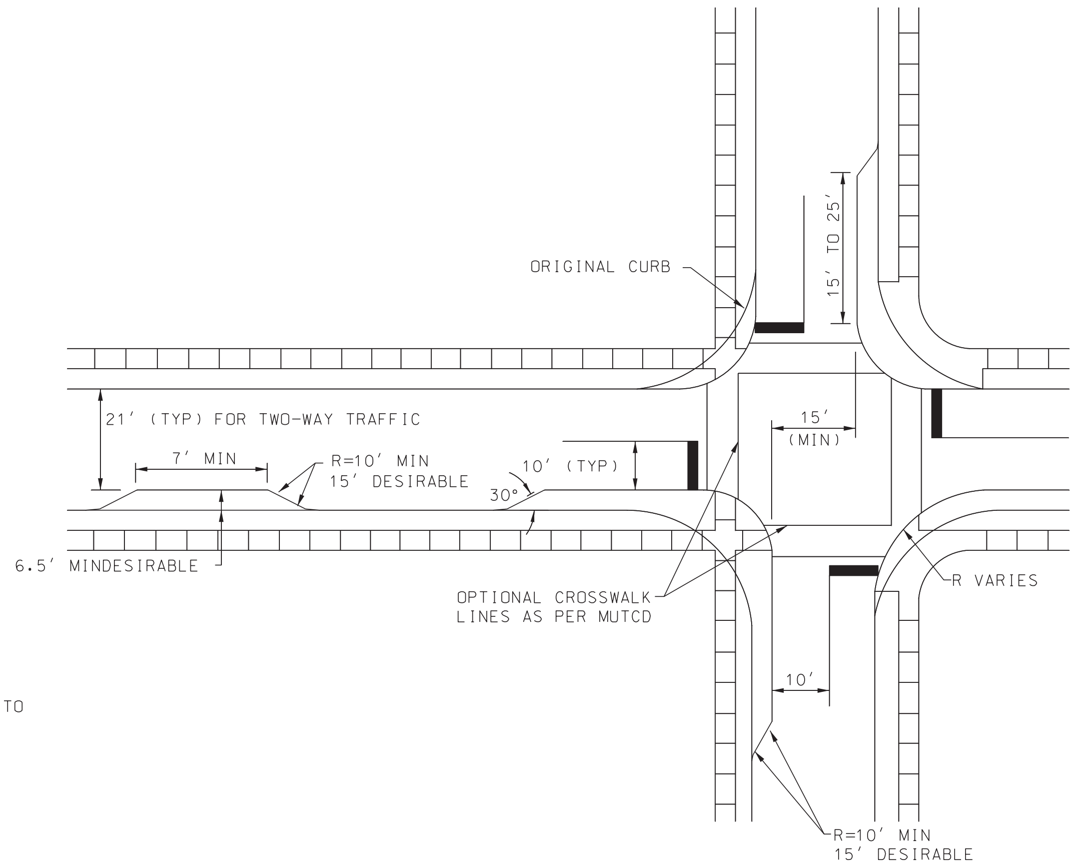
MARKINGS ARE OPTIONAL.



SECTION A-A

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE: RAISED MEDIAN THROUGH INTER.	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10					

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



INTERSECTION RADII SHOULD ACCOMMODATE DESIGN VEHICLES APPLICABLE TO STREET.

MID-BLOCK CURB EXTENSIONS SHOULD BE COMBINED WITH CROSSWALKS WHERE POSSIBLE.

LENGTH OF CURB EXTENSIONS MUST RECOGNIZE SITE CONDITIONS, E.G., DRIVEWAY LOCATIONS.

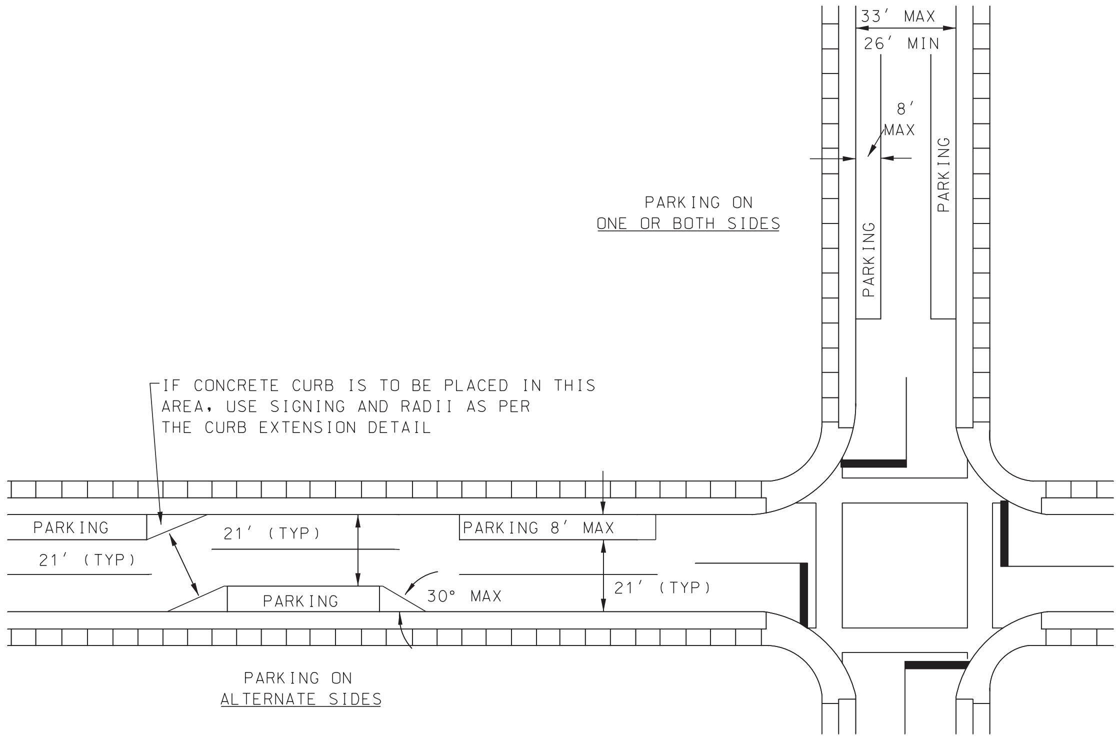
DEPENDING ON LOCAL CLIMATE AND PREFERENCE, VERTICAL DELINEATION OTHER THEN OBJECT MARKERS MAY BE MORE APPROPRIATE. POSSIBLE LANDSCAPING AND CURB PAINTING.

IF LOCAL CONDITIONS PERMIT, THE LANE WIDTHS AT MID-BLOCK CURB EXTENSIONS CAN BE REDUCED TO A 9' MINIMUM AND THE APPROACH LANE AT AN INTERSECTION CURB EXTENSION CAN BE 8' MINIMUM. IN ANY CASE, THE OVERALL ROADWAY WIDTH SHOULD BE 18' MINIMUM.

IF CURB EXTENSIONS ARE PLACED ON DIAGONALLY OPPOSITE CORNERS OF AN INTERSECTION, A MINIMUM CLEAR OFFSET BETWEEN EXTENSIONS OF 15' SHOULD BE PROVIDED TO MINIMIZE VEHICULAR CONFLICTS WITHIN THE INTERSECTION.

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				CURB EXTENSIONS	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



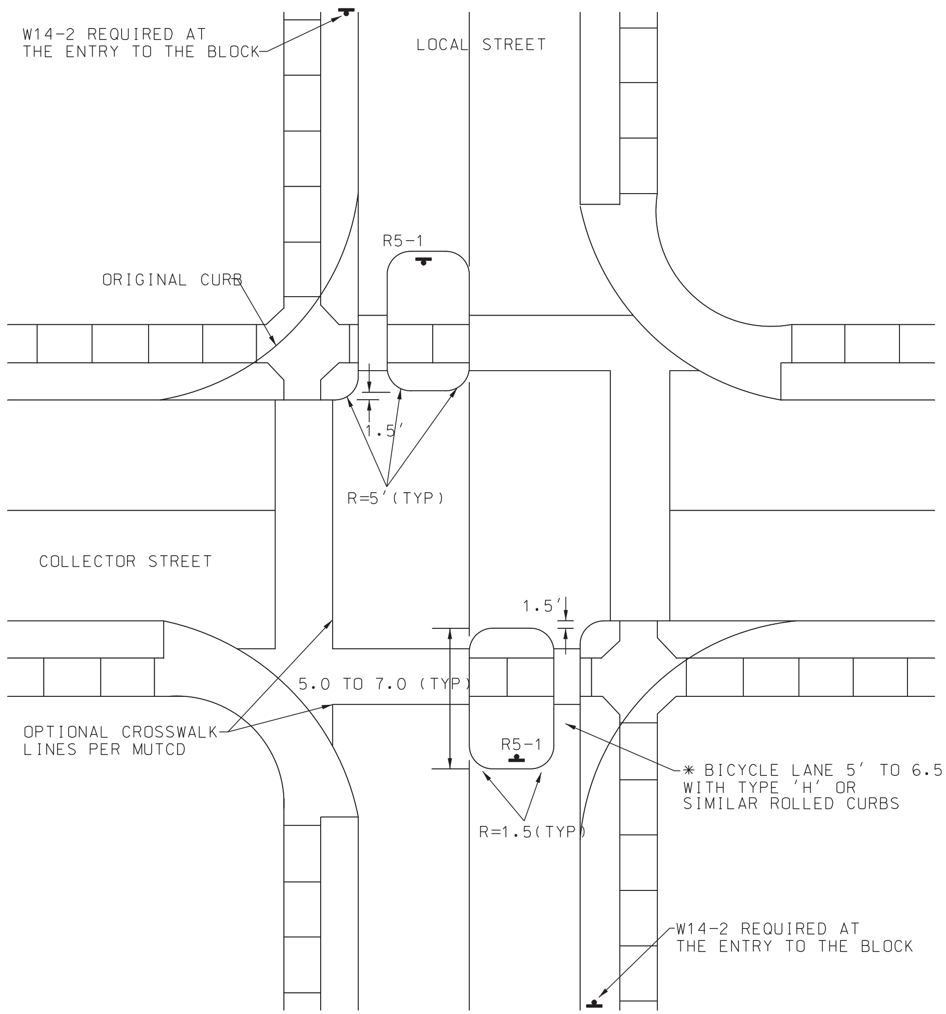
WHERE PARKING ALTERNATES FROM ONE SIDE OF THE ROADWAY TO THE OTHER, A 21 FOOT TYPICAL TWO-LANE WIDTH IS BASED ON TANGENT ALIGNMENT AS OPPOSED TO A CURVILINEAR ALIGNMENT OF THE CHICANE. FOR SINGLE LANE TRAFFIC THE LANE WIDTH CAN BE REDUCED TO 12 FEET MINIMUM.

WHERE PARKING ON BOTH SIDES OF THE ROADWAY IS ACCOMODATED, THE 33 FEET MAXIMUM ROADWAY WIDTH APPLIES. FOR ACCOMODATING PARKING ON ONE SIDE OF THE ROADWAY, THE 26 FEET ROADWAY WIDTH APPLIES.

THE DIMENSIONS SHOWN ARE PROPOSED FOR COLLECTOR STREET REQUIREMENTS, FOR LOW VOLUME LOCAL RESIDENTIAL STREETS, MINIMUM WIDTHS OF 14 FEET FOR TWO-WAY TRAFFIC AND 7 FEET FOR PARKING MAY APPLY. THESE WIDTHS, HOWEVER, MAY NOT ALLOW TWO DIRECTIONAL TRAFFIC TO PASS AT THE SAME TIME, IF VEHICLES ARE PARKED ON STREET.

LOCATION OF PARKING BLOCKS MUST RECOGNIZE LOCAL RESTRICTIONS, CODES, INTERSECTIONS, AND SITE CONDITION, E.G., DRIVEWAY LOCATIONS.

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N.T.S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				ON-STREET PARKING	



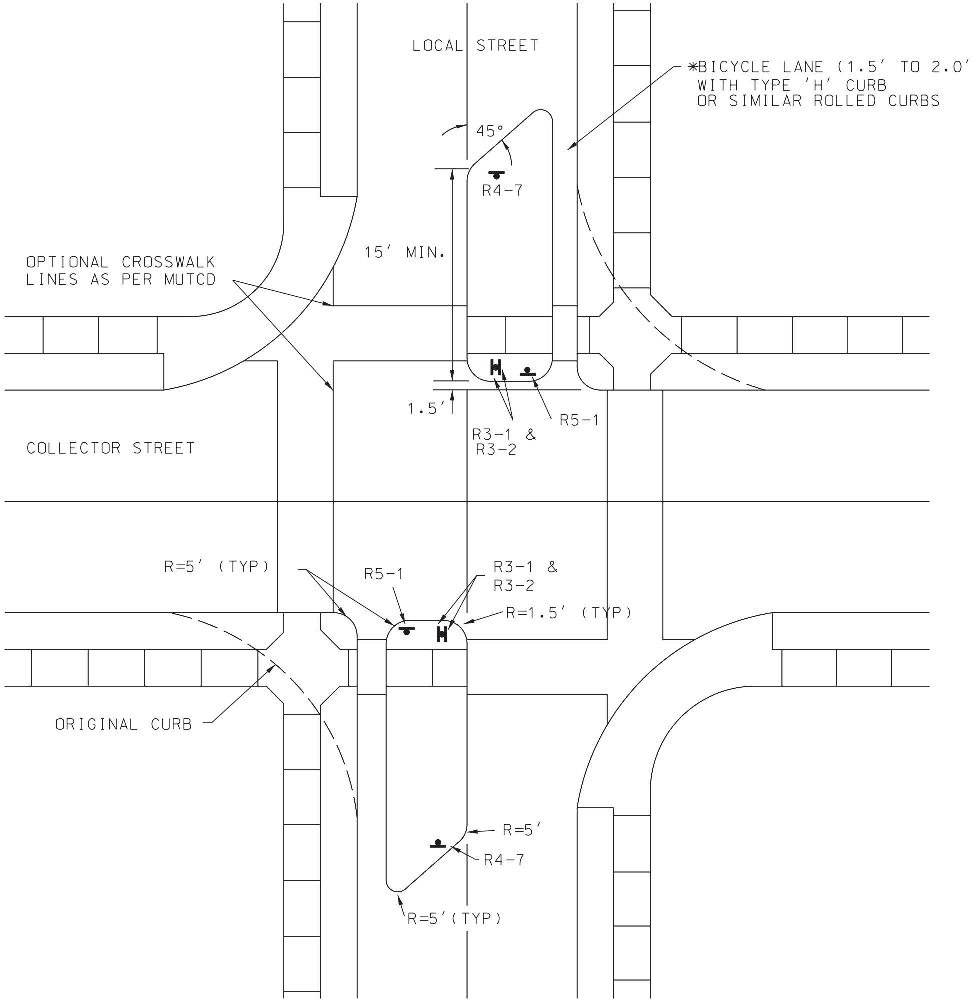
CLOSURE MAY BE LIMITED
TO ONE APPROACH

*BICYCLE LANE OPTIONAL

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				DIRECTIONAL CLOSURE (ENTRANCE ONLY)	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

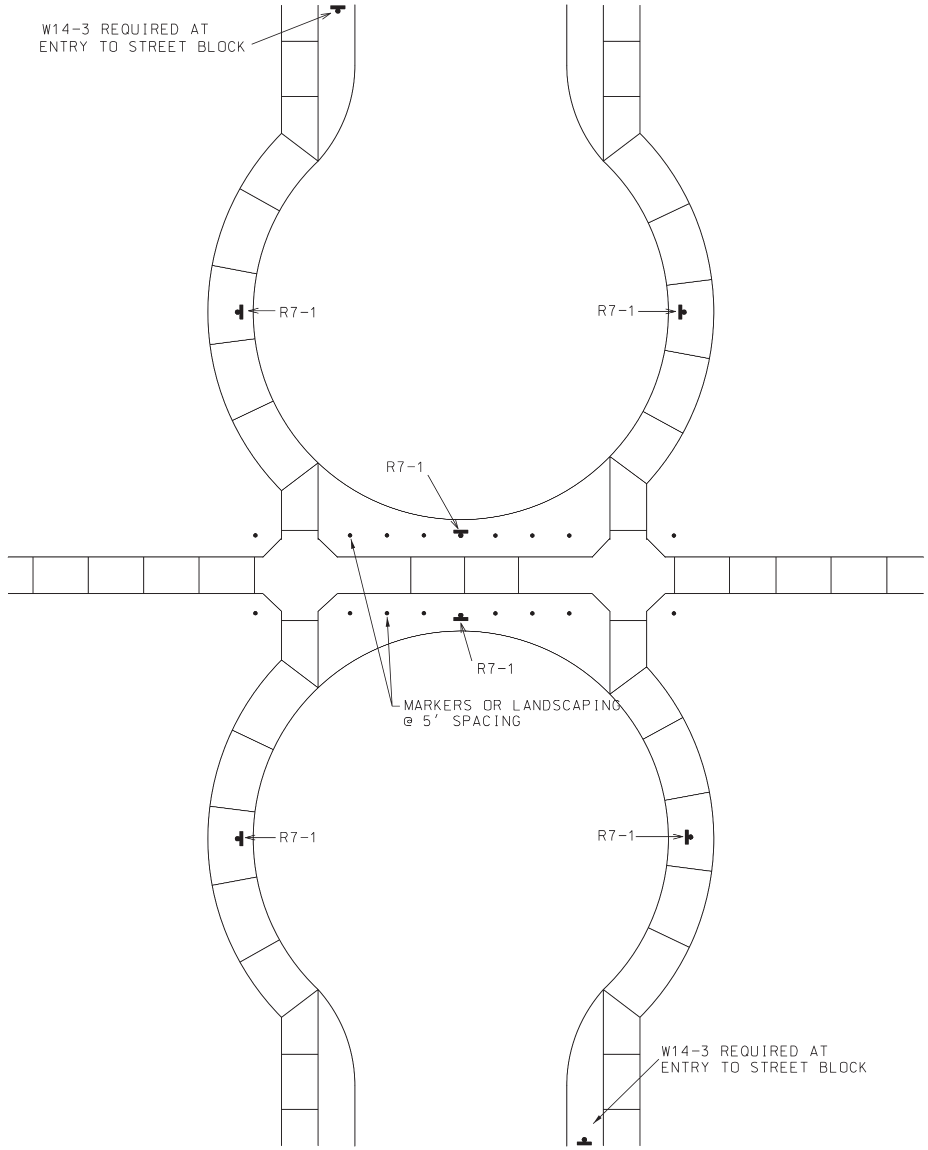


MARKINGS OPTIONAL

CLOSURE MAY BE LIMITED TO ONE APPROACH

* BICYCLE LANE OPTIONAL

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				DIRECTIONAL CLOSURE (EXIT ONLY)	



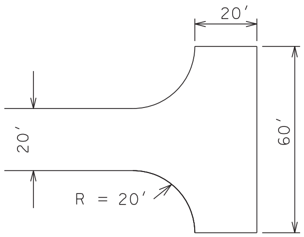
CUL-DE-SAC DESIGN AS PER AASHTO IS DESIRABLE. AVAILABLE RIGHT OF WAY MAY DICTATE A SMALLER OR ALTERNATIVE DESIGN.

ADDITIONAL PARKING PROHIBITED SIGNS MAY BE REQUIRED.

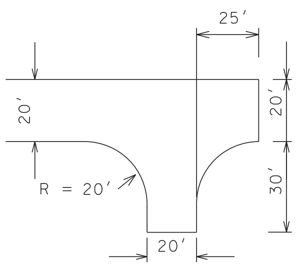
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				MIDBLOCK FULL CLOSURE	

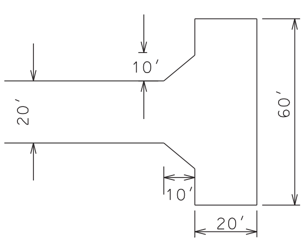
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



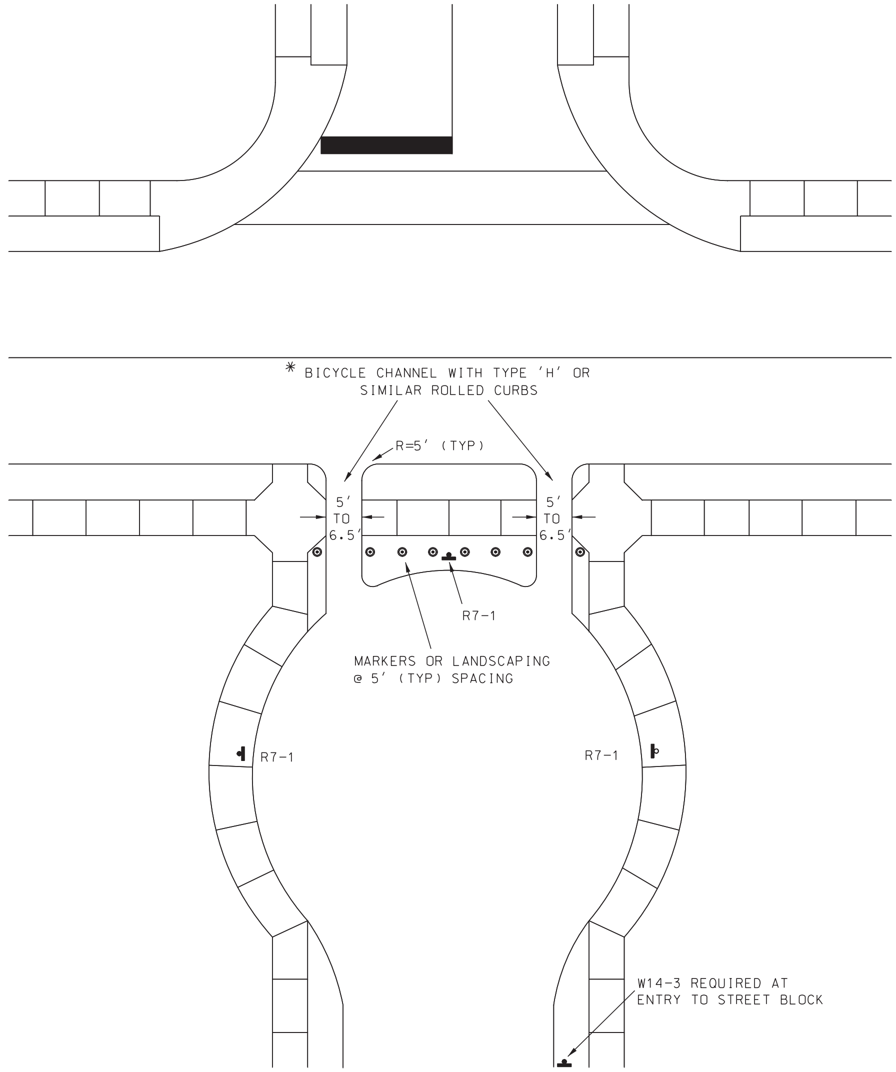
STANDARD TURNING AREA

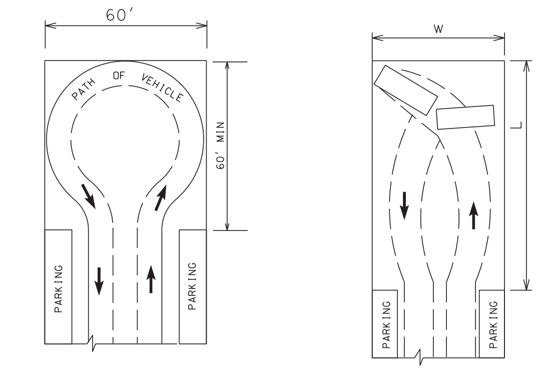


TURNING AREA



STANDARD CUT CORNERS



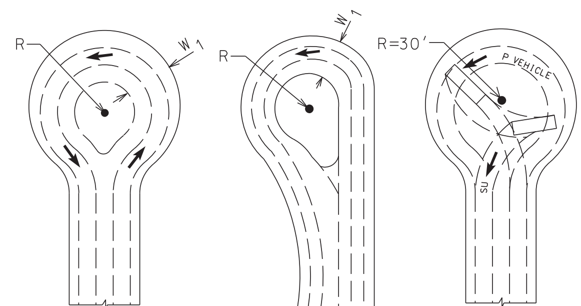


-A-

SQUARED END

-B-

DESIGN VEHICLE	DIMENSIONS (FT)	
	W	L
P	30	60
SU	50	100



CIRCULAR

-C-

CIRCULAR-OFFSET

-D-

30' for SU

CIRCULAR-ALL PAVED

-E-

DESIGN VEHICLE	DIMENSIONS (FT)	
	R	W_1
P	30	18
WB-40	42	25
SU & WB-50	47	30

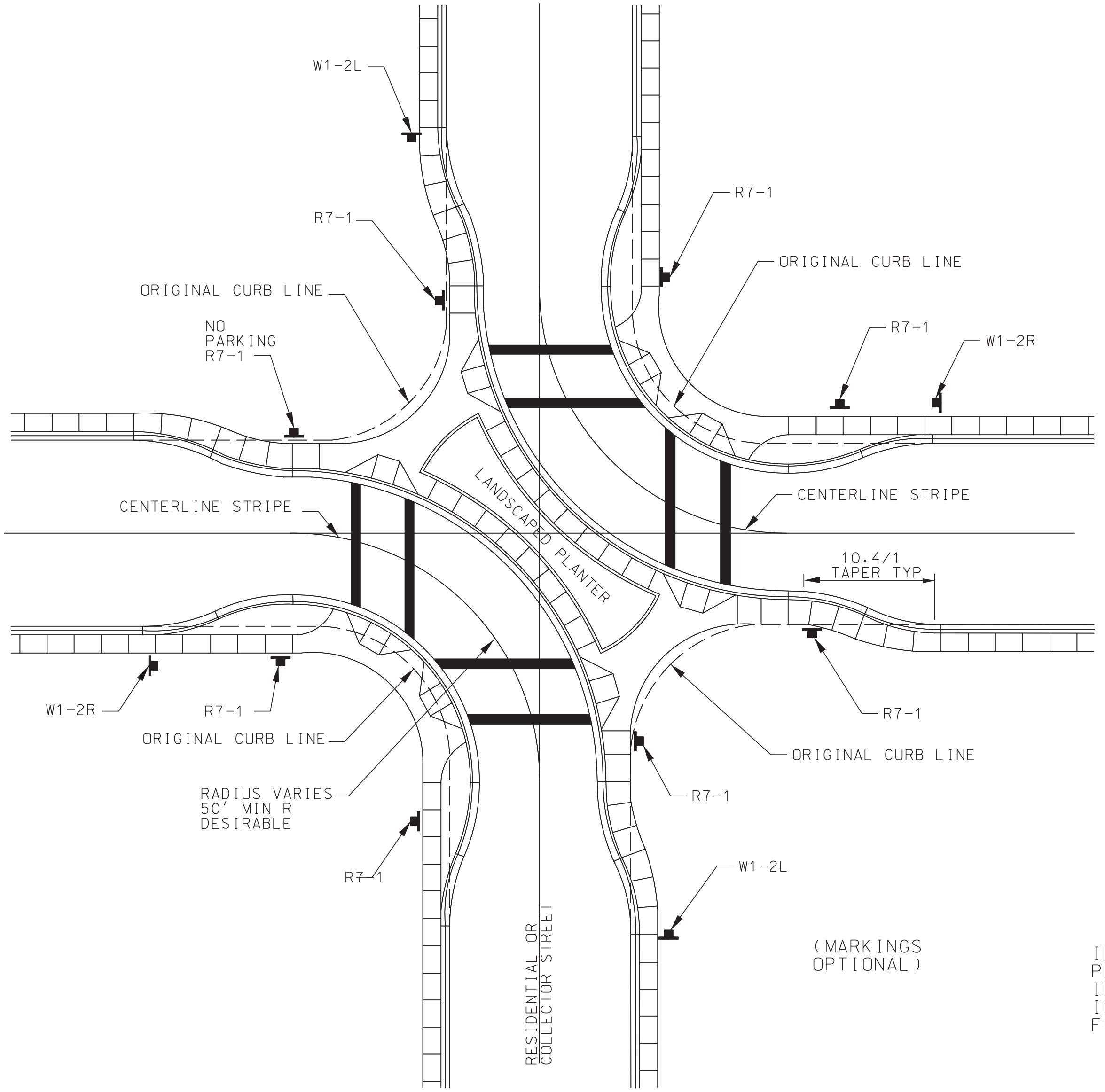
CUL-DE-SAC DESIGN AS PER AASHTO IS DESIRABLE. AVAILABLE RIGHT OF WAY MAY DICTATE A SMALLER OR ALTERNATIVE DESIGN.

ADDITIONAL PARKING PROHIBITED SIGNS MAY BE REQUIRED.

(MARKINGS OPTIONAL)

* BICYCLE LANE OPTIONAL

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				FULL CLOSURE	

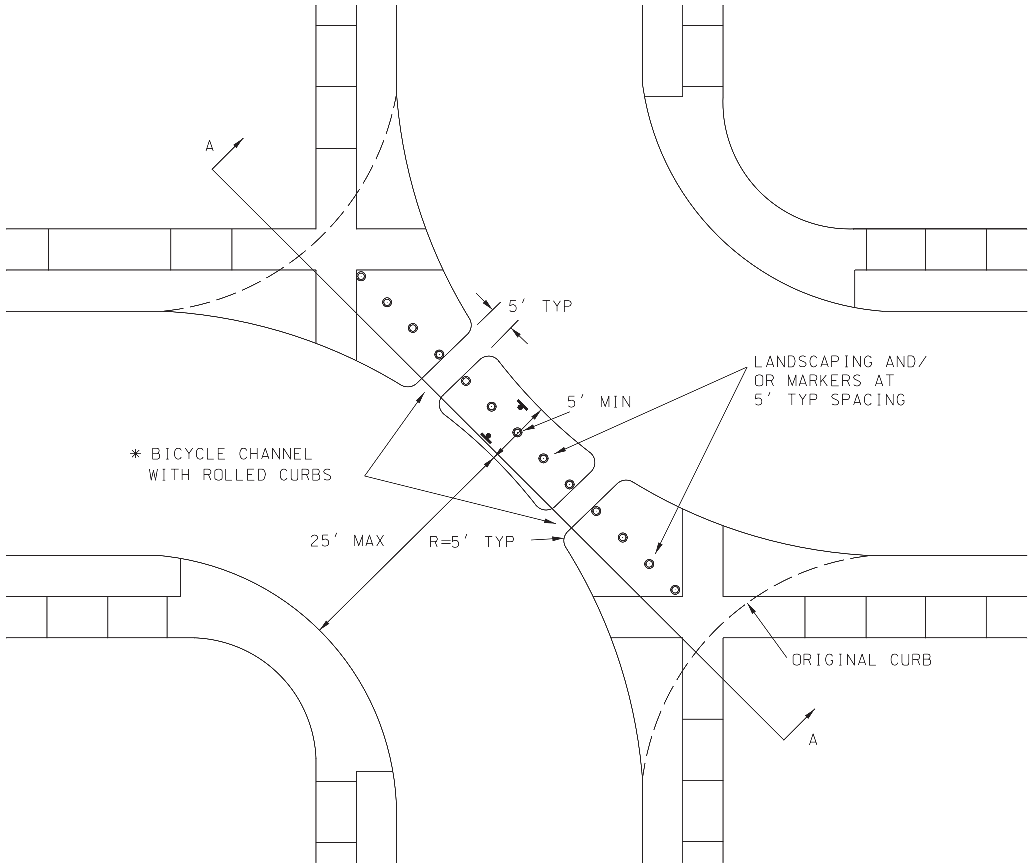


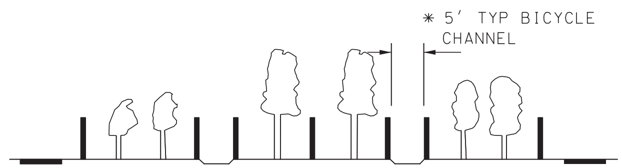
IF NECESSARY LANDSCAPED PLANTER MAY BE REDUCED IN SIZE AND MOUNTABLE CURB INSTALLED TO PROVIDE ACCESS FOR EMERGENCY VEHICLES.

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				DIAGONAL DIVERTER	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO





SECTION A-A

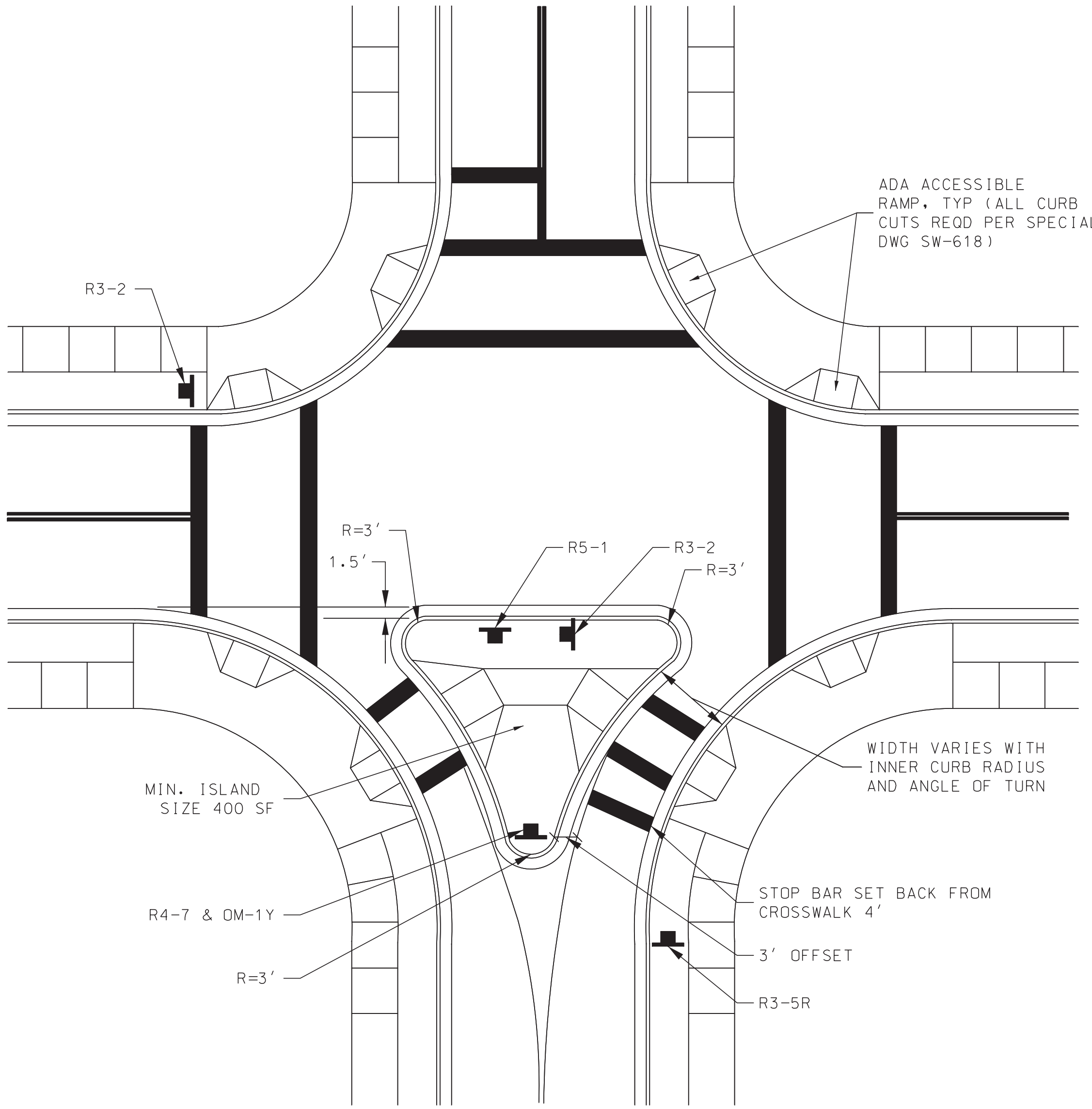
* BICYCLE CHANNEL OPTIONAL

DEPENDING ON PEDESTRIAN DEMAND AND OTHER LOCAL CONDITIONS, THE DIVERTER DESIGN CAN BE MODIFIED TO ACCOMMODATE A SIDEWALK ALONG ITS LENGTH. LANDSCAPING AND/OR BOLLARDS TO BE RETAINED

EMERGENY VEHICLES CAN BE ACCOMMODATED BY USE OF BREAK-AWAY OR LOCKED BOLLARDS, OR LOCKED GATES.

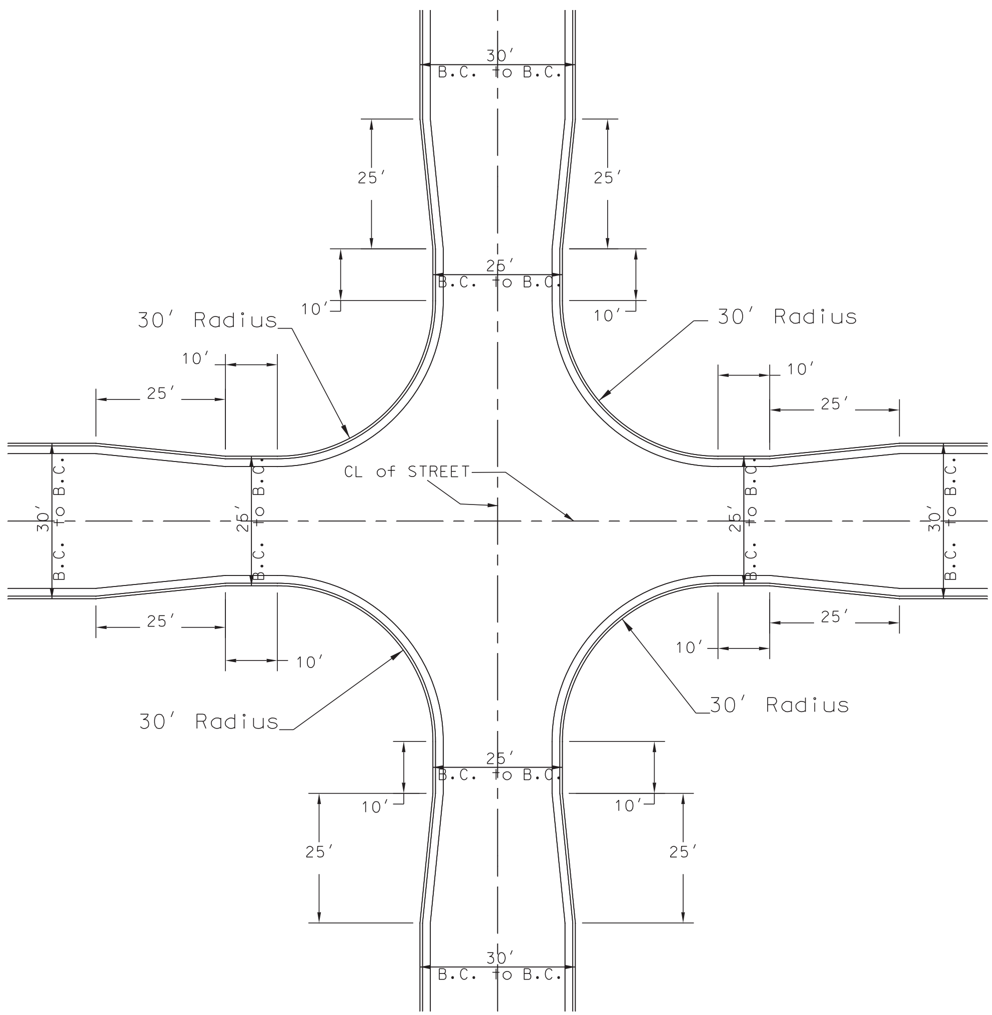
RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				DIVERTER (ALTERNATE DESIGN)	

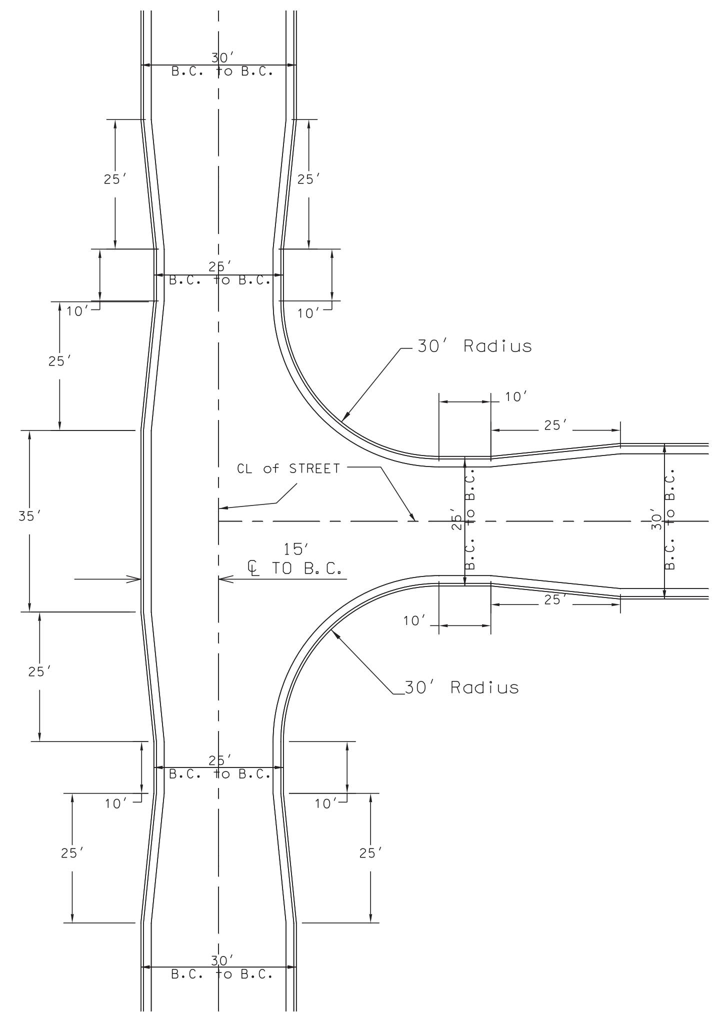
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N.T.S.	SHEET TITLE: FORCED TURN ISLAND
DATE: 7/20/10	DATE:	DATE: 7/20/10				ROUTE

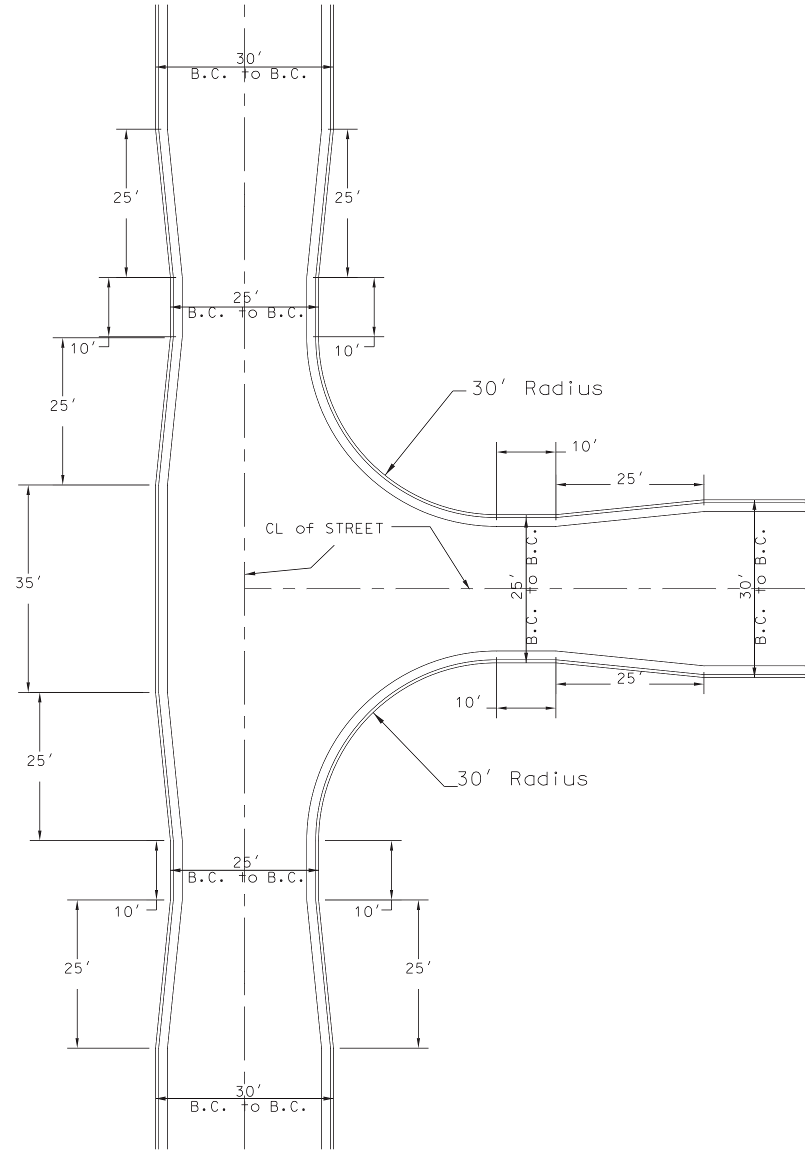
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO





RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				NECKDOWN	

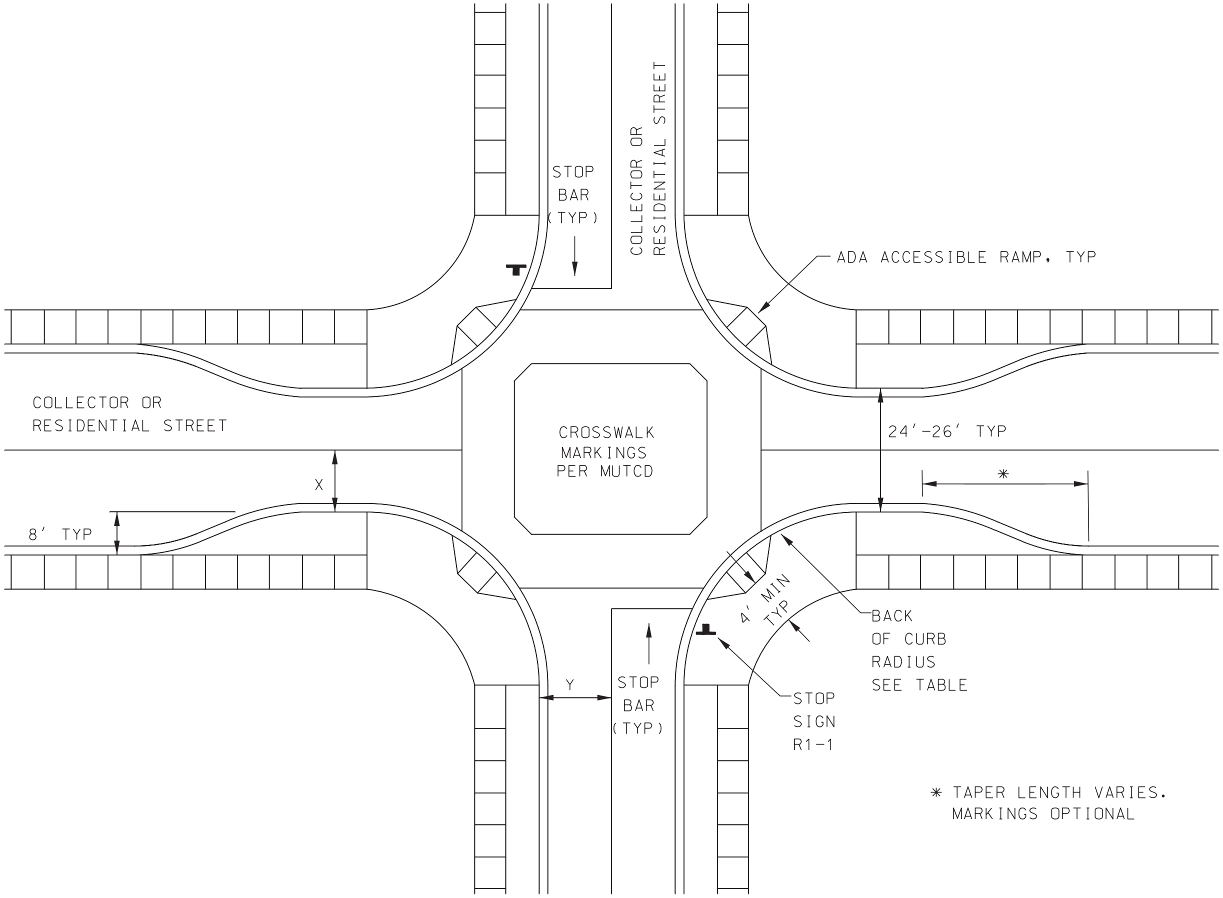
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



NEW DEVELOPMENT	EXISTING DEVELOPMENT
X	X

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				NECKDOWN	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

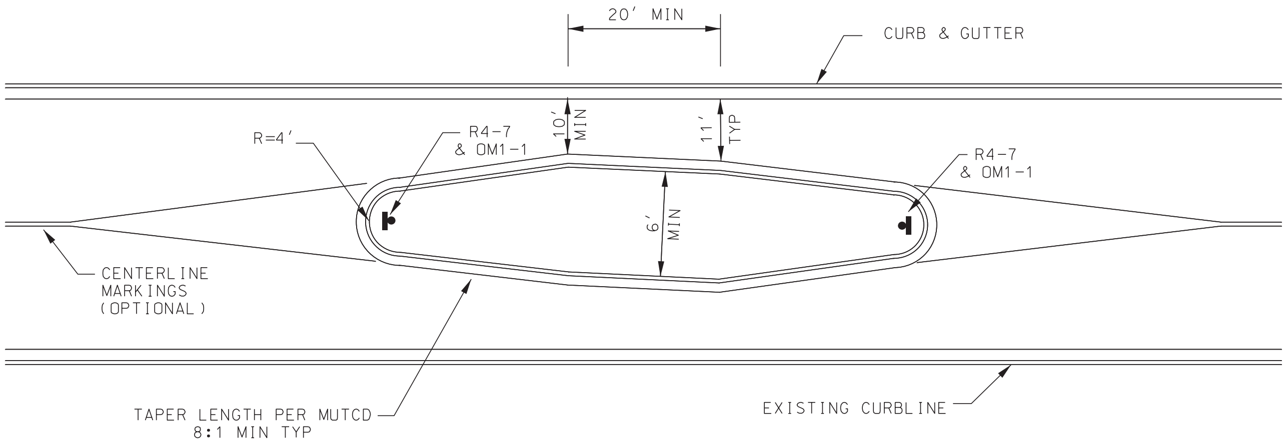


* TAPER LENGTH VARIES.
MARKINGS OPTIONAL

B.C. TO CENTERLINE		B.C. RADIUS
X	Y	
12'	12'	40'
12'	14'	32'
12'	16'	26'
14'	12'	37'
14'	14'	35'
14'	16'	24'

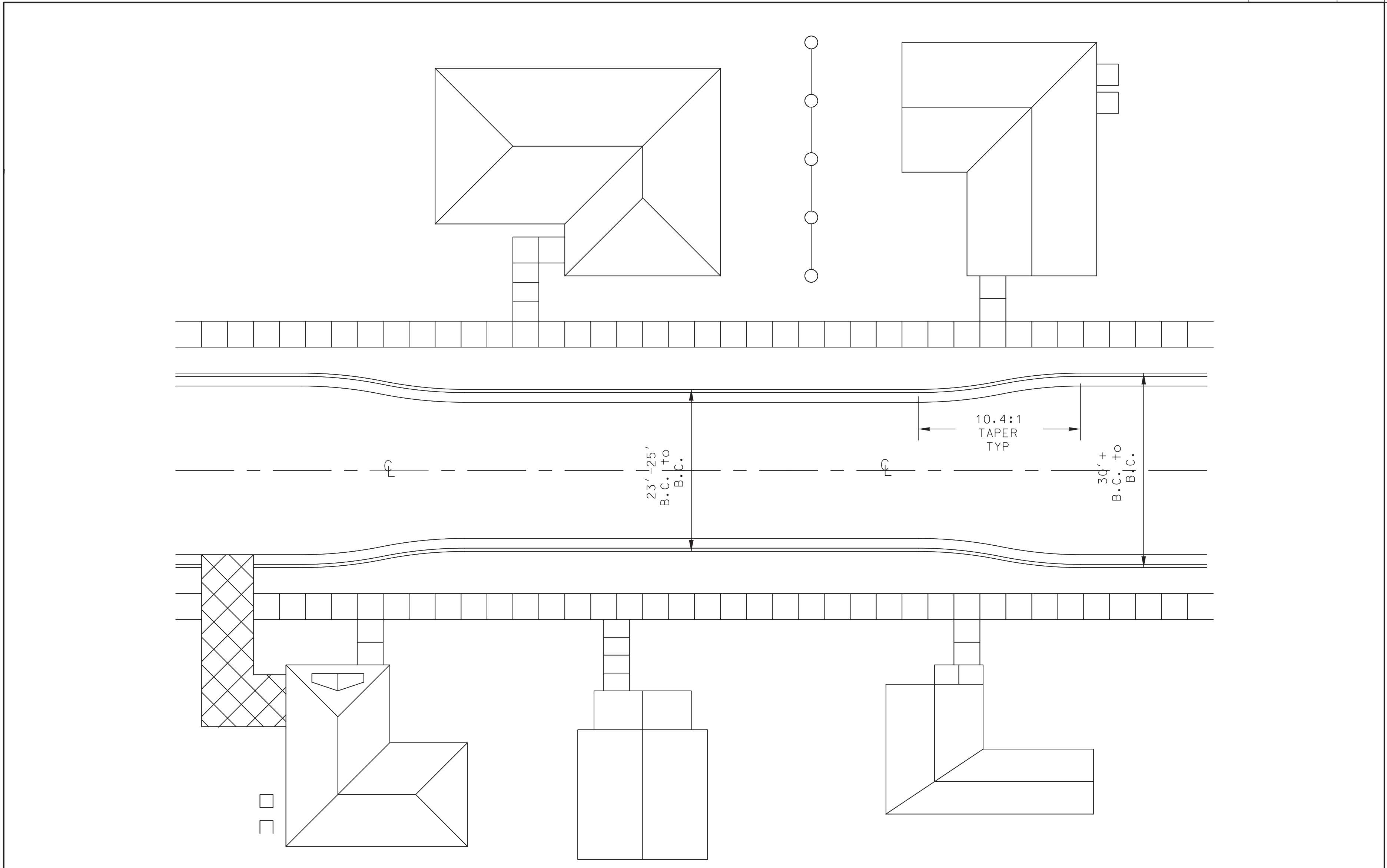
RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				NECKDOWN	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



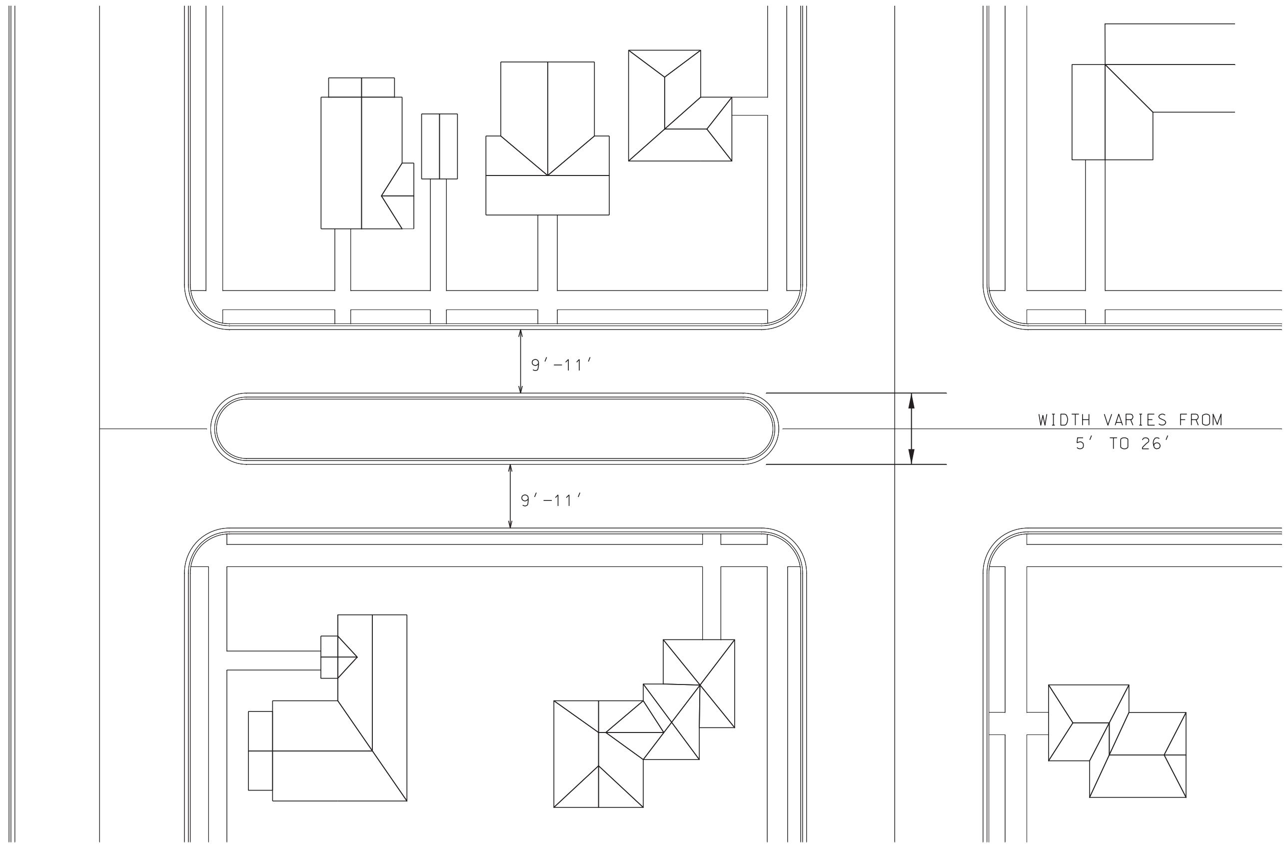
RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				SLOW POINT MEDIAN ISLAND	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

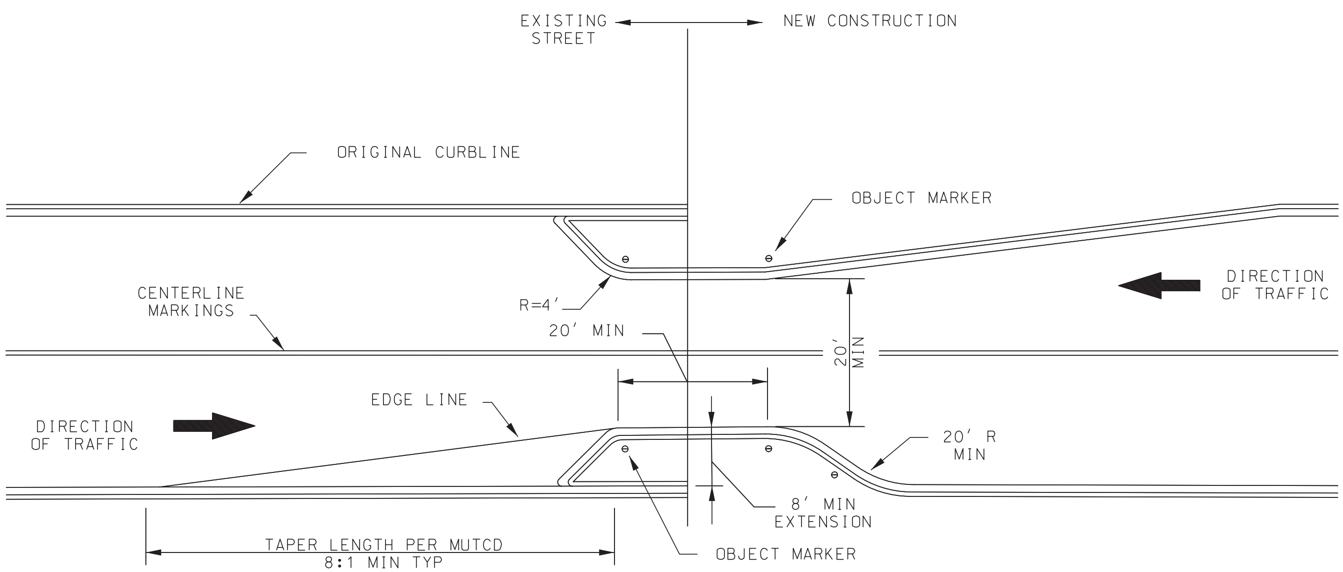


RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE: LANE NARROWING
DATE: 7/20/10	DATE:	DATE: 7/20/10				ROUTE

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



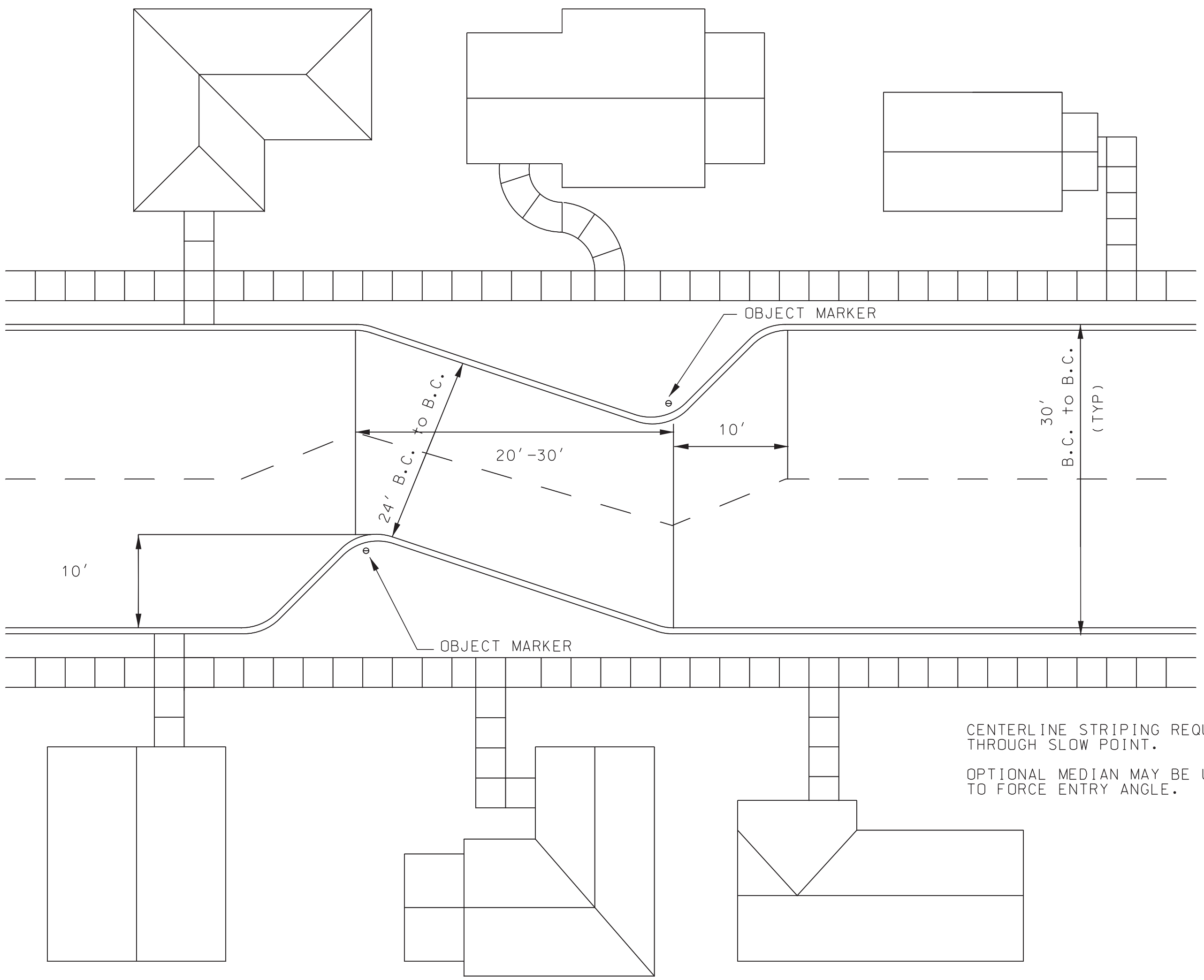
RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				MIDBLOCK MEDIAN	



REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				CHOKER	

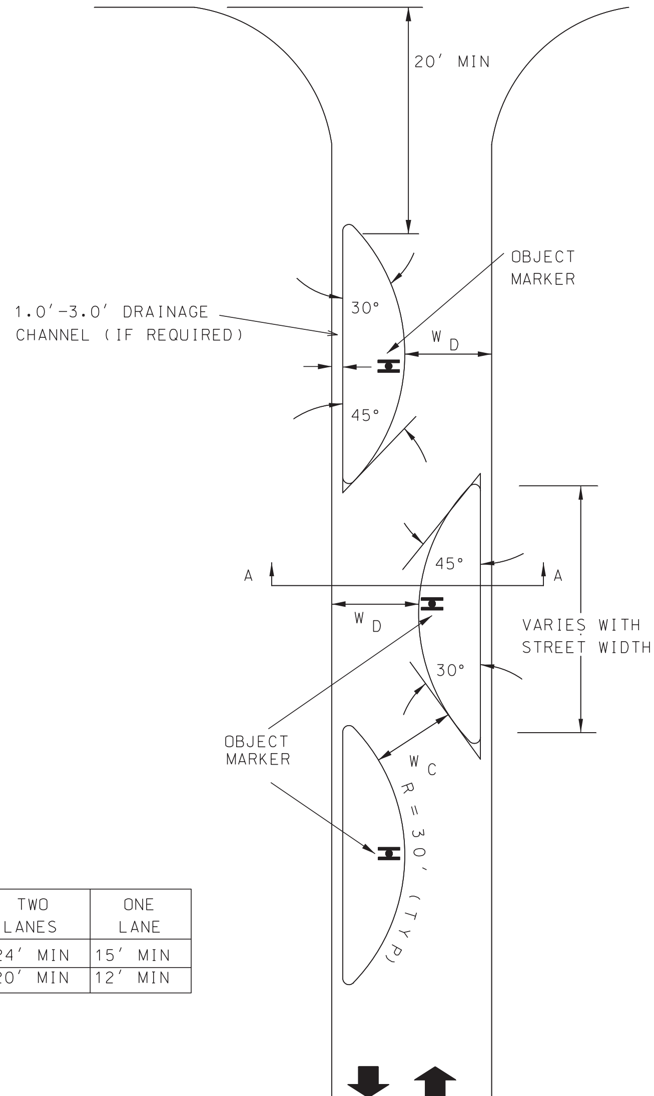
REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



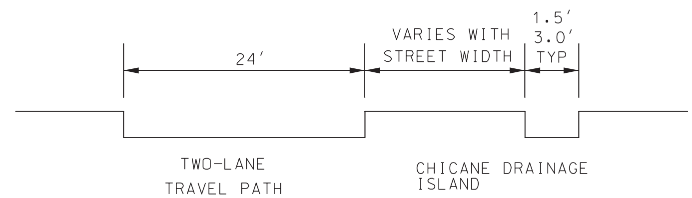
CENTERLINE STRIPING REQUIRED THROUGH SLOW POINT.

OPTIONAL MEDIAN MAY BE USED TO FORCE ENTRY ANGLE.

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				ANGLED SLOW POINT	



	TWO LANES	ONE LANE
W_D	24' MIN	15' MIN
W_C	20' MIN	12' MIN



SECTION A-A

THE TRAVEL PATH THROUGH THE CHICANE CAN BE ONE LANE OR TWO LANES AS NOTED.

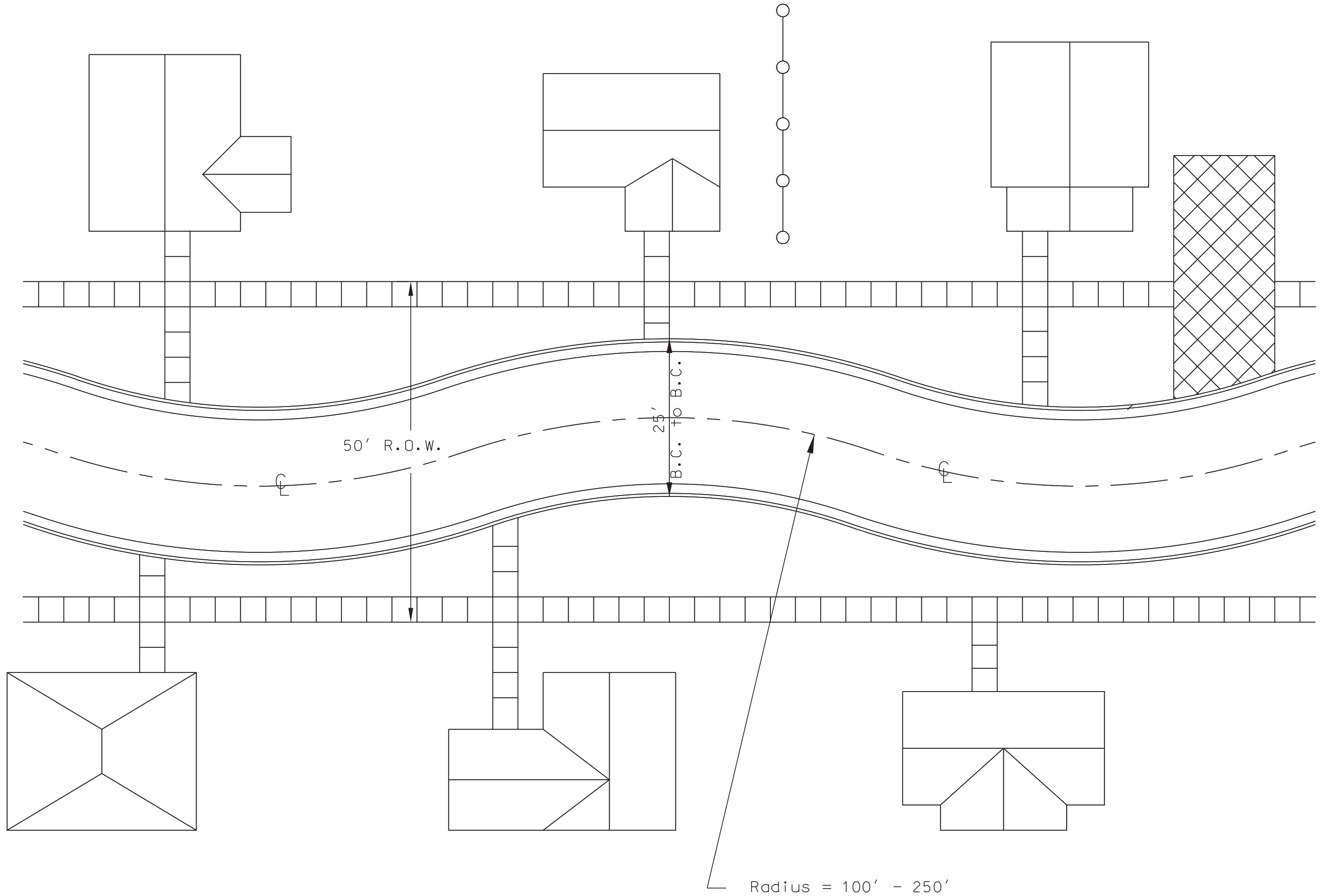
SPACING OF CHICANE SEGMENTS DEPENDENT ON SITE CONSIDERATIONS, E.G. DRIVEWAY LOCATIONS.

ISLAND PLANTING SHOULD NOT OBSCURE DRIVER'S VIEW OF CHICANE TRAFFIC, MAXIMUM OF 30" IN HEIGHT.

BICYCLES ARE TO USE THE SAME PATH AS MOTOR VEHICLES, NOT THE DRAINAGE CHANNEL.

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				CHICANE	

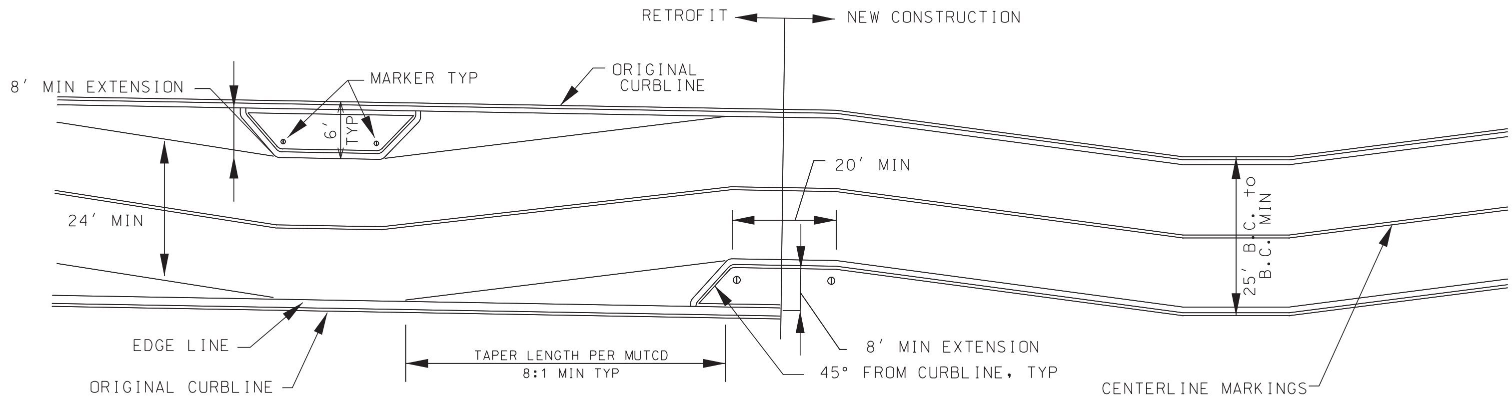


* SHOULD BE LIMITED TO LOW-VOLUME, LOW-SPEED ROADWAYS.

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

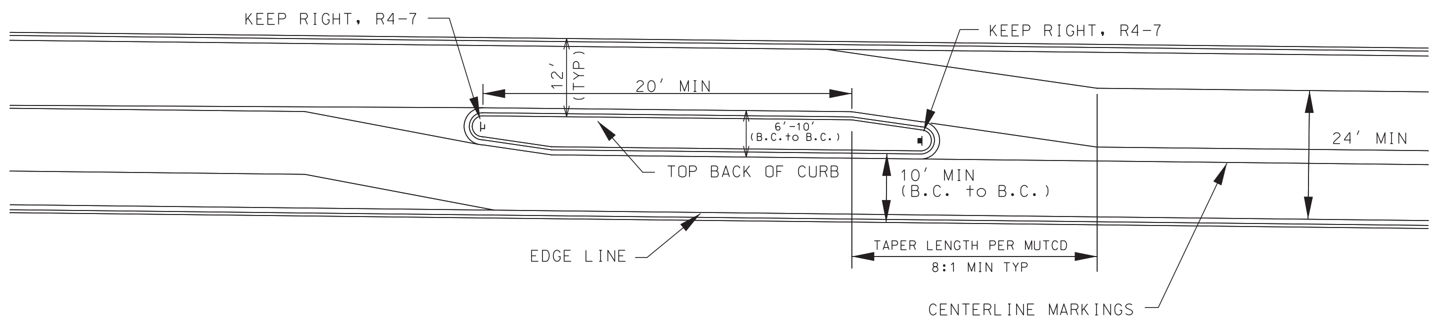
RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				DEVIATION/CHICANE	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



(MARKINGS OPTIONAL)

TYPICAL CHICANE

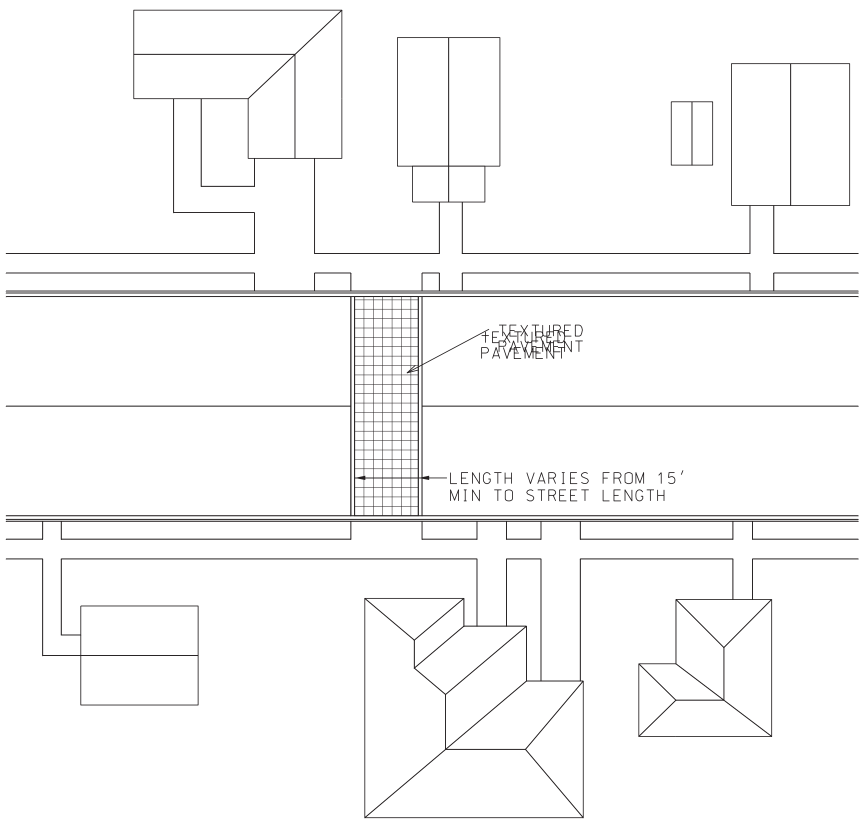


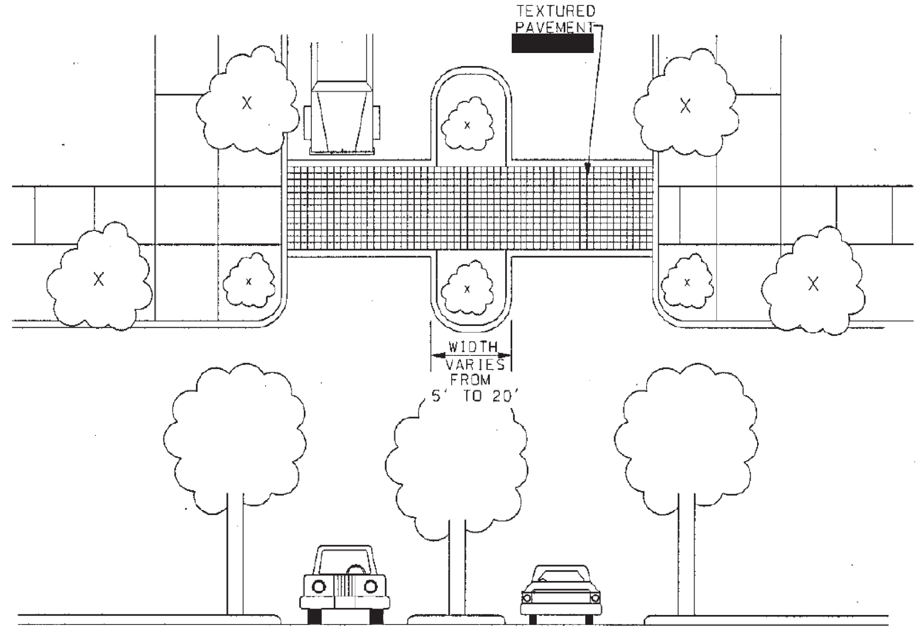
(MARKINGS OPTIONAL)

TYPICAL LATERAL SHIFT

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				CHICANE & LATERAL SHIFT	

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO



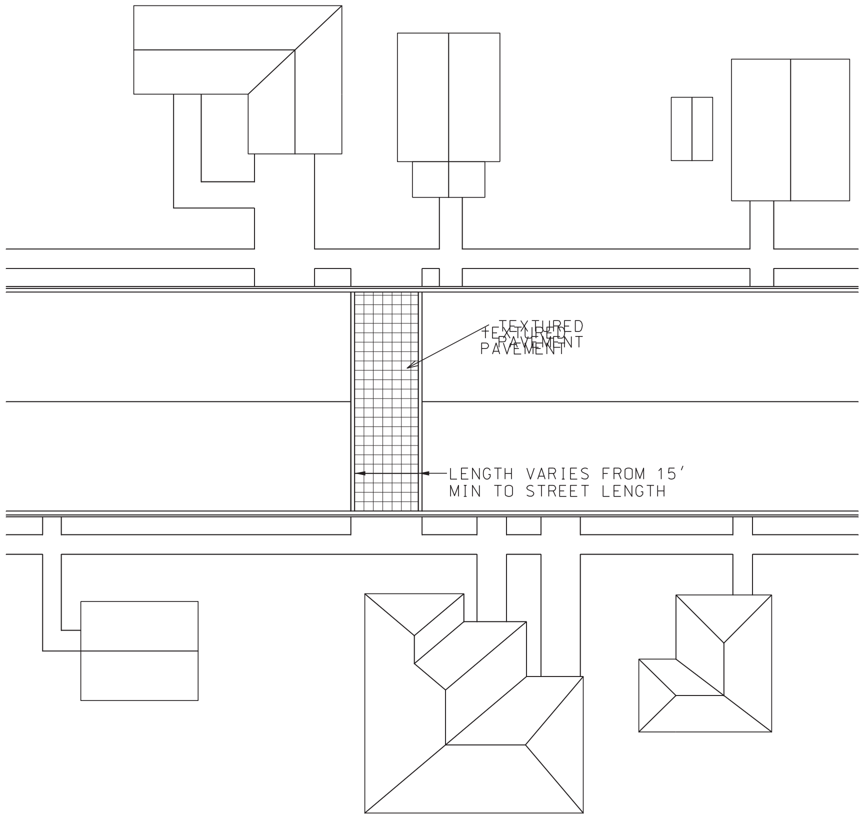


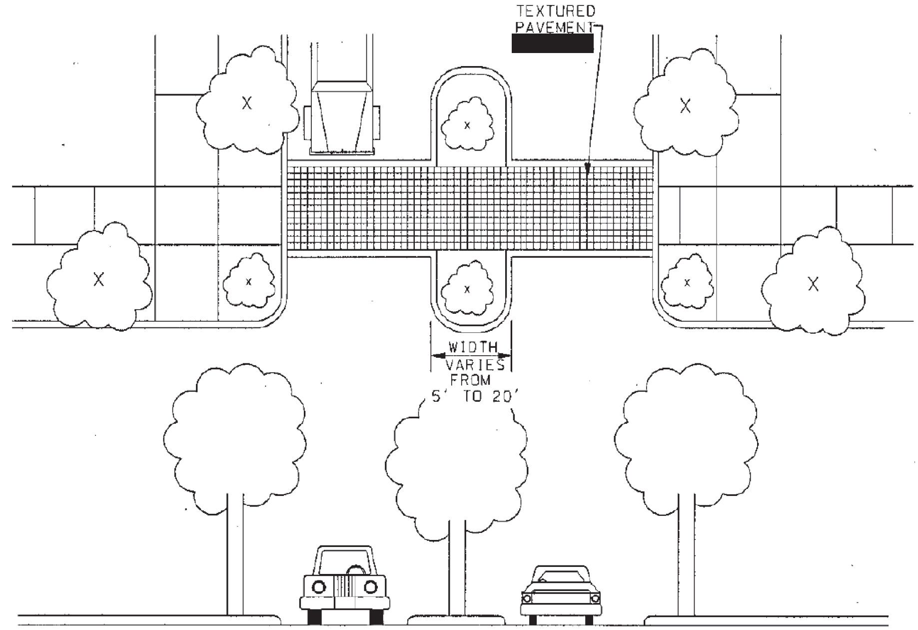
*TREE SIZE/PLANTINGS SHOULD BE LIMITED
FOR ROADSIDE SAFETY, INTERSECTION
SIGHT DISTANCE, AND TRAFFIC SIGN VISIBILITY.

TEXTURE MAY BE STAMPED BRICK, SCORED,
COBBLESTONE, OR OTHER APPROVED METHOD.

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10					

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO





*TREE SIZE/PLANTINGS SHOULD BE LIMITED FOR ROADSIDE SAFETY, INTERSECTION SIGHT DISTANCE, AND TRAFFIC SIGN VISIBILITY.

TEXTURE MAY BE STAMPED BRICK, SCORED, COBBLESTONE, OR OTHER APPROVED METHOD.

RESPONSIBLE PE: T.E. BARNETT	SUPERVISOR:	DESIGNER: C.A. FRANKLIN	PLAN SUBMITTAL	ALABAMA DEPARTMENT OF TRANSPORTATION	N. T. S.	SHEET TITLE	ROUTE
DATE: 7/20/10	DATE:	DATE: 7/20/10				TEXTURED PAVEMENT & GATEWAY TRMNT	

Appendix D – Code of Alabama

Section 32-5A-170

Reasonable and prudent speed.

No person shall drive a vehicle at a speed greater than is reasonable and prudent under the conditions and having regard to the actual and potential hazards then existing. Consistent with the foregoing, every person shall drive at a safe and appropriate speed when approaching and crossing an intersection or railroad grade crossing, when approaching and going around a curve, when approaching a hill crest, when traveling upon any narrow or winding roadway, and when special hazards exist with respect to pedestrians or other traffic or by reason of weather or highway conditions.

(Acts 1980, No. 80-434, p. 604, §8-101.)

Section 32-5A-171

Maximum limits.

Except when a special hazard exists that requires lower speed for compliance with Section 32-5A-170, the limits hereinafter specified or established as hereinafter authorized shall be maximum lawful speeds, and no person shall drive a vehicle at a speed in excess of the maximum limits.

(1) No person shall operate a vehicle in excess of 30 miles per hour in any urban district.

(2)a. No person shall operate a motor vehicle in excess of 35 miles per hour on any unpaved road. For purposes of this chapter the term unpaved road shall mean any highway under the jurisdiction of any county, the surface of which consists of natural earth, mixed soil, stabilized soil, aggregate, crushed sea shells, or similar materials without the use of asphalt, cement, or similar binders.

b. No person shall operate a motor vehicle on any county-maintained paved road in an unincorporated area of the state at a speed in excess of 45 miles per hour unless a different maximum speed is established under authority granted in subdivision (6) or as provided in subdivision (7) subject to the maximum rate of speed provided in subdivision (3).

(3) No person shall operate a motor vehicle on the highways in this state, other than interstate highways or highways having four or more traffic lanes, at a speed in excess of 55 miles per hour at any time unless a different maximum rate of speed is authorized by the Governor under authority granted in subdivision (6) or as provided in subdivision (7).

(4) No person shall operate a motor vehicle, on an interstate highway within the State of Alabama, at a speed in excess of 70 miles per hour or on any other highway having four or more traffic lanes at a speed in excess of 65 miles per hour, unless a different maximum rate of speed is authorized by the Governor under authority granted in subdivision (6) or as provided in subdivision (7). Notwithstanding the provisions of this subdivision, any portion of Corridor X/I-22 which is open between the

Alabama/Mississippi state line and the Jefferson County line shall be considered an interstate highway for the purpose of the maximum speed limit on the highway.

(5) Notwithstanding any provisions of this section to the contrary, no person shall operate a passenger vehicle, motor truck, or passenger bus which carries or transports explosives or flammable liquids, as defined in Section 32-1-1.1, or hazardous wastes, as defined in Section 22-30-3(5), in this state unless the vehicle, truck, or bus prominently displays a current decal, plate, or placard which is required by the rules or regulations of the DOT or the PSC which indicates or warns that the vehicle, truck, or bus is carrying or transporting the substances. No person shall operate the vehicle, truck, or bus at a rate of speed greater than 55 miles per hour at any time unless a different maximum rate of speed is authorized by the Governor under authority granted in subdivision (6) or as provided in subdivision (7).

(6) The Governor may prescribe the maximum rate of speed whenever a different rate of speed is required by federal law in order for Alabama to receive federal funds for highway maintenance and construction.

(7) The maximum speed limits set forth in this section may be altered as authorized in Sections 32-5A-172 and 32-5A-173.

(8) A law enforcement officer or a peace officer of any incorporated municipality or town which has less than 19,000 inhabitants according to the most recent federal decennial census shall not enforce this section on any interstate highway.

(9) Any speed limit set pursuant to this section shall be enforced by any municipality or any law enforcement officer of a municipality only within the corporate limits of the municipality and not within the police jurisdiction of the municipality.

(Acts 1980, No. 80-434, p. 604, §8-102; Acts 1987, No. 87-408, p. 593; Acts 1994, No. 94-617, p. 1147, §1; Acts 1996, No. 96-577, p. 913, §1; Act 2010-564, p. 1143, §1.)

Section 32-5A-172

Establishment of state speed zones.

Whenever the Director of Public Safety and the Director of Transportation, with the approval of the Governor, shall determine upon the basis of an engineering and traffic investigation that any maximum speed hereinbefore set forth is greater or less than is reasonable or safe under the conditions found to exist at any intersection or other place or upon any part of the state highway system, the directors may determine and declare a reasonable and safe maximum limit thereat, which shall be effective when appropriate signs giving notice thereof are erected. Such a maximum speed limit may be declared to be effective at all times or at such times as are indicated upon the signs; and differing limits may be established for different times of day, different types of vehicles, varying weather conditions, and other factors bearing on safe speeds, which shall be effective when posted upon appropriate fixed or variable signs.

(Acts 1980, No. 80-434, p. 604, §8-103.)

Section 32-5A-173

When local authorities may and shall alter maximum limits.

(a) Whenever local authorities in their respective jurisdictions determine on the basis of an engineering and traffic investigation that the maximum speed permitted under this article is greater or less than is reasonable and safe under the conditions found to exist upon a highway or part of a highway, the local authority may determine and declare a reasonable and safe maximum limit thereon which:

(1) Decreases the limit at intersections;

(2) Increases the limit within an urban district but not to more than the maximum rate of speed that may be prescribed by the Governor under subdivision (6) of Section 32-5A-171;

(3) Decreases the limit on any street, unpaved road, or highway under the jurisdiction and control of any county commission; or

(4) Increases the limit on any street, unpaved road, or highway under the jurisdiction and control of any county commission but not to more than the maximum rate of speed that is prescribed under subdivision (3) or by the Governor under subdivision (6) of Section 32-5A-171.

(b) Local authorities in their respective jurisdictions shall determine by an engineering and traffic investigation the proper maximum speed for all arterial streets and shall declare a reasonable and safe maximum limit thereon which may be greater or less than the maximum speed permitted under this chapter for an urban district.

(c) Any altered limit established as hereinabove authorized shall be effective at all times or during hours of darkness or at other times as may be determined when appropriate signs giving notice thereof are erected upon the street or highway.

(d) Any alteration of maximum limits on state highways or extensions thereof in a municipality by local authorities shall not be effective until the alteration has been approved by the Department of Transportation.

(e) Not more than six alterations as hereinabove authorized shall be made per mile along a street or highway, except in the case of reduced limits at intersections, and the difference between adjacent limits shall not be more than 10 miles per hour.

(Acts 1980, No. 80-434, p. 604, §8-104; Acts 1985, 2nd Ex. Sess., No. 85-998, p. 366, §2; Acts 1994, No. 94-617, p. 1147, §2.)

Section 32-5A-174

Minimum speed regulation.

(a) No person shall drive a motor vehicle at such a slow speed as to impede the normal and reasonable movement of traffic except when reduced speed is necessary for safe operation or in compliance with law.

(b) Whenever the Director of Public Safety and the Director of Transportation, with the approval of the Governor, or local authorities within their respective jurisdictions determine on the basis of an engineering and traffic investigation that slow speeds on any highway or part of a highway consistently impede the normal and reasonable movement of traffic, the directors or such local authority may determine and declare a minimum speed limit below which no person shall drive a vehicle except when necessary for safe operation or in compliance with law, and that limit shall be effective when posted upon appropriate fixed or variable signs.

(Acts 1980, No. 80-434, p. 604, §8-105.)

Section 32-5A-175

Special speed limitation on motor-driven cycles.

No person shall operate any motor-driven cycle at any time from a half hour after sunset to a half hour before sunrise nor at any other time when, due to insufficient light or unfavorable atmospheric conditions, persons and vehicles on the highway are not clearly discernible at a distance of 1,000 feet ahead at a speed greater than 35 miles per hour unless such motor-driven cycle is equipped with a head lamp or lamps which are adequate to reveal a person or vehicle at a distance of 300 feet ahead.

(Acts 1980, No. 80-434, p. 604, §8-106.)

Section 32-5A-176

Special speed limitation over bridge or elevated structure; conclusive evidence of speed.

(a) No person shall drive a vehicle over any bridge or other elevated structure constituting a part of a highway at a speed which is greater than the maximum speed which can be maintained with safety to such bridge or structure, when such structure is signposted as provided in this section.

(b) The Department of Transportation and local authorities on highways under their respective jurisdictions may conduct an investigation of any bridge or other elevated structure constituting a part of a highway, and if it shall thereupon find that such structure cannot with safety to itself withstand vehicles traveling at the speed otherwise permissible under this chapter, the Department of Transportation or local authority shall determine and declare the maximum speed of vehicles which such structure can safely withstand, and shall cause or permit suitable signs stating such maximum speed to be erected and maintained before each end of such structure.

(c) Upon the trial of any person charged with a violation of this section, proof of the determination of the maximum speed by the Department of Transportation and the existence of the signs shall constitute conclusive evidence of the maximum speed which can be maintained with safety to such bridge or structure.

(Acts 1980, No. 80-434, p. 604, §8-107.)

Appendix E – Blank Forms

- Establishment of State Speed Zone
- Establishment of Speed Ordinance
- Spot Speed Study Tally Sheet
- Spot Speed Study Results

ALABAMA DEPARTMENT OF PUBLIC SAFETY AND
ALABAMA DEPARTMENT OF TRANSPORTATION
MONTGOMERY, ALABAMA

Number:________________
County: ________________

ESTABLISHMENT OF STATE SPEED ZONE

As provided by Act No. 80-434, Section No. 8-103 enacted by the 1980 Alabama Legislature (Regular Session), the Director of Public Safety and the Director of the Alabama Department of Transportation recommended to the Governor that a speed zone be formally established as described below:

In order to regulate motor vehicle traffic on ___________________________________
(Route No.)

____
(Description)

in ____________________________ County, speed limits are established as described below:

On ____
(Route and Description)

beginning at ________________________ and extending _____________________________
(Mile Post Location) (Direction)

to _______________________ , the speed limit shall be ____________________, ( ) M.P.H.
(Mile Post Location)

The beginning and end of the zone to be properly signed and maintained with standard Alabama Department of Transportation speed limit signs with the above noted limits to be in full effect while such signs are in place.

RECOMMENDED: _______________________________ DATE: ______________
ALDOT Region Engineer

RECOMMENDED: _______________________________ DATE: ______________
ALDOT Maintenance Engineer

RECOMMENDED: _______________________________ DATE: ______________
Director
Department of Public Safety

RECOMMENDED: _______________________________ DATE: ______________
Director
Department of Transportation

APPROVED: ____________________________________ DATE: ______________
Governor
State of Alabama

CITY/TOWN OF ____

Number:________________
County: ________________

ESTABLISHMENT OF SPEED ORDINANCE

In order to regulate motor vehicle traffic on ___________________________________
(Route No.)

____
(Description)

in ____________________________ County, speed limits are established as described below:

On ____
(Route and Description)

beginning at ________________________ and extending _____________________________
(Mile Post Location) (Direction)

to _______________________ , the speed limit shall be ____________________, (   ) M.P.H.
(Mile Post Location)

RECOMMENDED: _______________________________ DATE: ______________
ALDOT Region Engineer

RECOMMENDED: _______________________________ DATE: ______________
ALDOT Traffic Engineer

RECOMMENDED: _______________________________ DATE: ______________
ALDOT Maintenance Engineer

APPROVED: _________________ DATE: ______________
Mayor

APPROVED: _________________ DATE: ______________
City Clerk

SPOT SPEED STUDY TALLY SHEET			
LOCATION ID/STREET NAME:			
CITY:		**LANE WIDTHS**	
COUNTY:		**NO. OF LANES**	
ALDOT DIVISION:		**WEATHER**	
DAY/DATE:		**TYPE OF LAND USE**	
LOCATION:		**OBSERVER**	
DIRECTION(S):		**PAVEMENT CONDITION**	
TIME PERIOD	FROM: TO:	**POSTED SPEED (MPH)**	
RELEVANT REMARKS			

		NO. OF VEHICLES	
SPEED RANGE	**MID-POINT**	**DIRECTION**	**DIRECTION**
15-20	17		
20-25	22		
25-30	27		
30-35	32		
35-40	37		
40-45	42		
45-50	47		
50-55	52		
55-60	57		
60-65	62		
65-70	67		
70-75	72		
75-80	77		

SPOT SPEED STUDY RESULTS

LOCATION ID/STREET NAME:	
CITY:	**LANE WIDTHS:**
COUNTY:	**NO. OF LANES:**
ALDOT DIVISION:	**WEATHER:**
DAY/DATE:	**TYPE OF LAND USE:**
LOCATION:	**OBSERVER:**
DIRECTION:	**PAVEMENT CONDITION:**
TIME	
STREET	**POSTED SPEED (MPH):**

SPEED RANGE	MID-POINT	NO. OF VEHICLES	% VEHICLES	% CUMULATIVE VEHICLES
15-20	17			
20-25	22			
25-30	27			
30-35	32			
35-40	37			
40-45	42			
45-50	47			
50-55	52			
55-60	57			
60-65	62			
65-70	67			
70-75	72			
75-80	77			

RESULTS (from graph)

Median Speed:	mph
85th Percentile:	mph
Analysis Recommended Speed Limit (**Directional**)*	mph

*Note: Data as recorded from the opposing direction should be gathered also and considered in combination in determining the proper speed limit for posting

Appendix F - Ball-Bank Indicator Usage Guidance

<u>Manual Ball-Bank Indicator</u>

Ball-bank indicators assist in determining advisory speeds for horizontal curves. They consist of a steel ball inside a liquid-filled, curved glass casing marked with incremental degrees. The degree reading from the indicator is a function of the lateral acceleration in the curve and the roll rate of the study vehicle. These values are correlated to the level of discomfort a driver experiences while travelling in a curve. As a vehicle travels through the curve, the lateral acceleration causes the steel ball to roll to a fixed angle position, which is then recorded and matched to predetermined values of speed. According to AASHTO's *A Policy on Geometric Design of Highways and Streets* (2004), ball-bank readings of 14 degrees are acceptable for speeds of 20 mph or less, readings of 12 degrees are acceptable for speeds of 25-30 mph, and readings of 10 degrees are acceptable for speeds of 35-50 mph. These values correspond to acceptable levels of driver discomfort and provide a sufficient margin of safety against skidding or vehicle rollover at the associated speed. The MUTCD (2009) lists acceptable readings as 16 degrees for speeds of 20 mph or less, 14 degrees for speeds of 25-30 mph, and 12 degrees for speeds of 35-50 mph.

Example of a Ball Bank Indicator

The following tasks describe the field measurement procedure for determining an advisory speed using a ball-bank indicator. The set of directions corresponds to one direction of travel at one speed. It is important to remember that different directions of travel may have different advisory speeds, and that the task must be performed several times at incrementally increasing speeds to determine the appropriate advisory speed. A ball-bank indicator with increments of 1 degree is necessary for this study. Also, because the indicator is a function of the lateral acceleration and roll rate, it is important to select an appropriate vehicle that is representative of vehicles used by the general public. Vehicles with higher or lower than average rollover thresholds, such as SUVs and sports cars, should not be used.

1. Attach the ball-bank indicator to the dashboard of the vehicle to be used in the study. Ensure that the indicator is visible from the recorder's field of view and that it will not move while the vehicle is in motion.
2. Level the ball-bank indicator. The ball should rest at the zero degree position when the vehicle is at rest in a level position. If it does not, the indicator should be leveled according to the manufacturer's instructions. It is also important that the angle of view of the recorder when the ball-bank indicator reads zero is the same during all trials because shifting positions may distort the reading of the indicator. Ensure that the vehicles tires are uniformly inflated to the manufacturer's recommended tire pressure.
3. Check the vehicle's speedometer using a calibrated radar gun, by timing the vehicle between a measured distance, or by another appropriate method.
4. Record the direction of travel and curve deflection (right or left) for the trial run.
5. Beginning at the predetermined lowest test speed, the driver drives the vehicle through the curve or successive curves at a constant speed while the recorder records the highest degree reading for

the curve or curves. For each test run, the driver must reach the test run speed at least ¼ mile in advance of the beginning of the curve, and maintain that speed throughout the curve. It is also important that the vehicle be positioned as close as possible to the center of the lane closest to the inside edge of the curve in the direction of travel. If the direction of travel has two lanes with differing superelevation rates, the lane with the lowest amount of superelevation should be used.

6. Due to the difficulty of maintaining precise speed and direction during the testing, at least three test runs should be made for each test speed in the travel direction.
7. The test is repeated with the vehicle speed increasing in 5 mph increments until the ball-bank indicator reading exceeds the acceptable maximum. For example, if a ball-bank indicator gave a reading of 15 degrees at a speed of 25 mph, the test would be concluded and the advisory speed set at 20 mph according to the MUTCD standards.
8. This procedure is repeated for the opposite direction. One exception is undivided roadways. If only one direction of an undivided roadway is determined to need an advisory speed, then only that direction should have a posted advisory speed.

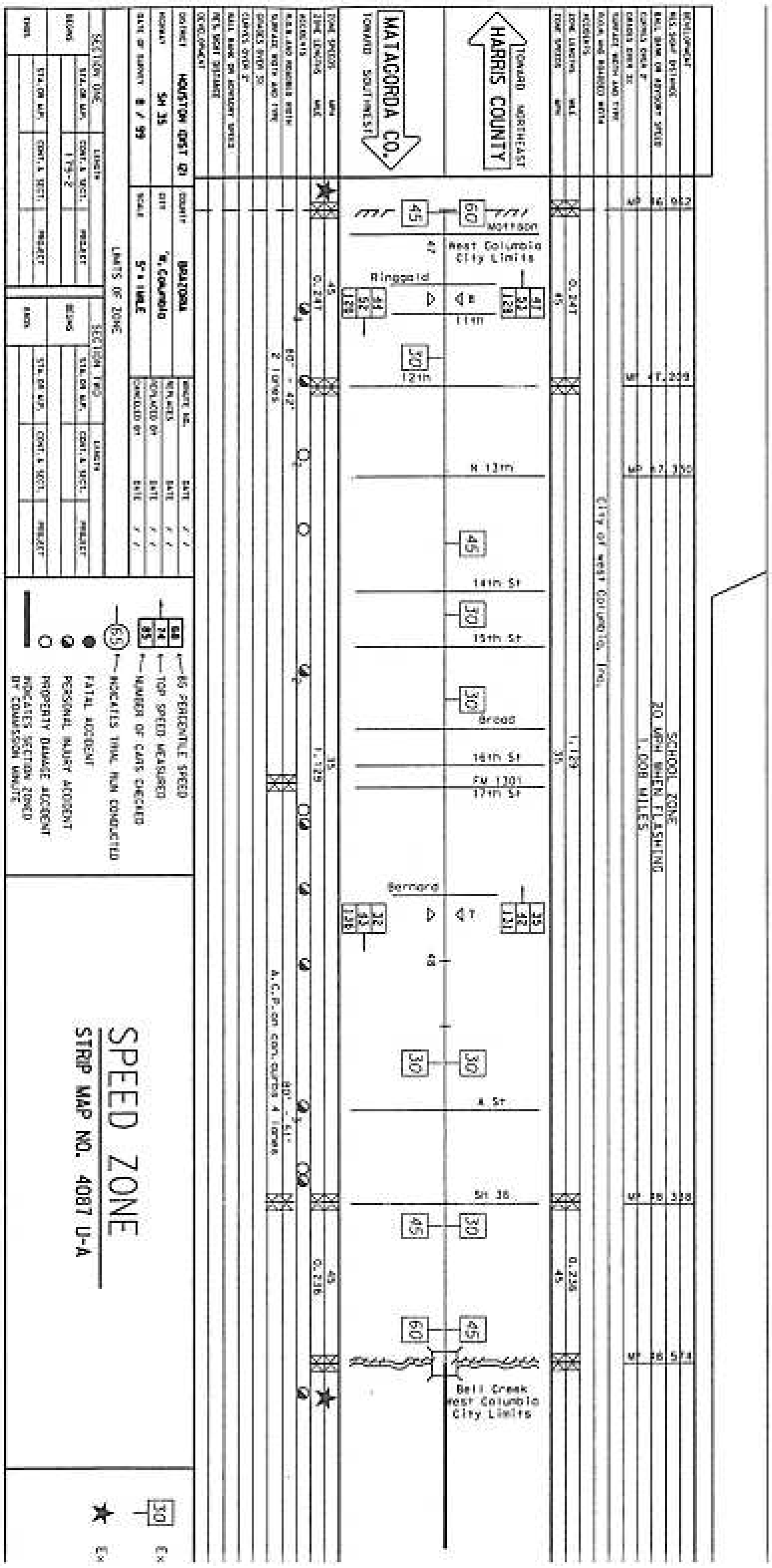
When two or more curves are present, each curve should be evaluated separately; however, if they are separated by a tangent section of 600 ft. or less, the advisory speed for the series of curves should be set according to the curve with the lowest advisory speed.

<u>Electronic Ball Bank Indicator</u>

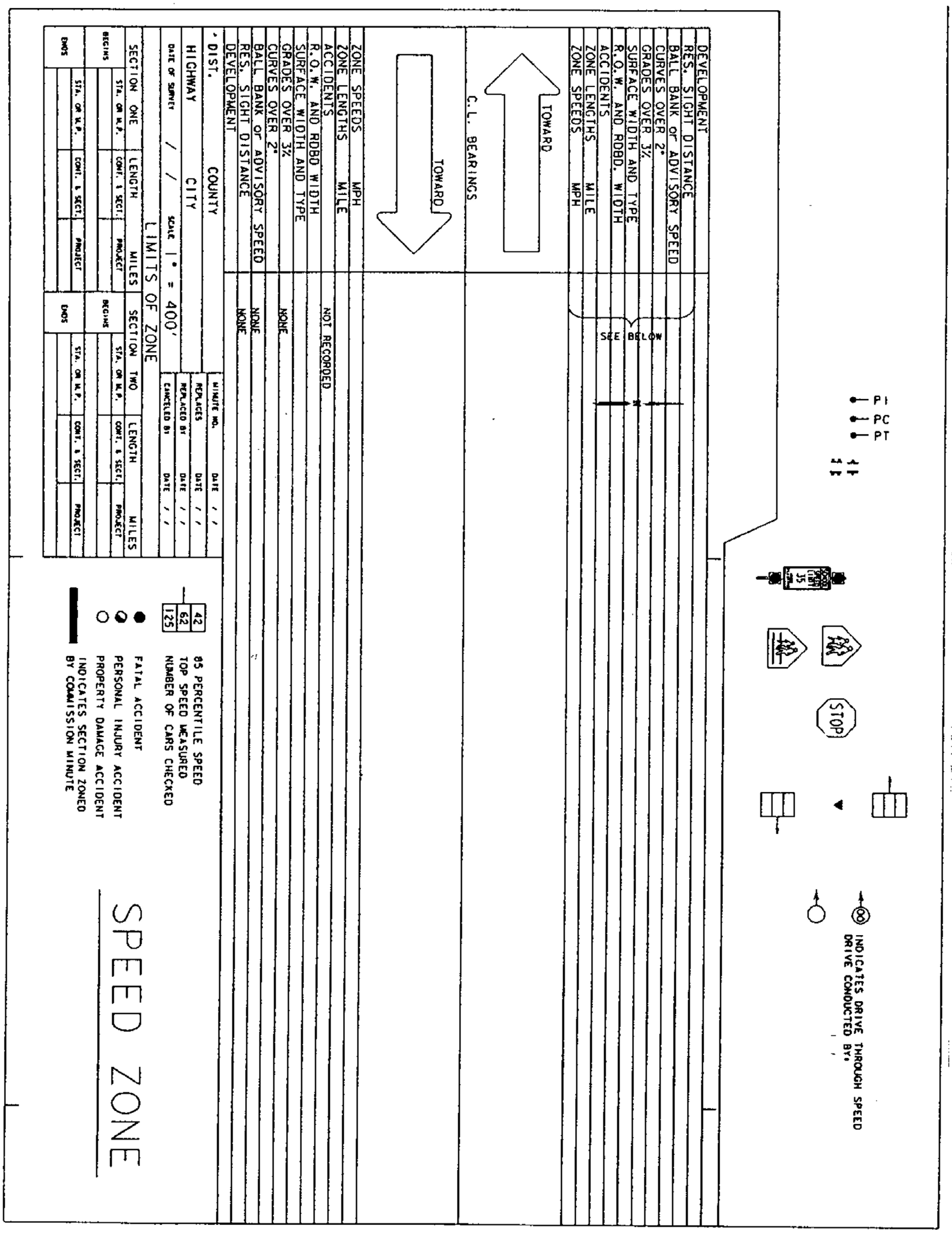
An electronic ball bank indicator (as shown below), allows data collection without the need for a second data collector. As the operator drives through a curve, the unit will record the largest positive and negative angles measured. The negative angle is recorded as a left turn and the positive angle is recorded as a right turn. After completing the data collection of a specific curve or the combination of an S- Curve, an operator can display the deflection angles of interest by pushing the units “Min Max” button and documenting the reading. Specific use and equipment set-up should be done per the specification of the electronic ball-bank indicator manufacture.

Appendix G – Strip Map Example and Blank

Appendices



SPEED ZONE
STRIP MAP NO. 4087 U-A
TOWARD NORTHEAST
HARRIS COUNTY
TOWARD SOUTHWEST
MATAGORDA CO.
SCHOOL ZONE
20 MPH WHEN FLASHING
1.000 MILES
West Columbia
City Limits
Bell Creek
West Columbia
City Limits


PI
PC
PT
INDICATES DRIVE THROUGH SPEED
DRIVE CONDUCTED BY:
STOP
DEVELOPMENT
RES. SIGHT DISTANCE
BALL BANK or ADVISORY SPEED
CURVES OVER 2°
GRADES OVER 3%
SURFACE WIDTH AND TYPE
R.O.W. AND RDBD. WIDTH
ACCIDENTS
ZONE LENGTHS MILE
ZONE SPEEDS MPH
SEE BELOW
TOWARD
C.L. BEARINGS
TOWARD
ZONE SPEEDS MPH
ZONE LENGTHS MILE
ACCIDENTS
NOT RECORDED
R.O.W. AND RDBD WIDTH
SURFACE WIDTH AND TYPE
GRADES OVER 3%
NONE
CURVES OVER 2°
BALL BANK or ADVISORY SPEED
NONE
RES. SIGHT DISTANCE
NONE
DEVELOPMENT
DIST. COUNTY
HIGHWAY CITY
DATE OF SURVEY / /
SCALE 1" = 400'
MINUTE NO. DATE / /
REPLACES DATE / /
REPLACED BY DATE / /
CANCELED BY DATE / /
LIMITS OF ZONE
SECTION ONE LENGTH MILES
SECTION TWO LENGTH MILES
BEGINS
ENDS
STA. OR M.P.
CONT. & SECT.
PROJECT
42
62
125
85 PERCENTILE SPEED
TOP SPEED MEASURED
NUMBER OF CARS CHECKED
FATAL ACCIDENT
PERSONAL INJURY ACCIDENT
PROPERTY DAMAGE ACCIDENT
INDICATES SECTION ZONED
BY COMMISSION MINUTE
SPEED ZONE

Appendix H – Glossary

85th Percentile Speed – the speed at or below which 85 percent of the free-flowing vehicles travel.

Advisory Speed Plaques – used to supplement any warning sign to indicate the advisory speed for a condition.

Average Speed – the average or mean speed is the most common measure of clustering of data around some central value. Using data from a spot speed study, the average is calculated by summing all the measured speeds and dividing by the sample size.

Ball-Bank Reading – a measure of the amount of lateral force (side friction) on the vehicle.

Delay – the time lost by a vehicle due to causes beyond the control of the driver.

Design Speed – the selected speed used to determine the various geometric design features of a roadway.

Engineering Judgment - the evaluation of available pertinent information, and the application of appropriate principles, education, discretion, standards, guidance, and practices for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. Engineering judgment shall be exercised by a professional civil engineer licensed in the state of Alabama or by an individual working under the supervision of a professional engineer, through the application of procedures and criteria established by the engineer.

Engineering Study - the comprehensive analysis and evaluation of available pertinent information, and the application of appropriate principles, engineering judgment, experience, education, discretion, standards, guidance, and practices as contained in this Manual and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. An engineering study shall be performed by a professional civil engineer, or by an individual working under the supervision of a professional engineer, through the application of procedures and criteria established by the engineer. An engineering study shall be documented.

Free-Flow Speed – the speed a driver chooses when there are no influences from other vehicles, conspicuous enforcement, or environmental factors; this is the speed the driver finds comfortable based on the appearance of the road.

Frequency Distribution – a table showing frequency of occurrences for varying speed ranges.

Median Speed – Half of the vehicles sample travel below this speed, the other half sample travel above this speed.

Pace – the speed range within defined limits, usually 10 mph, which contains the largest number of observations.

Prima Facie Speed – a reasonable and prudent speed above which drivers are presumed to be driving unlawfully but where, if charged with a violation, they may contend that their speed was safe for conditions existing on the roadway at the time and therefore, not guilty of a speed limit violation.

Rational Speed Limit – the speed limit that is based on a formal, analytical review of traffic flow, roadway design, local development, and crash data. For existing roads, it uses the 85th percentile speed of free-flowing vehicles operating under normal traffic, weather, and roadway conditions as the speed limit, adjusted down as necessary by road design or other factors not readily apparent to motorists. The analysis also considers crash history and the influence of speed as a contributing factor.

Speed – the rate of movement of a vehicle in distance per unit of time. Common units are miles per hour (mph) and feet per second (fps). The term is used in multiple applications:

- Advisory Speed
- Average Speed
- Design Speed
- 85th Percentile Speed
- Pace Speed
- Posted Speed
- Statutory Speed

Speed "Bins" (Range) – speed data information separated into defined ranges per hour.

Hour	<=40 MPH	41-45 MPH	46-50 MPH	51-55 MPH	56-60 MPH	61-65 MPH	66-70 MPH	71-75 MPH	76-80 MPH	81-85 MPH	86-100 MPH	101-110 MPH	> 110 MPH
00:00	6	2	14	36	118	112	47	20	4	3	3	0	0
01:00	9	6	13	36	94	69	32	12	3	3	1	0	0
02:00	9	5	9	33	84	47	20	8	2	2	0	0	1
03:00	9	5	8	28	57	65	23	5	1	1	0	1	0

Speed Dispersion – the normal spread in observed vehicle speeds within a study section.

Speed Test Run – performed by driving through a study area (potential speed zone) at a reasonable free-flow speed and collecting speed data, then using this data to confirm speed limits or speed data collected from other vehicles in the study area.

Speed Zoning – the process of performing an engineering study and establishing a reasonable and safe speed limit for a section of roadway where the statutory speed limits given in the motor vehicle laws do not fit the road or traffic conditions at a specific location.

Speeding – the legal definition of speeding is the act of exceeding the posted speed limit. In the road safety community, speeding is defined as exceeding the posted speed limit or traveling at a speed too fast for conditions.

Spot Speed – the instantaneous measure of speed at a specific location on a roadway.

Statutory Speed Limit – numerical speed limits specifically provided under a State's traffic codes that apply to various classes or categories of roads (e.g. rural expressways, residential streets, primary arterials, etc.) .

Travel Speed – the distance traveled divided by the travel time.

Work Zone – Activity being conducted within the roadway, adjacent to the roadway, within an intersection, at roadway connections, or at ramps.