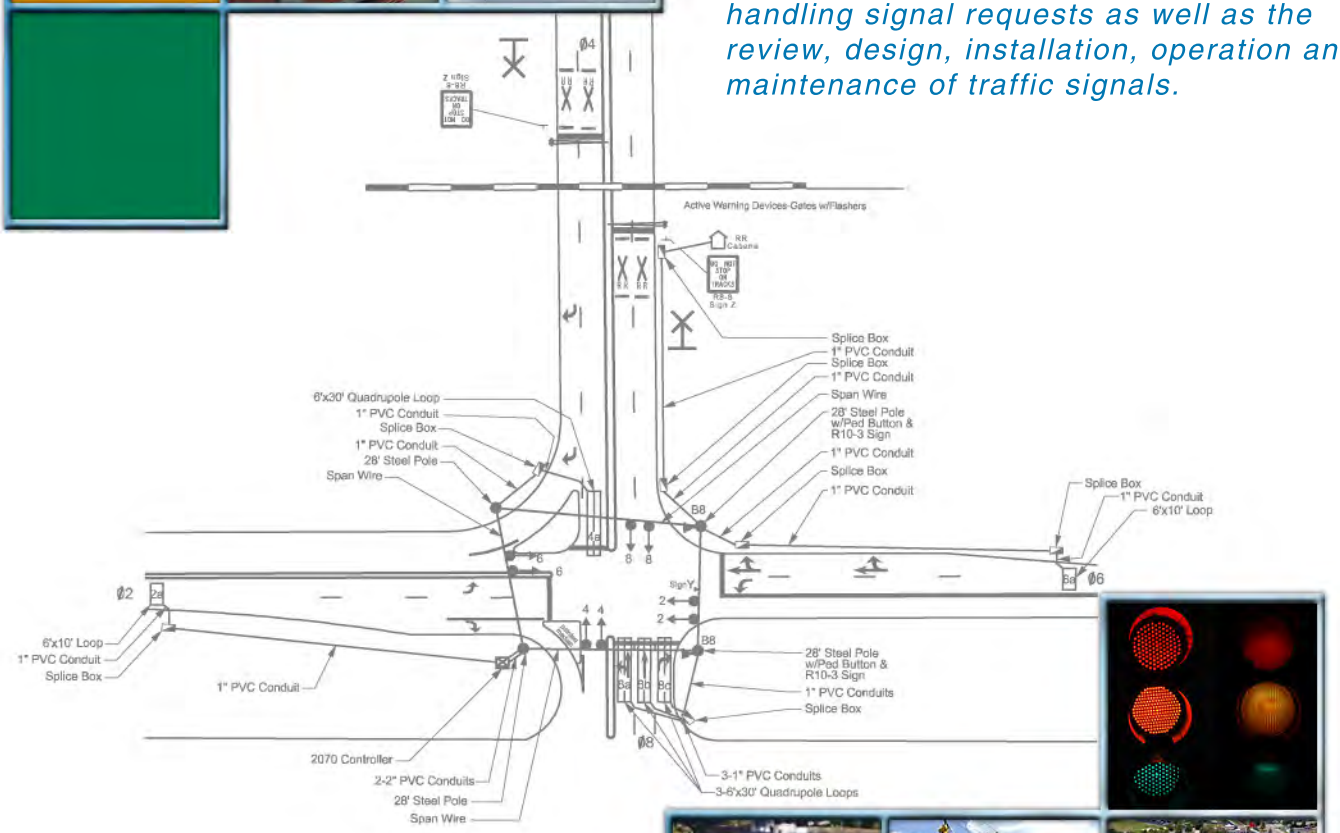
South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES

. . . a comprehensive document that details the South Carolina Department of Transportation's standard methodology of handling signal requests as well as the review, design, installation, operation and maintenance of traffic signals.



2009 edition

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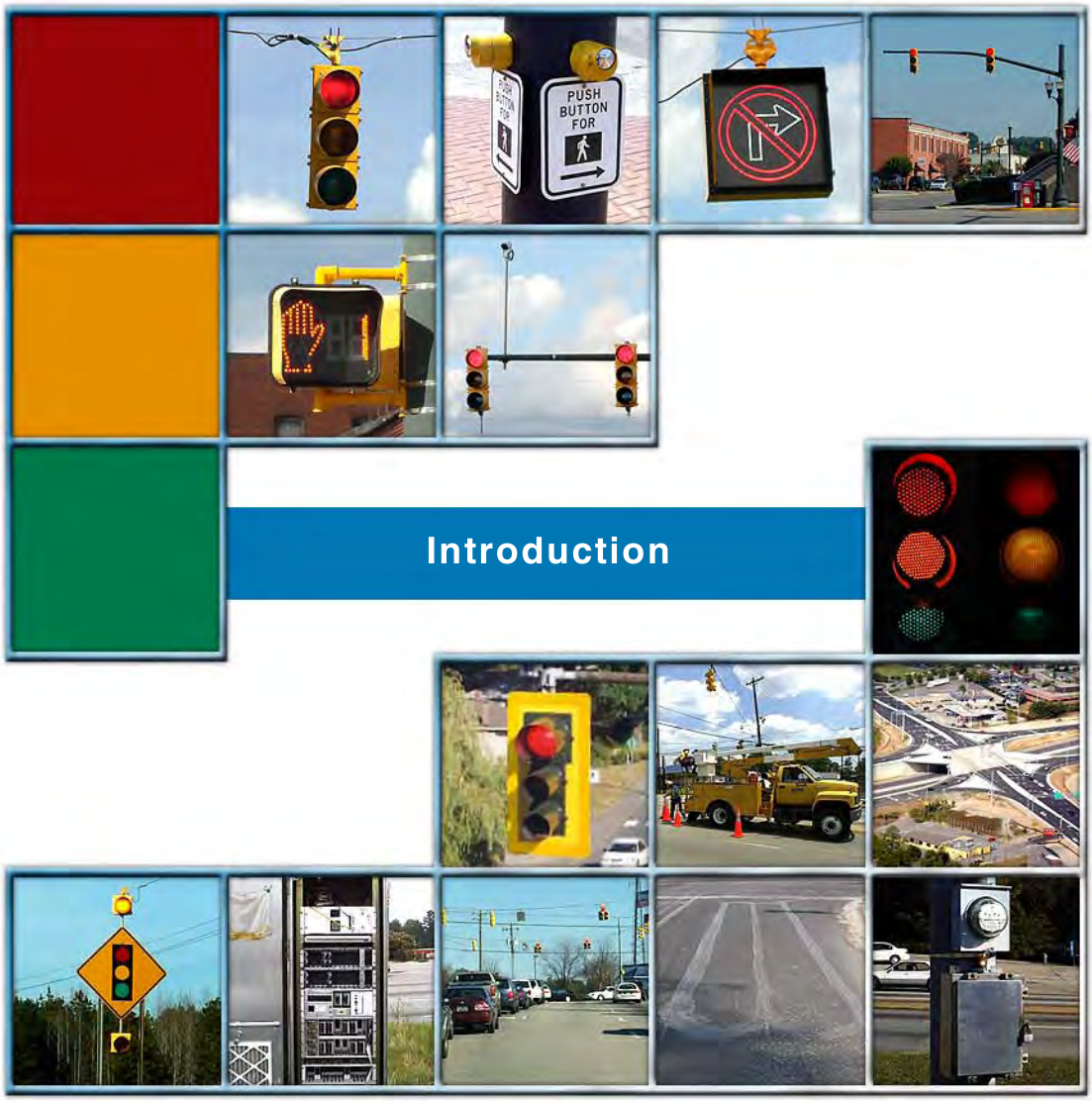
South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES

Chapter 1



Introduction

Introduction

This signal design guideline is intended to be a comprehensive document that details the Department's standard methodology of handling signal requests as well as the review, design, installation, operation and maintenance of traffic signals.

In addition, these guidelines provide guidance for the appropriate fiscal responsibilities for signals in municipalities, at private developments, at schools, etcetera.

These guidelines follow the standard practices set forth in the **Manual on Uniform Traffic Control Devices (MUTCD)**; however, particular practices pertaining to South Carolina are addressed in these guidelines and in the **SCDOT Enginering Directive Memorandum 2** which includes the fiscal and maintenance responsibilities for traffic signal installations on the state highway system. **SCDOT Engineering Directive Memorandum 33** is specifically for Mast Arms.

Special design guidelines, such as pedestrian treatments at signals and railroad preemption design are also included in this document.

The latest **SCDOT Signal Specifications (Special Provisions Traffic Signal Installation)** can be found on the internet, Installation of Signals, as well as the following **SCDOT Standard Drawings**: (*these are located on the last pages of the standard drawings division #600)*

Signal Location Detail 675-105-01

Signal Heads 675-105-02

Typical Wire and Cable Usage 675-110-00

Wood Pole and Spanwire Service, Grounding, and Bonding 675-115-01

Poles 675-115-02 & 03

Detectors 675-120-00

Interconnect 675-125-00

Cabinet 675-130-01 & 02 & 03

A **signal group discussion forum** has been developed for South Carolina Department of Transportation Employees. This forum gives the SCDOT signal group employees the opportunity to stay involved and up to date on any issues pertaining to signal systems.

Institute of Transportation Engineers (ITE) has implemented a publication by FHWA called the **Traffic Signal Timing Manual**. According to ITE, "*The manual, a culmination of research into practices across North America, is intended to provide a comprehensive collection of traffic signal timing concepts, analytical procedures and applications.*"

Please note that these are guidelines only, this is not a sealed document. Many areas of these guidelines require engineering judgement for final decisions. Since these are statewide guidelines, our 7 districts have different roadway characteristics and local governmental agencies that may impact a final decision in the request, review, design, installation, operation and maintenance of traffic signals.

Traffic Signal Classifications

A. Traffic Signals are classified as the following:

Device Types for Signal

Device	Category	Detection	Mode-Device Description
A	Flasher	n/a	Intersection or Sign Beacon
B	Flasher	n/a	School Flashers
C1	Stop & Go Signal	Pre-Timed	Isolated Traffic Signal
C2	Stop & Go Signal	Pre-Timed	Time Based Coordinate System
D	Stop & Go Signal	Pre-Timed	Signal System (w/out remote communication)
E	Stop & Go Signal	Pre-Timed	Signal System (with remote communication)
F1	Stop & Go Signal	Actuated	Isolated Traffic Signal
F2	Stop & Go Signal	Actuated	Time Based Coordinate System
G	Stop & Go Signal	Actuated	Signal System (w/out remote communication)
H	Stop & Go Signal	Actuated	Signal System (with remote communication)

Categories for Signals, Flashers and Railroad Signals

Stop-and-Go Signals

Stop-and-Go Signal w/Overhead Prepare to Stop When Flashing
Stop-and-Go Signal w/ Overhead Signal Ahead (w/flasher)
Stop-and- Go Pedestrian Signal
Stop-and-Go Emergency Signal
Stop-and-Go Signal w/ RR Preemption
Stop-and-Go Signal w/ Shoulder Signal Ahead (w/flasher)
Stop-and-Go Signal w/Fire Preemption
Stop-and-Go Signal w/ Fire and RR Preemption
Stop-and-Go Signal at Movable Bridges

Flashing Beacons, Overhead and Shoulder-Mounted, and Combinations

Flashing Beacon - Overhead - Intersection Beacon
Flashing Beacon - Overhead - School Zone Sign
Flashing Beacon - Overhead - Other
Flashing Beacon - Overhead - Stop Panel
Flashing Beacon - Overhead - Speed Limit Sign
Flashing Beacon - Shoulder - Stop Sign
Flashing Beacon - Shoulder - Stop Ahead Sign
Flashing Beacon - Shoulder - Yield Sign
Flashing Beacon - Shoulder - Yield Ahead Sign
Flashing Beacon - Shoulder - Speed Limit Sign
Flashing Beacon - Shoulder - School Zone sign
Flashing Beacon - Shoulder - Curve Warning Sign
Flashing Beacon - Shoulder - Side Road Warning Sign
Flashing Beacon - Shoulder - Pedestrian Warning Sign
Flashing Beacon - Shoulder - Other
Flashing Beacon - Shoulder - Signal Ahead Sign
Flashing Beacon - Shoulder - RR-Be Prepared to Stop When Flashing
Flashing Beacon -Combination-Shoulder and Overhead - School Zone Sign

Railroad Signals

Standard Flasher
Cantilever Flasher
Standard Flasher w/ Gates
Cantilever Flasher w/ Gates

B. **Traffic Signal Equipment:** Equipment includes the controller and a complete operating cabinet, detector units, and signal heads, including pedestrian heads and push buttons if utilized, and wood, concrete or steel poles. Special equipment such as decorative poles, mast arms, vehicle preemption systems, aluminum signal heads, signal heads with non-reflective yellow housing and signal controllers not on the SCDOT state contract are addressed in **SCDOT Enginering Directive Memorandum 2** . If replacement for any reason is required the Department will replace with standard equipment unless the requesting agency agrees to provide funding for special equipment.

C. **Traffic Signal Design:** Design includes the collection of geometric and traffic data, analysis of data, preparation of timing plans and preparation of signal plans. All signal design must be sealed by a South Carolina registered professional engineer (P.E.)

D. **Traffic Signal Installation:** Installation involves the erection of the equipment, including: poles, detector loops, cables, brackets, electrical work, labor, equipment rental, and all other necessary incidental materials.

E. **Traffic Signal Revisions:** Modifications to existing signals such as adding phases, signal heads or additional loops will be considered as a signal revision.

F. **Traffic Signal Operation:** Operation of traffic signals includes performing traffic studies to optimize the performance of the signal. Traffic studies include counts, field observations, re-timing, review of phasing, and accident updates.

G. **Traffic Signal Maintenance:** Maintenance includes repairs of, or necessary replacement of, equipment as defined above and the labor to accomplish this.

Additional Definitions can be found:

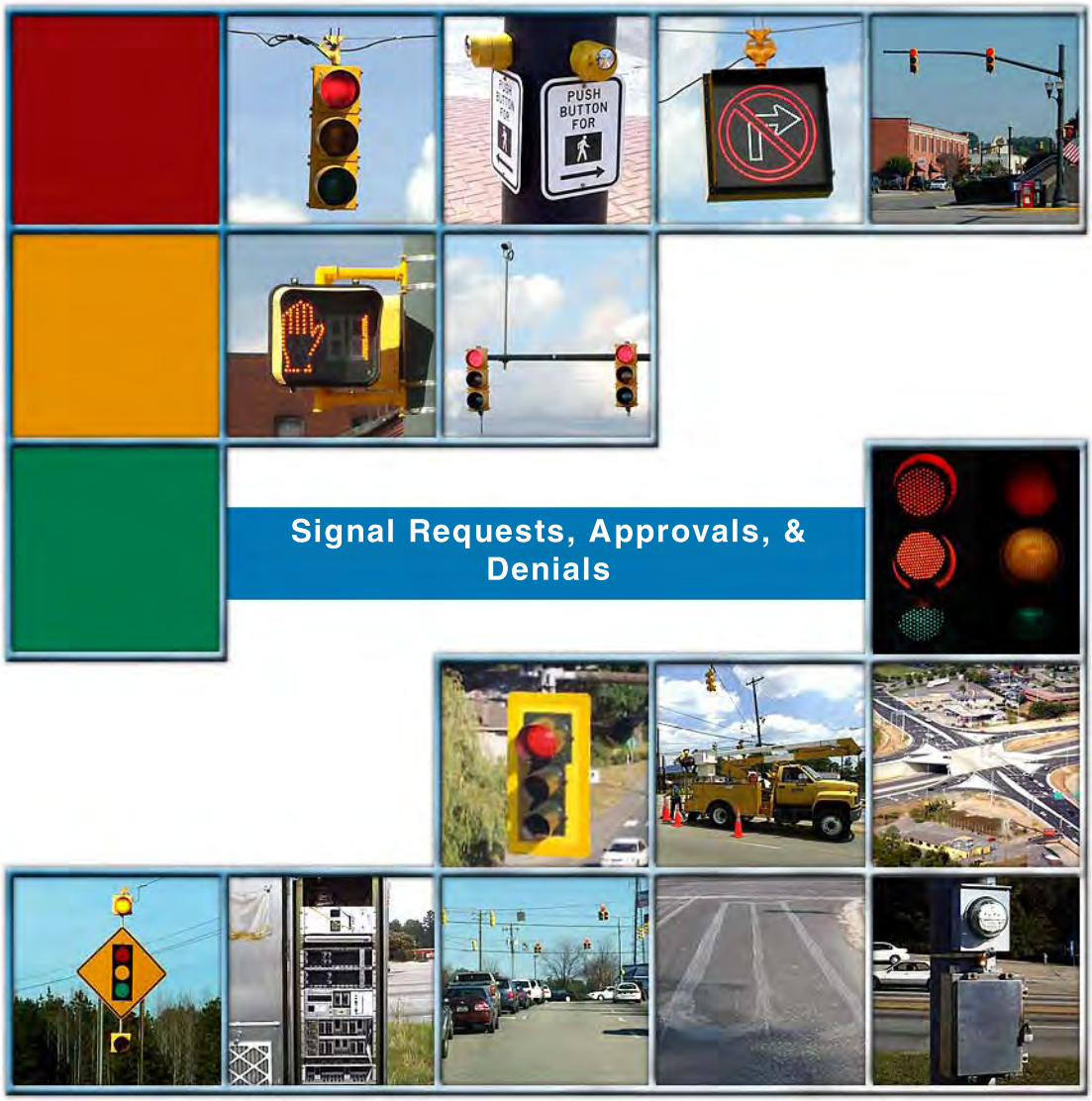
Chapter 4 of the **Manual on Uniform Traffic Control Devices (MUTCD)**.

FHWA's **Traffic Signal Timing Manual**

South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES

Chapter 2



Signal Requests, Approvals, & Denials

SIGNAL REQUEST

Upon receipt of a request, the District Engineering Office will have necessary studies conducted to determine whether a signal is justified and will approve or disapprove the request, advising the appropriate party. Copies of the studies and documentation shall be available by request through the District Engineering Office.

All Requests

All verbal and written requests shall be documented in HMMS detailing request information. **HMMS** is found on the SCDOT Intranet along with instructions on how to use the program.

Written Requests

If a written request does not provide adequate information to address the request, the person making the request shall be contacted to obtain the needed information.

All traffic study data shall be filed appropriately for easy access during inquiries.

When to Perform Study

Many signal requests can be repeat requests at location where we have previously denied a signal. An entire study may not need to be done if adequate and timely information is available in your files. Upon receiving a request, note the number of previous requests and or study information.

A If the previous study is less than 2 years old, you may check the following items to determine if you need to redo the traffic counts:

- Update accident history - If the intersection does not meet the accident warrant and if accidents have not drastically increased in the types correctable by signalization, you may not need to recount.
- Review ADT volumes if available - If these volumes have remained the same or have only slightly increased, you may not need to recount.
- Review development changes in area - If the area has not experienced a major development change, you may not need to recount.

A full study shall be performed if there has been:

- Major development changes influencing growth
- Roadway construction changes have occurred in the area, influencing traffic volumes or patterns
- If accident history has increased significantly

Otherwise, a field review to ensure the existing traffic control devices are appropriate and in fair condition should suffice. The response to the request may include the previous count information, the updated accident history, lack of increased traffic by way of development or average daily traffic volumes and a synopsis of the recent field review, preferably in a written

format.

B If no study has been done for over 2 years, the request may be acknowledged in writing indicating probable completion time or denial of signal based on the crash experience warrant stated in Chapter 4 of the **MUTCD.** If the manual indicates the likelihood of meeting signal warrants, a full signal study shall be performed including traffic counts, accident history, and a field review. Other additional studies may be performed including a delay study, a highway capacity analysis and a speed study. Upon completion of the study, a written response indicating findings may be provided to the requester.

SIGNAL APPROVAL OR DENIALS

SCDOT is responsible for the approval or denial of traffic signals on state maintained roadways. The Department follows the **MUTCD** Signal Warrant Analysis to determine the need for traffic control at an intersection. Engineering judgment should be used to determine if a signal is warranted. There are 8 warrants, and meeting one warrant does not mean a signal is necessary. Meeting all volume warrants does not indicate, necessarily, that a signal is needed. Use engineering judgment to review operation, accident history, delay and potential impact of signal on existing conditions, however safety concerns override level of service concerns.

When obtaining accident history, all accident reports should be obtained and a collision diagram prepared. Also, the accident warrant is may be met by lowering the volume threshold when 5 accidents, correctable by signalization, have occurred within a 12-month period. This 12-month period does not represent a calendar year, starting in January, but could occur in any consecutive 12 months. Be sure to check the dates of accidents closely to determine if this criterion is met.

Log any signal request and the process in **HMMS**.

If Signal is denied:

Respond in writing, if possible, indicating what studies were done and why the signal was not approved. Include a summary statement concerning the traffic count volumes, accident history, and field observations.

If a verbal response is given, state the facts of the study and offer to send a report by mail. Document the date and time of the call, including any pertinent information concerning the conversation, and file for future reference.

If Signal is approved:

Once the signal has been approved by the district engineering administrator; respond in writing, if possible, as outlined above. Typically, the District will design the signal and the appropriate registered engineer in the District will sign the plan. The original plan will be kept in the District office with all documentation for future use and Freedom of Information requests. For clarification of design, fiscal, installation and maintenance responsibilities for various entities and types of signals see the Signal Equipment Catalog.

SIGNAL STUDIES

Signal studies should adequately address the geometry of the intersection, sight distance, accident history (diagrams or breakdowns), traffic volumes, operational observations, and any unusual conditions. It is desirable that left turn phase studies include these items as well as left turn delay data. The following information should be gathered to provide information concerning the need for signalization:

Accident History - Accident data can be helpful in determining the appropriate traffic control at an intersection. A minimum of 3 years of data is helpful in determining accident trends. The following data may be helpful during a traffic study:

- Calculate accident rate for comparison with similar locations in the state
- Prepare collision diagram (Figure 3-1) indicating type, severity and time of collisions; tabu late accident average per intersection using the ***Crash Rate Equations spreadsheet (Appen dix 3:1)**** from the Highway Safety Manual.

To request accident data you may e-mail the Traffic Engineering Accident Research Office or submit the ***Request for Accident History (Appendix 3:2)**** form.

Traffic Volumes – Review ADT's to determine if traffic counts should be performed. Tube counts may be used to determine appropriate length and time for turning movement counts. Turning movement counts should be performed during peak traffic times, based on character of area. These counts may include:

- Pedestrian volumes and crossing patterns
- Bus & Truck volumes
- Observations of delay, queuing or other pertinent events such as driveway interference with traffic operations

A ***Consultant Traffic Count Reference Guide (Appendix 3:3-21)**** has been developed for our Fixed Price count contract. This may also be useful to anyone participating in a traffic count.

Field Reviews

May use the following:

- ***Traffic Signal Investigation Survey (Appendix 3:22-24)**** which is very detailed, the ***Intersection Inventory (Appendix 3:25)****, or a similar survey
- Before/After Study using a stop watch to record travel time through the study corridor or single intersection.

In addition to this information the following may also assist in completing an engineering study for signalization:

Average Annual Daily Traffic (AADT) volumes-

The **AADT** can be found on the internet.

Delay studies-

- Visual observations
- Measured observations using counting equipment
- Calculated delay using HCS or other software package

Level of Service analysis

Perform comparison of unsignalized operation versus signalized operation using HCS, Synchro, or other accepted methodology.

Synchro Analysis-This software allows us to model, optimize, manage, and simulate traffic systems. It calculates capacity, optimizes cycle lengths, splits and offsets, eliminating the need to try multiple timing plans. Synchro is a valuable tool, but it is not perfect. Field studies will need to be made once signal timings go into effect to ensure the system is working effectively. Some changes may need to take place.

Synchro defaults (Appendix 3:26)* -Synchro file that includes SCDOT preferred settings.

Synchro Design tips (Appendix 3:27-34)*- Inside tips for Signal System Design

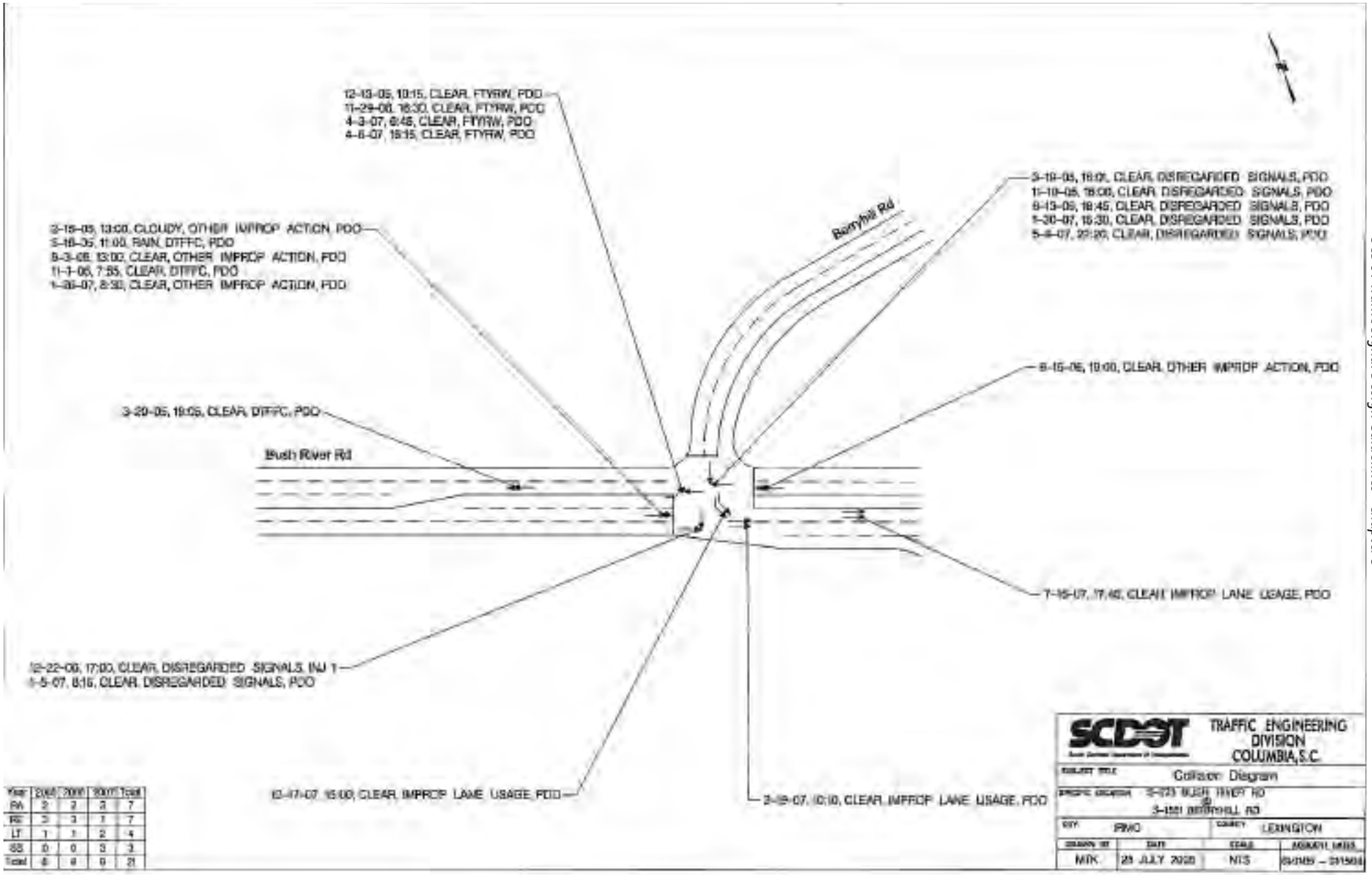
Synchro Comparison worksheet (Appendix 3:35)* - this worksheet is designed to allow comparison of different optimized cycle lengths including delay, level of service, and volume/capacity ratio. Instructions on how to use this spreadsheet can be found on the last page of the Synchro Design Tips.

The Manual of Uniform Traffic Control Devices(MUTCD) has information on Highway Traffic Signals, concerning Traffic Control Signal Needs Studies.

PART 4. HIGHWAY TRAFFIC SIGNALS
Chapter 4A. General
Chapter 4B. Traffic Control Signals — General
Chapter 4C. Traffic Control Signal Needs Studies
Chapter 4D. Traffic Control Signal Features
Chapter 4E. Pedestrian Control Features
Chapter 4F. Traffic Control Signals for Emergency Vehicle Access
Chapter 4G. Traffic Control Signals for One-Lane, Two-Way Facilities
Chapter 4H. Traffic Control Signals for Freeway Entrance Ramps
Chapter 4I. Traffic Control for Movable Bridges
Chapter 4J. Lane-Use Control Signals
Chapter 4K. Flashing Beacons
Chapter 4L. In-Roadway Lights

**Found in the Appendix-Chapter 3*

Figure 3-1: Collision Diagram Example



Year	2006	2007	2008	Total
RA	2	2	3	7
RE	3	3	1	7
LT	1	1	2	4
SS	0	0	3	3
Total	6	6	9	21

Left Turn Phase Studies

The following information should be gathered to provide information concerning the need for left turn signal revisions

Accident History - refer to page 1 of Chapter 4 for definition.

Field Reviews

- Left turn lane sight distances
- Roadway alignment
- Lane configuration
- Character of area
- Signs and markings
- Adjacent driveway location and spacing
- Operational characteristics of vehicles

Perform left turn delay studies and/or obtain turning movement counts for a minimum of 2 hours, based on character of area, including:

- o Pedestrian volumes and crossing patterns
- o Bus &Truck volumes
- o Observations of delay, queuing or other pertinent events such as driveway interference

Left Turn Phase Studies - Left turn signal phases facilitate left -turning traffic and may improve the safety of the intersection for left turning vehicles. However, this is done at the expense of the amount of green time available for through traffic and will usually reduce the capacity of the intersection. Left turn arrows also result in longer cycle lengths, which in turn have a detrimental effect by increasing stops and delays. While phases for protected left turning vehicles are popular and commonly requested, other methods of handling left turn conflicts also need to be considered. Potential solutions may include prohibiting left turns and geometric improvements. The following guidelines are listed to determine whether or not a left turn phase should be considered:

- The product of left turning vehicles & conflicting vehicles during peak hour is greater than 100,000
- Left turn volume greater than 100 vehicles per hour
- Left turn peak period volumes greater than 2 vehicles per cycle per approach still waiting at the end of green
- Left turn volumes greater than 50 vehicles per hour when speed exceeds 45 mph
- 5 left turn accidents in a 12 month period

Engineering judgment should be used in determining if left turn phasing will improve the overall operation of the intersection. Even if the volume warrants are met, a field review should be conducted to determine the number of vehicles waiting to turn left at the end of the phase. Consider the amount of queuing and the storage available to determine if there is adequate room to facilitate the volumes without installing the additional phase. If no safety issues are present, and sight distance and storage is adequate, give strong consideration to the effect of the additional phase on the level of service of the main traffic movements through the intersection. In addition, there are different types of left turn phasing, as shown below:

A. Protected/Permissive - This phasing allows a motorist an opportunity to choose to make their turn during the protected or the permissive part of the signal phase.

B. Protected only - This phasing only allows a motorist to turn on the protected phase for the left turn. This option provides more safety, however a good bit of efficiency is lost at the signal, since during low traffic times, a motorist must wait for the protected turn phase in order to make a turn.

To determine when to provide protected only phasing instead of the less restrictive protected/permissive phasing, the following should be considered:

- Installation of protected/permissive phasing has not reduced the left turn accident history
- 3 or more opposing lanes of traffic
- Limited sight distance for left turn lane, and no feasible or cost beneficial way to improve it

Lead/lag Left Turn Phasing - Generally leading left turn phasing should be used unless no opposing left turn movement exists or if the opposing left turn movement is controlled by protected only phasing. Exceptions to this general rule may exist with at signalized locations involving railroad preemption, where clearing the track may call for a lagging left turn phase during railroad preemption.

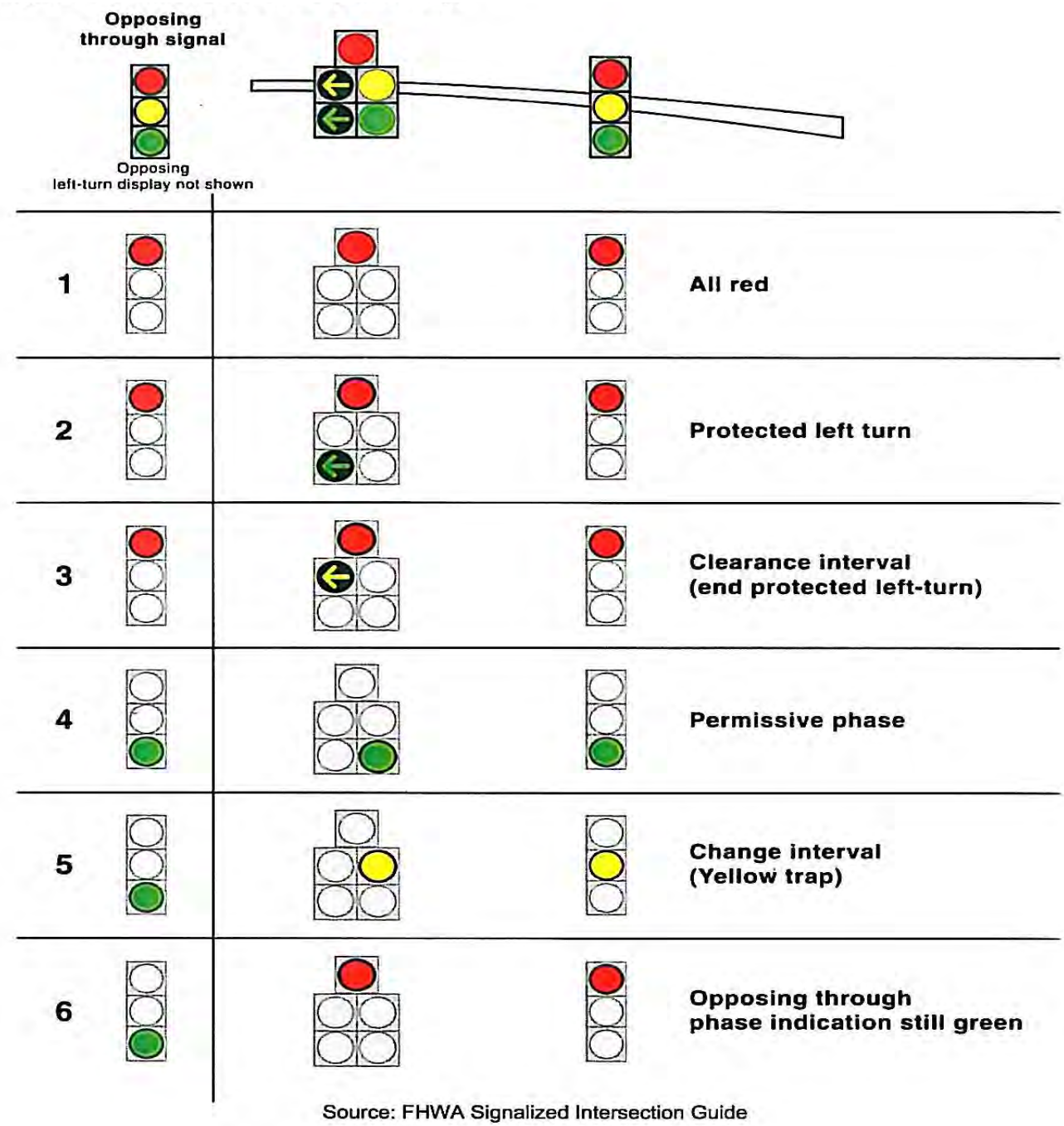
Lead/lag by time of day is permissible at signals with protected only phasing or at locations where left turn overlaps do not occur as a result of lagging left turns, such as 'T' intersections or at interchanges. If an intersection is a candidate for lead/lag phases special attention must be given to ensure a left turn trap is not created. FHWA's Signalized Intersection Guide (Figure 3-2) explains how a left-turn trap works.

Variable Left Turn Mode 4D.06, Variable Right Turn Mode 4D.07 - Use of variable left turn mode and/or variable right turn mode at traffic signals is not a standard practice in South Carolina and generally will not be approved.

A **Left-turn phase study spreadsheet (Appendix 3:36-37)** *can be found in the Appendix-Chapter 3.*

Figure 3-2

Yellow Turn Trap Explanation



Source: FHWA Signalized Intersection Guide

Intersection Control Beacon Signal Studies

The following information should be gathered to provide information concerning the need for an Intersection Control Beacon (Figure 3-3, 3-4), Warning and Stop Beacon (Figure 3-5), Road Ends Beacon (Figure 3-6) and Emergency Vehicle Signal Study (Figure 3-7).

Accident History - reference to page 1 of Chapter 4 for definition.

AADT Traffic Volumes

Field Reviews (See attached Field Review Sheet)

- Note location of utilities
- Approaching and entering sight distances
- Roadway alignment
- Lane configuration
- Character of area
- Signs and markings
- Adjacent driveway location and spacing
- Operational characteristics of vehicles utilizing intersection
- Roadway cross section
- Corner radii

Flashing Beacons should be installed according to engineering judgement using Chapter 4K and Traffic Control Signals for Emergency Vehicle Access in Chapter 4F in the **MUTCD**.

Specifications for the following flashing beacons can be found in the Appendix-Chapter 3.

24-7 single beacon solar flashing beacon (Appendix 3:38-39)

24-7 single beacon compact solar flashing beacon (Appendix 3:40-42)

Dual Beacon 24-7 solar flashing beacons (Appendix 3:43-44)

Figure 3-3

Intersection Control Overhead Stop Beacon Example

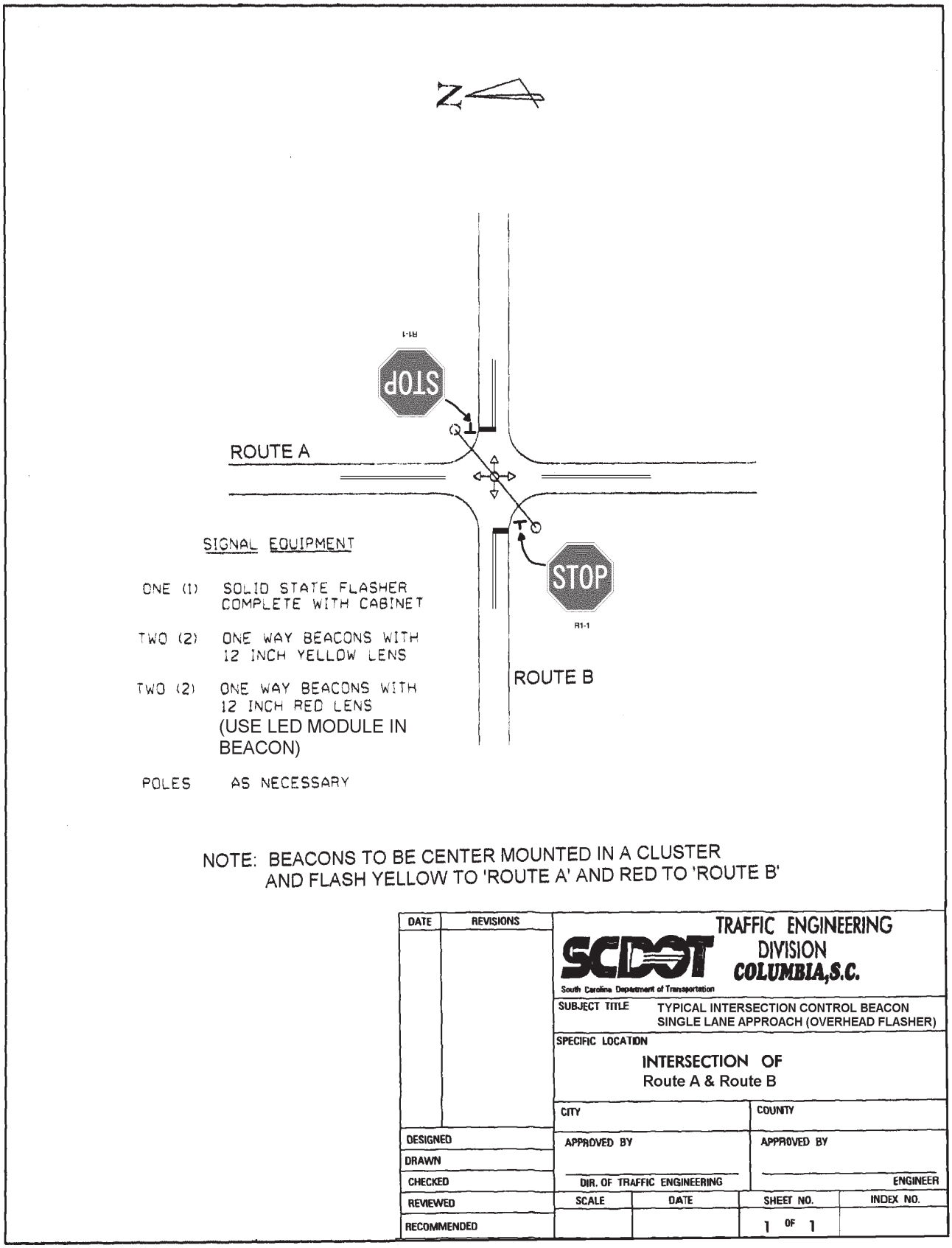


Figure 3-4

Multi-lane Intersection Control Overhead Stop Beacon Example

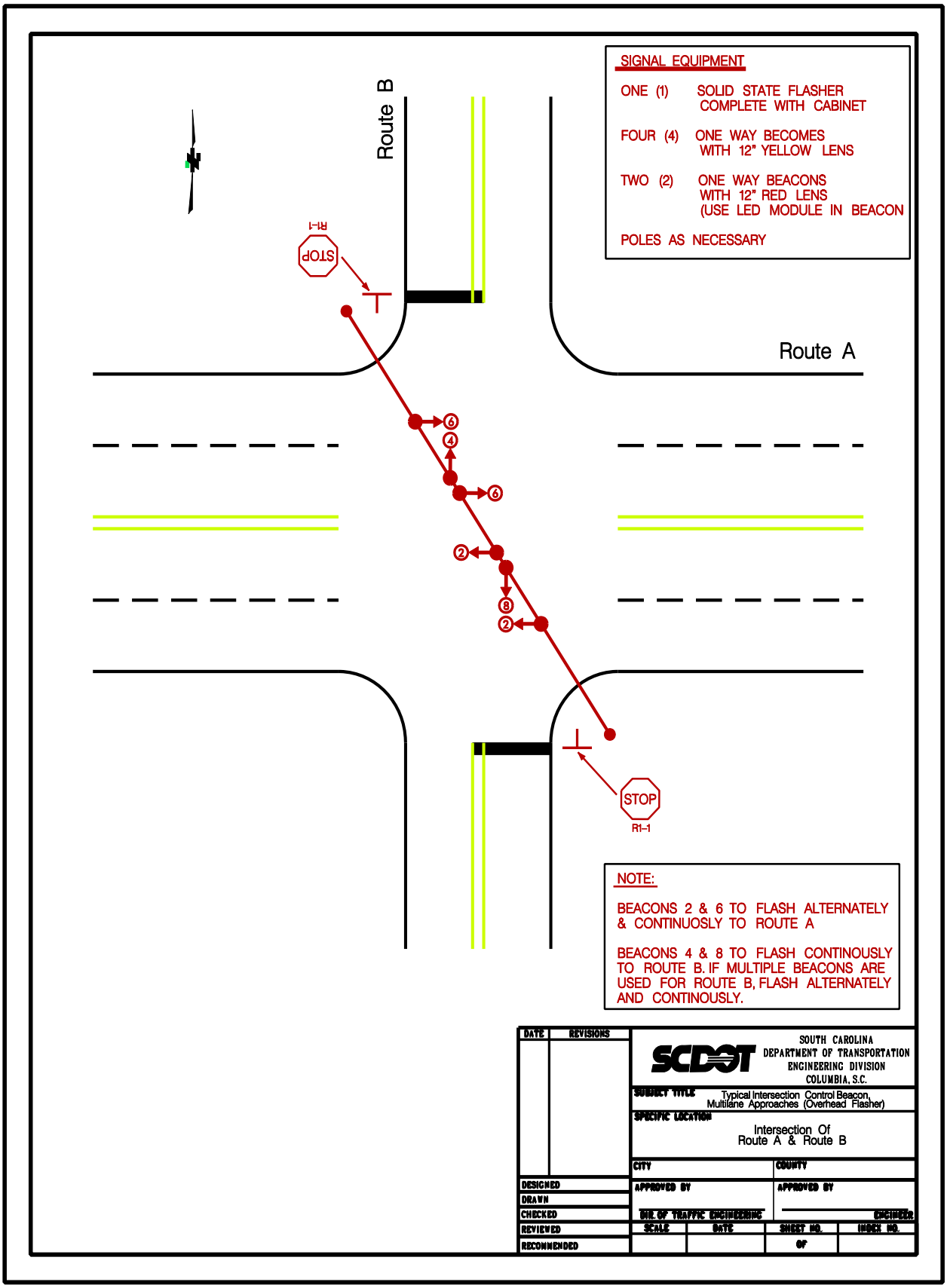
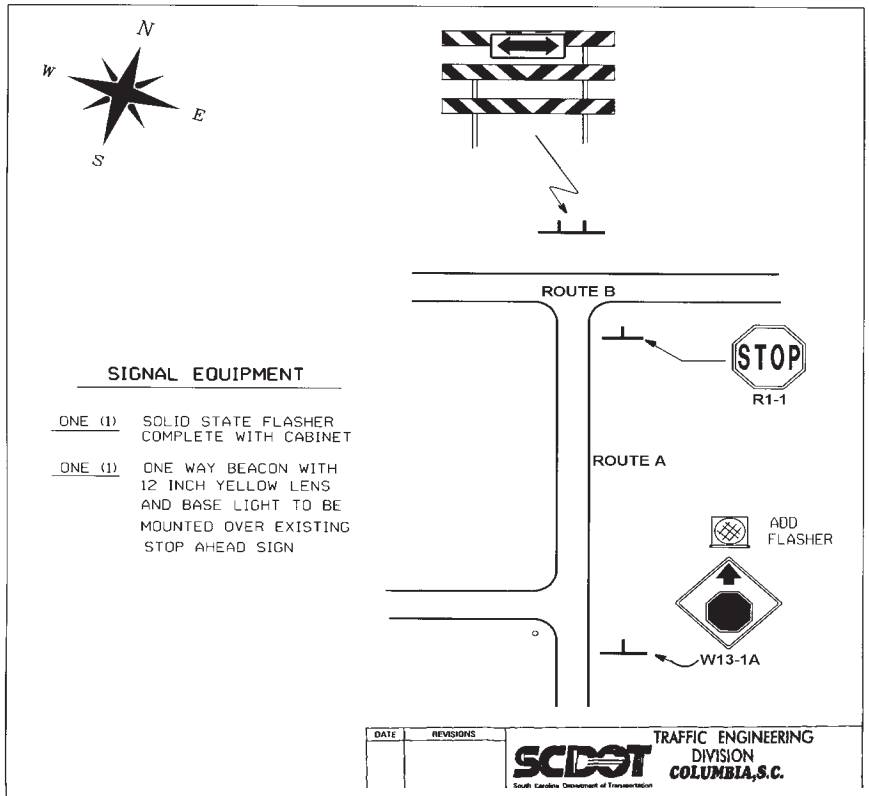


Figure 3-5

Warning Control Beacon Example



Typically the warning flasher/beacon is attached to the stop sign (warning sign) as shown below. The flasher/ beacon may be attached to the advanced warning sign depending on sight distance and engineering judgement on a case by case bases as shown to the left.

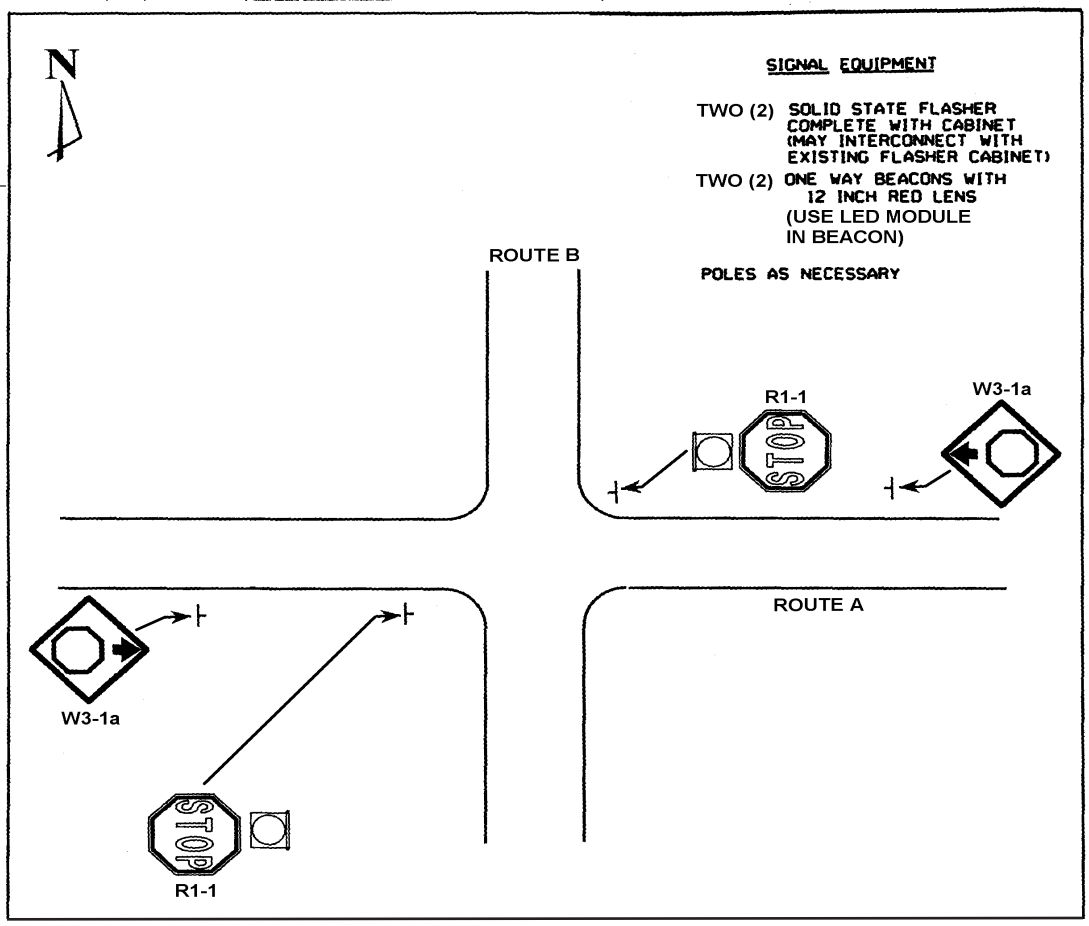


Figure 3-6

Flasher for Road Ends Example

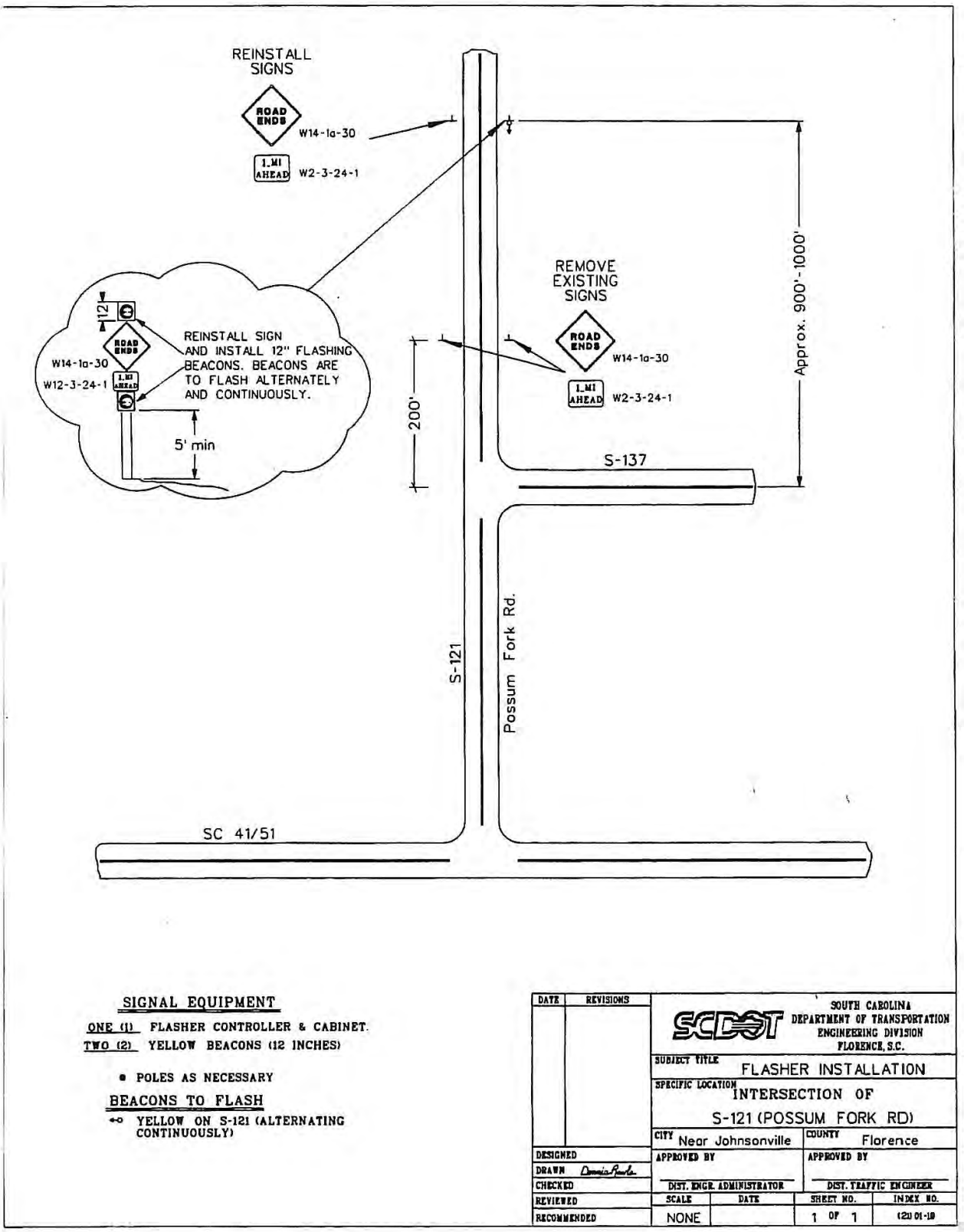


Figure 3-7: Emergency Signal Connected with Stop & Go Signal Example

PIN # 22518

FED. ROAD DIV. NO.	STATE	COUNTY	FILE NO.	PROJECT NO.	RTE. NO.	SHEET NO.	TOTAL SHEETS
3	S.C.	ANDERSON	4163A	BST-ACB1005	SC 81	TS-1	

SIGNAL EQUIPMENT

ONE 8 PHASE FULLY ACTUATED STANDARD 170 CONTROLLER WITH FLASHER, SIGNAL MONITOR UNIT, AND BASE-MOUNTED 336S CABINET.

4 VEHICLE DETECTOR UNITS.

1 PUSH BUTTON

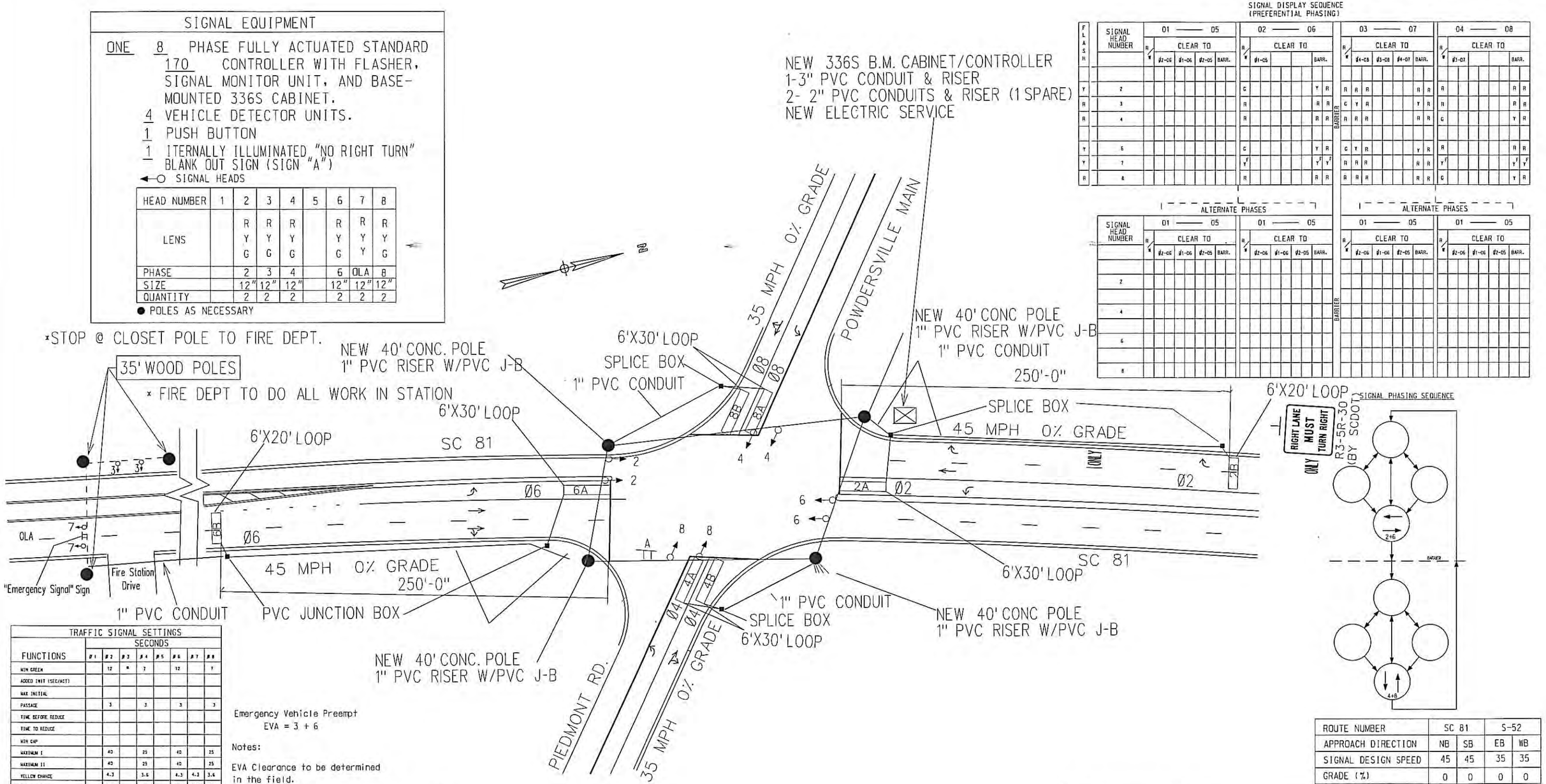
1 ITERNALLY ILLUMINATED "NO RIGHT TURN" BLANK OUT SIGN (SIGN "A")

←○ SIGNAL HEADS

HEAD NUMBER	1	2	3	4	5	6	7	8
LENS		R Y G	R Y G	R Y G		R Y G	R Y Y	R Y G
PHASE		2	3	4		6	OLA	8
SIZE		12"	12"	12"		12"	12"	12"
QUANTITY		2	2	2		2	2	2

● POLES AS NECESSARY

*STOP @ CLOSET POLE TO FIRE DEPT.



ROUTE NUMBER	SC 81		S-52	
APPROACH DIRECTION	NB	SB	EB	WB
SIGNAL DESIGN SPEED	45	45	35	35
GRADE (%)	0	0	0	0

TRAFFIC SIGNAL SETTINGS

FUNCTIONS	SECONDS Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8
MIN GREEN		12	*	7		12		7
ADDED INIT (SEC/ACT)								
MAX INITIAL								
PASSAGE		3		3		3		3
TIME BEFORE REDUCE								
TIME TO REDUCE								
MIN GAP								
MAXIMUM I		40		25		40		25
MAXIMUM II		40		25		40		25
YELLOW CHANGE		4.3		3.6		4.3	4.3	3.6
RED CLEAR		1.8		2.1		1.8	1.8	2.1
RECALL		MIN		OFF		MIN		OFF
DET. MEMORY		L		N		L		N
L - LOCK, N - NON-LOCK								
DET. DELAY				6				6
DET. MODE		PR		PR		PR		PR
P - PULSE, PR - PRESENCE								
WALK								
PEDESTRIAN CLEAR								

*Emergency Preempt time to be determined by field test.

Emergency Vehicle Preempt
EVA = 3 + 6

Notes:

EVA Clearance to be determined in the field.

Internally Illuminated "No Right Turn" sign to be illuminated at beginning of preemption and remain illuminated until the termination of preemption.

OVERLAP SETTINGS	
OLA 2+4+6+8	OLC ____
OLB ____	OLD ____

REV. NO.	BY	DATE	DESCRIPTION OF REVISION
4			
3			
2			
1			

TOPO. ____ DATE ____
DWG. X. FAN DATE SEP. 2001 SQUAD ____ - ____
R/W ____ DATE ____

SOUTH CAROLINA
DEPARTMENT OF TRANSPORTATION
COLUMBIA, S.C.

SIGNAL PLAN
SC 81 AT POWDERSVILLE MAIN
ANDERSON COUNTY

RTE. SC 81 DWG. NO. PN1

School Zone Flasher Signal Studies

The following information should be gathered to provide information concerning the need for School Zone Flasher (Figure 3-8, 3-9) Signal Studies:

Speed Studies-Visual observations and/or measured observations using radar equipment Traffic Volumes, including AADT volumes and pedestrian volumes during school take-in/dismissal

Field Reviews (See attached Field Review Sheet)

- Note location of utilities
- Approaching and entering sight distances
- Roadway alignment
- Lane configuration
- Character of area
- Signs and markings
- Adjacent driveway location and spacing
- Operational characteristics of vehicles utilizing intersection,
- Roadway cross section
- Corner radii

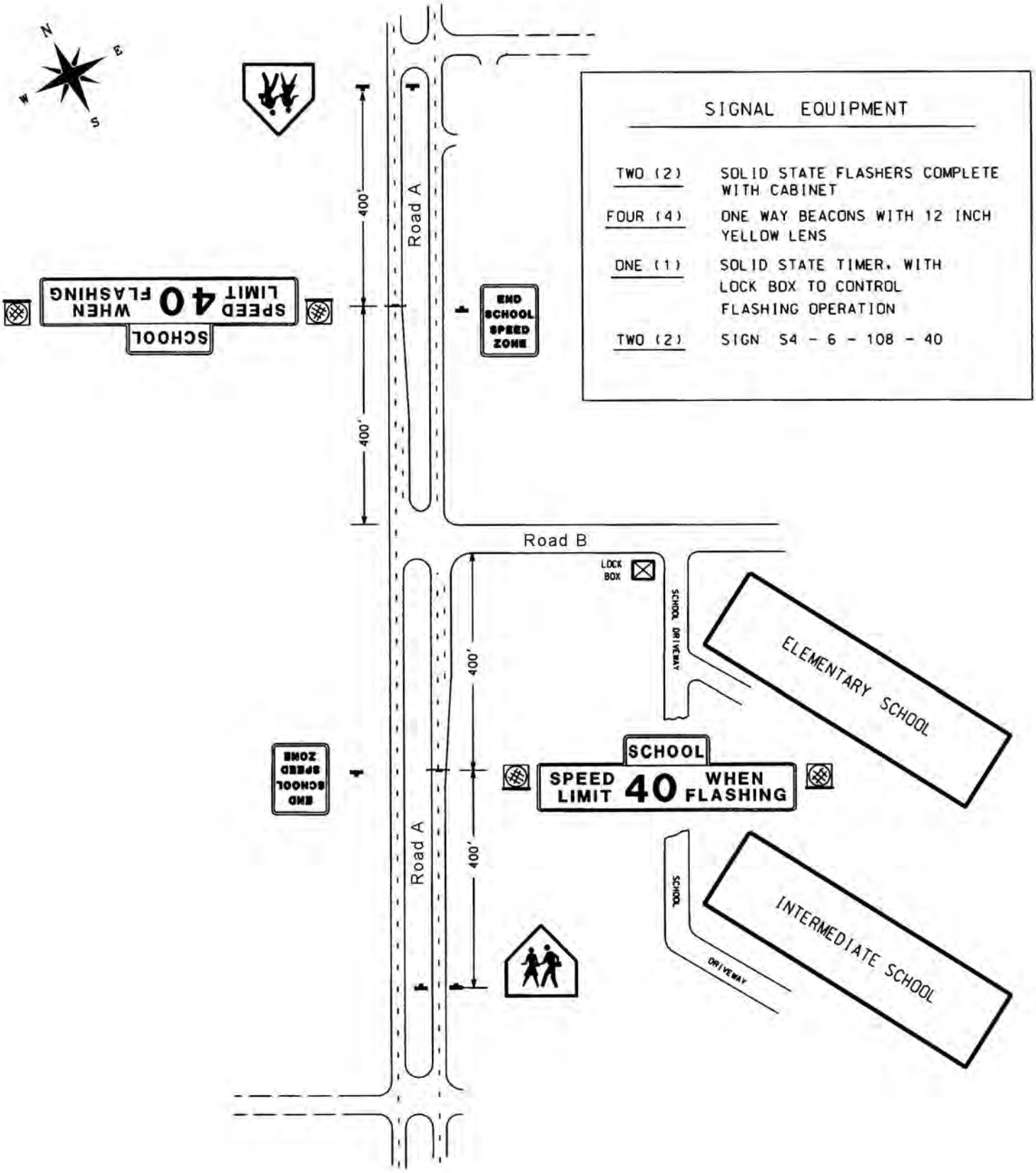
School Zones should be installed according to the **MUTCD** Chapter 7.

Specifications for the following school flashing beacons can be found *in the Appendix-Chapter 3.*

Dual Beacon solar school flashing beacons (Appendix 3:45-46)

Dual Compact Solar School Zone Flasher (Appendix 3:47-49)

Figure 3-8



SHEET NO. ..... OF .....

BY ..... DATE .....

CHKD. By..... DATE .....

TITLE SCHOOL FLASHER INSTALLATION

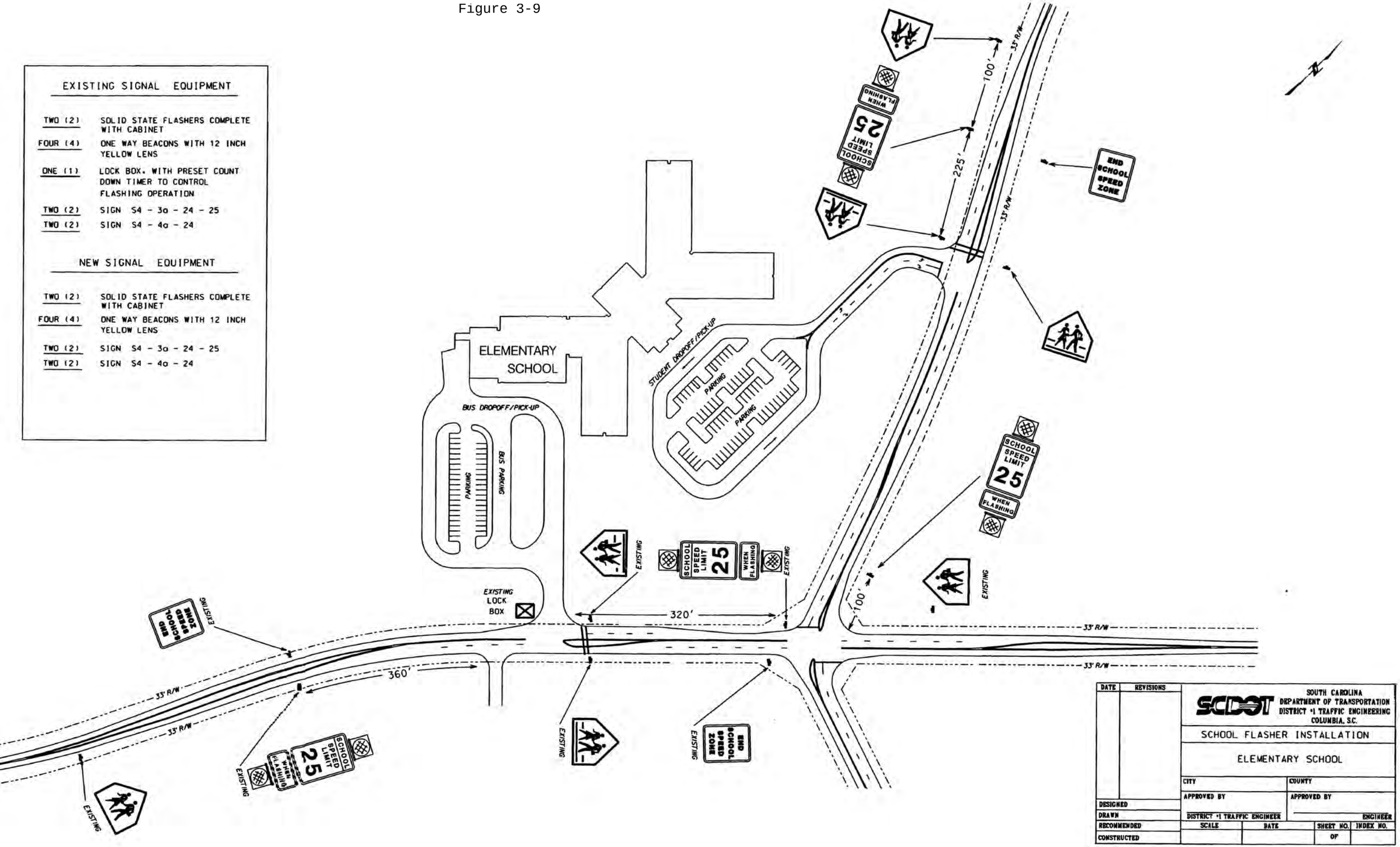
US Route at ELEMENTARY and

INTERMEDIATE SCHOOLS

SCDOT

DISTRICT 1 TRAFFIC

Figure 3-9


EXISTING SIGNAL EQUIPMENT
TWO (2) SOLID STATE FLASHERS COMPLETE WITH CABINET
FOUR (4) ONE WAY BEACONS WITH 12 INCH YELLOW LENS
ONE (1) LOCK BOX, WITH PRESET COUNT DOWN TIMER TO CONTROL FLASHING OPERATION
TWO (2) SIGN S4 - 3a - 24 - 25
TWO (2) SIGN S4 - 4a - 24
NEW SIGNAL EQUIPMENT
TWO (2) SOLID STATE FLASHERS COMPLETE WITH CABINET
FOUR (4) ONE WAY BEACONS WITH 12 INCH YELLOW LENS
TWO (2) SIGN S4 - 3a - 24 - 25
TWO (2) SIGN S4 - 4a - 24
ELEMENTARY SCHOOL
STUDENT DROPOFF/PICK-UP
PARKING
PARKING
BUS DROPOFF/PICK-UP
PARKING
BUS PARKING
EXISTING LOCK BOX
320'
360'
100'
225'
100'
33' R/W
33' R/W
33' R/W
33' R/W
SCHOOL SPEED LIMIT 25
WHEN FLASHING
END SCHOOL SPEED ZONE
EXISTING
SCDOT
SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION DISTRICT #1 TRAFFIC ENGINEERING COLUMBIA, S.C.
SCHOOL FLASHER INSTALLATION
ELEMENTARY SCHOOL
DATE
REVISIONS
CITY
COUNTY
APPROVED BY
APPROVED BY
DESIGNED
DRAWN
DISTRICT #1 TRAFFIC ENGINEER
ENGINEER
RECOMMENDED
CONSTRUCTED
SCALE
DATE
SHEET NO.
OF
INDEX NO.

INSTALLATION OF TRAFFIC SIGNALS

In order to provide uniformity in the manner in which signals are installed and placed in operation, all District Electrical Personnel should use the following procedure for the installation or replacement of new traffic signals.

1. Install poles, guys, overhead cable including signal head connections, but do not install signal heads until ready to place in flashing mode.

2. Install controller cabinet, cut loops and complete incidental work necessary to place signal in flashing mode.

3. Install heads and "bag" if necessary until the head can be placed in flashing mode and flash for at least 3 and not more than 7 days. Bag signal heads only in the event where all of the heads can not be installed within the same work day or if the intersection is a replacement of a closed loop system where the entire system is to be placed in operation at one time and the existing system will remain in operation until the switch over is initiated. **In the event where signalized intersections are replaced with new equipment, there is no mandatory flash period required.**

4. On the day the signal is to be placed in stop and go operation, erect "Signal Ahead" signs (**MUTCD** W3-3) on all approaches with a "NEW" plaque above the signs. When the signal is placed into operation, remove the "Stop" signs from the side street and "Stop Ahead" signs if applicable. Supplement the "Signal Ahead" signs with portable flashers and/or orange flags to draw attention to the signs.

5. The signal should be placed into operation on a normal workday, after the morning peak hour and prior to the afternoon peak hour.

6. The flags or flashers and the "NEW" plaques should be removed approximately two months after the signal is placed in operation.

The SCDOT follows the **MUTCD** for the following topics:

Traffic Control Signals for One-Lane, Two-Way Facilites - Chapter 4G

Traffic Control Signals for Freeway Entrance Ramps - Chapter 4H

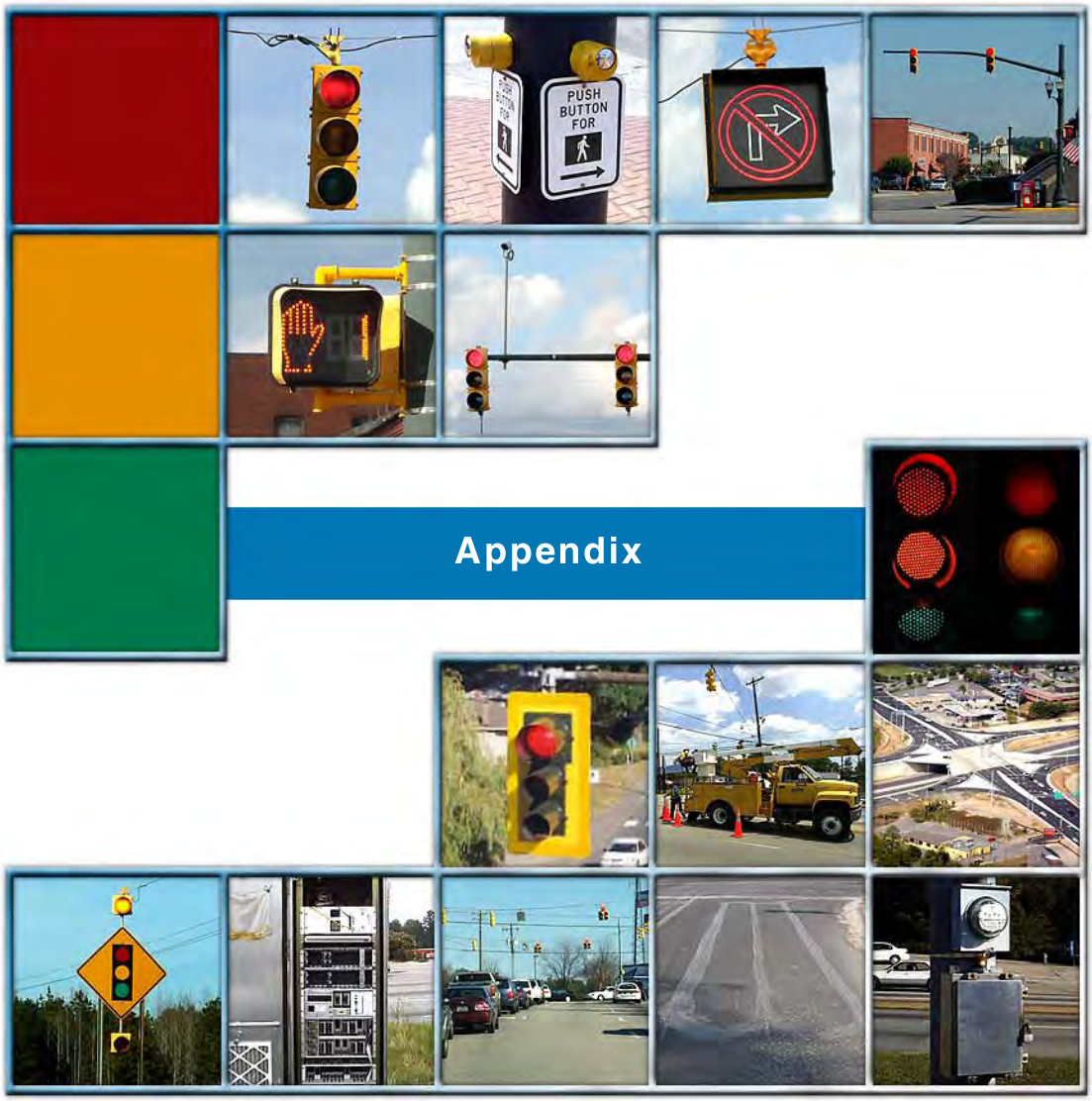
Traffic Control for Movable Bridges - Chapter 4I

Lane-Use Control Signals - Chapter 4J

In-Roadway Lights - Chapter 4L

South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES



Appendix

EXAMPLE CRASH RATE EQUATION SPREADSHEET:

SAFETY PERFORMANCE FUNCTIONS FOR INTERSECTIONS

Jun-08

Please enter traffic volumes for intersecting Roads in yellow cells

Able Street & Wine Road		
Traffic Volume for Major Road/Street in ADT	ADT1	3850
Traffic Volume for Minor Road/Street in ADT	ADT2	700

Intersection type and control:		**Predicted TOTAL ACCIDENTS per year**
Rural Two-Lane roads IHSDM		
Rural_3 Approach one-way stop of Stem of T		0.31
Rural_3 Approach Signalized		0.78
Rural_4 Approach 2-way Stop Control		0.68
Rural_4 Approach Signalized		1.71
Urban Two-lane Roads SPF		
3-leg intersections with minor-road STOP control		0.49
3-leg intersections with signal control		0.52
4-leg intersections with minor-road STOP control		1.17
4-leg intersections with signal control		2.50
Multilane 3 leg stop control SPF		
Rural_SPF		0.20
Urban_SPF (multiple vehicle crashes w/o ped & bike)		0.21
Urban_SPF (single vehicle crashes w/o ped & bike)		0.11
Urban_SPF (total vehicle crashes w/o ped & bike)		0.33
3ST Urban SPF (Total vehicle+Ped&Bike)		0.33
Multilane 3 leg signalized SPF		
Rural_SPF		0.68
Urban_SPF (multiple vehicle crashes w/o ped & bike)		0.47
Urban_SPF (single vehicle crashes w/o ped & bike)		0.09
Urban_SPF (total vehicle crashes w/o ped & bike)		0.55
3SG Urban SPF (Total vehicle+Ped&Bike)		0.56
Multilane 4 leg stop control SPF		
Rural_SPF		0.46
Urban_SPF (multiple vehicle crashes w/o ped & bike)		0.57
Urban_SPF (single vehicle crashes w/o ped & bike)		0.15
Urban_SPF (total vehicle crashes w/o ped & bike)		0.72
4ST Urban SPF (Total vehicle+Ped&Bike)		0.74
Multilane 4 leg signalized SPF		
Rural_SPF		2.11
Urban_SPF (multiple vehicle crashes w/o ped & bike)		0.75
Urban_SPF (single vehicle crashes w/o ped & bike)		0.08
Urban_SPF (total vehicle crashes w/o ped & bike)		0.83
4SG Urban SPF (Total vehicle+Ped&Bike)		0.86

3 leg Roundabout			
NCHRP 3-65 - single circulatory lane	8500	3500	1.11
NCHRP 3-65 - 2 circulatory lanes	8500	3500	1.82

4 leg Roundabout			
NCHRP 3-65 - single circulatory lane	15500	7500	4.25
NCHRP 3-65 - 2 circulatory lanes	15500	7500	7.03

5 leg Roundabout	1 c. Lane	2 circ. Lanes
Entering from Approach 1*	2100	6500
Entering from Approach 2*	2300	5500
Entering from Approach 3*	2500	3700
Entering from Approach 4*	1900	5000

REQUEST FOR ACCIDENT HISTORY FORM

REQUEST FOR ACCIDENT HISTORY

MEMO TO TRAFFIC ENGINEERING ACCIDENT RESEARCH OFFICE-SCDOT HQ

DATE _____ FROM _____

DISTRICT _____ DEPARTMENT _____ ROOM # _____

TELEPHONE NO. _____ ORGANIZATION _____ DOT _____

SPECIFY INFORMATION REQUESTED:

ACCIDENT HISTORY PRINTOUT & ACCIDENT REPORTS: ( ) / NO

ACCIDENT HISTORY PRINTOUT ONLY: YES / NO

ONE PAGE SUMMARIZED COUNT OF ACCIDENT HISTORY ONLY: YES / NO

OTHER: _____

SPECIFY LOCATION & TYPE OF REQUEST:

COUNTY _____ CITY _____

INTERSECTION OF (ROAD NO.): _____ AND _____

STREET NAME (IF OFF SYSTEM ROAD): OR _____

(STANDARD INTERSECTIONS RESEARCHED UP TO 200 FT IN ALL DIRECTIONS UNLESS OTHERWISE SPECIFIED): RESEARCH UP TO _____

SECTION OF ROADWAY (ROAD NO.): _____

FROM ROAD: _____ TO ROAD: _____

STREET NAMES (IF OFF SYSTEM ROADS):

FROM ROAD: _____ TO ROAD: _____

OTHER: _____

_____

_____

DESIRED ACCIDENT HISTORY IS FOR THE TIME FRAME OF: ____/____/____ TO ____/____/____

(STANDARD ACCIDENT RESEARCH IS CURRENT YEAR PLUS THREE PREVIOUS YEARS)

NOTE: FOR ALL REQUESTS, PLEASE ATTACH A MAP DENOTING LOCATION

CONSULTANT TRAFFIC COUNT REFERENCE GUIDE

29 September 2008

TABLE OF CONTENTS

CH. 1 INTRODUCTION

This document is provided to instruct consultants with knowledge of the entire count process. The document includes a list of what data is necessary, steps for collecting and processing data, and the transfer of that data to the Traffic Signals & Signal Systems office. This document will include a step-by-step process that will assist in producing the Final Report.

CH 2. TRAFFIC COUNT INVESTIGATION SURVEY

It is important that this entire survey is complete. Typically this survey can be completed between am and noon counts. Traffic volumes are fairly lower during this time making it easier to obtain the information needed.

The general form of the Traffic Count Investigation Survey has been condensed for consultant counts. The attached Traffic Count Investigation Survey includes a brief description or example of the type of information needed.

It can be noted that there is no place for a drawing or diagram. Generally, drawings or diagrams are done separate because this file will be sent as an electronic file.

CH. 3 THE DIAGRAM AND PICTURES

An intersection drawing or diagram is required. It does not matter how the drawing or diagram is formatted (ex: Petra or by hand) as long as it contains the following items:

- 400 feet of each approach,
- Street name and number,
- Businesses located at corners of the intersection,
- Lane configurations,
- Signs and pavement markings,
- Location of driveways near intersection,
- Signal head configuration,
- True North arrow,
- Directional labels for approaches,
- And location of count board during count

Pictures of the approach are not required, but the information the pictures provide may be used if it is given. Each photo should be labeled by direction of approach and intersection name (ex: SC 121 (Fastcar St) @ S-100 (Raceway Dr) NB).

Attached is an example of a drawing using Petra.

CH 4. THE COUNT

It is important that consultants pay close attention to the following guidelines for acquiring correct data.

Time Intervals

Always use **15-minute intervals** on the count board (5-minute intervals are too much and 30-minute intervals are too little).

Vehicle Classification

No matter whether school is in or out, always count cars, trucks, and busses individually. Use Cars-No Bank, Trucks-Bank 1, and Busses-Bank 2. See the Vehicle Classification Guide for more details.

Count Times

Typically, a weekday count is done on a Monday-Thursday at the times of 7-9am, 11-1pm, and 2-6pm. On Weekends, the count is Saturday at 10-2pm and 4-8pm. Other weekend count times may include Fridays 4-8pm, Saturdays 10-2pm and 4-8pm again, and Sundays 2-6pm (SCDOT will inform consultants if a count is needed for the full weekend)

Count Board Position

It is preferred that the consultant use the geographical placement of the location as an indicator of positioning the count board (Eastbound is Eastbound). However, if the count board is not positioned facing North, make sure to clearly indicate the intersection direction when submitting count data in Petra.

CH 5. PETRA SETTINGS AND DOWNLOADING THE COUNT

It is very important that the proper Petra settings be in place in order to process the count correctly. Wrong or misinterpreted data cannot be used, and the Millennium Signal Warrants-15min Spreadsheet will not be able to transfer and process the data correctly without these settings. There are two main settings. Unfortunately, the settings are not defaults in Petra, so these will have to be set by the consultant.

The first setting is the setup of the approach order in Petra. After the count is downloaded, each header is a different approach, probably labeled "southbound" or "from north," as shown in Petra. For counts, the order of these approaches needs to be From North, From East, From South, and From West, from left-to-right. If this is not the case in Petra, it can be changed following this path: Click **Tools**, Click **Approach Wizard**, select **Change the Order of the Approaches**, select **Next**, then move the approaches in the correct order using the arrows, and then Click **OK**. The reason for this change is the Millenium Signal Warrants-15min Spreadsheet reads the traffic volumes in this order and arranges them correctly for the file.

The second setting is the sub header underneath the header in Petra. The turning movements and pedestrians are the sub headers **Right-Thru-Left-Peds.** This should be arranged as **Left-Thru-Right-Peds**. Follow this path in order to fix it: Click on **File**, click **Preferences**, click the **Select Side** Tab, under Left Turn Column click **Show on Left Side**, and then click **OK**. Exiting out of Petra may be needed for this change to take place.

Some other important factors to know when downloading to the computer are as follows:

- Do not delete non-existent approaches. For example, whenever downloading a T-intersection, make sure the approach with no turning movements is left in Petra. This will act as a filler and keep the rest of the data in the correct place when it is transferred over to the Millenium Signal Warrants-15min Spreadsheet.
- Always label the approaches by street name or number. For example, From North: **Intersection Rd**; From South: **Wal-Mart Entrance**; From East: **US 78**; From West: **US 78**. This is done by clicking **Tools**, then **Intersection Design**, then selecting the appropriate

approach direction and label. That gives another verification that the count is in the right direction.

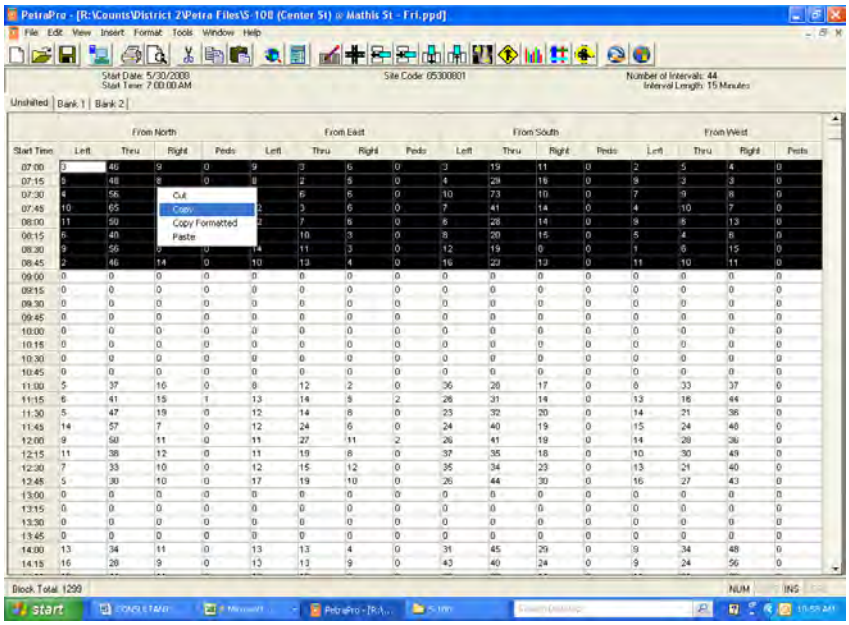
- If the counts are on the same day, do not split the data into three different counts. For example, Huger St @ Blossom St 7-9, Huger St @ Blossom St 11-1, and Huger St @ Blossom St 2-6. To continue a count, turn on the count board and select **Count** and then select **Continue**. (For ex: After completing the 7-9am count and you turn off the count board, when you turn the count board back on, follow the continue the count process to begin your 11-1pm count and do the same to continue your 2-6pm count.
- If the wrong button on the count board has constantly been selected for 15 minutes of the count, then there will be a noticeable problem in the count. If that happens and the problem and solution are easily verified in the count data on Petra, the problem may be changed in Excel and must be made note of on the Traffic Count Investigation Survey.

CH. 6 FROM PETRA TO EXCEL

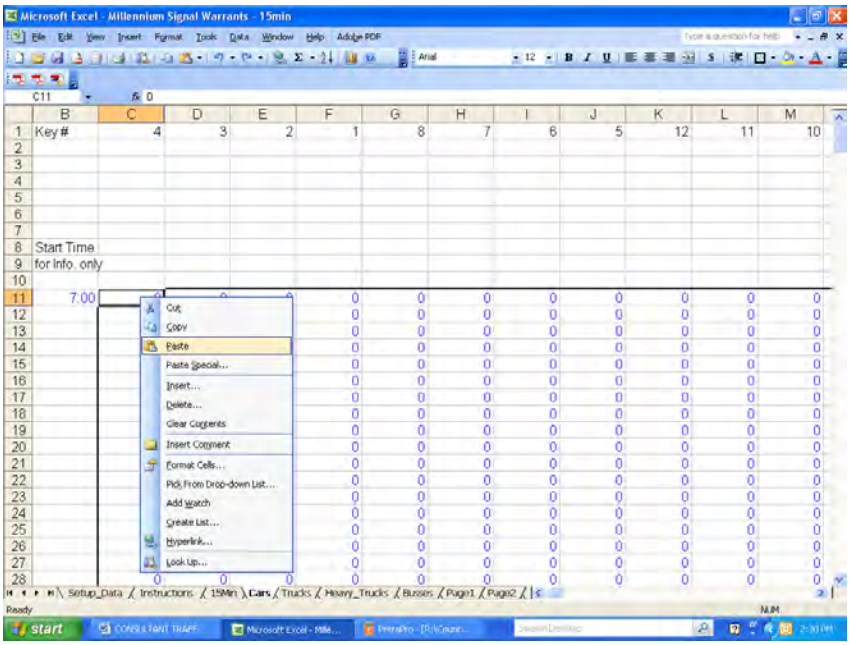
The Millenium Signal Warrants-15min Spreadsheet is required. This spreadsheet will identify a peak hour factor, AM peak hour, Noon peak hour, Afternoon peak hour, and other data that is significant to the Traffic Signals & Signal Systems office.

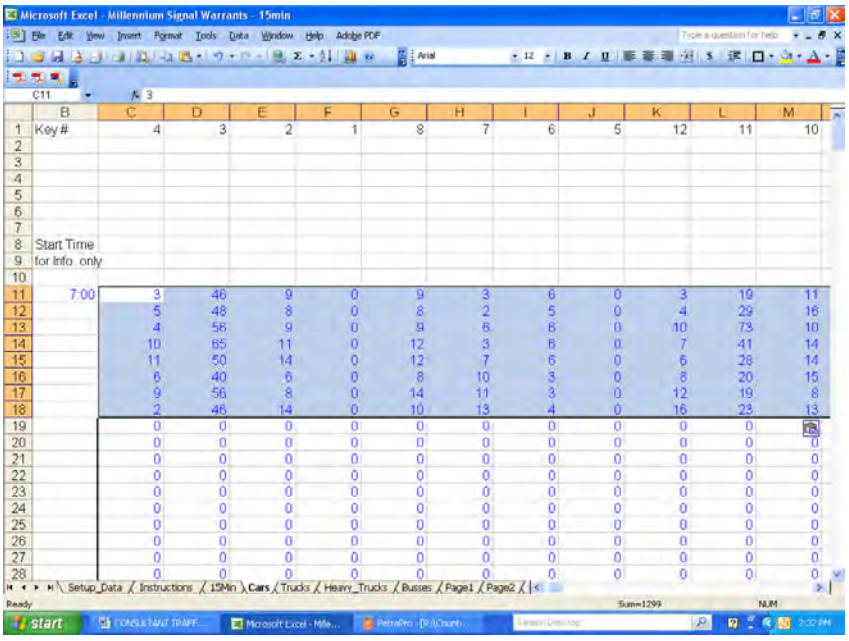
Petra and parts of the Traffic Count Investigation Survey will be used to enter data into the spreadsheet. Here is the procedure to follow step by step:

1. Have the matching Petra file and Traffic Count Investigation Survey open on the computer. Open the **15-Min Millenium Signal Warrant Analysis Spreadsheet**.
2. Save the spreadsheet as a separate project file.
3. The traffic volumes should be entered first. The **Cars** Tab should be selected first, which is located near the bottom of the Excel sheet.
4. Now, go to the Petra file. Making sure that the **Unshifted (Cars)** Tab is selected in Petra, select the beginning start time (ex: 7:00am) by pressing and holding the left mouse button. Still pressing the button, slide the mouse down until the last 15-minute interval of that section is highlighted (ex: If first count was from 7-9am, then select and highlight 07:00 to 08:45. This is because the last 15-minute interval starting time is at 8:45 and goes until 9:00.). Right-click the highlighted data and select **Copy** from the menu.

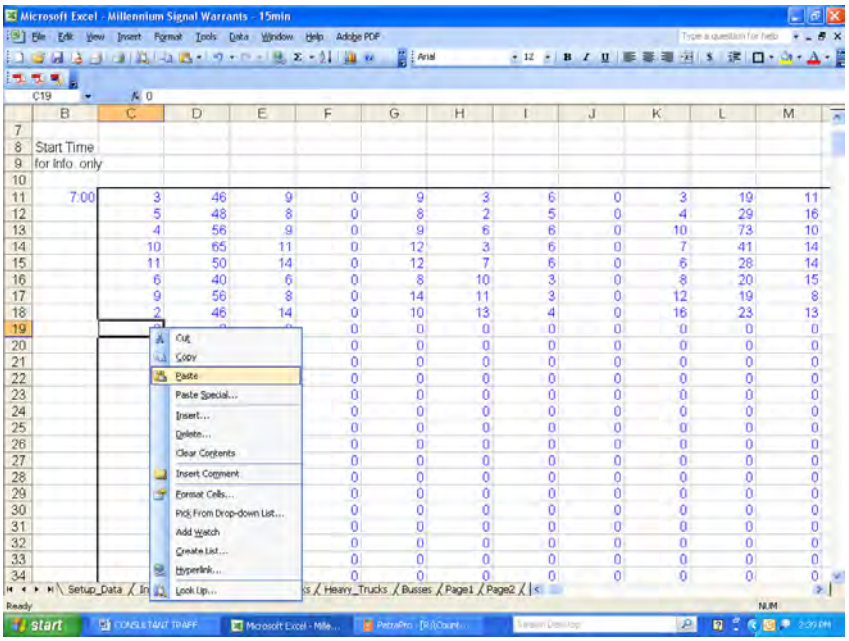


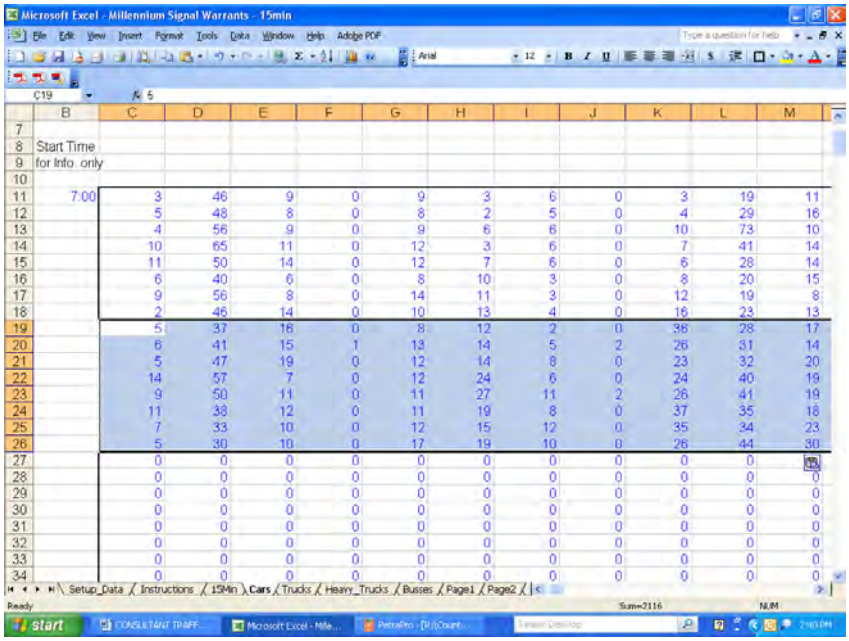
5. Now on the Millenium Signal Warrants-15min Spreadsheet in the **Cars** tab, Right-Click the C11 cell (directly next to 7:00 **regardless** if the interval copied starts at 7:00) and click **Paste**.





6. Then, the next increment of 15-minute intervals is put into the Spreadsheet. So once again, copy the increment in Petra (at whatever time the increment starts, ex: 11:00am to 12:45pm for the example). Then **Paste** it into the Spreadsheet directly underneath the last set of volumes (see example).





	B	C	D	E	F	G	H	I	J	K	L	M
7												
8	Start Time											
9	for Info. only											
10												
11	7:00	3	46	9	0	9	3	6	0	3	19	11
12		5	48	8	0	8	2	5	0	4	29	16
13		4	56	9	0	9	6	6	0	10	73	10
14		10	65	11	0	12	3	6	0	7	41	14
15		11	50	14	0	12	7	6	0	6	28	14
16		6	40	6	0	8	10	3	0	8	20	15
17		9	56	8	0	14	11	3	0	12	19	8
18		2	46	14	0	10	13	4	0	16	23	13
19		5	37	16	0	8	12	2	0	36	28	17
20		6	41	15	1	13	14	5	2	26	31	14
21		5	47	19	0	12	14	8	0	23	32	20
22		14	57	7	0	12	24	6	0	24	40	19
23		9	50	11	0	11	27	11	2	26	41	19
24		11	38	12	0	11	19	8	0	37	35	18
25		7	33	10	0	12	15	12	0	35	34	23
26		5	30	10	0	17	19	10	0	26	44	30
27		0	0	0	0	0	0	0	0	0	0	
28		0	0	0	0	0	0	0	0	0	0	0
29		0	0	0	0	0	0	0	0	0	0	0
30		0	0	0	0	0	0	0	0	0	0	0
31		0	0	0	0	0	0	0	0	0	0	0
32		0	0	0	0	0	0	0	0	0	0	0
33		0	0	0	0	0	0	0	0	0	0	0
34		0	0	0	0	0	0	0	0	0	0	0

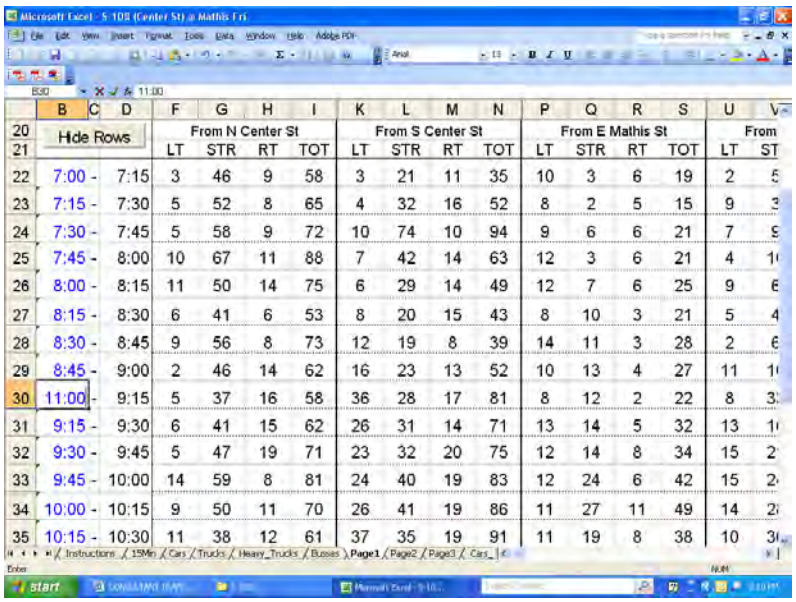
7. Then do the same if there is another increment of intervals. When finished, all increments of intervals should be directly below one another with no separation.

8. Now the truck volumes must be entered. Go to **Bank 1 (Trucks)** tab of Petra and click on the **Trucks** tab of the Spreadsheet. **DO NOT** use the **Heavy Trucks** tab, just use the **Trucks** tab. Repeat steps 3-6, making sure that the increments are back-to-back on the Millenium Signal Warrants-15min Spreadsheet and that no uncounted times are in between the increments in Excel.

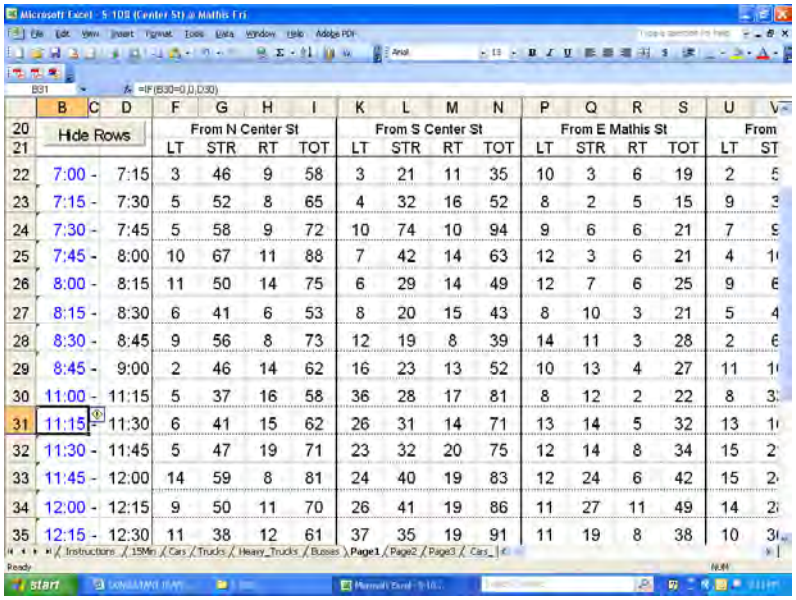
9. Now Repeat steps 3-6 filling in Bus volumes. Make sure that the data is copied out of the **Bank 2 (School Busses)** tab on Petra and pasted into the **Busses** tab of Excel.

10. All the traffic data should be entered into the spreadsheet. Next, enter the information regarding the intersection, most of this information will be on the traffic count investigation survey (except Intersection ADT) Go to **Page 1** tab in Excel and click on "Enter Here" next to "County". Type the county the count was done in. All the information in blue should be changed to provide information on the intersection, except the Intersection ADT. **It should have a calculated value, please DO NOT change this value.** Also the **Direction of Minor Street: N-S/E-W** is a drop down box. Simply click on the cell to get the menu and then select which one matches the intersection.

11. Once the intersection information is complete, the times need to change to reflect the times actually counted in Petra. As shown, the starting times run from 7:00 to 14:45. This will be changed by simply going down the column of blue starting times and manually changing the ones that are wrong. For instance, the first increment of starting times goes from 7:00 to 8:45, so those times stay the same. The next increment of starting times runs from 11:00 to 12:45. So the starting time directly after 8:45 (9:00) must be changed to 11:00 and after 12:45 change to 14:00 (for 2pm). Notice after hitting the Enter key, all starting times underneath change too.



			From N Center St				From S Center St				From E Mathis St				From
			LT	STR	RT	TOT	LT	STR	RT	TOT	LT	STR	RT	TOT	LT
22	7:00 -	7:15	3	46	9	58	3	21	11	35	10	3	6	19	2
23	7:15 -	7:30	5	52	8	65	4	32	16	52	8	2	5	15	9
24	7:30 -	7:45	5	58	9	72	10	74	10	94	9	6	6	21	7
25	7:45 -	8:00	10	67	11	88	7	42	14	63	12	3	6	21	4
26	8:00 -	8:15	11	50	14	75	6	29	14	49	12	7	6	25	9
27	8:15 -	8:30	6	41	6	53	8	20	15	43	8	10	3	21	5
28	8:30 -	8:45	9	56	8	73	12	19	8	39	14	11	3	28	2
29	8:45 -	9:00	2	46	14	62	16	23	13	52	10	13	4	27	11
30	11:00 -	9:15	5	37	16	58	36	28	17	81	8	12	2	22	8
31	9:15 -	9:30	6	41	15	62	26	31	14	71	13	14	5	32	13
32	9:30 -	9:45	5	47	19	71	23	32	20	75	12	14	8	34	15
33	9:45 -	10:00	14	59	8	81	24	40	19	83	12	24	6	42	15
34	10:00 -	10:15	9	50	11	70	26	41	19	86	11	27	11	49	14
35	10:15 -	10:30	11	38	12	61	37	35	19	91	11	19	8	38	10

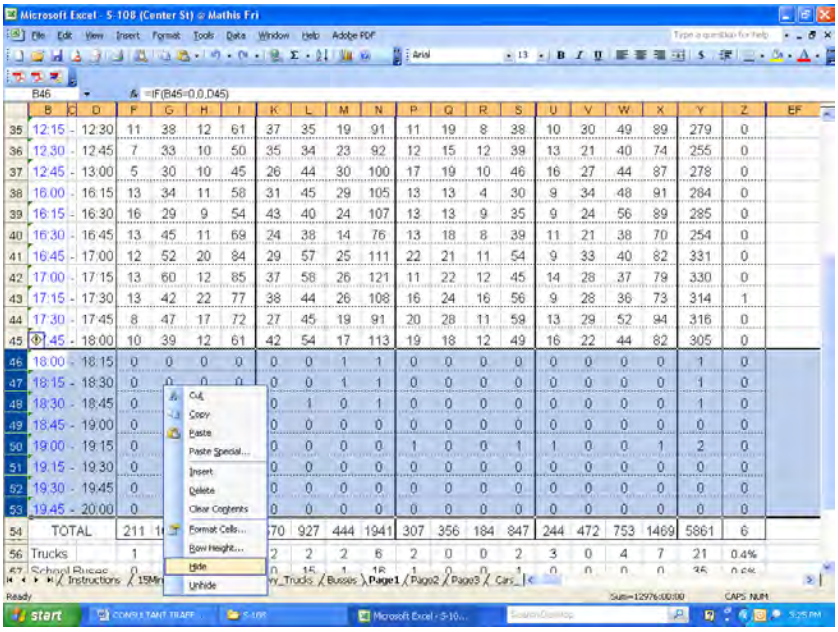


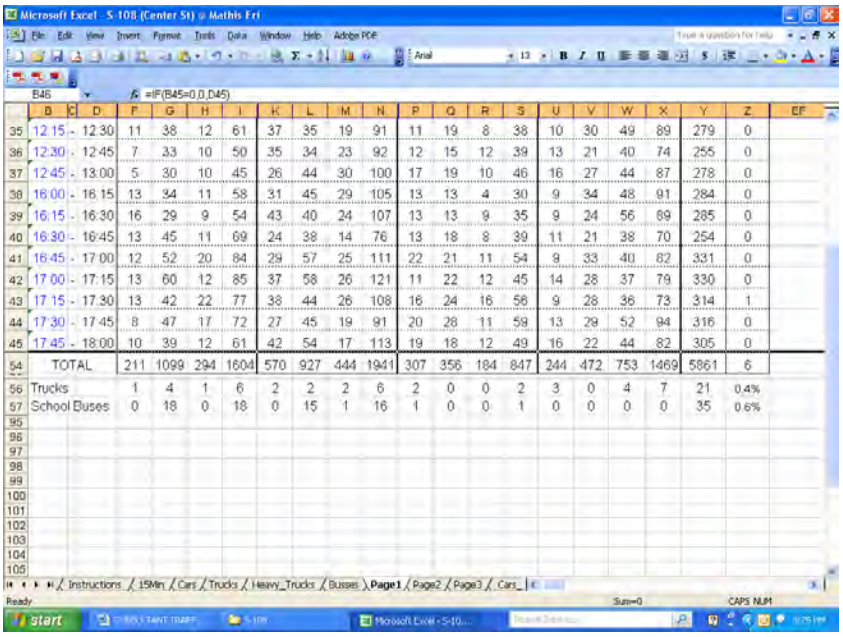
			From N Center St				From S Center St				From E Mathis St				From
			LT	STR	RT	TOT	LT	STR	RT	TOT	LT	STR	RT	TOT	LT
22	7:00 -	7:15	3	46	9	58	3	21	11	35	10	3	6	19	2
23	7:15 -	7:30	5	52	8	65	4	32	16	52	8	2	5	15	9
24	7:30 -	7:45	5	58	9	72	10	74	10	94	9	6	6	21	7
25	7:45 -	8:00	10	67	11	88	7	42	14	63	12	3	6	21	4
26	8:00 -	8:15	11	50	14	75	6	29	14	49	12	7	6	25	9
27	8:15 -	8:30	6	41	6	53	8	20	15	43	8	10	3	21	5
28	8:30 -	8:45	9	56	8	73	12	19	8	39	14	11	3	28	2
29	8:45 -	9:00	2	46	14	62	16	23	13	52	10	13	4	27	11
30	11:00 -	11:15	5	37	16	58	36	28	17	81	8	12	2	22	8
31	11:15 -	11:30	6	41	15	62	26	31	14	71	13	14	5	32	13
32	11:30 -	11:45	5	47	19	71	23	32	20	75	12	14	8	34	15
33	11:45 -	12:00	14	59	8	81	24	40	19	83	12	24	6	42	15
34	12:00 -	12:15	9	50	11	70	26	41	19	86	11	27	11	49	14
35	12:15 -	12:30	11	38	12	61	37	35	19	91	11	19	8	38	10

12. Then if there are more increments of starting times, those need to be changed as well, just continue down the page.

13. Now, the sheet needs to be Unprotected. Go to Tools, Protection, and Click Unprotect Sheet. This allows the user to do any changes to the Spreadsheet that had previously been Protected.

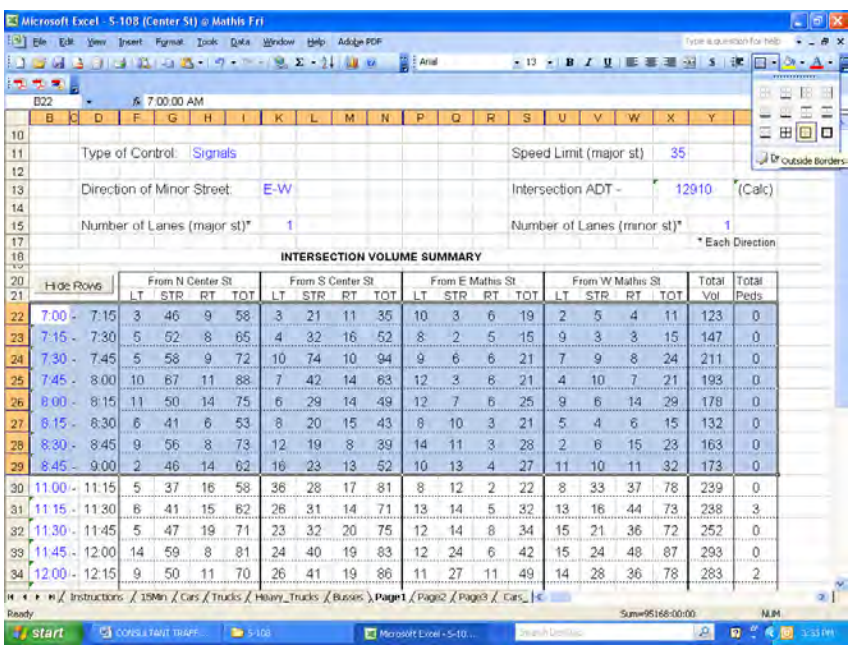
14. For 6 hour counts, there will be left-over rows that have all 0's for traffic volumes. Highlight the entire set of all 0 rows at the bottom and then Right-Click the highlighted area and then select Hide. This will hide the unneeded rows. DO NOT DELETE THESE ROWS. IT WILL CAUSE ALL ROWS UNDERNEATH THESE TO SHIFT UP AND REPLACE THOSE ROWS, WHICH WILL MISCALCULATE FORMULAS HIDDEN IN THESE SHEETS.





35	12:15 - 12:30	11	38	12	61	37	35	19	91	11	19	8	38	10	30	49	89	279	0				
36	12:30 - 12:45	7	33	10	50	35	34	23	92	12	15	12	39	13	21	40	74	255	0				
37	12:45 - 13:00	5	30	10	45	26	44	30	100	17	19	10	46	16	27	44	87	278	0				
38	16:00 - 16:15	13	34	11	58	31	45	29	105	13	13	4	30	9	34	48	91	284	0				
39	16:15 - 16:30	16	29	9	54	43	40	24	107	13	13	9	35	9	24	56	89	285	0				
40	16:30 - 16:45	13	45	11	69	24	38	14	76	13	18	8	39	11	21	38	70	254	0				
41	16:45 - 17:00	12	52	20	84	29	57	25	111	22	21	11	54	9	33	40	82	331	0				
42	17:00 - 17:15	13	60	12	85	37	58	26	121	11	22	12	45	14	28	37	79	330	0				
43	17:15 - 17:30	13	42	22	77	38	44	26	108	16	24	16	56	9	28	36	73	314	1				
44	17:30 - 17:45	8	47	17	72	27	45	19	91	20	28	11	59	13	29	52	94	316	0				
45	17:45 - 18:00	10	39	12	61	42	54	17	113	19	18	12	49	16	22	44	82	305	0				
54	TOTAL	211	1099	294	1604	570	927	444	1941	307	356	184	847	244	472	753	1469	5861	6				
56	Trucks	1	4	1	6	2	2	2	6	2	0	0	2	3	0	4	7	21	0.4%				
57	School Buses	0	18	0	18	0	15	1	16	1	0	0	1	0	0	0	0	35	0.6%				

15. The count duration increments should be separated by borders. Select the first increment of volumes including the times on the left side as shown below. Click on the triangle directly next to the **Borders** button. Select the **Outside Borders** button.

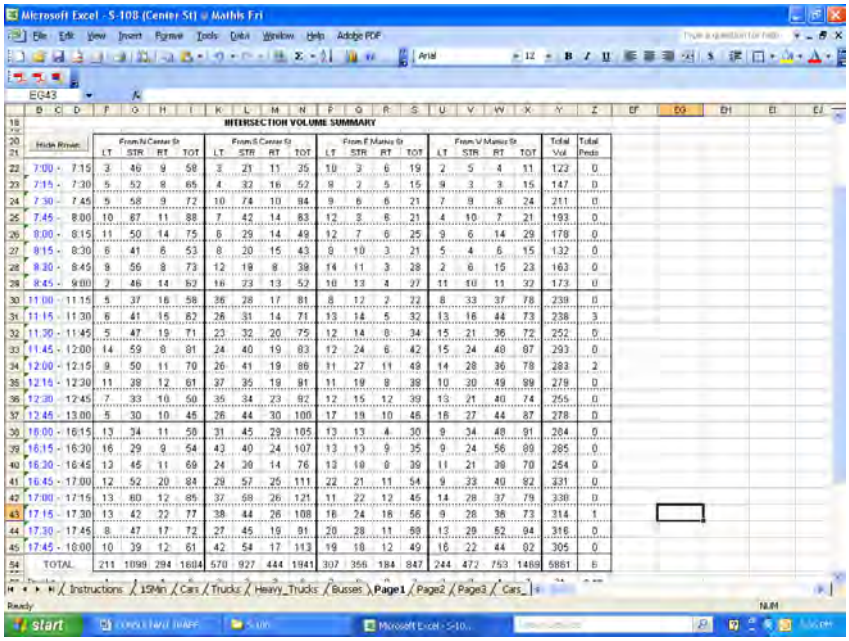


Type of Control: Signals
Speed Limit (major st): 35
Direction of Minor Street: E-W
Intersection ADT - 12910 (Calc)
Number of Lanes (major st)* 1
Number of Lanes (minor st)* 1
* Each Direction

INTERSECTION VOLUME SUMMARY

		From N Center St				From S Center St				From E Mathis St				From W Mathis St				Total	Total
		LT	STR	RT	TOT	LT	STR	RT	TOT	LT	STR	RT	TOT	LT	STR	RT	TOT	Vol	Peds
22	7:00 - 7:15	3	46	9	58	3	21	11	35	10	3	6	19	2	5	4	11	123	0
23	7:15 - 7:30	5	52	8	65	4	32	16	52	8	2	5	15	9	3	3	15	147	0
24	7:30 - 7:45	5	58	9	72	10	74	10	94	9	6	6	21	7	9	8	24	211	0
25	7:45 - 8:00	10	67	11	88	7	42	14	63	12	3	6	21	4	10	7	21	193	0
26	8:00 - 8:15	11	50	14	75	6	29	14	49	12	7	6	25	9	6	14	29	178	0
27	8:15 - 8:30	6	41	6	53	8	20	15	43	8	10	3	21	5	4	6	15	132	0
28	8:30 - 8:45	9	56	8	73	12	19	8	39	14	11	3	28	2	6	15	23	163	0
29	8:45 - 9:00	2	46	14	62	16	23	13	52	10	13	4	27	11	10	11	32	173	0
30	11:00 - 11:15	5	37	16	58	36	28	17	81	8	12	2	22	8	33	37	78	239	0
31	11:15 - 11:30	6	41	15	62	26	31	14	71	13	14	5	32	13	16	44	73	238	3
32	11:30 - 11:45	5	47	19	71	23	32	20	75	12	14	8	34	15	21	36	72	252	0
33	11:45 - 12:00	14	59	8	81	24	40	19	83	12	24	6	42	15	24	48	87	293	0
34	12:00 - 12:15	9	50	11	70	26	41	19	86	11	27	11	49	14	28	36	78	283	2

16. This should be repeated for all count durations of 15-minute intervals. See Example for completed table.



INTERSECTION VOLUME SUMMARY

		From N Center St				From S Center St				From E Mains St				From W Mains St				Total Vol	Total Peds
	Hide Rows:	LT	STR	RT	TOT	LT	STR	RT	TOT	LT	STR	RT	TOT	LT	STR	RT	TOT		
22	7:00 - 7:15	3	46	9	58	3	21	11	35	10	3	6	19	2	5	4	11	123	0
23	7:15 - 7:30	5	52	8	65	4	32	16	52	8	2	5	15	9	3	3	15	147	0
24	7:30 - 7:45	5	58	9	72	10	74	10	94	9	6	6	21	7	9	8	24	211	0
25	7:45 - 8:00	10	67	11	88	7	42	14	63	12	5	6	23	4	10	7	21	193	0
26	8:00 - 8:15	11	50	14	75	8	29	14	49	12	7	6	25	9	6	14	29	178	0
27	8:15 - 8:30	6	41	6	53	8	20	15	43	9	10	3	21	5	4	6	15	132	0
28	8:30 - 8:45	9	56	8	73	12	19	8	39	14	11	3	28	2	6	15	23	163	0
29	8:45 - 9:00	2	46	14	62	16	23	13	52	10	13	4	27	11	10	11	32	173	0
30	11:00 - 11:15	5	37	16	58	36	28	17	81	8	12	2	22	8	33	37	78	239	0
31	11:15 - 11:30	6	41	16	62	26	31	14	71	13	14	5	32	13	16	44	73	238	3
32	11:30 - 11:45	5	47	19	71	23	32	20	75	12	14	8	34	15	21	36	72	252	0
33	11:45 - 12:00	14	59	8	81	24	40	19	83	12	24	6	42	15	24	48	87	293	0
34	12:00 - 12:15	9	50	11	70	26	41	19	86	11	27	11	49	14	28	36	78	283	2
35	12:15 - 12:30	11	39	12	61	37	35	19	91	11	19	8	38	10	30	49	89	279	0
36	12:30 - 12:45	7	33	10	50	35	34	23	92	12	15	12	39	13	21	40	74	255	0
37	12:45 - 13:00	5	30	10	45	26	44	30	100	17	19	10	46	16	27	44	87	278	0
38	16:00 - 16:15	13	34	11	58	31	45	29	105	13	13	4	30	9	34	48	91	284	0
39	16:15 - 16:30	16	29	9	54	43	40	24	107	13	13	9	35	9	24	56	89	285	0
40	16:30 - 16:45	13	45	11	69	24	30	14	76	13	10	8	39	11	21	38	70	254	0
41	16:45 - 17:00	12	52	20	84	29	57	25	111	22	21	11	54	9	33	40	82	331	0
42	17:00 - 17:15	13	60	12	85	37	59	26	121	11	22	12	46	14	28	37	79	336	0
43	17:15 - 17:30	13	42	22	77	38	44	26	108	16	24	16	56	9	28	36	73	314	1
44	17:30 - 17:45	8	47	17	72	27	45	19	91	20	28	11	58	13	29	52	94	316	0
45	17:45 - 18:00	10	39	12	61	42	54	17	113	19	18	12	49	16	22	44	82	305	0
54	TOTAL	211	1099	294	1604	570	927	444	1941	307	356	184	847	244	472	753	1469	5861	6

17. The Spreadsheet should be complete. Check over the data. Make sure that the Column width is wide enough for the totals at the bottom of the table. Sometimes #### will show up instead of numbers. Extend the column by double clicking on the column letter directly above. Check **Page 2** tab to see if there are any #### as well.

18. Save the spreadsheet. To print the required hardcopies, Go to **Page 1** tab, hold down the **Ctrl** key and select **Page 2** tab and **Page 3** tab. Each page should print as one.

CH. 7 SUBMITTING THE COUNT

The SCDOT Signals & Signal Systems Office will need electronic files of Petra and Millenium Signal Warrants-15min Spreadsheet. It is also okay to include the electronic files, such as a diagram, the Traffic Count Investigation Survey, or any other useful information.

After the files are reviewed and made sure to be 100% complete, an email will be sent back to the consultant asking to send the Invoice and hardcopies.

CH. 8 SUBMITTING THE INVOICE

The Invoice should include the following information:

1. The Consultant's information.
2. The Invoice should be on official letterhead of the business.
3. The person's name who requested the count.
4. Charge Code provided to the consultant.
5. The county where the work was completed.
6. Separation of the different types of counts completed (The number of counts, the amount of people counting per location, and the time of the count). For example, Consultant A completed ten different counts. The consultant did (4) 2-person 4-hour counts, (4) 1-person 4-hour counts, and (2) 1-person 2-hour counts. Obviously this is for totaling purposes on the invoice.
7. Make sure that the total is provided at the bottom of the Invoice.

CH. 9 THE FINAL REPORT

The following hard copies are to be sent for the final:

1. Millenium Signal Warrants-15min Spreadsheet – The only parts of the spreadsheet that should be sent are **Page 1**, **Page 2**, and **Page 3** tabs. Refer to Ch. 6 FROM PETRA TO EXCEL.
2. Traffic Signal Investigation Worksheet
3. Diagrams or Drawings
4. The Invoice

TRAFFIC SIGNAL INVESTIGATION SURVEY

COUNTY:_____ DATE:_____

LOCATION:_____

REQUESTED BY:_____

SPECIFIC REQUEST:_____

POTENTIAL PROBLEM: _____

_____

DATE LAST REVIEWED:_____ACTION TAKEN:_____

_____

FIELD OR FILE REVIEW: _____IF FIELD, TIME OF DAY:_____

REVIEWED BY:_____

SIGNALIZED INTERSECTION DIAGRAM **(SEE ATTACHED DIAGRAM, PAGE 3)**

CURRENT TRAFFIC CONTROL DEVICE: _____

1. Are any traffic movements encountering problems?_____
2. Can motorists on the side street cross unimpeded? (Offsets, Tight radii, Rutting, etc?) _____

   _____
3. What are speed limits on both routes? _____

   Are they being observed and appropriate? _____
4. What are approach grades (approximate)? _____
5. Describe pedestrian activity. (Include pedestrian type - children, adults, senior citizens, handicapped, bicyclists)_____
6. Are there sporadic large influxes of vehicles (such as shift workers exiting an industrial plant) at the signal? _____

   If yes, describe conditions._____

   _____
7. If there is a large percentage of trucks, buses or other large vehicles, do conditions exist that restrict their movements?_____

   _____
8. Does parking affect traffic flow? Are there violations of parking or other traffic regulations? ___

   _____
9. Are there driveways that adversely affect operations?_____

   _____
10. Are skid marks and/or debris present that show evidence of a recent accident? _____

    _____

11. Describe condition of pavement markings. _____
12. Describe condition of signs. _____
13. Describe turning radii. _____
14. Are turn lanes available? _____
15. Is channelization (painted or raised islands) adequate for reducing conflict areas? Separating traffic flows? Defining movements? _____
16. Do sight obstructions exist at stop bar locations? ☐ Yes ☐ No If yes, what would be required to improve conditions? _____
17. Do sight obstructions exist along approaches to intersection? ☐ Yes ☐ No If yes, is appropriate advance warning given, and what type of warning device used? _____
18. Is signal design appropriate? _____
19. If signalization is recommended, what types of improvements would be needed prior to signal installation? _____

IF SIGNAL IS EXISTING:

20. Are loops functioning for each phase?_____ If not, which approaches are not operating Correctly? _____
21. Is traffic clearing on each approach during each phase? _____ If not, provide time of day and number of vehicles?_____
22. Were there any interruptions in traffic patterns during the count period such as wrecks, funerals, etc?___ _____
23. Observe and record signal timings (GYR) for each phase if it approachs max timings for comparison to signal plan.
    NB_____
    SB _____
    EB _____
    WB_____
24. Provide maximum queue lengths observed during peak hour and note which approaches experience the the greatest delays and conflicts:
    NB_____
    SB _____
    EB _____
    WB_____

NAME OF ANALYST: _____

SUMMARY ANALYSIS: _____

_____

_____

OPTIONS FOR SOLUTIONS: _____

_____

_____

PROFESSIONAL STANDARDS APPLIED: _____

FINAL DECISION MADE: _____

_____

SIGNALIZED INTERSECTION DIAGRAM

Ensure that the information below is included on the sketch or the signal plan (preferred) if available:

*** SHOW 400' OF EACH APPROACH**

1. **Street name and number**
2. **Use or type of business in each quadrant**
3. **Lane configurations, usage and widths***
4. **Signs (1000' in advance) and Pavement markings***
5. **Location of driveways near the intersection***
6. **Signal head configuration and location (Left or right turn heads, # of sections etc.)**
7. **Provide North arrow and location/direction of vehicle and/or count board during count.**
8. **Corner Radii**
9. **Location of Utilities**
10. **What quadrant is best location for controller/cabinet, based on transformer location and accessibility for maintenance operations?**
11. **Loop placement is based on speed limits or prevailing speed**
12. **What is best way to connect set back loops to cabinet, overhead or underground?**

INTERSECTION INVENTORY (For Field Review or Estimating Quantities)

Date: _____ Main Street: _____
District: _____ Side Street: _____
County: _____ Review done by: _____

1 SIGNAL HEADS: R.Y.G. | Ra.Ya.Ga. | Ra.Ra.Ya.Ga. | R.Y.G.Ya.Ga (RT)
R.Y.G.Ga | Other | R.Y.G.Ya.Ga (LT)

2 BACKPLATES: 3-section | 4-section | 5-section | other

3 OVERHEAD SIGNS:
(Left Arrow) Only
(Right Arrow) Only
(Through and Right Arrow) Only
Left Turn Yield on Green (Ball)
No Turn on Red
Other (_____)

4 LOOP DETECTOR AMPLIFIER: NEW | EXIST | TOTAL

5 3/8" SPANWIRE:

6 1/4" MESSENGER WIRE (TETHER):

7 SAWCUT:

8 LOOP WIRE (1 COND):

9 JUMPER (4 COND BLACK):

PED SIGNAL HEAD (4 COND BLACK): TOTAL

10 LOOP LEAD-IN(4 COND GRAY):

PED PUSH BUTTON (4 COND GREY): TOTAL

11 SIGNAL WIRE(8 COND BLACK):

12 LOOP LEAD-IN(8 COND GRAY):

13 PED SIGNAL HEADS:

BRACKETS: POLE SIDE | POST TOP

14 PED PUSH BUTTONS W/SIGNS:

15 13" x 28' STEEL POLE: STANDARD | CONTROLLER

16 13" x 32' STEEL POLE: STANDARD | CONTROLLER

17 WOOD POLE: 35' | 40' | 45'

18 40' CONC POLE: 40' | 45' | 50'

19 BACKGUY: STANDARD | SIDEWALK | AERIAL

20 1" PVC: TRENCH | RISER | TOTAL

21 2" PVC: TRENCH | RISER | TOTAL

22 3" PVC: TRENCH | RISER | TOTAL

23 1" STEEL: TRENCH | RISER

24 2" STEEL: TRENCH | RISER

25 ELECTRICAL SERVICE: O.H. | U.G.

SCDOT Synchro v7 Defaults

OPTIONS

Map setting
Intersection paths on

Network Settings

Peak Hour Factor – 0.90
Yellow – 4 sec
Red – 2 sec
Offset style – Begin of Yellow
Min split through – 22 sec
Min split left – 15 sec
Simulation taper length – 100 ft
Crosswalk width – 10 ft
Uncheck lead/lag optimize
Actuated uncord

Detector Templates

Left – Det1 50, size 30
Thru – Det1 255, Det2 385
Generally for side streets, use loops at stop bar
(leading to 0)

Edit template phases – 2 SB, 4 WB

Simtraffic

Intervals and volumes
Seed 10 min*, record 60 or record 4 15-min intervals
** for large networks seeding should cover saturating network*

Place file named defaults.syn in the trafficware directory where Synchro is installed

Signals and Signal System Design

Inside tips for Signal System Design

By:
SCDOT – Traffic Engineering
Signals and Signal System Staff

<u>Includes:</u>
Synchro Tips
LOS, V/C Ratio, and Intersection Delay Report

Synchro 7 - C:\Docume...on Road Signal System\ClemsonRoadSat70_Original.syn

File Edit Transfer Options Optimize Help

2 Clemson Road & Rhame Road

LANE SETTINGS	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
Lanes and Sharing (#RL)													# AND TYPE OF LANES
Traffic Volume (vph)	81	971	352	27	1036	200	470	241	32	180	172	90	FROM COUNTS FOR PEAK HOUR
Street Name	—	Clemson F	—	—	Clemson F	—	—	North Spr	—	—	Rhame R	—	NAME OF APPROACH
Link Distance (ft)	—	1300	—	—	1057	—	—	783	—	—	887	—	
Link Speed (mph)	—	45	—	—	45	—	—	35	—	—	35	—	POSTED SPEED IN FIELD
Set Arterial Name and Speed	—	EB	—	—	WB	—	—	NB	—	—	SB	—	
Travel Time (s)	—	19.7	—	—	16.0	—	—	15.3	—	—	17.3	—	
Ideal Satd. Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	
Lane Width (ft)	12	12	12	12	12	12	12	12	12	12	12	12	
Grade (%)	—	0	—	—	0	—	—	0	—	—	0	—	
Area Type CBD	—	☐	—	—	☐	—	—	☐	—	—	☐	—	
Storage Length (ft)	350	—	300	215	—	0	200	—	0	0	—	0	MEASURED IN FIELD
Storage Lanes (#)	1	—	0	1	—	—	1	—	—	—	—	—	AUTOMATICALLY INPUT FROM FIRST LINE
Right Turn Channelized	—	—	None	—	—	None	—	—	None	—	—	None	IS RIGHT TURN CHANNELIZED W/ PAINT
Curb Radius (ft)	—	—	—	—	—	—	—	—	—	—	—	—	OR MEDIAN (STOP, YIELD, FREE, OR NONE)
Add Lanes (#)	—	—	—	—	—	—	—	—	—	—	—	—	
Lane Utilization Factor	1.00	0.95	—	1.00	0.95	—	1.00	1.00	—	1.00	1.00	—	
Right Turn Factor	1.000	0.960	—	1.000	0.976	—	1.000	0.982	—	1.000	0.948	—	
Left Turn Factor (prot)	0.950	1.000	—	0.950	1.000	—	0.950	1.000	—	0.950	1.000	—	
Saturated Flow Rate (prot)	1787	3431	—	1787	3488	—	1787	1847	—	1787	1783	—	
Left Turn Factor (perm)	0.188	1.000	—	0.261	1.000	—	0.431	1.000	—	0.415	1.000	—	
Right Ped Bike Factor	1.000	1.000	—	1.000	1.000	—	1.000	1.000	—	1.000	1.000	—	
Left Ped Factor	1.000	1.000	—	1.000	1.000	—	1.000	1.000	—	1.000	1.000	—	
Saturated Flow Rate (perm)	354	3431	—	491	3488	—	811	1847	—	781	1783	—	
Right Turn on Red?	—	—	☑	—	—	☑	—	—	☑	—	—	☑	
Saturated Flow Rate (RTOR)	0	72	—	0	26	—	0	11	—	0	42	—	

Number of lanes and sharing (0 to 8, L, R)

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2 Clemson Road & Rhame Road

VOLUME SETTINGS	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lanes and Sharing (#RL)												
Traffic Volume (vph)	81	971	352	27	1036	200	470	241	32	180	172	90
Conflicting Peds. (#/hr)	0	—	0	0	—	0	0	—	0	0	—	0
Conflicting Bicycles (#/hr)	—	—	0	—	—	0	—	—	0	—	—	0
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Growth Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Heavy Vehicles (%)	1	1	1	1	1	1	1	1	1	1	1	1
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Adj. Parking Lane?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Parking Maneuvers (#/hr)	—	—	—	—	—	—	—	—	—	—	—	—
Traffic from mid-block (%)	—	0	—	—	0	—	—	0	—	—	0	—
Link OD Volumes	—	EB	—	—	WB	—	—	—	—	—	—	—
Adjusted Flow (vph)	89	1067	387	30	1138	220	516	265	35	198	189	99
Traffic in shared lane (%)	—	—	—	—	—	—	—	—	—	—	—	—
Lane Group Flow (vph)	89	1454	0	30	1358	0	516	300	0	198	288	0

FOOM COUNT PHF = $\frac{\text{TOTAL VOL. FOR PEAK HR}}{4 \times \text{PEAK 15 MIN}}$

Clemson Road & Rhame Road (9455 11327)

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2 Clemson Road & Rhame Road

NODE SETTINGS	
Node #	2
Zone:	
X East (ft):	9455
Y North (ft):	11327
Z Elevation (ft):	0
Description	
Control Type	Actd-Coord
Cycle Length (s):	70.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle(s):	70.0
Natural Cycle(s):	120.0
Max v/c Ratio:	1.61
Intersection Delay (s):	144.0
Intersection LOS:	F
ICU:	1.02
ICU LOS:	G
Offset (s):	22.0
Referenced to:	Begin of Yellow
Reference Phase:	2+6 - EBTL WBTL
Master Intersection:	☐
Yield Point:	Single

TIMING SETTINGS	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lanes and Sharing (#RL)											
Traffic Volume (vph)	81	971	352	27	1036	200	470	241	32	180	172
Turn Type	pm+pt	—	—	Perm	—	—	pm+pt	—	—	pm+pt	—
Protected Phases	5	2	—		6	—	3	8	—	7	4
Permitted Phases	2		—	6		—	8		—	4	
Detector Phases	5	2	—	6	6	—	3	8	—	7	4
Switch Phase	0	0	—	0	0	—	0	0	—	0	0
Leading Detector (ft)	20	100	—	20	100	—	20	100	—	20	100
Trailing Detector (ft)	0	0	—	0	0	—	0	0	—	0	0
Minimum Initial (s)	4.0	4.0	—	4.0	4.0	—	4.0	4.0	—	4.0	4.0
Minimum Split (s)	10.0	22.2	—	22.2	22.2	—	10.0	22.1	—	10.0	22.1
Total Split (s)	11.0	25.0	—	14.0	14.0	—	14.0	31.0	—	14.0	31.0
Yellow Time (s)	4.0	4.0	—	4.0	4.0	—	4.0	4.0	—	4.0	4.0
All-Red Time (s)	2.0	2.2	—	2.2	2.2	—	2.0	2.1	—	2.0	2.1
Lost Time Adjust (s)	0.0	0.0	—	0.0	0.0	—	0.0	0.0	—	0.0	0.0
Lagging Phase?	☐	—	—	☑	☑	—	☐	☑	—	☐	☑
Allow Lead/Lag Optimize?	☐	—	—	☐	☐	—	☐	☐	—	☐	☐
Recall Mode	None	C-Max	—	C-Max	C-Max	—	None	Min	—	None	Min
Actuated Effct. Green (s)	27.8	27.6	—	16.6	16.6	—	24.4	16.3	—	24.1	16.1
Actuated g/C Ratio	0.40	0.39	—	0.24	0.24	—	0.35	0.23	—	0.34	0.23
Volume to Capacity Ratio	0.31	1.04	—	0.26	1.61	—	1.31	0.68	—	0.52	0.65
Control Delay (s)	18.5	58.7	—	35.3	301.0	—	178.1	31.3	—	17.2	27.0
Queue Delay (s)	0.0	0.0	—	0.0	0.0	—	0.0	0.0	—	0.0	0.0
Total Delay (s)	18.5	58.7	—	35.3	301.0	—	178.1	31.3	—	17.2	27.0

TYPE OF PHASING CHECK TO MAKE SURE PHASING IS CORRECT DIRECTION ON SIGNAL PLAN AND SCDOT STANDARD

GREEN + YELLOW + RED FROM TIMING SHEETS

FROM TIMING SHEETS

FOR LAGGING LEFT

*LEAVE BLANK UNLESS DETERMINED BY WHERE LOOPS ARE AND WHAT IS ON PLAN. TYPICALLY MIN FOR MAIN ST AND NONE ON SIDE ROADS

v/c > 1 Min Err

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*LEAVE LEAD/LAG OPTIMIZED BLANK UNLESS YOU WANT TO CONSIDER LAGGING LEFTS

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2 Clemson Road & Rhame Road

NODE SETTINGS	
Node #	2
Zone:	
X East (ft):	9455
Y North (ft):	11327
Z Elevation (ft):	0
Description	
Control Type	Actd-Coord
Cycle Length (s):	70.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle 90th (s):	70.0
Actuated Cycle 70th (s):	70.0
Actuated Cycle 50th (s):	70.0
Actuated Cycle 30th (s):	70.0
Actuated Cycle 10th (s):	70.0
Natural Cycle(s):	120.0
Max v/c Ratio:	1.61
Intersection Delay (s):	144.0
Intersection LOS:	F
ICU:	1.02
ICU LOS:	G
Offset (s) :	22.0
Referenced to:	Begin of Yellow
Reference Phase:	2+6 - EBTL WBTL
Master Intersection:	☐
Yield Point:	Single

PHASING SETTINGS	2-EBTL	3-NBL	4-SBTL	5-EBL	6-WBTL	7-SBL	8-NBTL
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Minimum Split (s)	22.2	10.0	22.1	10.0	22.2	10.0	22.1
Maximum Split (s)	25.0	14.0	31.0	11.0	14.0	14.0	31.0
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	2.2	2.0	2.1	2.0	2.2	2.0	2.1
Lagging Phase?	—	☐	☑	☐	☑	☐	☑
Allow Lead/Lag Optimize?	—	☐	☐	☐	☐	☐	☐
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Minimum Gap (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Time Before Reduce (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Time To Reduce (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Recall Mode	C-Max	None	Min	None	C-Max	None	Min
Pedestrian Phase	☑	☐	☑	☐	☑	☐	☑
Walk Time (s)	5.0	—	5.0	—	5.0	—	5.0
Flash Dont Walk (s)	11.0	—	11.0	—	11.0	—	11.0
Pedestrian Calls (#/hr)	0	—	0	—	0	—	0
Dual Entry?	☑	☐	☑	☐	☑	☐	☑
Inhibit Max?	☑	☑	☑	☑	☑	☑	☑
90th %ile Green Time (s)	22 cd	8 mx	22 hd	8 mx	8 cd	8 mx	22 gp
70th %ile Green Time (s)	25 cd	8 mx	19 hd	9 gp	10 cd	8 mx	19 gp
50th %ile Green Time (s)	27 cd	8 mx	16 hd	8 gp	14 cd	8 mx	16 gp
30th %ile Green Time (s)	30 cd	8 mx	14 hd	7 gp	17 cd	8 mx	14 gp
10th %ile Green Time (s)	34 cd	8 mx	10 hd	0 sk	34 cd	7 gp	10 gp

SYNCHRO AUTOMATICALLY CALCULATES FOR YOU. IF YOU WANT TO CHANGE TO LOWER VALUE YOU WILL NEED TO CHANGE YOUR WALK AND DONT WALK TIME

LEAVE BLANK UNLESS HIGH PEDESTRIAN VOL

7 SEC. MINIMUM

DISTANCE ACROSS INTERSECTION DIVIDED BY 3.5 FT/SEC

Clemson Road & Rhame Road (9455 11327)

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Document1 - Microsoft Word

TYPICALLY I DO NOT CHANGE ANYTHING ON THIS PAGE, BUT IN SPECIAL CASES YOU MAY NEED TO

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2 Clemson Road & Rhame Road

SIMULATION SETTINGS	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
Lanes and Sharing (#RL)													
Traffic Volume (vph)	81	971	352	27	1036	200	470	241	32	180	172	90	
Storage Length (ft)	350	—	300	215	—	0	200	—	0	0	—	0	
Storage Lanes (#)	1	—	0	1	—	—	1	—	—	—	—	—	
Taper Length (ft)	25	—	25	25	—	—	25	—	—	—	—	—	MEASURED IN FIELD
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right	
Lane Width (ft)	12	12	12	12	12	12	12	12	12	12	12	12	MEASURED IN FIELD
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No	
Median Width (ft)	—	12	—	—	12	—	—	12	—	—	12	—	
Link Offset (ft)	—	0	—	—	0	—	—	0	—	—	0	—	
Crosswalk Width (ft)	—	16	—	—	16	—	—	16	—	—	16	—	MEASURED IN FIELD
TWLTL Median	—	☐	—	—	☐	—	—	☐	—	—	☐	—	THIS WAY LEFT TURN LANE, CHECK IF YES
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Turning Speed (mph)	15	—	9	15	—	9	15	—	9	15	—	9	MAY CHANGE IF THIS IS REFLECTED IN FIELD
Mandatory Distance (ft)	—	291	—	—	291	—	—	291	—	—	291	—	
Positioning Distance (ft)	—	1980	—	—	1980	—	—	1539	—	—	1539	—	
Mandatory Distance 2 (ft)	—	1320	—	—	1320	—	—	1026	—	—	1026	—	
Positioning Distance 2 (ft)	—	2640	—	—	2640	—	—	2052	—	—	2052	—	

Clemson Road & Rhame Road (9455 11327)

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2 Clemson Road & Rhame Road

DETECTOR SETTINGS	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lanes and Sharing (#RL)								
Traffic Volume (vph)	81	971	27	1036	470	241	180	172
Number of Detectors (#)	1	2	1	2	1	2	1	2
Detector Phases	5	2	6	6	3	8	7	4
Switch Phase	0	0	0	0	0	0	0	0
Leading Detector (ft)	20	100	20	100	20	100	20	100
Trailing Detector (ft)	0	0	0	0	0	0	0	0
* Detector Template	Left	Thru	Left	Thru	Left	Thru	Left	Thru
Add/Update Template								
Detector 1 Position (ft)	0	0	0	0	0	0	0	0
Detector 1 Size (ft)	20	6	20	6	20	6	20	6
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex
Detector 1 Channels								
Detector 1 Extend	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Detector 1 Queue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Detector 1 Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Detector 2 Position (ft)	—	94	—	94	—	94	—	94
Detector 2 Size (ft)	—	6	—	6	—	6	—	6
Detector 2 Type	—	Cl+Ex	—	Cl+Ex	—	Cl+Ex	—	Cl+Ex
Detector 2 Channels	—		—		—		—	
Detector 2 Extend	—	0.0	—	0.0	—	0.0	—	0.0

SHOWN ON PLAN OR SEEN IN FIELD

(LIKE A QUAD LEFT TURN LOOP)

IF YOU HAVE A DETECTOR THAT IS 6'X30' AND IS PLACED 50' BACK FROM THE STOP LINE THEN THE LEADING DETECTOR VALUE SHOULD BE 80 B/C 30+50=80. THE TRAILING DETECTOR VALUE SHOULD BE 50

DISTANCE FROM STOP LINE. IN ABOVE EXAMPLE THIS VALUE WOULD BE 50

LENGTH OF DETECTOR LOOP

IF YOU HAVE TWO DETECTORS THAT ARE SET BACK LOOPS LOCATED 255' AND 325' FROM STOP BAR THEN THE VALUES FOR THE LEADING DETECTOR WOULD BE 331 (325+6=331), TRAILING DETECTOR WOULD BE 255, DETECTOR 1 POSITION = 255, DETECTOR 1 SIZE = 6, DETECTOR 2 POSITION = 325, AND DETECTOR 2 SIZE = 6

* IT IS POSSIBLE TO CREATE YOUR OWN TEMPLATE FOR DETECTORS OR YOU CAN USE THE STANDARD TEMPLATES SYNCHRO HAS. TYPICALLY, I WOULD CHANGE THIS TO NONE.

Clemson Road & Rhame Road (9455 11327)

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Creating LOS, V/C Ratio, and Intersection Delay Report

From Synchro-

Follow instructions below to create data report for each of the following timing files:

AM Original	Mid Original	PM Original
AM Cycle 1	Mid Cycle 1	PM Cycle 1
AM Cycle 2	Mid Cycle 2	PM Cycle 2
AM Cycle 3	Mid Cycle 3	PM Cycle 3

1. Click on the **Create Report** icon.
2. Highlight first Report ***Int: Lanes, Volumes, Timings.***
3. Highlight each item in **Data To Include.**
4. Unhighlight ***Skip Unused Items.***
5. Click **Save Text** button and save the file.

In Excel Workbook-

On the **Info** Worksheet:

Enter County Name
Enter County Number
Enter the Name of the Signal System
Enter the Major Street
Enter each of the Minor Streets
Enter File Location
Enter Designed by
Enter Date Submitted

Follow instructions below for each of the text files created above:

1. Go to worksheet AMOrig and select cell D1.
2. **Data» Import External Data» Import Data**. Select AM Original text file.
3. Make sure **Delimited** is selected for Original data type, Start import at row: **1**, File origin **437 : OEM United States**. **Next**.
4. Make sure **Tab Delimiters** is selected Text qualifier: **“**. **Next**.
5. Make sure Column data format is **General**. **Finish**.
6. Put data in the **Existing worksheet: =D1**. **OK**
7. Highlight first 3 columns.
8. **Edit» Copy**
9. **Edit» Paste Special»** Select **Values.**
10. Select entire worksheet.
11. **Data» Sort»** Sort By **Column A** in **Ascending Order**. **OK**

Report should be complete on the **LOS,VCRatio,IntDelay** worksheet.

Lexington (32) - Bush River Rd

AM

	LOS				Mx V/C Ratio				Intersection Delay			
	Original	Cyce1	Cycle2	Cycle3	Original	Cyce1	Cycle2	Cycle3	Original	Cyce1	Cycle2	Cycle3
Bush River Road @	90	90	100	110	90	90	100	110	90	90	100	110
Outlet Point Blvd	C	C	C	B	0.74	0.86	0.78	0.78	25.7	22.9	21.3	19.7
Berryhill Rd	D	B	B	B	1.15	1.15	1.32	1.38	36.7	13.7	14.1	15.3
I-20 WB Ramp	B	C	C	C	1.15	1.15	1.32	1.38	19.7	30.1	26.3	21.8
I-20 EB Ramp	C	B	B	B	1.08	0.86	0.83	0.82	29.3	14.8	15.8	17.7
Independence Blvd	C	A	A	A	0.87	0.71	0.67	0.65	21.3	7.6	6.7	6.6

Average

	LOS				Mx V/C Ratio				Intersection Delay			
	Original	Cyce1	Cycle2	Cycle3	Original	Cyce1	Cycle2	Cycle3	Original	Cyce1	Cycle2	Cycle3
Bush River Road @	90	90	100	110	90	90	100	110	90	90	100	110
Outlet Point Blvd	B	B	B	B	0.61	0.61	0.59	0.57	19.1	14.6	14.6	13.6
Berryhill Rd	B	B	A	B	0.98	0.70	0.59	0.56	19.5	10.3	9.8	11.1
I-20 WB Ramp	B	B	B	B	0.98	0.70	0.59	0.56	18.6	13.6	13.5	13.6
I-20 EB Ramp	A	A	A	A	0.46	0.42	0.57	0.54	8.3	6.6	5.4	5.6
Independence Blvd	B	A	B	B	0.49	0.43	0.72	0.62	11.7	8.1	17.0	14.9

PM

	LOS				Mx V/C Ratio				Intersection Delay			
	Original	Cyce1	Cycle2	Cycle3	Original	Cyce1	Cycle2	Cycle3	Original	Cyce1	Cycle2	Cycle3
Bush River Road @	90	80	90	100	90	80	90	100	90	80	90	100
Outlet Point Blvd	B	B	B	B	0.58	0.59	0.58	0.56	13.2	14.2	13.8	16.2
Berryhill Rd	D	B	B	B	1.06	0.94	0.94	0.91	46.7	11.8	13.3	14.9
I-20 WB Ramp	C	C	C	D	1.06	0.94	0.94	0.91	27.5	28.4	33.0	42.2
I-20 EB Ramp	C	A	B	B	0.84	0.78	0.76	0.75	22.9	9.6	10.7	11.5
Independence Blvd	B	B	B	A	0.72	0.63	0.61	0.57	15.7	11.8	10.1	8.0

Other

	LOS				Mx V/C Ratio				Intersection Delay			
	Original	Cyce1	Cycle2	Cycle3	Original	Cyce1	Cycle2	Cycle3	Original	Cyce1	Cycle2	Cycle3
Bush River Road @	90	80	90	100	90	80	90	100	90	80	90	100
Outlet Point Blvd	B	B	B	B	0.52	0.53	0.51	0.50	13.2	14.1	12.9	13.9
Berryhill Rd	C	A	A	A	0.75	0.63	0.62	0.64	22.1	6.3	6.8	6.0
I-20 WB Ramp	C	B	B	B	0.75	0.63	0.62	0.64	22.6	11.6	11.5	13.5
I-20 EB Ramp	A	A	A	A	0.45	0.42	0.42	0.56	9.7	7.7	8.7	5.3
Independence Blvd	B	A	A	B	0.44	0.40	0.37	0.62	11.1	9.6	9.3	13.9

File: lependence
Designed By:
Date Submitted: 39626

Left Turn Analysis
SCDOT - District Traffic Engineering

Intersection:	Street A & Street B	Street:	A
Count Date:		Left-turn Movement	Westbound
Counted By:		Number Opposing Lanes:	2

Speed Limit or 85th Percentile of Opposing Traffic?	45
Is the current left turn Protected/Permitted? (Y/N)	N
Peak Hour Delay/Left Turn Vehicle?	#DIV/0!

Count Data

Time	Left Turn Volume	Opp Thru Volume	Cycle Length	Max Green	Cross Product	Left Turns Per Cycle
7:00 AM	73	1244	67	40	90812	1.4
8:00 AM	67	866	67	40	58022	1.2
11:00 AM	109	722	67	40	78698	2.0
12:00 PM	132	741	67	40	97812	2.5
4:00 PM	214	904	67	40	193456	4.0
5:00 PM	226	951	67	40	214926	4.2
Average	137	905	67	40	122288	2.5
Peak Hour	13	18	67	45	234	0.2
Peak Time	4:15 PM					

Accident History

Year	Left Turn Accidents
2000	0
2001	1
2002	0
2003	2

Guidelines for Left Turn Phase Installation

Summary of Guidelines	Guideline Met?	Hours/Years
Minimum Left-turn Volume	Yes	3
Minimum Cross Product of Opposing and Left-turns	Yes	2
Minimum Number of Lefts/Cycle	Yes	4
Minimum Left-turn Volume vs. Opposing Speed Limit	Yes	6
Accident History Analysis	No	***
Minimum Left-turn Delay	#DIV/0!	#DIV/0!

Minimum Left Turn Volume							*Criteria=*	*120*
Begin				*Percent Satisfied*				
Time	7:00	8:00	11:00	12:00	16:00	17:00	Average	Peak Hour
	61%	56%	91%	110%	178%	188%	114%	11%

Total Hours Met	3

Minimum Cross Product of Opposing Through and Left Turns							Criteria=	100000
Begin				*Percent Satisfied*				
Time	7:00	8:00	11:00	12:00	16:00	17:00	Average	Peak Hour
	91%	58%	79%	98%	193%	215%	122%	0%
Total Hours Met	2							

Minimum Number of Lefts/Cycle							Criteria=	2
Begin				*Percent Satisfied*				
Time	7:00	8:00	11:00	12:00	16:00	17:00	Average	Peak Hour
	68%	62%	101%	123%	199%	210%	127%	12%
Total Hours Met	4							

Minimum Left Turn Volume vs. Opposing Speed Limit							Criteria=	30
Begin				*Percent Satisfied*				
Time	7:00	8:00	11:00	12:00	16:00	17:00	Average	Peak Hour
	247%	227%	369%	446%	724%	764%	463%	44%
Total Hours Met	6							

Accident History Analysis			*Criteria=4/1yr,6/2yrs,8/3yrs*		
Year	2000	2001	2002	2003	0
Min. Met?	No	No	No	No	No
Total Years Met	0				

Minumum Left Turn Delay		*Criteria=*	*11*
Begin			
Time	Peak Hour		
4:15 PM	#DIV/0!		
Met?	#DIV/0!		

This report does not constitute a recommendation, other factors and criteria should be considered.

South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES

Chapter 4

Stop & Go Signal Design

STOP & GO SIGNAL DESIGN

The following information should be used to design the signal plan. In addition, the **SCDOT Signal Specifications** along with the **SCDOT Standard Drawings** should be followed during both the design and installation phase. Specific parameters given are intended to apply under relatively normal conditions and, if warranted and justifiable in individual cases, actual designs may differ somewhat from that indicated.

SIGNAL PLAN DRAWING

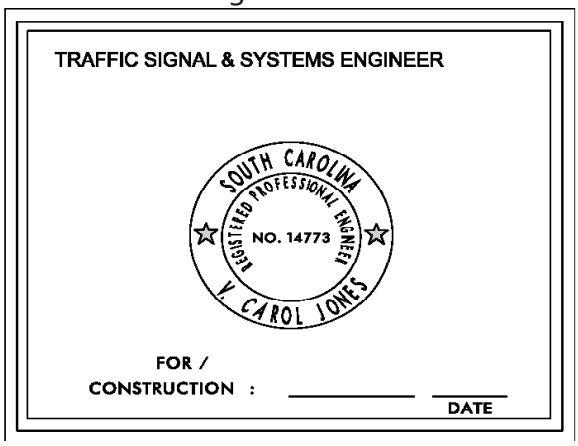
Signal plans should include accurate depictions of pavement markings, signal head placement, span wires, right-of-ways, driveways, sidewalks, control of access, and also should indicate signal timings, speed limits, grades, route names and numbers, adjacent development, coordination details etc. An example Signal Plan drawing can be found in Appendix 4:1 and a signal plan checklist in Appendix 4:2-3. When reviewing a signal plan, there is a helpful guide to follow in the Appendix 4:4-5.

Descriptions of items shown on the signal plan:

PE SEAL

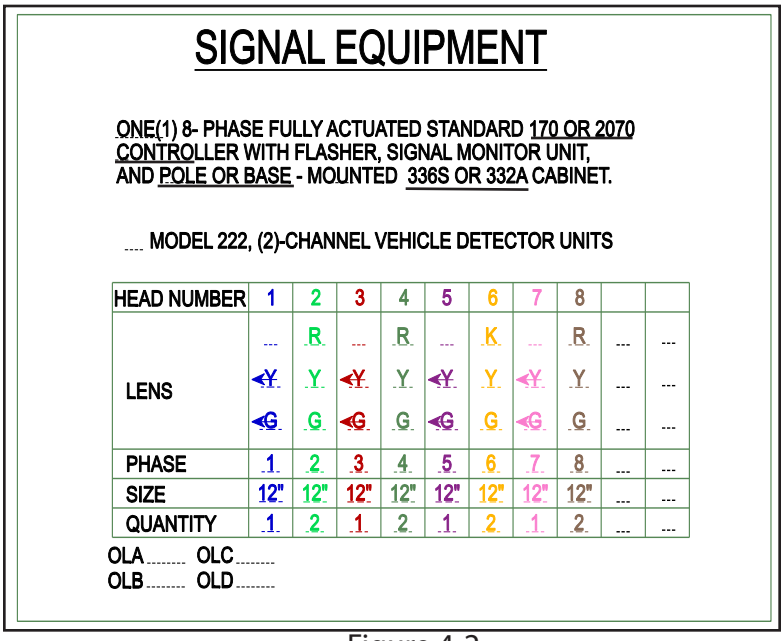
Signal plans should be prepared under the supervision of a South Carolina registered engineer. The signal plan should be signed and sealed by the same engineer.

Figure 4-1



SIGNAL EQUIPMENT

The signal equipment chart (Figure 4-2) details the controller type, cabinet type, number of detector units, pedestrian heads/detectors, traffic signal heads lens description per phase and pedestrian heads by phase. Overlap information is also depicted in this chart.



SIGNAL EQUIPMENT

ONE(1) 8- PHASE FULLY ACTUATED STANDARD 170 OR 2070 CONTROLLER WITH FLASHER, SIGNAL MONITOR UNIT, AND POLE OR BASE - MOUNTED 336S OR 332A CABINET.

.... MODEL 222, (2)-CHANNEL VEHICLE DETECTOR UNITS

HEAD NUMBER	1	2	3	4	5	6	7	8		
LENS	...	R	...	R	...	K	...	R	...	...
	◄Y	Y	◄Y	Y	◄Y	Y	◄Y	Y	...	...
	◄G	G	◄G	G	◄G	G	◄G	G	...	...
PHASE	1	2	3	4	5	6	7	8	...	...
SIZE	12"	12"	12"	12"	12"	12"	12"	12"	...	...
QUANTITY	1	2	1	2	1	2	1	2	...	...

OLA..... OLC.....
OLB..... OLD.....

Figure 4-2

SIGNAL PHASING

Phase Numbering - Figures 4-3, 4, & 5 detail the phase and movement numbering convention. **Phases 2 and 6 are for the arterial street (i.e., main street) and phase 2 shall always be east-bound or southbound.** These will be the coordinated phases in a coordinated signal system.

Figure 4-3

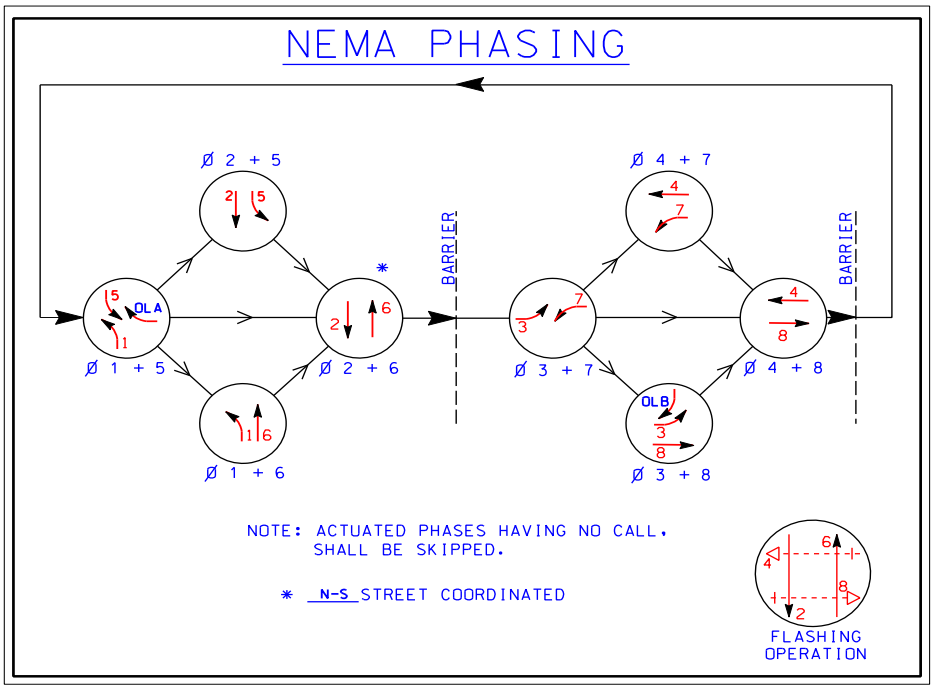


Figure 4-4: **Dual Sequential Phasing**

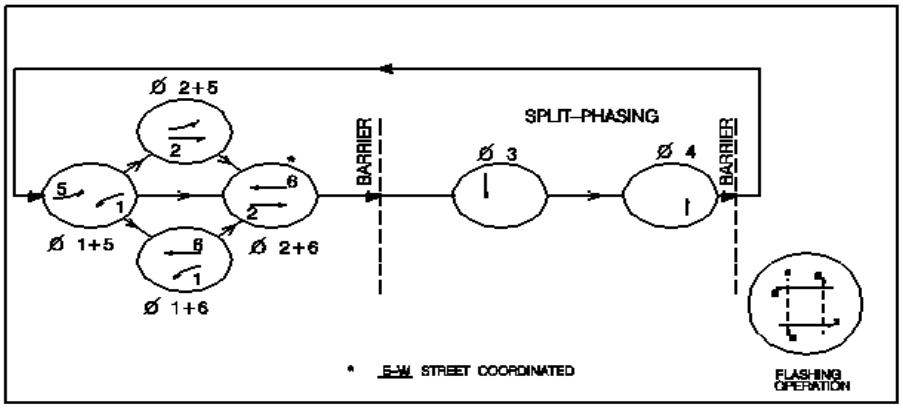
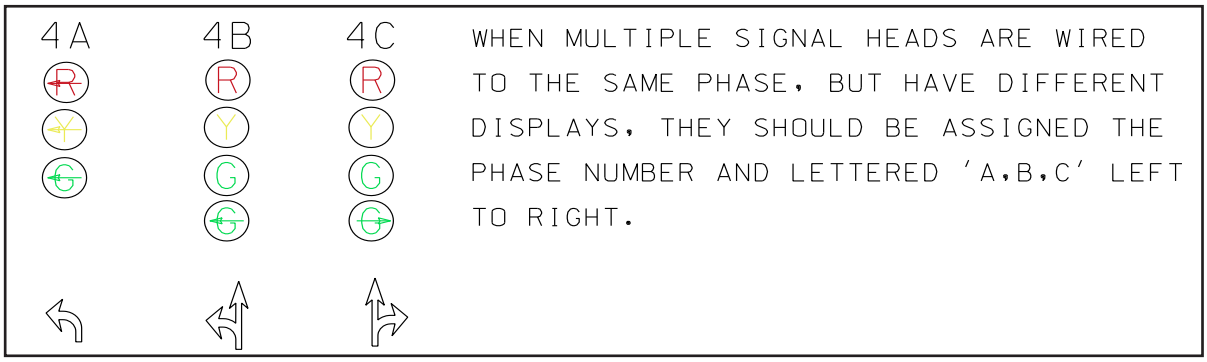
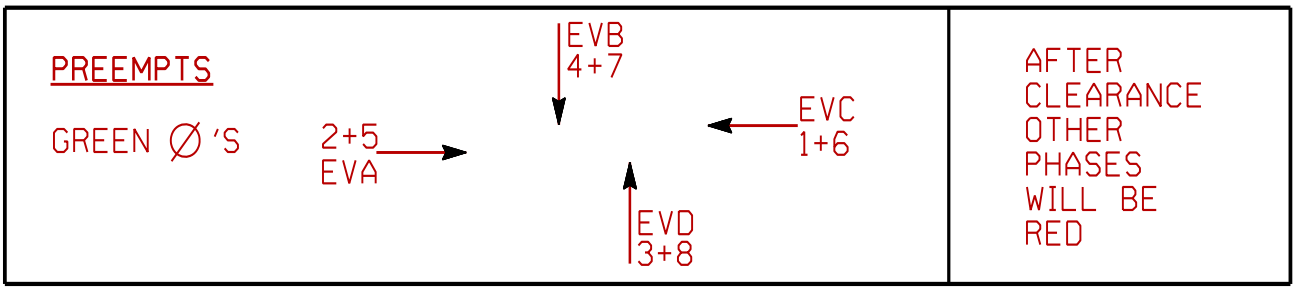


Figure 4-5: Signal Head Numbering



Emergency Vehicle & Railroad Preempt Numbering - With regard to the 170 and 2070 controllers, emergency vehicle preemption designates four inputs, each of which calls a pair of phases. These are shown on Figure 4-6 for phase numbering as EVA, EVB, EVC, and EVD, together with the phases they call.

Figure 4-6



RAILROAD PRE-EMPT

RR1 -TRACK CLEAR Ø3 & Ø8 = 14 SEC

RR1 - Ø2 & Ø6 FLASH YELLOW, Ø4 & Ø8 FLASH RED

RR2 - TRACK CLEAR Ø3 & Ø8 = 24 SEC

RR2 - LIMITED SERVICE Ø2-Ø6, Ø5, & Ø7

Typically railroad pre-empt is shown on the plan as a side note including the track clear, flash yellow, and/or limited service phases and time in seconds. When using a 170 or 2070 controller the RR1 and RR2 are designated out in the field cabinet and the track clear and limited service options can easily be switched using controller technology.

For more information reference Chapter 6, Railroad Pre-emption Design.

Phase Sequencing - Figure 4-7 details the phase sequence for single or double ring operation.

Figure 4-7

G-GREEN
Y-YELLOW
R-RED
G-G, ARROW
Y-Y, ARROW
W-WALK **
DW-DON'T WALK

SIGNAL DISPLAY SEQUENCE CHART

PHASE ON (A)	NON-CONFLICTION PHASE (B)	CONFLICTING PHASE *
1	5, 6, 6P	2,3,4,7, 8, 2P, 4P, 8P
2	5,6, 2P, 6P	1,3,4, 7, 8, 4P, 8P
3	7, 8, 8P	1,2,4, 5,6, 2P, 4P, 6P
4	7, 8,4P, 8P	1,2,3,5, 6, 2P, 6P
5	1,2, 2P	3,4,6,7, 8,4P, 6P, 8P
6	1,2, 2P, 6P	3,4, 5,7, 8,4P, 8P
7	3,4,4P,	1,2,5,6,8, 2P, 6P
8	3,4,4P, 8P	1,2,5,6,7, 2P, 6P

'C' = COORDINATE Ø2 ; Ø6

NOTE A: ANY ACTUATED PHASE FOR WHICH THERE IS NO CALL SHALL BE OMITTED.
NOTE B: WHEN ONE PHASE IS ON ALONE, ANY/NON-CONFLICTING PHASE MAY START TIMING CONCURRENTLY WITHOUT A CLEARANCE INTERVAL (SEE CHART).
* CONFLICTING PHASES REQUIRE A CLEARANCE INTERVAL.

** WHEN CALLED, DISPLAY SOLID 'WALKING PERSON' AND TIMES OUT WALK TIMING; THEN DISPLAYS FLASHING 'UPRAISED HAND' AND TIMES WALK CLEARANCE (DON'T WALK TIMING), THEN DISPLAYS A SOLID 'UPRAISED HAND'.

SIGNAL DISPLAY SEQUENCE (PREFERENTIAL PHASING)

FLASH	SIGNAL HEAD NUMBER	Ø1—Ø5 R/W	Ø1-Ø6	Ø2-Ø5	Ø2-Ø6	BARR.	Ø2—Ø6 R/W	Ø1-Ø5	BARR.	Ø3—Ø7 R/W	Ø3-Ø8	Ø4-Ø7	Ø4-Ø8	BARR.	Ø4—Ø8 R/W	BARR.
-	1	G	G	G	Y	-	Y	-	Y	-	-	-	-	-	-	- -
Y	2	R	R	R	R	R	R	R	R	G	Y	R	R	R	R	R R
-	3	-	-	-	-	-	-	-	-	-	-	-	G	G	-	- -
R	4	R	R	R	R	R	R	R	R	R	R	R	R	R	G	Y R
-	5	G	Y	-	G	G	Y	-	Y	-	-	-	-	-	-	- -
Y	6	R	R	R	R	R	R	R	R	G	Y	R	R	R	R	R R
-	7	-	-	-	-	-	-	-	-	-	-	-	G	Y	-	- -
R	8	R	R	R	R	R	R	R	R	R	R	R	R	R	G	Y R
–	2P	DW	DW	DW	DW	DW	DW	DW	DW	* *	DW	DW	DW	DW	DW	DW DW
–	4P	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	* *	DW DW
–	6P	DW	DW	DW	DW	DW	DW	DW	DW	* *	DW	DW	DW	DW	DW	DW DW
–	8P	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	* *	DW DW

BARRIER

ALTERNATE PHASES

SIGNAL HEAD NUMBER	Ø1—Ø6 R/W	Ø2-Ø6	BARR.	Ø2—Ø5 R/W	Ø1-Ø5	Ø2-Ø6	BARR.	Ø3—Ø8 R/W	Ø4-Ø8	BARR.	Ø4—Ø7 R/W	Ø4-Ø8	BARR.
1	G	Y	-	-	-	-	-	-	-	-	-	-	-
2	R	R	R	G	G	G	Y R	R	R	R	R	R	R
3	-	-	-	-	-	-	- -	G	Y	Y	-	-	-
4	R	R	R	R	R	R	R R	R	R	R	G	G	Y R
5	-	-	-	G	Y	Y	-	-	-	-	-	-	-
6	G	G	Y R	R	R	R	R R	R	R	R	R	R	R R
7	-	-	-	-	-	-	- -	-	-	-	G	Y	Y -
8	R	R	R	R	R	R	R R	G	G	Y	R	R	R R
2P	DW	DW	DW	* *	* * * *		DW DW	DW	DW	DW	DW	DW	DW DW
4P	DW	DW	DW	DW	DW		DW DW	DW	DW	DW	* *	* * * *	DW DW
6P	* *	* * * *	DW	DW	DW		DW DW	DW	DW	DW	DW	DW	DW DW
8P	DW	DW	DW	DW	DW		DW DW	* *	* * * *	DW	DW	DW	DW DW

BARRIER

ALTERNATE PHASES

New_SCDOT_Signal_Border_EB_22x36.dgn 2/13/2009 10:16:36 AM

SIGNAL TIMING

Figure 4-8 is the Traffic Signal Timings chart used on signal plans.

Figure 4-8

SIGNAL TIMINGS

INTERVAL	PHASE 1	2	3	4	5	6	7	8
WALK		7		7		7		7
DON'T WALK		20		17		20		17
MIN INITIAL	8	15		8	8	15		8
MAX INITIAL								
ADD/VEH								
VEH EXT	3.0	3.0		3.0	3.0	3.0		3.0
TIM BFR REDUC								
TIME TO REDUC								
MIN GAP								
MAX LIMIT	15	35		30	15	35		30
MAXIMUM 2								
YELLOW	4.0	4.5		4.4	4.0	4.8		4.0
RED CLEAR	2.0	2.0		2.5	2.0	2.0		3.3

Summit Parkway Signal.dgn 2/2/2009 9:30:50 AM

MAX/MIN Initial or MAX/MIN Green

VEH EXT or PASSAGE

MINIMUM INITIAL, VEHICLE EXTENSION (VEH EXT.) MINIMUM GAP SETTINGS

Minimum green timings and passage timings for major routes should conform to that shown on chart below. Side streets may also function as major routes in some cases. When standard side street detector loops are to be placed at the stop bar, minimum green timing should fall between 4 and 8 seconds and passage timing should be 2 to 3 seconds. In cases where pedestrian needs are substantial, minimum green timing may increased appropriately beyond the indicated limits if necessary to address these needs; just as if no pedestrian detection is planned ensure that appropriate min times are given.

Chart 4-1: Major Route Signal Design *Single* Detector (phase 2 & 6 timing)

		Distance to Detector from Stop Bar (ft)		Recommended Timings			
		Min	Max	Min Green Normal	Min Green Volume Density	Passage Low End	Passage High End
Approach Speed (mph)	25	80	130	14	N/A	2.0	2.2
	30	115	165	15	N/A	2.0	3.1
	35	160	210	15	8 - 15	2.1	3.1
	40	205	255	15	8 - 15	2.5	3.5

The passage times shown are intended to be used with the corresponding minimum and maximum detector spacings.

Chart 4-2: Major Route Signal Design *Multiple Point* Detector (phase 2 & 6 timings)

		Distance to Detector from Stop Bar (ft)		Recommended Timings Volume Density	
		#1	#2	Min Green Normal	Min Gap
Approach Speed (mph)					
	45-55	255	385	8-15	2.5

It is recommended that minimum greens be kept to a maximum of 15 seconds. Although this may not be sufficient to clear the area between the first detector loop and the stop bar, it is extremely unlikely that a situation would arise in which enough traffic existed to fill this area and not also extend the green when the minimum times out.

The above detector spacing and passage times are designed to minimize the possibility of vehicles being located in the dilemma zone when a phase times out. The multiple point detection spacing above is designed to cover a range of speeds from 40 mph to 55 mph.

MAXIMUM LIMIT, MAXIMUM 2

These values are the maximum green time per signal phase. These settings should be calculated based on existing or projected traffic volumes, lane capacity, and phasing relationships as determined by widely accepted methods or engineering analysis. SCDOT often uses Synchro software to assist in these calculations.

Signal Cycle- The signal cycle is the sum of the maximum green settings the yellow change and the red clear settings for each non compatible phase; i.e., you would not add the settings for phase 2 and 6 together, since they will likely run simultaneously most of the time. The signal may not operate a full cycle each time, since some phases may 'gap out' or even be skipped, based on lack of demand. This is true, especially in non-peak traffic times. Signal cycles should be as short as possible, to reduce delay and to serve each phase as many times as possible during a peak hour.

Volume-Density Control should be utilized at all but the very simplest intersections. (i.e. intersections with major route speed limits of 35 MPH or less do not typically benefit from this type of control.) Consider the use of Volume Density Timing for major approaches where the speed limit equals or exceeds 40 mph. Volume Density Timing will only operate if the loops are operational; therefore maintenance of the signal is an important consideration. Short gap times and long maximum green times provide best results.

Volume Density Timing allows an alternate minimum (initial) green time to be calculated to ensure vehicles queuing at the stop bar are able to dissipate without additional loop activations. This is accomplished using the *Added Initial* input on the controller software. *Added Initial* counts the number of loop actuations and adds a certain amount of time per loop actuation, as shown below. The minimum green time served is the greater of the "preset *Minimum Green*" or the sum of the "*Added Initial*" (shown as ADD/VEH on timing chart-Figure 4-8) time.

Added Initial when loops on both approaches are hooked to the same phase:
= 0.3 to 1.2 s for two approach lanes (4 lane rdwy) with one loop per approach
= 0.6 to 1.2 for single approach lane (2 lane rdwy) with one loop per approach
= 0.15 to 0.6 for two approach lanes (4 lane rdwy) with two loops per approach
= 0.3 to 0.6 for single approach lane (2 lane rdwy) with two loops per approach

Added Initial when loops on each approach are hooked to different phase:
= 0.6 to 1.2 for two approach lanes (4 lane rdwy) with one loop per approach
= 1.2 sec for one approach lane (2 lane rdwy) with one loop per approach
= 0.3 to 0.7 for two approach lanes (4 lane rdwy) with two loops per approach
= 1.1" for one approach lane (2 lane rdwy) with two loops per approach

Volume Density Timing allows the reduction of the gap (passage) to improve the efficiency of the intersection. Gap times need to be longer at the beginning of the green to allow vehicles to start up from a queued position and begin to pick up speed and increase the headway between them. At that point the gap time can be reduced to obtain the most efficiency at the intersection. Three inputs control this action, *Minimum Gap, Time before Reduction*, and *Time to Reduce*.

Minimum Gap is the gap time to be used to allow the most efficient operation of the signal, and is typically 2.5 seconds.

Time before Reduction is the time to allow the queue at the stop line to dissolve and vehicles begin to arrive with uniform headway, typically between 10 to 20 seconds and greater than the minimum green time.

Time to Reduce must be short enough to ensure gap out and is based on the difference between your minimum green time, the time before reduction and the maximum green time. For example if the minimum green time was 15 seconds, and the Time before Reduction was 20 seconds, and the Max Green Time was 55 seconds, the *Time to Reduce* could be 10 seconds, allowing 25 seconds of the phase to operate with the Minimum Gap Time. You would not typically use less than 5 seconds for *Time to Reduce* and you would typically want at least 15 seconds of time for the *Minimum Gap* to operate.

The chart below is provided to give values for the minimum gap time and the maximum initial interval times for volume density.

Chart 4-3: Volume Density

MAJOR ROUTE SPEED LIMIT	DETECTOR SETBACK	VEHICLE EXTENSION	MIN GAP	MIN INITIAL	MAX INITIAL
35	160' - 210'	3.5 to 4.9 s	2.6 to 3.9 s	*	22 s ** to 29 S
40	205' - 255'	3.9 to 5.1 s	3.1 to 4.3 s	*	27 s ** to 34 s
45	255' & 385' (DZP)	3.8 s	2.3 s	*	30 s **
50	255' & 385' (DZP)	3.5 s	2.3 s	*	30 s **
55	255' & 385' (DZP)	3.1 s	2.3 s	*	30 s **

** 6 to 15 seconds, according to significance of route, number of lanes, etc.*
*** Maximum initial interval for volume density control*
DZP = Dilemma Zone Protection

Clearance Timings

Clearance Timings shall be based on appropriate formulas that adhere to current professional standards. The clearance time consists of the yellow time and the all red time that separates phases. Approach speed, approach grade, and intersection width must all be considered as shown on below:

Yellow Time = the length of time such that the distance traveled at the 85th percentile speed in that length of time is equal to the distance required to stop from the 85th percentile speed.

Yellow Time Based On The Formula Y = t + v/2(a+32.174g)
(Where a = 10 ft/s/s, and t = 1 second, And v = speed in ft/s)

Chart 4-4: Yellow Change

Grade (Percent)

Speed (MPH)	5	4	3	2	1	0	-1	-2	-3	-4	-5
25	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.1	3.2
30	3.0	3.0	3.0	3.1	3.1	3.2	3.3	3.4	3.4	3.5	3.6
35	3.2	3.3	3.3	3.4	3.5	3.6	3.7	3.7	3.8	3.9	4.1
40	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.2	4.4	4.5
45	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.7	4.8	4.9
50	4.2	4.2	4.3	4.4	4.6	4.7	4.8	4.9	5.1	5.2	5.4
55	4.5	4.6	4.7	4.8	4.9	5.0	5.2	5.3	5.5	5.6	5.8
60	4.8	4.9	5.0	5.1	5.3	5.4	5.5	5.7	5.9	6.0	*
65	5.1	5.2	5.3	5.5	5.6	5.8	5.9	*	*	*	*
70	5.4	5.5	5.7	5.8	6.0	*	*	*	*	*	*

***Min Yellow time should be 3.0", if the calculated Yellow is greater than 6.0" an engineering study should be performed.**

Red Time = the length of time to clear the intersection based on the vehicle speed.

All Red Time Based On The Formula AR = (w+l)/v
(Where: w = width of intersection (stop bar to opposite curb), l = length of vehicle (20'), v=speed in ft/s)

Chart 4-5: Red Clear

Width of Intersection (ft)

Speed (MPH)	20	30	40	50	60	70	80	90	100	110	120	130
25			1.6	1.9	2.2	2.5	2.7	3.0	*	*	*	*
30				1.6	1.8	2.0	2.3	2.5	2.7	3.0	*	*
35					1.6	1.8	1.9	2.1	2.3	2.5	2.7	2.9
40						1.5	1.7	1.9	2.0	2.2	2.4	2.6
45							1.5	1.7	1.8	2.0	2.1	2.3
50								1.5	1.6	1.8	1.9	2.0
55									1.5	1.6	1.7	1.9
60										1.5	1.6	1.7
65											1.5	1.6
70												1.5

***Red time should be a minimum of 1.5", if calculated red time is greater than 3.0" an engineering study should be performed.**

FHWA's recommended practice on Clearance Timings can be found in the **Traffic Signal Timing Manual** in Chapter 5.

Detection

The Department uses mainly inductive loop detection, however there are some intersections operating video detection, microwave or radar type detection. Inductive loops are used at the majority of the signalized intersections around the state; however, the new video detection technology is now being installed at locations where inductive loops aren't as feasible.

Inductive loop detection

Detector Memory indicates whether or not the detector should 'remember' the call placed by a vehicle, once the vehicle moves off the loop. Typically, a stop bar loop would have detector memory off and the setting would be 'N' for non-lock. A setback loop would typically have the detector memory on and the setting would be ' L' for locked (or non-locked for left-turn setback loops).

Detector Delay is a setting to be used if you wanted to place a delay on the loop for vehicle actuation. The typical use is for the right most stop bar loop on a side street. A delay would be placed on the loop to allow a motorist, making a right turn, to do so without placing a call on the controller, if the turn was made within 8-10 seconds. The typical delay is 8-10 seconds.

Figure 4-9

LOOP DETECTOR INSTALLATION CHART

PHASE/ LOOP LTR#	DETECTOR AMP NO.	DETECTOR CHAN NO.	WIRED TO PHASE(S)	X LOCK	X NON-LOCK	X PULSE	X PRES	OPERATION DELAY SEC	OPERATION EXT SEC	SPECIAL FEATURES TIME OF DAY-TOD, SWITCHING, etc.	LOOP DESIGN SIZE X	LOOP DESIGN NO.OF TURNS	LOOP DESIGN DIST. FROM ℄
2a			2		X		X			QUAD	6' X 30'	2-4-2	50'
2b			2	X			X				6' X 6'	4	230'
4a			4		X		X			QUAD	6' X 30'	2-4-2	-10'
6a			6		X		X			QUAD	6' X 30'	2-4-2	50'
6b			6	X			X				6' X 6'	4	230'
8a			8		X		X			QUAD	6' X 30'	2-4-2	-10'

US 78 @ S-131 Signal Plan.dgn 1/6/2009 2:28:40 PM

This Loop Detector Installation Chart is shown on the Signal plan. It gives detail information about each detector loop shown on the drawing.

Detector Mode - A detector can be set to 'Presence' or to 'Pulse' mode. SCDOT typically sets all detectors in Presence mode since Pulse mode would not recognize the 'presence' of a vehicle on the loop, as may occur during substantial queuing.

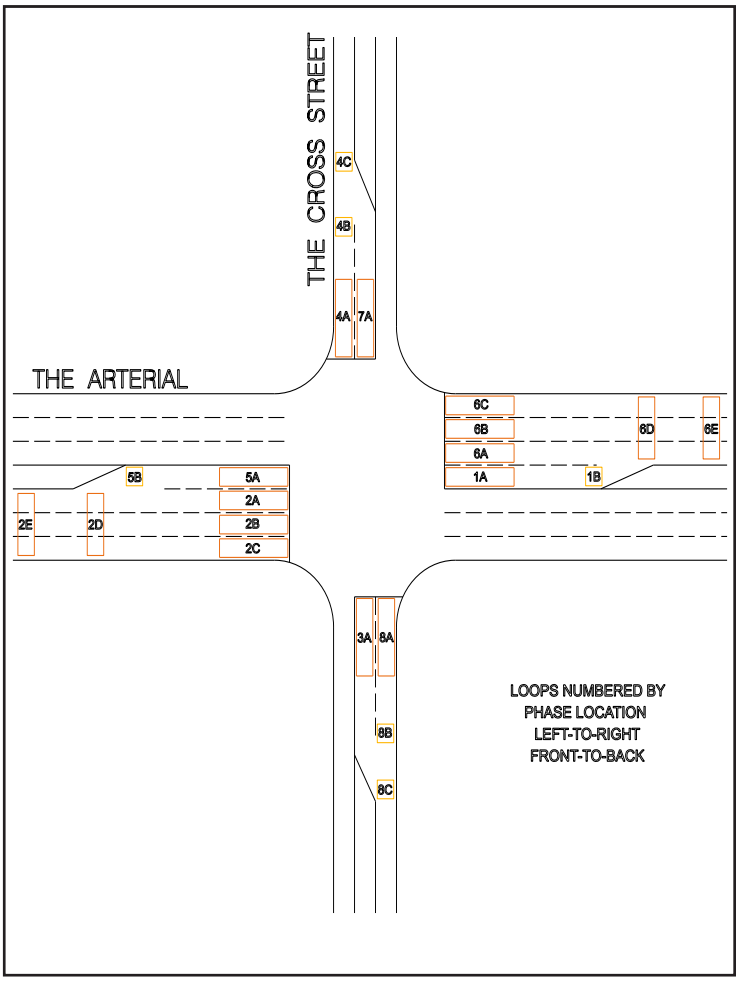
Lock and Non-lock - Lock mode extends the time as the car rolls over the loop and non-lock does not. In non-lock, a vehicle must rest on the loop to be detected and as long as the car is on the loop a call is placed. If the car leaves the detection zone, the call is lost. Typically a loop on or near the stop bar would be in non-lock mode and the set back loops would be lock.

Quadrapole loops should be used on side streets at the stop bar and in the left turn lane on the main street when a permitted or protected-permitted phase is present at the stop bar or 50' back from the stop bar depending on the districts preference. For protected left turn phasing, loops should be present at the stop bar. Our standard is a 6' x 30' quadrapole loop.

Semi-Actuated Designs should only be utilized or considered when a signal is being included in a coordinated system. This type of design is not efficient during non-coordinated operation, as the main street never gaps out.

Numbering - Loop detectors should be numbered according to the phase with which they are associated. If there are multiple loops on one phase then add letter designations, according to their location, left to right and from front to back as shown on the diagram to the right.

Figure 4-10



Loop Detector Placement

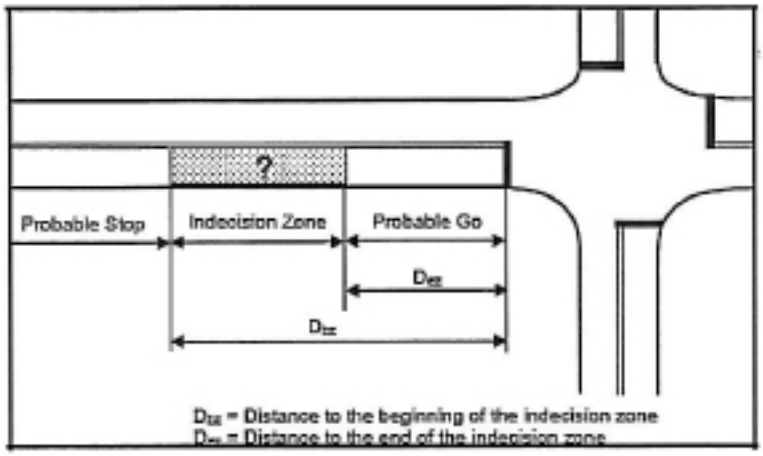
- Placement on major routes should conform to that shown in the chart under the Signal Timing section.
- Side streets may also function as the major routes by time of day, however the side street typically has stop bar loops.
- If both the main line and side street have high speed and have similar volumes, setback loops may be used on both roadways.
- System loops are typically placed on the departure side of the signal, while detection loops are placed on the signal approach.
- Detection zones of loops have a typical range of 3' on either side of the loop, so avoid placing too close to adjacent lane or opposing traffic flow area. The typical height of the detection zone is 3' for a square loop and 18-24" for a quadrapole loop. Adjusting the sensitivity of the loop can help if motorcycles or bikes are not being detected.
- Never place loops where driveways intersect, before or after driveways. Set back loops may be needed where high volume driveways exist to detect the driveway vehicle.
- See SCDOT Standard Drawings and the SCDOT Signal Specifications for more details.

Multiple Point Detection should be used on major routes to provide "dilemma zone" protection when the posted speed limit is 45 MPH or greater, or when a speed study has indicated that the 85th percentile speed is 45 MPH or greater.

ZONES OF INDECISION

The design of advance detection on high-speed approaches requires special attention. Drivers within a few seconds travel time of the intersection tend to be indecisive about their ability to stop at the onset of the yellow indication. This behavior yields an "indecision zone" (also known as a "dilemma zone") in advance of the stop line wherein some drivers may proceed and others may stop. The location of this zone is shown in Figure 4-11.

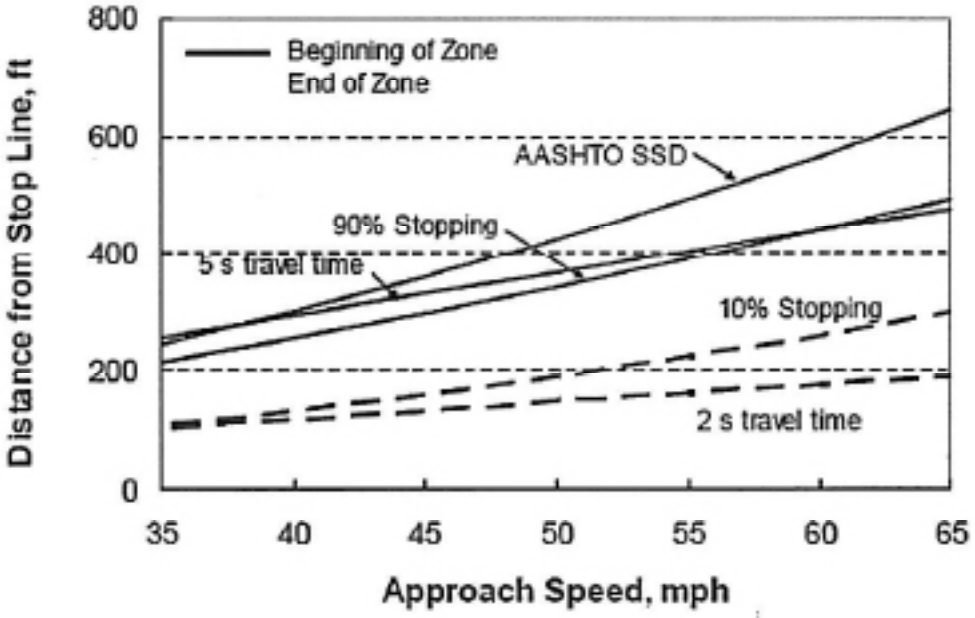
Figure 4-11 Indecision zone boundaries on a typical intersection approach
The indecision zone location has been defined in several ways.



- *Distance from stop line. Some researchers have defined it in terms of distance from the stop line. They define the beginning of the zone as the distance beyond which 90 percent of all drivers would stop if presented a yellow indication. They define the end of the zone as the distance within which only 10 percent of all drivers would stop. The distance to the beginning of the zone recommended by Zegeer and Deen corresponds to about 5 seconds of travel time. That recommended by ITE increases exponentially with speed, ranging from 4.2 to 5.2 s travel time, with the larger values corresponding to higher speeds.*
- *Travel time. Another definition of the indecision zone boundary is based on observed travel time to the stop line. Chang et al. (18) found that 85 percent of drivers stopped if they were more than 3 s from the stop line, regardless of their speed. Similarly, they found that drivers less than 2 s from the stop line would almost always continue through the intersection.*
- *Stopping sight distance. A third definition of the beginning of the indecision zone is based on safe stopping sight distance (SSD). A method for computing this distance is described in Chapter 3 of the AASHTO document, A Policy on the Geometric Design of Highways and Streets (19).*

The zone boundaries obtained by these three definitions are compared in Figure 4-12. The boundaries based on distance typically have an exponential relationship. Those based on travel time have a linear relationship. Based on the trends shown in the figure, the beginning and end of the indecision zone tend to be about 5.5 and 2.5 seconds, respectively, travel time from the stop line. These times equate to about the 90th-percentile and 10th-percentile drivers, respectively.[1]

Figure 4-12 Distance to the beginning and end of the indecision zone



1 ***The information on Zones of Indecision is referenced from the Federal Highway Administration [Traffic Signal Timing Manual.]***

LOOP PLACEMENT EXAMPLES

LEFT TURN LOOPS

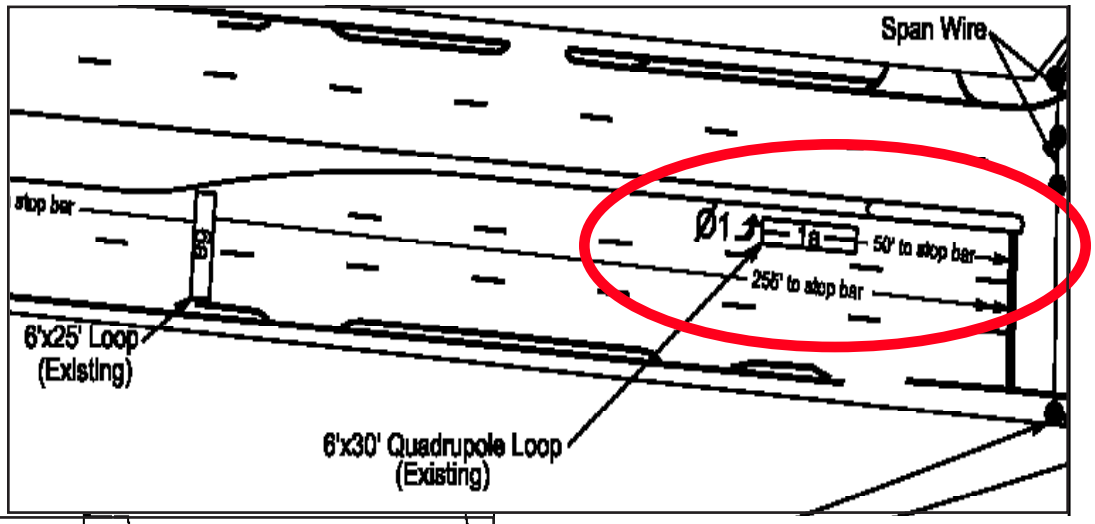


Figure 4-13
50' Set-back Quadrupole loops from the stop bar

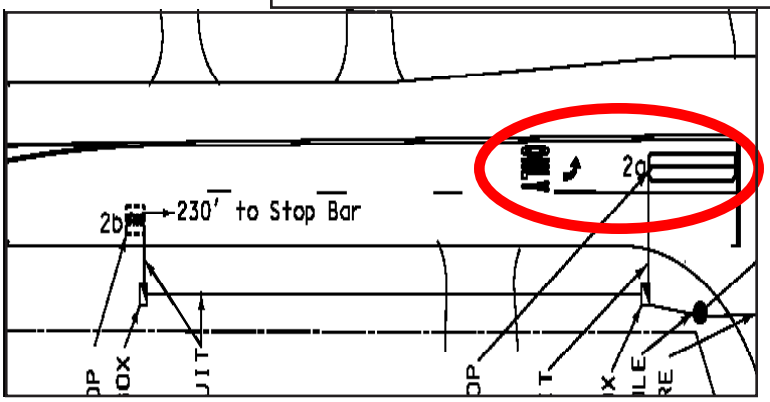


Figure 4-14
Quadrupole loop at the stop bar

SIDE STREET LOOPS

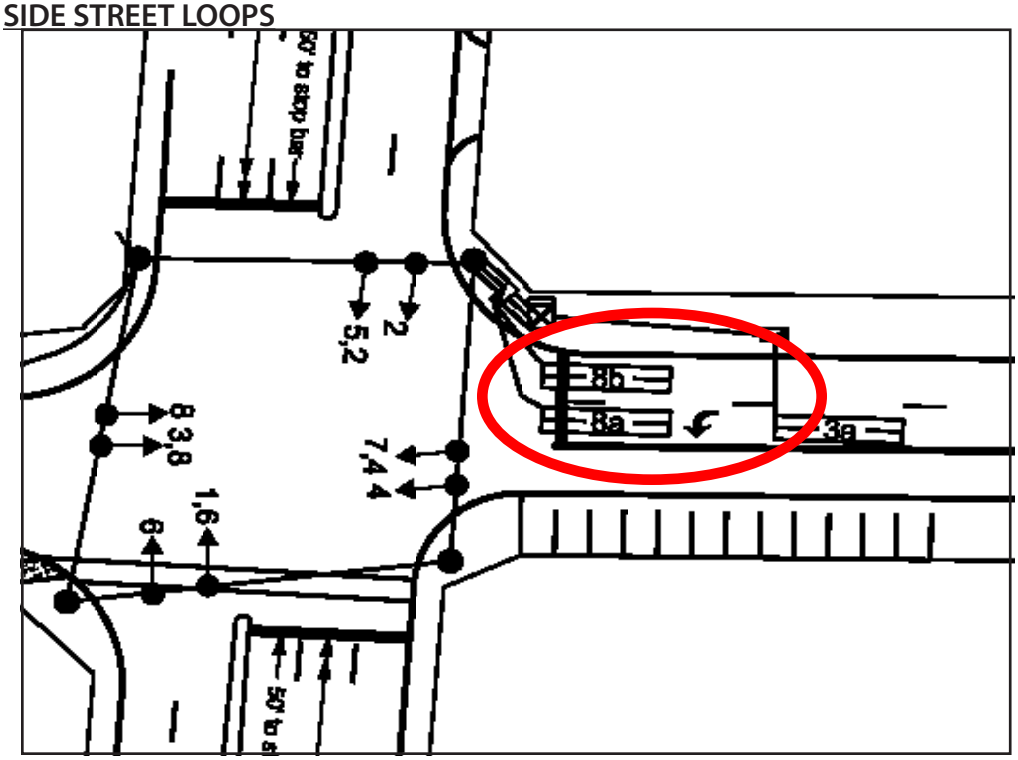


Figure 4-15
Quadrupole loops for each lane at the stop bar

LOOP PLACEMENT EXAMPLES

main line extension loops

Figure 4-16

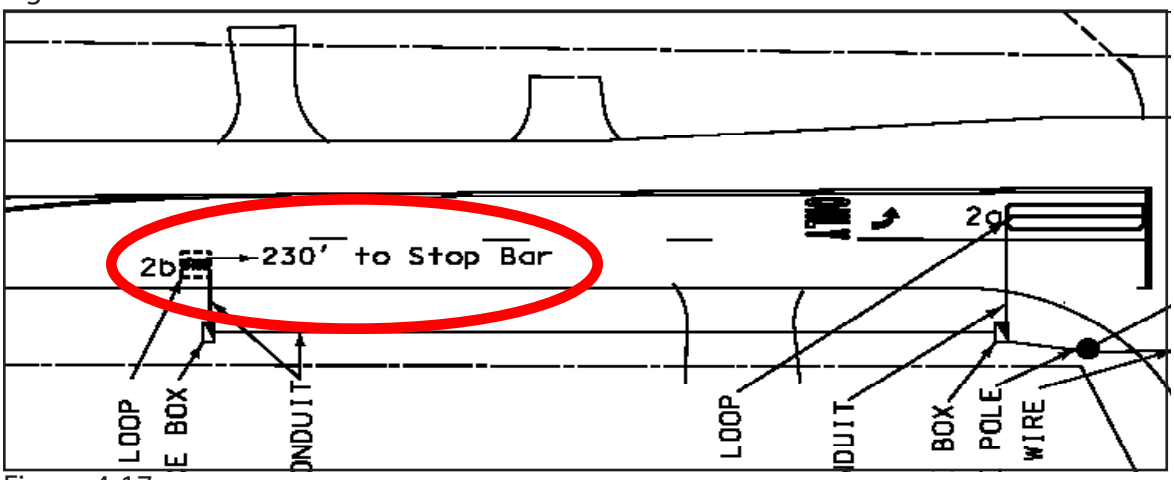
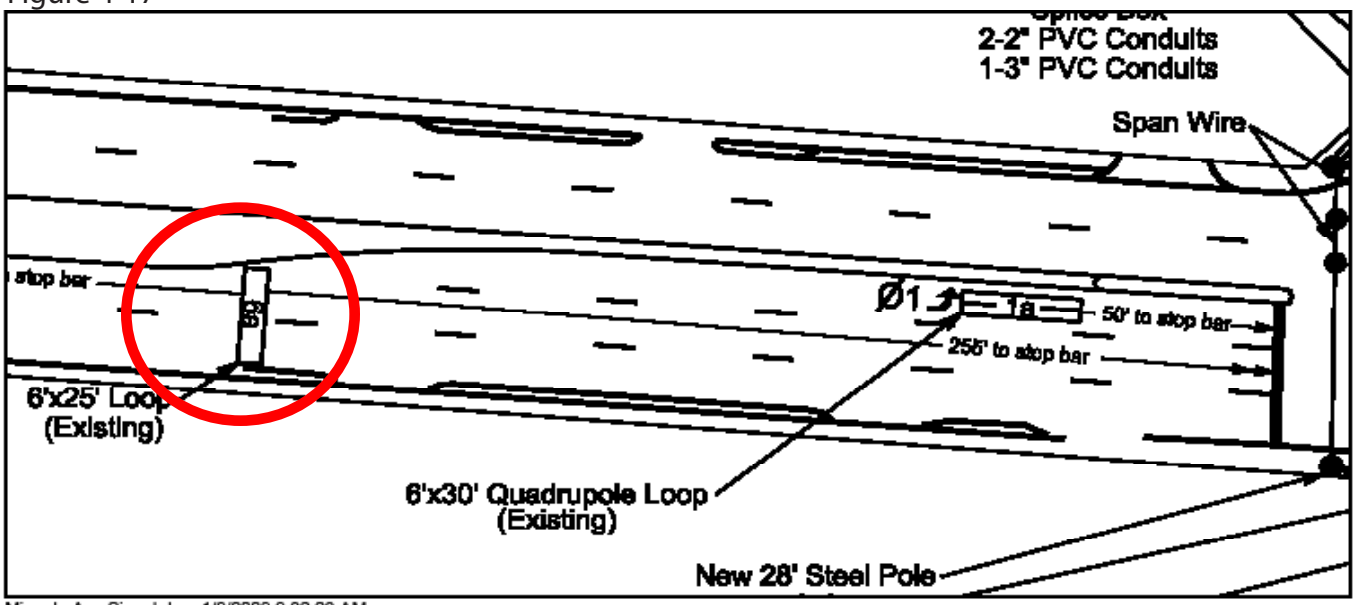
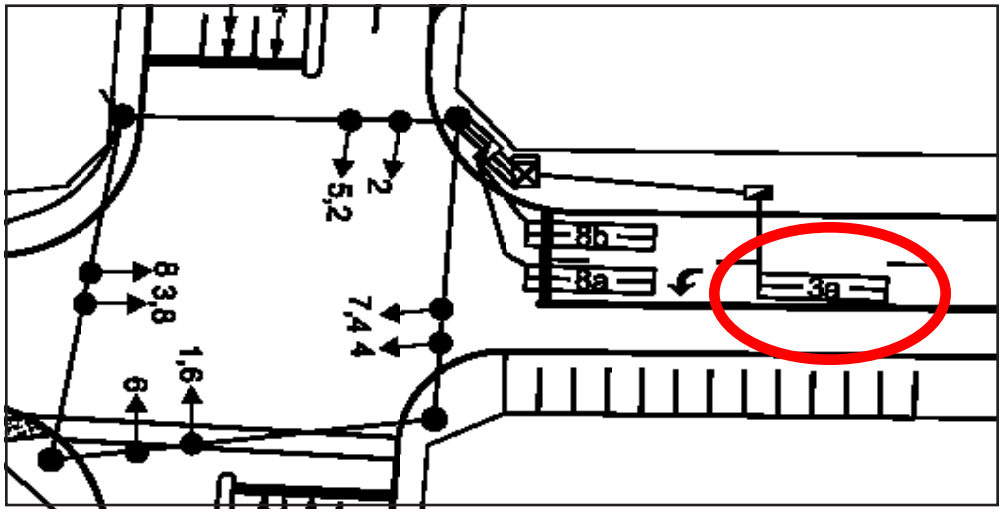


Figure 4-17



left turn lane extension loops

Figure 4-18



For more information on Loop Detection refer to FHWA's **Traffic Signal Timing Manual**.

Video Detection

Video Detection may be installed at intersections where there are unusual pavement conditions such as rutting, where there may be future lane reassignments, and during construction when lane shifts are present.

Environmental changes such as fog, rain, or snow can cause pixel changes in video detection causing the equipment to temporarily malfunction.

Video detection works best at locations with some lighting and slow approach speeds. The detection works best at the stop bar and is more effective if installed higher up to avoid occlusion (blocking from adjacent lanes).

Figure 4-19: Video Detection vs. Loop Detection

	Video Detection	Inductive loop
Installation	easy & quick	difficult & slow
Maintenance cost	low-medium	high
# of detection zones	up to 8	1
# of lanes detected	4	1
verification of detection	visual-cabinet software	field tested
lifetime expectancy	> 10 yrs	< 5 yrs

Pedestrian Treatment Design

BACKGROUND: Since SCDOT typically installs semi-actuated or fully actuated signal control the need for pedestrian provision at traffic signals has been identified. Although the **Manual on Uniform Traffic Control Devices** in Chapter 4E indicates where the pedestrian warrant is met that full pedestrian treatment (detectors and pedestrian signal heads) should be installed, it is unclear as to the requirement at traffic signals where the pedestrian warrant is not met. These guidelines have been developed to promote uniformity in the application of pedestrian detectors and heads at traffic signals.

Installation of Pedestrian Detectors only (usually push buttons)

Pedestrian detectors allow minimal interruption of the normal signal operation and should be considered prior to the installation of both pedestrian signal heads and detectors. Pedestrian detection **should** be provided at traffic signals under any of the following conditions:

- *In areas where pedestrians can be expected*,* and where signals are of the fully- or semi-actuated type and the recall feature is not used.
- *In areas where pedestrians can be expected*,* and where the pedestrian would not have sufficient minimum green signal time to cross the street or road.

Installation of Pedestrian Signal Heads & Detectors

The installation of pedestrian signal heads typically requires more time to operate the pedestrian phase. ***The department currently uses countdown pedestrian heads with push buttons for all new installations and upgrades***. Consideration for the installation of pedestrian signal heads should be given if the traffic signals meet any the following conditions and if engineering judgment indicates this addition will not severely impair the overall traffic operation of the intersection:

- the signal will currently meet the Pedestrian Signal Warrant.
- the crossing at the signal is an obvious established school crossing.
- an exclusive, protected phase is available for pedestrians in one or more directions.
- Where multiphase operation is used in *an area where pedestrians can be expected*,* and the signal phasing may be confusing to the pedestrian as to when to cross.
- *In an area where pedestrians can be expected*, a*t T-intersections, one-way streets and other locations where pedestrians cannot see the vehicular signal head associated with the crossing they are initiating, based on the cones of visibility.

- On wide streets where signals are designed to allow pedestrians to cross the roadway in two stages with the expectation of a stop on a refuge island, additional detection should be provided in the median area. The following items must be considered in this situation:
    - Median design must be appropriate for storage of pedestrians (width, accessibility)
    - Adequate pedestrian timing to cross entire street is extremely detrimental to vehicular progression, resulting in severe delays and queuing
    - Pedestrian traffic is present and is not restricted by signage
- Where mitigation is needed to reduce pedestrian-related crashes, related to intersection operations.
- On wide streets where providing pedestrian clearance information is important and moderate to high numbers of crossings occur.

Installation of Pedestrian Heads only:

In downtown business districts and other areas where pedestrian traffic is crossing regularly during business hours, it may be more feasible to operate the signal cycle in a pre-timed or recalled mode, providing sufficient time for pedestrian crossings during each cycle. Pedestrian heads may be installed under these conditions, without detectors, for the phase that is always on recall or for pret-imed operation.

Restricting Pedestrian Traffic

Restricting pedestrians at a particular intersection can be accomplished through appropriate signing and direction to adjacent, preferable locations. Pedestrians should be prohibited from using unmarked crosswalks where pedestrian movements would present a serious consistent safety concern, by using R9-3-12 (NO PEDESTRIAN CROSSING) signing.

***Areas where pedestrians can be expected**

This phrase describes a location that meets one or more of the following conditions:

- *There are sidewalks at the intersection, even if only on one leg.*
- *Studies or official observations have documented the presence and volumes of pedestrians*
- *There exists the physical evidence of pedestrian activity and there exists logical beginning and end points for short trips (generally less than ½ mile; typically made on foot) on opposite sides of the intersection, even in isolated areas. Examples include, but are not limited to, the following:*
    - *Homes on one side, a grocery store or general store on the other*
    - *Homes on one side, a park or other attraction on the other*
    - *Motels on one side, a food establishment on the other*
    - *An established bus stop on one side, homes on the other*
    - *An established bus stop on one side, places of employment on the other*

Pedestrian Signal Heads, Signs and Markings

- New and replacement pedestrian signal heads will use raised hand and walking man with countdown one section heads.
- Pedestrian heads should be placed where they are clearly visible within the entire crosswalk.
- When not activated, and if sufficient time does not exist during the minimum green time for the active phase, the pedestrian signal head displays should rest in the solid hand mode. If adequate time is available in the minimum green time, the pedestrian signal head display may operate without activation.
- Pedestrian detectors (buttons) or heads may be supplemented with the use of proper signs to indicate appropriate use of signal for pedestrians and/or to provide explanation and guidance to the use of the detector and pedestrian signals.
- Crosswalk locations should be provided based on the conditions at the intersection, namely signal phasing, existing or expected pedestrian patterns and safety. One or more crosswalks may be provided across the mainline roadway, based on engineering judgment. If only one crosswalk is provided across the mainline, adequate direction in the way of signs or marking should direct pedestrians to the crossing location. Pedestrian signals must be in place at each end of each marked crosswalk at the intersection.
- If used, pedestrian heads must be in place at each end of each marked main street crosswalk at the intersection.

Channelized Islands:

In situations where a pedestrian must cross an uncontrolled, channelized movement, such as a channelized right turn lane, the pedestrian treatment should be placed on the channelizing island. This puts the responsibility of crossing the uncontrolled lane on the pedestrian.

Calculation of Pedestrian Timing

3.5 ft/sec is used for the walking speed of pedestrians.

Pedestrian Detectors (push buttons) only:

- Divide the roadway distance (edge of roadway at crosswalk area to mid-way through the last travel lane, worst case scenario) by the normal walking speed (3.5 ft/ sec) and subtract out the yellow/red clearance.
- When using pedestrian detectors only, the pedestrian is required to use the signal

heads as guidance and SCDOT typically operates pedestrian time simultaneously, not sequentially to the yellow-red clearance.

- Typically, the pedestrian detector activates the maximum green time for the appropriate phase allowing the street to be crossed.

Pedestrian detectors and pedestrian signal heads:

- Walk time is a value typically between 4-7 seconds, depending on the number of pedestrians waiting to cross the roadway.
- The pedestrian clearance is calculated by dividing the roadway distance (curb to curb) by the normal walking speed (3.5 ft/sec).
- When using pedestrian heads, SCDOT typically operates pedestrian time sequentially, not simultaneously to the yellow-red clearance. In essence, the walk time is served, the pedestrian clearance time is served, and then the yellow/red clearance is served, prior to the opposing street green. Simultaneous clearance is acceptable for areas where the pedestrian clearance would significantly impact the level of service of the system or the signal timing in an adverse way.

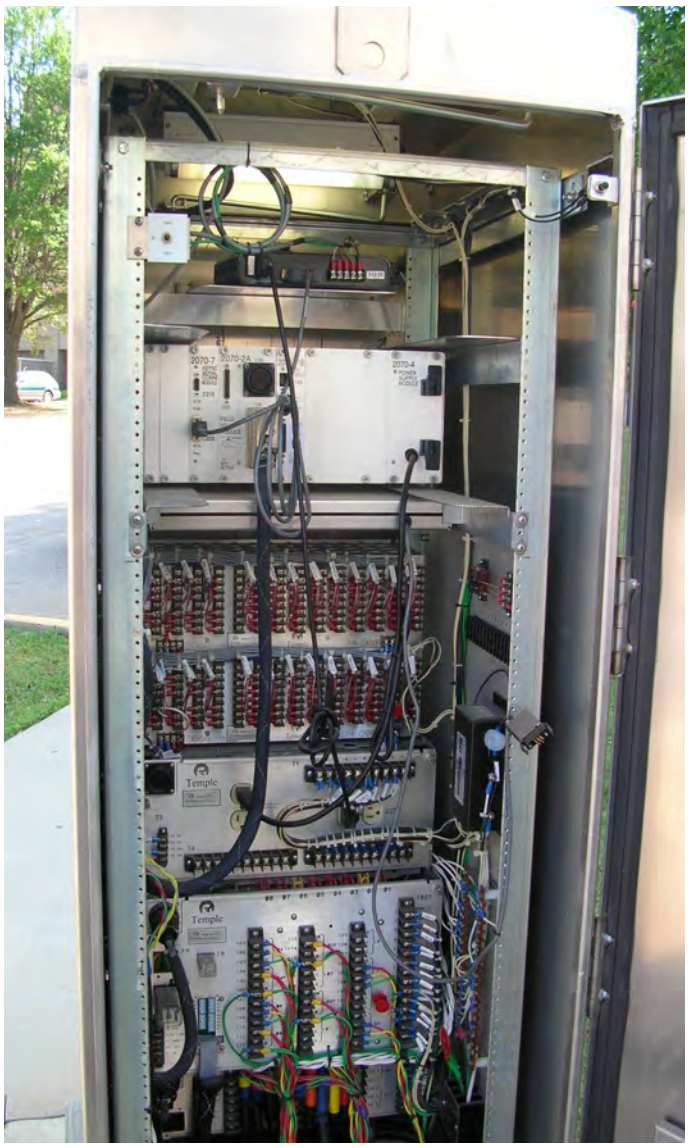
Americans with Disabilities Act (ADA) Considerations Consistent with the guidance contained in **Manual on Uniform Traffic Control Devices** Chapter 4, when special accessible pedestrian detectors (vibro-tactile pushbuttons, with guidance in Braille) or Audible Pedestrian Signals are requested at a location, an investigation shall be conducted and pedestrian treatments that are accessible to persons with vision impairments or blindness shall be provided if possible.

CONTROLLER/CABINET

A traffic signal controller is a solid-state, electrical device for controlling the sequence and phase duration of the traffic signal indications. SCDOT uses 170 and 2070L signal controller equipment. This equipement has the ability to simulate several opertational modes of traffic signal control; pretimed, semi-actuated , full-actuated, and actuated with volume-density control.

Software packages used in SCDOT 170 and 2070L controllers vary by district and contract subject to the venders software.

2070 & 170 Controllers



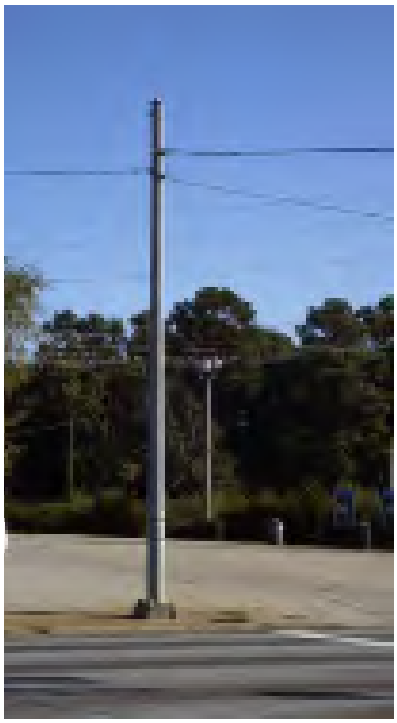
Wiring in Signal Cabinet

Most of our Districts favor the ground mounted controller cabinet, however lack of right of way or other issues will sometimes dictate the need for a pole mounted cabinet.

POLES

The Department prefers steel and concrete poles in installations, especially where right of way is limited, in urbanized areas, at locations subject to heavy wind loading, and at very wide intersections. A class 4 wood pole with back guys is still a viable option for signal poles.

Concrete Pole



Steel Pole

Wood Pole w/ 2 guys

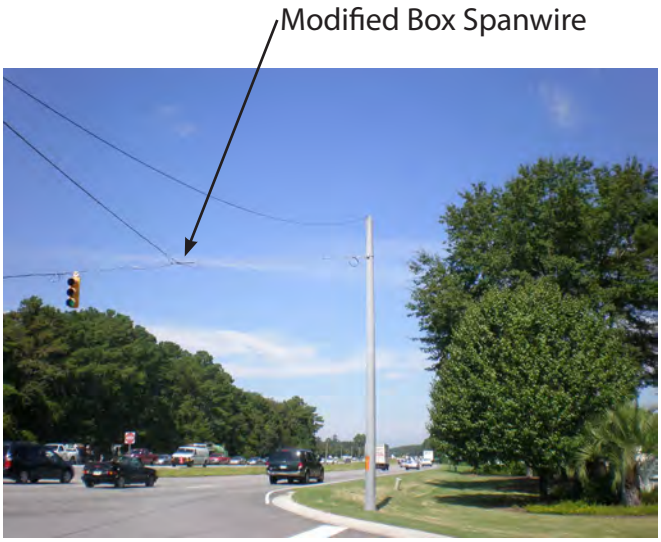
MASTARMS

SCDOT typically does not install mast arms unless circumstances indicate that mast arms are the most economically feasible. For example, right-of-way constraints or wind loading may dictate the use of mast arms. SCDOT prefers a 22' vertical clearance (minimum 19') from the roadway. When constructing the steel pole foundation, the top of the foundation shall be even with sidewalk or between 3-6" above grade when no sidewalk is present. For more information on mast arms refer to the **SCDOT Engineering Directive Memorandum 33**. and **SCDOT Standard Drawing** 675 115-02 (Traffic Signal Pole with Mast-arm).

JUNCTION BOXES, SPLICE BOXES AND CONDUIT

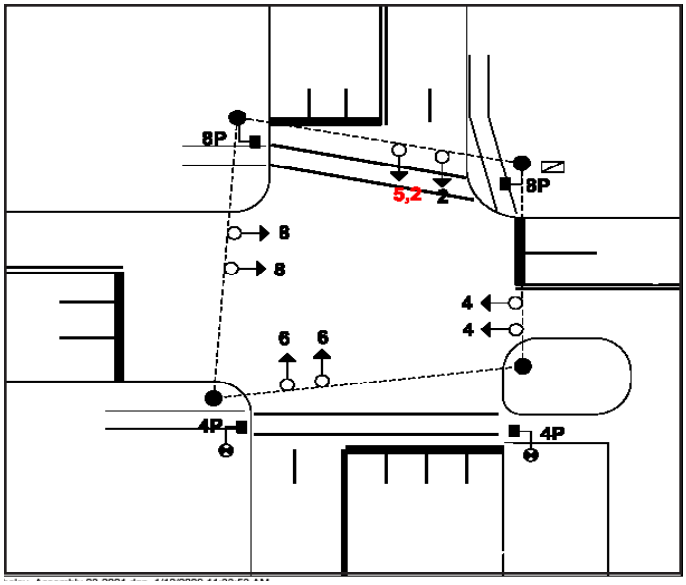
Examples:

SPANWIRE



Signal Heads

Figure 4-20



Numbering - Signal heads should be numbered according to the phase(s) to which they are wired. For example, Figure 4-20 shows the left-most five-section signal head would be number 5,2 because it is wired to phase 5 for the left-turn arrow and phase 2 for the through movement. Multiple signal heads wired to the same phase should be numbered according to that phase. When an overlap phase is used, signal heads should be numbered according to the overlap with which they are associated.

Note: The outside housing is highway yellow and the material is plastic.

Pedestrian intervals and the associated pedestrian signal heads running concurrently with the arterial phases should be numbered 2P and 6P, and those running with the cross-street phases, 4P and 8P. If pedestrian buttons only, that interval is labeled with the phase number and the letter B. (ex: 2B, 6B)

Placement - As shown on the drawing, the signal heads should be located between 40 and 180' from the stop bar for each approach. There should be a minimum of two signal heads per approach, and they should be within a 20-degree cone of vision. Signal heads should have a Minimum 8' apart and a Maximum 16' apart, 1 signal per lane for thru movements.
See **SCDOT Standard Drawings**.

Size - The SCDOT uses 12" section signal heads as a standard installation size. In special situations 8" signal heads maybe used, such as the bottom yellow on emergency flashers or the far-side green at a timed overlap for clearance.

Type - The **SCDOT Signal Specifications** specify using all LED signal heads (red, yellow and green) and LED pedestrian signals as well. LED's are used for reduced power consumption and for ease of maintenance scheduling.

Visibility - Both of the signal heads should be visible for the minimum distances shown in the **Manual on Uniform Traffic Control Devices** Chapter 4 for various approach speeds. If this visibility cannot be achieved, a near side signal head should be mounted to conform to these distances.

Overhead lane-control signs should be used for signalized intersections that include lane drops, multiple-lane turns, shared thru-turn lanes, and other unexpected lane use.

Red turn arrow - should be used for protected only left turn phases and placed within the 20-degree cone of vision for the exclusive left turn lane. This eliminates the use of the left turn signal sign.

Typical Signal Signs

Typical signal signs can be used to improve the safety or operation at a stop and go traffic signal. Guidelines for their use can be found in the Manual on Uniform Traffic Control Devices.
Chapter 2b - Regulatory Signs
Chapter 2C - Warning Signs.

Street Name Signs on Signal Span Wires or Mast Arms
To maintain uniformity in this type of signing SCDOT has developed a **TG-1 Guideline**.

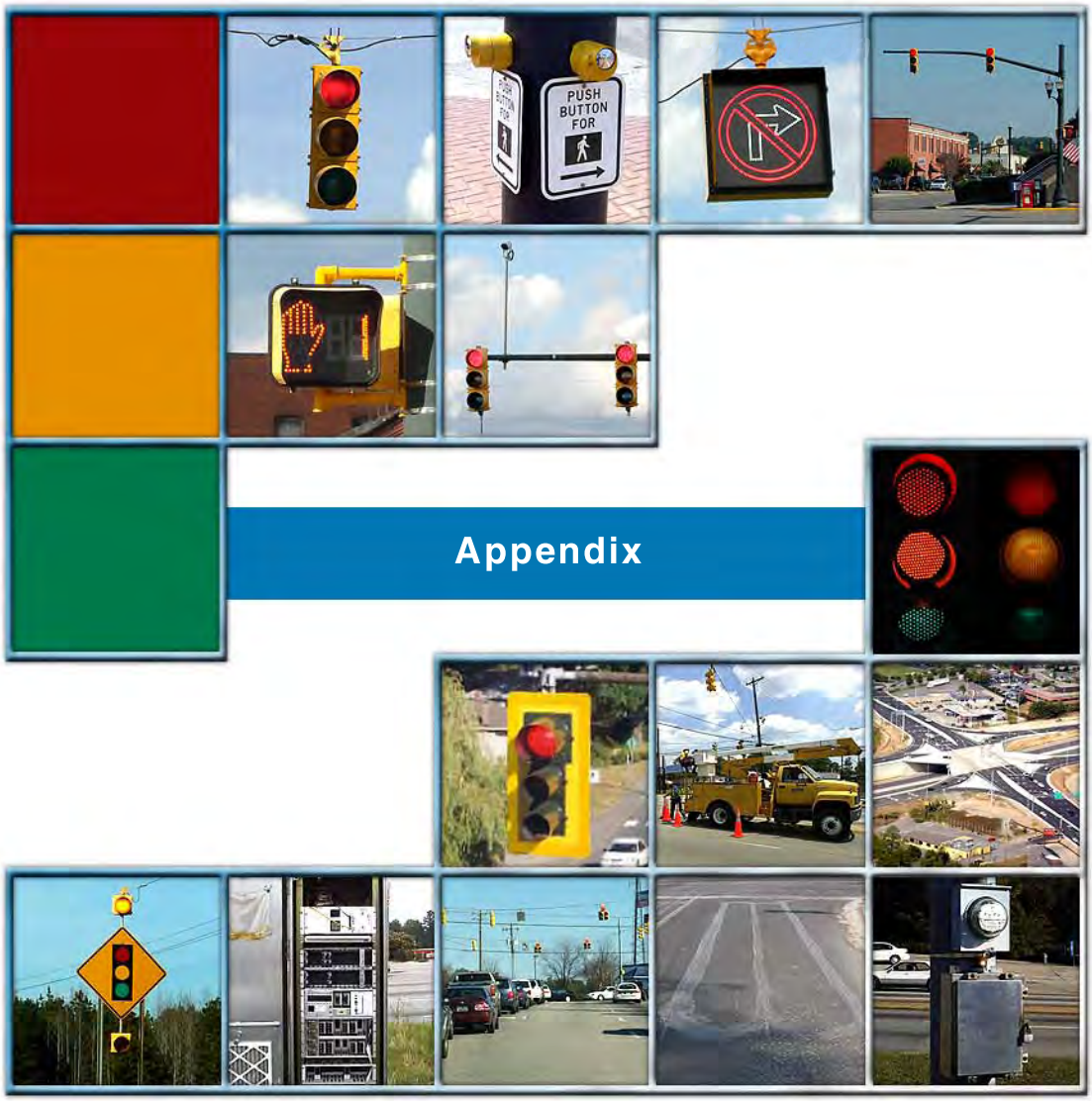
Advanced Street Name Plaques and Signs
SCDOT has a **TG-11 Guideline** for these signs.

Signal Quantities

The **Signal Equipment Catalog** is provided to give a method of measurement and basis of payment for materials used in the installation of traffic signals.

South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES



Appendix

FED. ROAD DIV. NO.	STATE	COUNTY	FILE NO.	PROJECT NO.	ROUTE NO.	SHEET NO.	TOTAL SHEETS
	S.C.	DORCHESTER	18.101B	24512	US 78		

SIGNAL EQUIPMENT

ONE (1) - 8 PHASE FULLY ACTUATED STANDARD 2070 CONTROLLER WITH FLASHER, SIGNAL MONITOR UNIT, AND BASE-MOUNTED 332A CABINET. EXT. PROP.

4 MODEL 222, (2)-CHANNEL VEHICLE DETECTOR UNITS

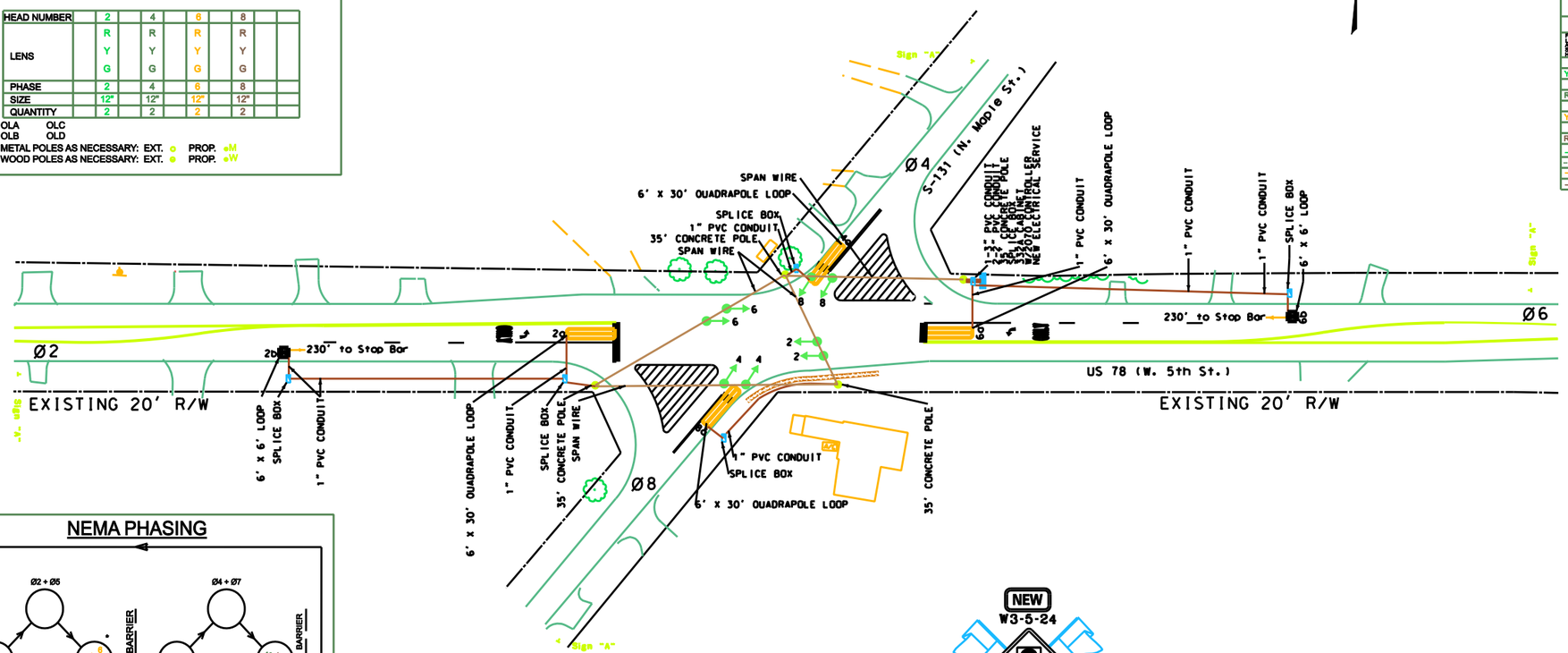
PEDESTRIAN SIGNALS: EXT. PROP. W/ACT. & SIGN

VEHICLE SIGNALS: EXT. PROP.

HEAD NUMBER	2	4	6	8		
LENS	R Y G	R Y G	R Y G	R Y G		
PHASE	2	4	6	8		
SIZE	12"	12"	12"	12"		
QUANTITY	2	2	2	2		

OLA OLC
OLB OLD

METAL POLES AS NECESSARY: EXT. PROP. M
WOOD POLES AS NECESSARY: EXT. PROP. W



SIGNAL DISPLAY SEQUENCE CHART

G-GREEN
Y-YELLOW
R-RED
G-G, ARROW
Y-Y, ARROW
W-WALK **
DW-DON'T WALK

PHASE ON (A)	NON-CONFLICTION PHASE (B)	CONFLICTING PHASE *
1	5, 6P	2, 4, 6, 2P, 4P, 8P
2	6, 2P, 8P	4, 6, 4P, 8P
3	8, 8P	2,4, 6,2P, 4P, 6P
4	6,4P, 8P	2, 6, 2P, 6P
5	2, 2P	4,6, 6,4P, 6P, 8P
6	2,2P, 8P	4, 8,4P, 8P
7	4,4P,	2, 6,8,2P, 6P
8	4,4P, 6P	2, 6, 2P, 6P

"C" = COORDINATE Ø2 ; Ø6

NOTE A: ANY ACTUATED PHASE FOR WHICH THERE IS NO CALL SHALL BE OMITTED.
NOTE B: WHEN ONE PHASE IS ON ALONE, ANY NON-CONFLICTING PHASE MAY START TIMING CONCURRENTLY WITHOUT A CLEARANCE INTERVAL (SEE CHART).
* CONFLICTING PHASES REQUIRE A CLEARANCE INTERVAL.

** WHEN CALLED, DISPLAY SOLID 'WALKING PERSON' AND TIMES OUT WALK TIMING; THEN DISPLAYS FLASHING 'UPRAISED HAND' AND TIMES WALK CLEARANCE (DON'T WALK TIMING), THEN DISPLAYS A SOLID 'UPRAISED HAND'.

SIGNAL DISPLAY SEQUENCE (PREFERENTIAL PHASING)

SIGNAL HEAD NUMBER	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	BARR.	Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	BARR.
	R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO				R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO			
Y	2	R	R	R	R	R	R	R		G						Y	R	
R	4	R	R	R	R	R	R	R		R						R	R	
Y	6	R	R	R	R	R	R	R		G						Y	R	
R	8	R	R	R	R	R	R	R		R						R	R	
–	2P	DW	DW	DW	DW	DW	DW	DW		*						DW	DW	
–	4P	DW	DW	DW	DW	DW	DW	DW		DW						DW	DW	
–	6P	DW	DW	DW	DW	DW	DW	DW		DW						DW	DW	
–	8P	DW	DW	DW	DW	DW	DW	DW		DW						DW	DW	

SIGNAL HEAD NUMBER	R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO				R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO			
Y	2	R	R	R	R	R	R	R		G						Y	R	
R	4	R	R	R	R	R	R	R		R						R	R	
Y	6	R	R	R	R	R	R	R		G						Y	R	
R	8	R	R	R	R	R	R	R		R						R	R	
–	2P	DW	DW	DW	DW	DW	DW	DW		*						DW	DW	
–	4P	DW	DW	DW	DW	DW	DW	DW		DW						DW	DW	
–	6P	DW	DW	DW	DW	DW	DW	DW		DW						DW	DW	
–	8P	DW	DW	DW	DW	DW	DW	DW		DW						DW	DW	

BARRIER

SIGNAL HEAD NUMBER	R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO				R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO			
Y	2	R	R	R	R	R	R	R		G						Y	R	
R	4	R	R	R	R	R	R	R		R						R	R	
Y	6	R	R	R	R	R	R	R		G						Y	R	
R	8	R	R	R	R	R	R	R		R						R	R	
–	2P	DW	DW	DW	DW	DW	DW	DW		*						DW	DW	
–	4P	DW	DW	DW	DW	DW	DW	DW		DW						DW	DW	
–	6P	DW	DW	DW	DW	DW	DW	DW		DW						DW	DW	
–	8P	DW	DW	DW	DW	DW	DW	DW		DW						DW	DW	

BARRIER

ALTERNATE PHASES

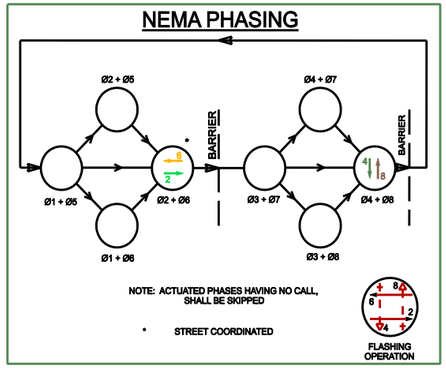
SIGNAL HEAD NUMBER	R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO				R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO			

ALTERNATE PHASES

SIGNAL HEAD NUMBER	R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO				R/W	Ø1-Ø6	Ø2-Ø6	Ø3-Ø6	Ø4-Ø6	CLEAR TO			

BARRIER

NEMA PHASING



SIGNAL TIMINGS

	PHASE 2	4	6	8
WALK				
DON'T WALK				
MIN INITIAL	15	8	15	8
MAX INITIAL				
ADD/VEH				
VEH EXT	3	3	3	3
TIM BFR REDUC				
TIME TO REDUC				
MIN GAP				
MAX LIMIT	30	15	30	15
MAXIMUM 2				
YELLOW	4	4	4	4
RED CLEAR	3	2	3	2

INTERVAL

LOOP DETECTOR INSTALLATION CHART

PHASE/ LOOP LTR#	DETECTOR AMP NO.	DETECTOR CHAN NO.	WIRED TO PHASE(S)	LOCK X	NON-LOCK X	PULSE X	PRES X	OPERATION DELAY SEC	OPERATION EXT SEC	SPECIAL FEATURES TIME OF DAY-TOD, SWITCHING, etc.	LOOP DESIGN SIZE X	NO.OF TURNS	DIST. FROM ℄
2a			2		x		x			QUAD	6' x 30'	2-4-2	50'
2b			2	x			x				6' x 6'	4	230'
4a			4		x		x			QUAD	6' x 30'	2-4-2	-10'
6a			6		x		x			QUAD	6' x 30'	2-4-2	50'
6b			6	x			x				6' x 6'	4	230'
8a			8		x		x			QUAD	6' x 30'	2-4-2	-10'

NEW
W3-5-24
W3-3-36

SIGN "A"
INSTALL APPROXIMATELY 650' FROM STOP BAR - US 78
INSTALL APPROXIMATELY 450' FROM STOP BAR - S-131

NOTE:
Coordinate with Existing Utilities for Placement of Conduit and Pole Foundations.

Install signal heads with backplates

Bore conduit under driveways

Tether Span Wire

SPECIAL PROJECTS & OPERATIONS ENGINEER

SOUTH CAROLINA REGISTERED PROFESSIONAL ENGINEER NO. 14773 V. CAROL JONES

FOR / CONSTRUCTION : _____ DATE

SCDOT
South Carolina Department of Transportation
Post Office Box 191
Columbia, South Carolina 29202 ©

This intersection border drawing including the information blocks contained within, is intended only for the specific purpose and client for which it was prepared. Reuse of and improper reliance on the sheet without written authorization from the SCDOT Traffic Engineering office is prohibited.

ROUTE NUMBER	US 78		S-131	
APPROACH DIRECTION	EB	WB	NB	SB
SIGNAL DESIGN SPEED	40	40	35	35
GRADE (%)	0	0	0	0

* ESTIMATED FILE #: SHEET #:

DATE	REVISIONS

SCDOT
SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION
ENGINEERING DIVISION
COLUMBIA , S.C.

SUBJECT TITLE: TRAFFIC SIGNAL PLAN

SPECIFIC LOCATION: INTERSECTION OF US 78(West 5th St) & S-131(Maple St)

CITY: SUMMERVILLE COUNTY: DORCHESTER

DESIGNED
DRAWN: EHC
CHECKED
REVIEWED
RECOMMENDED

APPROVED BY
DISTRICT # TRAFFIC ENGINEER ENGINEER

SCALE	DATE	SHEET NO.	INDEX NO.
1"= 40'		OF	

SIGNAL PLAN CHECKLIST
PROJECT NO._____
NUMBER OF SIGNALS_____
INTERSECTION_____

TYPE OF CONSTRUCTION
- ☐ NEW FACILITY
- ☐ RELOCATION
- ☐ WIDENING
- ☐ SAFETY
- ☐ INTERSECTION IMPROVEMENT

CHARTS
- ☐ SIGNAL EQUIPMENT BOX
- ☐ NEMA PHASES BOX
- ☐ SIGNAL TIMINGS BOX
- ☐ LOOP DETECTOR INSTALLATION CHART
- ☐ ENGINEERING SEAL
- ☐ SIGNAL DISPLAY SEQUENCE CHART
- ☐ MAP
- ☐ NOTES

DRAWING
- ☐ NORTH ARROW
- ☐ RIGHT OF WAY
- ☐ ROAD NAMES Example: US 78 (W. 5TH St.)
- ☐ STOP BARS
- ☐ CROSSWALKS
- ☐ SIDEWALKS
- ☐ ISLANDS
- ☐ DRIVEWAYS
- ☐ EXISTING POLES

SIGNAL EQUIPMENT (LABEL)
- ☐ DETECTORS + LABEL DISTANCE FROM STOP BAR
- ☐ SIGNAL POLES (CONCRETE, STEEL, WOOD AND HEIGHT)
- ☐ SPLICE BOXES
- ☐ PVC CONDUIT
- ☐ TRAFFIC SIGNAL HEADS
- ☐ PEDESTRIAN HEADS/BUTTONS
- ☐ CONTROLLER
- ☐ SPAN WIRE
- ☐ SIGNS

TIMINGS
- ☐ YELLOWS/REDS CHECKED W/SPEEDS & GRADES & GEOMETRY
- ☐ CHECK MIN AND MAX GREENS, PASSAGE, MAX 1 & 2 TIMINGS
- ☐ PED TIMINGS
- ☐ LOOP SETTINGS
- ☐ VOL DENSITY TIMINGS

OTHER

- ◻ LABEL LOCATION OF FILE ON OUTSIDE OF PLAN
  Example:ZALESKIWJ
  R:\SIGNAL PLANS/DISTICT 1/AIKEN GRANITEVILLE_SIGNAL.DGN
  17-OCTOBER-2006
- ◻ FILL OUT INFORMATION ON TITLE BLOCK
- ◻ QUANTITIES
- ◻ LOOP WIRE (1 COND), # DETECTORS, SAWCUT, GREY WIRE (4& 8 COND)
- ◻ CONTROLLER CABINET
- ◻ BLACK WIRE (4 & 8 COND)
- ◻ SIGNAL & PED HEADS, POLES, BUTTONS
- ◻ # POLES, GUYS
- ◻ SALVAGE MATERIAL
- ◻ NEW ELECTRICAL SERVICE
- ◻ TEMPORARY ADJUSTMENT OF EQUIPMENT/SITE VISIT FOR TIMING ADJUSTMENT

Reviewing Traffic Signals By Consultants (PS&E)

1. Make at least three copies of plans – a copy for your mark-up, a copy for district comments, and an extra. Keep originals and do not mark-up.

2. Review plans and mark your changes on one copy.

3. Contact District Traffic Engineer to determine if they are familiar with the project, and if they have any comments of preferences for the traffic signal(s). Set up a time to visit intersection(s).

4. Combine your remarks and district remarks on the extra set of plans.

5. Write summary of general comments and specific intersection

Guidelines for Traffic Signal Reviews

1. Ensure that the phases are oriented and labeled correctly. Is the north arrow oriented correctly?

2. Check roadway name and numbers.

3. Ensure loops are placed, sized, and labeled correctly. Are the loops that are located at the stop bars quadrapole loops? Why not?

4. Ensure that conduits, tether wires, and splice boxes are labeled and placed correctly.

5. If there are sidewalks, are there pedestrian signals? Are the pedestrian signals labeled correctly?

6. If there are sidewalks, are there crosswalks? How is the alignment with the corners?

7. If there are pedestrian signals, are they mounted on traffic signal poles or pedestrian poles? Are the pedestrian poles needed? Can the traffic signal poles be relocated to apply to both (adjacent) crosswalks?

8. Ensure that all accessories mounted on poles and pole lengths are labeled for each traffic signal pole.

9. Check the layout of the span wires. Is it appropriate? Is a box layout used? If not, why?

10. Ensure all signs and pavement markings are placed and labeled correctly? Are there any additional signs and pavement markings needed? Not needed?

11. Are concurrent lefts in conflicting turning patterns? Are the radii appropriate?

12. Are there any protected phases? Why?

13. Ensure that the proper information is listed in the **Signal Equipment** chart. Do the signal heads that are shown correspond to what is shown on the drawing? If there are pedestrian signals, is the Hand/Man, phasing, and quantities included?

14. Is there a **Signal Timing** chart? Is it the correct chart? If timings are provided, how were they generated? Is there a need for peek period (AM/PM) timing? Check reds and yellows?

15. Ensure that there is a **Loop Detector** chart. Is it appropriate? Does the information on the chart correspond to what is on the drawing?

16. Ensure that there is a **Controller Sequence Diagram** chart. Is the information provided correct? Has the information for unused phases been deleted?

17. Ensure that there is a chart for the street names & numbers, approach directions, speeds, and grades. Is the information provided correct?

18. Check the phasing on the **NEMA Phasing** chart. Do the phases correspond to the signal heads shown in the **Signal Equipment** chart and drawing?

19. Check the information provided in the title block. Is the scale appropriate and correct?

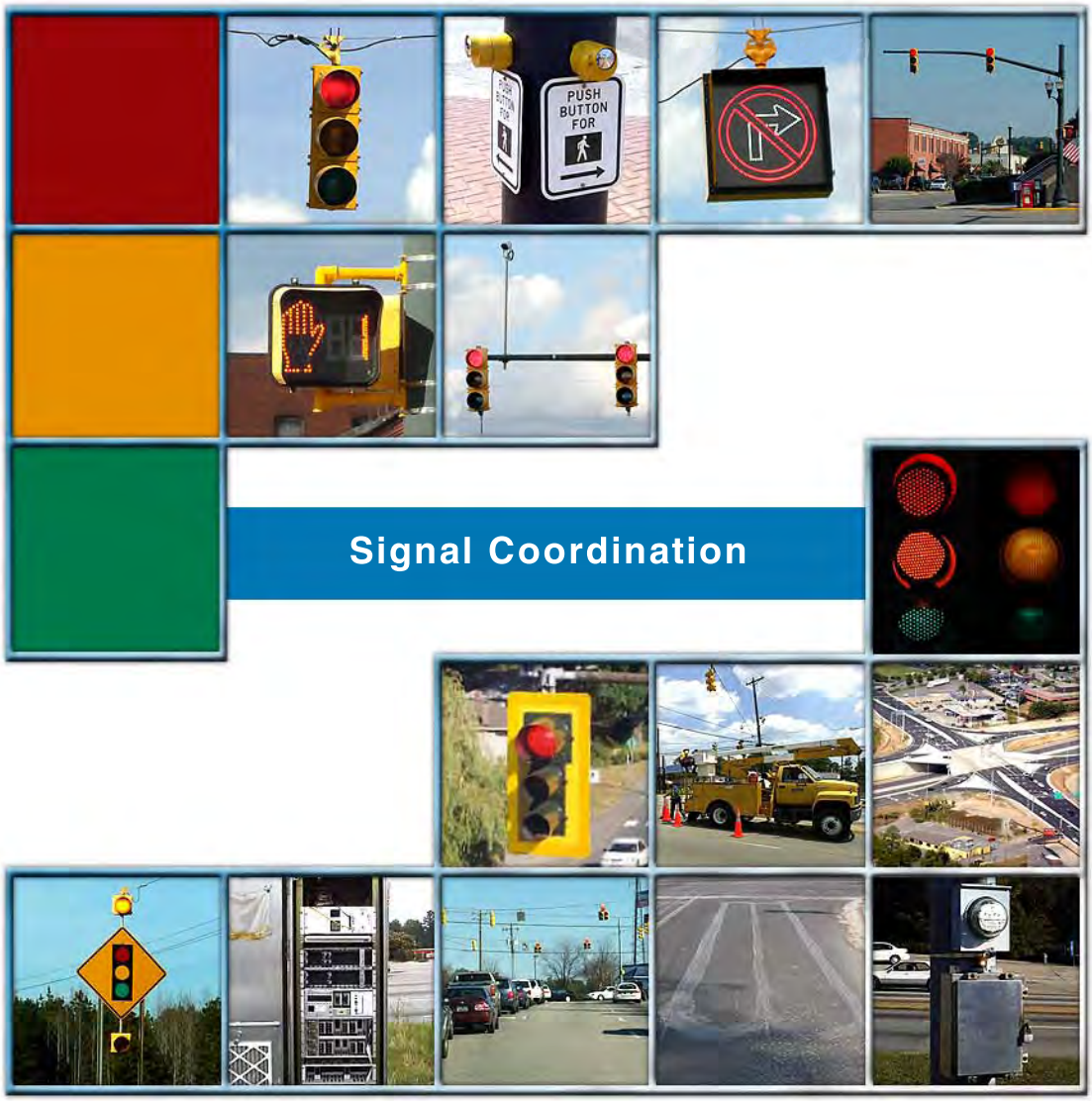
20. Is there any extra information provided on the plans, such as charts or notes? Is this information appropriate and correct? Do any notes need to be added to the plans?

21. Is there a Professional Engineer Seal and a SCDOT legal statement provided?

South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES

Chapter 5



Signal Coordination

Signal Coordination

The coordination of signals spaced no more than a quarter mile apart is desirable to promote a non-stopping flow of vehicles through the signalized area during peak traffic hours (a.m., noon, school dismissal, p.m.) during the weekday . This will improve the efficiency of traffic flow and minimize stops, delays and queueing.

Signal coordination can be established using Time Based Coordination (TBC) where the signals are not physically connected by hard wire, but instead uses the internal clock to time the coordination. Although this is the least costly method, drifting can occur, resulting in the signals being out of sync, and requiring a visit to each signal to make timing adjustments. Signals served from different power sources have a greater tendency to drift.

Another method of achieving coordination is by physically connecting the signal controllers together using hard wire, in the form of a copper interconnect, twisted pair, conductor cable, or fiber optics. Typically the most critical signal within the system is established as the master controller, in which changes to the other signals can be made. If a phone line or fiber optic connection is made back to the District or Headquarter's office, this 'system' can be remotely monitored and changes made based on planned or unplanned events such as evacuations, detours, or special events like football games, state fairs, etc.

A full signal system would have all the following elements, interconnected signals, on-site master, communications (phone lines, DSL, direct connect) to a remote location, plus system detection (loops, video detection) that feed traffic data information to a computing system that evaluates existing conditions. Video cameras may even be employed for observation purposes.

Timing plans

Time of Day Coordination:

There can be multiple groups of settings for time of day, day of week, week of year traffic needs,. There can even be special event timing plans.

The following is the timing and phasing information needed to establish these timing plans:

The cycle length must be the same or half the value of the cycle for all signals to be coordinated.

Cycle splits: The cycle split is the percent (or actual seconds) of time each phase is served, in relation to the over all cycle length. This is calculated by summing the maximum green, yellow and red time for each phase.

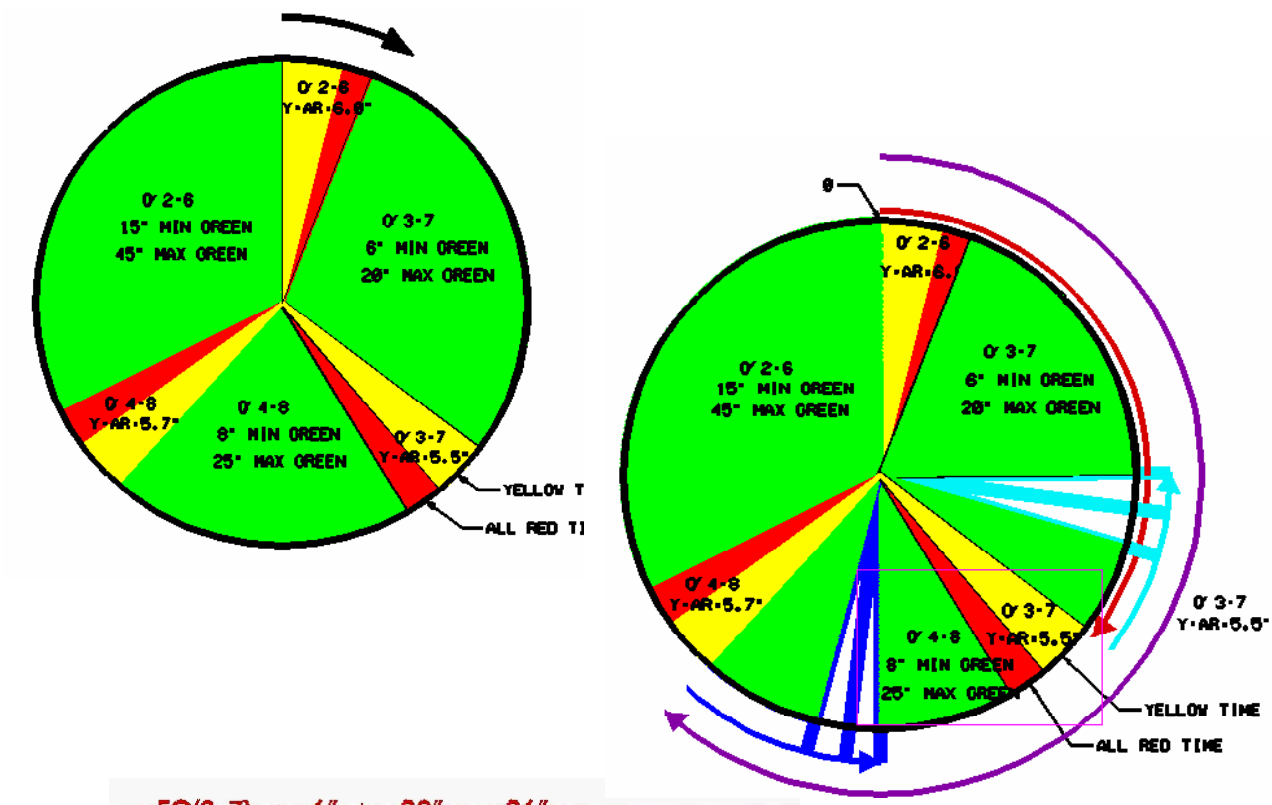
Phase Sequence: The phase sequence is the predetermined order the phases occur under steady demand.

Offset: This is a relational value calculated based on the speed of travel, the distance between intersections and the green time on the mainline roadway, using a time space diagram. The reference point in the phase is typically the beginning of yellow for the side street phase.

Force Off: Used to terminate side street green and is equal to the non-coordinated maximum green time (determined from time/space diagram) + coordinated phase clearance (yellow +all red) + any non-coordinated phases between this phase and the coordinated phase and their clearance

Permissive Period: Allows controller to yield if a call is placed shortly after the yield point, and is calculated by taking the non-coordinated phase force off and subtracting the sum of that phases initial + passage (minimum green time) and subtracting out the main street clearance (yellow + all red).

By example, using Figure 5-1 below, the force off would be calculated as follows:



FO(3–7) = 6″ + 20″ = 26″
FO(4–8) = 6″ + 20″ + 5.5″ + 25″ = 56.5″

PP(3–7) = 26″ – 6.0′ – 6.0″ = 14.0″
PP(4–8) = 56.5″ – 8.0″ – 6.0″ = 42.5″

Recall - This setting can be set to "MIN" or "MAX" for the phases desired for the controller to serve, regardless of traffic demand. Typically, phases 2 and 6 are set to 'MIN' recall.

Red Revert - (0-25.5 sec) applies to all phases that are programmed as red rest phases. This parameter insures that the phase will remain in red rest for the minimum period specified before the phase is re-serviced.

Float - Phases other than the coordinated phase(s) are active for their assigned split time only. This causes unused split time to revert to the coordinated phase.

Fixed - Phases are forced-off at fixed points in the cycle. This allows unused split time of a phase to revert to the phases served next in the sequence.

Traffic Responsive Coordination -minimizes stops on high speed arterial or in a grid of regularly spaced intersections by split control and cycle length selection.

Traffic Adaptive Coordination - minimizes stop delay in an open network of roadways with similar characteristics by reducing cycle lengths and optimizing splits.

Synchro

Synchro can assist in the determination of cycle lengths and splits for isolated intersections or for signal systems where coordination is needed. Synchro will yield reports concerning level of service, delay, and queuing to assist in obtaining a starting point for signal coordination. Sim Traffic models the intersection or signal systems vehicle traffic and also has the ability to view data in 3D.

Figure 5-2

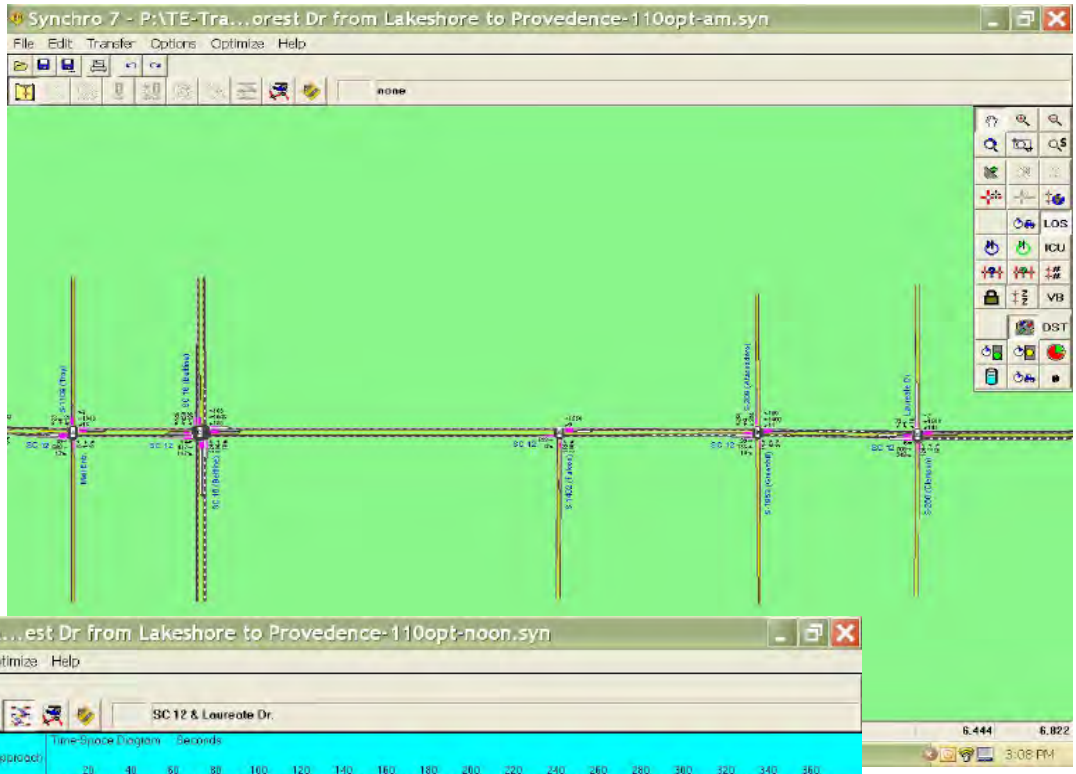
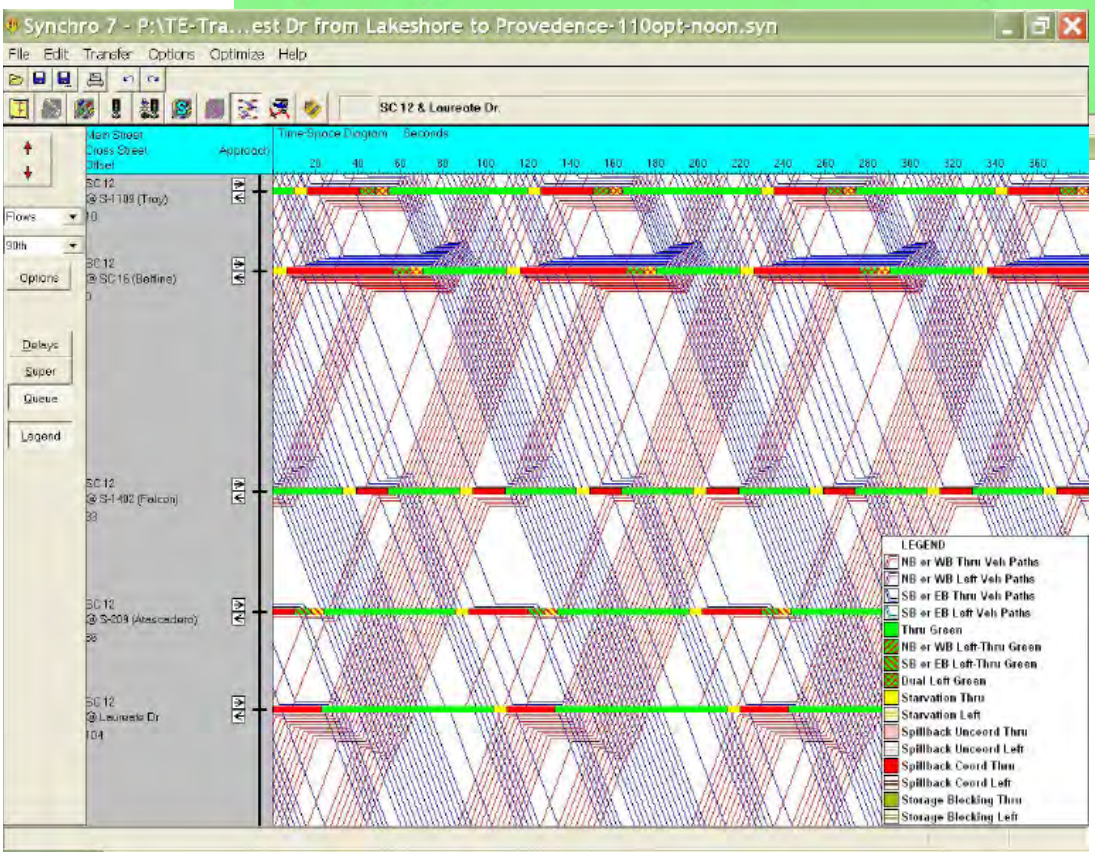


Figure 5-3



In addition, adjustments can be made to the automated time-space diagram to fine tune system timings and offsets.

Signal Coordination Timing Plans

The SCDOT has timing sheets for 170 and 2070 controllers. Once Coordination is determined it is logged on these timing sheets and sent to the district signal shop for installation in the controllers. Once the signal timing has been programed for the intersection or system, there will be a field review by the Engineer to determine if any timing changes need to be implemented.

Signal Retimings

Signal retimings should be considered at least every 3 years.

Several changes to signalized intersections warrant the retiming of traffic signals.

1. When a new signal is added or a signal is updated
2. When traffic or pedestrian volumes, or turning movements change significantly
3. When access to a roadway changes
4. When there is a change in the geometry of a roadway.

This information came from ITE, "Traffic Control System Operations: Installation, Management and Maintenance"

Notes on 170 timing sheets:

The Min Green and Max Green times may be overridden when the signal is operating a coordination plan

Second Maximum (Max II) - instituting a Max II for a certain time of day will override the maximum time for that time period. This may be used if you have a intersection leg that may need more extended time during a certain time of day (Ex: school, industry)

Figure 5-4: assigns the calculated phase timings per phase.

Table 1- Phase Timings

0+Key			Phase+Key		Phase							
FUNCTION	KEY	12345678	FUNCTION	KEY	Ph 1	Ph 2	Ph 3	Ph 4	Ph 5	Ph 6	Ph 7	Ph 8
Vehicle Recall	0	2 6	Max I	D	25	22	10	50	22	25	10	50
Ped Recall	1	2 6	Max II/HFDW	1								
Red Lock	2		Walk	2		7						7
Yellow Lock	3		Flashing DW	3		18						18
Permits	4	2 4 6 8	Max Initial	4								
Ped Phases	5	2 4 6 8	Min Green	5	8	15	8	15	8	15	8	15
Lead Phases	6	1 3 5 7	TBR	6								
Double Entry	7	2 4 6 8	TTR	7								
Sequential Timing	8		Observe Gap	8								
Startup Green	9	2 6	Passage	9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Overlap A	A		Min Gap	A	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Overlap B	B		Added Actuation	B								
Overlap C	C		Yellow	C	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Overlap D	D		Red Clear	D	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.0
Exclusive	E		Red Revert	E	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Simultaneous Gap	F	2 4 6 8	Walk II	F								

Intersection Street A & Street B

System Signal System

Extras:

No Coor. Ped Recall D+3+E= 1 So that peds will not be automatically recalled

Local Operating Mode B+D+4= 1 for T.O.D. operation
3 for Sys. operation

Max Recall C+F+B= Ph. 1-8

Left turn Trap Protection A+3+A= 2 for Prot/Perm

Figure 5-5: assigns a function for a time of day. The Day Plan assigns a function, the function drives the coordination plan.

Day of Week

6:30-9:00 AM Mon-Fri

4:00-7:00 PM Mon-Fri

TABLE 5 TOD EVENTS

System:

A+Code

EVENT	1234567	HOUR	MIN	FUNC	CODE	EVENT	1234567	HOUR	MIN	FUNC	CODE
1	23456	6	30	1	80-83	17		0	0	0	C0-C3
2	23456	9	0	3	84-87	18		0	0	0	C4-C7
3	23456	16	0	2	88-8B	19		0	0	0	C8-CB
4	23456	19	0	3	8C-8F	20		0	0	0	CC-CF
5	23456	22	0	20	90-93	21		0	0	0	D0-D3
6	1 7	6	30	3	94-97	22		0	0	0	D4-D7
7	1 7	22	0	20	98-9B	23		0	0	0	D8-DB
8		0	0	0	9C-9F	24		0	0	0	DC-DF
9		0	0	0	A0-A3	25		0	0	0	E0-E3
10		0	0	0	A4-A7	26		0	0	0	E4-E7
11		0	0	0	A8-AB	27		0	0	0	E8-EB
12		0	0	0	AC-AF	28		0	0	0	EC-EF
13		0	0	0	B0-B3	29		0	0	0	F0-F3
14		0	0	0	B4-B7	30		0	0	0	F4-F7
15		0	0	0	B8-BB	31		0	0	0	F8-FB
16		0	0	0	BC-BF	32		0	0	0	FC-FF

Free (Non-coordinated Operation)

TOD Events

TOD/DOW FUNCTION CODES	ON	OFF
Coordination plans	1--20	20=Free
Detector Reset Pulse	23	
Red Rest	25	24
Max. Recall	27	26
Ped Recall	29	28
Max II	129	128
Detector count (15 min)	131	130
Detector Count (60 min)	132	130
Clear detector count log	133	
Detector Diag. On	136	135
Detector Diag. On Test only	137	135
Clear Detector Diag. Log	138	
Send real Time	199	

Figure 5-6 - Coordination Plans - Defines a cycle length, gives an offset, and assigns forceoff timings for each phase to a specific coordination plan.

Sheet 1	**Table 7 - Coordination Plans**									
B+Plan+Key		Plan								
FUNCTION	KEY	1	2	3						
Cycle Length	0	90	90	80						
Forceoff Phase 1	1	48	42	43						
Forceoff Phase 2	2	—	—	—	—	—				
Forceoff Phase 3	3									
Forceoff Phase 4	4	29	25	28						
Forceoff Phase 5	5									
Forceoff Phase 6	6	—	—	—	—	—				
Forceoff Phase 7	7									
Forceoff Phase 8	8	29	25	28						
Offset	9	85	2	6						
Permissive Length	A	6	8							
Max Dwell	B									
		12345678	12345678	12345678	12345678	12345678	12345678	12345678	12345678	12345678
Lead Phases	C	1 3 5 7	1 3 5 7	1 3 5 7						
Coord Phases	D	2 6	2 6	2 6						
Perm 2 Phases	E									
Min Recall	F	2 6	2 6	2 6						

Sheet 2		Plan 10	Plan 11	Plan 12	Plan 13	Plan 14	Plan 15	Plan 16	Plan 17	Plan 18
B+D+Key1+Key2		Key 1								
FUNCTION	KEY	1	2	3	4	5	6	7	8	9
Cycle Length	0									
Forceoff Phase 1	1									
Forceoff Phase 2	2									
Forceoff Phase 3	3									
Forceoff Phase 4	4									
Forceoff Phase 5	5									
Forceoff Phase 6	6									
Forceoff Phase 7	7									
Forceoff Phase 8	8									
Offset	9									
Permissive Length	A									
Max Dwell	B									
		12345678	12345678	12345678	12345678	12345678	12345678	12345678	12345678	12345678
Lead Phases	C									
Coord Phases	D									
Perm 2 Phases	E									
Min Recall	F									

TITLE : Bush River Road
LOCATION OF INTERSECTION : Outlet Point Blvd.
CITY : Columbia
COUNTY : Lexington

Figure 5-7: Notes on 2070 timing sheets:

Times table- For free operation. The Min Green and Max times maybe overridden when the signal is operating a coordination plan

Pattern table - For coordination plans. Assigns a cycle length, offset, and a sequence plan to a specific split table. Only one pattern may be active at a time.

Split table - references the pattern table, assigns a split time for each phase.

Coord Modes table - provides basic features related to coordination and applies to all coordination patterns and may not be modified by time of day

Max 1, Max 2, or Max Inhib

Float, Fixed, or Other

Unit Params - assigns controller operation

STD 8 - used for most intersections or QuSEQ - used for split phased intersections

Options table -assigns operations to phases

Day Plan - assigns an action for a time of day, the action calls a pattern.

Times [1.1.1]	1	2	3	4	5	6	7	8
Min Green		20		6		20		6
Gap, Ext		3		3		3		3
Max 1		45		30		45		30
Max 2								
Yel Clear		5		4		5		4
Red Clear		2		2		2		2
Walk		7		7				7
Ped Clear		9		12				12
Red Revert								
Add Initial								
Max Initial								
Time B4 Reduct								
Cars B4 Reduct								
Time to Reduce								
Reduced By								
Min Gap		3		3		3		3
DyMaxLim								
Max Step								
Options [1.1.2]	1	2	3	4	5	6	7	8
Enable		1		1		1		1
Min Recall		1				1		
Max Recall								
Ped Recall								
Soft Recall								
Lock Calls		1		1		1		1
Auto Flash Entry				1				1
Auto Flash Exit		1				1		
Dual Entry		1		1		1		1
Enable Simul Gap		1		1		1		1
Guarantee Pass.								
Rest in Walk								
Condition Serv.								
Non-Actuated 1								
Non-Actuated 2								
Add Init Calc								
Options [1.1.3]	1	2	3	4	5	6	7	8
Reservice								
PedClr Thru Yel								
Skip Red No Call								
Red Rest								
Max II								
Conflicting Pha								
Conflicting Pha								
Omit Yellow								
Ped Delay								
Grn/Ped Delay								

System: Bush River Rd
Intersection: Independence Blvd

pat#	Cyc	Off	Split	Seq	pat#	Cyc	Off	Split	Seq	pat#	Cyc	Off	Split	Seq	pat#	Cyc	Off	Split	Seq
1	90	28	1	1	13					25					37				
2	90	25	2	1	14					26					38				
3	90	13	3	1	15					27					39				
4					16					28					40				
5					17					29					41				
6					18					30					42				
7					19					31					43				
8					20					32					44				
9					21					33					45				
10					22					34					46				
11					23					35					47				
12					24					36					48				

Split		1	2	3	4	5	6	7	8	Split		1	2	3	4	5	6	7	8
1	Coord		61		29		61		29	13	Coord								
in	2		Max				Max				2		Max				Max		
2	Coord		61		29		61		29	14	Coord								
ave	2		Max				Max				2		Max				Max		
3	Coord		61		29		61		29	15	Coord								
out	2		Max				Max				2		Max				Max		
4	Coord									16	Coord								
in	2		Max				Max				2		Max				Max		
5	Coord									17	Coord								
ave	2		Max				Max				2		Max				Max		
6	Coord									18	Coord								
out	2		Max				Max				2		Max				Max		
7	Coord									19	Coord								
in	2		Max				Max				2		Max				Max		
8	Coord									20	Coord								
ave	2		Max				Max				2		Max				Max		
9	Coord									21	Coord								
out	2		Max				Max				2		Max				Max		
10	Coord									22	Coord								
	2		Max				Max				2		Max				Max		
11	Coord									23	Coord								
	2		Max				Max				2		Max				Max		
12	Coord									24	Coord								
	2		Max				Max				2		Max				Max		

DayPlan1 M-F			
	Hour	Min	Act
1	0	0	99
2	7	0	1
3	9	0	2
4	16	0	3
5	18	30	2
6	22	0	99
7			
8			

Act 99 = free

DayPlan2 Sat&Sun			
	Hour	Min	Act
1	0	0	99
2	8	30	2
3	20	0	99
4			
5			
6			
7			
8			

DayPlan3			
	Hour	Min	Act
1			
2			
3			
4			
5			
6			
7			
8			

Notes

2	4
6	8

STD8

Ring/Startup [1.1.4]			
Phs	Ring	Start	Enable
1	1	RED	1
2	1	Green	1
3	1	RED	1
4	1	RED	1
5	2	RED	1
6	2	Green	1
7	2	RED	1
8	2	RED	1

Coord Modes [2.1]	
Test OpMode	0
Correction	SHRT/LNG
Maximum	Max inhib
Force-off	FLOAT
Closed Loop	ON
Stop-in-Walk	ON
Auto Rest	ON
Expand Split	ON
Ped Recycle	No Recycle
Before	Timed
After	Timed

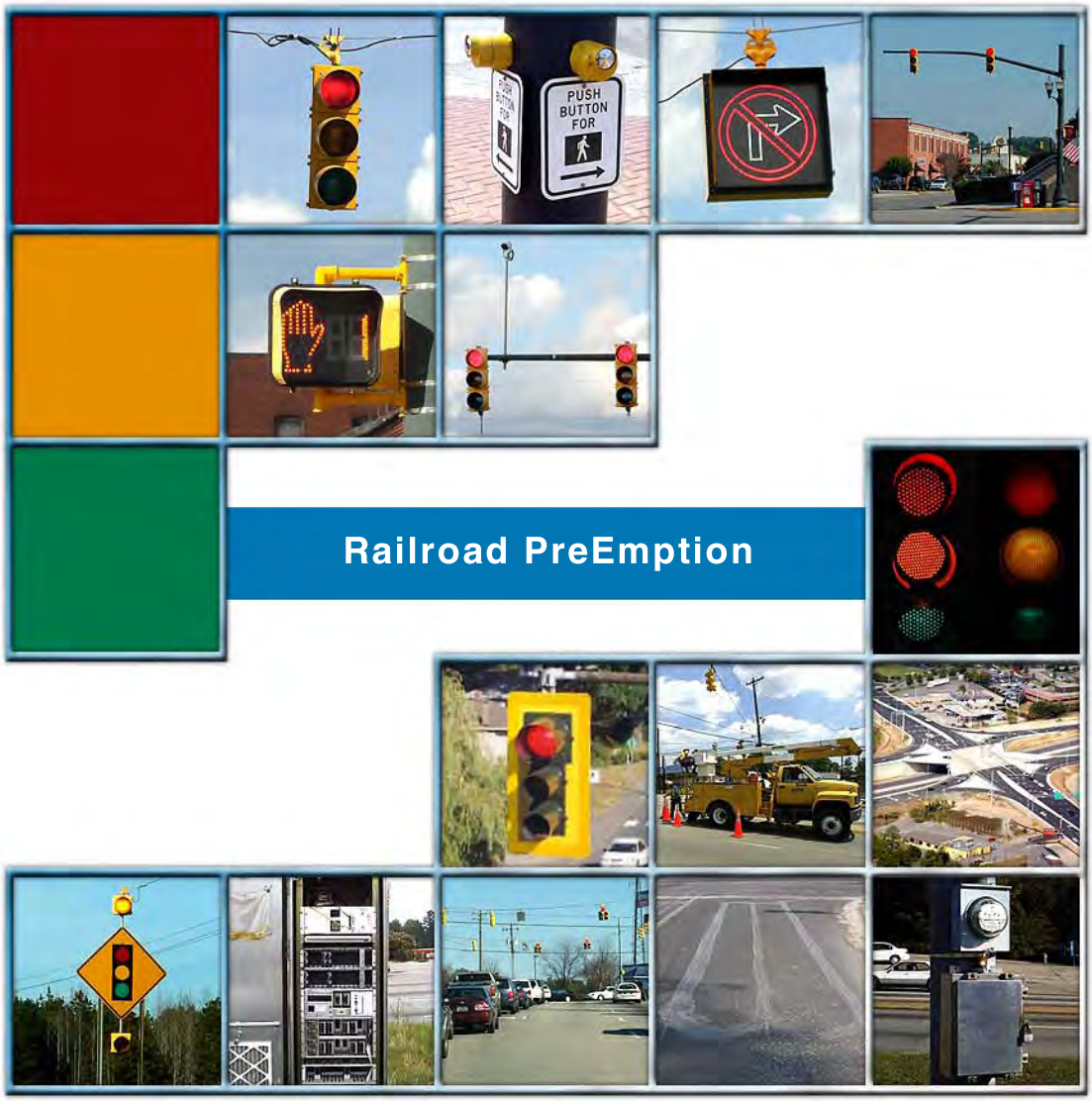
Auto Flash [1.4.1]	
Auto Flash	PH OVER
Flash Yel	2 6
Flash Red	4 8

Unit Params [1.2.1]	
Phase Mode	STD8
IO mode	Mode 0
Loc Flsh Start	ON
Start Flash(s)	0
Star ALLRed	0
Yellow < 3	OFF
Display Time	15
Red Revert	4
MCE Timeout	0
Feature Profile	0
Free Ring Seq	1
Auxswitch	STOPTM
SDLC Retry	0
TS3 Dir Fault	OFF
Auto Ped Clear	OFF
SDLC Retry	0

South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES

Chapter 6



Railroad PreEmption

Railroad Preemption Design

As indicated in the Traffic Control Devices Handbook, "The highway-rail grade crossing is a unique intersection serving several modes of transportation." As such, particular attention has been applied to those locations where there are two active modes of traffic control, active railroad warning devices and traffic signals. When these two traffic control devices are in close proximity, it is imperative that they work together to prevent confusion to the motorist. Therefore, these guidelines have been written to assist the engineer in designing and reviewing those locations where traffic signals are preempted by active railraod warning devices. In addition, guidance is given to assist the engineer in making a decision concerning the need for interconnection, based on nationally accepted practice.

As of January 2009, South Carolina has 168 railroad crossings where traffic signals are or have been interconnected with and preempted by active railroad warning devices. There are eight railroad companies in South Carolina that our signals are or have been interconnected with, as shown in Chart 6-2 below:

District	Number of Preempted Railroad Crossings
1	46
2	11
3	37
4	22
5	20
6	21
7	11
Total	168

Chart 6-1

District	1	2	3	4	5	6	7	Total
CSX RR	22	8	7		8	14	8	67
NS RR	18	2	19	22		5	3	69
CPRR		1	7					8
SCC					8			8
MID RR (CALA)					4			4
PKN			2					2
PYRL RR						1		1
USN						1		1
not listed	6		2					8
Total	46	11	35	22	20	21	11	168

Chart 6-2

For more information on Railroad Signal Studies refer to **SCDOT Engineering Directive Memorandum 2.**

Chapter 4 of the **Manual on Uniform Traffic Control Devices** covers the preemption and priority control of traffic control signals and Chapter 8 of the **Manual on Uniform Traffic Control Devices** covers traffic controls for highway-rail grade crossings.

Measuring Track Clearance Distance (TCD) & Clear Storage Distance (CSD) Area

As indicated in the glossary of terms, there are two distinct areas that should be measured to determine the appropriate design of the pre-emption operation and track clearance time.

- The Track Clearance Distance (TCD) is measured from 6′ downstream of the rail to 12′ upstream from the centerline of the rail. The national terminology indicates a couple of other areas that could be the measuring point, upstream of the rail, including the railroad stop bar on the track approach or the railroad-warning device. The Department typically uses the 6′ and 12′ measurement.

If the track and the roadway are not perpendicular, care should be taken to measure the longest distance, using either the edge of pavement or the centerline, depending on the skew. The longest TCD should be measured for the track clearance calculation.

- The Clear Storage Distance (CSD) is measured from the edge of the TCD (6′ from the rail) to the stop bar or the normal stopping point of the adjacent signalized intersection.

If the track and the roadway are not perpendicular, care should be taken to measure the shortest distance, using either the edge of pavement or the centerline, depending on the skew. The shortest CSD should be measured for the track clearance calculation.

Figures 6-1 to 6-3 are provided for assistance in determining the appropriate measurement of the TCD and the CSD.

Further **terminology** can be found in the Appendix 6:1.

Figure 6-1

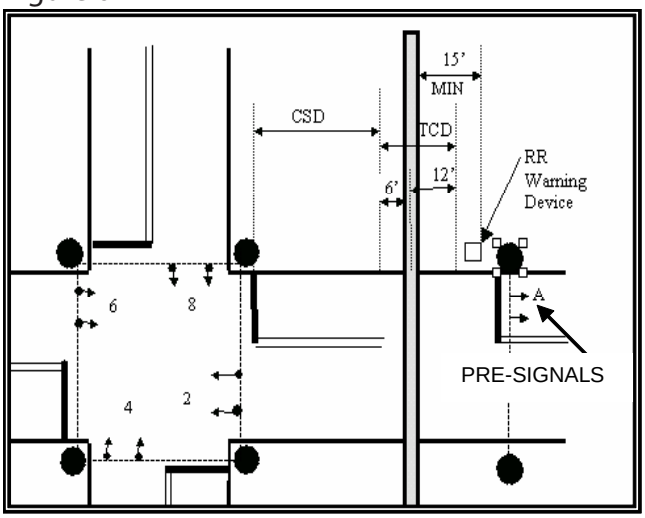


Figure 6-2

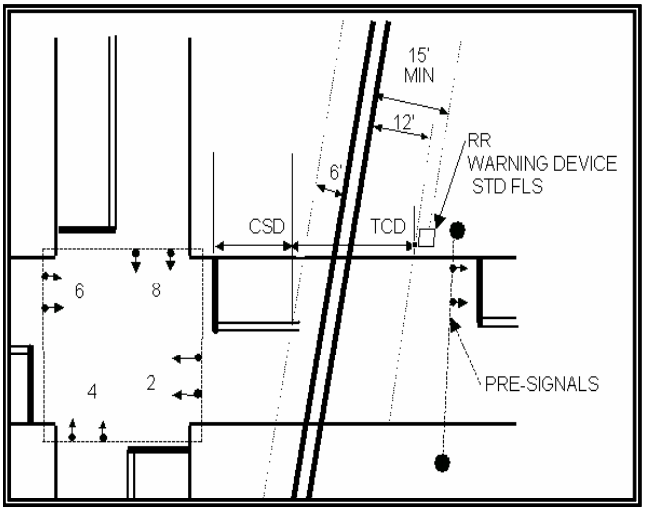
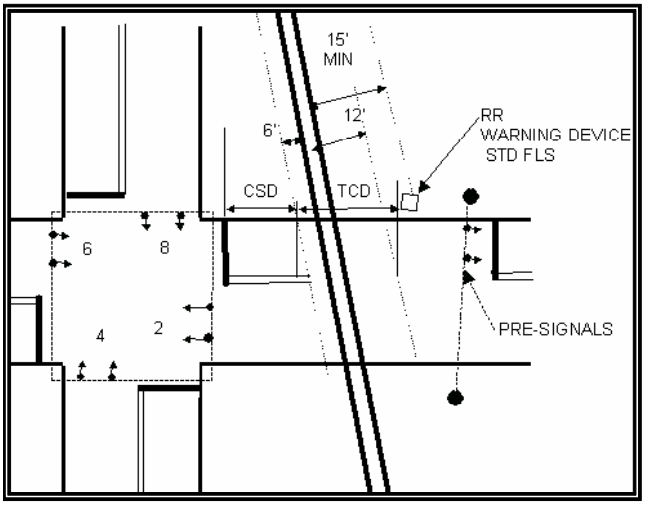


Figure 6-3



Criteria for Interconnection

Below are the items to consider when determining if interconnection is needed at existing traffic signals (all should be met):

- Rail crossing is typically within 200' of signalized highway intersection (Not limited to 200', but rarely greater than 500')
- Queuing regularly[1] occurs within Track Clearance Distance
- Signal timing adjustments do not resolve regularity of queuing
- Signal timings that are needed to serve motor vehicles result in queuing across crossing.
- Active railroad warning devices are existing or planned
- Train speeds exceed 20 mph

Design Methodology

Conduct Field Review - Review location in field/plan to obtain the as built signal design including the following information:

- Existing signs and markings, utilities & signal components
- Existing/proposed active railroad warning devices (gates, flashers), cabana
- Clear Storage Distance (CSD), Track Clearance Distance (TCD)
- Traffic Signal Operation

Calculate Needed Queue Clearance Time - to Calculate the needed queue clearance time use chart and/or field observations.

Determine Storage Availability - Determine if adequate storage is available in the CSD for the vehicles. If not, provide stop bar in advance of track with detection device for those vehicles unable to store in CSD without overhanging into the TCD area; if CSD is severely limited, consider stopping all vehicles in advance of track, using "Stop Here on Red" signs

Determine if pre-signal is needed - If railroad gates are not present or planned, and the geometric design of the intersection allows vehicles to store between the intersection and the at-grade crossing (within the CSD), a pre-signal should be provided. If advanced preemption (not simultaneous preemption) is provided, consider using pre-signals to control traffic since railroad warning devices will not be activated until after our preemption clear sequence has begun. If timed overlap is used, presignals would be needed even if gates are present.

If used, install two pre-signals or one dual red, 4-section signal head.

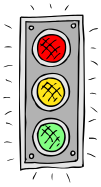
- If pre-signal is used, provide stop bar in advance of the at-grade crossing.

Typically, pre-signals are placed on the approach side of the crossing and care should be taken to prevent their placement from blocking the visibility of any overhead railroad flashers. Pre-signals are supplemental traffic control equipment, to reinforce the message the railroad's active warning devices are displaying. As such, they are targeted more so at motorists approaching the rail/grade crossing.

1 *Regularly means during normal peak traffic times, queuing occurs within TCD area. This can be determined by observation or see "Design Guidelines for Railroad Preemption at Signalized Intersections" ITE Journal, February 1997, for estimating queues. Other publications for additional design information are "Preemption of traffic Signals at or Near Railroad Grade Crossings with Active Warning Devices, #RP-025A, ITE, 1997, "Traffic Control Devices Handbook, Chapter 11, Draft - March 2001, Implementation Report of the USDOT Grade Crossing Safety Task Force, June 1, 1997, USDOT*

It is desirable to place the pre-signals where they would be visible from the stop bar on the upstream side of the crossing. However in many cases, the appropriate stopping point for motorists waiting on a train to clear the track is too close to the crossing for the Department to be able to obtain 40′ between pre-signals and stop bar. The engineer should attempt to obtain the maximum distance between the pre-signal and stop bar possible, not to exceed a reasonable stopping distance for motorists approaching the grade crossing. Acceptable methods of increasing this visibility are shown at the end of the railroad section of this document.

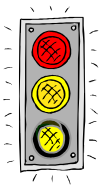
Determine what type pre-signal is needed:



One type of pre-signal is the **"R, Y, G"** signal, used to operate a timed overlap that "clears" the TCD during both normal and preempted signal operation. A timed overlap extends the green time on the same approach, at the downstream intersection signal heads, while the "pre-signal" (upstream in advance of the RR crossing) heads clear to yellow and red. The green is typically extended 3 to 5 seconds, based on the TCD & CSD distance. During preemption, the green time may be extended for a greater period of time than during normal operation, if necessary.

These are often used when the CSD is too small to store vehicles, but where it is not practical to stop all vehicles in advance of the crossing. These are also used when a frontage road (parallel and adjacent to the track on the upstream side of the crossing) exists to prevent blocking of the frontage road.

These pre-signals may be used regardless of the type of active railroad warning device and should be designed to operate effectively during both normal operation and preempted operation.



Another type of pre-signal is the **"R, Y, Y"** signal, where the bottom section is an 8″ section yellow, while the top and middle sections are 12″ red and yellow sections, respectively. During normal operation, the bottom yellow section flashes yellow at all times. Upon preemption activation, the signal display changes from flashing yellow on the 8″ head to a solid yellow on the middle head and then a solid red on the top head, and remains solid red until the preemption call is dropped. These pre-signals serve as a supplemental indication at those locations that serve a track clearance phase during preemption.

This type of pre-signals should be installed if railroad gates are not present and a track clearance phase is planned to operate within the preemption sequence.

An I**nterconnected RR/Traffic Signal Preemption Operation Design & Annual Inspection Form** can be found in Appendix 6:2.

Acceptable methods of increasing pre-signal visibility

1. Placing pre-signals on upstream side of rail/grade crossing, as close as possible to active warning devices. Place stop bar as far a feasible from the active warning device, between 15 and 40'.

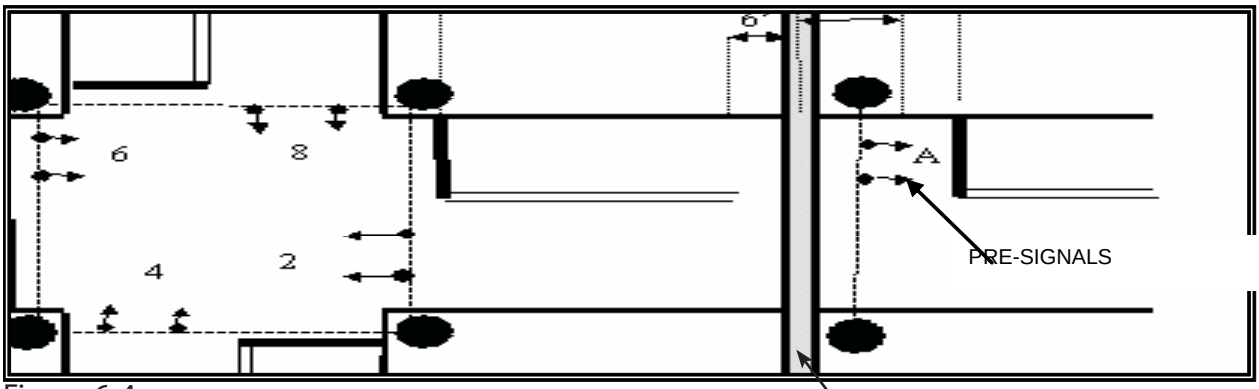
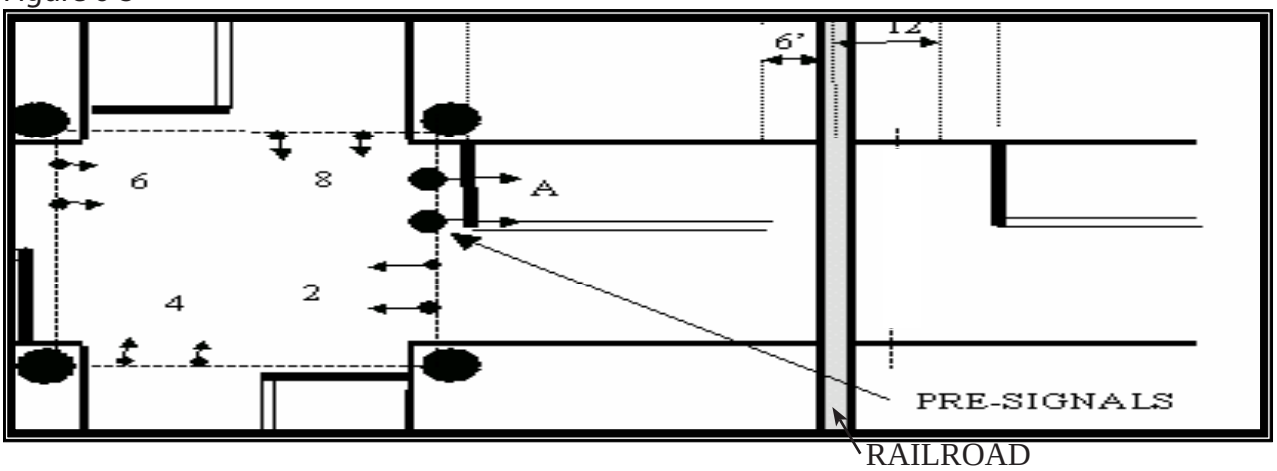


Figure 6-4

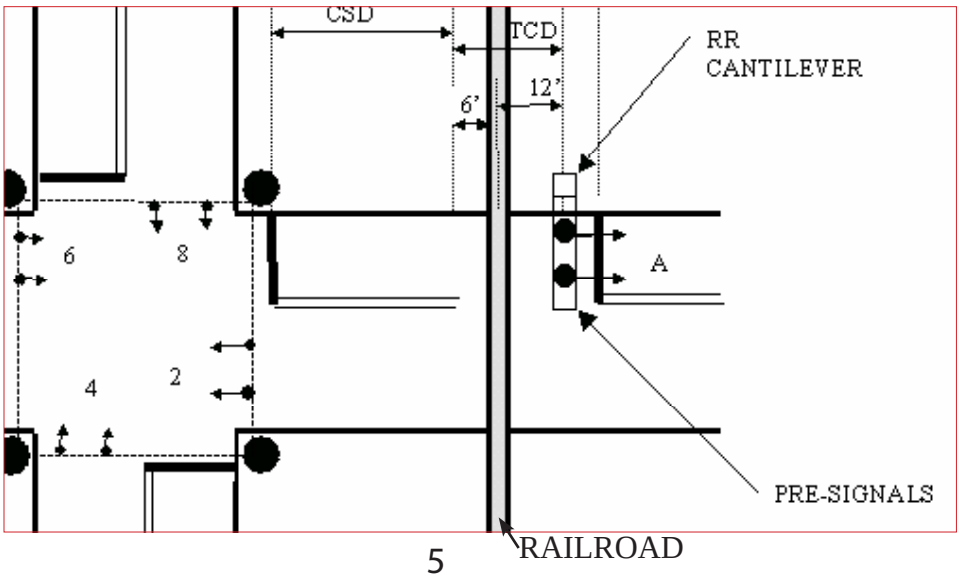
2. Placing the pre-signals on the downstream side of the rail/grade crossing either mounted separately or on the near side intersection signal span wire (When the train occupies the crossing, the visibility of these signal heads may become blocked by the train.)

Figure 6-5



3. Placing the pre-signals on the railroad's cantilever structure (must obtain permission from the railroad)

Figure 6-6



Calculate Maximum Signal Preemption Time

Calculate Maximum Signal Preemption Time by summing the Right of Way Transfer Time (RTT), Queue Clearance Time (QCT), and Separation Time (ST)

Right of Way Transfer Time

Right of Way Transfer Time (RTT) is the maximum amount of time needed for the worst-case condition, prior to display of the clear track green interval or the preemption hold interval. This includes any pedestrian clearance, minimum green, yellow change, and red clearance interval for opposing traffic. Check all possible phase combinations, using the maximum value to determine the needed TRWT by summing the factors (1-4) below (Use maximum value to determine MSPT):

Pedestrian Clearance - If pedestrian treatment is present or needed, certain measures must be implemented to ensure appropriate clearance is provided for both the pedestrian phase and the track clearance phase. If push buttons, only, are present, when preemption occurs, the controller may be programmed to immediately leave the current phase, serving only the yellow and red clearances. If pedestrian heads are existing or required, that cannot run simultaneous with the track clear approach, any pedestrian activation will have to be cleared prior to running the track clearance phase. The Walk phase may be immediately terminated, however a pedestrian clearance, a Flashing Don't Walk indication, must be served. This pedestrian clearance (flashing don't walk) time may be reduced upon preemption. To calculate this value divide the crossing distance by 5 feet/sec and subtract out the normal operation yellow and red clearances; If the Total Railroad Warning Time is severely limited the reduced clearance time may be shortened to run concurrently with the normal operation yellow and red time.

Minimum Green - Use only if engineering study indicates it is vital to safety of intersection and if adequate Railroad Warning Time is available.

Yellow Change - This is the normal operation yellow time for the phase that is operational when preemption occurs; do not reduce.

Red Clearance - This is the normal operation red time for the phase that is operational when preemption occurs; do not reduce.

Queue Clearance Time (QCT) - This is the "track clearance" time equal to the track approach green, yellow and red (optional), calculated by summing the Track Approach Green Time, the Yellow Time and the Red Time:

Track Approach Green Time (Some states extend this time until train arrival) There are two ways of calculating the track approach green time:

1. If Clear Storage Distance < Design Vehicle Length, the storage length to be cleared would be equal to Track Clear Distance + Clear Storage Distance. This will allow the design vehicle stopped within the TCD to clear the TCD area.

2. If Clear Storage Distance > Design Vehicle Length, the storage length to be cleared would be equal to the Track Clearance Distance

Use Greenshields formula &/or field observations to determine this time:

GS=4+2n

Greenshields = 4(start up time)+2 (headway) n (number of vehicles queued in area)

(Observations: observe and measure queue clearance times during peak traffic times and off peak times, noting operational characteristics of vehicles crossing and moving through the Clear Storage Distance & Track Clear Distance)

Yellow Time - normal operation yellow time for the track approach phase

Red Time- Optional; if used, normal operation red time for the track approach phase; do not reduce

Separation Time (ST) - The component of maximum preemption time during which the TCD is clear of vehicular traffic prior to the arrival of the train, 2 seconds minimum. Exception: If gates are present, the track clearance green may be programmed that will not allow a separation time to be present. The train may arrive at the crossing when the track clearance green, yellow or red is operating.

Railroad Company Information

The Railroad Companies are required to provide a minimum of 20 seconds of warning time at locations where train speeds are 20 mph or higher. According to AAR part 3.3.10, the Total Railroad Warning Time (TRWT) is calculated by summing the Minimum Warning Time, Clearance Time, Adjustment Time, & Buffer Time:

Minimum Warning Time (MWT) =20 seconds. The least amount of time active warning devices shall operate prior to the arrival of a train at a railroad grade crossing, per MUTCD and AAR Signal Manual, part 3.3.10.

Clearance Time (CT) - The MWT should be increased by 1 second for each 10' the TCD is > 35'.

Adjustment Time (AT) - Adjustments may be made to provide for 1) Equipment response time, 2) Gates- Note: Each gate arm shall start its downward motion not less that three seconds after flashing lights begin to operate and shall assume the horizontal position at least five seconds before the arrival of any train at the crossing, 3) Motion Sensitive systems or constant warning time system, as defined in AAR, part 3.3.10.

Buffer Time (BT) - may be provided in addition to MWT and CT (AAR Signal Manual, part 3.3.10)

Activation Distance (AD) - The distance the activation devices are from the at-grade crossing. If the TRWT is not provided, one can use this information and the maximum train speed to calculate a ballpark warning time provided by the railroad. If calculated, subtract out the activation time for the particular warning device, between 2-3 seconds.

Maximum Train Speed (MTS)- The maximum speed limit for trains approaching the at-grade crossing. If the TRWT is not provided,

one can use this information and the activation distance to calculate a ballpark warning time provided by the railroad. If calculated, subtract out the activation time for the particular warning device, typically less than 3 seconds.

Simultaneous vs. Advance Preemption

Simultaneous Preemption is the simultaneous notification of an approaching train to the highway traffic controller unit and railroad active devices at the same time.

Advance Preemption is prior notification of an approaching train to the highway traffic controller unit by railroad in advance of railroad active-warning device activation.

1. ***If Total Railroad Warning Time is greater than or equal to Maximum Signal Preemption Time:***

- Use Simultaneous Preemption, meaning the notification of an approaching train is forwarded to the highway traffic controller unit and railroad active devices at the same time. If needed, re-review signal operation to ensure operation is as desired.

2. ***If Total Railroad Warning Time is less than Maximum Signal Preemption Time:***

- Re-review signal operation and make adjustments to the "Maximum Signal Preemption Time" within engineering judgment.

- If MSPT cannot be reduced, determine how much additional time is needed and coordinate with Headquarters staff to obtain advanced preemption. Advance Preemption is prior notification of an approaching train to the highway traffic controller unit by railroad in advance of railroad active-warning device activation.

Operational Guidelines

Preemption Hold Interval - 1) limited service, 2) Flashing - a) all-way red flash or b) yellow/red flash.

- Limited Service allows certain phases, that do not conflict or direct traffic to the at-grade crossing, to operate a normal green, yellow, red sequence. These are typically feasible with multiple lane approaches where the mainline traffic runs parallel to the railroad track. Limited service allows the operation of turn phases as well as through phases, as long as traffic is not directed to the track area.

- Flashing operation best suits those areas that have one-lane approaches, where traffic volumes are either low on the side streets, or equal between mainline and side street. It is also used where the at-grade crossing crosses the mainline roadway. Flashing operation typically flashes red to the road perpendicular to the railroad track and yellow on the parallel roadway, however an all way red flash can also be used, as appropriate.

Exiting the Preemption Hold Interval (re-entering normal operation)

- Limited Service - Upon exiting limited service operation, the next served phase is typically the track approach. Exceptions may be where the turning movement across the track, from the parallel roadway, is heavy and large queues occur in this lane during limited service. Continued service to the parallel phase may be needed to allow the turn lanes to clear during gaps or

if no left turn trap would occur, service to a left turn phase across the crossing may be needed. Traffic counts and train passage schedules can assist in determining the most critical phase to be served after preemption. Normal clearance times must be served when exiting preemption dwell and entering normal operation.

- Flashing operation - There are several acceptable methods to exit a flashing operation:

1. First determine the first phase that needs to be served after preemption, as indicated in the limited service paragraph above. Then, if the flashing operation is all way red flash, simply serve the full all red clearance time, then advance to the phase to be served.

2. If the flashing operation is yellow/red, and the phase to be served next is on the flashing yellow approach, the flashing yellow can transition immediately to green. The perpendicular street transitions from flashing red to solid red.

3. If the roadway is flashing yellow/red, and the phase to be served next is on the flashing red approach, a solid red should be shown on that approach, for the same time period that the perpendicular roadway is going from yellow flash to solid yellow, and then solid red. Once the full normal operation clearance times have been served, normal signal operation can begin, starting with the needed phase, first.

The SCDOT reviews all interconnected locations on a 5 year cycle.

Blankout Signs

The MUTCD requires blankout signs or phase restrictions across the track during preemption. The SCDOT uses 24" No Right Turn or No Left Turn Blank out signs.

Signs and Markings pertinent to Railroad Preemption

At preempted locations we typically use the "Do Not Stop on Track" sign and the "Turn Restriction" blank out signs. Other signs that may be appropriate are the "Stop Here on Red" signs or the "No Turn on Red" signs. We recommend the use of these signs as appropriate based on an engineering study.

For more information on railroad signs refer to the **Manual on Uniform Traffic Control Devices** Chapter 8.

SIGNAL PLAN

Information on the signal plan concerning railroad preemption will consist of the following:

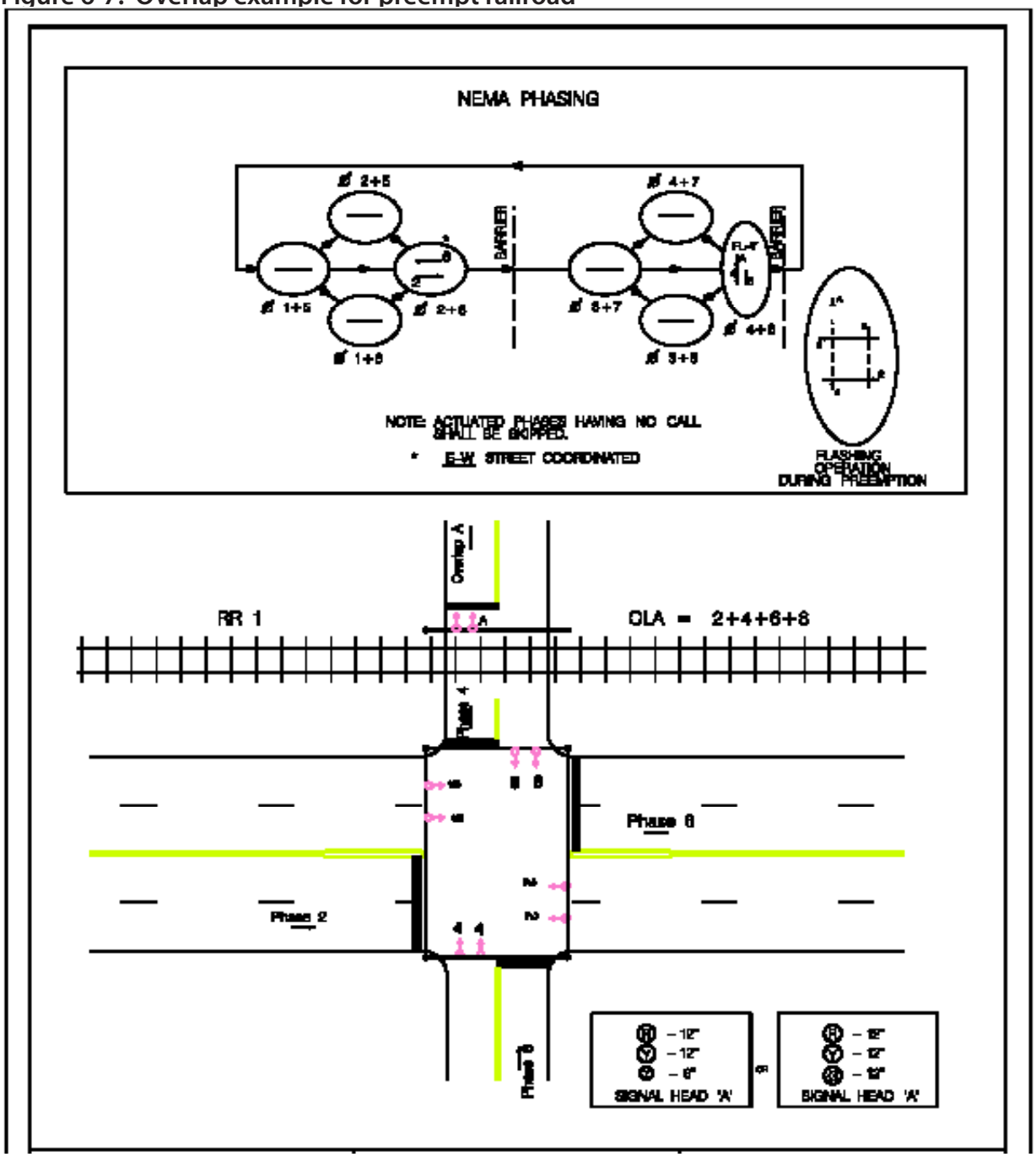
Railroad Preemption:

Track clearance phase #__ (cardinal direction_____) = ___ seconds

Preemption Hold Interval: _____(Limited Service, All way Red Flash, Yellow/Red Flash) Phase #____, Phase #_____

The Railroad Preemption Sequence chart is not required on the plan, however it should be included in the design calculation package

Figure 6-7: Overlap example for preempt railroad



South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES

Chapter 7

Maintenance & Operations

Traffic Signal Maintenance

Maintenance

Traffic signal maintenance generally includes performing emergency maintenance (trouble calls), replacing LED and/or incandescent bulbs, checking and repairing loops, maintaining the signal cabinet, and verifying that the wiring is in good operating shape. Trouble calls are documented in a trouble log in the cabinet.

LED modules typically have a 5-year lifespan, but once 40% of the LED module is out, the entire head will go dark and the module is replaced. Other maintenance includes maintaining loop detectors by either repairing or recutting when there is a problem in order to maintain efficient traffic flow and replacing any equipment that is not working properly.

Extraordinary maintenance is defined as repairs needed beyond ordinary maintenance. Some examples would be a signal knockdown from a tree falling or a vehicle collision or over-height vehicle. When emergency repairs are needed beyond typical maintenance, public safety is the number one goal, and it becomes vital to reinstate signal operation as soon as possible.

Preventive Maintenance

SCDOT has established a 15 year target lifecycle for signal controller/cabling, 7.5 years for signal head replacements (modules may need more frequent replacement), and 30 years for signal supports (poles). This cycle for upgrades helps with scheduling signal management tool. Replacing signal elements in accordance with life cycles is considered a maintenance operation.

Preventive maintenance checks are also performed at each signal annually. This check follows a preventive maintenance form and is entered into the signal management tool. The purpose of the check is to clean around and inside the cabinet, to verify the plans in the cabinet are current, the cabinet equipment is working properly, the signals are working properly, the signal height is correct, and the loops are all working properly. Any items that cannot be addressed immediately are noted in the signal maintenance tool and are added to a work order list for scheduled repair, or replacements.

Operations

Operations experts monitor and verify communications between signals in a system. Fine tuning signal systems in the field by adjusting offsets and splits (as provided by the engineer) are also part of operating a signal system. Count data and Synchro are tools used as an aid in this endeavor.

Verification of communication is recorded on the Communication Checklist according to the requirements below and on the form provided by SCDOT for each signal system.

Two times per month:

- Verify dial-up communication with master controllers.
- Download system time to controller real-time clock.

One time per month:

- Verify communication with each local intersection within a system.

One time per year:

- Verify integrity of fiber optic and copper interconnect cables.

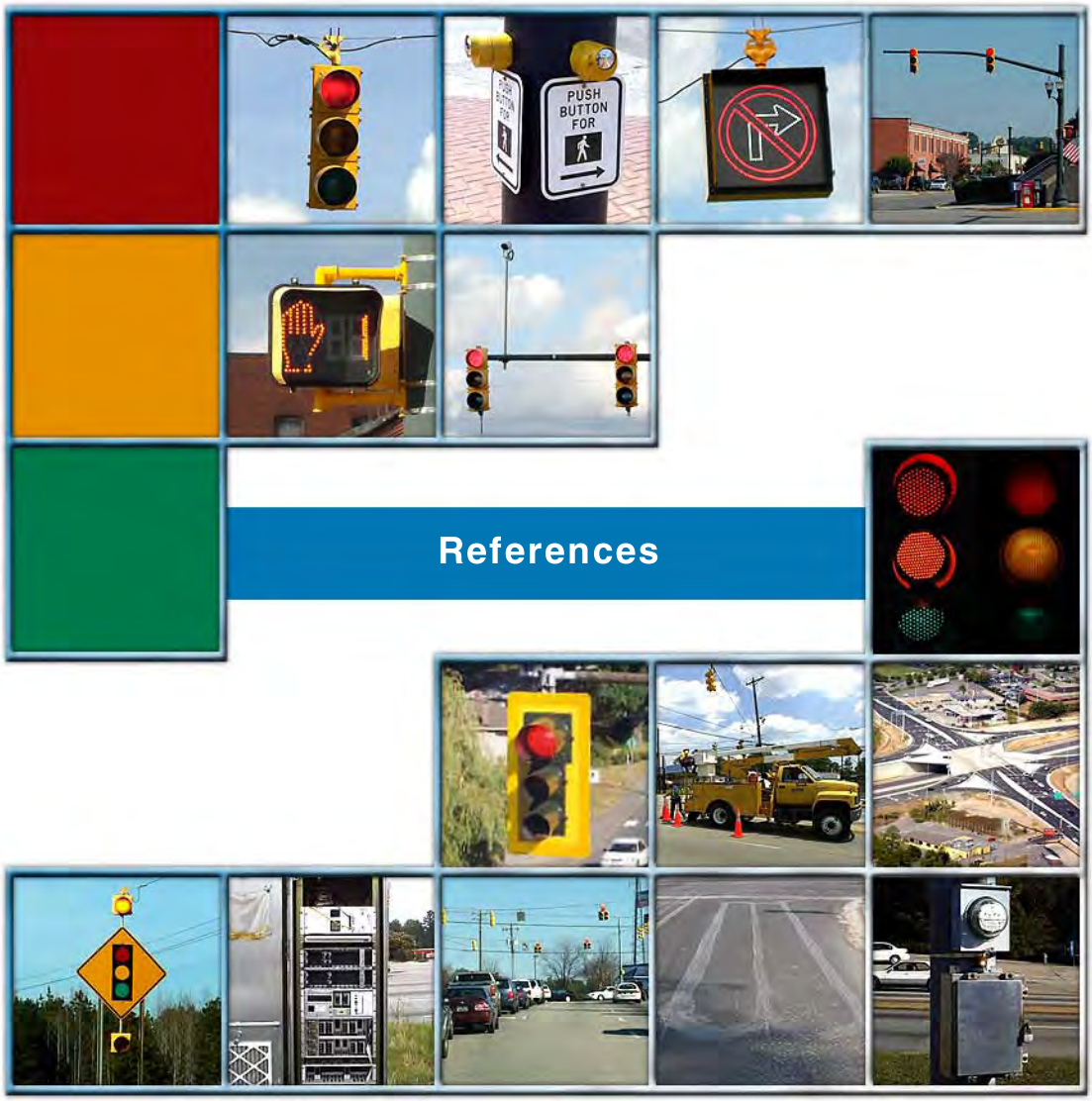
Typically the signal maintainers have a remote server for the controller software to reside, along with a phone line or other type of communication capability to monitor signal systems, a designated laptop computer, and Synchro 6 or 7.

Railroad Maintenance & Operation

At railroad pre-empted signals, a special 5-year statewide inspection cycle is performed in addition to the normal annual preventative maintenance inspections. This special review includes details and recommendations on railroad signing, railroad marking and signal operation during preemption. Any observed malfunction or problem with the traffic signal or railroad warning device operation is reported to both the railroad company and the signal maintainers and engineers.

South Carolina Department of Transportation

TRAFFIC SIGNAL DESIGN GUIDELINES



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