

Traffic Signal Design Guide



Department of Highways & Traffic
St. Louis County, Missouri

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Additional Resources

- 1) ***St. Louis County Standard Specifications for Highway Construction, Division 900, Section 904 - St. Louis County Traffic Signals:***

www.stlouisco.com/Portals/8/docs/Document%20Library/highways/Standard_Specs/09_Division_900/Section_904_2010-12-01.pdf

- 2) ***Design Criteria for the Preparation of Improvement Plans:***

www.stlouisco.com/PropertyandRoads/HighwayPublicationsManuals/DesignCriteriaManual

- 3) ***St. Louis County Standard Drawings - Traffic Signal Details:***

www.stlouisco.com/PropertyandRoads/HighwayPublicationsManuals/StandardDrawings

- 4) ***Manual on Uniform Traffic Control Devices (MUTCD):***

<http://mutcd.fhwa.dot.gov/>

- 5) ***ADA Standards for Accessible Design:***

www.ada.gov/2010ADASTandards_index.htm

- 6) ***American Association of State Highway and Transportation Officials (AASHTO):***

www.transportation.org/

Introduction

The purpose of this guide is to provide instruction for practices and standards used in the design of St. Louis County traffic signals. This guide describes typical practices for new or modified traffic signal control system installations countywide. This guide shall be used in conjunction with the most current ADA Standards for Accessible Design, Manual on Uniform Traffic Control Devices (MUTCD), and the most recent version of St. Louis County's Design Criteria for Improvement Plans, Standard Specifications for Highway Construction, Standard Drawings, Special Provisions, and other current design policies. Deviations from these guidelines shall be based on informed engineering decisions approved by St Louis County.

Definition of Traffic Signal

Traffic control devices utilizing strategically placed signs and electric powered lighted symbols used to assign coordinated right of way movements and eliminate conflicts between motorists, cyclists and pedestrians. Traffic control devices additionally used to heighten awareness of significant changes in roadway conditions and /or regulations.

Types of Traffic Signals

Intersection

Assigns right of way to non-conflicting movements of traffic on one street until a determination is made to reassign the right of way to non-conflicting movements of traffic on the intersecting street.

Fire Station

To reassign the right of way from the traffic on the street to a fire station entrance, to provide immediate and safe egress to vehicles from the fire station to respond to emergency calls.

Pedestrian

To reassign the right of way from the vehicles on the street to a designated location for pedestrians to safely cross the street.

Flasher

To heighten awareness of significant changes in roadway conditions and/or regulations that could adversely affect the safety of motorists, cyclists, and pedestrians.

General Information

Requirements for Traffic Signals

The Department of Highways and Traffic requires the proposed signal to meet at least one signal warrant in the MUTCD. A signal warrant is a minimum condition for which a signal may be installed. However, satisfying a warrant does not mandate the installation of a traffic signal. A warranting condition indicates that an engineering study is required to determine whether the signal is justified.

An engineering study is required for every proposed traffic signal. Typically, the study includes intersection capacity analysis to determine the level-of-service (LOS) for the AM and PM peak hour traffic condition. Depending upon the location and circumstances, an LOS analysis may be required by the Department for other periods as well. Prior to signal design, the Department's Highway Planning Division must approve the engineering study.

A queue analysis may be required to determine the appropriate lane configuration and length for the intersection. Based on the results of the engineering study, the appropriate number of lanes, length of turning lanes, and signal phasing will be determined. Close coordination with the Highway Planning Division is required throughout the engineering study to develop the optimum intersection configuration.

Signal spacing should be considered during the development of a traffic signal design. Signalized intersections should be located to maintain progression of traffic along arterial streets. This normally entails relatively uniform spacing and sufficient distances between signals to allow vehicles to travel at reasonable speeds. The optimal spacing is a function of the cycle length and the progression speed of traffic along the major street. The proposed signalized intersection shall be based on an arterial progression analysis and provide acceptable green band and level of service.

Standard References

The following are standard reference documents for the design of traffic signals:

- 1) Plans shall be prepared in accordance with the St. Louis County Department of Highways and Traffic's active **Traffic Signal Design Guide**.
- 2) Equipment, materials, construction requirements and installation procedures shall meet or exceed the most recent version of **St. Louis County Standard Specifications for Highway Construction Division 900 - Section 904** and **St. Louis County Standard Drawings - Traffic Signal Details**, unless noted otherwise in the construction documents, or superseded by direction in this guide.
- 3) All new or upgraded signal installations shall conform to the requirements in Part IV of the **MUTCD**.

Special Agreements

Special agreements, when applicable, must be executed in response to an entity's request to install special equipment relating to the traffic signal. These agreements include lighting, street landscape, signal priority control, and red light photo enforcement.

Design Plans

1) Overview

A single traffic signal design package typically is comprised of three sheets. These are:

Sheet 1 - Cover Sheet

Sheet 2 - Plan View / General Traffic Signal Layout Sheet

Sheet 3 - Signal Equipment/Materials and Quantity Sheet

Details regarding requirements for each sheet are provided in the following guidance. These sheets shall be no larger than twenty-two inches by thirty-four inches (22" x 34"). Example plans are provided in the Appendix for reference. Traffic signal designs are frequently included as part of a larger civil design package, which may include multiple signal designs. In this instance, no separate cover sheet for signal design is required.

2) Sheet 1 - Cover Sheet

The cover sheet is to be the first sheet in a set of plans. The cover sheet shall contain the location and the extent of the work to be performed. The cover sheet should include all of the relevant project information such as the project name, roadway ADT, design speed, development number, job number, plan number, sheet index, legend of symbols, general notes, and a location map w/north arrow.

3) Sheet 2 – Plan View / General Traffic Signal Layout Sheet

The plan view of the proposed intersection geometry and traffic signal installation shall be drawn to a scale of one inch equals twenty feet (1" = 20') and include the following elements:

- NEMA Traffic Signal Phasing Chart (vehicular and pedestrian)
- North Arrow (North shall be oriented to the top or to the right of the sheet)
- Graphical Scale
- Signal Installation Notes

The Department's Standard Drawing of Traffic Signal Symbols shall be followed for all symbols with line styles and weights used to represent existing and proposed traffic signal equipment. (See Standard Drawing C904.00)

The plan view shall show the location of existing and proposed:

- Utilities
- Topographic features
- Improvements
- Sewer Structures
- Underground utilities and sewers
- Rights-of-Way and Easements
- Lane Usage

4) Sheet 3 - Signal Equipment/Materials and Quantity Sheet

This sheet shall be prepared according to the following guidelines and standards. Refer to the **example plans** in the Appendix.

Traffic Signal Items:

- Item Numbers (listed in numerical order)
- Description
- Unit
- Quantity

Pull Box Schedule:

- Box Number (referenced from plan view sheet)
- Box Type (concrete-single/double, preformed-size, preformed-size w/1'wide concrete apron)

Signal Base & Equipment Schedule:

- Base Number (referenced from plan view sheet)
- Concrete Base Type
- Mast Arm or Post Type
- Signal Equipment Type

Induction Loop Detector Schedule:

- Loop Number (referenced from plan view sheet)
- Size & Type of Loop (Standard 3-turn, Quadropole 2-4-2)
- Card position in Rack (inside controller cabinet)
- Channel Used

Design Submittal Process

1) New signal or existing signal modification as part of a Special Use Permit (S.U.P.) project.

Plan submittals for projects requiring a special use permit shall be made in accordance with the County's Special Use Permit Section.

2) New signal or existing signal modification as part of a Capital Improvements Project (C.I.P.).

In general, it is recommended, but not required, that four submittals be made for approval of the signal plans. These submittals should represent approximately 30%, 70%, 90%, and 100% of the overall signal design work. All traffic signal plans shall be submitted on sheets no larger than 22" x 34".

A) The initial (30 percent) submittal shall show the existing and proposed:

- curbs and ramps
- construction centerlines
- lane configurations and striping
- utilities
- rights-of-way and/or easements
- signal poles
- vehicle and pedestrian signal heads
- base and pull box numbering
- signal face displays
- controller and power supply assembly
- loop detectors and numbering
- phasing chart

(Two sets of plans are required for the first submittal.)

B) The second (70 percent) submittal shall include the signal cable and wire notes.

C) The third (90 percent) submittal shall include quantities for all traffic signal equipment. This submittal shall also include one set of special provisions for review, if any.

D) If outstanding design issues exist, the Department may require the signal designer to resubmit plans for review and comment prior to the final (100 percent) submittal. If there are no outstanding design issues after the 90 percent submittal, the 100 percent submittal shall be one plan set, and one set of special provisions, for approval signatures. The plans and special provisions shall be signed and sealed by a professional engineer licensed in the state of Missouri.

Design Guidelines

Survey Requirements

Existing Improvements, Underground and Overhead Utilities, and Sewers:

All signal plans shall show the location of existing improvements, underground and overhead utilities, and sewers as taken from observed evidence together with plans and markings obtained from utility companies or other appropriate sources. The designer should contact the Department's Division of Operations (Signal Section) at (314) 615-0215 for marking the location of St. Louis County's underground traffic signal facilities. Overhead utilities shall be verified for minimum clearance to the proposed signal equipment. When potential conflicts with utilities exist, additional right-of-way or easement is required to avoid the utility. If this is not feasible, the utility company should be contacted regarding the relocation of the utility.

The type of pavement shall be noted on the plan. Joints in concrete pavement shall be shown on the plan to assist in determining induction detector loop placement. If possible, avoid placing detector loops and leads across pavement joints.

The Department's **Traffic Signal Symbols**, Standard Drawing C904.00, shall be used to depict all traffic signal equipment on the plan.

Rights-of-way and Easements:

All signal plans shall show existing and proposed rights-of-way and easements for locating traffic signal equipment. All traffic signal equipment shall be in public right-of-way or in a permanent easement which is in the name of the County and specifically allows for the placement and maintenance of traffic signal equipment. This would include power supply equipment, loop detectors, conduit, poles, mast arms, posts, pull boxes, traffic controller cabinets, bases, and cameras.

There shall be at least five feet of clearance beyond any traffic signal equipment to the edge of the easement or right-of-way to allow for working room.

Intersection Geometry

Intersection approaching and receiving lane offsets should be avoided. Opposing exclusive left-turn lanes should have no offsets so that they directly align opposite each other. If a left turn lane is offset into the path of the approaching through lane, the left turning driver might assume that the approaching vehicles are also in a left turn lane and fail to yield. Also, when a left turn lane is offset too far right of the centerline, the opposing left turning vehicles may obstruct visibility of opposing through vehicles.

For through movement traffic, the approaching lanes should line up with the receiving lanes. Because of their geometry, skewed intersections are difficult to signalize and delineate. Keep the skew angle as close to 90 degrees as possible to provide more normal approaches and exits.

If roadway approaches and driveways / commercial entrances are located too close to an intersection, then traffic from these facilities can affect the intersection level of service. Consider restricting the access to right in / right out operation.

Public transit "stop" and "pull-out" locations can affect signal operation as well. When possible, locate these "stops" and "pull-outs" on the far side of the intersection.

Stop lines define the point where vehicles must stop to not be in the path of the design vehicle's left turn. Check the geometric layout based on the design vehicle's turning radii. Also, check the turning paths of opposing left turn movements to insure this operation is possible for concurrent left turn movements.

Crosswalks, Curb Ramps, Pedestrian Signal Heads and Push Buttons

Crosswalks should be provided at all intersections where there is pedestrian activity or existing sidewalks. Curb ramps are required by the Americans with Disabilities Act (ADA). These ramps should be designed in accordance with the Department's Standard Drawings.

Curb ramps, pedestrian signal heads and push buttons are required where a crosswalk is marked at a signalized intersection. Crosswalks should be ten feet wide and located as close as possible to the intersection. This improves pedestrian visibility for the turning traffic. In order to maximize the overall signal efficiency, crosswalks crossing a major street may be reduced to one crossing if the side street operation is split phased. The following factors should also be considered when designing crosswalks, curb ramps, and stop lines:

- Align crosswalks and stop lines as close to perpendicular to the approach traffic lanes as possible.
- Center the curb ramps in the crosswalks.
- Minimize pedestrian exposure to turning vehicles.
- Ensure that pedestrians waiting at the curb ramps are readily visible to drivers of approaching and turning vehicles.
- Minimize pedestrian crossing distance and crossing time.
- Clarify and simplify the pedestrian's crossing route.

Pedestrian signal heads should be placed to maximize the visibility of the signal to pedestrians using the crosswalk for which the signal head provides indications.

Pedestrian push buttons should be located in the normal travel path of the pedestrian. Push buttons should be located within five feet of the crosswalk line and within six feet of the curb. The lateral reach distance from the sidewalk to the push button shall not exceed 24 inches.

In addition, push buttons shall be located adjacent to a level landing area. Poles, pull boxes, and other obstructions should not be located in the curb ramps or in the landing areas.

Signal Indications and Layouts

Post top mounted signals are to be used only where the Department determines it is not physically suitable to install mast arms.

The face of pole / post shall have a horizontal clearance of not less than three feet from the face of curb, island, median or edge of pavement.

Far left indications are required for County signal installations wherever left turns are permitted. However, this does not apply for left turns into residential entrances.

The intersecting approach at T-type intersections should include left and right arrows, provided no pedestrian conflict exists.

Straight thru arrow indications on street approaches shall only be used with Department approval.

Flashing yellow arrow indications on street approaches shall only be used with Department approval.

Back plates shall be required for all vehicular signal heads.

Vehicle Detection

Advance detection is required at intersection and pedestrian signals in through lanes on major streets and some cases on side streets if volume is high, or grades are steep.

*Vehicle Speed (MPH)	Distance from Stop Line to front of 6' x 6' Loop (Feet)	Distance Traveled in Extension Interval of 6 Seconds 1.47 x MPH x 6 sec. (Feet)
30	250-270	264
35	300-320	309
40	340-360	353
45	390-410	397
50	430-450	441

*85th percentile speed or 5 MPH greater than the posted speed limit.

Where advance detection in through lanes of the major street is not possible, standard 6' x 6' induction loop detectors shall be installed at the stop line in all through lanes.

The Department requires induction loop detectors for vehicle detection. Video detection should not be considered. Under conditions where a bridge deck or railroad track conflict exists, and would prohibit the installation of induction loops, the Department shall be contacted for guidance and authorization of alternative detection equipment.

Stop line detection generally consists of multiple quadrupole loops configured to provide a lane detection area 6' wide by approximately 40' long.

In concrete pavement, multiple loops should be placed end to end and centered in the lane to provide a 6' wide by approximately 40' long lane detection area. Loops should be 6' wide, but the length of each loop is determined by the size of each individual pavement slab. Typically the loops are installed one foot from the transverse pavement joint. Sawed slots that construct the loops should not cross transverse pavement joints and shall have a 1' minimum clearance from the sawed slots constructing other loops.

In asphalt pavement, two 6' wide by 20' long loops should be placed end to end and centered in the lane to provide a 6' wide by 40' long lane detection area. Sawed slots constructing the loops shall have a 1' minimum clearance from sawed slots constructing other loops.

Where major and minor streets intersect, loops are provided, at the stop bar, for exclusive left turn lanes on the major street and all approach lanes for the minor street. Where two major streets intersect, loops may be required in all approach lanes of both streets as determined by the Department.

Stop line detection should also be provided in the dedicated right turn lane when right turn overlap phasing is proposed.

Interconnect and Closed Loop Systems

Traffic signal interconnect may be required where a signal is within 1,320 feet of another signal. If interconnect is not immediately needed, the installation of interconnect conduit with trace wire may be required for future signals at qualifying locations. The signal designer should coordinate with the Department to identify if interconnect is to be included with the signal design.

If interconnect is required, it shall be included as part of the signal design. It may be necessary to provide separate interconnect layout plans to illustrate the connection between adjacent signals. Location of conduit, pull boxes, and cables (if required) shall be included.

Interconnect cables and equipment shall be compatible with existing and proposed closed loop systems.

Interconnect conduit shall have 17" W x 30" L x 26" Min. H preformed pull boxes spaced at intervals no greater than 400 feet.

Interconnect cables shall terminate at controller cabinets only. Cable splices will not be allowed.

Interconnect conduit and cable should be incorporated into the signal pull box and conduit facilities for connection at the designated signal controller cabinets.

Pull Boxes and Conduit Sizes

A single concrete pull box is required adjacent to each signal base. A double concrete pull box is required adjacent to the controller base, in the island nearest to the controller base and wherever the number of conductors entering a pull box is greater than 100.

The preferred location of the concrete pull box is no further than 10 feet from the signal or controller base and no further than 6 feet from the face of island when practical. The placement of concrete pull boxes in sidewalk or curb ramps should be avoided when possible.

Reinforced Plastic Concrete pull boxes may be installed for interconnect systems and advance loop detectors. Unlike concrete pull boxes, the sidewalk is the preferred location for RPC pull boxes.

Conduit shall not be filled with cable to more than 40% capacity. (Refer to Table 3 and Table 4)

Conduit Size	Application
¾"	Between pull box and face of curb, island, median or edge of pavement (for loop detectors)
2"	Between pull box and pushbutton / pedestrian only base
	Between pull box and power supply
	Between pull boxes for interconnect system
4"	Between pull box and signal base
	Between pull boxes crossing streets (only one crossing permitted for major street)
4" (Two)	Between double pull boxes and to controller base (a single 4" conduit is sufficient for a 4 phase controller base)

Table 1. Conduit required for traffic signal installation

Types of Cable and Wire

Type of Cable and Wire (no. of conductors #AWG)	Application
1c#6(P)	Power Supply
1c#6(G)	Bare Stranded Ground Wire (between base and adjacent pull box)
1c#14 w/tube jacket	Detector Loop and Lead
2c#18(S)	Detector Loop Lead-in
	Pedestrian Push Button
5c#14	One/Two Pedestrian Head(s)
7c#14	Beam Mount, Side or Post Top Mount Vehicle Head (one for each face)
3pr.#16(S)	Closed Loop System Interconnect
7c#14(I)	Interconnect (except for Fiber Optic Cable)
F.O.C. (36 Fibers)	Interconnect (Fiber Optic Cable)
4pr.#24(S)	Video Communication for PTZ camera
	Video Communication/Power for Video Detection camera (communication and power delivered by a single cable)
3c#14(P)	Video Power for PTZ camera
2c#14 (lighting)	Luminaire on Signal Pole

Table 2. Cable and wire required for traffic signal installation.

Number of Cables	Cable Size (Sq. In.)								
	1c#6(G) (Ground)	1c#14 w/ tube jacket	2c#18(S) (Shielded)	5c#14 (Pedestrian)	7c#14 (Vehicle)	1c#6(P) (Power)	F.O.C. (36 Fibers)	4pr. #24(S) (Video Comm.)	3c#14(P) (Video Power)
1	0.035	0.053	0.053	0.142	0.170	0.075	0.160	0.055	0.105
2	-	0.106	0.106	0.284	0.340	0.150	0.320	0.110	0.210
3	-	-	0.159	0.426	0.510	0.225	0.480	0.165	-
4	-	-	0.212	0.568	0.680	0.300	0.640	0.220	-
5	-	-	0.265	0.710	0.850	-	-	0.275	-
6	-	-	0.318	0.852	1.020	-	-	0.330	-
7	-	-	0.371	0.994	1.190	-	-	0.385	-
8	-	-	0.424	1.136	1.360	-	-	0.440	-
9	-	-	0.477	1.278	1.530	-	-	0.495	-
10	-	-	0.530	1.420	1.700	-	-	-	-

Table 3. Cable sizes for conduit capacity.

Conduit Size (Nom. Dia.)	¾"	2"	4"
40% Area (Sq. In.)	0.18	1.26	5.03

Table 4. Maximum cable area for conduit capacity.

Calculating Conduit, Cable and Wire Quantities

Quantities for conduit, cable and wire shall be scaled or calculated from the plans. Measurements for conduit and cable or wire are made from center to center of structures. Also, additional lengths of cable and wire are necessary for the traffic signal equipment. (See Table 5) The total for each size of conduit is rounded to the nearest foot. The total for each type of cable or wire is rounded to the next 10 foot increment.

<i>Additional Length (L.F.)</i>	<i>Location</i>
20' + arm length	Beam mounted vehicular signal head
15'	Side mounted vehicular signal head
20'	Post top mounted vehicular signal head
10'	Post top or side mounted pedestrian signal head(s)
5'	Pedestrian push button
6'	Single pull box (except for 1c#14 w/tube jacket and Fiber Optic Cable)
3'	Single pull box (for 1c#14 w/tube jacket)
10'	Single pull box (for Fiber Optic Cable)
6'	Double pull box (except for 1c#14 w/tube jacket and Fiber Optic Cable)
3'	Double pull box (for 1c#14 w/tube jacket)
30'	Double pull box (for Fiber Optic Cable)
10'	Controller (except for Fiber Optic Cable)
10'	Utility pole or pedestal supporting power supply
35'	Post extension PTZ camera mounting
35'	Post extension video detection camera mounting
45'	Mast arm video detection camera mounting
45'	Luminaire arm video detection camera mounting

Table 5. Additional cable and wire required for traffic signal equipment.

For calculating 1c#14 w/Tube Jacket in Sawed Slot quantity

Scale drawing from the loop along sawed slot to curb/edge of pavement and multiply by two (2) cables.

Add detector loop quantities from Table 6 below

+ _____

Total the two quantities

= _____

Lineal Feet of Wire	Type of Loop	Size of Loop	(4 x Width) + (8 x Length)
72'	Standard (3 Turns)	6'x6'	
104'	Quadrupole (2-4-2)	6'x10'	
112'	Quadrupole (2-4-2)	6'x11'	
120'	Quadrupole (2-4-2)	6'x12'	
128'	Quadrupole (2-4-2)	6'x13'	
136'	Quadrupole (2-4-2)	6'x14'	
144'	Quadrupole (2-4-2)	6'x15'	
152'	Quadrupole (2-4-2)	6'x16'	
160'	Quadrupole (2-4-2)	6'x17'	
168'	Quadrupole (2-4-2)	6'x18'	
176'	Quadrupole (2-4-2)	6'x19'	
184'	Quadrupole (2-4-2)	6'x20'	
264'	Quadrupole (2-4-2)	6'x30'	

Table 6. Detector loop quantities

For calculating 1c#14 w/Tube Jacket in 3/4" Conduit and Pull Boxes quantity

L.F. of 3/4" conduit with cable inside and multiply by two (2) cables

Add number of detector loops times 3 ft. coiled in pull box times two (2) cables (number of loops x 3 x 2)

+ _____

Total the two quantities

= _____

Controller Unit and Power Supply Assembly

The traffic signal controller unit shall be NEMA configuration and compatible with the existing and proposed closed loop systems. A closed loop system using twisted pair communication cable requires a controller unit with an internal FSK modem. A closed loop system using fiber optic cable requires a controller unit with an internal fiber optic modem and termination housing. For controller units with other interconnect wires, a fiber optic modem should be installed to accommodate future installation of fiber optic interconnect cables.

A battery backup system shall be provided in new controller cabinets.

The controller cabinet should be located along the minor street in the far-left or near-right corner of the intersection. The controller cabinet should not be located so as to restrict sight distance at the intersection.

The controller cabinet and electric service pedestal foundations shall be positioned beyond the AASHTO clear zone requirement of both roadways whenever possible.

Controller cabinets shall be placed in a location that can be safely accessed by the signal technician and provide visibility of the indications on both streets. The cabinet door shall face the intersection. A concrete pad or sidewalk shall be provided in front of the cabinet door. Controller cabinets and power supply assemblies shall not be located in areas susceptible to water immersion, flooding, or sprinkler spray.

The power supply assembly should be mounted on the power company's wood utility pole, as agreed to by the power company and the County. The power cables may share the same conduit as the traffic signal cables. The power supply assembly should be located as close to the controller cabinet as possible.

A special pedestal type power supply assembly shall only be used when overhead service is not available. The power company transformer shall be located within ten feet of the power supply assembly unless otherwise approved by the resident engineer.

Signal Phasing

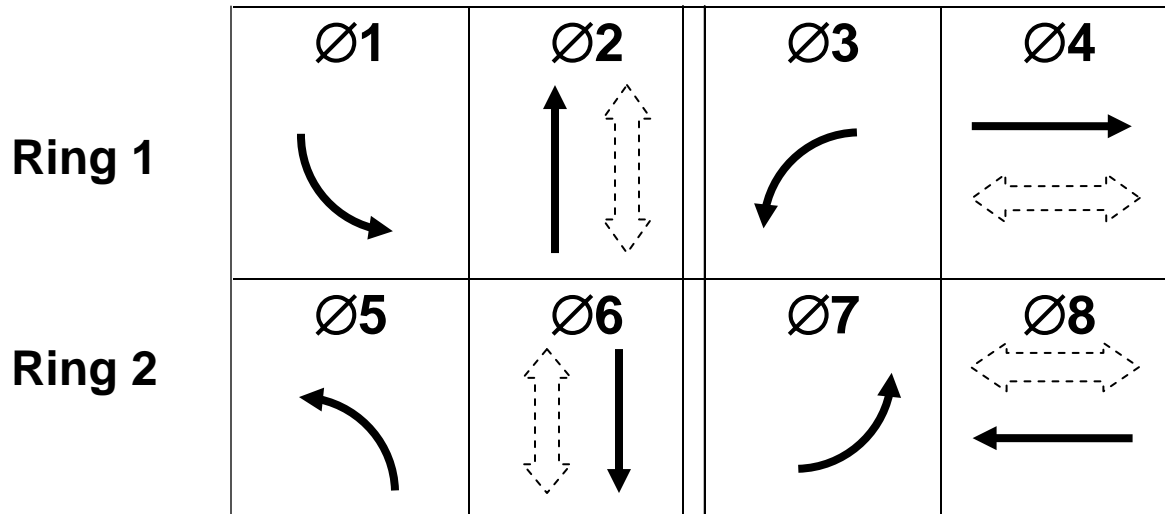
The appropriate signal phasing shall be determined based on intersection geometrics, traffic volumes, traffic composition, and level of service. An intersection capacity analysis shall be performed to establish a phasing scheme.

If protected phasing is needed for the left turn movement (as determined by the engineering study), the Department prefers protected-only phasing for the movement with dual (or more) left turns, or when there are three or more through lanes opposing the left turn, or when there is a sight distance restriction. A combined protected and permitted left-turn phasing is recommended only if there are one or two lanes opposing the left turn.

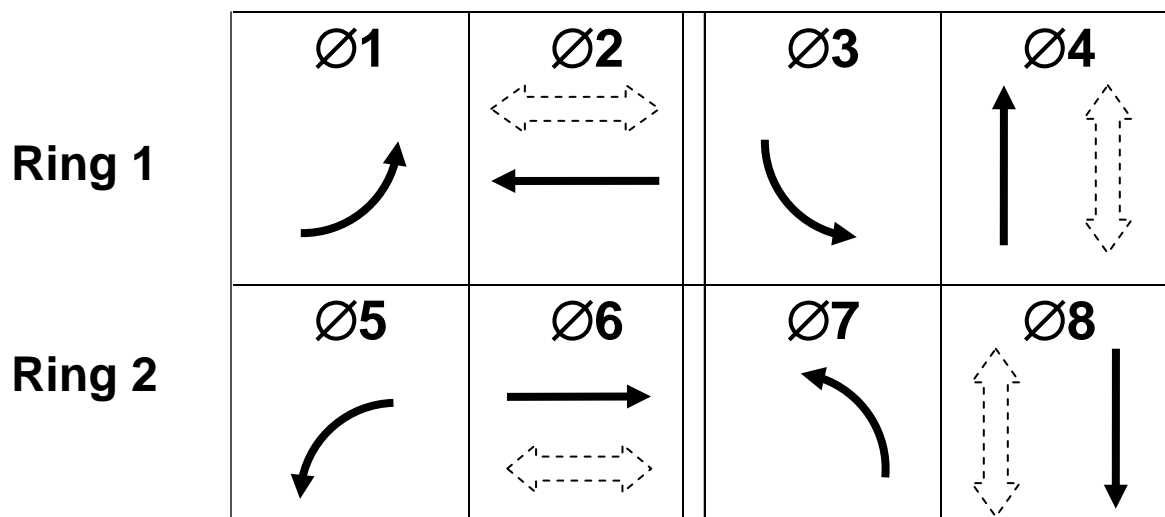
Right-turn overlap phasing should be considered at locations with a dedicated right-turn lane where the intersecting street has a complimentary protected left-turn movement and U-turns are prohibited. However, the overlap phase design should take into account any concurrent pedestrian movements that could cause a point of conflict with the right turning vehicles. Right-turn overlap should be considered for the non-conflicting movement at T-intersections. Split phasing is discouraged, and if proposed, must be justified by the engineering study.

Protected phasing should be considered when:

- Left turns are 100 vehicles or more during the peak hour.
- There is a sight distance restriction
- The 85th percentile speed is greater than 50 MPH
- Crossing three or more lanes of traffic



N-S Major Street Phasing Diagram (North is to top of page)
(Dashed lines represent pedestrian movements)



E-W Major Street Phasing Diagram (North is to top of page)
(Dashed lines represent pedestrian movements)

Fig. 2. Typical Ring Diagram.

NEMA standard phase designations should be used. The NEMA movements should be oriented such that phases 2 and 6 align with the major street. For intersections of two major streets, the Department's Operations Division should be consulted to provide direction for phasing orientation.

Appendix

Notes on Plans

Include the following notes, when applicable, on plans for Special Use Permit projects and Capital Improvement Projects:

The Contractor shall notify the St. Louis County Department of Highways and Traffic's Division of Operations (Striping Section) at (314) 615-0233, 24 hours in advance of any striping related work. The Contractor shall perform all grinding of existing striping and installation of temporary striping as required by the Engineer. Permanent striping at the intersection will be installed by the St. Louis County Department of Highways and Traffic.

Existing underground facilities, structures and utilities, if shown on these plans, shall be considered approximate only. Verification of the locations of all existing facilities, structures and utilities either shown or not shown on these plans, shall be the responsibility of the Contractor, and shall be verified prior to any grading, excavation or construction of improvements.

Include the following additional notes, as applicable, on plans for Special Use Permit projects:

TRAFFIC SIGNAL PRECONSTRUCTION NOTE:

Unless noted otherwise, all traffic signal work on this project shall be in accordance with **St. Louis County Standard Specifications for Highway Construction, "Division 900, Section 904 – St. Louis County Traffic Signals"**; and with **"St. Louis County Standard Drawings – Traffic Signal Details"**. The Contractor shall have said references on the job site at all times during construction/installation of the signalization equipment.

The Section 904 specifications are available at:

www.stlouisco.com/Portals/8/docs/Document%20Library/highways/Standard_Specs/Section_904.pdf

The Section 904 specifications in effect for this project will be those available for viewing on the date the signal plans were approved.

The Traffic Signal Detail drawings (C904.00 through 904.80) are available at:

www.stlouisco.com/PropertyandRoads/HighwayPublicationsManuals/StandardDrawings

The contractor shall be responsible for checking the Standard Drawings Errata Sheet to ensure their set of drawings is current. The Standard Drawings in effect for this project will be those drawings available for viewing on the date the signal plans were approved.

Include the following additional note, as applicable, on plans where an existing signal is to be removed or modified:

NEW TRAFFIC SIGNALIZATION AT EXISTING SIGNALIZED INTERSECTION

The existing intersection signals at _____ and _____, including detectors and interconnect, shall remain in normal operation during construction of this project, except during the period of time when the traffic signal must be turned off for alterations or to change over to the new traffic signal equipment. The traffic signal shutdown shall take place after 9:00 AM on a normal workday, at which time temporary Stop signs shall be installed, as directed by the Engineer. The Contractor shall have the new traffic signal equipment in place and in normal operation by 3:00 PM the same day. The Contractor shall notify the Department of Highways and Traffic's Signal Shop personnel at (314) 615-0213, 48 hours in advance of any traffic signal shutdown.

Prior to any disruption of service to the existing vehicle detection system(s), at any and all signalized intersections within the construction limits of this project, the Applicant shall furnish and install a temporary vehicle detection system for the approach(es) where the existing vehicle detection system is disrupted. The Applicant shall make any and all necessary adjustment for proper operation of the temporary detection equipment and maintain the equipment until the new permanent detection system is in place and operational. The Applicant shall provide to the County the type of temporary vehicle detection system proposed for use a minimum of forty eight (48) hours in advance of installing the temporary equipment for approval by contacting the St. Louis County Signal Shop at (314) 615-0213. The County has the sole right to approve, modify, or reject the temporary vehicle detection system proposed by the Applicant. The Applicant shall not disrupt any existing vehicle detection system before the temporary vehicle detection system is operational and approval is provided by the County. Failure to comply with these requirements may result in immediate retraction of the special use permit.

Include the following note on plans when existing signal conduit and cable is within the project construction limits:

CAUTION! EXISTING UNDERGROUND TRAFFIC SIGNAL CONDUIT/CABLE

It is the responsibility of the contractor / developer to contact St. Louis County Department of Highways and Traffic, Division of Operations (Signals Section) at (314) 615-0215 a minimum of 48 hours in advance of construction work for locating and spotting existing traffic signal conduit. In the event the contractor damages the conduit and cable, repairs shall be made within 72 hours at their cost by an electrical contractor, as directed by St. Louis County.

Include the following note on plans when Flashing Yellow Arrow indications are being installed and the existing cabinet is not being replaced:

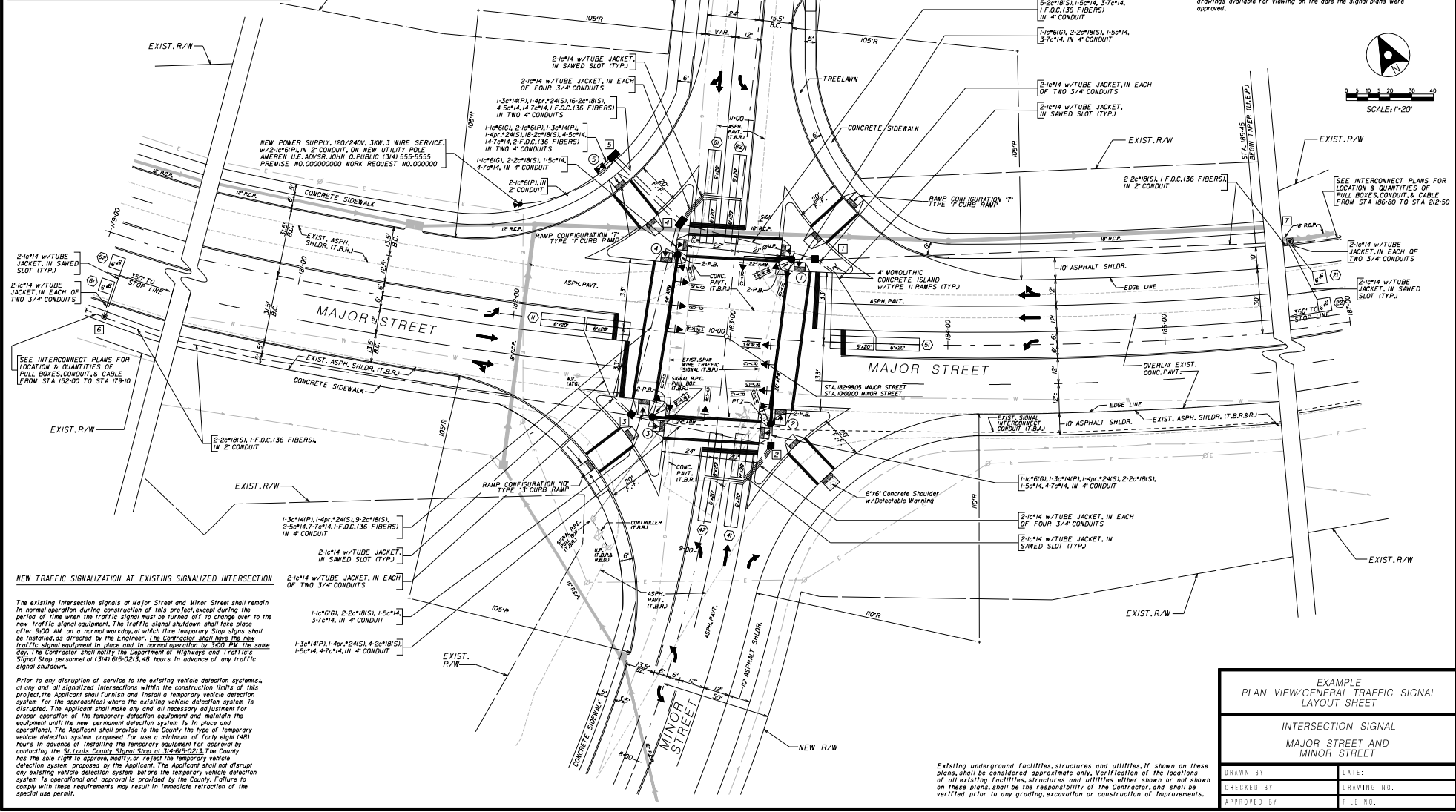
Contractor shall provide and install all equipment necessary to accommodate the new flashing yellow arrows.

Include the following note on plans when Flashing Yellow Arrow indications are being installed and a new cabinet is being installed:

Contractor shall ensure that the new controller and equipment are compatible with the proper operation of the flashing yellow arrow indications.

SIGNAL PHASING	
E.B. LEFT - MAJOR STREET	Ø1
E.B. THRU - MAJOR STREET w/ PED. SOUTH SIDE	Ø6 + PED.
W.B. LEFT - MAJOR STREET	Ø5
W.B. THRU - MAJOR STREET w/ PED. NORTH SIDE	Ø2 + PED.
N.B. - MINOR STREET w/ PED. EAST SIDE	Ø4 + PED.
S.B. - MINOR STREET w/ PED. WEST SIDE	Ø8 + PED.

- The controller unit shall be NEMA configuration.
- The cabinet back panel shall be completely wired with harnesses for 8-phase operation with four concurrent pedestrian phases.
- Contractor shall ensure that the new controller and equipment are compatible with the proper operation of the flashing yellow arrow indications.



The Contractor shall notify the Saint Louis County Department of Highways and Traffic's Division of Operations (Striping Section at (314) 615-0233, 24 hours in advance of any striping related work. The Contractor shall perform all grading of existing striping and installation of temporary striping as required by the Engineer. Permanent striping shall be installed by the existing striping on the Job site at all times during construction/Installation of the signalization equipment.

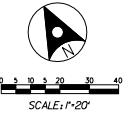
TRAFFIC SIGNAL PRECONSTRUCTION NOTE:
Unless noted otherwise, all traffic signal work on this project shall be in accordance with St. Louis County Standard Specifications for Highway Construction, Division 900, Section 904 - St. Louis County Traffic Signals and with St. Louis County Standard Drawings Traffic Signal Details. The Contractor shall have said references on the Job site at all times during construction/Installation of the signalization equipment.

The Section 904 specifications are available at www.stlouisco.com/PropertyandRoads/HighwayPublicationsManuals/StandardDrawings

The Section 904 specifications in effect for this project will be those available for viewing on the date the signal plans were approved.

The Traffic Signal Detail drawings are available at www.stlouisco.com/PropertyandRoads/HighwayPublicationsManuals/StandardDrawings

The contractor shall be responsible for checking the Standard Drawings Error Sheet to ensure their set of drawings is current. The Standard Drawings in effect for this project will be those drawings available for viewing on the date the signal plans were approved.



EXAMPLE
PLAN VIEW/GENERAL TRAFFIC SIGNAL
LAYOUT SHEET

INTERSECTION SIGNAL
MAJOR STREET AND
MINOR STREET

DRAWN BY	DATE:
CHECKED BY	DRAWING NO.
APPROVED BY	FILE NO.

Existing underground facilities, structures and utilities, if shown on these plans, shall be considered approximate only. Verification of the locations of all existing facilities, structures and utilities either shown or not shown on these plans, shall be the responsibility of the Contractor, and shall be verified prior to any grading, excavation or construction of improvements.

NEW TRAFFIC SIGNALIZATION AT EXISTING SIGNALIZED INTERSECTION

The existing Intersection signals at Major Street and Minor Street shall remain in normal operation during construction of this project, except during the period of time when the traffic signal must be turned off to change over to the new traffic signal equipment. The traffic signal shutdown shall take place after 5:00 AM on a normal workday at which time temporary Stop signs shall be installed, as directed by the Engineer. The Contractor shall place the new traffic signal equipment in place and in normal operation by 3:00 PM the same day. The Contractor shall notify the Department of Highways and Traffic's Signal Shop personnel at (314) 615-0233, 48 hours in advance of any traffic signal shutdown.

Prior to any disruption of service to the existing vehicle detection systems, at any and all signalized intersections within the construction limits of this project, the Applicant shall furnish and install a temporary vehicle detection system for the approaches where the existing vehicle detection system is disrupted. The Applicant shall make any and all necessary adjustment for proper operation of the temporary detection equipment and maintain the equipment until the new permanent detection system is in place and operational. The Applicant shall provide to the County the type of temporary vehicle detection system proposed for use a minimum of forty eight (48) hours in advance of installing the temporary equipment for approval by contacting the St. Louis County Signal Shop, at 314-615-0233. The County has the sole right to approve, modify or reject the temporary vehicle detection system proposed by the Applicant. The Applicant shall not disrupt any existing vehicle detection system before the temporary vehicle detection system is operational and approval is provided by the County. Failure to comply with these requirements may result in immediate retraction of the special use permit.

TRAFFIC SIGNAL ITEMS			
ITEM NO.	DESCRIPTION	UNIT	QUANT.
904-02.13	Signal Head, Type 3S	Ea.	2
904-02.34	Signal Head, Type 34S	Ea.	2
904-05.43	Signal Head, Type 3B, Terminal Compartment, and Astro Bracket	Ea.	6
	Mounting		
904-05.44	Signal Head, Type 4B, Terminal Compartment, and Astro Bracket	Ea.	2
	Mounting		
904-24.02	Signal Head, Type 1S, Pedestrian	Ea.	8
904-29.14	Post, Extension, 4-1/2" O.D. x 14', Aluminum, w/Mounting Hardware and Post Cap	Ea.	1
904-32.22	19' Pole, w/22' Mast Arm, Steel	Ea.	1
904-32.24	19' Pole, w/24' Mast Arm, Steel	Ea.	1
904-32.34	19' Pole, w/34' Mast Arm, Steel	Ea.	1
904-32.36	19' Pole, w/36' Mast Arm, Steel	Ea.	1
904-43.88	Controller, Fully Actuated, (8 Phase Timer, in Aluminum Cabinet Approx. 55"H x 44"W x 26"D, Wired for 8 Phase Operation) w/Internal Fiber Optic Modem and Termination Housing TS2, Type 2, w/Battery Backup	Ea.	1
904-49.20	Detector, Pedestrian Push Button, Freezeproof	Ea.	8
904-49.35	Detector, Vehicle Induction Loop, Card Rack Mtg., 2 Channel, w/Delay and Extension Timing and Relay Outputs	Ea.	6
904-49.51	Pan Tilt Zoom (PTZ) Internet Protocol Video Surveillance Camera System (Camera w/Bracket, Lightning Surge Protector, Managed Ethernet Switch and Misc. Cables)	Ea.	1
904-50.75	Conduit, 3/4"	L.F.	140
904-52.00	Conduit, 2"	L.F.	741
904-54.00	Conduit, 4"	L.F.	371
904-82.06	Cable, Power, #6 Gauge, 1 Conductor	L.F.	170
904-83.05	Cable, Signal, #14 Gauge, 5 Conductor	L.F.	720
904-83.07	Cable, Signal, #14 Gauge, 7 Conductor	L.F.	2820
904-84.00	Wire, Stranded Ground, #6 Gauge	L.F.	100
904-85.05	Cable, Detector Loop, #14 Gauge, 1 Conductor, w/Tube Jacket (In 3/4" Conduit and Pull Boxes)	L.F.	380
904-85.06	Cable, Detector Loop, #14 Gauge, 1 Conductor, w/Tube Jacket (In Sawed Slot)	L.F.	3110
904-85.18	Cable, Push Button and/or Detector Loop Lead-In, #18 Gauge, 2 Conductor (Shielded)	L.F.	4380
904-85.36	Cable, Communication, Fiber Optic, 36 Fibers (30 Single-Mode and 6 Multi-Mode)	L.F.	1110
904-85.81	Cable, Video Communication, PTZ and/or Detector, #24 Gauge, 4 Pair (Shielded)	L.F.	290
904-85.82	Cable, Video Power, PTZ, #14 Gauge, 3 Conductor	L.F.	290
904-86.01	Power Supply Assembly, on Wood Utility Pole, 120/240 Volt	Ea.	1
904-88.01	Pull Box, Single, Concrete	Ea.	3
904-88.02	Pull Box, Double, Concrete	Ea.	2
904-89.17	Preformed Pull Box, (17"W x 30"L x 26"Min. H) Reinforced Polymer Concrete	Ea.	1
904-90.17	Preformed Pull Box, (17"W x 30"L x 26"Min. H) Reinforced Polymer Concrete w/1' Concrete Apron	Ea.	1
904-91.56	Base, Type B-6, Concrete	Ea.	2
904-91.57	Base, Type B-7, Concrete	Ea.	2
904-91.88	Base, Type D-8PH, Concrete	Ea.	1
904-95.30	Removal of Preformed Pull Box	Ea.	2
904-96.21	Removal of Concrete Controller Base	Ea.	1
904-97.20	Removal of Signal Equipment (Intersection)	Ea.	1
904-97.43	Removal of Power Supply Assembly	Ea.	1

PULL BOX SCHEDULE			
BOX NUMBER	BOX TYPE		
	CONCRETE	REINFORCED PLASTIC MORTAR	REINFORCED PLASTIC MORTAR W/CONC. APRON
1 2 3	SINGLE		
4 5	DOUBLE		
6		(17"Wx30"Lx26"MIN. H)	
7			(17"Wx30"Lx26"MIN. H)

SIGNAL BASE AND EQUIPMENT SCHEDULE			
BASE NO.	CONCRETE BASE TYPE	MAST ARM OR POST TYPE	SIGNAL EQUIPMENT TYPE
1	B-6	STEEL TRAFFIC SIGNAL POLE w/22' ARM	1 - 3B w/BP (ALL 12") 1 - 34S w/BP (ALL 12") 2 - 1S PED. (APPROX. 16"x18") 2 - PUSH BUTTONS
2	B-7	STEEL TRAFFIC SIGNAL POLE w/36' ARM & w/14' ALUMINUM POST EXTENSION	1 - 4B w/BP (ALL 12") 2 - 3B w/BP (ALL 12") 1 - 3S w/BP (ALL 12") 2 - 1S PED. (APPROX. 16"x18") 2 - PUSH BUTTONS 1 - PTZ SURVEILLANCE CAMERA
3	B-6	STEEL TRAFFIC SIGNAL POLE w/24' ARM	1 - 3B w/BP (ALL 12") 1 - 34S w/BP (ALL 12") 2 - 1S PED. (APPROX. 16"x18") 2 - PUSH BUTTONS
4	B-7	STEEL TRAFFIC SIGNAL POLE w/34' ARM	1 - 4B w/BP (ALL 12") 2 - 3B w/BP (ALL 12") 1 - 3S w/BP (ALL 12") 2 - 1S PED. (APPROX. 16"x18") 2 - PUSH BUTTONS
5	D-8PH		CONTROLLER, GROUND MOUNT, ALUMINUM CABINET (APPROX. 55"Hx44"Wx26"D) w/BATTERY BACKUP

INDUCTION LOOP DETECTOR SCHEDULE				
LOOP NO.	SIZE AND TYPE OF LOOP		CARD IN POSITION RACK	CHANNEL USED
	STANDARD (3-TURNS)	QUADRUPOLE (2-4-2)		
21	6'x6'		2	A
22	6'x6'		2	B
61	6'x6'		6	A
62	6'x6'		6	B
41		(2) 6'x20'	4	A
42		(2) 6'x20'	4	B
81		(2) 6'x20'	8	A
82		(2) 6'x20'	8	B
11		(2) 6'x20'	1	A
51		(2) 6'x20'	5	A
CARDS PROVIDED FOR FUTURE USE				
OPEN SLOTS IN CARD RACK			3,7	

EXAMPLE SIGNAL EQUIPMENT/MATERIALS AND QUANTITY SHEET	
INTERSECTION SIGNAL	
MAJOR STREET AND MINOR STREET	
DRAWN BY	DATE:
CHECKED BY	DRAWING NO.
APPROVED BY	FILE NO.