

City of Houston

Design Manual

Chapter 15

TRAFFIC AND SIGNAL DESIGN REQUIREMENTS

Chapter 15

TRAFFIC AND SIGNAL DESIGN REQUIREMENTS

15.01 CHAPTER INCLUDES

- A. Criteria for the design of traffic and signal requirements.

15.02 REFERENCES

- A. Refer to the reference lists in Chapter 1 - General Requirements and Chapter 10 - Street Paving Design Requirements
- B. Roundabout Informational Guide, Current Edition
- C. Signal Timing Manual, Current Edition
- D. Trip Generation, Current Edition (An ITE Informational Report, Institute of Transportation Engineers, Washington, D.C.)
- E. TxDOT Traffic Signal Manual, Current Edition
- F. City of Houston, Standard Details, Current Edition
- G. City of Houston, Standard Specifications, Current Edition

15.03 DEFINITIONS

- A. **Access Management** is the systematic control of the location, spacing, design and operation of driveways, median openings, intersections, bike lanes, and auxiliary lanes.
- B. **ADT** is the average daily traffic volume. It represents the total two-way traffic on a street for some period less than a year, divided by the total number of days it represents, and includes both weekday and weekend traffic. Usually, ADT is adjusted for day of the week, seasonal variations, and/or vehicle classifications.
- C. **Auxiliary Lane** is a lane striped for use as an acceleration lane, deceleration lane, right-turn lane, or left-turn lane, but not for through traffic use.
- D. **Central Business District** shall mean the area bounded by Interstate Highway 45, United States Highway 59, and Interstate Highway 10.
- E. **Connection Spacing** is the distance between connections, which is measured along the edge of the traveled way from the closest edge of pavement of the first access connection to the closest edge of pavement of the second access connection.

- F. **Corner Clearance** is the distance along the edge of the traveled way from the closest edge of pavement of the intersecting public or private street to the closet edge of pavement of the nearest driveway.
- G. **Design Exception** shall mean any City Engineer approved variation from the design requirements listed in this chapter.
- H. **Driveway** is an access connection constructed within the public right-of-way, used to connect a public or private street with adjacent property.
- I. **Driveway Permit** - Permit issued by the Building Official based upon Section 3110.4 of the Houston Amendments to the 2006 International Building Code or latest revisions. Driveway permits for access to Freeways, Highways, Frontage Roads, Tollways and Farm to Market Roads are not under the jurisdiction of the City of Houston. Driveway approvals from the appropriate agency with jurisdiction is required with building permit application.
- J. **Intersection Limits** shall mean the functional portion of the intersection and shall be defined as the extent or limit of turning bays unless otherwise defined by the City Engineer.
- K. **Joint Access** See "Shared Access"
- L. **Major Activity Center** shall mean those areas designated as Major Activity Centers pursuant to Section 42-274 of the Code of Ordinances of the City of Houston, Texas.
- M. **Median** is the portion of a divided street separating opposing traffic flows. A median may be traversable or nontraversable.
- N. **Shared Access** is a single connection serving two or more adjoining lots or parcels.
- O. **Sight Distance** is the distance visible to the driver of a passenger vehicle measured along the normal travel path of a street from a designated vehicle location and to a specified height above the street when the view is unobstructed by traffic. Refer to AASHTO, Geometric Design of Highways and Streets (Current Edition), for application to specific design needs such as stopping sight distance, other sight requirements.
- P. **Storage Lane Length** is the portion of an auxiliary lane required to store the number of vehicles expected to accumulate in the lane.
- Q. **Transit Corridor** is a road along a rail corridor (non-freight) designated on the Major Thoroughfare and Freeway Plan with definition defined in Chapter 42, Code of Ordinances.

15.04 TRAFFIC STUDIES FOR SITE DEVELOPMENT

A. APPLICABILITY

1. Two levels of traffic studies are identified and are dependent upon specific site location conditions, adjacent street configurations/capacities and traffic generation rates for proposed development. These studies are referred to as "Access Management Data" and "Traffic Impact Studies (TIA)". Figure 15.04.01 provides an overview of the submittal and review process.
2. For each proposed development or redevelopment, an Access Management Data Summary Form must be submitted.
Access Management Form provides general property information and an initial estimate of traffic volumes associated with the property.
3. Exceptions to the requirements for the submittal of Access Management Data Summary Form include:
 - a. Construction, reconstruction, remodel or additions to a single family residence.
 - b. Remodel of commercial developments with no change in use and/or size.
4. In addition to filing the Access Management Date Form, a Traffic Impact Analysis may be required.
 - a. If the proposed development or redevelopment generates 100 or more new peak hour trips (PHT), the Analysis Engineer should meet with the City to determine the requirement for a Traffic Impact Study.
 - b. If after discussion with the City, a Traffic Impact Study is required, the extent of the area to be studied will be determined.
 - c. If an applicant submits a development plat application or building permit application for new development or redevelopment, the applicant may voluntarily submit a TIA to support the trip generation rates and access management needs to the adjacent street system for the proposed project.
5. The City may ask for a technical memorandum in lieu of a full Traffic Impact Analysis (TIA). The technical memo shall be submitted when the proposed development generates 80 vph -120 vph during AM or PM peak hours, utilizing the trip generation rates in the latest edition of the Traffic Generation Manual. The technical memo shall address the immediate intersection(s) to the proposed development. The intersection(s) to be included in the technical memorandum shall be decided by the City. The memorandum shall address the studies intersection(s) in terms of:
 - a. Existing traffic counts (turning movements and 24-hour counts)

- b. Existing signal timing
- c. The Intersection geometric layout including:
 - (1) Number of lanes for each approach
 - (2) Lane width
 - (3) Medians widths and median openings locations
 - (4) Existing driveways location near the proposed development
 - (5) Signage and lane marking
- d. Existing operation performance using SYNCHRO or HCM compatible software packages
- e. Number of trips generated by the proposed development
- f. The impact of the proposed development on the intersection(s) traffic operation performance under the existing conditions (using SYNCHRO or HCM compatible software packages)
- g. The proposed mitigation measures including but not limited to:
 - (1) Changing lane usage and marking
 - (2) Changing geometric and/or layout
 - (3) Changing traffic control type
 - (4) Adding lanes
- h. The impact of the proposed mitigation measures on the intersection traffic operation performance (using SYNCHRO or HCM compatible software packages).

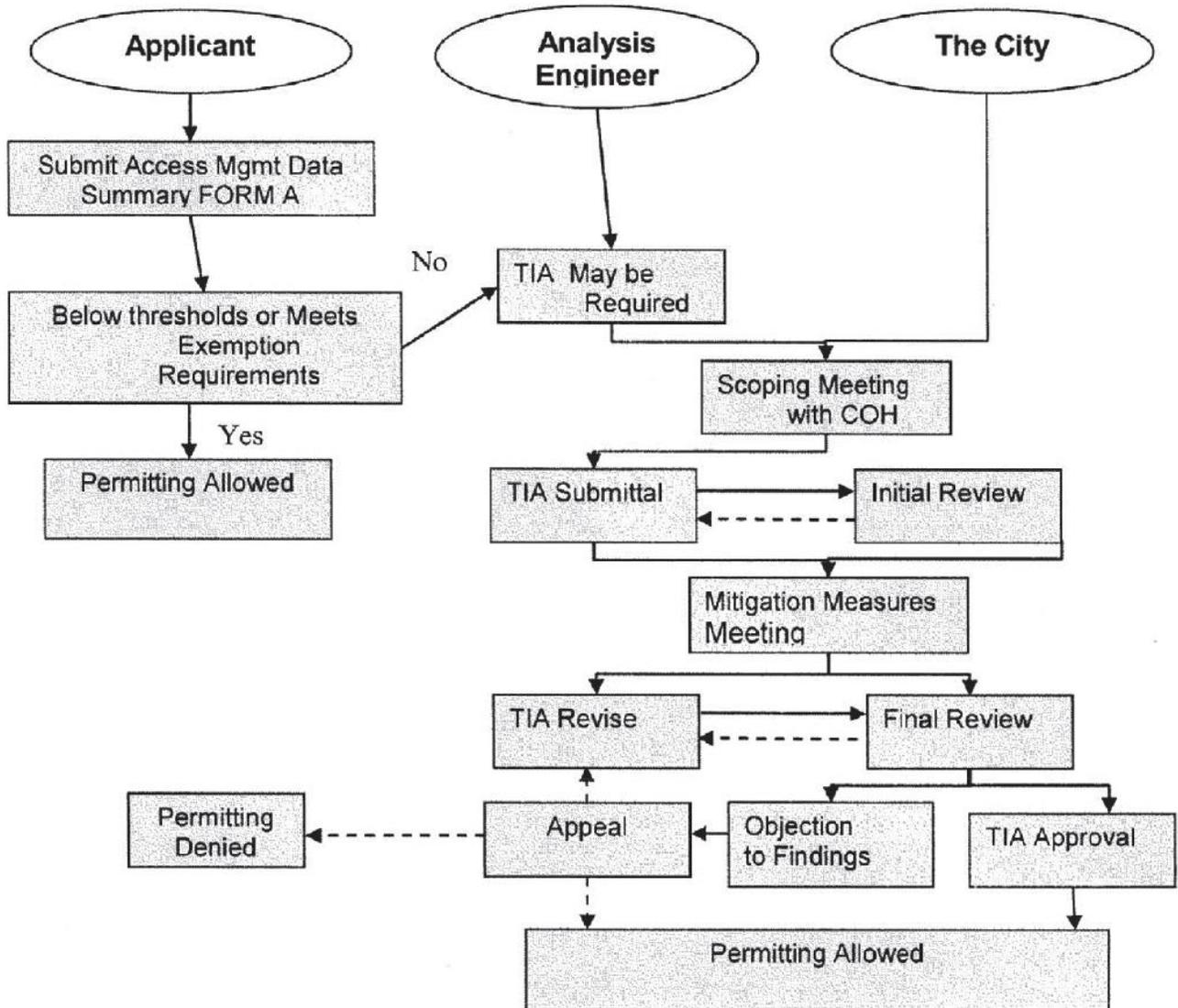


Figure 15.04.01 Overview of Traffic Impact Analysis Process

ACCESS MANAGEMENT DATA FORM



City of Houston
Access Form

Project Name: _____ Project Number: _____

Critical Item:

An Access Form is required for all commercial developments with the exception of developments with no change in use and/or size. Alterations to roadway access points **may result in significant site plan revisions.** For this reason, Access Forms should be submitted prior to or during plat submittal. If platting is not required, this form shall be approved prior to submitting plans for permitting.

Background:

This Access Form provides general property information and initial estimates of traffic volumes associated with the property. Chapter 15 of the City of Houston Infrastructure Design Manual (IDM) requires all commercial properties to submit an Access Form and a Traffic Impact Analysis (TIA) (if applicable). Exceptions to the submittal of an Access Form are:

- a) Construction, reconstruction, remodel or additions to a single family residence.
- b) Remodel of commercial developments with no change in use and/or size.

Furthermore, existing driveways in the right of way are not grandfathered.

Instructions:

This Access Form must be completely filled and submitted to PWEACCESSFORM@HOUSTONTX.GOV for review. It **must** be accompanied by a dimensioned site plan layout with driveway locations indicating the extent of the access which the commercial property has or (is planned) to access public streets. On-site traffic related features (loading docks, emergency lanes, and driveway entrance/exits) **must** be depicted on the site plan.

ACCESS MANAGEMENT DATA FORM

Access Form

Project Name: _____ Project Number: _____

Project Address: _____

Applicant: _____

Telephone: _____ Email: _____

<input type="checkbox"/> I have read and understand all items on page 1 of this Access Form (Check mark and initials are required to start review)	Initials: _____
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EXISTING DEVELOPMENT (IF FUNCTIONAL):

Tract Number: _____ Tract Size: _____

Building Sq. Ft.	Land Use Description & I.T.E Code	Trip Rate		Peak Hour Trips		Average Daily Traffic Rate	Average Daily Traffic
		AM	PM	AM	PM		
Total							

PROPOSED DEVELOPMENT (NEW ADDED TRIPS):

Tract Number: _____ Tract Size: _____

NET NEW ADDED TRIPS:	
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Building Sq. Ft.	Land Use Description & I.T.E Code	Trip Rate		Peak Hour Trips		Average Daily Traffic Rate	Average Daily Traffic
		AM	PM	AM	PM		
Total							

ABUTTING ROADWAYS:

Street Name	Number of Driveways	R.O.W Width	Pavement Width

ACCESS MANAGEMENT DATA FORM

Access Form

Project Name: _____ Project Number: _____

FOR OFFICE USE ONLY:

- The Office of City Engineer (OCE) has reviewed the Access Form provided for this project. At this time, the OCE has no objection to permitting for driveway access on the basis of vehicle trips generated by this development. **(Please provide a copy of this form with your permit documents.)**

However, this statement of no objection does not supersede requirements to comply with geometric design standards, codes and ordinances pertaining to median opening/modifications, driveways, auxiliary lane and other roadway improvements. All geometric design modifications must be approved by the Office of the City Engineer.

Reviewed by: _____ Date: _____

- At this time, a Technical Memorandum is required in lieu of a full Traffic Impact Analysis (TIA). The technical memo shall be submitted when the proposed development generates 80 vph -120 vph during AM or PM peak hours, utilizing the trip generation rates in the latest edition of the Traffic Generation Manual.

(If additional concerns arise through the review of a Technical Memorandum, the City of Houston may request a full Traffic Impact Study.)

- A Traffic Impact Analysis is required. The Analysis Engineer should meet with the City to determine the scope for a Traffic Impact study and the extent of the study area.

	Traffic Impact Category	Site Traffic Thresholds New Peak Hour Trips (PHT) On Adjacent Street
<input type="radio"/>	Category I	PHT < 100
<input type="radio"/>	Category II	100 to 499
<input type="radio"/>	Category III	500 to 999
<input type="radio"/>	Category IV	PHT ≥ 1000

B. TRAFFIC IMPACT ANALYSIS GUIDELINES (TIA)

1. General

a. Authorization to Perform a TIA

A TIA shall be prepared by an individual, group, firm, or corporation having demonstrated professional emphasis and experience in traffic engineering, and the preparation of similar analysis, hereinafter referred to as the "Analysis Engineer". The TIA document shall bear the seal and signature of a Texas Licensed Professional Engineer specializing in the branch of civil engineering. The responsibility for assessing the traffic impacts associated with a proposed development/redevelopment, hereinafter referred to as the "Development," rests with the Applicant and the Analysis Engineer, while the City shall serve as the review and approval authority.

b. Purpose and Intent of TIA Guidelines

The purpose of the TIA is to identify the adequacy of the existing street right of way to accommodate any changes in trips generated from a proposed development/redevelopment (as a stand-alone development or a stage of a master plan). If impacts are identified, potential mitigation measures (on-site or off-site) can be proposed and evaluated. The traffic impact analysis will be used to make a determination as to whether driveway(s) being considered are necessary to provide reasonable access to the private property consistent with the safety and convenience of the public.

c. Goals of a TIA Completed Within the City of Houston

- (1) To identify any and all potential adverse traffic impacts to the existing area street system, the surrounding community and to additional proposed developments.
- (2) To identify transportation improvements with an aim to cost effectively mitigate identified adverse traffic impacts to mobility within the study area/analysis area.
- (3) To assist public and private sector entities in identifying and resolving issues related to the location of driveways, median openings, turn lanes, traffic signals, and other transportation facilities.

d. Document Limitations

While this section (15.04) contains guidelines and requirements necessary to complete a TIA for the City, the City does not intend this section to be a sole reference for the preparation of a TIA. For more specific information regarding the various aspects of TIA preparation, the City suggests that the reader obtain and refer to the Institute of Transportation Engineer's (ITE) current edition of Transportation Impact Analyses for Site Development (An

ITE Proposed Recommended Practice).

2. The Traffic Impact Analysis Process
 - a. The TIA report shall bear the seal and signature of a Texas Licensed Professional Engineer specializing in the branch of civil engineering. The responsibility for assessing the traffic impacts associated with a proposed development or redevelopment rests with the applicant and the Analysis Engineer, while the City shall serve as the review and approval authority.
 - b. A TIA determines traffic impacts of a development/redevelopment on the surrounding street system. The City will use this information to assist in establishing immediate transportation infrastructure needs and potential transportation improvements. If the development/redevelopment is a stage of a future larger development (master plan), the TIA should include the impact of the overall development (all stages).
 - c. It is a goal of the City that these guidelines will allow for the maximization of efficiency and safety associated with area development/redevelopment. The City emphasizes that the TIA process can begin when the Applicant initiates development planning (i.e. prior to plat preparation).
 - d. If a TIA is required or the applicant chooses to prepare a TIA, the completed TIA may be submitted at any time prior to or during the plat submittal. If platting is not required, a TIA shall be approved prior to submitting plans for permitting. TIA review may result in significant site plan revisions. The final site plan approval shall not be issued without the TIA approval.
 - e. Prior to submitting an application for development platting or a building permit the Applicant may be required to submit a revised TIA and obtain approval by the City if any changes have been made to the development (site plan) or original TIA assumptions related to:
 - (1) Land-use (revisions required only for an increase in trips),
 - (2) Increase in the trip generation variable(s) (revisions required only for an increase in trips),
 - (3) Intersection and street design, and
 - (4) Access connections placement and design assumptions.
3. The Proposal of Scope and Initial Trip Generation Estimate
 - a. Using proposed development redevelopment, or master plan attributes (type, size, etc.), determine a corresponding traffic impact category for the Development by calculating the highest number of estimated new peak hour trips generated for an adjacent street (See Table 15.04.01).

Table 15.04.01 Traffic Impact Categories

Traffic Impact Category	Site Traffic Thresholds New Peak Hour Trips (PHT) on Adjacent Street
Category I	PHT < 100
Category II	100 to 499
Category III	500 to 999
Category IV	PHT ≥ 1000

b. The City requires that the Analysis Engineer generate site traffic using the methodologies found in the current edition of the ITE publication. This includes following the "Recommended Procedure for Estimating Trip Generation", as shown in Figure 15.04.02.

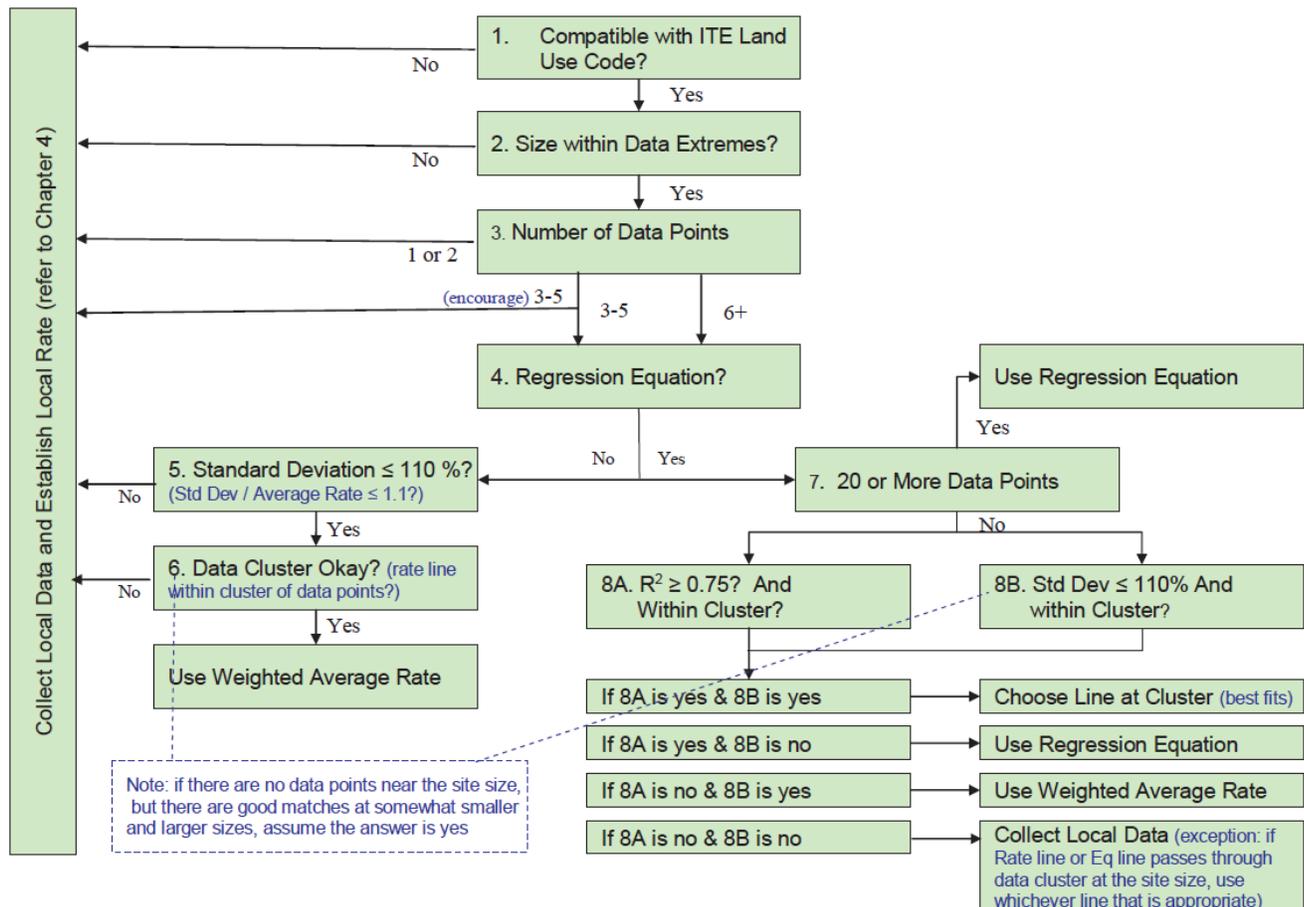


Figure 15.04.02 Recommended Procedure for Estimating Trip Generation

- c. Using the resulting traffic impact category and the Boundaries and Horizons Guidelines in Table 15.04.02, the Analysis Engineer shall prepare and submit to the City Engineer a proposed scope for the TIA.
 - d. It is also a goal of the proposed scope to minimize deliverables. It is mandatory that, regardless of traffic impact category (II, III, or IV), the Analysis Engineer holds a preliminary scoping meeting with the City Traffic Engineer.
 - e. An approved proposal of scope ensures that the submittal of a TIA will allow the City to evaluate the overall traffic impact of the development on area transportation infrastructure.
4. Preparing the TIA

The TIA shall be prepared according to the requirements detailed in the Traffic Impact Analysis Preparation Overview Figure 15.04.03.

Table 15.04.02 Boundaries and Horizons Guidelines

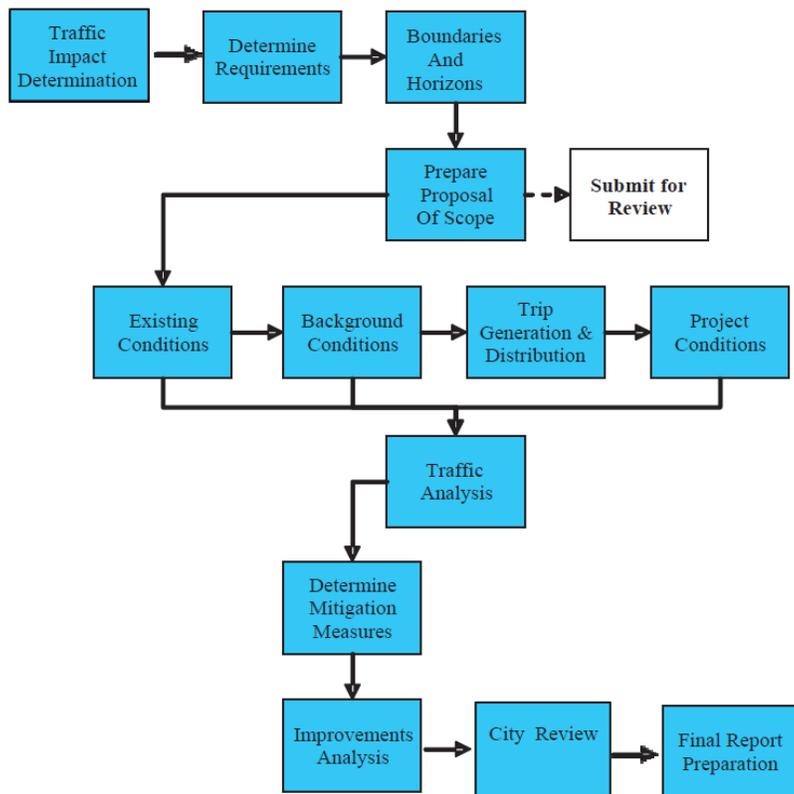
Requirements		Category I	Category II	Category III	Category IV
General	Access Management Data Summary Form	X	X	X	X
	Scoping Meeting with the City Traffic Engineer		X	X	X
	Proposed Scope		X	X	X
Horizon	Opening Year		X	X	X
	Full Build-Out Year ⁽¹⁾			X	X
Limits ⁽³⁾	Analysis Area (From boundaries of development) ⁽²⁾		¼ Mile	½ Mile	½ or 1 Mile
	All Site Access Driveways		X	X	X
	All Site Access Private Street Intersections		X	X	X
	All Adjacent Signalized Intersections		X	X	X
	All Adjacent Major Unsignalized Intersections		X	X	X
	All Analysis Area Signalized Intersections			X	X
	All Analysis Area Major Unsignalized Intersections			X	X

- (1) Including the full implementation of master plan.
- (2) Category II, III and IV studies should extend to first signalized intersection (minimum) even if outside of Boundary and include any critical intersections as defined by the City.
- (3) Shall be defined as the limits of the master plan.

5. TIA Submission and Review

- a. All TIA submittals should be addressed to the Office of the City Engineer. Paper copies should be submitted through the Office of the City Engineer, 2nd floor of 1002 Washington Avenue, Houston, TX. Electronic copies should be emailed directly to the Office of the City Engineer.
- b. The Applicant shall submit to the City two (2) paper copies and one electronic copy. In addition, one electronic version of the TIA appendix is required (paper copies of the appendix are not necessary unless requested by the City).

Figure 15.04.03 Traffic Impact Analysis Preparation Overview



- c. The City will make an initial review of the TIA to determine if the Analysis Engineer completed the TIA in accordance with the technical requirements and within the submission requirements of the analysis as outlined in this manual or as established at the preliminary scoping meeting or proposal of scope. If the City finds deviations from the technical requirements and/or the submission requirements of the study, the City will terminate the initial review until the Analysis Engineer has addressed said deficiencies. At such a time when the City identifies deficiencies, the City will send a notice of deficiencies to the Analysis Engineer and Applicant. Submittal should include, if available, electronics copies of traffic counts (in Excel and pdf formats) and other collected data (i.e., queuing, delay studies, etc.) as well as any traffic analysis models used and reference in the TIA.
 - d. All TIA submittals should include either an interim seal or a final seal, which is signed by a Licensed Professional Engineer in the State of Texas.
 - e. When the Applicant submits a final TIA that meets the technical and submission requirements established in this document or at the preliminary scoping meeting or proposal of scope, the City will conduct a final review of the TIA.
 - f. Following the City's completion of the final review, the City will provide to the Analysis Engineer and Applicant written objection to the findings or adequacy of the proposed mitigation measures to address impacts. If no objections are noted, the City will interpose no objection to permitting for the proposed development. If the Applicant disagrees with the objections made by the City, the Applicant may write an appeal to the Director of Public Works.
 - g. Approval of a TIA will remain valid for a maximum of three years (from date of final TIA approval). Validity of an approved TIA beyond three years will be allowed by the City Engineer so long as the phased development is proceeding according to the approved plan and the schedule contained within such approved plan. The applicant may be required to update traffic impact data to address changes within the area and will meet with the City Engineer prior to the expiration of the three-year period to determine if an updated TIA is required.
6. Mitigation Measures Requirements
- a. The TIA shall have identified significant adverse traffic impacts in order to trigger the need for mitigation. The need for mitigation is determined by using the qualitative measure Level-of-Service (LOS). The threshold of significance for transportation facilities on the area street system is LOS D.

- b. Transit Corridor Streets - Chapter 42 of the City of Houston Code of Ordinances (Subdivisions, Developments and Platting) and this Infrastructure Design Manual provide planning rules and design standards to achieve multi-modal transportation corridors along designated Transit Streets.

Where a TIA for proposed development along a Transit Corridor Street is required by this chapter, it shall include trip generation estimates in accordance with guidelines presented in Figure 15.04.02. The TIA shall include a summary of estimated trips by applicable transportation categories. Transportation categories may include automobile, truck, transit, bicycle and pedestrian. Trip allocations shall be supported by documentation including data from local planning agencies, records of actual ridership from local transit agencies, statistical data from similar projects in other locations, standards from professional organizations, and other applicable resources. Where the existing, background or projected conditions are LOS E or F and existing physical conditions limit available mitigation measures, the Analysis Engineer shall meet with the City Engineer to review probable community impacts and possible mitigation measures, if any. Approval of TIA's along Transit Corridor Streets may not be withheld where all reasonable and feasible access management and offsite mitigation measures in the public street right of way have been exhausted. Access management and offsite mitigation measures may include the addition of pedestrian/bicycle facilities transit amenities, the installation of turn lanes and/or additional lanes of traffic such as deceleration lanes, the installation of traffic signals, the construction of traffic control features or medians, and/or limitations on the number of driveways.

- c. Major Thoroughfares - Chapter 42 of the City of Houston Code of Ordinances establish roadways to be classified as Major Thoroughfares by inclusion on the Major Thoroughfare and Freeway Plan (MTFP). Major Thoroughfares are roadways designed to allow for access from large traffic trip generators and move traffic between adjacent activity centers. Projects in Traffic Impact Categories II, III and IV (see Table 15.04.01) along Major Thoroughfares are expected and fostered because of the traffic carrying capacity. Similar to a Transit Corridor Street, where the existing, background or projected conditions are LOS E or F and existing physical conditions limit available mitigation measures, the Analysis Engineer shall meet with the City Engineer to review probable community impacts and possible mitigation measures if any. Approval of TIA's along Major Thoroughfares may not be withheld where all reasonable and feasible access management and offsite mitigation measures in the public street right of way have been exhausted. Access management and offsite mitigation measures may include the addition of pedestrian/bicycle facilities, the installation of turn lanes and/or additional lanes of traffic such as deceleration lanes, the installation of traffic signals, the construction of traffic control features or medians, and/or limitations on the

number of driveways.

- d. Central Business District - Boundaries of the Central Business District (CBD) are defined in Section 15.03. Development and redevelopment of the CBD are anticipated to involve high rise, large traffic generating facilities. Similar to a Transit Corridor Street, where the existing, background or projected conditions are LOS E or F and existing physical conditions limit available mitigation measures, the Analysis Engineer shall meet with the City Engineer to review probable community impacts and possible mitigation measures if any. Approval of TIA's in the CBD may not be withheld where all reasonable and feasible access management and offsite mitigation measures in the public street right of way have been exhausted. Access management and offsite mitigation measures may include the addition of pedestrian/bicycle facilities, the installation of turn lanes and/or additional lanes of traffic such as deceleration lanes, the installation of traffic signals, the construction of traffic control features or medians, and/or limitations on the number of driveways.
- e. Major Activity Centers are defined in Section 15.03. Development and redevelopment in Major Activity Centers is anticipated to involve high rise, large traffic generating facilities. Similar to a Transit Corridor Street or Major Thoroughfare, where the existing background or projected conditions are LOS E or F and existing physical conditions limit available mitigation measures, the Analysis Engineer shall meet with the City Engineer to review probable community impacts and mitigation measures, if any. Approval of TIAs within a Major Activity Center may not be withheld when all reasonable and feasible access management and offsite mitigation measures in the public street right of way have been exhausted. Access management and offsite mitigation measures may include the addition of pedestrian/bicycle facilities transit amenities, the installation of turn lanes and/or additional lanes of traffic such as deceleration lanes, the installation of traffic signals, the construction of traffic control features or medians, and/or limitations on the number of driveways.
- f. The Mitigation Decision Tree for local roadways and collector streets is shown in Figure 15.04.04 below. The chart is color coded. Purple indicates acceptable levels of service A-D; yellow indicates marginal level of service E; and red indicates unacceptable level of service F. The Tree components are defined as follows:
 - (1) Existing - represents the performance of the existing street network
 - (2) Background - represents the performance of the street network for a future year, "no build" scenario. Includes future volumes without the proposed development; accounts for traffic from projects under construction but not yet in operation; and includes any future improvements to the street network that are already programmed, regardless of whether the proposed development is built.

- (3) Projected - represents the performance of the street network for a future year, "build scenario", which represents the future street volumes with the proposed development in place. Other than changes in traffic volumes, the "Projected" scenario includes the same street network conditions as the "Background" scenario.
 - (4) Mitigation - represents the performance of the future street network with the proposed development and with proposed mitigations resulting from the proposed development. Mitigation action is required for all conditions indicated in this row of the Decision Tree.
 - (5) LOS E and LOS F
 - (a) Prior to final approval/disapproval involving LOS E and LOS F, the Applicant will meet with City Engineer to review all aspects of proposed development and adjacent roadway conditions including intersection delays.
 - (b) For areas in the street system where the current LOS is E, the existing LOS must be maintained or improved after development. For example, if the LOS prior to the proposed development is E, then once the development is in place, the projected LOS must be at least E.
 - (c) For areas in the street system where the current LOS is F, the traffic impacts of the development on the streets and intersection within the analysis area shall be mitigated such that the delay and queuing do not deteriorate beyond Background Conditions.
- g. Methodology for computing each type of MOE and determining corresponding LOS can be found in the Highway Capacity Manual (HCM).

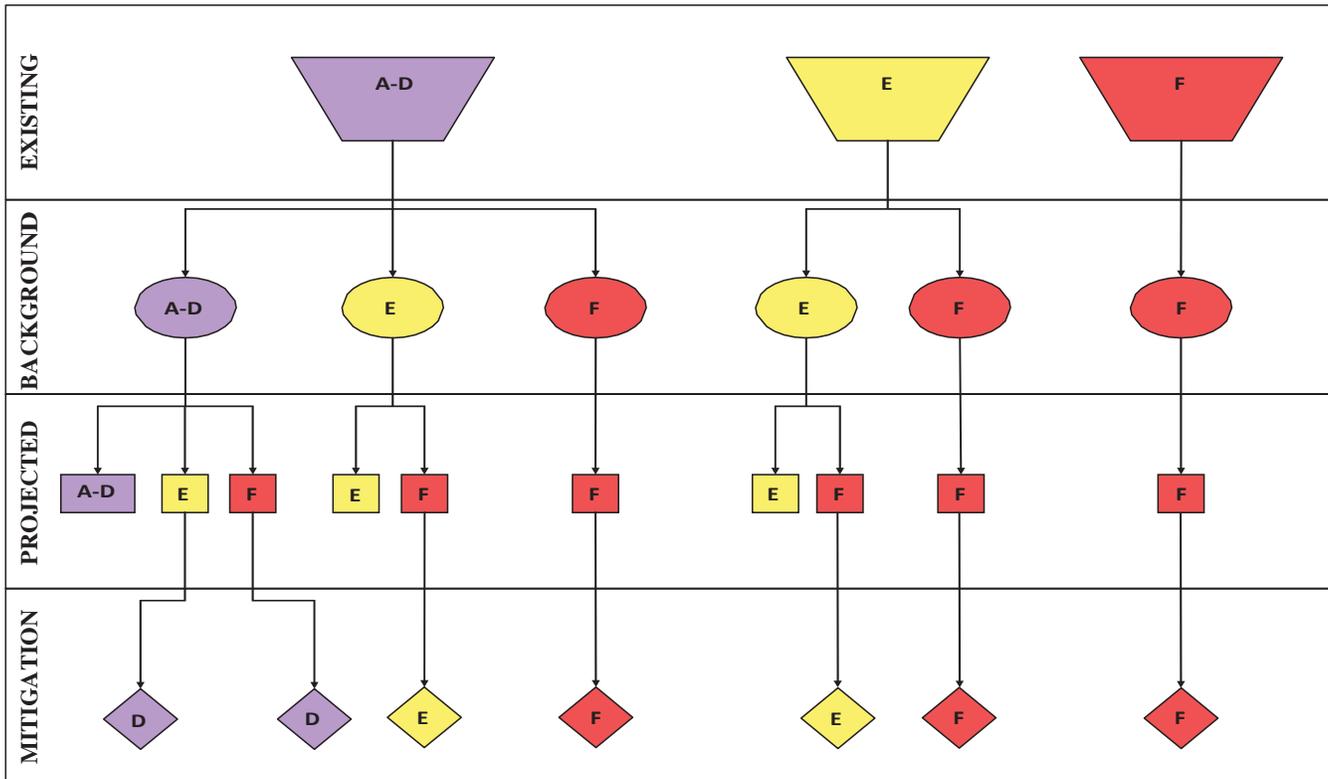


Figure 15.04.04 Mitigation Decision Tree (Collector and Local Roadways)

- h. Traffic signal retiming is not considered an acceptable mitigation measure unless it is first approved by the City of Houston Traffic Signal Operations. Typically, an individual intersection cannot be re-optimized in the future if it is a part of coordinated street network. This may only be possible if the entire street network is re-timed to allow for system wide signal progression. If signal retiming is approved by the City as a mitigation measure, it should be included in the "Mitigation" scenario.

7. Traffic Impact Analysis Submission Requirements

- a. The Analysis Engineer must identify all of the required data and information in the appropriate sections of the report.
- b. Text contained in the document shall be comprehensive and complete.
- c. The report shall have an electronic copy of final submittals along with the bound copy.
- d. The report shall contain a table of contents, lists of figures and list of tables. A typical TIA report outline is shown in the following sections.

I. Executive Summary

- (a) *Site Location & Analysis Area*
- (b) *Development Description*
- (c) *Conclusions*
- (d) *Recommendations*

II. Introduction

- (a) *A statement about the purpose and objectives of the analysis.*
- (b) *A description of the existing and expected land use and intensity.*
 - (1) *If residential, number and type of dwelling units.*
 - (2) *If commercial or industrial, square footage and type.*
 - (3) *If redevelopment, what is the expected trip generation differential.*
- (c) *A vicinity map identifying major industrial and site access intersections and other approved projects near the development.*
- (d) *A site plan for the development.*
- (e) *A description of development phasing and estimate year each phase will begin and end.*

III. Area Conditions

- (a) *A description of the analysis area.*
- (b) *A description of existing and future land uses within the analysis area. The description should include current land use, densities and occupancy, anticipated development, undeveloped properties, and current master plans.*
 - (1) *If residential, number and type of dwelling units.*
 - (2) *If commercial or industrial, square footage and type.*
- (c) *A combination of narratives, tables and figures detailing area street system characteristics within the analysis area including:*
 - (1) *Programmed street improvements in the area (City of Houston 5 year Capital Improvement Plan)*
 - (2) *Additional streets that may be impacted*
 - (3) *Functional Street Classifications (based upon Major Thoroughfare and Freeway Plan)*
 - (4) *Posted Speed Limits*
 - (5) *Distance, and alignments from existing streets, driveways, and/or median openings to development access (need to assess Access Management Standards)*
 - (6) *Traffic control devices (traffic signals and Stop signs)*
 - (7) *Signal locations and timings (offsets need to be shown if in coordination)*
 - (8) *Intersection layout, lane usage, and street configuration*
 - (9) *Street right-of-way widths*
 - (10) *Lane widths*
 - (11) *Current traffic volumes within the past 1 year to have been captured on a typical Tuesday, Wednesday, or Thursday for all streets in the analysis. Any traffic volumes older than 1 year may not be*

acceptable and will need to be justified. The Analysis Engineer should also make every reasonable effort to count traffic that accurately reflects a true “peak period” for the area, which includes any potential seasonal variations (i.e. schools, churches, etc.). Depending on the type of development, it may also be necessary to capture volumes on a typical weekend.

- i. 24-hour counts at major intersection and site access intersections*
- ii. Turning movement counts (Peak Hours)*
- (12) Pedestrians and Bikes (If Applicable)**
 - i. Facilities*
 - ii. Volumes*
- (13) Transit Service (If Applicable)**
 - i. All bus stops, bus pads, bus shelters*
 - ii. Ridership (where applicable/when available)*
 - iii. Routes and Service Intervals*
- (14) Crash Analysis (if Applicable) over the past 3 years, including number and types of crashes as well as severity of injuries.**
- (15) Existing sight distances – Intersection and stopping sight distances, vertical and horizontal clearances. Refer to Chapter 10, Section 10.06.B.3. Intersection Sight Distance.**

IV. Required Table(s)

- (a) Twenty-four hour approach volumes at major and site access intersections.*
- (b) Peak Hour approach volumes at major and site access intersections.*

V. Required Figure(s)

- (a) Major and site access intersection lane configuration diagrams with existing Twenty-four hour approach volumes. Preferably overlaid onto aerial photography.*
- (b) Major and site access intersection lane configuration diagrams with existing AM and PM peak hour turning movement volumes. Preferably overlaid onto aerial photography.*
- (c) The Analysis Engineer may also use photographs (identifying location from where it was taken as well as the date and time stamp) to document existing conditions.*

VI. Projected Traffic

- (a) Sufficient details of calculations so that all calculations can be verified.*
- (b) Site generated traffic volumes (24-hour and peak periods) by corresponding development phase or year.*
- (c) Trip Generation - List of trip generation rates and/or sources of rates used for the study.*
- (d) Trip Distribution and Assignment - The gravity model or other acceptable trip distribution model used to estimate trip distribution. The Analysis Engineer can complete this task either manually or with applicable*

computer models.

- (1) Background traffic volumes (24-hour and peak periods) by corresponding development phase or year.*
- (e) Traffic Volumes should account for all approved developments in the analysis area as well as area growth beyond the analysis area. Contact the City for information about surrounding developments.*
 - (1) Pass-by and diverted traffic volume reduction rates, if applicable.*
 - (2) Pedestrian, bicycle and transit reduction rates, and supporting evidence, if applicable.*
 - (3) Internal capture reduction rates, if applicable.*
 - (4) Total project traffic volumes (24-hour and peak periods) by corresponding development phase or year. Future traffic as may be required for a development with multiple phases should also be included.*
- (f) Required Table(s)*
 - (1) Pass-by trip, internal capture, pedestrian, bicycles, and transit reduction rates used, if applicable.*
 - (2) Twenty-Four hour approach volumes for background, pass-by, site generated, and total project traffic conditions at major and site access intersections and any additional transportation facilities specified by the City.*
 - (3) Peak Hour approach volumes for background, pass-by, site generated, and total project traffic conditions at major and site access intersections and any additional transportation facilities specified by the City.*
- (g) Required Figure(s)*
 - (1) Twenty-Four hour, and peak hour approach volumes for background, pass-by, site generated, and total project traffic conditions overlaid onto major and site access intersections lane configuration diagrams. Preferably overlaid onto aerial photography.*
 - (2) Peak hour turning movement volumes for background, pass-by, site generated, and total project traffic conditions overlaid onto major and site access intersections lane configuration diagrams. Preferably overlaid onto aerial photography.*
 - (3) Distribution and assignment rates for pass-by and site generated traffic volumes overlaid onto major and site access intersections lane configuration diagrams. Preferably overlaid onto aerial photography.*

VII. Traffic Analysis

Analyze existing, background and project Traffic Conditions LOS and Delay at all major and site access intersections and determine MOEs of any additional transportation facilities within the analysis area as necessary or as specified by the City.

- (a) Analysis must utilize existing traffic volumes.*
- (b) Analysis must utilize total projected traffic volumes which include site*

generated traffic and the background traffic to complete analyses for the required study limits and horizons as they correspond to the predetermined TIA category.

- (c) Analysis may be prepared manually or by using various software programs such as Highway Capacity Software, Synchro or as approved by the City.*
- (d) Analysis must utilize the capacity analysis methodology found in the current edition of the Highway Capacity Manual, or control delay calculations from Synchro or other software as approved by the City, and/or delay calculations from micro-simulation of the complete street network (no individual intersections) to determine LOS.*
- (e) Determination of necessary or specified MOEs should be completed using state- of-the-practice engineering methods.*
- (f) In addition to LOS and delay, the Analysis Engineer should identify critical movements regarding capacity and potential locations of queue spillback.*
- (g) The Analysis Engineer should perform a signal warrant analysis for unsignalized intersections (engineering judgment) using the signal warrant guidelines. Additionally, as part of the improvements analysis the Analysis Engineer should analyze any unsignalized intersections warranting a signal as a signalized intersection and discuss within the TIA report.*
- (h) Tables of existing, background and project traffic conditions LOS and delay for each major and site access intersection and MOEs for any additional transportation facilities specified by the City, include critical movements and queue spillbacks.*

VIII. Additional Information (If Applicable)

- (a) Site circulation and off-site parking requirements.*
- (b) Potential parking impact to adjacent neighborhoods and neighborhood parking*
- (c) Evaluation of potential need for traffic calming including bulb out, chicanes, roundabouts, or those elements found in Section 15.19 of this chapter.*
- (d) Others (If Applicable)*
 - (1) Crash Analysis*
 - (2) Traffic control needs*
 - (3) Transit (bus and rail)*
 - (4) Pedestrian and bicycle access*
 - (5) Delivery and service vehicles*
 - (6) Transportation demand management.*

IX. Transportation Improvements Analysis (Mitigation Measures)

- (a) A description and justification of needed transportation improvements to accommodate project traffic conditions*
- (b) LOS and Delay evaluation and comparison including review of critical*

- movements and queue spillbacks*
- (c) *MOE comparison for any additional transportation facilities specified by the City*
- (d) *Table(s)*
 - (1) *LOS and Delay comparisons for improvements including critical movements and queue spillback*
 - (2) *MOE comparisons for any additional transportation facilities improvements*
- (e) *Figure(s)*
 - (1) *Concept schematics of improvements including corresponding LOS and Delay values.*

X. Site Improvement Analysis

- (a) *A description of site circulation and recommendations for improvement.*
- (b) *A description of on-site parking and recommendations for improvement including shared parking, if applicable*
- (c) *A description of expected delivery and service vehicle operation and facility use and recommendations for improvement.*
- (d) *A description of expected site passenger loading characteristics related to bus stop/transit and recommendations for improvement.*
- (e) *A description of adherence to related access management concepts as can be found in the City's set of Access Management Standards including driveway design, access spacing, and turning movement treatments.*

XI. Conclusions and Recommendations

- (a) *Traffic Impacts*
- (b) *Adjacent transportation improvements for each horizon year addressing, at a minimum, the following:*
 - (1) *Traffic control device(s) (modification or installation)*
 - (2) *Additional capacity (left, right, or through lanes)*
 - (3) *Need for acceleration or deceleration lanes*
 - (4) *Critical movements*
 - (5) *Length of storage bays*
 - (6) *Implementation schedule*
- (c) *Off site transportation improvements*
 - (1) *Modification to existing traffic control device(s)*
 - (2) *Additional traffic control device(s)*
 - (3) *Additional capacity at major intersections*
 - (4) *Additional street capacity*
 - (5) *Other*
- (d) *Site transportation improvements*
 - (1) *Access Management*
 - (2) *Site circulation and parking*
- (e) *Mitigation Measures*
 - (1) *The TIA report shall identify the mitigation measures needed as a result of any traffic impacts of the proposed development or redevelopment. The TIA report should also identify who or what*

exactly caused the need for each mitigation measure. This information will be used when the Applicant meets with the City Engineer about the implementation and cost appropriations for mitigations measures.

XII. Appendices

Appendices may be included as an attached CD having individual electronic file folders for each appendix and appropriately titled Adobe PDF files.

- (a) Basic Trip Generation Worksheet*
- (b) Capacity Analysis Worksheets or Modeling Software Output*
- (c) Traffic Volumes (24-hour and peak hour turning movement counts)*
- (d) Selected Photographs*

C. TECHNICAL NOTES

1. Background Trip Determination

Background or non-site traffic forecasts are necessary to determine the impact of the development in horizon years such as the projected year of opening, year of full build-out and five years after full build-out. Background traffic consists of all trips that do not begin or end in the analysis area and all attraction and production trips from existing development within the analysis area. Trips generated from existing development within the analysis area are important as the proposed development may influence existing traffic patterns and potentially generate new trips for existing developments. Background traffic volumes should also include trips generated from other proposed developments within the analysis area. The Analysis Engineer should check with the City to ensure that all approved developments have been included in background traffic determination.

2. Methodologies for Background Traffic Determination

- a. There are three basic methodologies used to determine background traffic volumes: build-out, area transportation planning, and trending. Each of these methodologies has strengths and weaknesses. Some methods may be more appropriate depending on the category of the Development. The Analysis Engineer may use any of the three aforementioned methods to determine background traffic volumes. The City anticipates that the majority of background traffic calculations will be completed using trending methods. For this reason, the City provides the following information on trending.
- b. Trending or the use of growth rates is a common method used to generate background traffic. This method is particularly useful for smaller developments and studies having shorter horizon periods (5 to 10 years). City of Houston traffic volumes have typically grown between one and two percent per year. Although these growth rates are typical for the whole of the City,

there are some areas that may have higher and lower rates of growth. The Analysis Engineer may find higher growth rates in outlying areas of the City having lower development density, and lower growth rates in older more mature areas of the City that have little or no year-to-year changes in traffic. In general, the City of Houston experiences a growth rate of one percent for all trending analyses. It is a requirement and the responsibility of the Analysis Engineer to apply appropriate growth rates as they correspond to different areas of the city. The Analysis Engineer should provide and justify an expected area growth rate in the proposal of scope for approval by the City. Where feasible, growth rates should be calculated from historical counts.

3. Site Trip Generation

The City requires that the Analysis Engineer generate site traffic using the methodologies found in the current edition of the ITE publication, Trip Generation Handbook. This includes following the "Recommended Procedure for Estimating Trip Generation", as shown in Figure 15.04.02. General Trip Generation Rates shall be obtained from the Trip Generation Handbook, current edition.

The ITE publication suggests using rates from local studies as a preferred method for generating site traffic. If the Analysis Engineer utilizes local studies to determine appropriate rates, it is a requirement and the responsibility of the Analysis Engineer to reference these studies in the TIA report. In addition, the Analysis Engineer must make available copies of the referenced studies if requested by the City. If local rates are not available, the Analysis Engineer shall use equations and rates from the current edition of the ITE Trip Generation report as long as it follows the ITE Recommended Procedure, as shown in Figure 15.04.02. Otherwise, Analysis Engineer should consult with the City and local data may need to be collected

4. Pass-by Trips / Internal Capture

- a. The City Traffic Engineer shall approve all pass-by and internal capture reduction for use in the TIA.
- b. The added pass-by trip will have little impact on through movement traffic operations or be part of a potential change in travel demand requiring adjacent transportation infrastructure improvements. However, the City recognizes that pass-by trips can affect left- and right- turning movement frequency and may require installation of turn lanes or other forms of mitigation (i.e., exclusive phasing, timing optimization, capacity increase). The Analysis Engineer should redistribute pass-by trips from the through movement to the appropriate left- or right- turning movement for analysis purposes. The Analysis Engineer should provide and justify an expected reduction rate for pass-by trips in the proposal of scope for approval by the City.
- c. Development access connections should still carry pass-by trips and the Analysis Engineer should consider those trips in calculating the total number

of trips generated by the proposed development and for necessary adjacent street improvements due to these trips. The City also recommends that the Analysis Engineer account for pass-by trips in the trip assignment step to ensure appropriate left and right turning movement volumes as these added turning vehicles may require the need for the installation of new or additional storage at existing left- and right-turn lanes.

- d. Internal capture is the application of a percent reduction in generated trips (driveway trips) and is typically applicable to projects such as shopping centers with out-lots.
5. Generating Trips for Redevelopment
 - a. For proposed redevelopment, the City allows the Analysis Engineer to subtract trips generated by the existing development from those the new development will generate. Existing trips are preferably derived from traffic counts.
 - b. If an Applicant proposes changes to only a portion of an existing development, the City allows the Analysis Engineer to subtract any trips associated with that portion of the existing development from the trip that the proposed redevelopment will generate.
 6. Site Trip Distribution and Assignment
 - a. Site traffic distribution and assignment are very subjective tasks and requires the Analysis Engineer to exercise engineering judgment and to call on past experiences in transportation planning.
 - b. Trip Distribution
 - (1) Trip distribution efforts, in general, take into consideration the Development as a whole. Determining how generated traffic will access the proposed development can vary greatly and depends on several factors:
 - (a) Type of development
 - (b) Size of the development
 - (c) Where the development will draw or attract traffic from
 - (d) Competing developments in the area
 - (e) Surrounding land uses
 - (f) Condition and capacity of the surrounding street system
 - (2) The City recommends the Analysis Engineer refer to, or utilize previously determined trip distribution models, planning software, or other recognized and substantiated methods to distribute traffic.
 - (3) It is a requirement and the responsibility of the Analysis Engineer to document the methodologies or references utilized in completing the task of trip distribution in the TIA report. The Analysis Engineer will also be responsible to provide copies of referenced studies or models if

requested by the City.

7. Trip Assignment

Assigning trips determines the amount of traffic on routes within the street network and analysis area. The Analysis Engineer should assign trips after considering several area and street network characteristics such as logical routings, left-turn movements at unsignalized intersections and access connections, available capacity and existing travel times. The Analysis Engineer should consider traffic conditions for each horizon year and adjust trip assignments accordingly. The Analysis Engineer may also find it necessary to prepare different sets of trip assignments for site generated trips. This may especially be useful if there are a significant number of pass-by trips. It is a requirement and the responsibility of the Analysis Engineer to detail and explain assumptions in the narrative portion of the TIA report.

8. Traffic Analysis

- a. Capacity analyses shall be performed on the transportation facilities within the determined analysis area. The Analysis Engineer shall use the methodology of the HCM to complete any capacity analysis. The analyses may be prepared manually or by using various available software programs such as HCS, Synchro, or as approved by the City. In addition to capacity analyses, the Analysis Engineer should consider other factors including safety, circulation, traffic control needs, transit, neighborhood traffic impacts, pedestrian and bicycle access, delivery and service vehicles and transportation demand management.
- b. For each analysis horizon, the Analysis Engineer shall utilize the total project traffic volume which includes site generated traffic and the background traffic. Background traffic shall include traffic from other proposed developments within the analysis area and horizon. The Analysis Engineer shall also complete capacity analyses for existing and background conditions in order to provide LOS comparisons.
- c. The analysis and site plan of the Development are an iterative process required for each horizon year. The purpose is to show the relationship between the site, its circulation, and plan along with the existing area street system. Accomplishing this allows the Analysis Engineer to better determine deficiencies and develop alternatives for consideration. The Analysis Engineer should define and identify impacts, deficiencies, and need for improvement. The analysis of existing conditions is essential in order to determine pre-development deficiencies and need for improvements.
- d. The Analysis Engineer shall tabulate and report LOS and Delay for the transportation facilities within the determined analysis area. The Analysis Engineer should tabulate overall intersection LOS and delay for each

approach and individual movements. The City recognizes that left turning movements and in many cases, the approach LOS may be less than desirable at stop-controlled facilities. Intersection capacity analysis shall include analysis of queue spillbacks and capacity of left and right turn lanes. The LOS for turning movements at all access connections (driveways and turning lanes) at the project site shall also be analyzed.

- e. If the Applicant is proposing a traffic signal at an intersection or access connections, the Analysis Engineer shall use the warranting process prescribed by the City's Signal Engineering Section Design Guidelines.
- f. All capacity analysis worksheets and modeling software outputs for the existing conditions and horizon years shall be included in the TIA report as an appendix. The City may also require the actual model to be submitted in electronic form.

9. Site Access and Off-Site Improvements

- a. The Analysis Engineer should identify needs and deficiencies using the previously prepared analyses. In addition, the Analysis Engineer should develop alternatives to address these needs and should address both on- and off-site improvements, if applicable.
- b. Mitigation measures can include, but are not limited to, median openings, turn lanes, bicycle/pedestrian/transit amenities, traffic calming and traffic signals. The Analysis Engineer shall analyze proposed mitigation measures for capacity and other factors. The Analysis Engineer shall base capacity improvements on the LOS.

10. Previously Proposed Transportation Improvements

The Analysis Engineer can factor proposed network improvements into the analysis and can use them as mitigation measures. For example, if the Applicant schedules a Development to open in three years, and the City has a capital project that will widen the street before that time, the Analysis Engineer can consider the proposed capital improvement in the analysis.

11. Phased Developments

- a. Phased Developments often present a challenge for the Applicant. In many cases, Phase I of the development is well defined while additional phases are vague and may change with market conditions.
- b. It is acceptable to the City for an Applicant to submit a TIA for all phases of the Development including proposed improvements at the start of a project. However, if future phases of the Development change, generating more traffic

than what the Applicant had previously submitted to the City, it will be necessary for an Analysis Engineer to update the existing TIA or prepare a new one. If the Applicant only submits to the City the first phase of the Development, the Applicant should be aware that conditions may change potentially requiring additional on- and off-site improvements. If a Development is to be completed in phases, the TIA can also propose phasing of mitigation. However, the Analysis Engineer must analyze any mitigation measures proposed for the appropriate horizon year.

12. On-Site Planning

- a. An integral component of any TIA should include basic site planning. This includes the identification of access connections (e.g., transit connections to existing bicycle and pedestrian facilities), internal circulation, service and delivery access connections and service bays including the use of turning templates as appropriate, and the identification of optimal building locations.
- b. Access connections operate as intersections and the City treats them as such. They should have an appropriate number of lanes, adequate storage "ready access to existing transit facilities," pedestrian facilities and appropriate signing and pavement markings. Adequate storage for a larger Development's access connections is often a concern, and if not designed properly, will operate inefficiently creating the potential for traffic to back up onto the street system. Joint access between adjoining properties is desirable; particularly where street frontages are short or internal volumes will be low. Driveways should be located near the property line if possible or the Applicant should make cross access agreements with adjoining property owners.
- c. On-site circulation and street design should be consistent with off-site streets. The area street system has shaped driver behavior and expectations; violating these expectations provides potential for safety problems.
- d. Consistency between off-site and on-site signage and pavement markings is desirable for managing drivers' expectations. To the extent practical, use of Texas Manual on Uniform Traffic Control Devices (TxMUTCD) approved signs and pavement markings is recommended. Site access connections shall conform to City of Houston Access Management Standards and the Applicant and the Analysis Engineer should consider the following principles:
 - (1) Locating proposed traffic signals to provide for progression along the intersecting street.
 - (2) Providing the minimum number of access connections that can adequately serve all anticipated traffic traveling to the site.
 - (3) Providing adequate capacity/storage at access connections to ensure that traffic accessing the site does not spill back onto adjacent streets.
 - (4) Intersecting two-way driveways with streets as close to perpendicular as possible.

- (5) Providing adequate capacity/storage at internal intersections, especially those adjacent to public street access connections, to ensure that traffic within the site does not spill back onto adjacent streets.
 - (6) Providing adequate sight distance and appropriate safety measures at all access connections and internal intersections.
 - (7) Locate site driveways across from existing public streets, driveways or existing median break locations, i.e., avoid offset driveways or access connections.
- e. The Analysis Engineer should base storage lengths at access connections on the City of Houston Design Manual and Access Management Standards. For smaller developments, the Analysis Engineer should design parking and access connections to allow vehicles to align themselves perpendicularly to the adjacent street system. For larger developments, the Analysis Engineer should provide adequate storage to ensure that exiting traffic does not hinder internal circulation. The Analysis Engineer should estimate potential on-site queuing and provide adequate stacking spaces to prevent impacts on adjacent streets as well as bicycle/pedestrian facilities.

D. Traffic Analysis in Major Activity Centers

The City Engineer, together with the Planning and Development Department, may cooperate with management districts, development authorities or other public or private organizations to prepare a transportation plan within a Major Activity Center. While the City may provide oversight, the preparation of the plan is not the responsibility of the City.

1. Transportation Plan and Traffic Analysis

- a. The horizon year projections can be used to generate trips for the Major Activity Center study area. A Traffic Impact Analysis can be prepared using this transportation plan identifying impacts and mitigation measures. A plan can be included for how mitigation measures are implemented and these can be incorporated into transportation plans and capital improvement programs within a Major Activity Center.
- b. It may be necessary for the Transportation Plan and Traffic Analysis to be updated once every three years.
- c. Any proposed development within the Transportation Plan and Traffic Analysis Study Area that will produce the same or less PHT than a use described in the Transportation Plan shall be exempt from preparing a TIA.
- d. Any proposed development within the Transportation Plan and Traffic Analysis Study Area that will produce more PHT than described in the Transportation Plan shall be required to amend the Plan or submit a separate stand alone TIA.

2. Developments within a Major Activity Center without a Transportation Plan and associated Traffic Analysis will follow the traffic study requirements in this chapter.
3. Developments within a Major Activity Center will always have the option of preparing a separate TIA specifically for their development.

15.05 TRAFFIC ENGINEERING STUDY FOR DESIGN

15.05.01 GENERAL

Whenever a new roadway is constructed, or when changes are proposed to the cross section of an existing roadway, a Traffic Engineering Study should be performed to determine critical design criteria for the project. Example of projects that may modify the cross section of an existing roadway include the dedication of one or multiple lanes to transit vehicles or pavement marking modifications for implementation of bicycle facilities.

General considerations for a Traffic Engineering Study:

- A. The scope of a proposed Traffic Engineering Study shall be coordinated with Transportation and Drainage Operations.
- B. A Traffic Engineering Study should emphasize roadway safety for all modes of transportation. Access management strategies should be considered for their potential safety benefits. These strategies can include location of driveways; locations of median openings; and turn restrictions.
- C. A traffic engineering study shall be prepared for:
 - a. New roadway construction
 - b. Roadway reconstruction
 - c. Existing roadway cross section modification (e.g. for inclusion of transit, bicycle, or pedestrian infrastructure)
- D. The recommendations of the Traffic Engineering Study for design will address such issues including but not limited to:
 - a. Number of lanes
 - b. Lane assignments
 - c. Traffic control including roundabouts and traffic signals
 - d. Access management (including driveway locations, median openings, and turn restrictions), and
 - e. Accommodations for bicyclists, pedestrians, and transit services
- E. The Traffic Engineering Study will comply with requirements of the most recent versions of the Texas Manual on Uniform Traffic Control Devices (TMUTCD), Transportation Research Board Highway Capacity Manual (HCM), AASHTO A Policy on Geometric Design of Highways and Streets ("Green Book"), and other standards of traffic engineering practice, as appropriate.

- F. Computer simulation modeling software used in the development of the Traffic Engineering Study must be approved by the City Traffic Engineer for use.
- G. When prepared for City of Houston Capital Projects, study findings will be summarized and documented in the Traffic Engineering Report (TER) for design.

15.05.02 COMPONENTS OF TRAFFIC ENGINEERING STUDY

The following sections summarize general components of a Traffic Engineering Study. Specific scope and level of detail should be coordinated with the City Traffic Engineer to tailor the study to the specific design project.

- A. Executive Summary – A one- to two-page summary of key features of the report with an emphasis on recommendations. It should be suitable for distribution as an informational handout on the project at public open houses or meetings with citizens.
- B. Introduction - a general project description with location map and a discussion of significant landmarks and destinations in the vicinity.
- C. Existing Conditions
 - 1. Roadway - Inventory of existing conditions for all roadways, intersecting roadways, and intersections to be improved. The inventory shall include but is not limited to:
 - a. Roadway geometry and typical roadway cross sections including median treatments and channelization
 - b. Major traffic-control devices (roundabouts, signals, school zones, stop signs)
 - c. Auxiliary lanes (left- and right-turn lanes)
 - d. Sidewalks and designated pedestrian/bicyclist crossing locations
 - e. Type and frequency of transit as well as any transit stops or stations
 - f. Bicycle recommendations from the Houston Bike Plan for the corridor and intersecting roadways/trails
 - g. Availability and location of on-street parking
 - h. Posted speed limits
 - i. Ongoing and planned roadway construction projects along or across the project corridor that could impact traffic operations
 - j. Planned major development in the vicinity of the project

- k. Locations of schools and other major traffic generators, including those in development
 - l. Description of intersection, roadway, and pedestrian lighting
 - m. Description of existing Intelligent Transportation Systems (ITS) based on Transportation and Drainage Operations data
 - n. Traffic signs and pavement markings, when requested
2. Traffic data — Traffic data collected for the traffic study shall comply with Section 15.06: Traffic Volumes. The traffic data collection schedule shall be coordinated and approved by the City Traffic Engineer. Data collected should include:
- a. Turning movement traffic counts for critical intersections (a.m. and p.m. peak hours). Critical intersections will be determined during the project scoping process. If major off-peak activity is identified (including the weekends), traffic counts for additional hours may be required.
 - b. Hourly approach traffic volume counts for one full 24-hour period at critical intersections may be needed to determine feasibility of various traffic control options, or if additional peak hours are identified.
 - c. Average Daily Traffic (ADT) with directional information, hourly volumes, and vehicle speed and classification along the project corridor between existing signalized intersections and other intersecting major streets and critical side streets.
 - d. Optional: At least one year of crash data from the Houston Police Department for the roadway and at critical intersections collision data (city data). Crash data is required for safety mitigation projects. Crashes should be categorized by "signal-correctable" or "not-signal-correctable." Signal-correctable crashes include right-angle crashes and crashes involving bicyclists and/or pedestrians. They do not include crashes involving left-turn "failure to yield" crashes from the major street or crashes involving right-turning traffic.
 - e. Capacity and level-of-service analyses for existing conditions along the segments and at critical intersections (a.m. and p.m. peak-hour periods).
 - f. K (proportion of the ADT occurring in the peak hour) and D (proportion of the peak-hour traffic in the peak direction) factors.
 - g. Peak-hour factor by approach and by movement at critical intersections as determined by the project manager in coordination with the traffic engineer.
 - h. Heavy vehicle (truck and bus) percentage during the peak a.m. and p.m. peak periods.

D. Future Projected Design Conditions

Future conditions shall be analyzed for opening day with existing geometry and opening day with proposed alternatives. Additionally, analyses may be requested for a future design year (typically 20 years in the future). The future analyses shall include:

1. Peak hour volume projections for all roadways, intersecting roadways, intersections, and major driveways within the limits of the project or as determined by the Project Manager in coordination with the City Traffic Engineer. The volumes should be based on existing traffic volumes and on traffic projections prepared by the City of Houston or by the Houston-Galveston Area Council regional transportation demand model.
2. Capacity analyses shall be performed at critical intersections impacted by the project for all peak hours. For corridor projects that do not impact critical intersections, Generalized Daily Service Volumes as defined by the HCM may be used to estimate corridor LOS.
3. Discussion of potential traffic impacts on adjacent neighborhoods (both during and after construction), including traffic calming and access management issues, as well as potential mitigation strategies.
4. Preparation of traffic signal warrant analyses for the project opening year at critical intersections as determined by the Project Manager in coordination with the City Traffic Engineer and identified in the project scoping process. Traffic signal warrant analyses will be conducted in accordance with Section 15.11.
5. Preparation of hybrid pedestrian beacon (HAWK) warrants at major midblock crossing locations (e.g. main entrances of schools, trail crossings).

E. Conclusions and Recommendations

1. Summary of improvements necessary to achieve safety, multimodal, and LOS goals as determined by Project Manager in coordination with the City Traffic Engineer.
2. Conceptual improvement diagram illustrating recommended improvements.
3. Recommendations for traffic control including roundabouts, traffic signals, and STOP signs.
4. Proposed roadway typical cross sections, including general purpose lanes, bike lanes, parking lanes, medians, pedestrian realm, and sidewalk.

5. Proposed lane assignments at critical intersections to achieve safety, multimodal, and LOS goals.
6. Auxiliary lanes (left- and right-turn lanes, acceleration and deceleration lanes) including recommended lengths per City approved methodology.
7. Recommendations for transit, pedestrian, and bicyclist facilities, including:
 - i. Bike facility type
 - ii. Transit facility stop/station locations and special accommodations
 - iii. Sidewalks and curb ramps
 - iv. Pedestrian/bicyclist crossing locations, including midblock crosswalks and median openings
 - v. Pedestrian amenities, including street trees
8. For proposed roundabouts: provide a high-level discussion of proposed lane assignments and expected ROW impacts
9. When the Traffic Engineering Study is prepared to support a City of Houston Capital Project, provide design parameters to be used during final project design including:
 - i. Design speeds
 - ii. Design vehicle(s)
 - iii. Sight distances
 - iv. Shoulders
 - v. Access control
 - vi. Clear zones
10. Access management features, including:
 - i. Proposed driveway locations
 - ii. Proposed median opening locations
 - iii. Access/turn restrictions
11. Proposed strategies for mitigating traffic impact to adjacent neighborhoods.
12. Speed zones if any are proposed that vary from state-defined prima facie speeds, including school speed zones.
13. Recommended locations for school zone flashing beacons.
14. ITS recommendations based on Transportation and Drainage Operations program requirements.

15.06 TRAFFIC VOLUMES

- A. The City of Houston, HPW collects and stores a broad range of traffic data to assist design engineers in maintaining and designing safe, and cost effective facilities. The traffic data collection efforts include traffic volume and vehicle classification and speed data surveys, utilizing road tubes, permanent loop sensors, or other devices.
- B. The City of Houston uploads and stores historical traffic counts on the City GeoLink portal.¹

15.06.01 TRAFFIC STUDIES

- A. New traffic volumes must be collected for all traffic studies if existing counts are more than 1 year old if located in an area experiencing high growth or more than 2 years old in all other areas.
- B. Counts must be conducted between Tuesday and Thursday when school is in session. They must not be collected on holidays or the day before or after a holiday or when special events may disrupt typical traffic flows.
- C. Summer counts may not be used unless authorized by the City Traffic Engineer.
- D. General peak hour counts should be conducted between 7-9 am and 4-6 pm. If there is a peak hour generator (such as a bus stop or school) that may affect the designated peak times, this must be identified and approved by the City Traffic Engineer prior to use.
- E. ADT and approach counts should include vehicle speeds and a calculated 85th-percentile speed as well as vehicle classifications broken into at least three categories based on size or number of axles.

15.06.02 ADJUSTMENT FACTORS

- 1. Seasonal Factors. If requested, traffic volumes should be adjusted to reflect the seasonal changes in traffic volumes. The monthly seasonal factor for a particular month is computed by dividing the average annual daily traffic (AADT) by the particular month average daily traffic (ADT):

$$SF = \frac{AADT}{MonthlyADT}$$

¹ <https://geohub.houstontx.gov>

2. Peak Hour Factor (PHF). The hourly volume during the analysis hour divided by the peak 15-minute flow rate within the analysis hour. Hourly counts used in traffic analyses must use a PHF adjustment, which is computed by dividing the measured hourly volume by the PHF. Intersection PHF will be applied to all turning movement volumes unless otherwise directed by the City Traffic Engineer.

$$PHF = \frac{\text{Hourly Volume}}{4V_{15}}$$

3. K Factors (design hour factor)
- The proportion of the AADT occurring in a peak hour. The K- factor is utilized in traffic forecasts to estimate a future peak hour volume to determine roadway capacity needs. The K-factor is used to determine the Design Hour Volume (DHV).
 - Traffic projections are expressed as AADT and DHV. AADT and DHV are related to each other by use of the K-factor:

$$DHV = AADT \times K$$

4. D-Factor (Directional Distribution)
- The percentage of the total, two-way design hour traffic traveling in the peak direction.
 - The directional distribution is an essential traffic parameter used to determine the Directional Design Hour Volume (DDHV) for the design year. The DDHV is the product obtained by multiplying the DHV and the D-Factor.

$$DDHV = DHV \times D$$

15.07 SCHOOL ZONE POLICIES

15.07.01 GENERAL

- The City of Houston, HPW, Transportation and Drainage Operations, Schools Coordination Program works with school principals or their designated representatives to develop a plan for creating safe and efficient school zones which balance pedestrian safety, bicycle safety, and roadway mobility needs.
- School speed zones are installed where students cross or are likely to cross roadways by themselves but may not have a level of mental cognizance to do so safely. The school must be clearly defined as an elementary or middle/junior high school.
- As the school's principal is in overall responsible charge for all activities associated with a school, the City does not respond specifically to requests from the community at large but do

present any suggestions received to the principal for consideration.

- D. All proposed changes or new school zone requests shall be referred to the School Coordinator, at 832-395-3000. In addition, detailed School Zone Policy can be obtained at https://www.publicworks.houstontx.gov/sites/default/files/assets/004-schoolzone_policy_2019.pdf.

15.07.02 DESIGN REQUIREMENTS ON ROADWAYS WITH EXISTING SCHOOL ZONE

A. Description of Design/Review Process

1. Project Initiation

- a. The Consultant shall meet with the City of Houston to discuss the project in detail prior to beginning the school zone redesign/replacement. At this meeting, typical and any specialty school zone issues within the project limits will be discussed. The meeting regarding school zone will generally occur as part of other project initiation meetings and will not require a separate meeting.

2. Collect School Zone Data and Design

- a. Collect all data required to develop existing school zone items including but not limited to school zone beacons, designated school crossings, designated or proposed bikeways and school start time and dismissal time. Typically, school zone information will be included as part of the general existing condition data collection effort as defined by the Policy and Procedures for School Zone Installation and Removal.
- b. The Consultant shall prepare a plan to maintain existing school zones in safe operational manner if school is in session during construction and replace existing school zones as implemented previously before start of construction. Complete replacement or modification may be required by City of Houston to meet the current standards.

15.07.03 EXISTING SCHOOL ZONES DURING CONSTRUCTION

- A. It is the responsibility of the Contractor performing the work to accommodate safe movement of school related activities during the entire duration of the construction period.
- B. The Contractor may need to relocate school beacons, school zone signs temporarily during construction before implementation of school zone equipment per design plans at the Contractor's expense. Coordinate relocation of flashing beacons and signage with City staff and school principal.

15.08 ACCESS MANAGEMENT STANDARDS

A. APPLICABILITY

1. The Access Management Standards contained in this section are applicable to each development, all or a portion, which is located within the defined corporate city limits of the City of Houston, Texas.
2. The requirements contained within this section are design standards and will serve as a basis for development plat approvals and building permits. These standards should be used in conjunction with the Houston City Code of Ordinances and other requirements set forth in the Infrastructure Design Manual.
3. Requirements for Access Management Design Techniques - Additional references/resources are available in Chapter 40 - Streets and Sidewalks of the City of Houston Municipal Code of Ordinances and the Houston Amendments to the 2003 International Building Code; <http://www.municode.com/resources/gateway.asp?pid=10123&sid=43>.

B. GENERAL

The overall purpose of implementing the City of Houston Access Management Standards is to enhance the functionality of City streets. This enhancement will be accomplished through preservation and improvement of operational efficiency and safety. "Access Management" is the systematic control of the location, spacing, design, and operation of driveways, medians, auxiliary lanes, and intersections in order to improve the balance between access and mobility while preserving street efficiency and safety.

C. ACCESS MANAGEMENT DESIGN

1. Driveways
 - a. Driveways and their associated openings should be located and designed to provide reasonable access between private property and the street right of way. The driveway should not create an unmanaged traffic hazard for drivers entering the street or for drivers on the through street, nor negatively impact normal use of street right of way.
 - b. The proper location and design of a driveway should be consistent with the safety and convenience of the public and must take into account nature and volume of traffic on abutting streets, dimensions and construction of abutting streets, use of developed property, dimensions of the developed property, and type and locations of improvements to the developed property.
 - c. Driveway design considers the effect of vehicles to/from developed property on the movement of traffic and the safety of traveling public on abutting

streets.

- d. Driveways are based on two property classifications: single family residential and all others.
- e. Driveways to/from a property should include no more than the minimum number to provide reasonable access between the property and abutting street.
- f. Driveway width is measured at the beginning of the driveway radii tangents within the driveway (see Figure 15.08.01). Driveway Radius is the rounded edge of a driveway that permits easier entry and exit by turning vehicles. Design standards for minimum driveway width and radius can be found in Table 15.08.01.

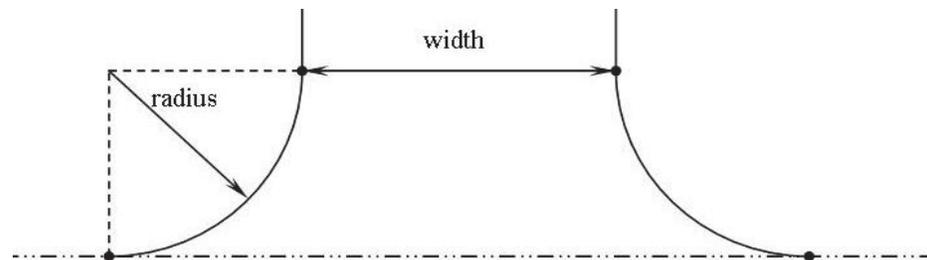


Figure 15.08.01 Driveway Radius and Width

Table 15.08.01 Driveway Design Criteria												
	Single Family Residential				Townhomes / Condos				Commercial			
	Radius (ft)		Width (ft)		Radius (ft)		Width (ft)		Radius (ft)		Width (ft)	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Two-way or Shared Access	10	4	24	12	10	4	24	18	20	10	35	24
One-Way	10	4	20	12	10	4	24	15	20	10	20	15

- g. General Driveway Design Criteria
 - (1) A driveway shall not connect to a sub-standard street. This will not apply to removal and replacement of single-family residential driveways.
 - (2) A shared driveway cannot connect to a street with a width of less than 18-feet
 - (3) One-way driveways must intersect city streets between 45 and 90 degrees.
 - (4) Skewed, one-way drives are permitted only on one-way streets and divided streets with no median opening.
 - (5) Two-way driveways must intersect city streets at approximately 90 degrees.
 - (6) Where situations permit, AASHTO design vehicles may be used to justify driveway radii.

- (7) No driveway radius shall encroach on abutting property or corner radius.
 - (8) Driveways shall not be permitted within limits of any intersection. (Design exception shall be required for major thoroughfare locations with existing esplanades and streets used for residential access.)
 - (9) For one-way driveways, the entry driveway shall precede exit driveways (in direction of adjacent travel lane).
 - (10) Driveway must remain tangential for a minimum of 20 feet past the property line.
 - (11) Where present or projected traffic operations indicate needs for alternative driveway geometrics, additional consideration may be given.
2. Driveways and Loading Docks/Wells/Berths
- a. Loading docks/wells/berths are not permitted for back-in loading from an adjacent Major Thoroughfare.
 - b. Loading docks/wells/berths must be located on site to provide for approach and maneuvering on-site with appropriate space to accommodate dimensions of vehicles accessing site.
 - c. Loading docks/wells/berths must be located on site such that sufficient area is available to store commercial motor vehicle, truck-tractor, trailer, or semi-trailer or combination of such vehicles within the developed property and no part of vehicle shall protrude over the property line or obstruct any public street or sidewalk in whole or in part.
3. Driveway and Corner Clearance Spacing
- a. General Driveway Spacing Criteria
 - (1) The distance between connections (driveway-driveway and driveway-street) is measured along the edge of traveled way from the closest edge of pavement of the first connection to the closest edge of pavement of the second connection
 - (2) A pair of one-way driveways (entry and exit) should be considered as a two-way driveway for driveway spacing purposes.
 - (3) Spacing between one-way driveways requires the entry precedes the exit in the direction off the adjacent travel lane and the one-way pair meets spacing requirements from adjacent driveways or streets.
 - (4) For the special situation of multiple entry driveways placed on one-way street and exit driveways placed on a different street, two same street driveways should be considered as a one-way pair.
 - (5) Driveways on a street without a median should align with driveways on the opposite side of the street.

- (6) Driveways shall not be placed in the intersection limits (see 15.03.I for definition of intersection limits).
 - (7) Driveway should be placed of a minimum offset distance of 75 ft from the median nose.
- b. Residential Driveway Spacing - see Figure 15.08.02 for residential driveway spacing definitions and Table 15.08.02 for residential driveway spacing criteria.

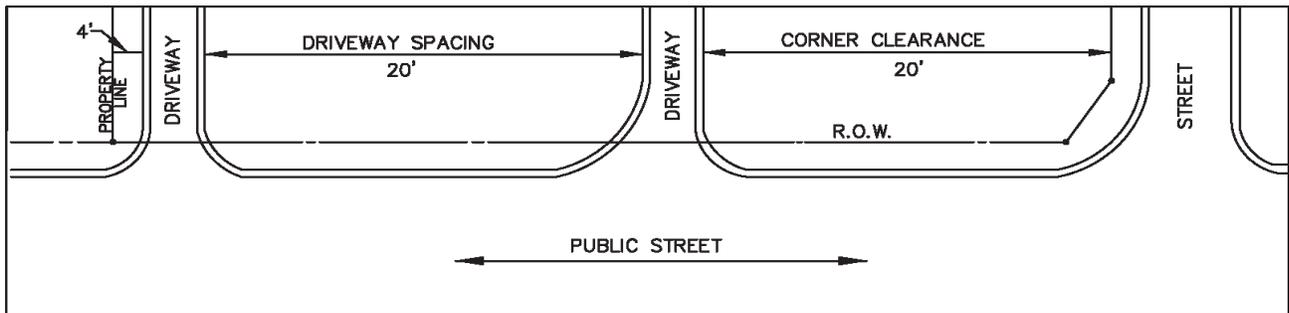


Figure 15.08.02 Residential Driveway Spacing

Table 15.08.02 Residential Driveway Spacing Criteria				
	Between Adjacent Driveways	Between Adjacent Street ROW	Between Side Property Line	Maximum Number of Driveways
	Spacing (Minimum dimension in ft)			
Single Family Residential	20(1)	20	4(5)	2
(1) 10 foot minimum between pair of one-way driveways (2) All proposed access connections must be placed to achieve adequate intersection sight distance for safe and efficient departure from the proposed location (comply with AASHTO standard). (3) Driveway radius cannot extend beyond property line. (4) Driveway radius cannot extend into public street or other driveway curb radius. (5) When spacing of driveways results in a roadside ditch that is less than 8' long (e.g., less than 8' between culverts), options shall be considered to address maintenance challenges and may include replacement of the short roadside ditch with a long run culvert.				

- c. Non-Residential Driveway Spacing - see Figure 15.08.03 for non-residential driveway spacing definitions and Table 15.08.03 for non-residential driveway placement criteria.

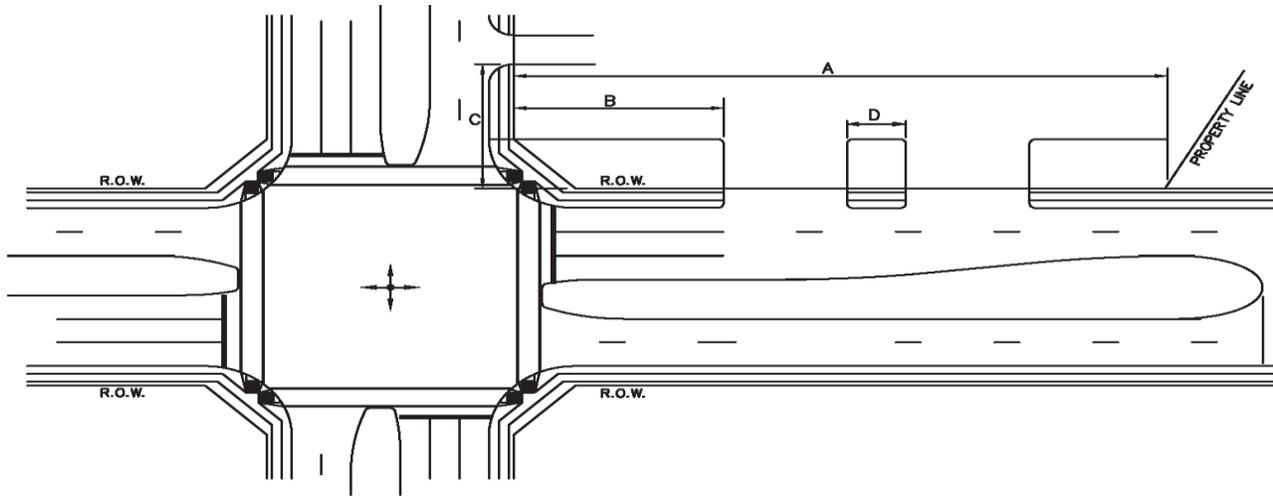


Figure 15.08.03 Driveway Placement

Table 15.08.03 Non-Residential Driveway Placement Criteria (1)

A Frontage (2)	Number of Driveways	B Minimum Driveway Offset (Primary Street)	C Minimum Driveway Offset (8) (Intersecting Street)	D Minimum Driveway Spacing
Up to 170 feet	1	100 feet	60 feet	20 feet
170 to 250 feet	2	100 feet	60 feet	40 feet
250 to 450 feet	3	100 feet	60 feet	40 feet
> 450 feet	1 additional / 250' frontage	100 feet	60 feet	40 feet

- (1) Applicable to driveways designed for commercial traffic (auto, truck, and bus access).
- (2) Where the development frontage is equal to or greater than the distance to first median opening, at least one driveway will be aligned with the existing and/or future location of the median opening.
- (3) For CBD or Locations unable to comply, approval of the City Engineer required.
- (4) All proposed access connections must be placed to achieve adequate intersection sight distance for safe and efficient departure from the proposed access connection (comply with AASHTO standard).
- (5) The minimum driveway offset for all major thoroughfare shall be 100 feet.
- (6) Driveway radius cannot extend beyond property line.
- (7) Driveway radius cannot extend into public street or other driveway curb radius.
- (8) Minimum offset will be 100' along bus routes.

4. Medians
 - a. Median design involves mainly median type, opening, and length. Installing medians provides the potential for safer street operation, increased capacity, and improved aesthetics.
 - b. Median Openings
Median openings allow vehicles to cross opposing traffic lanes at designated locations. Requirements for median openings can be found in Chapter 10.08 of this manual.
 - c. Minimum Median Lengths
The minimum lengths of medians between openings are determined by the functional classification of the street and the type of interruption (thoroughfare, collector, local street, private driveway, etc.) of the adjacent openings. Requirements can be found in Chapter 10.08 of this Manual.
5. Treatments for Turning Movements
 - a. Turn lanes provide a refuge area for left and right turning vehicles. Turn lanes may be placed at intersection approaches, driveway approaches, and median openings to remove turning vehicles from the through lanes, thus reducing congestion and improving traffic operations, capacity, and safety.
 - b. Dedicated Left-Turn Lanes
 - (1) Left-turn lanes shall be considered in the following situations:
 - (a) All signalized intersection approaches along planned or existing streets having a classification of collector or higher;
 - (b) All unsignalized intersections and driveways along divided streets having a classification of collector or higher;
 - (c) All unsignalized intersections and driveways along undivided streets having a classification of thoroughfare or higher;
 - (d) All developments in excess of five acres located within 500 feet of the intersection of two or more thoroughfare facilities;
 - (e) New public or private school construction;
 - (f) Shopping centers and other traffic generators with a lease space in excess of one hundred thousand square feet;
 - (g) Places of worship.
 - (2) Request not to install dedicated left-turn lanes shall be guided by a traffic study and requires approval from the City Engineer.
 - c. Dedicated Right-Turn Lanes
The use of dedicated right-turn lanes should always be guided by a traffic study.

6. Minimum Turning Treatment Storage Length
 - a. Storage length, as shown in Figure 15.08.04, is an important design element that ensures the provision of sufficient turn lane storage capacity to reduce instances of spillback. Left- and right-turn lane storage lengths must not be less than the minimum requirements outlined in Chapter 10.06 of this Manual.

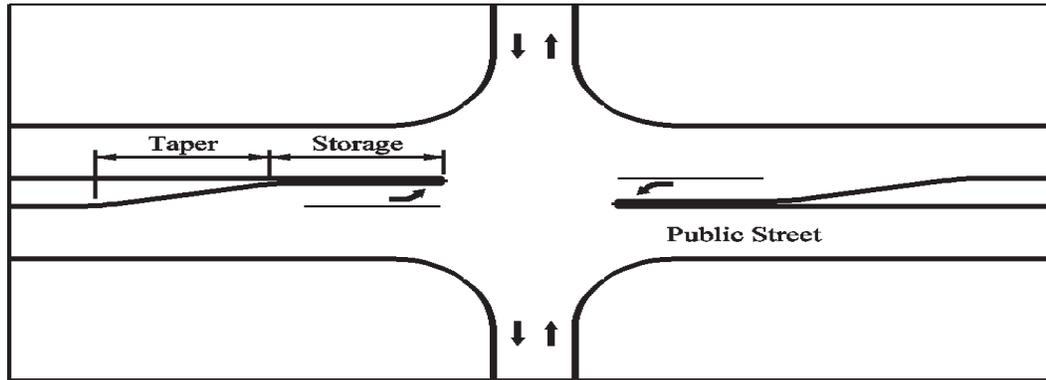


Figure 15.08.04 Turn Lane Details

- b. Calculating Required Storage Length (Single Lane)
The required storage length for both left- and right-turn lanes can be obtained using traffic modeling software such as the latest version of the HCM Software (HCS) or Synchro/SimTraffic. The 95th percentile queue length is a widely accepted value for storage length. The following methods may be used to determine storage length.

Signalized Storage Length

For signalized intersections, the storage length should be determined based on results from computer analysis software.

Unsignalized Storage Length

Equation 1 is used to calculate unsignalized storage length.

$$L=(V/30)(2)(S) \quad \text{(Equation 1)}$$

Where:

L = storage length in feet

V/30 = turning volume in a two-minute interval

2 = a factor that provides for storage of all left-turning vehicles on most cycles

S = queue storage length, in feet per vehicle

15.09 TRAFFIC SIGNS

15.09.01 GENERAL

- A. This section of the Design Manual contains the criteria and formats to be used in designing and preparing plans for the installation and refurbishing of traffic signs in the City of Houston. The intent is to establish standard procedures and requirements that will be used by engineering designers and consultants when designing signing for City of Houston projects. All design shall also be in accordance with the Standard Highway Sign Designs (SHSD) for Texas and with the Texas Manual of Uniform Traffic Control Devices (TMUTCD).
- B. This document provides Designers and Consultants with:
1. the design requirements and guidelines for ensuring uniformity in sign types, mounting, size, and placement; and
 2. the required format of plan sheets to allow ease of review, minimization of construction errors, and facilitation of maintenance.

15.09.02 DESIGN REQUIREMENTS

A. Description of Design/Review Process

1. Project Initiation
 - a. Determine Requirements of Other Agencies.
If the project falls under TxDOT's jurisdiction, verify TxDOT's signing requirements and if discrepancies exist between the City's requirements and TxDOT's, the Consultant shall meet with the City Traffic Engineer to reconcile any differences.
 - b. The Consultant shall meet with the City of Houston prior to beginning the signing design to discuss the project in detail. At this meeting, typical and any specialty signing within the project limits will be discussed. The meeting regarding traffic signing will generally occur as part of other project initiation meetings and will not require a separate meeting.
2. Collect Engineering Data
 - a. Collect all data required to develop a base map of existing conditions which can be used for the design process. Typically, traffic signing design will be included as part of a roadway, intersection, or traffic signal design project, and base maps for traffic signing design can be generated from the topographic survey and/or other design sheets.
 - b. The Consultant shall visit the project site to inventory and identify physical features that may impact traffic signing designs.

- c. The Consultant shall perform an inventory of existing signing. The inventory shall include but is not limited to the following:
 - (1) Sign size, sign material, and general condition of the sign
 - (2) Sign type and legend
 - (3) Posted speed limit(s)
 - (4) Any specialty signs
 - (5) Sign post and foundation type
 - (6) Identify signs that will need to be relocated or replaced.
 - (7) Any obstructions or geometric features that may interfere with the installation or visibility of signs.
3. Develop Base Map of Existing Conditions
 - a. The Consultant shall develop a base map showing all the applicable data collected. The base map or drawing will be used to show the traffic signing design.
 - b. The base map shall include but is not limited to the following information:
 - (1) All roadway curb and gutter or edges of pavement
 - (2) Roadway stations and centerline
 - (3) Right-of-way, easements and street names
 - (4) Driveways and intersections
 - (5) Sidewalks, bus stops, pads, and shelters
 - (6) Other features deemed pertinent
4. Plans and Drawings
 - a. General
 - (1) All traffic signing design shall be prepared on design sheet size required by the Project Manager, using the Standard City of Houston, Houston Public Works Title Block. On the Traffic signing plans; proposed pavement markings shall be shown as a background information without callouts. Refer to Section 15.10, Pavement Markings, for details regarding the design of pavement markings.
 - (2) All full size designs shall be prepared at a scale of 1 inch equals 40 feet. If other design scales are needed, approval from the City Project Manager is needed before beginning design.
 - (3) All construction drawings shall be prepared in accordance with Chapter 3, Graphic Requirements.
 - (4) On projects where the Consultant finds it necessary to deviate from the standard format presented herein, due to project scope or design requirements, the City's Project Manager should be consulted to determine an acceptable alternate format. Any changes to the format are at the discretion of the City's project manager.

b. General Notes

General Notes shown on City of Houston Standard Detail 01509-01 should appear on all traffic sign design sheets. Additional notes may be added by the Consultant as may be necessary to properly clarify the intent of the design.

The general notes in short include but not limited to the following items.

- (1) Prior to start of construction, all existing signs within the area of construction shall be inventoried and documented jointly by the City Inspector and the Contractor. This document will be jointly signed by both parties reflecting the sign type, sign size, sign condition, sign location, reflectivity adequacy, etc. The Contractor is held accountable for these signs throughout the Project and at the Project's completion.
- (2) The Contractor will be responsible for safeguarding existing signs so that they either continue to remain visible and upright in the field or they are collected and stored in a secure area when temporary signs are used in lieu of the existing signs.
- (3) The Contractor will be responsible for re-installing existing signs that have been removed and stored by the Contractor if required per construction plans. The Contractor will provide and install signs that were documented missing prior to the start of work.
- (4) The Contractor shall replace any signs that are lost or damaged during construction. All signs shall meet City standards.
- (5) The Contractor shall install all permanent signs, posts and hardware as shown on the plans.

c. Ground Mounted Signs

- (1) All ground mounted signs, unless noted otherwise, shall be mounted at a height of 7 feet measured from the bottom of the sign to the top of curb or top of roadway at edge of pavement and shall be a minimum of 24 inches from the edge of pavement or curb.
- (2) All ground mounted signs shall use perforated square metal tubing 1-3/4" by 1-3/4". Special permission from the City Traffic Engineer will be required to use any other metal sign post.
- (3) Refer to City of Houston Standard Details 01509-01 and 01509-01A for additional design requirements.

d. Street Name Signs

- (1) Street name signs shall include block numbers per the Standard Details.
- (2) Ground-mounted street name signs shall have a height of 9 inches. The length shall be 30 inches minimum and 48 inches maximum (in 1- inch increments). Sign plates longer than 48 inches must be approved by the City Traffic Engineer.
- (3) Refer to City of Houston Standard Detail 01509-02 (Street Name Sign and Sign Mounting) for additional requirements related to ground mounted street name signs. Refer to Chapter 15, Section 15.11 (Traffic

- Signals) of this Manual for overhead mounted street name signs.
- (4) Customized street name signs require separate approval from the City Traffic Engineer. This includes ground mounted signs, overhead street name signs, and sign toppers. Interested parties should contact the Traffic Hotline at 832-395-3000 to apply.
 - (5) All new signs shall have the City bar code stickers.
- e. Ground Mounted Sign Sizes
- (1) All "STOP" and "YIELD" signs installed in the City of Houston shall be a minimum of 36 inches for vehicular traffic and 18 inches for non-motorized traffic.
 - (2) Refer to City of Houston Standard Detail 01509-03 (Ground Mounted Sign Sizes) for dimensions of typically used sign plates and dimension of attachment holes.
- f. Sign Placement
- (1) The placement of all signs shall be in conformance with the latest edition of the Texas Manual of Uniform Traffic Control Devices (TMUTCD).
 - (2) Refer to City of Houston Standard Detail 01509-04 (Sign Placement) for typical sign placement details and street name signs at typical intersections.
 - (3) Refer to Traffic Signal Details for additional information regarding typical placement and location for signs mounted on mast arms.
- g. City of Houston Approved Signs
- (1) City of Houston Standard Detail 01509-05 and 01509-06 provide lists of Regulatory, Warning, Construction Work, Bicycle, and School signs with corresponding sign nomenclature, and dimension.
 - (2) The designer shall use the signs listed on City of Houston Standard Detail 01509-05 and 01509-06. Special permission from the City Traffic Engineer will be required to adjust the sign dimensions and/or use additional signs approved by TMUTCD. Note that this does not apply to special signs and guide signs specifically tailored for a specific location.

- (3) Guide signs for the following entities may be permitted within the City right-of-way. These entities may be required to install and maintain their own signs:
- Public airports with a minimum of 15 regularly scheduled flights daily.
 - College and university campuses with a minimum of 500 off-street parking spaces.
 - Recreation and cultural interest facilities with minimum annual attendance of 100,000 visitors.
 - Hospitals with designated trauma facilities.
- Contact TDO for submittal and approval requirements.

h. Sign Summary Sheet

The Consultant shall include a sign summary sheet as part of the signing design. The format of the Sign Summary Sheet is shown by City of Houston Standard Detail 01509-07 (Summary of Signs). The sign summary table shall include the following information: plan sheet number, sign number, sign nomenclature, sign text, dimensions, post type, number of posts, sign area (square footage only for special signs), and sign post size.

15.10 TRAFFIC PAVEMENT MARKINGS

15.10.01 GENERAL

- A. This section of the Design Manual contains the criteria and formats to be used in designing and preparing plans for the installation of pavement markings in the City of Houston. The intent is to establish standard procedures and requirements that will be used by engineering designers and consultants when designing pavement markings for City of Houston projects. All design shall also be in accordance with the Texas Manual of Uniform Traffic Control Devices (TMUTCD).
- B. This document provides Designers and Consultants with:
1. The design requirements and guidelines for ensuring uniformity in pavement marking materials, arrangement, and details; and
 2. The required format of plan sheets to allow ease of review, minimization of construction errors, and facilitation of maintenance.

15.10.02 DESIGN REQUIREMENTS

A. Description of Design/Review Process

1. Project Initiation

- a. Determine Requirements of Other Agencies. If the project falls under TxDOT's jurisdiction, verify TxDOT's pavement marking requirements and if discrepancies exist between the City's requirements and TxDOT's, the Consultant shall meet with the City Traffic Engineer to reconcile any differences.
- b. The Consultant shall meet with the City of Houston prior to beginning the pavement marking design to discuss the project in detail. At this meeting, typical and any specialty pavement markings within the project limits will be discussed. The meeting regarding pavement marking generally occurs as part of other project initiation meetings and will not require a separate meeting.

2. Collect Engineering Data

- a. Collect all data required to develop a base map of existing conditions which can be used for the design process. Typically, pavement marking design will be included as part of a roadway, intersection, or traffic signal design project and base maps for traffic pavement marking design can be generated from the topographic survey and/or other design sheets.
- b. The Consultant shall visit the project site to inventory and identify physical features that may impact pavement marking design.
- c. The Consultant shall perform an inventory of existing pavement markings. The inventory shall include but is not limited to the following:
 - (1) Lane width, pavement marking material, and general condition of the markings
 - (2) Posted speed limit(s)
 - (3) Any special pavement markings such as rail crossings, school zone, bicycle facilities, etc., and
 - (4) Existing lane configurations and lane assignments.

3. Develop Base Map of Existing Conditions

- a. The Consultant shall develop a base map showing all the applicable data collected. The base map or drawing will be used to show the pavement marking design.

- b. The base map shall include but is not limited to the following information:
 - (1) All roadway curb and gutter or edges of pavement
 - (2) Roadway stations and centerline
 - (3) Right-of-way
 - (4) Driveways and intersections
 - (5) Sidewalks, bus stops, pads, and shelters
 - (6) Other features deemed pertinent
4. Plans and Drawings
 - a. General
 - (1) All pavement markings design shall be prepared on design sheet size required by the Project Manager, using the Standard City of Houston, Houston Public Works Title Block. Traffic signing and pavement markings shall be shown on different plan sheets. Refer to Section 15.09, Traffic Signs, for details regarding the design of traffic signs.
 - (2) All full size designs shall be prepared at a scale of 1 inch equals 40 feet excluding notes and detail sheets. If other design scales are needed, approval from the City Project Manager is needed before beginning design.
 - (3) All construction drawings shall be prepared in accordance with Chapter 3, Graphic Requirements.
 - (4) On projects where the Consultant finds it necessary to deviate from the standard format presented herein, due to project scope or design requirements, the City's Project Manager should be consulted to determine an acceptable alternate format. Any changes to the format are at the discretion of the City's project manager.
 - (5) Limits of the project (beginning and ending stations) are to be provided including centerlines and stationing at 100-foot intervals.
 - (6) All changes to pavement marking lines and symbols shall be labeled by station call-outs to the nearest whole number (##+##).
 - (7) Existing pavement markings to remain and proposed items such as ROW lines, edge of pavement, and curbs shall be delineated at lighter weight/shade than proposed pavement markings on pavement marking design sheets.
 - (8) At a minimum, lane widths between lane markings and face of curb/edge of pavements shall be provided every 500 feet using the center of the pavement markings as a reference point.
 - (9) General notes and quantities of pavement markings and sheet shall be prepared for every design project. In addition, line style designation methodology shown on City of Houston Standard Detail 01510-01 shall be used to call out pavement marking line types on all design sheets.

b. General Notes

General Notes shown in City of Houston Standard Detail 01510-01 should appear on all pavement marking design sheets. Additional notes may be added by the Designer as may be necessary to properly clarify the intent of the design.

- (1) With the general notes a table showing bid items and quantities shall be provided.
- (2) Every type of pavement marking line width, pattern, and width combination shall be assigned specific bid item with quantity in linear feet (LF). For example, lane lines (WB4) will have total LF quantity and unique bid item number.
- (3) Every symbol and text type shall be assigned a bid item with quantity as Each (EA). For example, white single arrow will have total count quantity and unique bid item number.
- (4) Every type of Raised Pavement Marker (RPM) shall be assigned a bid item with quantity as Each (EA). For example, Type I-C "C" RRPM will have total count quantity and unique bid item number.

c. Left/Right-Turn "Only" and Arrow Spacing (Refer to City of Houston Standard Detail 01510-02)

d. Pavement Marking Words (Refer to City of Houston Standard Detail 01510-03)

e. Pavement Marking Symbols and Arrows (Refer to City of Houston Standard Detail 01510-04)

f. Standard Pavement Markings with Reflective Raised Pavement Markers for Position Guidance (Refer to City of Houston Standard Detail 01510-05)

g. Use of Reflective Chip Seal Marker for Temporary Markings (Refer to City of Houston Standard Detail 01510-06)

- (1) On some long term temporary pavement markings plan, the designer may select use of raised pavement marker buttons instead of chip seal marker. In such cases the designer has to provide special temporary pavement marking RPM button arrangements for each line type and use of reflective raised pavement markers.

h. Pavement Marking for Accessible Parking (Refer to City of Houston Standard Detail 01510-07)

- (1) Please note that angled parking on public streets requires City Council approval before implementation per City of Houston Code of Ordinances.

i. Railroad Crossing Pavement Markings (Refer to City of Houston Standard Detail 01510-08)

- j. Bicycle Facilities Pavement Markings (Refer to City of Houston Standard Detail 01510-09)
- k. Crosswalks Pavement Markings (Refer to City of Houston Standard Detail 01510-10)
 - (1) High visibility crosswalks should only be used where documented need is identified such as designated school crossings.
- l. Right- and Left-Turn Lanes (Refer to City of Houston Standard Details 01510-11 and 01510-12)
- m. Two-Way Left-Turn Lanes (Refer to City of Houston Standard Details 01510-13 and 01510-14)

15.11 TRAFFIC SIGNALS

Requirements for reviewed and approved plans not constructed within a 2-year period.

15.11.01 GENERAL

- A. This document presents the criteria and formats to be used in designing improvements and preparing plans for traffic signal work in the City of Houston. It will also outline general requirements and guidelines to be followed by the designers of traffic signals for the City of Houston. This section is not intended to replace sound engineering judgment or the standards of engineering practice. The designer shall also follow the guidelines published in the Texas Manual on Uniform Traffic Control Devices and in documents from the Institute of Transportation Engineers.
- B. These design guidelines are applicable to both new traffic signal construction and to the modification of existing traffic signals. If any portion of a traffic signal installation is being modified, the City requires the entire signal be upgraded to current standards. Permission to deviate from these standards must be received prior to submission on construction drawings for review and approval.
- C. The document provides consultants with:
 - 1. The analysis requirements for determining what improvements should be recommended,
 - 2. The design requirements and guidelines for ensuring uniformity in type and location of equipment, operational features, and intersection layout; and
 - 3. The required format of plans and contract documents to allow ease of review, minimization of construction errors, and facilitation of maintenance.

15.11.02 DESIGN REQUIREMENTS

- A. Description of Design/ Review Process

1. Solicit Information From Other Agencies
 - a. Determine Requirements of Other Agencies & Property Owners.
Verify with TxDOT their requirements if the intersection or street approaches fall under their jurisdiction. If discrepancies exist between the City's requirements and TxDOT's, the Consultant shall meet with the City Traffic Engineer to reconcile any differences. If access to private property (residential, industrial, or commercial, etc.) is involved, the Consultant shall contact the property owner involved, determine how the access will be affected, and coordinate with the City any differences which may exist.
 - b. Contact Appropriate Electrical Utility for Power Hook-up and Illumination Requirements. The Consultant shall verify with the electric utility involved in the project the power hook-up requirements. The Consultant shall work with the Utility to determine the service location during design and this location shall be indicated on the plans. The Consultant shall note who is responsible for each component of a service hook-up, including the conduit and cable run from the load center to the power source, the conduit riser on the power pole and the actual splice into the power system. The responsibilities shall be clearly stated in the project plans.
 - c. Contact the Railroads and Verify Their Requirements Regarding Traffic Signal Pre-emption or Crossing of Tracks with Conduit Runs.
If railroad pre-emption is required in compliance with MUTCD guidelines, contact should be made with the railroad's manager of telecommunications and signals, and the City of Houston's signal operations representative early in the design process to determine their needs or requirements. If railroad right-of-way must be crossed with conduit runs, the Consultant shall determine the railroad's requirements for conduit type, size, depth, construction methods and restrictions.
2. Collect Engineering Data.
 - a. Collect all data required to develop a base map of existing conditions which can be used for the design process and operational evaluation.
 - b. Topographic Features
On each approach where advance detection or street improvements are anticipated, detailed information on topographic features should be collected for the area within 500 feet of the intersection. Otherwise, the topographic information is only required for the distance anticipated for the detection zone setbacks and for poles, traffic signal controllers, and related underground conduits.
 - (1) Widths and alignments of streets, lanes, and shoulders
 - (2) Median widths and lengths
 - (3) Curve radii
 - (4) Tapers
 - (5) Turn lanes

- (6) Driveways & sidewalks
- (7) Pavement type
- (8) Existing pavement markings and raised channelization
- (9) Grades
- (10) Sight distance obstructions
- (11) Parking conditions
- (12) Right-of-way lines and easements
- (13) Building lines
- (14) Angle of intersecting streets
- (15) Trees and shrubs
- (16) Railings and barriers
- (17) ADA accessible curb ramps
- (18) Street furniture
- (19) Drainage features
- (20) Traffic signal equipment:
 - (a) Pole locations
 - (b) Signal head locations and types
 - (c) Controller cabinet location
 - (d) Pull boxes (location and size), and conduits
 - (e) Detector locations
 - (f) Service location (existing and potential)
 - (g) Existing signal communications system and associated infrastructure
 - (h) Emergency and/or railroad preemption systems
- (21) Existing illumination (location and type)
- (22) Existing signs
- (23) Existing pavement markings
- (24) Overhead utilities (horizontal and vertical clearances)
- (25) Underground utilities

Special attention should be given to obtaining a precise location of utilities. The designer shall request utility information from all utilities within the survey area. Field location should be requested for all utilities including traffic signal cables, conduits and detectors. Accurate horizontal and vertical clearance information shall be obtained for overhead utility lines including the sag of the cables between supports.

- c. Operational Data (If the Location has an Existing Traffic Signal):
 - (1) Phasing and timings
 - (2) Signal displays
 - (3) Type of controller and cabinet
 - (4) Detection methodology
 - (5) Traffic Signal Communications System Features
- d. Traffic Data (If Required by the City):
 - (1) Counts and projected volumes (24-hour approach and turning

- movements in am, pm, and noon peaks)
 - (2) Speed limit and speed study
 - (3) Accident history and diagrams (if available)
 - (4) Pedestrian volume and patterns
- e. Miscellaneous Data:
- (1) Bus stops and routes
 - (2) Adjacent land uses
 - (3) Proximity of railroad crossings
 - (4) Proximity of emergency vehicle sources
 - (5) Other construction in progress in the area
 - (6) Adjacent street and drainage structures

It may be possible to obtain information on existing topographic features from existing plans or maps. This data may be used for reference, but all plan preparation shall be based on field survey unless pre-approved by the City. Operational data and traffic data may be available from the City but may need to be supplemented by studies conducted by the Consultant.

3. Develop Base Map of Existing Conditions.

- a. The Consultant shall develop a base map showing all the applicable data collected. This map will be used as a base for showing all phases of the traffic signal design work and all geometric design work.
- b. Directional Orientation

All plan sheets shall have the intersection oriented with North to the top of the sheet or to the right of the sheet (if required to provide significantly better utilization of space).

- c. Scale

Traffic signal plans should be drawn a 1" = 20' scale at full size. Break lines may be used to show advanced detection of other features away from the intersection. Blown up details at a larger scale shall be used to illustrate areas with numerous conflicts or many items to be shown in a compact area such as intersection corners.

- d. Existing Conditions

The traffic signal base maps shall be printed using CSI Standards resulting in a lighter tone for existing conditions. The plan shall include, but not be limited to, the following information:

- (1) Right-of-way, easements and street names
- (2) Curbs and medians
- (3) Lane lines and channelization
- (4) Sidewalks

- (5) Utilities (underground and overhead):
 - (a) Electric
 - (b) Gas
 - (c) Telephone
 - (d) Communications & Cable TV
 - (e) Traffic and Illumination
 - (f) Sanitary Sewer
 - (g) Storm Sewer
 - (h) Water
 - (i) Utility manholes, vaults and valves
- (6) Monuments and benchmarks
- (7) Driveways
- (8) Signs and poles
- (9) Angle of intersecting streets
- (10) Building lines
- (11) Other pertinent features (e.g., trees, shrubs, street furniture, bus stops, etc.)

4. Plans and Drawings

a. General.

- (1) All plans and drawings should be prepared with black ink on Consultant furnished 22-inch x 34-inch Mylar reproducible sheets, using the Standard City of Houston, Transportation and Drainage Operations Title Block on all traffic sheets.
- (2) Standard Title Sheet, General Notes and Responsibilities Sheet, Traffic Signal Plan Sheet(s), Pole Schedule and Cable Schematic Sheet, and Detail Sheets, should be used for all traffic signal projects. An electronic Title Sheet, General Notes and Responsibilities Sheet and blank Pole Schedule are available from the City for use on traffic signal projects. Plan sets should not include copies of the City's standard traffic signal details.
- (3) If necessary, additional sheets for plans and profiles, pavement markings or signing shall be provided as needed or as directed.
- (4) A legend will be provided showing any non-standard symbols.
- (5) On projects where the Consultant finds it necessary to deviate from the standard format presented herein, due to project scope or design requirements, the City's Project Manager should be consulted to determine an acceptable alternate format. Any changes to the format are at the discretion of the City's project manager.
- (6) Graphic requirements for engineering drawings shall comply with Chapter 3, Graphic Requirements. New lane striping shall be shown using CSI/NCS pen format.

b. Plan sets should consist of the elements listed below:

- (1) Title Sheet (City Standard)
- (2) General Notes and Responsibilities Sheet
- (3) Traffic Signal Plan Sheet(s)

- (4) Pole Schedule and Cable Schematic Sheet(s)
- (5) Special (or nonstandard) Detail Sheet(s) (as required)
- (6) Plan and Profile Sheets (as required)
- (7) Pavement Marking Sheet(s) (as required)
- (8) Signing Plan Sheet(s) (as required)
- (9) 11-inch by 17-inch plan sheet showing locations of curb lines, sidewalks/ramps, signals and signal cabinets with WB-50 turn movements superimposed over the intersection. This sheet is to be submitted with plan sets for review but is not required as mylar sheet in final plan set.

City of Houston Standard Traffic Drawings shall **NOT** be included as a part of the plan set.

- c. Provide a table showing stations and offsets for vehicle detection systems and stop lines on the plan sheet. A sample table is shown below.

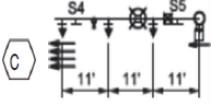
ITEM BY DIRECTION	STREET 1 STATION OF APPROACH EDGE	OFFSET FROM CONST. CL TO CL OF DETECTOR	ITEM BY DIRECTION	STREET 2 STATION OF APPROACH EDGE	OFFSET FROM CONST. CL TO CL OF DETECTOR
EASTBOUND: STOP LINE:	STA. XX+XX STA.		SOUTHBOU: STOP LINE:	STA. XX+XX	
PHASE 2 PULSE LOOP	XX+XX STA	CENTERED IN LANE	PHASE 4 PULSE LOOP	STA. XX+XX	CENTERED IN LANE
PHASE 5 PRESENCE LOOP	XX+XX	CENTERED IN LANE			
WESTBOUND: STOP LINE:	STA. XX+XX STA.		NORTHBOUND: STOP LINE:	STA. XX+XX	
PHASE 6 PULSE LOOP	XX+XX	CENTERED IN LANE	PHASE 8 PULSE LOOP	STA. XX+XX	CENTERED IN LANE

Example Stop Line and Detector Locations Schedule

d. Pole Schedule, Traffic Signal Controller, and Cable Schematic Sheets.

(1) Pole Schedule

A pole schedule shall be provided showing the pole and its identifier, the pole type, information on the mast arm(s), signal heads, luminaire, pedestrian pushbuttons and signs, pole location, communications system, and relative City standards. Each pole will have its own row within the schedule. The pole schedule shall be a table formatted as shown below.

POLE NUMBER	POLE TYPE	MAST ARM		SIGNALS		LUMINAIRE TYPE	PED PB TYPE/SIGN	REMARKS	LOCATION	STANDARDS
		SIGNAL	LUMINAIRE	MOUNTING	FACE					
	TYPE 1	35'	15'	3 - ASTROBRAC 1 - SIDE OF POLE	1 - H4LF 2 - H3 1 - CDP	106 WATT SYSTEM MAX. LED COBRA HEAD LUMINAIRE	POLARA NAVIGATOR R10-3E (L)	PREEMPT SENSOR (DUALTURRETS) SPP RADIO SIGNS: S4 - R10-17T {36"x42"} S5 - STREET NAME	POLE C; STA 4+08, 56'LT xxxx ROAD. CONSTR. CENTERLINE	02893-02
										02893-03
										02893-04A
										02893-04B
										02893-05
										02893-09
										02893-12

Example Traffic Signal Pole Schedule

(2) Traffic Signal Controller

Meter service and signal controller cabinet assemblies shall be displayed in the Traffic Signal Controller table.

CABINET	TYPE	CONTROLLER	AUX CONTROL	REMARKS	LOCATION	STANDARDS
	METERED PEDESTAL SERVICE UL TYPE 3R	METERED SERVICE PEDESTAL WITH 30 AMP & 60 AMP SINGLE POLE CIRCUIT BREAKERS	-	PROVIDE METER SOCKET WINDOW 4"H X 6"W	STA. 5+53.18, 53.36' RT (TO CENTER OF CABINET) xxx RD CENTERLINE	02893-14
	TYPE 340 ITS	2070LX W/1C CPU MODULE W/GPS SERIAL COMMUNICATIONS MODULE	-	STD SPEC 16730 & 16731 UNINTERRUPTIBLE POWER SUPPLY, STD SPEC 16732 FIELD HARDENED ETHERNET SWITCH (MIN. TWO FIBER PORTS AND SIX COPPER PORTS), STD SPEC 16733 WIMAX, STD SPEC 16734 GPS SERIAL COMMUNICATIONS MODULE, STD SPEC 16785	STA. 5+71.84, 52.55' RT (TO CENTER OF CABINET) xxx ROAD CENTERLINE	02893-10C

Example Traffic Signal Controller Schedule

(3) Cable Schematic

Low and high-voltage cable schematics shall be displayed on the pole schedule and cable schematic sheet. The cable schematic shall include:

- (a) Conduit Run Identifiers
- (b) Conduit Size
- (c) Type of Conductors in each run
- (d) Legend
- (e) Consultant shall conduct interim review of project status and technical issues with city at appropriate project milestones agreed upon by City and consultant.

5. Field Books

- a. Typically, field books will be prepared by the City upon receipt of signed and sealed plans in PDF format and original CAD files. A designer should not submit a field book unless specifically requested by the City.
- b. If requested, field books should contain the following:
 - (1) 2070 Programming/Timing Sheets
 - (2) CMU Programming Sheets
 - (3) ITS Cabinet Drawings
 - (4) Input Panel Sheets
 - (5) Output Panel Sheets
 - (6) Intersection Signal Layout
 - (7) Field Terminal Wiring
 - (8) Accessible Pedestrian Signal Sheets
 - (9) Output Assembly/Controller Interface
 - (10) Complete Assembly

If any timing data is requested by the City, it shall be submitted electronically in a format specified by the City.

B. Intersection Design Study

The purpose of this operational analysis is to document the information, assumptions, and procedures used to develop the preliminary design and to affirm that the design level of service will be provided through the design year.

1. Conditions to be analyzed

The Intersection Design Study shall present an analysis of the intersection traffic operation and level of service for the AM and PM peak hours for each of the following conditions:

- a. Existing traffic and geometric conditions.

- b. Projected traffic and proposed geometric conditions in the design year with the traffic signal(s) in operations.
- c. Projected traffic and proposed geometric conditions at project completion, including projections of any new traffic due to trip diversions and/or known new trip generation with traffic signals in operation.
- d. Projected traffic and proposed geometric conditions in the intermediate year with traffic signals in operation.

2. Method of Analysis

The level of service for the signalized conditions shall be determined in accordance with the procedures defined in the current edition of the Highway Capacity Manual (HCM). An approved software (Highway Capacity Software (HCS), Synchro or VisSim) will be used, and the printouts from that software will be part of the study. Other software packages may be acceptable, but their use will require prior approval by the City. When the Consultant proposes a less conservative design than determined by HCM method, Consultant will be required to provide supporting evidence to the satisfaction of the City. If the City requests additional analysis to evaluate new/alternative technology and such work causes additional work, Consultant shall obtain written authorization from the City prior to initiating work.

3. Required Level of Service:

The level of service to be provided in the design year shall be level of service D or better (i.e., LOS A, B, or C).

4. Application Method

The Operational method shall be used for all analysis.

5. Procedure

The Consultant shall determine the geometrics required to provide the design level of service in the design year. After determining the required geometrics, the Consultant shall analyze the intersection for the proposed geometrics and projected traffic upon project completion using the methodology for unsignalized intersections. If these conditions result in a level of service "B" or better for all movements, additional analysis may be required, but will be considered extra work.

6. Traffic Signal Warrant Analysis

- a. The engineer shall obtain a previously completed traffic signal warrant analysis or perform a new traffic signal warrant analysis for the intersection.

- b. Signal warrant analyses shall employ the traffic signal warrants contained in the Texas Manual in Uniform Traffic Control Devices. New analyses should focus on the "strong" warrants, which the City defines as Warrants 1 - Eight-Hour Vehicular Volume and Warrant 7 - Crash Experience. The other warrants may be considered in special circumstances and with approval by the City Traffic Engineer. Satisfaction of one or more signal warrants does not guarantee approval of a traffic signal. All new traffic signals must be approved by the City Traffic Engineer prior to construction. In the case of satisfaction of Warrant 7 - Crash Experience, all other feasible options for mitigation of the crash problem must be exhausted before a signal is approved.
- c. The engineer should note that not all warrants are applicable to all intersections.
- d. The engineer shall also avoid mid-block locations for new signals. New signals should be spaced at least $\frac{1}{4}$ mile away from existing or planned signals.
- e. The City requires that a minimum of eight (8) hours (includes am and pm peak hours) of turning movement counts be collected for a traffic signal warrant analysis. If a right turn lane is available or is recommended, all right turning traffic shall be deducted from the hourly approach volumes. If a shared through/right turn lane exists, one half of all right turning traffic on the approach shall be deducted. This is based on the presumption that right turning vehicles typically do not require a traffic signal in order to safely enter another street. In the case of a de-facto right-turn lane, such as when right-turning traffic greatly exceeds through traffic in the rightmost lane, engineering judgment should be used to determine the appropriate reduction of right-turn volumes.
- f. When conducting a traffic signal warrant analysis, engineering judgment is required to determine whether the left turn lane is counted as an additional lane. As a rule of thumb, the engineer should consider the ratio of left turning traffic to the other traffic. If the left turning volume exceeds twenty (20) percent of the total traffic, the left turn lane should be counted as an additional lane. Exclusive right turn lanes are not to be counted as an additional lane since their volumes are be deducted from the totals.
- g. Crash analysis: One year of crash data shall be used for assessing Warrant 7 - Crash History. Crash records can be obtained through the TxDOT Crash Record Information System (C.R.I.S.) online database or from Houston Police Department. Crashes should be categorized as "signal-correctable" or "not-signal-correctable." Signal-correctable crashes include right-angle crashes and crashes involving bicyclists and/or pedestrians. They do not include crashes involving left-turn "failure to yield" crashes from the major street or crashes involving right-turning traffic. Only "signal-correctable" crashes are to be used in the warrant analysis.

7. Hybrid Pedestrian Signals

- a. Hybrid Pedestrian Signals or High Intensity Activated Crosswalks (HAWK) studies shall follow the same basic procedures as those for a standard traffic signal warrant analysis except they shall use the warranting conditions set forth in Section 4F.01 Application of Pedestrian Hybrid Beacons of the Texas Manual on Uniform Traffic Control Devices.
- b. HAWK signals are intended for use at mid-block crossings and should not be proposed in conflict with guidelines provided by the Texas Manual on Uniform Traffic Control Devices without discussing with the City Traffic Engineer.

8. Bicycle Signals

An engineering analysis of operational and geometric conditions shall be performed to determine the need and recommendation for bicycle signals. Considerations for application of bicycle signals include but are not limited to the following:

- a. Where a stand-alone bike path or multi-use path crosses a street, especially where the needed bicycle clearance time differs substantially from the needed pedestrian clearance time.
- b. To split signal phases at intersections where a predominant bicycle movement conflicts with a main motor vehicle movement during the same green phase.
- c. At intersections where a bicycle facility transitions from a cycle track to a bicycle lane, if turning movements are significant.
- d. At intersections with contra-flow bicycle movements that otherwise would have no signal indication and where a normal traffic signal head may encourage wrong-way driving by motorists.
- e. To give bicyclists an advanced green (leading pedestrian interval), or to indicate an "all-bike" phase where bicyclist turning movements are high.
- f. To make it legal for bicyclists to enter an intersection during an all-pedestrian phase.
- g. At complex intersections that may otherwise be difficult for bicyclists to navigate.
- h. At intersections with high numbers of bicycle and motor vehicle crashes.
- i. At intersections near schools (primary, secondary, and university).
- j. At intersections near rail stations, transit centers, and where two or more bus routes intersect.

9. Left Turn Phasing Analysis
 - a. Purpose. These guidelines provide a method to uniformly evaluate and install appropriate left turn phasing at traffic signals within the City of Houston. These guidelines attempt to minimize the restrictions placed on motorists' ability to turn safely through gaps in opposing traffic when such turns can be performed safely.
 - b. Procedure. Information should be obtained by means of engineering studies and compared with these guidelines. Rigid adherence to these guidelines is not a replacement for good engineering judgment.
 - c. General Guidelines and Considerations.
 - (1) Traffic engineering judgment must be used to determine left turn phasing recommendations. Final engineering recommendations, based on engineering judgment may supersede any or all guidelines.
 - (2) The least restrictive form of left turn phasing, that can operate safely, should be considered for implementation. More restrictive control can be made as traffic conditions change.
 - (3) Proper "yellow trap" protection phasing is required when protected-permitted phasing is used in a lead-lag configuration.
 - (4) Permitted left turn phasing is primarily suited for intersections where opposing and left turn volumes are low and left turns are able to turn through gaps in traffic without great difficulty or excessive delay.
 - (5) Protected-permitted phasing is appropriate when the left turn need is based predominately on volume and delay and the signal is at a moderately traveled intersection where frequent gaps for left turns occur.
 - (6) Protected-only left turn phasing should be used when left turn phasing is required primarily for safety reasons based on left turn crash experience or site conditions, or when the opposing number of lanes is three or more.
 - d. Permitted Left Turn Phasing. Permitted left turn phasing may be installed based on the following guidelines:
 - (1) Traffic Volumes. This guideline is based on minimum peak hour left turn volume and the product of the peak hour left turn and opposing volumes (LT x OV) and the number of opposing lanes (NL). Permitted phasing may be appropriate if:
 - (a) Peak hour left turn volume is less than 2 vehicles per cycle.
 - (b) Peak hour (LT x OV)/NL is below 50,000.
 - (2) Site Conditions. This guideline is based on several existing conditions at the intersection location. Permitted phasing may be appropriate if:
 - (a) Available sight distance is greater than 350 feet when the opposing traffic is traveling at 35 mph or less, or greater than 400 feet when the opposing traffic is traveling at 40 mph.
 - (b) Opposing speed is less than 45 mph.

- (c) Multiple left turns are not in operation.
 - (d) Median width and the number of opposing lanes do not preclude safe permitted turn operations.
 - (3) Vehicle Delay. This guideline is based on peak hour left turn delay. Permitted phasing may be appropriate if:
 - (a) The mean peak hour delay per left turning vehicle is less than 50 seconds.
 - (b) The total peak hour left turn delay is less than 3.0 vehicle hours.
 - (4) Crash Experience. The installation of a more restrictive form of left turn control may be required if six (6) or more left turn crashes occurred in the past twelve (12) months.
- e. Protected - Permitted Left Turn Phasing. Protected-permitted left turn phasing provides the benefits of permitted left turn phasing while adding left turn capacity and can reduce delay to motorists. Protected-permitted phasing may be appropriate for the following conditions:
 - (1) Traffic Volume. Protected-permitted phasing may be appropriate if:
 - (a) Peak hour left turn volume is greater than 2 vehicles per cycle.
 - (b) Product of the peak hour (LT x OV) is less than 400,000.
 - (c) Peak hour (LT x OV)/NL is between 50,000 and 200,000.
 - (2) Site Conditions. See guideline for permitted left turn signal phasing.
 - (3) Vehicle Delay. Protected-permitted phasing may be appropriate if:
 - (a) The mean peak hour delay per left turning vehicle exceeds 50 seconds.
 - (b) The total peak hour left turn delay exceeds 3.0 vehicle hours (per leg).
 - (4) Crash Experience. See guideline for permitted left turn phasing.
- f. Protected-Only Left Turn Phasing. Protected-only left turn phasing is the most restrictive form of left turn control. Protected-only left turn phasing may be appropriate under the following conditions.
 - (1) Traffic Volume. Protected- only phasing may be appropriate if:
 - (a) Peak hour left turn volume is greater than 2 vehicles per cycle.
 - (b) Product of peak hour (LT x OV) is greater than 400,000.
 - (c) Peak hour (LT x OV)\NL is greater than 200,000.
 - (2) Site Conditions. Protected-only phasing may be appropriate if:
 - (a) Available sight distance is less than 350 feet when the opposing traffic is traveling at 35 mph or less, or less than 400 feet when the opposing traffic is traveling at 40 mph or more.
 - (b) Opposing speed is greater than, or equal to 45 mph.
 - (c) Multiple left turns are in operation.
 - (d) Median width and number of opposing lanes preclude safe permitted turn operations.
 - (3) Vehicle Delay. See guideline for protected-permitted left turn signal phasing.
 - (4) Crash Experience.
 - (a) Six (6) or more left turn crashes occurred in the most recent

twelve (12) month period.

- (5) Policy Compliance. All new left turn phasing installed within the City of Houston will be evaluated and installed using these guidelines and engineering judgment.
- (6) Policy Exception. Exceptions shall be allowed, as deemed appropriate, by the Assistant Director managing the Traffic Operations Branch.

10. Alternative Lane Configurations

- a. The level of service analysis shall be used to determine the required number of through lanes and auxiliary lanes (left and/or right turn lanes) needed to most economically provide the necessary level of service.
- b. Left turn lanes greatly benefit the operation of an intersection which has enough traffic to require signals. As a result, all new traffic signal designs shall require the inclusion of a left turn lane unless otherwise specified by the City. In areas such as the Central Business District, where speeds are low and right-of-way is not available or is very expensive, the benefits of left turn lanes may be outweighed by the cost.
- c. Right turn lanes and double left turn lanes should be considered as a means of achieving the desired level of service where the specific turning volumes are very high.

11. Alternative Phasing

- a. Permitted Left Turns. Permitted only left turns (no separate signal phase displayed) shall be used unless more restrictive left turn phasing is required as described below.
- b. Protected/Permitted Left Turn Phasing. Protected/permitted left turn phases are required when any one of the following criteria is met:
 - (1) They are needed to achieve the required level of service.
 - (2) The left-turn demand meets the guidelines stated in the current "Left Turn Phasing Analysis" section of this document.
- c. Protected Left Turn Phases. Protected only left turn phases are required when the following criterion is met:

The left-turn demand meets the guidelines stated in the current "Left Turn Phasing Guidelines" section of this document.
- d. Split Phasing. Split phasing shall be defined as separating two opposing directions of traffic such that the compatible through and protected left turn movement receives the right-of-way simultaneously. Split phasing shall require the approval of the City prior to submitting the preliminary design plans. This phasing should only be used if one of the following conditions exists:

- (1) The opposing approaches are offset to the extent that simultaneous left turns in opposing directions would cause a high number of conflicts, resulting in a high collision potential, and the left turn demand is sufficiently high to require as much green time as the adjacent through movement. When left turn volumes are lighter, and physical conflict exists, lead-lag operation should be used.
 - (2) Double left turn lanes are used in one or both directions and the turning radii are not sufficient to allow simultaneous left turns without conflicts between opposing left turn traffic, and subject to the same volume requirements in item (a) above.
 - (3) The left turn volume is extremely heavy on an approach that does not allow the construction of a separate left turn lane.
 - (4) Left turn volumes are extremely heavy on opposing approaches and both are nearly equal to the adjacent through movement critical lane volume (A check should be made to determine that the design hour level of service will be significantly improved and that there will not be substantial decreases in level of service during other hours of the day).
 - (5) The critical lane volumes are lowest when drivers are permitted to turn left from more than one lane, and are also permitted to use the right-most left turn lane as a through lane.
 - (6) If the intersection is in an interconnected system and the coordination plan would be improved by splitting the phases.
- e. Right Turn Overlaps. Overlaps are encouraged where needed. Right-turn overlaps should be used only if there is a dedicated right turn lane on the approach and pedestrians are prohibited from crossing parallel and to the right of the concurrent through movement from the same approach. If right turn overlaps are provided, it will be necessary to prohibit u-turns for the opposing left turn approach. Appropriate signing should be detailed in the plans. An example of this operation would be when the left turn arrows on the main street approach are displayed simultaneously with a right turn arrow on one or both side street approaches. This type of operation should only be used where:
- (1) there are 250 or more right turns during a peak hour and;
 - (2) there are 200 or more corresponding left turns during the same hour and;
 - (3) the per lane through volume for the same approach is approximately equal to, or less than, the right turn volume.

C. Geometric Design Elements

If the construction of geometric changes in the street is required, the work shall be done in accordance with the City of Houston's Uniform Development Code, Chapter 10 of the Infrastructure Design Manual, and in accordance with the following criteria:

1. Design Speed

The design speed for a street shall be based on the 85th percentile speed, or as directed.

2. Design Vehicle

The design vehicle shall be a WB-50 (AASHTO Green Book) or as directed.

3. Auxiliary Lane Design

- a. Opposing left turn lanes shall be designed for protected/permitted left turn signalization unless protected only left turn phasing is required by Section 15.11.02.B.7. Sight distance for drivers of left turning vehicles to see beyond opposing left turning vehicles shall be calculated in accordance with Case III A - Crossing Maneuver (AASHTO Green Book).
- b. The storage length of the left or right turn lanes shall be determined based on the expected queue length as defined in Section 15.08 C.6. of the Infrastructure Design Manual. The minimum left turn lane storage length shall be 100 feet unless restricted by other factors. The maximum left-turn lane length should be 400 feet. If the expected queue storage length exceeds 400 feet or the left turning volume during the peak hour exceeds 200 vehicles, dual left turn lanes should be considered.

4. Tapers

- a. A taper, in this context, refers to the transition in pavement width between the centerline and the edge of pavement, e.g., the lateral transition of a median to accommodate a left turn bay. Wherever possible, the transition taper shall be a symmetrical reverse curve. This taper length shall not be subtracted from the total required storage length (Total Turn Lane Length = Storage Length + Transition Taper length).
- b. All approach taper ratios for collectors and thoroughfares shall be based on the posted speed limit plus 5 mph or 85th percentile speed (whichever is greater) and shall be calculated using the formulas described in the Texas Manual on Uniform Traffic Control Devices.

5. Islands

Generally, raised (curbed) islands for the use of channelizing traffic, as in the case of a right turn lane, shall not be used. When islands are needed, sizes and dimensions should meet the recommended AASHTO requirements. Mountable curb and gutter shall be used on all islands.

6. Medians

- a. The minimum width of a raised median shall be four feet from face of curb to face of curb. A six-foot width shall be considered where a left turn lane is opposed by three or more right and through lanes to provide greater pedestrian storage and to reduce pedestrian clearance timings.
- b. Both vehicle and pedestrian characteristics should be considered for design of the location of the median nose.
- c. Bullet nose medians shall be required adjacent to a left turn bay at an intersection with a street other than a primary arterial. This 3-centered curve shall have radii of 50', 3', and 50'.
- d. The median opening must be wide enough to provide for adequate turning movements by left turning vehicles. In no case shall the median opening be narrower than 40 ft.
- e. In the development of a left or right turn lane; the pavement shall be widened via a symmetrical reverse curve as described in the Infrastructure Design Manual, Figure 10.06-07.

7. Pedestrian Access Ramps

At intersection corners without sidewalks, where traffic signal poles are to be installed, a pedestrian landing shall be constructed according to the City of Houston Specifications and Standard Drawings. The ramp design should be directional and in most cases, two directional ramps per corner shall be required. Approval of the ramp design as part of intersection layout should not be construed as approval of the ramp designs for traffic signal designs.

8. Curb Return Radius

Where two streets intersect, certain radii are required for the curbs per the Infrastructure Design Manual.

D. Pavement Markings

Before traffic signals are located on the base map, the pavement markings (existing or proposed) should be located to act as a guide in the location of signal heads and detector loops. Pavement markings shall conform to the Standard Specifications and Detail Sheets as well as meet the following guidelines:

1. Pavement Marking Materials

- a. Preformed plastic pavement markings, as specified in the Standard Specifications, shall be used for all lane lines, island markings, cross hatching, arrows and legends.

- b. Preformed plastic pavement markings, as specified in the Standard Specifications, shall be used for all pedestrian crosswalks and stop bars.

2. Lane Lines

- a. Lane lines shall be aligned with corresponding lane lines on the opposite side of the intersection.
- b. Lane lines shall terminate at the stop or at the curb return (on uncontrolled approaches).

3. Crosswalks

- a. Crosswalks shall be installed across all approaches except where pedestrians are prohibited from crossing. They shall provide access to all corners of an intersection.
- b. Crosswalks shall be ten feet wide. See the City of Houston Standard Detail for crosswalk configuration.
- c. Crosswalks should match up with ADA accessible ramps where possible.
- d. No transverse marking shall be placed within 18" of the curb or raised median.
- e. High visibility crosswalks shall be used only in exceptional scenarios at signalized and non-signalized crossings on collector and thoroughfare roadways requiring extra emphasis such as immediately adjacent school facilities, rail stations, transit centers, and/or any other consideration evaluated and approved by the City.

4. Stop Lines

- a. Stop lines shall be placed at all signalized locations.
- b. The stop lines shall be 24" wide and extend from a point 18" from the curb to the solid double yellow line (or a point 18" from the raised median). It shall be in accordance with City Standards.

5. Turn Arrows and Legends

City of Houston only uses Arrows or Only's in exclusive turn lanes.

E. Traffic Signal Hardware Design

The traffic signal hardware shall be designed in accordance with the following criteria:

1. Traffic Signal Heads and Lane Use Control Signs

- a. Number and Location of Heads:
- (1) The minimum number of traffic signal heads for all approaches shall be in conformance with the current edition of the TMUTCD.
 - (2) Generally, one traffic signal head will be provided for each through lane.
 - (3) Generally, the traffic signal heads shall be located directly above the center of the travel lane.
 - (4) Typically, a minimum of two left turn traffic signal heads shall be provided. One left turn traffic signal head will be located centered over the left turn lane. A second left turn head shall be provided on the far-left corner of the intersection adequately aligned with the left turning path. Additional left turn traffic signal heads are required for multiple left turn lanes.
 - (5) Where there is only one approach lane, two signal heads shall be located at least 8 feet apart between edge of backplates, with the center of the separation between the heads located over the center of the lane.
 - (6) Bicycle signal heads shall be placed in a location clearly visible to oncoming bicycles. Typically, a single signal head is sufficient; however, consideration of near-sided bicycle signals may be given for improved visibility.
- b. Size and Configuration:
- (1) Generally, all traffic signal heads shall be oriented in a horizontal alignment.
 - (2) All pole mounted traffic signal heads shall be mounted vertically in line with the pole shaft.
 - (3) All sections of vehicular traffic signal heads shall have 12" LED indications.
 - (4) For permissive only mode left turns, steady 3-section RYG shall be used (H3 horizontal, V3 vertical). R10-12 "LEFT TURN YIELD ON GREEN BALL" sign shall be installed immediately adjacent to the traffic signal head.
 - (5) For protected/permissive mode left turns with an exclusive left turn lane, 4-section RYYG flashing yellow arrow signal shall be used (H4LF horizontal, V4LF vertical). R10-17T "LEFT TURN YIELD ON FLASHING YELLOW ARROW" sign shall be installed immediately adjacent to the left turn signal head, and below the second left turn head placed on the far-left corner.
 - (6) For protected/permissive mode left turns with a left/through share lane, steady 5-section RYYGG signal shall be used (H5L horizontal, V5L vertical). R10-12 "LEFT TURN YIELD ON GREEN BALL" sign shall be installed immediately adjacent to the traffic signal head if horizontal, and below the left turn head if vertical. No supplemental signal head in the far-left corner is required for this case.
 - (7) For protected only mode left turns, steady 3-section RYG all arrows shall be used (H3L horizontal, V3L vertical). R10-5 "LEFT TURN ON GREEN ARROW ONLY" sign shall be installed immediately adjacent to the left turn signal head, and below the second left turn

- head placed on the far-left corner.
- (8) At split-phase approaches, the left-most head shall be a 4-section RYGG head with a left arrow section (H4TL horizontal, V4TL vertical). No sign is required to accompany this signal head. No supplemental signal head in the far-left corner is required for this case.
 - (9) Signal heads located in the Downtown and Uptown District shall be black in color. All other traffic signal heads in the City shall be yellow unless otherwise specified by the City.
 - (10) Bicycle signal heads shall be mounted vertically.
 - (11) All sections of bicycle signal heads shall have 12" LED bicycle indications. Steady vertical 3-section RYG bicycle shall be used (B3). "*bicycle symbol* SIGNAL" sign plaque (R10-10B) shall be added below the bicycle signal head.
- c. Type of Signal Head:
- (1) All signal head housings shall be constructed of polycarbonate in accordance with the Standard Specifications.
 - (2) Optically programmed signal heads shall be used whenever the indications can be viewed by two or more conflicting movements of traffic at skewed intersections, or where two sets of indications for the same direction are not to be viewed simultaneously, such as the second set of indications on the cross street at an offset intersection.
 - (3) Bi-modal indication signal sections shall not be used.
- d. Type of Mounting:
- (1) All mast arm-mounted traffic signal heads will be mounted on a tenon using a fully adjustable "Astro-Brac Atlas Large Capacity" mount assembly, or an approved equal. In exceptional circumstances when a tenon is not available on the mast arm and after obtaining authorization from the City of Houston, a hole should be drilled and a tenon clamp kit used.
 - (2) Side-mount signal heads shall be mounted using standard mountings and shown on the plans as being on a side of the pole away from vehicular traffic.
- e. Backplates:
- (1) All vehicular traffic signal heads on steel poles shall be equipped with black louvered backplates conforming to Standard Specifications.
 - (2) All bicycle signal heads (B3) shall be equipped with yellow louvered backplates conforming to Standard Specifications.
- f. Installation Procedures:
- Mast arms shall be drilled for wire accesses after installation on the pole base to provide concealed wiring and proper signal head location. All signal head installations shall comply with mounting requirements per Standard Specification 16715 Vehicle Signal Heads.

2. Pedestrian Traffic Signal Heads

a. Type and Number:

- (1) Pedestrian traffic signal heads shall be installed wherever crosswalks are provided, except crossing free right turn lanes.
- (2) Two pedestrian traffic signal heads shall be installed, one at each end of the crosswalk being controlled. Pedestrian signals may be placed on median islands if the signal heads are not visible for the entire length of the crossing and/or operational considerations indicate benefit of two-stage crossings along with adequate pedestrian refuge area available on the median. In such case, additional pedestrian signal heads shall be placed in the median facing each direction.

b. Legend:

Generally, all pedestrian signal heads shall have international symbol messages consisting of a Portland orange upraised hand (symbolizing DON'T WALK) and a lunar white walking man (symbolizing WALK).

c. Size and Configuration:

- (1) All pedestrian traffic signal heads shall have 16" LED Countdown indications.
- (2) Pedestrian traffic signal heads located in the Downtown and Uptown District shall be black in color. All other pedestrian traffic signal heads in the City shall be yellow unless otherwise specified by the City.

d. Location:

Pedestrian traffic signal heads shall be located as nearly in line with the crosswalk as possible. If the mast arm pole is located such that the pedestrian signal will be blocked by stopped vehicles or if it is more than 20 feet outside of the crosswalk lines extended, then an alternative means of mounting shall be designed. Pedestrian traffic signal heads shall be mounted 8 feet (to the bottom of the head) above the walking surface on the side of pole away from vehicular traffic. Pedestrian traffic signals shall be shown on the plans as being mounted on the side of the pole away from vehicular traffic by use of the respective symbol.

3. Relocating Traffic Signal Heads

Signal heads shall be relocated only when they are in good condition, are in conformance with this section, and no modifications are necessary. The relocation of any traffic signal heads shall require the prior approval of the City.

4. Mast Arm Assemblies and Poles

Typically, the City requires that mast arm poles be used for all new traffic signal installations. In special cases, the City may allow strain pole installations based on a written recommendation by the engineer explaining the need for a span wire design. Traffic signal heads mounted vertically on a pole shaft shall be allowed as supplemental signal indications, but shall not be used as the exclusive method of mounting traffic signals for any approach without prior approval from the City.

a. Location (Including Setback):

- (1) On streets with curbing, poles shall be located such the center of the pole is a minimum of five (5) feet from the face of curb. On streets without curbing, or with speeds greater than 35 MPH, poles shall be located a minimum of 10 feet behind the edge of pavement or 3 feet behind the edge of the paved shoulder, whichever is greater, and should be located 15 feet from a line extended from the edge of the through traffic lanes.
- (2) Mast arm traffic signal poles should not be located in the median unless no other option exists. Any mast arm poles located in the median shall require approval by the City prior to the preliminary plan submittal.
- (3) Poles should be located in line with the opposing directions stop line (approximately four feet behind the crosswalk line).
- (4) Poles should be located as close to the sidewalk or pedestrian landing as possible for pedestrian pushbutton access, yet still be within the guidelines for distance from the curb or traveled way.
- (5) No poles shall be located in wheelchair ramps or such that they are an obstruction to pedestrians or wheelchairs.
- (6) On the plans, the Consultant shall tie down the location of all poles referenced to the street centerline by station to the nearest foot and offset to the nearest half foot.

b. Mast Arm Lengths:

- (1) Minimum mast arm length that shall be used is 25 feet.
- (2) Mast arms longer than 55 feet in length may require an evaluation of the pole and foundation to be used as determined by the City.
- (3) Mast arm lengths should allow for probable future modifications to the signal. If a left turn lane exists, the arm should extend to the center of the left turn lane.

c. Clearances from Utilities:

Poles shall be located such that all portions of the poles and attached equipment have clearances from overhead utilities in accordance with the requirements of the local utility and the National Electrical Safety Code (NESC).

d. Material and Style:

- (1) All poles shall conform to the Standard Specifications and Details. Special poles and features shall be coordinated and approved by the City.
- (2) The centerline of the mast arm shall be at 90 degrees to the centerline of the approach it is serving unless otherwise required.

e. Delivery Time:

Typical delivery time for mast arm poles is 8 - 12 weeks from the approval of submittals. The number of days specified in the contract should account for the long delivery time.

f. Luminaires and Luminaire Mast Arms:

Luminaires shall be included in all intersection designs unless otherwise indicated by the City, and shall meet the following requirements:

- (1) One luminaire shall be utilized for each leg of the intersection.
- (2) Luminaires to be positioned to illuminate crosswalks.
- (3) All installations shall meet the current National Electrical Code requirements.
- (4) The street lighting photo cell shall be mounted in the traffic signal service panel unless otherwise designated by the City of Houston.
- (5) Power for the street lighting should come from the traffic signal service panel.
- (6) Fixture attributes shall adhere to the latest City specifications for intersection lighting.

g. Device Mounting:

No non-traffic related devices may be mounted on the mast arm. Non-traffic related devices may be mounted on the pole shaft with approval. All devices to be installed on the signal pole and mast arm assembly shall be in accordance with the maximum loading information provided by the manufacturer. Reference to City of Houston Standard Detail for Traffic Signal Structures 02893-04B. The installation of any device in deviation of the traffic signal items defined on Standard Detail 02893-04B shall be submitted for review to the City with the respective supporting structural analysis.

5. Pedestrian Pushbuttons

Pedestrian pushbuttons shall be required at all new or modified traffic signal locations within the City of Houston. The omission of pedestrian pushbuttons at any location shall require the approval of the City.

- a. All pedestrian pushbuttons shall be Polara Navigator or approved equal Accessible Pedestrian Systems (APS).

- b. No more than one pedestrian pushbutton shall be located on a single traffic signal pole.
- c. Pedestrian pushbuttons should be located no more than ten (10) feet from the face of curb or more than five (5) feet from the crosswalk extension.
- d. Pedestrian pushbuttons shall be separated by a minimum distance of ten (10) feet.
- e. All pedestrian pushbutton stations shall be accompanied by a pedestrian pushbutton sign (R10-3e) with instructions.

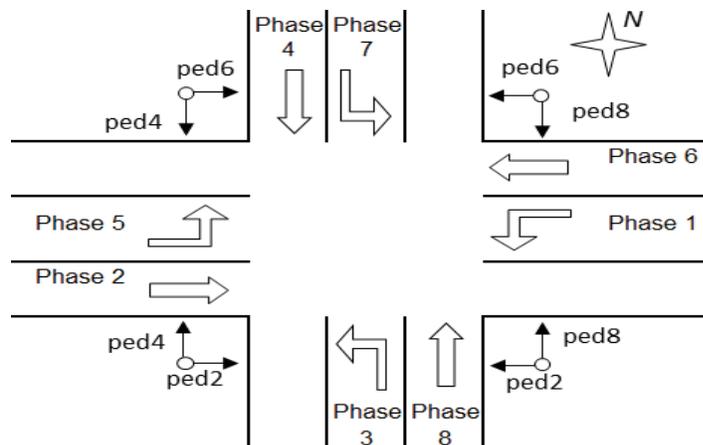
F. Controller and Cabinet Design

1. Controllers

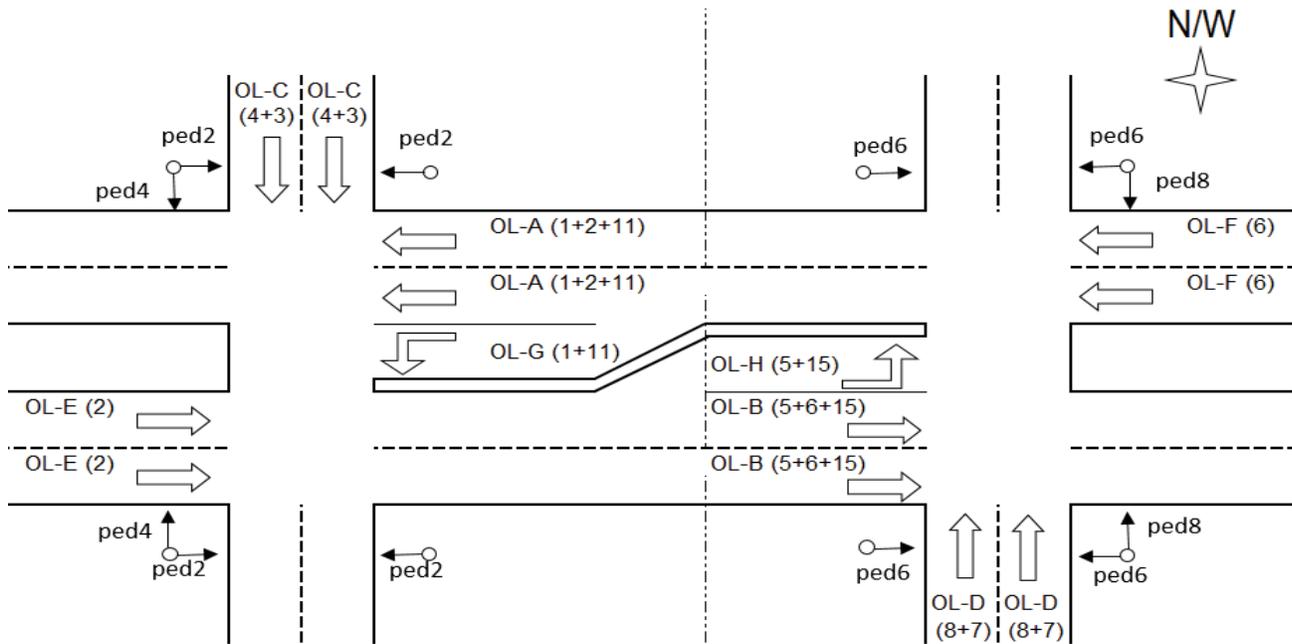
All new controllers shall be the Type 2070 Advanced Traffic Controllers (ATC) in compliance with the latest Model 2070 Controller Unit Specification unless otherwise directed by the City.

2. Phasing

- a. The sequence of operations shall be shown by the phasing sequence diagram for each intersection on the plan sheet. Permitted movements shall not be indicated unless part of a protected/permitted sequence. All pedestrian movements shall be shown.
- b. Phases shall be designated on the traffic signal plan sheet in accordance with the standard NEMA phase designations. In addition, the phases shall be assigned as follows (unless limited by the controller cabinet). As shown, phases 3 and 8 are to be oriented north on standard 8-phase intersections, and phase 8 is to be assigned to the feeder road approach oriented north or west as shown.



Standard 8-phase Intersection



Standard Diamond Interchange Intersection (4-Phase Operation)

3. Controller Cabinet Type
 - a. New Type 2070 ATC controllers shall be housed in one of a selection of four cabinets from the Standard Specifications:
 - (1) Type 340 ITS Cabinet (Housing Package Type 3) - This is the standard cabinet for installation at City of Houston Intersections. This cabinet shall be used at locations where 8 or more phase operation would be employed in the new or future system. This cabinet will fit on a standard NEMA "P" cabinet foundation. Type 342 ITS Cabinet (Housing Package Type 1) - The Type 342 ITS cabinet is a smaller cabinet that uses the Type 332 cabinet profile and will fit a Type 332 cabinet foundation. This cabinet should only be used on intersection retrofit projects where the existing foundations and conduit system are to remain. It should not be specified without prior approval by the City. Type 346 ITS Cabinet (Housing Package Type 2) - The Type 346 ITS cabinet generally has the same capabilities as the Type 342 cabinet in a smaller unit. These cabinets are to be used in the Downtown area, pedestrian hybrid beacon locations, and fire stations.
 - b. Selection of which cabinet to use shall be based on the cabinet use descriptions above, and approved by the City.

4. Controller Cabinet Location

- a. The controller cabinet should be located to minimize the probability of being hit by a vehicle. Locations particularly susceptible to accident damage are:
 - (1) The far corner (apex) for a dual left turn or right turn movement where the crossing street doesn't have a raised median.
 - (2) The far corner (apex) for a heavy left turn movement.
 - (3) The far right corner of a high-speed approach where a right angle collision can knock a car into the controller.
 - (4) Generally, the controller should be located upstream on the heaviest approach and/or back from the corner on the minor approach if there is a significant difference in approach volumes or speeds. Consideration should be given to locating the controller where it is protected by an existing non-breakaway pole or a mast arm pole.
- b. Where possible, the controller should be located on the same corner as the power supply. Special care should be taken that the load center is not separated from the controller by a wide, high speed or high volume street.
- c. Areas subject to flooding shall be avoided. Where not possible, the foundation should be raised 2' above the 100-year flood plain.
- d. Cabinet placement should not obstruct the minimum sight distance of any approach of the intersection. The cabinet should not obstruct the sidewalk or
- e. the ramp, even when the doors are open. Care shall be taken such that the cabinet doors do not open off the right-of-way.
- f. Cabinets shall be positioned such that when the door opens, the maintenance personnel will have a clear view of the intersection and the inside of the cabinet. If the cabinet is too high to see over, the cabinet shall be positioned and oriented so that the technician has a clear view of the intersection without looking around the open door.
- g. No device serving purposes different that traffic signal operations shall be placed on top or attached in any way to the traffic signal cabinet without the prior review and approval of the City. No device compromising the physical integrity of the signal cabinet will be authorized.

G. Detector Design

1. General

The City's practice is to install inductive loop detectors as primary detection method at all new traffic signal installations. The use of wireless magnetometers as an alternative detection method shall be considered if the installation of inductive loops is unfeasible (e.g. bridge deck, paver surface) or impractical (e.g. poor pavement conditions). Video detection should not be proposed as a permanent system as it will

only be considered during temporary construction. Any other detection technologies shall require prior approval of the City.

2. Emergency Vehicle Pre-Emption Equipment

All new City traffic signal installations shall require the installation of GTT Opticom emergency pre-emption equipment. Sensors shall be installed for all intersection approaches. The City of Houston uses a coded system which requires proprietary software. For this reason, only GTT (Global Technologies, LLC) Opticom equipment can be used for City installations.

3. Inductive Loop Detectors

Inductive loop detectors are the standard means of vehicle detection to be used in the City of Houston.

a. Types of loop installations shall be broken into two categories depending on the proposed pavement work:

- (1) Pre-formed Loops - Use pre-formed loops any place where the entire loop falls in an area of new, overlaid, milled and replaced, or seal-coated pavement. The excavation and patching required are easily covered up by the pavement work, and the pre-formed loops can last virtually forever, if properly installed.
- (2) Saw cut Loops - Use saw cut loops if the loop or any part of the loop would end up in an existing pavement that will not be modified by any of the methods noted above. This is a less desirable method of loop installation, but can give acceptable loop life if properly installed.

b. The detector lead-in cable is a shielded twisted pair cable extending from the loop pull box to the controller cabinet. The detector lead-in cable shall be a continuous run without splices.

c. Except where noted otherwise, dimensions for detector loop setbacks shall be referenced from stop line. The detector reference line should be curved if needed to follow the alignment of the street.

d. Each loop shall be connected to its own detector lead-in cable. Multiple detector lead-in cables may run in the same conduit.

4. Wireless Magnetometers

Wireless magnetometers vehicle detection systems (WMVDS) are accepted as a secondary method to provide actuation at an intersection. WMVDS may be proposed only when unfeasible and/or impractical circumstances prevent from installing inductance loops.

a. Magnetometers are small sensors embedded in holes drilled in the road surface. The installation for this method of detection consists of multiple

components including but not limited to access points, contact closure cards, radios, and repeaters. Care shall be taken to assure proper location and placement of each to achieve the envisioned performance.

- b. A single magnetometer sensor provides a 6-foot by 6-foot detection zone. Multiple wireless magnetometer sensors shall be used to provide the equivalent detection zones defined for high and low-speed approaches.
- c. All wireless magnetometers shall be called out on the signal plan sheet with specific labels, stations and offsets for accurate placement.

5. Identification Scheme

Detectors shall be identified on the plan sheets by their phase, lane and purpose. Each lane will be numbered from left to right starting with the lane closest to the centerline. Advance detection loops shall be identified as pulse loops. Detectors in through lanes at the stop line will be designated as call detectors. Finally, detectors in the turn lanes or on low speed minor approaches shall be presence detectors. For example, when speaking about the advance loop for eastbound in the lane closest to the median would be referred to as the Phase 2 pulse loop 1.

6. Advance Detectors on Higher Speed Approaches (Posted Speed > 30 MPH)

a. Location

- (1) For higher speed approaches, advance inductance loop detectors for the through lanes of traffic are required and shall be located five (5) seconds from the stop line using the following table:

Advance Detector Location Table

Posted Speed/ Design Speed (mph)	Advance Detector Distance (ft.)*
30	220
35	260
40	300
45	330
50	370
55	410
*As measured from the leading detector edge to the stop line.	

- (2) In addition to the advance detectors, call detectors in each lane shall be placed near the crosswalk. The front edge of a 6' x 6' detection zone (either pre-formed or saw cut loops, or magnetometers) shall be located four (4) feet back from the stop line. At locations involving skewed intersections, or other extenuating circumstances, the detector positions and sizes may need to be adjusted to account for vehicles stopping in front of or in the crosswalk. In all cases, detection must be provided 10 feet upstream from the back of the crosswalk. The intent

of the detectors placement is to prevent the smallest passenger cars, motorcycles and bicycles from being caught in an undetected area. If adjusted, the size and spacing of the detectors shall remain constant.

b. Detector Lead-in Cable

- (1) The upstream pulse loops for the dilemma zone protection shall be on separate detector amplifier channels.
- (2) If there is more than one through lane, adjacent upstream loops shall be placed on separate channels without connection to any other loop.
- (3) The two stop line loops shall be spliced in series at the cabinet and connected to the same detector amplifier. This amplifier shall be the "call" input amplifier, with the loops of each lane split between the two channels.
- (4) The upstream loop detector lead-in cables shall be routed to the nearest junction box along a patch perpendicular to the direction of travel. Homeruns for adjacent loops, less than 16 feet apart, should be routed to the nearest junction box in the same cut to the extent possible to minimize excavation of the pavement. When loops are adjacent to medians, the homerun can be routed directly to the median and then to the nearest junction box.
- (5) The stop line loop lead-in cable will generally be routed to the same junction box. All the detector lead-in cables for conduit-encased loops should be routed parallel and adjacent to each other along a path perpendicular to the direction of travel. A path parallel to the direction of travel may be needed from the individual loop to the common perpendicular routing.

7. Detectors on Low Speed Approaches

a. Location

- (1) Large area presence detection shall be used on approaches with less than 35 MPH posted or anticipated 85th percentile speed. It shall also be used on side street approaches, with a posted or anticipated 85th percentile speed of 35 MPH, if the higher through phase critical lane volume is less than one-half the critical lane volume of the highest volume main street through phase.
 - (a) Pre-formed Loops. A 6' x 21' presence detection zone shall consist of one (1) 6' x 6' detector loop placed in each lane beginning at the stop line, and a second 6' x 6' detector loop placed an additional 9 feet upstream of the trailing edge of the first detector. An additional 6'x6' detector loop shall be placed in front of the stop line if the curb return allows for a full vehicle length to the stop line.
 - (b) Saw cut Loops. A 6' x 20' presence detection zone shall consist of one (1) 6' x 6' detector loop placed in each lane beginning at the stop line, and one (1) 6' x 10' detector loop placed 4 feet upstream of the trailing edge of the first detector. An additional

6'x6' detector loop shall be placed in front of the stop line if the extension of the curb line allows for a full vehicle length to the stop line.

- (c) If using magnetometer vehicle detectors, an equivalent detection zone shall be provided considering a single sensor offers a 6-foot by 6-foot coverage. An additional sensor shall be placed in front of the stop line if the curb return allows for a full vehicle length to the stop line.
- (2) At locations involving skewed intersections, or other extenuating circumstances, the detector positions, number or sizes may need to be adjusted to account for vehicles stopping in front of or in the crosswalk. Care should be taken to not leave too much undetected space immediately upstream of the crosswalk. The intent of the detector placement is to prevent the smallest passenger cars, motorcycles and bicycles from being caught in an undetected area. If adjusted, the distances between the detectors shall remain constant.

b. Detector Lead-in Cable

- (1) In the case of the pre-formed detector loops, the loops in a lane may be combined on one channel. In all cases, each loop shall be spliced to its own detector lead-in cable running back to the cabinet.
- (2) Detector lead-in cables for the loops closest to the intersection should be routed to the same junction box. Detector lead-in cables for adjacent loops should be routed to the nearest junction box in the same cut to the extent possible to minimize excavation of the pavement. A path parallel to the direction of travel may be needed from the individual loop to the common perpendicular routing.

8. Downstream Detection

Downstream detector loops shall be placed on the receiving lanes of all through approaches, low and high speed, one hundred (100) feet measured from the crosswalk line furthest from the intersection. In case of no crosswalk line present or not clearly marked, downstream detector loops to be placed one hundred (100) feet measured from the curb return furthest from the intersection.

9. Left Turn Lane Detection

a. Location

- (1) Large area presence detection shall be used for left turn lane detections.
 - (a) Pre-formed Loops. A 6'x 51' presence detection zone shall consist of one (1) 6'x 6' detector loop with trailing edge four (4) feet in front of the stop line extending into the crosswalk, and additional three (3) 6'x 6' detector loops placed at nine (9) feet intervals upstream starting at the trailing edge of each loop.
 - (b) Saw cut Loops. A 6'x 50' presence detection zone shall generally consist of one (1) 6'x 6' detector loop with trailing

edge four (4) feet in front of the stop line extending into the crosswalk, one (1) 6'x 6' detector loop placed with leading edge at the stop line, and one (1) 6'x 30' detector loop placed four (4) feet behind the trailing edge of the stop line detector loop.

- (c) If using magnetometer vehicle detectors, an equivalent detection zone shall be provided considering a single sensor offers a 6-foot by 6-foot coverage.
- (2) At locations involving skewed intersections, or other extenuating circumstances, the detector positions, number or sizes may need to be adjusted to account for vehicles stopping in front of or in the crosswalk. Care should be taken to not leave too much undetected space immediately upstream of the crosswalk. The intent of the detector placement is to prevent the smallest passenger cars, motorcycles and bicycles from being caught in an undetected area. If adjusted, the distances between the detectors shall remain constant.

b. Detector Lead-in Cable

- (1) Where medians are constructed adjacent to left turn lanes, the detector lead-in cable(s) should be routed to a junction box in the median.
- (2) In the case of the pre-formed loops, the upstream loop shall be connected to its own channel on an amplifier. The other loops may be combined on one channel. For multiple saw cut loops, the rear loop and front loops shall be on separate channels. In all cases, each loop shall be spliced to its own lead-in cable running back to the cabinet.
- (3) If there are two or more left turn lanes, all the loops in one lane shall be connected in a like manner as described in paragraph b. above.

10. Right Turn Lane Detection

a. Location

Detection for a right turn lane shall be installed in the same manner as a presence detection zone for a through lane on a low speed approach.

b. Detector Lead-in Cable

The right turn presence detection loop shall be connected into its own detector lead-in cable, and separate channel on an extension amplifier for the through phase.

11. Installation of Vehicle Detection Systems

See the Standard Specifications and Details for construction requirements for primary (inductance loops) and secondary (wireless magnetometers) vehicle detection methods.

12. Video Imaging Vehicle Detection Systems (VIVDS)

The City's practice is to install inductive loop detectors as a standard means of detection. Wireless magnetometers are considered acceptable when installation of loops is unfeasible and/or impractical. Video detection is only to be used to provide vehicle detection on a temporary basis (e.g. construction) and in special cases where the City has approved its use prior to the preparation of final plans.

When using video detection systems, at least one camera shall be installed for each intersection approach.

13. Bicycle Detection

- (a) Bicycle detection systems shall be consistent with the method used for vehicle detection at the intersection.
- (b) Bicycle detection shall be considered at new and modified signalized intersections when the existing or proposed bicycle lane meets any of the conditions to warrant a bicycle signal.
- (c) Bicycle detection shall be installed at new and modified signalized intersections when the existing or proposed bicycle lane is on an approach typically operated in actuated mode, and that therefore, requires a method to recognize the presence of a bicycle to receive a green indication and proceed parallel to the adjacent vehicular movement.
- (d) Bicycle detection shall not be installed at signalized intersections when none of the applications to warrant bicycle signals are met, or the bicycle lane is located on a major approach typically operated in fixed-time mode, and that therefore, does not requires a method to recognize the presence of a bicycle to receive a green indication and proceed parallel to the adjacent vehicular movement served every signal cycle.
- (e) If loop detectors are used, diagonal slashed and quadrupole loop detectors are recommended for bicycle lanes. Refer to Loop Detector Standard Details.
- (f) If wireless sensors are used, the system selected shall supplement and be compatible with the existing or selected wireless vehicle detection system used at the intersection.

When bicycle detection is used, a Bicycle Signal Actuation sign (R10-22) shall be used, and a symbol shall be placed on the pavement indicating the optimal position for a bicyclist to actuate the signal. Refer to Standard Signs and Pavement Markings Drawings.

14. Other Detection Devices

The engineer may recommend other detection technologies and submit a written recommendation outlining the benefits of the technology. However, the City reserves the final authority to approve or disapprove the use of these technologies.

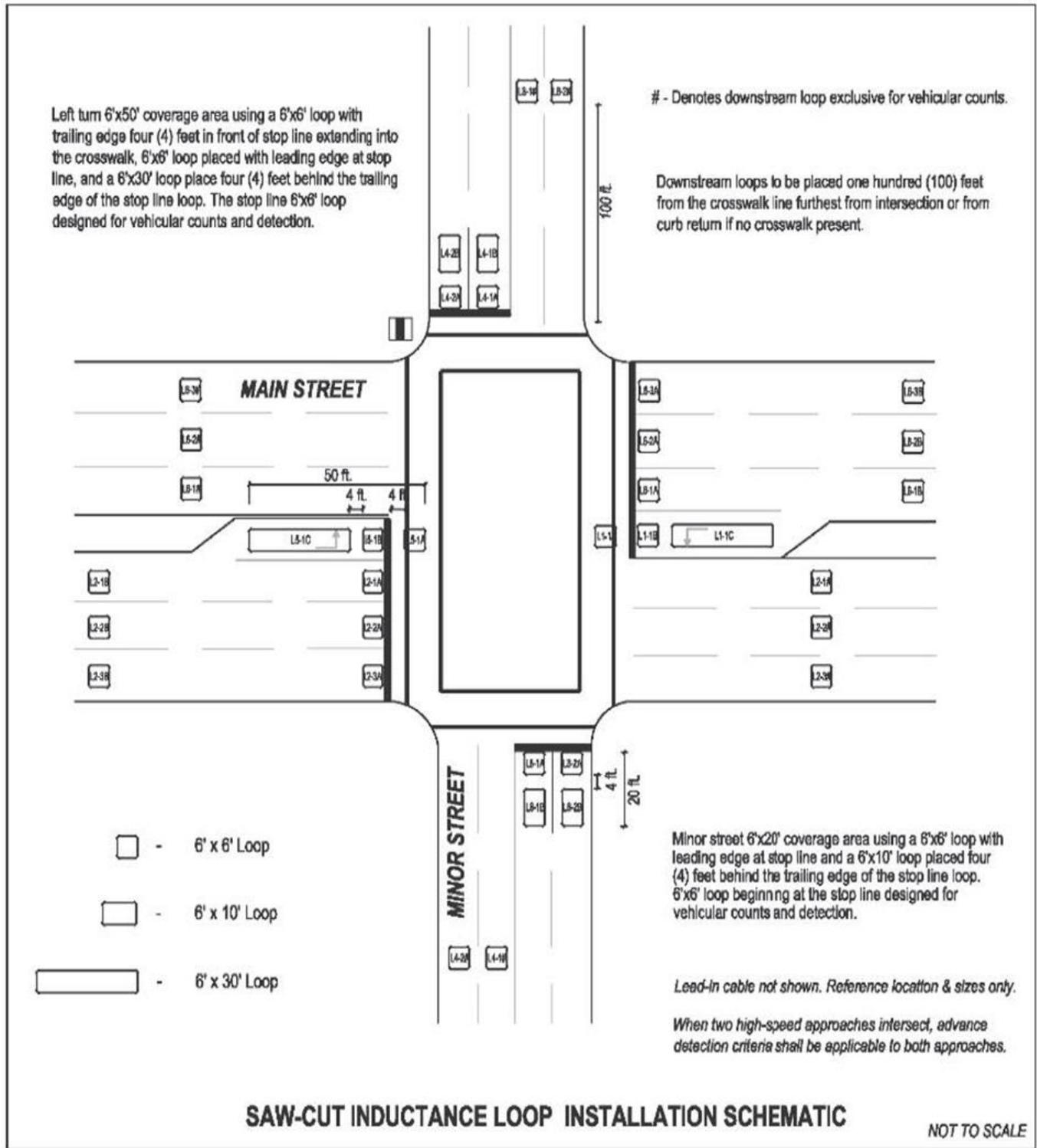


Figure 15.11.01a Saw-Cut Inductance Loop Installation Schematic

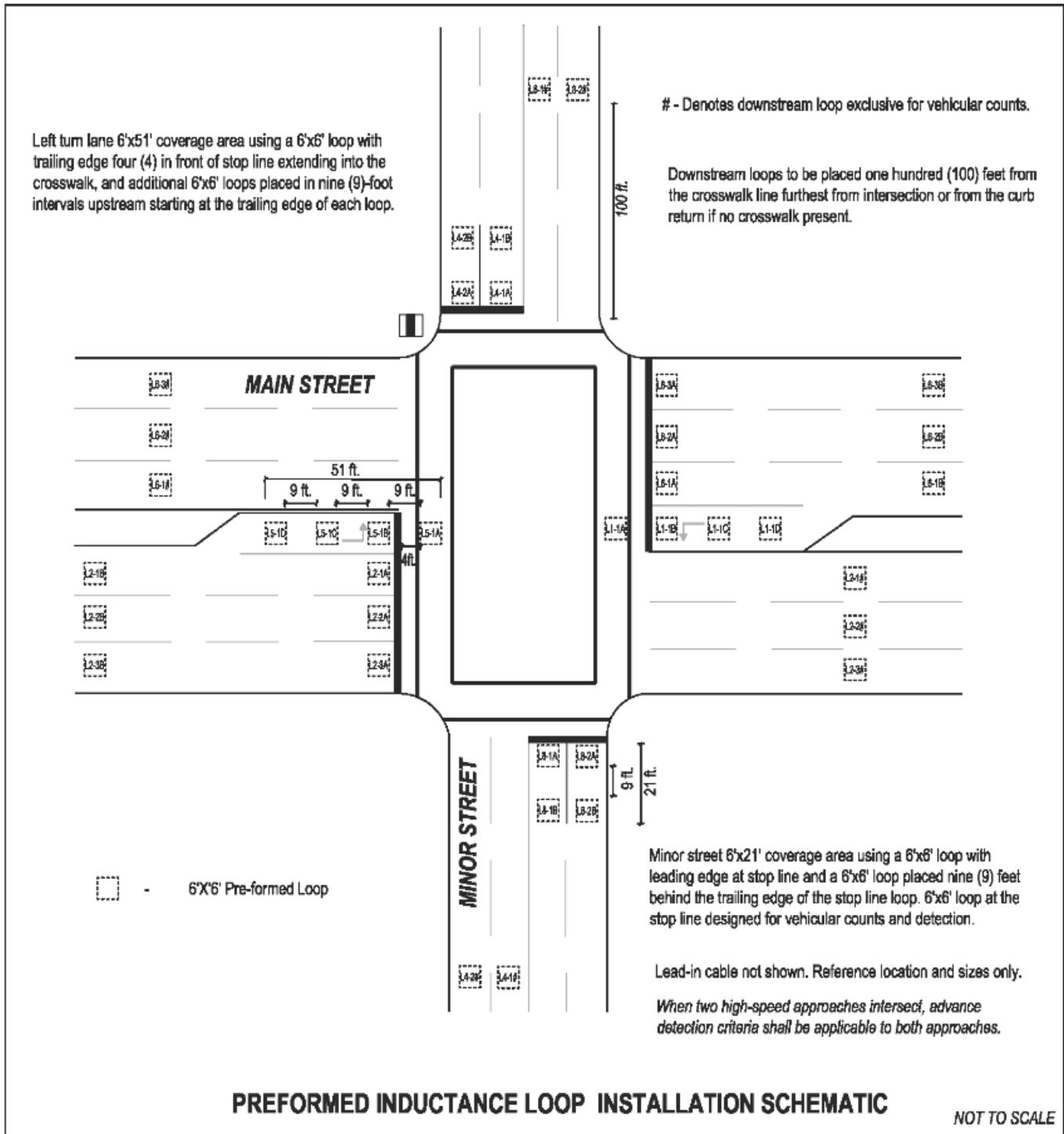


Figure 15.11.01b Pre-Formed Inductance Loop Installation Schematic

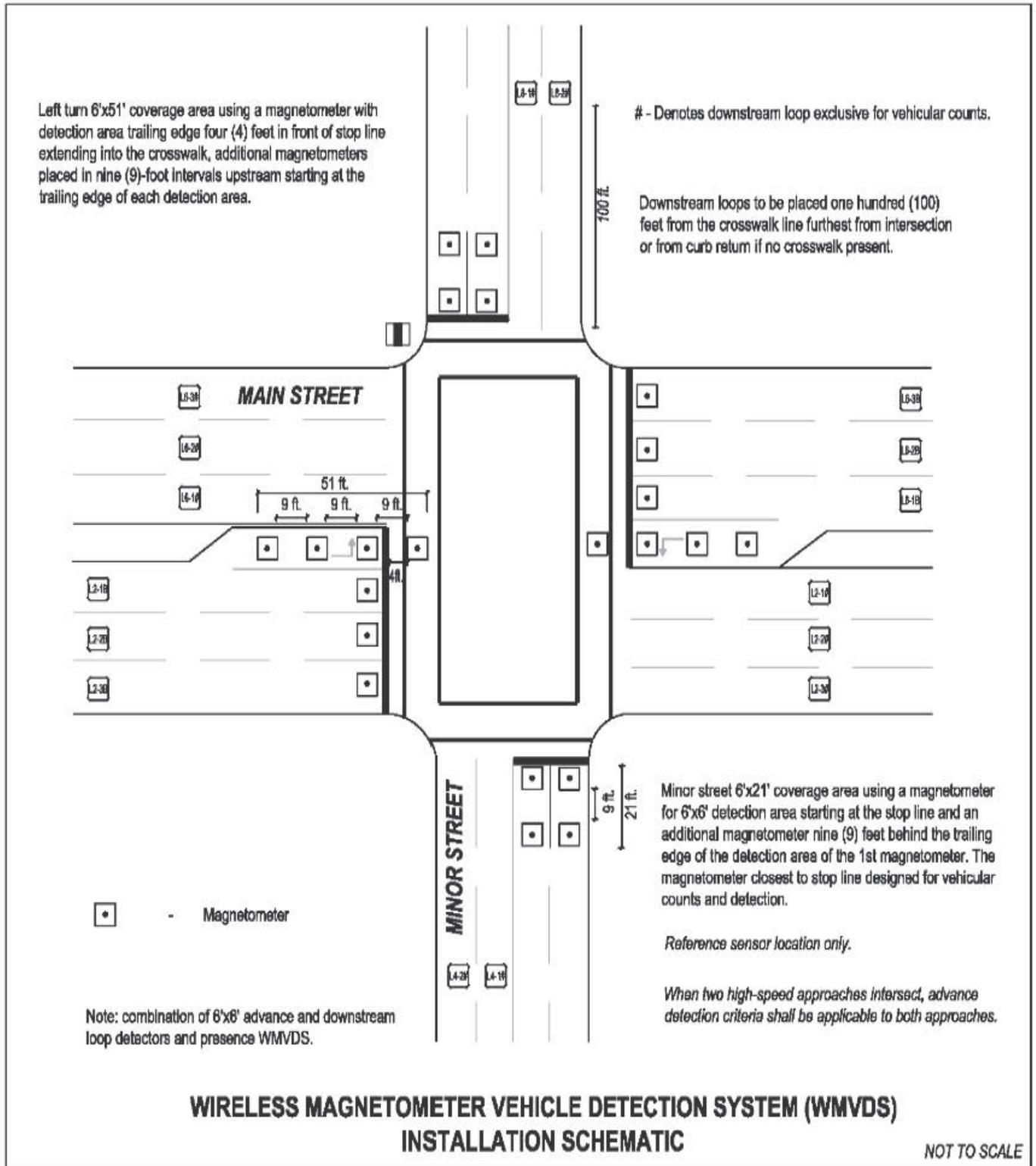


Figure 15.11.01c Wireless Magnetometer Vehicle Detection System (WMVDS) Installation Schematic

H. Underground Systems

1. Conduit

a. Type of Conduit

All conduits shall be as specified in the Standard Specifications. The designer must pay careful attention to where the Standard Specifications call for certain types of conduits for certain uses as well as when boring and encasing is to be used so the estimates can accurately reflect the field quantities.

b. Installation

- (1) Conduit shall be installed according to the Standard Specifications. Requirements for depth below finish grade shall be strictly adhered to.
- (2) The Consultant, in conjunction with the City, shall determine if conduit crossing certain paved streets should be shown as open cut or bored due to extensive utility problems. The specifications should require an alternate bid option of both methods to allow for unforeseen factors.
- (3) In general, conduit runs crossing paved alleys, drives, and streets shall be bored.

c. Conduit Sizing

- (1) Conduits shall be sized according to minimum allowed sizes and allowed conduit fill.
- (2) Conduit placed under roadway shall not be less than 3-inch in diameter.
- (3) Conduit shall be in 1/2" incremental sizes, with the exception of the rigid galvanized conduits on span-wire installations as shown in the Standard Details.
- (4) Conduit fill shall not exceed 40% on any one conduit or 26% average for all conduits on any one run.
- (5) When crossing the street with interconnects cable, the spare conduit required for a street crossing may be used if adequate capacity is available.
- (6) One (1) inch conduit shall only be used to protect the Street Loop Wire from the loop to the adjacent pull box.

Table 15.11.01
Dimensions and Maximum Percentage of Filled Area of Conduit

Trade Size	Internal Diameter (In)	Cross Sectional Area (Sq In)	26% Fill (Sq In)	40% Fill (Sq In)
1"	1.029	0.83	0.22	0.33
2"	2.047	3.29	0.86	1.32
2-1/2"	2.445	4.70	1.22	1.88
3"	3.042	7.27	1.89	2.91
4"	3.998	12.55	3.26	5.02

Source: National Electrical Code; Chapter 9, Table 4.

d. Length of Conduit Run

Conduit runs should be limited to 190 feet between pull boxes or structures where the cable is reasonably accessible for pulling. If the conduit run is very straight, with no more than 180 degrees of bend, and contains only a single cable, the run may be extended to about 350 feet.

e. Spare Conduits

Spare conduits shall be installed as shown in the Standard Details.

f. Location of Conduit Runs

- (1) If new sidewalk is part of the construction, conduit runs may be located under the new sidewalk with the junction boxes being constructed flush with the sidewalk.
- (2) If the sidewalk is existing, and a planting strip exists between the curb and the sidewalk, the conduit and junction boxes should be located either in the planting strip or on the other side of the sidewalk (right-of-way permitting), whichever has fewer utility conflicts.
- (3) If there is no curb and gutter, the conduit and junction boxes should be located as far as possible back near the right-of-way, but not in drainage areas.
- (4) Conduit runs shall be located away from drainage collection points whenever possible.

2. Pull Boxes

a. Size

Three sizes are available for use from the Standard Specifications and Details. The designer shall select the applicable box based on number and size of conduits to be contained in the box. If the designer is concerned that the standard pull box will be too small, they should select the next larger size pull box. The three sizes of standard pull boxes used by the City and their applications are:

Type A - To be used for detector loop pull boxes and hardwire interconnect boxes.

Type B - This is the standard traffic signal pull box, but may also be used as a detector loop pull box where multiple loops enter a single pull box.

Type C - This is the standard pull box to be used for most communications applications. It can also be used for traffic signals where a large pull box is required due to multiple large conduits entering the pull box. The most frequent use of this pull box in traffic signal construction is for the pull box adjacent to the controller cabinet.

b. Location

- (1) A pull box is generally required adjacent to each loop, set behind the curb or located on the shoulder to minimize being run over by vehicles.
- (2) For low speed approach and turn lane detectors, a junction box should be located to minimize the length of the detector lead-in cable.
- (3) Each quadrant of the intersection shall have a pull box that is within 30 feet of the traffic signal pole. This pull box should service the traffic signal pole, detector lead-in conduit, and the conduit crossing the street. If the intersection is actuated, this pull box can usually be the same box servicing the detectors at the crosswalk, and possibly the left turn detectors if no median island exists. It should be located to allow the most direct path for the detector lead-in cables as well as the conduit crossing the street.
- (4) Pull boxes located on corners should be positioned so that turning vehicles do not track across the pull box.
- (5) At span-wire signal installations, item c. holds true for the pull box location with the exception that you do not have a street-crossing conduit running to this pull box in most cases.
- (6) On the quadrant where the controller cabinet is located, there should generally be only the one pull box which services the conduit crossing the street, some detector loops, traffic signal pole, and the controller cabinet. An additional pull box is required in the Type 332 foundation, per the Standard Detail, and is also required in many cases where the controller cabinet is post-mounted.
- (7) For interconnect runs between intersections, pull boxes shall be provided at appropriate intervals.

3. Traffic Signal Communications

See requirements in Section 15.19.

I. Electrical Cable

1. Detector Lead-In Cable

- a. Detector lead-in cable shall be 14 AWG IMSA 50-2-1984 shielded cable meeting the requirements of the Standard Specifications.
- b. All detector lead-ins cables shall be continuous runs from the splice with the loop to the controller cabinet terminal strip.
- c. Each loop shall be individually brought back to the cabinet on a separate shielded cable.

2. Street Loop Wire

Street Loop Wire shall be 14 AWG IMSA 51-5-1985 cable.

3. Power Cable

- a. Power shall be 120 volt, single-cycle, 60 Hz AC.
- b. All services shall comply with Electric Company requirements and consist of six (6) #4 AWG XHHW stranded wires and an 8 AWG Solid Bare Ground. The six #4 AWG XHHW wires shall consist of two (2) white, one (1) black, one (1) red and two (2) green wires. A black #4 AWG XHHW stranded wire will be used for the "hot" signal leg and a white #4 AWG XHHW stranded wire will be used for the "common" signal leg. The two green, one red and one spare white #4 AWG XHHW stranded wires shall be reserved as spares or for future luminaire usage.

4. Signal Cable

a. Traffic Signal Heads

- (1) All traffic signal heads shall be serviced with a 7 conductor, 14 AWG IMSA 19-1-1984 cable meeting the requirements of the Standard Specifications.
- (2) IMSA cables are to run un-spliced from the controller cabinet to the terminal strip in the pole or to the signal heads where termination in the pole is unavailable.
- (3) Each approach will require that at least two heads be on separate IMSA cables. For additional heads, cables may be run from the first through head with a second cable from the first head to the additional heads.
- (4) Each protected/permissive and protected only left turn signal heads

shall be serviced by its own cable with no splices to other heads.

- b. Pedestrian Signal Heads and Pushbuttons
 - (1) Each pedestrian signal head shall be serviced by its own five (5) conductors, 14 AWG IMSA 19-1-1984 cables with no splices to other heads.
 - (2) Each pedestrian pushbutton shall be serviced by a three (3) conductor, 14 AWG IMSA 19-1-1984 cables.
- c. Installation, Continuity of Cables, and Splices
All cable shall meet the requirements of the Standard Specifications for installation, continuity, and splices.

No conduit or isolated cable for purposes different than traffic signal service should be attached or placed inside any signal pole.

5. Spare Cables

Where future pedestrian movements or left turn signal heads are anticipated, spare electric cables shall be routed from the controller cabinet to the pole on which they would be installed. In all cases, sufficient spare cable should be provided to connect to the future location of the equipment.

6. Voltage Drop Calculations

The designer shall take into account voltage drop calculations where applicable due to loss over long distances and consider special exceptions to the wire sizes normally used to accommodate losses.

J. Electrical Services

1. Type

The City's standard installation for electrical service will be a service pedestal. All service pedestals and poles shall be as shown in the Standard Specifications and Details and in compliance with the electric company standards.

2. Procedures for Hook-Up to Utility Company

- a. The utility company shall be contacted for the location of the power source and to verify their procedures for hook-up of power during the design process.
- b. Appropriate notes shall be placed on the plan sheet detailing the Contractor's responsibilities for hook-up, including sufficient advance notice to allow hook-up when the signal system is ready for testing.

- c. The service center shall be a ground-mounted service pedestal when there is to be a steel pole installation. On wood pole span-wire type installations, a wood pole-mounted service assembly is appropriate. Under no circumstances will the electric company or the City allow a meter assembly to be attached to an electric company pole. The assembly has to be located either on a corner signal support pole or a separately installed service pole, put in by the contractor.

K. Signs

1. General

All traffic sign codes in this section are from the current editions of the Standard Highway Sign Designs for Texas and the TMUTCD.

2. Overhead Mounted Street Name Signs

- a. A street name sign (D3, Texas Manual on Uniform Traffic Control Devices) for each approach shall be installed on the mast arm between the pole and the first signal head as shown on the Standard Detail.
- b. If the two legs of the cross street have different names, two signs with arrows shall be installed in lieu of a single street name sign. The sign on the left shall have an arrow pointing left followed by the street name. To the right of this sign is a sign with the name of the street to the right followed by an arrow pointing right.
- c. Street name signs shall include block numbers per the Standard Details.
- d. Customized street name signs require separate approval from the City Traffic Engineer. Interested parties should contact the Traffic Hotline at 832-395-3000 to apply.

3. Overhead Lane Use Control Signs

Refer to Traffic Signal Heads and Lane Use Control Signs in Section E.

4. Median and Island Approaches

- a. Median approaches should have an R4-7 Keep Right sign (symbol only) mounted at the nose of the median.
- b. Island approaches, with same directional traffic on both sides shall have a W12-1 Double Arrow sign mounted at the nose of the island.

5. Pedestrian Pushbutton Signs

Pedestrian Pushbutton signs shall be as shown in the Standard Details.

- a. An R10-3e shall be used at most locations.
- b. An R10-3b may be used at installations where standard pedestrian indications without the countdown feature are used.

6. No Pedestrian Crossing Signs

An R9-3A sign with plaque shall be installed on the mast arm pole at each side of an approach where no pedestrian signals or crosswalks are used.

7. Sheeting on Intersection Control Signs

All traffic control signs that are mounted overhead shall have diamond grade reflective sheeting. This applies to street name signs, one-way signs, turn restriction signs, etc. Any other supplemental intersection control signs that are ground mounted shall use at a minimum high intensity prismatic reflective sheeting.

8. Other Traffic Signs

Other traffic control signs, e.g., one-way, left lane must turn left, no right turn on red, no parking, etc., shall be installed as needed. These signs shall meet the requirements of the TMUTCD.

L. Battery Backup/ Uninterrupted Power Supply (UPS) Systems

1. General

The City of Houston shall require the installation of Battery Back Up/Uninterrupted Power Supply (UPS) systems on all new or reconstructed traffic signals. The Battery Backup/UPS System will meet the requirements of the Standard Specifications.

15.12 TRAFFIC CONTROL PLAN

15.12.01 GENERAL

- A. This section of the Design Manual contains general guidelines and instructions to be used in determining appropriate construction sequencing and preparation of traffic control plans. The intent is to establish standard procedures and requirements that will be used by engineering designers and consultants when preparing traffic control plans for City of Houston projects. In turn consistent application of lane closures and minimal inconvenience to the traveling public will reduce frustration due to negative impacts of construction activities and improve safety because of uniformity of lane/sidewalk closure techniques. All design shall also be in accordance with the latest version of the Texas Manual on Uniform Traffic Control Devices (TMUTCD).
- B. This document provides Designers and Consultants with:
1. requirements and guidelines for ensuring uniformity in lane/sidewalk closure techniques; and
 2. the required format of plan sheets to allow ease of review, minimization of construction errors, and facilitation of maintenance of traffic control setup by the Contractor.

15.12.02 DESIGN REQUIREMENTS

A. Description of Design/Review Process

1. Project Initiation
 - a. Determine Requirements of Other Agencies. If the project falls under TxDOT's jurisdiction, verify TxDOT's traffic control requirements and approval process is needed. The Consultant shall meet with appropriate TxDOT personnel to determine how to prepare the traffic control setup. After the meeting the Consultant shall meet with City of Houston Project Manager/City Traffic Engineer to discuss traffic control plans per TxDOT requirements and come up with an action plan to prepare construction sequencing and traffic control plans. This task could be handled via phone/e-mail correspondence.
 - b. The Consultant shall meet with the City of Houston prior to beginning the construction sequencing and traffic control plans to discuss the project in detail. At this meeting, typical and any conditions that need to be considered in preparation of construction sequencing and traffic control plans will be discussed. The meeting regarding traffic control plans will generally occur as part of other project initiation meetings and design review meetings. Based on the discretion of the City Traffic Engineer and/or City of Houston Project Manager a special meeting may be organized to discuss specifics of the

project in regards to construction sequencing and traffic control setup.

B. Data Collection

- a. Collect all data required to produce construction sequencing plans and traffic control plans. Typically, at this stage of the design process proposed improvements and goals of the project have been developed. Therefore, existing topographic survey and/or improvement design sheets will be used as the base file to produce construction sequencing plans.
- b. The Consultant shall visit the project site to inventory and identify physical features that may impact construction sequencing and traffic control plans such as access driveways to special adjacent properties that may require special considerations in preparing traffic control plans such as schools, police stations, fire stations, churches, properties with only one access point, and relatively high demand commercial developments.

C. Plans and Drawings

a. General

- (1) All construction sequencing and traffic control design plans shall be prepared on 22" x 34" Mylar reproducible sheets, using the Standard City of Houston, Houston Public Works Title Block. Construction sequencing and traffic control plans shall be shown on different plan sheets.
- (2) All full size designs for construction sequencing and traffic control plans shall be prepared at any scale as long as the notes and callouts are readable.
- (3) All construction drawings shall be prepared in accordance with Chapter 3, Graphic Requirements.
- (4) On projects where the Consultant finds it necessary to deviate from the standard format presented herein, due to project scope or design requirements, the City's Project Manager should be consulted to determine an acceptable alternate format. Any changes to the format are at the discretion of the City's project manager.
- (5) Construction sequencing plan should include all aspects of the improvement project such as removal of existing features such as curb, pavement, signs, implementation of temporary pavement to facilitate traffic, implementation of temporary signal locations, and installation of all proposed elements of the project.
- (6) Each phase of construction sequencing plan shall have separate traffic

control plan including associated detour routes and signal modification plans as necessary. The Consultant should look into using standard lane closures to reduce the number of plan sheets from phase to phase. In addition, if simple signal head adjustments are need for signal modification of different phases, the Consultant is encouraged to only use one signal modification plan for different phases.

- (7) Each phase of construction sequencing plan shall make every effort to leave existing sidewalk accessible to pedestrians while project related improvement activities commence forward. Complete sidewalk closure must be minimized as much as possible.
- (8) The contractor shall provide 11 foot travel lanes on traffic control plans outside the Central Business District (CBD), and a minimum 10 foot wide travel lanes within the CBD. Any deviation will have to be approved by the City Traffic Engineer.
- (9) The Contractor shall provide at a minimum two traversable lanes within the CBD. Any deviation will have to be approved by the City Traffic Engineer.
- (10) Where a bicycle facility is present, the Contractor shall provide as high comfort bicycle detour as possible. See Chapter 17 for the design of high comfort bicycle facilities. If the bus stop is present, the contractor shall provide an accessible comfortable pedestrian route to access the bus stop.
- (11) Lane closures on Major Thoroughfares according to the latest classifications by the Planning and Development Department; existing directional vehicular movements shall be maintained throughout the duration of the construction project. There may be special construction activities that may require limitations of movements on major thoroughfares. These situations must be approved by the City Traffic Engineer. Typically, such approvals are associated with peak period restrictions and/or special traffic control plan and requirement of extensive advertisement to the traveling public especially to stake holders substantially impacted in the vicinity.
- (12) Trench walls should not be three feet from the edge of the traveled way at any stage of the construction.
- (13) Traffic control devices shall be in place before starting any excavation.
- (14) For vertical drop-off greater than one foot along roadway, low profile concrete barriers with appropriate end protections must be installed.

b. General Notes.

The following General Notes should be included on the traffic control plan. Additional notes may be added by the Consultant as may be necessary to properly clarify the intent of the design.

- (1) The Contractor shall provide and install traffic control devices in conformance with Part VI of Texas Manual on Uniform Traffic Control Devices (TMUTCD) latest edition with revisions during the entire construction period.
- (2) All signs and traffic control devices shall conform to the latest version of the TMUTCD.
- (3) No lanes shall be closed during the hours of 7:00 AM to 9:00 AM and 4:00 PM to 6:00 PM Monday thru Friday without approval of the City Traffic Engineer.
- (4) No work shall be performed in residential areas from 7:00 PM to 7:00 AM.
- (5) Contractor shall maintain approved number of through lanes of traffic in each direction during construction working hours. Traffic control plans shall include one-way and/or detour plans. Contractor shall maintain ADA compliant pedestrian access to bus stops and adequate bus access to the bus stops.
- (6) Contractor shall maintain traffic lanes and detours according to traffic control plans during working hours.
- (7) Contractor shall cover open pavement excavations for minor utility work with anchored steel plates during non-working hours, and open lanes for normal traffic flow when feasible.
- (8) If the Contractor chooses to use a different method of "Traffic Control Plans" during the construction than what is outlined in the contract drawings, the Contractor shall be responsible to prepare and submit an alternate set of traffic control plans to the City of Houston Project Manager for approval ten working days prior to implementation. These plans shall be drawn to scale on reproducible mylars and shall be sealed by a Licensed Engineer in the State of Texas. Transportation & Drainage Operations representative approval is required to accept the proposed changes.
- (9) Contractor shall secure lane/sidewalk/bicycle facility closure permits from Transportation & Drainage Operations before implementing the

traffic control plan.² The application must be submitted at least ten business days prior to the implementation of the traffic control plan and/or beginning construction work. The Contractor shall provide traffic control plans, construction sequencing, and construction schedule with the application.

- (10) Contractor shall have approved traffic control plan and permit at the job site for inspection at all times.
- (11) During pavement surface restoration projects; the Contractor shall not open closed lanes until the pavement surface has cured enough to allow vehicular traffic according to City of Houston Standard Specifications.
- (12) The Contractor is responsible for scheduling and coordinating all construction activities with stake holders in the vicinity including emergency response agencies such as Houston Police Department, Houston Fire Department, and Metropolitan Transit Authority.
- (13) Contractor shall be responsible for issuing all work directives to all sub-contractors, utility companies, and all other entities performing construction work associated with the project.
- (14) Nothing in these notes or plans shall relieve the Contractor of the responsibility for job site conditions during the course of construction of the project; including safety of all modes of transportation, persons, and property, and that this requirement shall apply continuously and not be limited to working hours.
- (15) The Transportation & Drainage Operations (Mobility Permits Group) per the direction of the City Traffic Engineer have the right to demand the installation of additional traffic control devices or modifications to these plans and notes, as deemed necessary to promote the safe and orderly flow of traffic, including pedestrians and bicycles, through the construction work zone. The Contractor shall comply with these additional requests or modifications with due diligence.
- (16) All existing traffic control signs and pavement markings shall be maintained in visible locations during construction unless prior written approval is obtained from City of Houston Project Manager. The Contractor shall restore or replace (at the discretion of the City Traffic Engineer) any pavement marking or signing damaged during construction operations, including Raised Pavement Markers (RPMs).

² Refer to Mobility Permit System weblink at <https://geohub.houstontx.gov> for permit requirements

- (17) When entering or leaving roadways carrying public traffic, the Contractors equipment, whether empty or loaded shall in all cases yield to public traffic with the assistance of Contractor provided certified flagger/peace officer.
 - (18) Access to driveways adjacent to the construction work zone shall be maintained at all times as much as possible. Additional cones and/or delineators may be required to delineate the driveway access route through the construction work zone. A minimum of one travel lane shall be maintained across the driveways, unless prior written approval is obtained from City of Houston Project Manager.
 - (19) Spillage resulting from hauling operations along or across any public traveled way shall be removed immediately by the Contractor.
 - (20) The Contractor shall submit an application for temporary parking restrictions if there are parking meters located at the proposed lane closures from Parking Management Division (832-393-8690) at least ten business days before implementation of lane closures. In addition, temporary no parking signs shall be posted 24 hours prior to commencement of work.
 - (21) Additional off duty police officers/flaggers may be requested to direct traffic when lanes are blocked at the discretion of the City Project Manager even if they are not specifically identified on the project plans.
 - (22) The Contractor shall replace within 72 hours, all traffic signal loop detectors damaged during construction.
 - (23) In general, a solar powered flashing arrow board shall be required on all major thoroughfare lane closures. Exceptions to flashing arrow boards and/or implementation on residential lane closures shall be approved by the City Traffic Engineer.
 - (24) Approved traffic control plan shall be in place before starting any excavation.
- c. General Notes and Channelization Spacing (Refer to City of Houston Standard Detail 01512- 01)
 - d. General Lane Closure Guidance (Refer to City of Houston Standard Detail 01512-02)
 - e. General Detour Guidance (Refer to City of Houston Standard Detail 01512-03)

- f. Long Term Major Street Lane Closure (Refer to City of Houston Standard Detail 01512-04)
- g. Long Term Minor Street Lane Closure (Refer to City of Houston Standard Detail 01512-05)
- h. Short term Minor Street Intersection Lane Closures (Refer to City of Houston Standard Details 01512-06 through 01512-12)

15.13 MINIMUM VERTICAL CLEARANCE

15.13.01 GENERAL

This section of the design manual contains the requirements for minimum vertical clearances for structures, utilities and traffic control devices.

15.13.02 MINIMUM VERTICAL CLEARANCE GUIDANCE

- A. Pedestrian Sky Bridges
Refer Chapter 16, Miscellaneous, for sky bridge clearance requirements.
- B. Overhead Traffic Signal Devices
Refer Chapter 15, Section 11 of this manual and Standard Detail # 02893 for minimum clearance requirements for overhead traffic signal devices.
- C. Traffic Signs
Refer to Chapter 15, Section 11 traffic signal section of this manual, and TMUTCD for overhead sign installation requirements.
- D. Vehicular Bridge
The bottom of the lowest point of the structure in the public right of way should be a minimum of 14.5 feet over the entire roadway width. If a clearance is less than 17.5 ft, it must contain appropriate signs, and it requires approval of the City Engineer and the City Traffic Engineer.
- E. Building Structures Over Public Right of Way
The bottom of the lowest point of the structure in public right of way should be a minimum of 18.5 feet over the entire roadway width.
- F. Railroad Overpass Clearances
Highway structures over railroads are referred to as railroad overpasses. Vertical clearance for new structures over railroad tracks must be 23'-6" feet minimum measured from the top of rail to the lowest obstruction under the highway structure. In cases where electric powered trains are involved, additional vertical clearance may be required.
- G. Railroad Underpass
Prior to resurfacing under railroads, approval must be obtained from the railroad company.

- H. Obtain approval from Office of City Engineer for exception or deviations from these requirements.

15.14 STREET EXTENSIONS

- A. For streets that will be extended, the traffic study will recommend appropriate posted speed limit and parking restrictions that are consistent with the existing street segments at both ends.
- B. For street extensions that occur in phases, the design will include installations of appropriate pavement markings and warning signs (e.g., speed reduction signs, no outlet.) to ensure safe traffic operations and street transition until the full extensions are completed.

15.15 NEIGHBORHOOD TRAFFIC MANAGEMENT PROGRAM

15.15.01 GENERAL

- A. The City of Houston, HPW, Transportation & Drainage Operations administers the Neighborhood Traffic Management Program (NTMP) per the requirements of City of Houston Code of Ordinances Chapter 45, Article XV.
- B. Due to House Bill 3082, the City of Houston is obligated to go through the NTMP process as prescribed by City of Houston Code of Ordinances Chapter 45, Article XV in order to implement traffic calming devices within City of Houston jurisdiction.
- C. Traffic calming device is any type of device consisting of the physical structure or other improvement constructed, placed, whether on a temporary or a permanent basis, to mitigate speeding or cut-through traffic on local streets such as but not limited to speed cushions, median islands, traffic circles, chicanes, chokers, and raised pedestrian crossing islands.
- D. The NTMP comprises of the Speed Control Program and Volume Control Program. For neighborhoods that are interested in only speed cushions, the Speed Control Program offers a shorter process with no traffic study and public meeting requirements.
- E. All proposed traffic calming measures shall have to go through the NTMP process before implementation. Detailed information on the process, brochure, and application form can be obtained at <https://www.publicworks.houstontx.gov/tdo-documents>. The requestor can also contact the NTMP group at NTMP@Houstontx.gov or 832-395-3000 for additional assistance.
- F. If a project receives public requests for traffic calming devices, the design team shall strive to accommodate the requests within the project limits. The NTMP staff can guide the team through the process to obtain the appropriate approvals. Installation cost of the approved devices will be incidental to the project.

15.15.02 DESIGN REQUIREMENTS ON ROADWAYS WITH ALREADY APPROVED TRAFFIC CALMING DEVICES

A. Description of Design/Review Process

1. Project Initiation

- a. The Consultant shall meet with the City of Houston prior to beginning the redesign/replacement of traffic calming devices to discuss the project in detail. At this meeting, typical and any specialty items in regard to the traffic calming measures will be discussed. The meeting regarding traffic calming measures will generally occur as part of other project initiation meetings and will not require a separate meeting.

2. Collect Traffic Calming Measures Data and Design

- a. Collect all data required including but not limited locations of existing speed humps, speed cushions, and any other traffic calming devices.

3. The City of Houston does not use speed humps anymore. Therefore, all existing speed humps within the affected construction limit of a given project shall be replaced with speed cushions per the requirements of City of Houston Standard Detail 13501-01 as part of the improvement project and using the project funds.

4. Typically, all existing traffic calming devices shall be returned in place at the same location unless directed by the City Project Manager/City Traffic Engineer to adjust.

15.15.03 NTMP PROCESS

- A. The NTMP process is detailed in the City of Houston Code of Ordinances Chapter 45, Article XV. In summary, Figures 15.15.01 and 15.15.02 outline the process including the requirements of City Council approval for the Speed Control and Volume Control Programs.

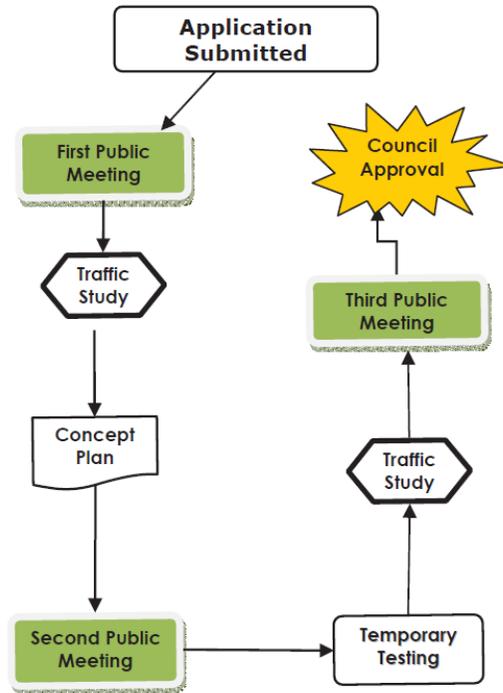


Figure 15.15.01 - Summarized NTMP Process - Volume Control Program

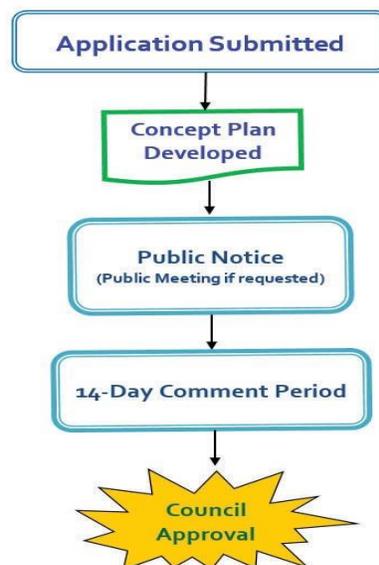


Figure 15.15.02 - Summarized NTMP Process - Speed Control Program

- B. Typically, the NTMP group directs an applicant through the process. In some cases, a neighborhood group or organization may choose to use a Consultant to go through the process, and construct the traffic calming devices using private funds.
1. The Consultant tasked by the group shall meet with the City of Houston Transportation & Drainage Operations staff responsible for the NTMP prior to starting the design. At this meeting, there will be discussion of the level of involvement by the Consultant to go through the process.
 2. If the Consultant requests City of Houston resources to assist with some of the tasks, there may be a waiting period to start the process.

15.16 STREETLIGHT DESIGN REQUIREMENTS

15.16.01 DESIGN REQUIREMENTS - CAPITAL IMPROVEMENT PROJECTS

The following design requirements are applicable within the City street rights-of-way and are intended for lights owned and installed by CenterPoint Energy. The Consultant is to contact the City's prior to implementing the below criteria to determine ownership and design methodology. This recommended practice is applicable to all capital improvement projects, including but not limited to street, bridge, water, wastewater, and storm sewer projects. The consultant will be responsible for designing the street lighting layout associated with each project by following the guidelines listed below. Note that the below criteria are solely for the use of the standard Cobra style light fixtures on cobra poles. Areas requiring or requesting decorative type lighting will need direction from the City's Streetlight Section on developing a streetlight design and cost.

1. It is the City's practice to upgrade the street lighting along all roadways to current recommended levels as part of capital improvement projects.
2. Areas without wood power poles are considered candidates for metal pole streetlights. The design consultant will prepare the lighting layout, spacing the streetlights at a distance of approximately 200' +/- 20' for driveway/utility conflicts. Typically, a streetlight placed 3-4 ft. behind back of curb will illuminate two lanes. Roadway sections that are four or more lanes should be illuminated from both sides. For sections less than four lanes, stagger the streetlights along both sides of the roadway, maintaining the 200' +/- 20' spacing. The design should also include any existing street lighting. Proposed and existing street lights should be called out by station numbers. Generally, begin layouts at intersections and work away.
3. The design must identify which of the existing streetlights will require relocating or temporary removal during the construction phase. Plans shall be submitted to the Transportation & Drainage Operations for review/approval. Upon our approval, the City will submit the approved layout to CenterPoint Energy for a conduit/pullbox layout and cost estimate for the temporary removal/re-installation of the existing streetlights. These costs will then be forwarded to the Project Manager and included as a line item in the bidding documents for cash allowance to pay CenterPoint. Note that CenterPoint will require payment prior to providing service.

4. When overhead power and wood pole street lighting exist in an area, the design should utilize existing wooden utility poles for any additional streetlights while maintaining a 175' +/- 15' spacing. Mixing of wood and metal pole streetlights along local streets in neighborhoods is generally not allowed and shall require prior approval from the City.
5. Along thoroughfares and collectors with four or more lanes, wood poles may exist along only one side of the roadway. In these instances, it is acceptable to have wood pole streetlights along one side while having metal pole streetlights along the other.
6. Upon completion of the project it is the contractor's responsibility to notify the Streetlight Section in writing that the conduit has been installed & inspected and meets CenterPoint's specifications before the authorization for new/re-installed metal pole streetlights can proceed.
7. Locations of existing and proposed street lights (station numbers) need to be shown. Do not show lighting outside of the public roadway right-of-way.
8. Pole number for existing street lights must be shown. This is a 6-digit number that is stenciled approximately 6' above grade on the street side of the light.
9. Depict type of existing and proposed street lights (metal pole or wood pole) - note: wood poles are never installed for the sole purpose of street lighting).
10. All metal pole street lights that could potentially be impacted by construction activities shall be removed and reinstalled. The removal and reinstallation will be completed by CenterPoint. The cost for this service will be included in the project as cash allowance to pay CenterPoint.
11. The proposed locations of new street lights should not necessarily be based on the existing light locations. The layout should be created from scratch, following the spacing criteria described above.
12. When removing/replacing lights in residential areas, it is generally preferable to replace lights in the same location, unless relocation is necessary to meet the lighting and spacing criteria.
13. In residential area, show parcel boundaries (property lines)
14. In residential areas, place lights on property lines and at property corners 2' off the radius of the curve (refer to the CenterPoint Energy streetlight staking detail).
15. No lights should be placed at a 45 degree angle at the intersections
16. Do not place proposed lights under heavy tree canopy (typical mounting height of a streetlight pole is 26'). Field verify to ensure appropriate clearance. Where tree canopy is unavoidable, plans must specify that tree canopy will need to be trimmed a minimum 5' radius around the projected streetlight pole mounting height (all trimming to be part of project cost, CNP will not trim trees nor install lights in heavy

tree canopy).

17. Do not place proposed lights in any wheelchair ramps or sidewalks.
18. If decorative lighting is requested by the neighborhood, the Consultant will submit the standard layout to the City. CenterPoint will prepare a separate decorative lighting layout. The City will review both layouts and determine which layout will be implemented.
19. Based on the City approved layout, CenterPoint will prepare a conduit layout, which the Consultant will incorporate into the design. The Contractor is responsible for the conduit installation. CenterPoint will be responsible for installing and energizing the streetlights. Payment to CenterPoint will be included in the project as a cash allowance item.
20. If temporary lighting is required, design and installation will be completed by CNP. Cost for this service will be included in the project as cash allowance from the contractor to CNP.

15.16.02 DESIGN REQUIREMENTS - CITIZEN REQUEST

1. The primary purpose of street lighting is to illuminate the roadway. Street lights are not intended for providing security lighting, pedestrian lighting, parking lots lighting or any other private property lighting. A street segment must be within the City limits in order to be eligible for street lights. All street lights are installed, owned and maintained by Center Point Energy. However, the City must approve for any street light installation that is within the City right-of-way. Once it is installed, the City pays for the operating and maintenance cost of the street light.
2. Street light types - The City of Houston standard street light type includes Light Emitting Diode (LED) in a cobra style light fixture mounted on wooden pole or metal pole.
 - a. Wood Pole Lights: The City will authorize for street light installation on wooden utility poles wherever possible.
 - b. Metal Pole Lights: If an area does not have existing wooden pole with overhead power lines, then a metal pole streetlight powered by underground lines will be installed. There may be a cost associated with this type of installation.
 - c. Wattage: Various wattages will be installed depending on the road to be illuminated. 45 watt LED fixtures will be installed on local roadways and 95 watt LED fixtures on collector type roadways. 115 watt LED fixtures are typically installed along major thoroughfares. LED street lights technology continues to advance. Increased efficiencies will change the applicable wattages and the designer should refer to the latest City specification for roadway lighting.

3. Street light spacing requirements. Metal pole street lights are typically installed approximately 200 feet apart (+/- 20') with 10 feet for property line adjustment. Street lights are typically installed on public right-of-way avoiding obstructions such as trees, manhole, and inlets. Spacing for street lights on wooden utility poles may vary depending on the existing location of the wood poles. However, spacing will normally be 150 to 200 feet apart for adequate roadway illumination.
4. Street light(s) can be requested by application. A Street Light Survey Request Form is available through the City of Houston website (<https://www.publicworks.houstontx.gov/tdo-documents>) or by calling (832) 395-3000. This application must be completely filled out and submitted to the City by mail or by fax. Upon receipt of the application, the City will conduct a street light survey and provide a written response in approximately 6 - 8 weeks thereafter. If the City determines that street light is feasible as a result of the survey, the City will authorize Center Point Energy for street light installation. Streetlights deemed necessary along Major Thoroughfares will incur an installation cost by CenterPoint Energy. Funding for the installation cost will be processed and paid by the City. CenterPoint Energy will schedule the installation once it receives payment. Timelines for the installation will vary depending on the City's ability to fund the request.
5. Cost for street lights. Typically, there is no charge to the applicant for any street light that can be installed on an existing wooden pole, or any street light (wooden or metal) that is installed on a roadway that is classified as a major thoroughfare per the City of Houston. However, there is a charge for the installation of a new street light on a metal pole on city local roads. There may be an additional charge by CNP for local roads that require a high level of illumination. Per Section 40-3 of the City Code of Ordinances, the applicant is required to pay for the first year's operating cost prior to authorizing the installation of the street light. This is a one-time charge to the applicant. The cost may vary but average around \$200.00 per street light.
6. Enhanced street light. The street light program also offers enhanced street lights upon request. Locations and types of enhanced street lights must meet the following requirements:
 - a. Locations of enhanced street lights must be within a current Management District, Tax Increment Reinvestment Zone (TIRZ), recognized by City of Houston.
 - b. Enhanced street light must be approved by the Street Light Program coordinator coordinated with City's other Capital Improvement Project.

15.17 COMPLETE STREET CLOSURE

- A. A street can permanently be closed by a private entity after the City relinquishes the street right-of-way and access easement. The City Joint Referral Committee (JRC) reviews and approves all abandonment and sale of street, alley, or easement. Information about the JRC can be found here:
<https://www.publicworks.houstontx.gov/joint-referral-committee>.

- B. A local, residential street can be closed for traffic calming purposes. Requests for such closure are administered by the Neighborhood Traffic Calming Program (NTMP).
- C. Temporary complete street closure is strongly discouraged. If such closures are required and demonstrated to minimize construction impacts and improve public safety, closure permit can be obtained from the Mobility Permit Section. Temporary closure to serve a special event will require a permit from the Mayor's Office. Below are general requirements for temporary, construction-related street closures.
 - Planned full street closures require a mobility permit from the Traffic Management Branch.
 - Purpose and anticipated duration of the proposed full street closure must accompany the mobility permit application.
 - Traffic Control and Detour Plan must be sealed by a Texas licensed Professional Engineer.
 - Public notification. Change message signs (CMS) must be displayed a minimum of 7 days in advance of the proposed full street closure.

15.18 INTERSECTION TURNING TEMPLATES / DESIGN VEHICLES

- Pedestrian and bicycle connections should be maintained whenever possible; otherwise, most direct detours should be provided.
- Criteria for selecting design vehicles are provided in Chapter 10
- Dimensions and turning templates of design vehicles may be found in the AASHTO Green Book
- Dual left-turn and dual right-turn lanes should be designed for the SU-30 in the inside lane and the standard design vehicle in the outside lane
- Turning template diagrams will be submitted to the City upon request

15.19 INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

15.19.01 ITS Devices

All existing ITS infrastructure must be shown on design plans and kept operational during construction. All new and redesigned traffic signals shall have new ITS infrastructure included in the design. All ITS devices shall be designed with the following criteria:

- Ethernet Switch - A new Field Hardened Managed Ethernet Switches shall be installed at all traffic signals. If fiber cable is the communication method then the switch shall have City of Houston standard fiber cable ports.
- Bluetooth - A new Bluetooth card and antenna shall be installed at all traffic signals with existing Bluetooth infrastructure. All new Bluetooth equipment shall be compatible with existing Bluetooth travel time monitoring system.
- Gateway - A new Gateway shall be installed at all traffic signals. The Gateway shall be Meraki Z1 Teleworker or an approved equal and shall include a 5 year enterprise license.

- Dynamic Message Sign (DMS) - A new DMS shall be installed on all projects that require the removal or relocation of existing DMS.
- Closed Circuit TV (CCTV) - A new CCTV camera shall be installed at all traffic signals with existing cameras.
- Midblock Count Station - A new midblock count station shall be installed on all projects that require the removal or relocation of existing midblock count stations.

15.19.02 General Requirements

It is the responsibility of the design engineer to field verify all ITS devices and communications infrastructure within the project limits. Also, it is the responsibility of the design engineer to perform all necessary research, coordination and analysis for ITS device and communications deployment.

All ITS devices and communications infrastructure shall be:

- Compatible with existing infrastructure;
- Securely installed and mounted on din rail / shelf if applicable;
- Integrated into the relevant central system for control and monitoring;
- Kept operational during construction;
- Properly configured to current City of Houston Specifications and Standards.

Refer to the City of Houston's website for ITS device specifications and standard drawings. Contact Transportation & Drainage Operations / ITS section for compatibility questions with City of Houston ITS and/or communications infrastructure. Contact the Transportation & Drainage Operations / ITS section for questions and/or request at 713.881.3172.

15.19.03 Traffic Signal Communications

Fiber Optic Cable (FOC) shall be the standard form of traffic signal communications. All City of Houston projects shall include provisions for new FOC. Also, provisions for tying the new FOC into Houston TranStar via existing FOC (or Wireless Broadband (WB) if no FOC path exists to Houston TranStar) shall be included.

- Fiber Optic Cable (FOC)
 - All drop cable shall be terminated in an SFDU;
 - Pre-connectorized pigtails shall be used - all cables to be spliced;
 - For traffic signals being reconstructed:
 - Ensure new conduit is deployed between traffic signal cabinet and splice enclosure;
 - Deploy new drop cable at all locations;
 - Deploy new communications service box next to cabinet;
 - Deploy new splice enclosure at all locations.
 - All FOC deployed shall be tied into existing FOC for backhaul to Houston TranStar (if the existing FOC is within close proximity**);

- All design plans need to have splice details.
- WB Subscribers - In special cases where there is no FOC backhaul to Houston TranStar, within close proximity**, WB subscribers shall be deployed as the communications backhaul method. The subscriber shall be installed on a 10 foot extension pole mounted on top of traffic signal pole.
- Cellular - USB air cards are in use at many traffic signals. These shall be maintained during construction. Also, the air card shall be reinstalled with newly deployed ITS infrastructure.

**Close proximity is considered less than ½ mile. If existing FOC is further, contact the Transportation & Drainage Operations / ITS section for guidance and clarification at 713.881.3172. A FOC master plan is maintained by the ITS section. This will be referenced to determine if FOC shall be routed to the existing FOC even if further than ½ mile.

15.19.04 ITS Notes to be added to all plans:

- A. Any interruption of ITS operations requires City of Houston Transportation & Drainage Operations / ITS section approval at a minimum of one (1) week in advance at 713.881.3172 or 713-881-3000 (Houston TranStar).
- B. All existing ITS infrastructure and traffic signal communications shall be kept operational during construction.
- C. Any questions or concerns related to deployment of any ITS device call City of Houston Transportation & Drainage Operations / ITS section at 713.881.3172 or 713-881-3000 (Houston TranStar).
- D. All ITS devices removed shall be given to Transportation & Drainage Operations / ITS section staff immediately upon removal.

END OF CHAPTER

APPENDIX 1

CHAPTER 15

Appendix 1 presents a typical City of Houston signalized intersection design illustrating the requirements for proposed new traffic signal installation or reconstruction of existing ones. Existing field conditions vary from one location to another; therefore, the design engineer with consultation with the City of Houston's project manager shall determine the appropriate type, size, and location of any applicable traffic component.

Typical positions and arrangements of traffic signal heads and signs related to various configurations are also shown in Appendix 1.

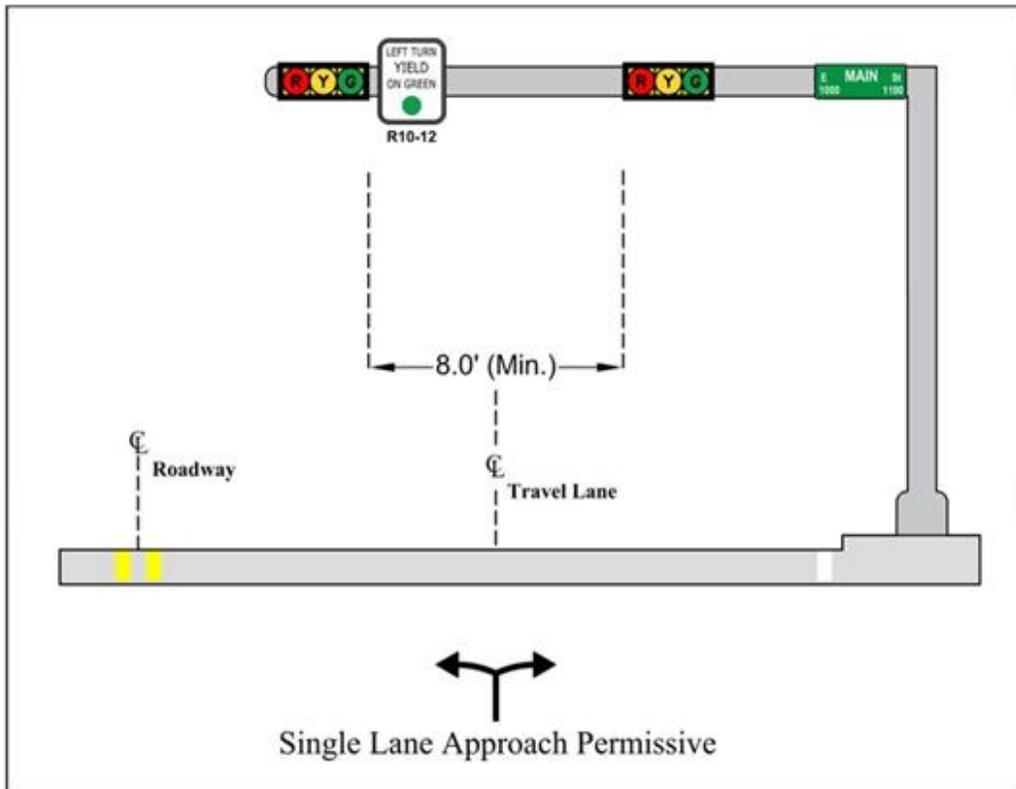


Figure 1

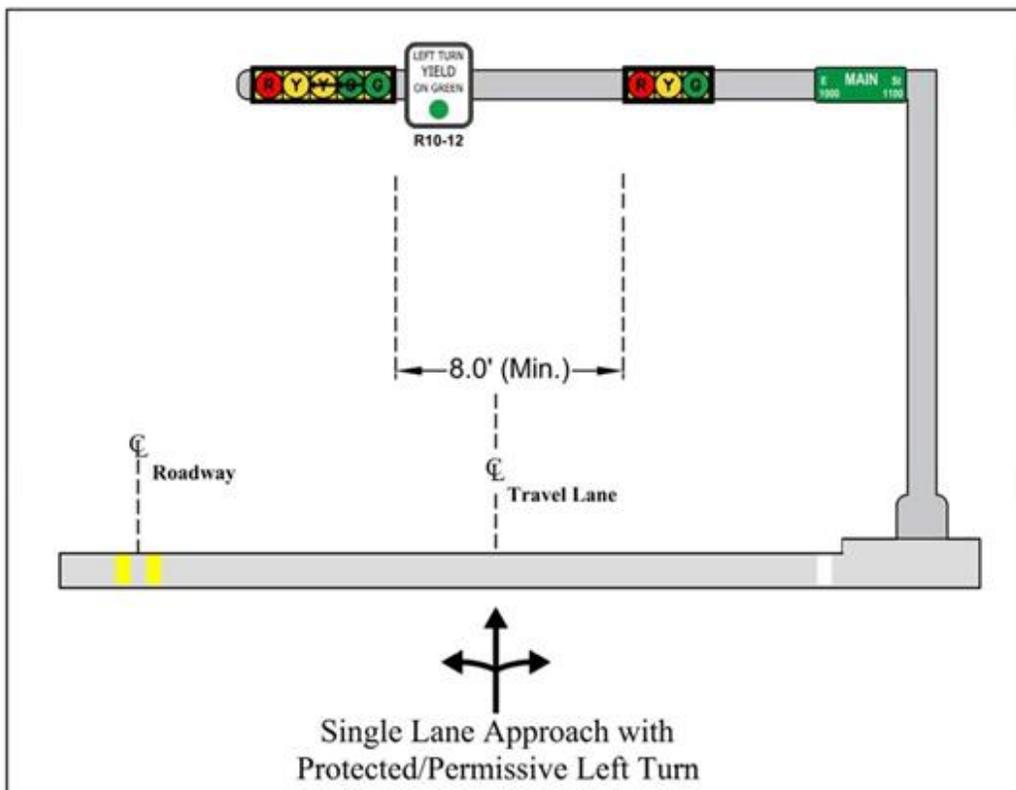


Figure 2

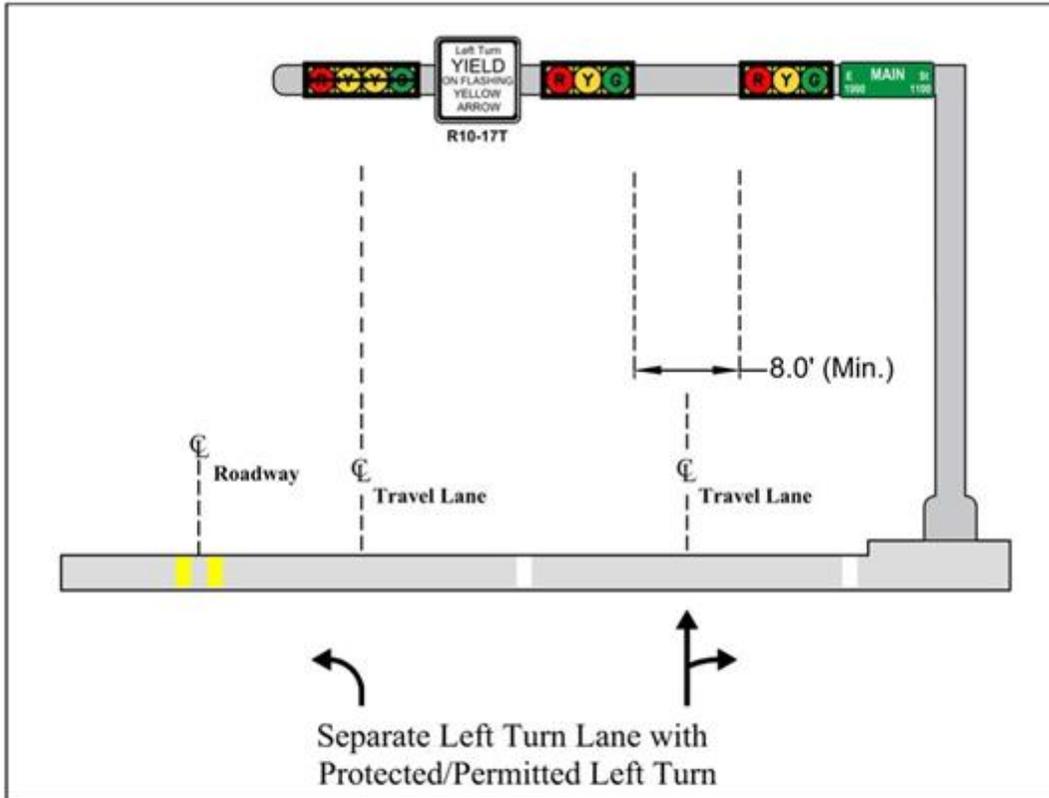


Figure 3

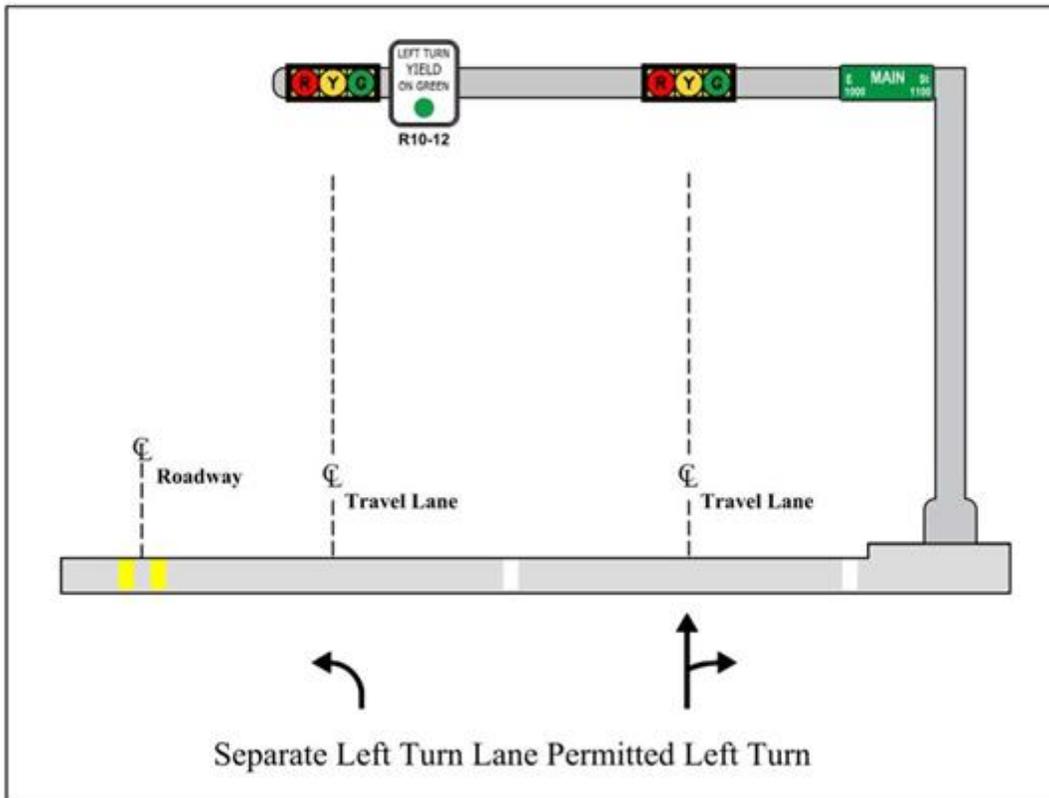


Figure 4

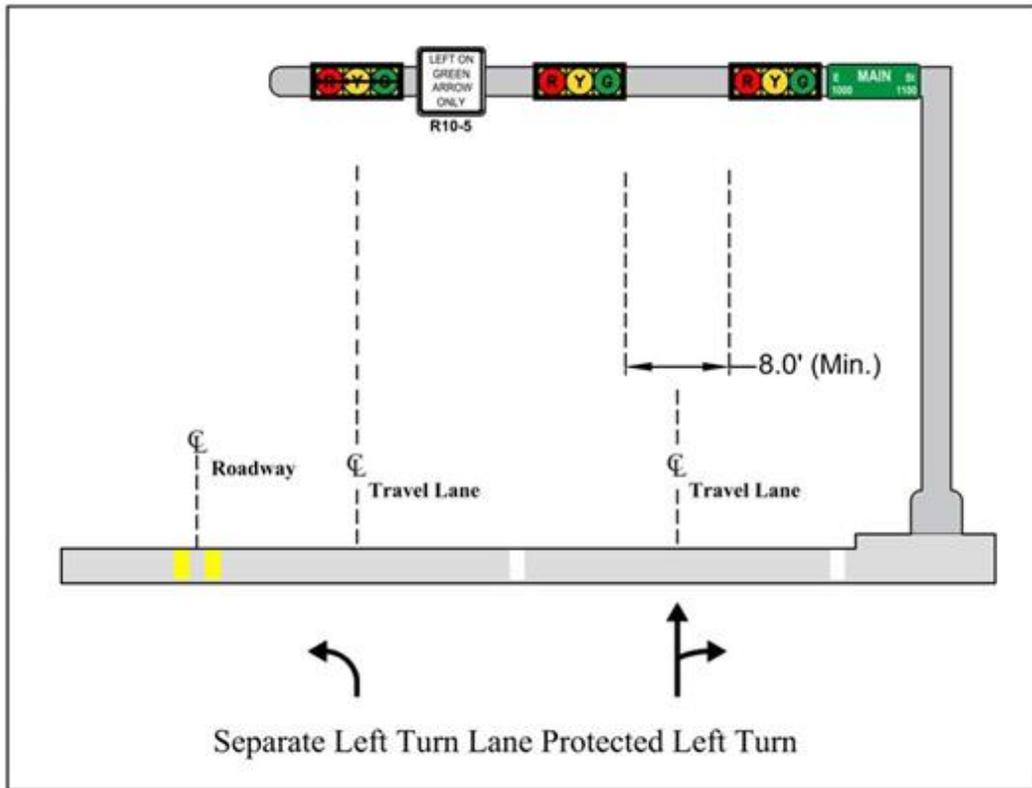


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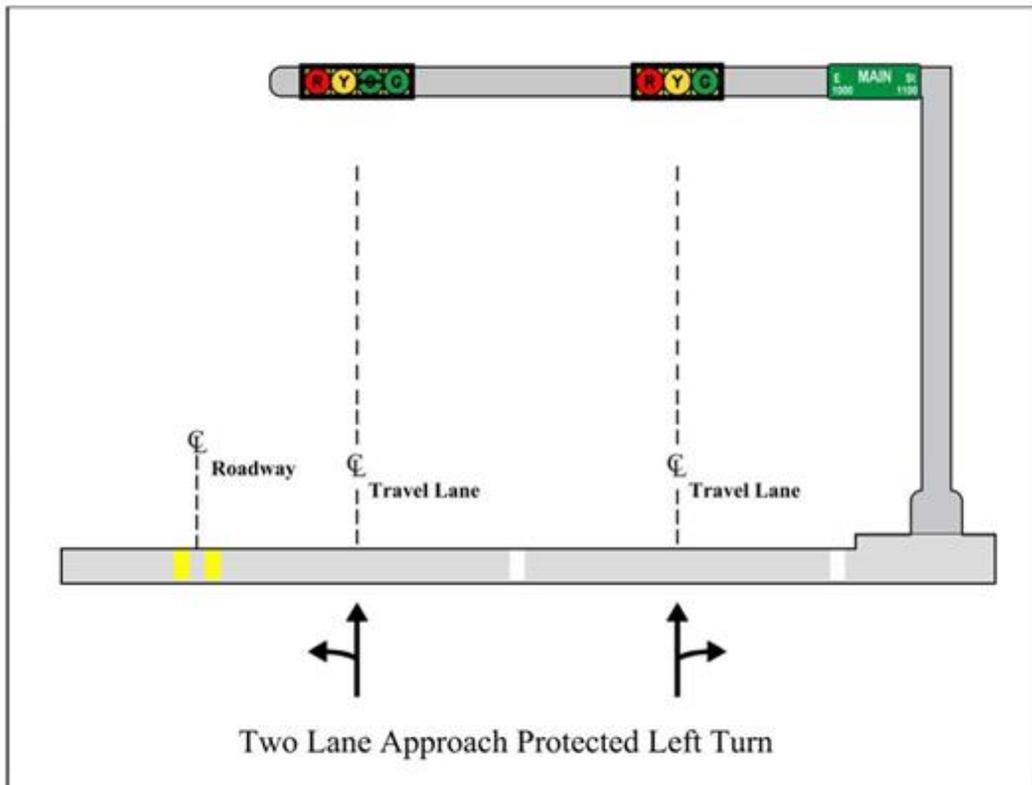


Figure 6

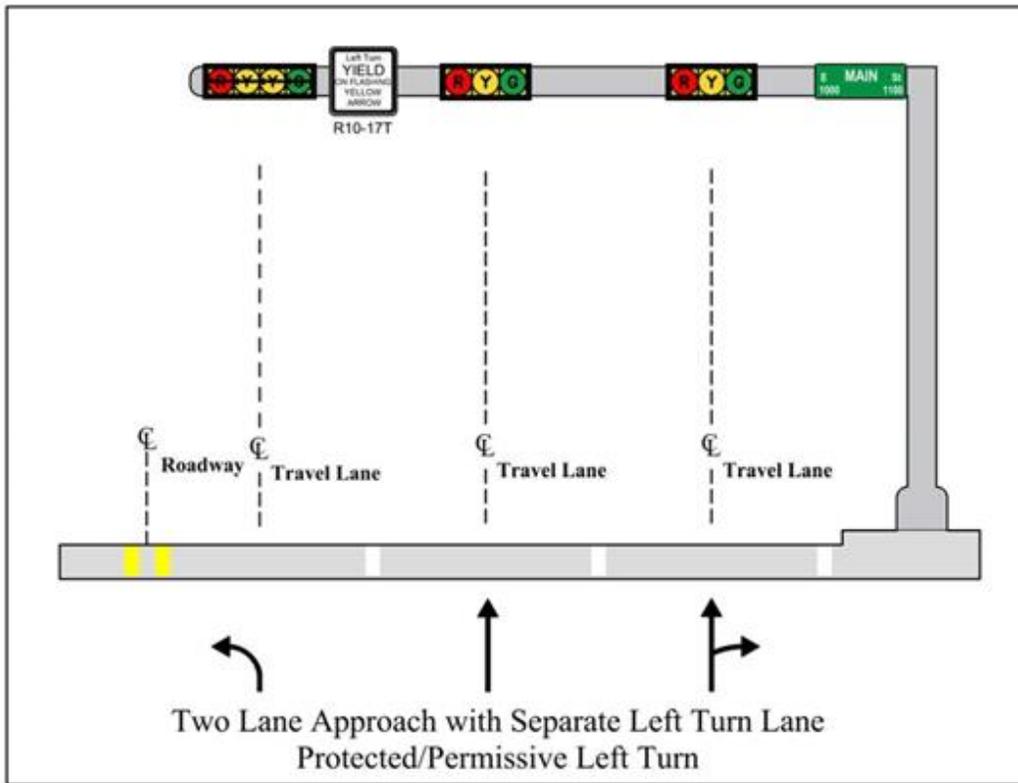


Figure 7

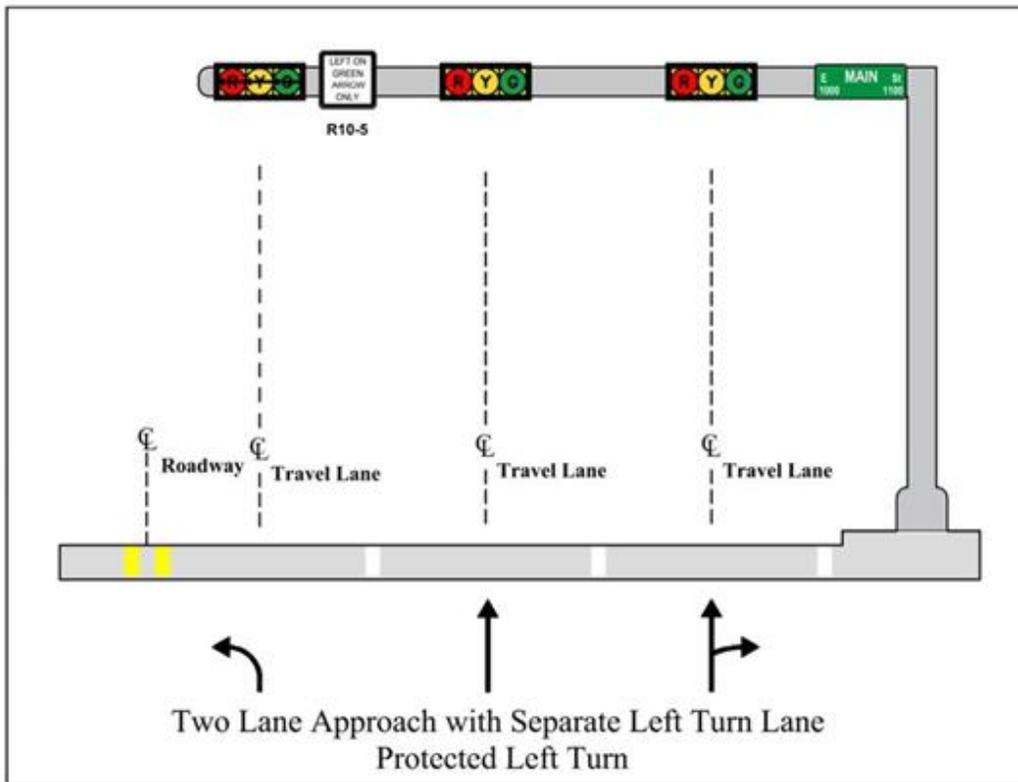


Figure 8

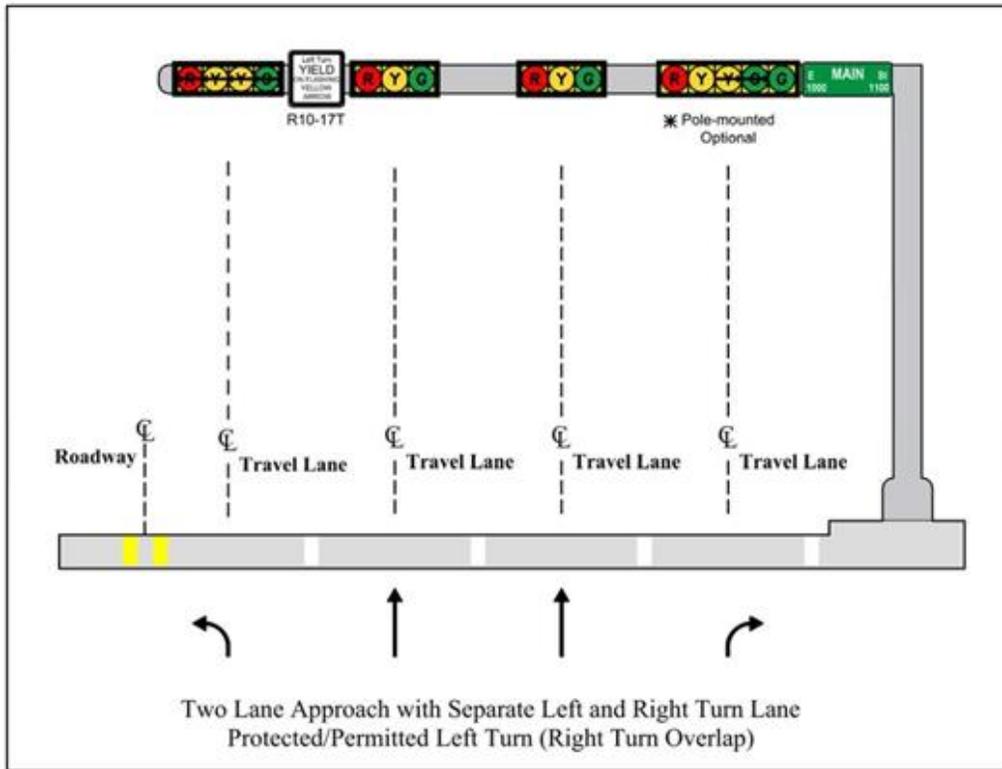


Figure 9

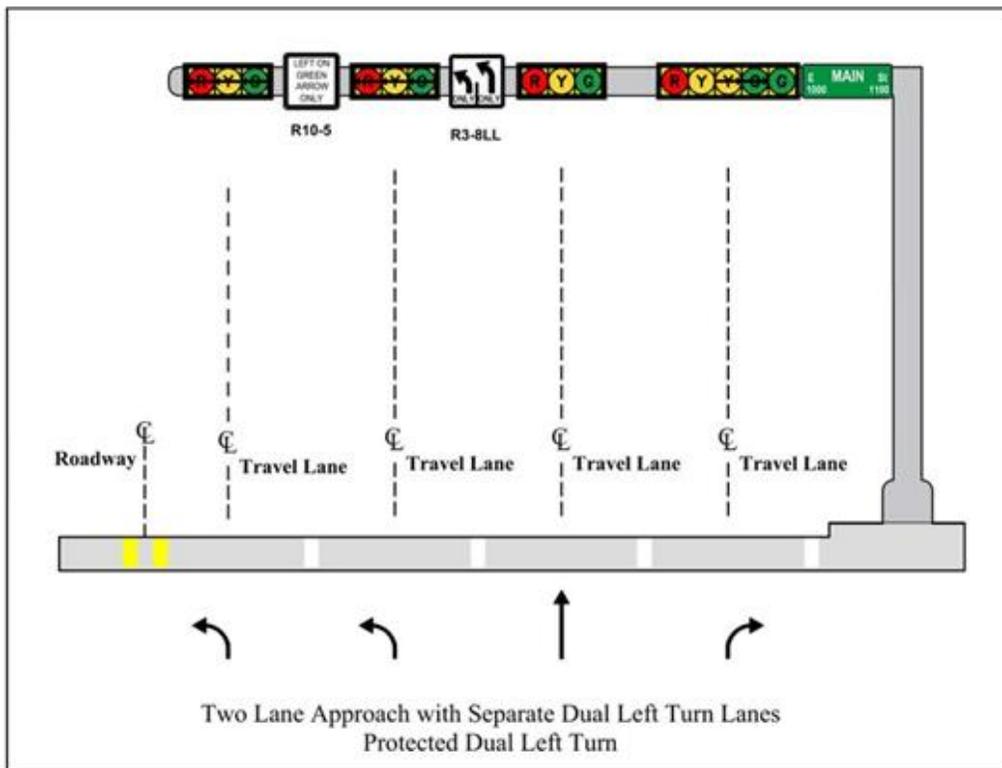


Figure 10

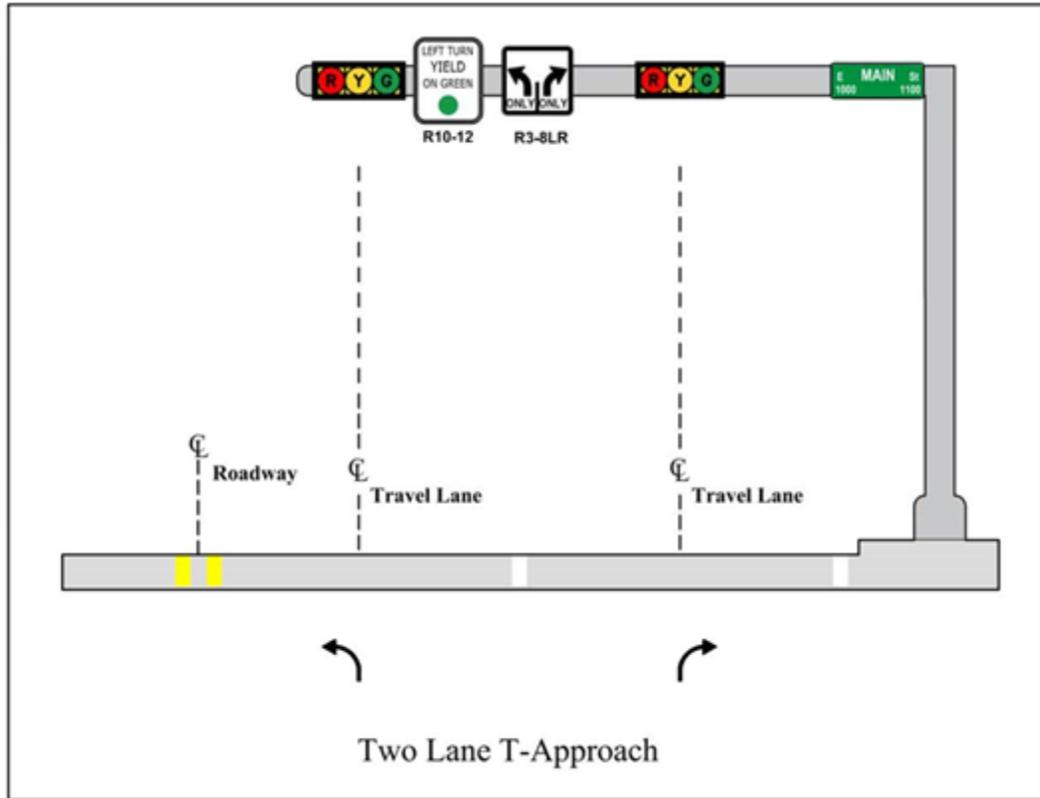
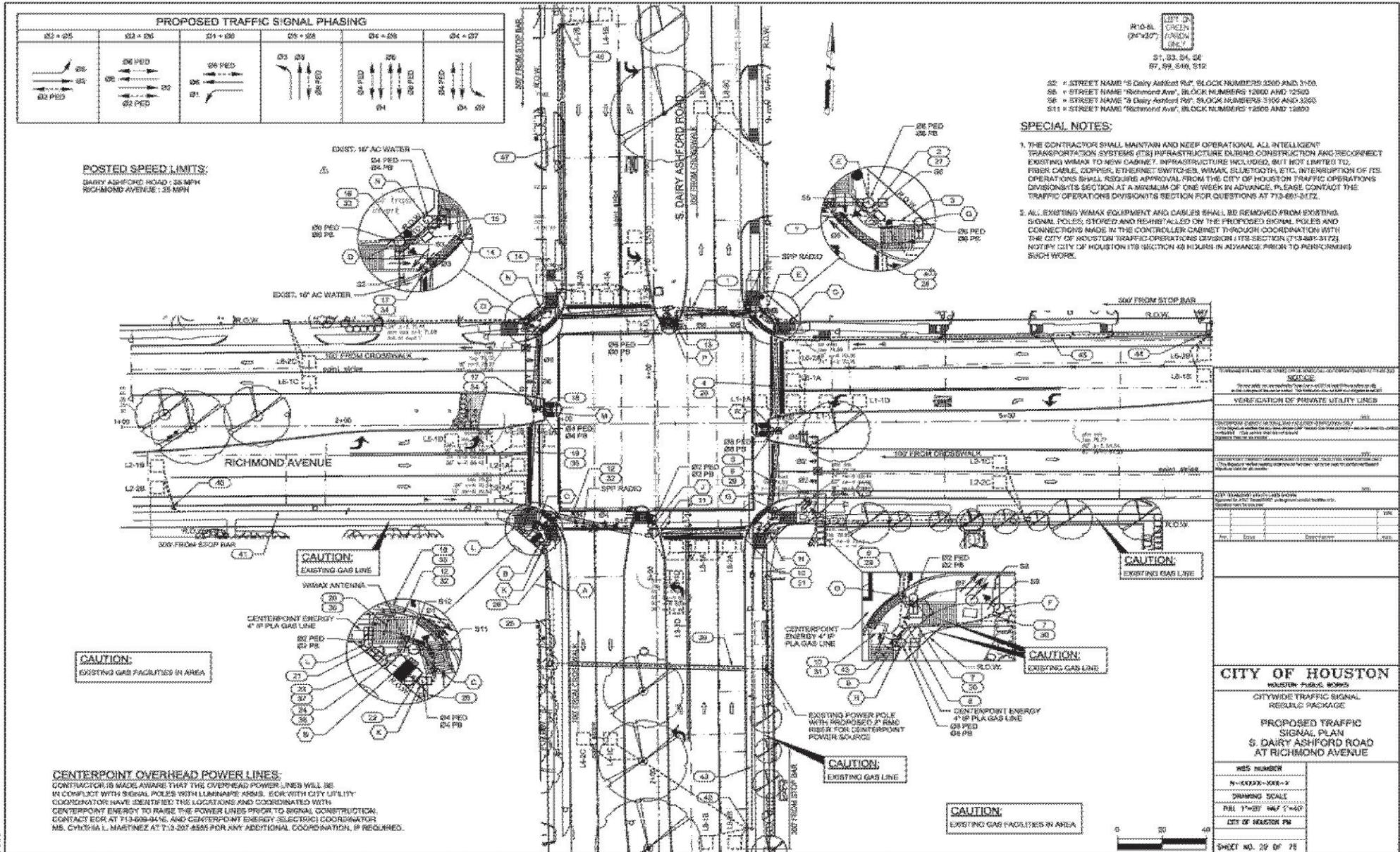
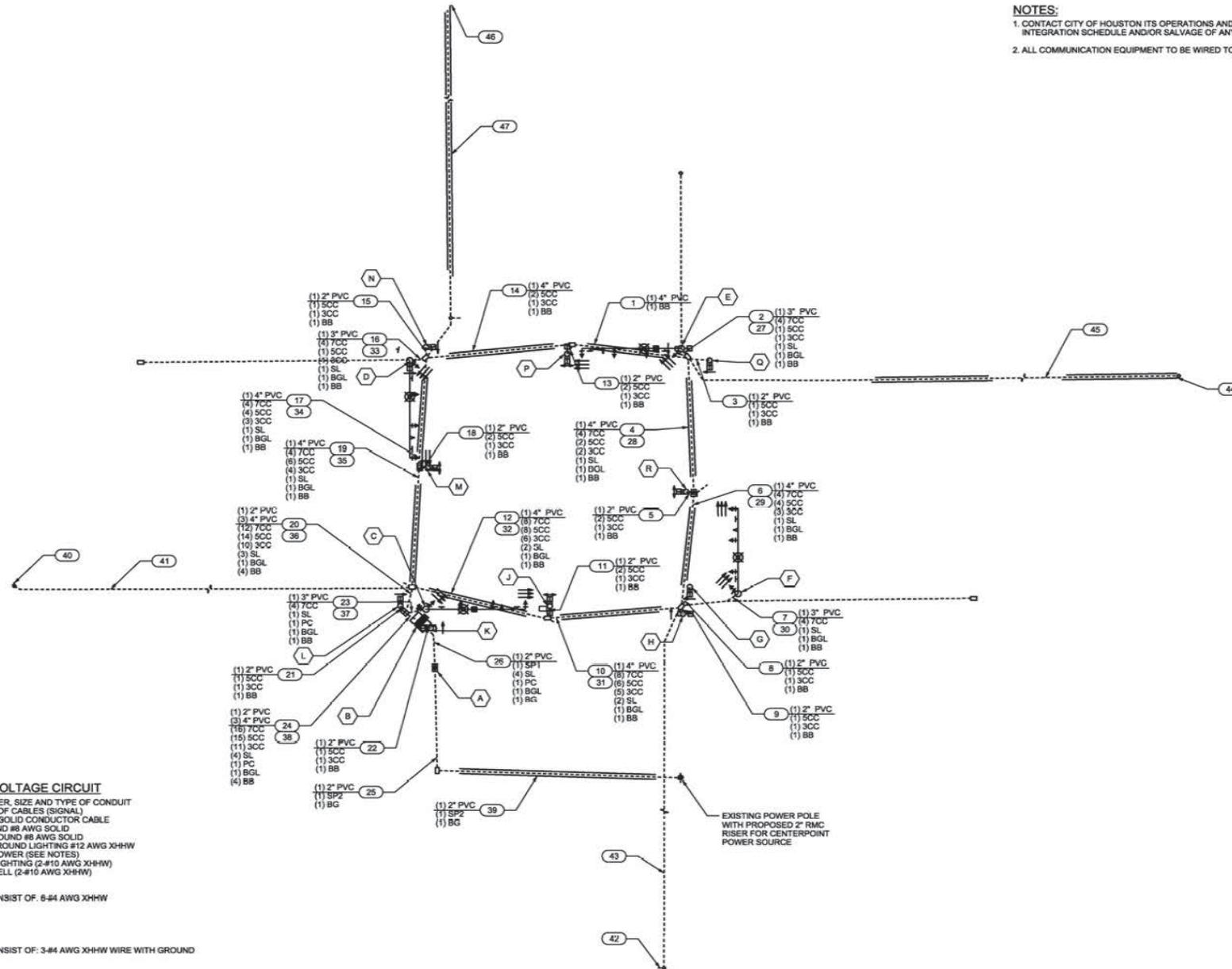


Figure 11

Traffic Signal Design Exhibits





- NOTES:**
 1. CONTACT CITY OF HOUSTON ITS OPERATIONS AND SAFETY SECTION (713-881-3052) FOR INTEGRATION SCHEDULE AND/OR SALVAGE OF ANY COMMUNICATION EQUIPMENT.
 2. ALL COMMUNICATION EQUIPMENT TO BE WIRED TO NEW CABINET.

HIGH VOLTAGE CIRCUIT

(X)Y" = NUMBER, SIZE AND TYPE OF CONDUIT
 (X) = NUMBER OF CABLES (SIGNAL)
 CC = #14 AWG SOLID CONDUCTOR CABLE
 BB = BARE BOND #8 AWG SOLID
 BG = BARE GROUND #8 AWG SOLID
 BGL = BARE GROUND LIGHTING #12 AWG XHHW
 SP = SIGNAL POWER (SEE NOTES)
 SL = STREET LIGHTING (2-#10 AWG XHHW)
 PC = PHOTO CELL (2-#10 AWG XHHW)

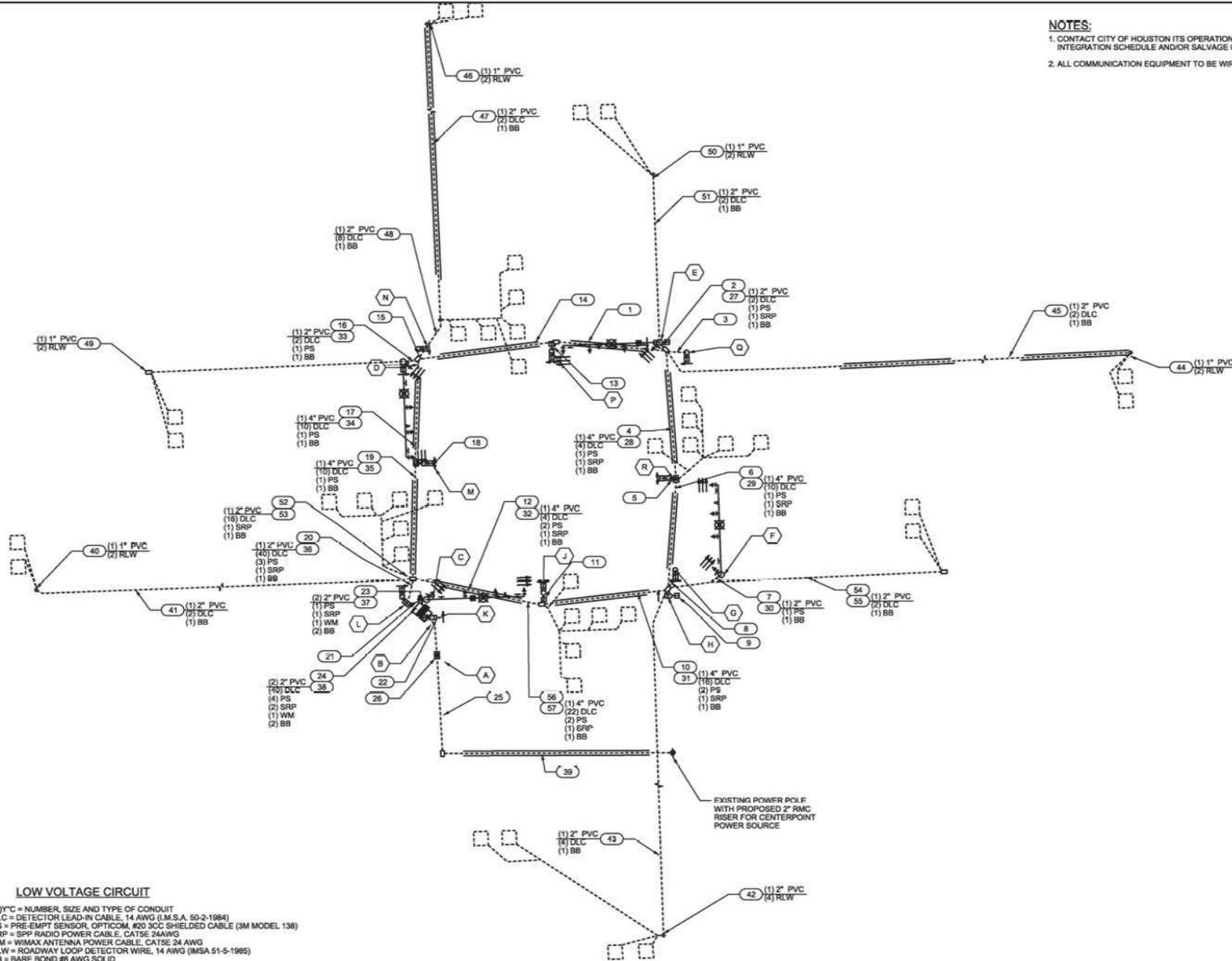
NOTES:
 SP1 SHALL CONSIST OF: 6-#4 AWG XHHW
 2 - WHITE
 1 - BLACK
 1 - RED
 2 - GREEN

SP2 SHALL CONSIST OF: 3-#4 AWG XHHW WIRE WITH GROUND

No.	Date	Description	App.
CITY OF HOUSTON			
HOUSTON PUBLIC WORKS			
CITYWIDE TRAFFIC SIGNAL REBUILD PACKAGE			
CABLE SCHEMATIC S. DAIRY ASHFORD ROAD AT RICHMOND AVENUE			
SHEET 1 OF 2			
WGS NUMBER			
N-XXXXX-XXX-X			
DRAWING SCALE			
NOT TO SCALE			
CITY OF HOUSTON PW			
SHEET NO. 31 OF 78			

NOTES:

1. CONTACT CITY OF HOUSTON ITS OPERATIONS AND SAFETY SECTION (713-881-3052) FOR INTEGRATION SCHEDULE AND/OR SALVAGE OF ANY COMMUNICATION EQUIPMENT.
2. ALL COMMUNICATION EQUIPMENT TO BE WIRED TO NEW CABINET.



LOW VOLTAGE CIRCUIT

(X)YC = NUMBER, SIZE AND TYPE OF CONDUIT
 DLC = DETECTOR LEAD-IN CABLE, 14 AWG (I.M.S.A. 50-2-1984)
 PS = PRE-EMPT SENSOR, OPTICOM, #20 3CC SHIELDED CABLE (3M MODEL 138)
 SRP = SRP RADIO POWER CABLE, CAT5E 24AWG
 WM = WIMAX ANTENNA POWER CABLE, CAT5E 24 AWG
 RLW = ROADWAY LOOP DETECTOR WIRE, 14 AWG (MSA 51-5-1995)
 BB = BARE BOND #8 AWG SOLID

No.	Date	Description	App.
CITY OF HOUSTON			
HOUSTON PUBLIC WORKS			
CITYWIDE TRAFFIC SIGNAL REBUILD PACKAGE			
CABLE SCHEMATIC S. DAIRY ASHFORD ROAD AT RICHMOND AVENUE			
SHEET 2 OF 2			
WBS NUMBER			
N-XXXX-XXX-X			
DRAWING SCALE			
NOT TO SCALE			
CITY OF HOUSTON PW			
SHEET NO. 32 OF 78			