

CITY OF HOUSTON HOUSTON PUBLIC WORKS

INFRASTRUCTURE DESIGN MANUAL

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JULY 2019

HOUSTON
PUBLIC WORKS



CITY OF HOUSTON
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July 1, 2019

The 2019 edition of the City of Houston Infrastructure Design Manual will be effective July 1, 2019. The manual has been updated and revised to reflect changes to the City of Houston's (City) graphic requirements, storm water design requirements, and the storm water quality design requirements.

Please keep in mind that the purpose of this manual is to establish the basic criteria from which engineers can design infrastructure in a manner acceptable to the Department and is not intended to address all design conditions or specialized situations.

For Houston Public Works capital improvement projects managed by the Capital Projects service line, Phase II final designs that have not been submitted for a required review prior to July 1, 2019, will be required to comply with all standards in the 2019 Infrastructure Design Manual. The only exception will be the new graphic requirements outlined in Chapter 3. See the attached Executive Summary for additional information.

Projects in the public/private sector that submit plans for initial review after July 1, 2019 will be required to comply with all standards in the 2019 Infrastructure Design Manual.

For more detailed information concerning the updates to the Infrastructure Design Manual, standard drawings and the City's Construction Specifications see the attached Executive Summary.

Respectfully,

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Director, Houston Public Works

Joseph T. Myers, P.E., CFM
City Engineer

Attachment: Executive Summary

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City of Houston
Houston Public Works

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***Bold chapters have been revised 07-01-2019.**

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City of Houston

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Chapter 1

GENERAL REQUIREMENTS

Chapter 1

GENERAL REQUIREMENTS

1.01 CHAPTER INCLUDES

- A. Research and submittal requirements for projects inside the city limits of Houston or within Houston's extraterritorial jurisdiction (ETJ).

1.02 REFERENCES

The following references should be reviewed in conjunction with this manual:

- A. Latest revision of the following City of Houston Code of Ordinances:
 - 1. Article IV Chapter 33, City Surveys
 - 2. Article V Chapter 40, Street and Sidewalk
 - 3. Chapter 42, Subdivisions, Developments and Platting
 - 4. Article V, Chapter 47, Water and Sewers
- B. Texas Accessibility Standards (TAS) of the Architectural Barriers Act, Article 9102, Texas Civil Statutes.
- C. City of Houston Standard Specifications and Standard Details, latest revision.
- D. Rules and Regulations published by Texas Commission on Environmental Quality (TCEQ).
 - 1. TCEQ, Water Supply Division, Rules and Regulations for Public Water Systems, latest revision.
 - 2. TCEQ, Design Criteria for Sewer Systems, Texas Administrative Code, latest revision.
- E. State of Texas Engineering Practice Act.
- F. State of Texas Professional Land Surveying Practices Act.
- G. Storm Water Management Handbook for Construction Activities, Latest Edition as Prepared by Harris County, Harris County Flood Control District (HCFCD), and City of Houston.
- H. Harris County Public Infrastructure Department's Rules and Regulations.

1.03 DEFINITIONS

- A. City Engineer - The authorized representative of the City, or his designee, having approval authority for privately-funded projects, or having authority for administration of design and construction contracts for the City.
- B. Review Authorities - The authorized representatives of City departments, divisions, branches or sections responsible for reviewing and approving calculations and drawings for privately-funded projects and for design and construction contracts with the City.
- C. Drawings - Plan, profile, detail, and other graphic sheets to be used in a construction contract which define character and scope of the project.
- D. Design Analysis - Narratives and calculations necessary to support design of a project.
- E. Professional Engineer - An engineer currently licensed and in good standing with the Texas Board of Professional Engineers.
- F. Professional Land Surveyor - A surveyor currently registered and in good standing with State of Texas Board of Professional Land Surveying.
- G. Specifications - City of Houston Standard Specifications plus project-specific narrative descriptions of procedures, requirements, and materials for a particular project.

1.04 PLAT AND CONSTRUCTION DRAWING REVIEW PROCESS

- A. Review of plat and construction drawings by the Department of Houston Public Works is a required part of the overall platting process under purview of the City Planning Commission and the Planning and Development Department of the City of Houston.
- B. The process to be followed in submitting documents for review and approval of water, wastewater, storm drainage, and street paving is described by the flowchart depicted in Figure 4.1, Review and Approval Process for Plats and Drawings.
- C. Utility and paving construction in projects requiring subdivision plats is not permitted until the final plat has been released. Plat release by Department of Houston Public Works is authorized by signature of the Director, or his designee, on final design drawings.
- D. Construction of utilities and paving in projects not requiring a subdivision plat is not permitted until final design drawings are approved and signed by the Director, Department of Houston Public Works, or his designee.
- E. Signature of the Director, Department of Houston Public Works, or his designee, on final design drawings for utilities which are intended to remain private, does not infer acceptance of the City for ownership or maintenance or operation of facilities indicated on the drawings.

1.05 SUBMITTALS

A. Submittal Procedures

For Privately-funded Projects:

1. To obtain review of final design drawings for both publicly-funded and privately-funded projects, first submit drawings to the Houston Public Works Plan Review Center for assignment of a log number before review will commence. The log number will remain in effect for one year.
2. Once a log number is assigned, reference the number in all correspondence relating to that project.
3. Obtain and complete plan review application forms for each review phase when the project is logged in. The same log number will be used for all review phases of each project unless review of a subsequent phase is delayed by over one year.
4. Plan Review Center personnel will process reviews through appropriate review teams in the Department of Houston Public Works.
5. If a project has begun the review process but becomes inactive for a period of 12 months from the date of the last correspondence, the project will be considered stopped, and the log number inactivated.
6. The City has a weekly one-day walk-through procedure for the signature stage of small projects. Instruction sheets for this procedure may be obtained in the Plan Review Center.
7. Projects involving construction of privately owned facilities require review and approval of any connection to a public water line, sanitary sewer, or storm sewer or to a public street, using the process defined in this manual.

For Design Contracts with the City: Submit documents in accordance with requirements of the professional engineering services contract.

B. Preliminary Design

1. Privately-funded Projects: Submit one set of the preliminary overall design concept with supporting evidence as described in Paragraph 1.07 and Paragraph 1.08.
2. Design Contracts with the City: Submit documents in accordance with requirements of the professional engineering services contract.

- C. Final Design.
 - 1. Privately-funded Projects:
 - a. Submit sets of the final design drawings with prints containing preliminary review comments.
 - b. For complex projects, it is recommended that a copy of the City review comments on the preliminary drawings be returned with the revised final design drawings.
 - 2. Design Contracts with the City:
 - a. Submit documents in accordance with requirements of the professional engineering services contract.
 - b. Submit a copy of the City review comments on the preliminary drawings.
- D. Signature Stage.
 - 1. Submit original tracings with prints containing previous review comments.
 - 2. Specification submittals:
 - a. Submit final design specifications for review on all City funded projects.
 - b. Provide notes on plans for all privately funded projects stating that all facilities shall be constructed in accordance with City of Houston Standards.
 - 3. On City projects, submit final computer-generated drawing files in acceptable electronic media including vicinity maps, right-of-way drawings, construction drawings, or other information pertinent to the project. Submit surveyor's field book and electronic data in accordance with Chapter 2, Survey Requirements.
 - 4. On privately funded projects, submit final computer generated drawing files in acceptable electronic media including plat, right-of-way maps, and construction drawings. Scanned images may be acceptable if project is less than 3 sheets.

1.06 QUALITY ASSURANCE

- A. Have surveying and platting accomplished under direction of a Professional Land Surveyor.
- B. Have recording documents sealed, signed, and dated by a Professional Land Surveyor.

- C. Have calculations prepared by or under the direct supervision of a Professional Engineer trained and licensed in disciplines required by the project scope.
- D. Have final design drawings sealed, signed, and dated by the Professional Engineer responsible for development of the drawings.

1.07 RESEARCH REQUIREMENTS

- A. Research existing utility and right-of-way information with the City departments listed below. Present and discuss the concept of the project with these same departments.
 - 1. Houston Airport System
 - 2. Department of Houston Public Works
 - a. Engineering and Construction Division
 - b. Planning and Development Services Division File Room
 - c. Right-of-Way and Fleet Maintenance Division and Traffic & Transportation Division
 - d. Planning and Development Services Division, Utility Planning and Analysis Branch
 - e. Public Utility Division
 - 3. Planning and Development Department
 - 4. Parks and Recreation Department
 - 5. Finance Department, Franchise Administration
- B. Research existing utilities and rights-of-way or easements for conflicts with the following public and private organizations:
 - 1. Texas Department of Transportation
 - 2. Harris County Public Infrastructure Department
 - 3. Harris County Toll Road Authority
 - 4. Metropolitan Transit Authority of Harris County
 - 5. Harris County Flood Control District

6. Other City and County Governments
7. Franchise Holders:
 - a. CenterPoint Energy - Gas
 - b. AT & T Company
 - c. CenterPoint Energy - Electric
8. Cable television and data communications companies
9. Other utility companies:
 - a. Utility districts
 - b. Private utilities/franchises
 - c. Railroad companies
 - d. Pipeline companies

- C. Verify that no restrictions or conflicts exist that will prevent approval and permitting of the project.

1.08 DESIGN REQUIREMENTS

A. Preliminary Design.

1. Privately-funded Projects:
 - a. Prior to preliminary design submittal, City reviewers are available to discuss alternate solutions for project elements where alternate designs may be considered.
 - b. Provide the Office of City Engineer with drawings in sufficient detail to describe the proposed improvements. Include proposed materials, if different from materials approved by the City. Identify any problems or conflicts associated with the project. Information furnished must be in sufficient detail for the City Engineer to assess whether the design meets current City design standards.
 - c. Provide rights-of-way and easement requirements for the project.

2. Design Contracts with the City:
 - a. Participate in preliminary conferences with the City Project Manager outlining the scope of work and extent of the preliminary report.
 - b. Prepare preliminary engineering studies and designs based upon the scope of work and as outlined in the professional engineering services contract with the City.
 - c. Prepare the contractually specified number of copies of preliminary layouts, sketches, reports, and calculations supporting the preliminary layouts. Prepare alternate solutions, where applicable to the project, and include the engineer's specific recommendations.
 - d. Prepare preliminary cost estimates for primary and alternate solutions of the proposed construction.
 - e. Participate in conferences with the City to determine final design.
 - f. When required by the professional services contract, provide detailed soils and geotechnical investigations and environmental investigations to support proposed construction of utilities and paving.
 - g. Provide required real estate, rights-of-way, and easement requirements for the project.
- B. Final Design
 1. Privately-funded Projects:
 - a. Revise design to reflect comments of the City Engineer and review authorities. Include design calculations to support proposed improvements.
 - b. Provide review prints to the City Engineer and review authorities for verification and compliance with prior review comments.
 - c. Obtain required signatures from governmental agencies (other than the City of Houston) and private utility companies prior to requesting signature by the City.
 - d. Include the following note on construction drawings - "Contractor shall notify the City of Houston, Department of Houston Public Works (832-394-9098) 48 hours before starting work on this project."

2. Design Contracts with the City:
 - a. Furnish the City, where applicable, engineering data necessary for applications for routine permits required by local, state, and federal authorities.
 - b. Prepare detailed final design drawings and specifications in compliance with comments received from the City subsequent to the review of the preliminary design.
 - c. Prepare detailed cost estimates and proposal forms for the authorized project.
 - d. Provide estimated construction duration. Include all back up calculations and assumptions. Provide assumed number of holidays, weekends, severe weather and other non-working days as applicable.

- C. Original Drawings
 1. Approved drawings for projects within the city limits and within the ETJ will be assigned a City drawing number and will be filed in the City File Room prior to release back to the engineer of record. File Room record files for facilities within public rights-of-way will be available to the public. Record files associated with plants, buildings and other facilities outside public rights-of-way will be restricted pending security constraints.

END OF CHAPTER

City of Houston

Design Manual

Chapter 2

SURVEY REQUIREMENTS

Chapter 2

SURVEY REQUIREMENTS

2.01 CHAPTER INCLUDES

- A. Suggested guidelines for use by surveyors and engineers in development of construction drawings and right-of-way maps inside the Houston city limits and outside the Houston city limits within the ETJ. These guidelines are required for Capital Improvement Projects designed under professional services contracts with the City of Houston.

2.02 REFERENCES

- A. Article IV, Chapter 33, City Surveys, of the City of Houston Code of Ordinances.
- B. Professional Land Surveying Practices Act, Texas Occupations Code Sec. 1071, latest revision.
- C. Texas Board of Professional Land Surveying (TBPLS) Professional and Technical Standards (Texas Administrative Code, Title 22, Part 29, Chapter 663, Subchapter B, Professional And Technical Standards),
- D. Texas Society of Professional Surveyors (TSPS) Manual of Practice for Land Surveying in Texas, latest edition
- E. City of Houston Department of Houston Public Works website

2.03 DEFINITIONS

- A. Survey Field Books - Bound standard engineer's field books for transit and level, 7-1/4 inch by 4-3/4 inch.
- B. Data Collection File - An electronic file reflecting station occupied, backsight, point number, angle, distance, elevations, and identification code; or station and offset left and right from a traverse line or design baseline.
- C. Chief Surveyor - An authorized representative of the City having approval authority for privately-funded projects or having authority for administration of contracts for the City.
- D. GNSS - Global Navigation Satellite System - a satellite based positioning system. When it is used with proper observation procedures and equipment, it can provide survey quality locations in terrestrial space.

- E. Site Control Monuments - horizontal and vertical Monuments needed to augment existing City monuments, conforming to standards established by the Chief Surveyor.
- F. Street Reference Monuments - historic monuments used to re-establish existing City street rights of way
- G. Right of Way - In this chapter, right-of-way refers to any real estate that the City currently has an interest in or will be acquiring an interest in.

2.04 DESIGN REQUIREMENTS

- A. Adhere to these guidelines for Capital Improvement Projects designed under professional services contracts with the City of Houston.

2.05 SUBMITTALS

- A. For work performed through a professional service contract with the City, deliver:
 - 1. Original Field Books, signed & sealed by a Registered Professional Land Surveyor (RPLS). Photocopies or carbon copies of field books are not acceptable.
 - 2. An electronic text file in standard ASCII format (Point Number, Northing, Easting, Elevation, Description) containing all points collected, calculated and set for the project.
 - 3. Computer Aided Drafting files in AutoDesk DWG or DXF format
 - 4. Data Collection Files
- B. For projects identifying or describing acquisition of new or additional rights-of-way, additional documents to be submitted are:
 - 1. Drawings:
 - a. Overall index map identifying all right-of-way parcels for the project.
 - b. Individual survey drawings of each parcel,
 - c. All maps and drawings shall be mylar, signed and sealed by an RPLS.
 - 2. Metes & Bounds descriptions (signed and sealed) and Closure report printouts for each parcel.
 - 3. Abstract information, all recorded plats and copies of instruments used (i.e., deeds) in preparation of the right-of-way drawings.

4. Electronic Shape files generated for parcels to be placed in a GIS environment.

- C. For projects requiring new Site Control Monuments, the surveyor responsible for setting the monuments shall submit sealed City of Houston monument sheets, with necessary supporting data, to the City Survey Office.
- D. All submittals will be retained in the City's permanent files.

2.06 QUALITY ASSURANCE

- A. Field surveying used in the development of construction drawings, calculations and preparation of metes & bounds descriptions and right-of-way maps, shall be performed by or under the direct supervision of an RPLS.
- B. Field books, metes & bounds descriptions and right-of-way maps shall have the imprinted or embossed seal of the responsible RPLS and shall be dated and signed by the RPLS.
- C. When establishing Horizontal Control, surveyors shall transcribe onto the pages of a standard Survey Field Book, as described in Paragraph 2.03.A, all angles and distances, at the time of measurement, with an accompanying recovery sketch. When establishing Vertical Control, the surveyor shall use differential leveling, and transcribe the vertical data onto the pages of a standard Survey Field Book, with an accompanying recovery sketch. When establishing control using GNSS/GPS methods, record the date, time, and length of each observation. Temporary Benchmarks (TBM) should be set where they are not likely to be destroyed during construction.
- D. For projects in which the Horizontal Control exceeds a distance of 2,000 feet from a found City of Houston monument, a Site Control Monument shall be set. Additional Site Control Monuments shall be set should the Horizontal Control exceed a radial distance of 2,000 feet from an existing City of Houston monument or newly set Site Control Monument. Obtain City monument designation numbers from the City Survey Office. If an existing Site Control Monument is used to reference the project, said Site Control monument must be re-observed and re-submitted with the resultant horizontal and vertical coordinates. All recovery ties must be re-observed and present on the new recovery sheets.

2.07 FIELD WORK

- A. For engineering contracts with the City, field work shall be recorded in field books or electronic field books. Obtain a field book number from the Survey Section and record this identification in the title block on drawing sheets.
- B. The traverse line and design baseline must be monumented at its beginning, end, street intersections and at angle points with markers of a permanent nature, such as iron rods, spikes, or other lasting identification. Make reference drawings for each control monument showing ties to planimetric features to allow easy recovery. Set markers at a maximum of

1000 feet on long lines. (Wherever practical, all Horizontal and Vertical Control monuments must be marked in such a way as to identify the surveyor in responsible charge.)

- C. Locate any found monuments and/or property corners and reference them to the design baseline according to the existing City of Houston survey system, as required by Article IV, Chapter 33, City Surveys, of the Code of Ordinances.
- D. Use the City datum (Code of Ordinances section 33, article 4) as a basis for all elevations. Set temporary bench marks (TBMs) within 200 feet of the beginning and end of each project baseline and at intervals not to exceed 1000 feet throughout the project.
- E. Show the stations of all side street construction centerlines with angular relationships or bearings of said centerlines of side streets with the main roadway centerline station.
- F. Record topographic features within the public right-of-way, proposed right-of-way, any contiguous easements to the right-of-way, and any construction right-of-way of the project and on intersecting streets for a distance of 20 feet beyond the intersection of the right-of-way lines. Identify all visible underground structures, such as inlets, manholes, and junction boxes, with size, depth, and type.
- G. Cross sections shall be taken at intervals of 100 feet for projects outside of the CBD. For projects within the CBD, take cross sections at 25 or 50 foot intervals. For levels recorded in field books, record rod readings or elevations as + or - and distance right or left of the design baseline or roadway centerline. Data collector of a total station can be used to acquire necessary elevations at required intervals. Record elevation of driveways at intersection of driveway centerline with existing or proposed right-of-way line. Cross sections shall include a reading at the following points: street centerline, flow-line of ditch or gutter, curb or pavement edge, sidewalk, the existing or proposed right-of-way line, 20 feet beyond the right of way line if possible, and on intersecting streets for a distance of 100 feet beyond proposed pavement. See Figure 2.1 Perimeter of Standard Topographical Survey.
- H. For acquisition of new or additional rights-of-way:
 - 1. Tie all points of beginnings (POB) for each parcel and points of commencing (POC) to the Official Coordinate System as defined in Chapter 33, Code of Ordinances for the City of Houston.
 - 2. Set iron rods or permanent markers at the intersections of the proposed right-of-way and property lines of parcels to be acquired.
 - 3. Identify monuments, corners, angle points, points of curve (PCs), points of intersection (PIs), points of tangency (PTs), and other points as either "found" or "set." Describe each monument in such a way as to clearly define size, type of material and the nature of the monument, i.e., 3/4-inch iron pipe, 5/8-inch iron rod, cotton spindle, mag nail, etc.

4. Locate visible improvements, buildings, fences, permanent signs, utilities and other structures within 10 feet of the proposed right-of-way line.

2.08 CALCULATIONS

- A. Calculate coordinates of proposed right-of-way parcels, control points, found or set monuments, curve data, lengths, stations and offsets to monuments, and proposed improvement features.
- B. Electronic ASCII files of the coordinate calculations should be submitted to the City with field books and database files.

2.09 CONSTRUCTION DRAWINGS

- A. All found monuments (property corners, Street Reference Monuments, bench marks etc.) must be plainly shown on the drawings and located by station and distance, right or left from the traverse line, or design baseline. Monuments used to establish the design line or traverse must be identified as Control Points, and their relationship to the design baseline and to the proposed right-of-way lines must be shown. If the project is dimensioned from a traverse line, which is different than the design baseline, it must be established and monumented in accordance with the requirements of Paragraph 2.07. Coordinates for traverse control points and all points of curve, points of tangency, and points of intersection along the design baseline shall be shown.
- B. Show location and identification of existing Site Control Monuments and found Street Reference Monuments, by station and distance and whether right or left of traverse line or design baseline. Show swing ties for all control points and Street Reference Monuments using the City of Houston Recovery sheet format.
- C. Show and identify location of the City datum monuments and temporary bench marks used for elevation control. List the TBM located closest to that particular sheet in a station/offset, description and elevation format.
- D. Show centerline angles of intersection of side streets with main roadway centerline. Where bearings are used, identify source of bearings and show bearings on both control line and project centerline when they are not the same line.
- E. For bridges, overpasses and underpasses show top of pavement elevations at gutter line and centerline for the following locations:
 1. Construction joints
 2. Armor or expansion joints

3. Intervals between bents that correspond to the increments used for dead load deflection calculations.
- F. For bridges and grade separations, drawings must incorporate layout sheets which identify proposed centerline and curve information plus:
1. Surface coordinates for control points so that an inverse between coordinates reflects a surface distance. Identify origin of coordinate system used.
 2. Show coordinates of design baseline at PIs.
 3. Show coordinates of curb lines at their intersection with the centerline of bents and abutments for irregular structures.
- G. For all horizontal and vertical control monuments, show coordinates on the Official Coordinate System as defined in Chapter 33, Code of Ordinances for the City of Houston. Proper metadata for GPS - derived points should include the vertical adjustment, the Geoid used, the ITRF used and the current published coordinates of the base stations at the time of calculation.

2.10 RIGHT-OF-WAY MAPS

- A. Show "x," "y" values on monuments based on the City survey control and the scale factor used to convert grid coordinates to "surface" coordinates. All Distances shall be shown as "surface" distances and plainly marked as such. All bearings shall be based on the Texas Coordinate System of 1983.
- B. Distances on proposed right-of-way lines shall be continuous from beginning to end of the job. Show either straight line or arc distance across intersecting streets.
- C. Where a parcel is taken from a larger tract, show dimensions, distances, and area of the remainder of the tract based on recorded information.
- D. Identify the evidence used to decide the final placement or establishment of the proposed right-of-way line, such as angle points, or corner monuments, as either "set" or "found." The description of each point used shall be shown on the drawing as identified in the field survey.
- E. Grid Coordinate values of "x," "y" shall be shown for PCs, PTs, and PIs of curves on the proposed right-of-way lines. Curve data must include the following: delta, radius, arc length, chord length, and chord bearing.
- F. Grid Coordinate values of "x," "y" must be given on the POB of each parcel. Show coordinates on map and metes and bounds with the scale factor.
- G. Other information to be shown on right-of-way maps:

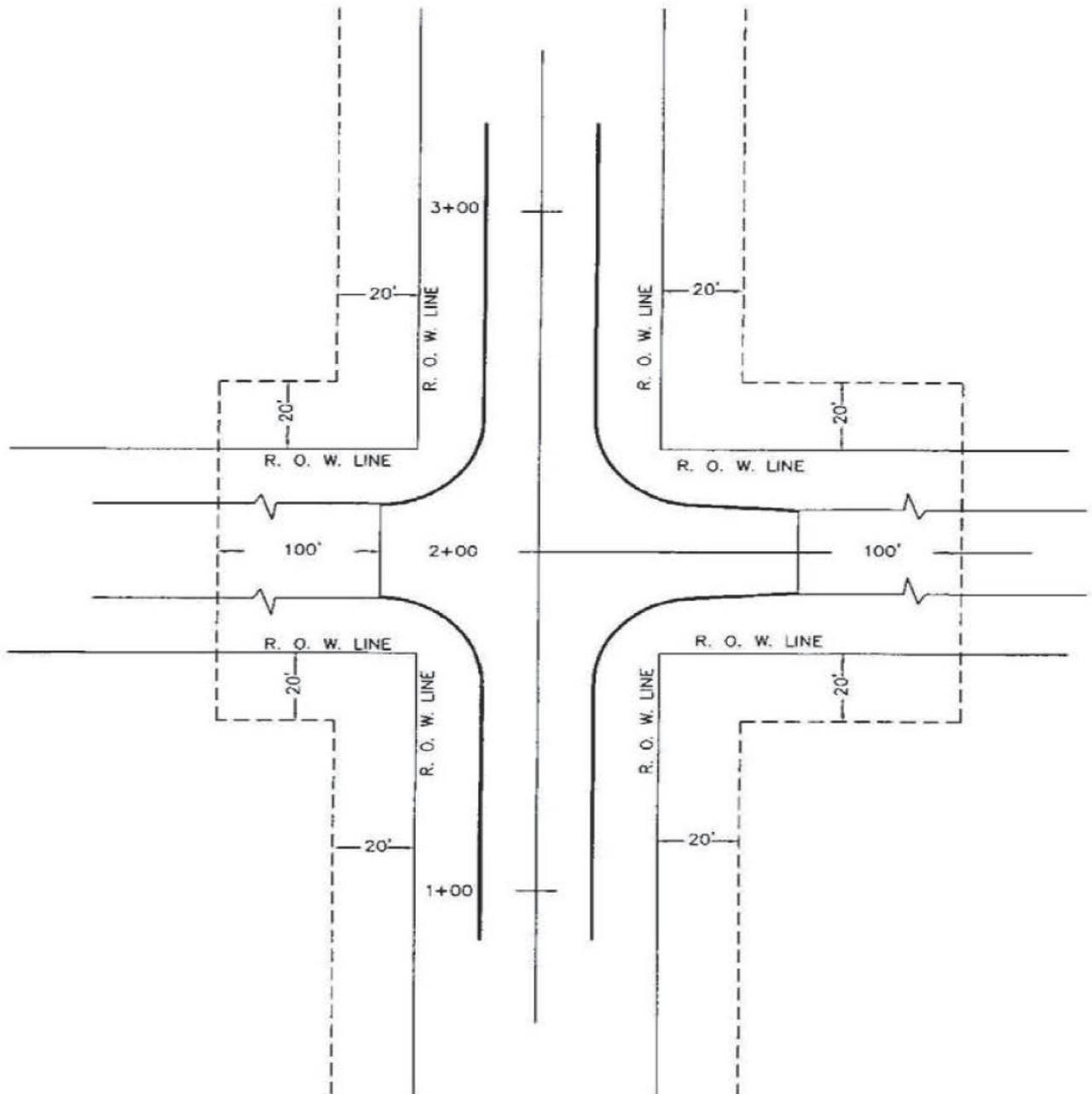
1. All visible improvements such as buildings, fences, permanent signs, utilities, and other structures located on the property or within 10 feet outside the right-of-way line, if accessible.
2. Abstract information used in preparation of the right-of-way map.
3. Field book numbers obtained from the Chief Surveyor.
4. Real estate numbers obtained from the Chief Surveyor, right-of-way engineer, or Real Estate Division.

2.11 DOCUMENTS

- A. Where new construction will damage, destroy, or alter existing Street Reference Monuments, include in specifications a requirement for installation of survey marker boxes by construction contractor at a unit price per box. The Chief Surveyor will determine the number and location of boxes to be furnished and installed by the contractor.
- B. Plats, metes and bounds description and field books shall have the Professional Surveyor's seal, signature and date affixed to the instrument.

END OF CHAPTER

FIGURE 2.1
PERIMETER OF STANDARD
TOPOGRAPHICAL SURVEY



City of Houston

Design Manual

Chapter 3

GRAPHIC REQUIREMENTS

Chapter 3
Graphic Requirements
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Chapter 3

GRAPHIC REQUIREMENTS

SECTION 1 – OVERVIEW

3.1.01 CHAPTER INCLUDES

Graphic requirements are provided for a consistent uniform appearance for engineering drawings. It is not the intent of this manual to be a training guide for AutoCAD, ArcGIS or other software products.

This chapter is to be used for all new projects. For projects already underway, coordinate with the City Project Manager to assess the appropriateness of implementation. It is not intent of this update to cause existing projects to incur additional time or cost, and measure should be taken to avoid such.

3.1.02 REFERENCES

1. City of Houston monument ties in compliance with Article IV, Chapter 33, City Surveys, of the Code of Ordinances.
2. City of Houston, Standard Details, Current Edition.
3. City of Houston, Standard Specifications, Current Edition.
4. HCFCD – Harris County Flood Control District.
5. NCS – U.S. National CAD Standard is published by the National Institute of Building Sciences.

3.1.03 DEFINITIONS

1. AutoCAD - is a CAD software platform for two and three-dimensional design and drafting. The file format of AutoCAD is DWG. AutoCAD has included file format support for DXF and DWF.
2. ArcGIS – Provides an infrastructure for making maps and geographic information.
3. Computer Aided Design (CAD) - Preparation of drawings, plans, prints, and other related documents through the use of computer equipment and software programs.
4. Geographic Information System (GIS) – A system designed to capture, store, manipulate, analyze, manage, and present geographic data.

5. U.S. National CAD Standard (NCS) – was created to encourage a more rational construction regulatory environment. The National CAD Standard is published by the National Institute of Building Sciences. <https://www.nationalcadstandard.org/ncs6/>

3.1.04 SOFTWARE AND DATA FORMAT

All CAD files, both references and sheet file deliverables, shall be provided in .DWG file extension format compatible with the most recent version of AutoCAD.

However, the use of other software with the ability to convert files into the proper DWG format, will also be acceptable.

3.1.05 IMPORTING STANDARD DRAWINGS

Standard Details shall be imported on the sheet files. For visibility each sheet shall only have up to four 8 ½” x 11” Standard Detail Drawings. The current standard drawings can be found here: https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html

SECTION 2 – GENERAL SHEET CONTENT**3.2.01 GENERAL SHEET CONTENT**

1. Plan sets for typical projects shall be produced to scale on 22" x 34", ANSI D sheet sizes.
2. Final design drawings shall be India ink on mylar, or produced by CAD on mylar using non-water based ink. Do not use adhesive-backed material on final drawings.
3. The seal, date, and original signature of the Professional Engineer responsible for the drawings is required on each sheet developed by the design engineer. The design engineer may use stamped seal or embossed imprint; however, the embossed imprint must be shaded so that it will reproduce on prints. Use of an electronic seal for plan submittal needs to be in accordance with the Texas Engineering Practice Act and Rules. Survey Control sheets require seal and signature of RPLS.
4. Applicable city standards shall be included in the engineering plan set.
5. Develop drawings to accurate scale showing proposed pavement, typical cross sections, details, lines and grades, and existing topography within street right-of-way, and any easement contiguous with the right-of-way. At the intersection, the cross-street details shall be shown at sufficient distance (20-foot minimum distance outside the existing or proposed roadway right-of-way, of which the wider right-of-way shall govern) in each direction along cross street for designing adequate street crossings.
6. If a roadway exists where drawings are being prepared to improve or construct new pavement or a utility, label the existing roadway width, surfacing type, and thickness.
7. Show all street and road alignments on drawings refer to Chapter 2, Section 2.09, Construction Drawings.

3.2.02 DRAWING FILE ASSEMBLY

To ensure consistency, the same drawing file assembly convention must be followed. This section describes the use of reference files, sheet files, model and layout space.

3.2.03 REFERENCE FILES

Contain the subset of design elements and geometric components, with all content drawn and placed in Model Space. All reference files are to be drawn full scale 1' = 1' with pertinent annotation, text, and dimensions.

3.2.04 SHEET FILES

Reference file attachments shall be included in model space except for the title block. The title block shall be attached in layout space.

3.2.05 MODEL SPACE

A limitless 3D drawing area that is the default in AutoCAD software used for the beginning of a design. Annotation, text, and dimensions that are directly related to the elements in the reference files shall be placed in model space. Reference files are to be attached in model Space.

3.2.06 LAYOUT SPACE

Commonly known as “Paper Space”, is the area designated for producing printed deliverables. Annotation and text typical to the sheet content shall be placed in layout space. Typical sheet items include north arrow, bar scales, matchlines, benchmarks, revision clouds and deltas, sheet and project text, title block information, specific notes, profile street names, profile stationing, and any other annotation unique to each sheet.

3.2.07 DRAWING SCALE

Draw key overall layouts to a minimum scale of 1" = 200'.

Standard scales for plan and profile are required on construction drawings are as follows:

1. Major thoroughfares, streets with esplanades over 400 feet in length, or special intersections/situations.

1" = 20' Horizontal, 1" = 2' Vertical

2. Minimum standard scales for Minor or residential single-family streets.

1" = 20' Horizontal, 1" = 2' Vertical

1" = 40' Horizontal, 1" = 4' Vertical

1" = 50' Horizontal, 1" = 5' Vertical

3. Larger scales may be used to show details of construction.
4. Single-banked plan and profile drawings are acceptable; double-banked plan and profile sheets are allowed such as off-site utility lines in undeveloped areas.
5. Details of special structures (not covered by approved standard drawings, such as stream or gully crossings, special manholes, or junction boxes) shall be drawn with vertical and horizontal scales equal to each other.

3.2.08 TITLE BLOCK

Signature Block: Use latest edition of Signature Blocks issued by Capital Projects for private and City projects.

3.2.09 NORTH ARROW

A north arrow is required on all sheets and should be oriented either toward the top or to the right. The approved City north arrow can be found on the symbols sheet found here:

https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html

This requirement is waived under the following conditions:

1. A storm water or sanitary sewer with flow from east to west or from north to south.
2. A primary outfall drainage ditch with flow from east to west or from north to south.
3. Stationing is intended to start from the cardinal points of the compass and proceed in the direction of construction.
4. The north arrow can be down or to the left on a loop street.

3.2.10 GENERAL NOTES

General Notes for Privately Funded Projects can be found in the Tools section located here:

https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html

These Notes are not intended to be used on City Funded Projects.

General Notes for City Funded Projects can be found in the Capital Projects section located here:

https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html

These notes shall only include third party notes. Any direction given to a contractor shall be handled through the use of Construction Specification to be accompanied by a unit price item if appropriate.

3.2.11 STATIONING

Plan stationing must run from left to right, except for short streets or lines originating from a major intersection, where the full length can be shown on one sheet. Tic symbols shall be used to mark stations.

1. Never commence stationing at 0+00, acceptable start stations are 1+00 or 10+00.
2. Every even X+00 station shall be annotated with station text and a tic mark.
3. Every X+50 station shall only contain a tic mark.

3.2.12 MATCH LINES

1. Match lines shall be located at each end of plan view, perpendicular to the design centerline and shall be labeled as to station, and matching sheet number.

2. Match lines between plan and profile sheets shall not be placed or shown within cross street intersections including cross street right-of-way.

3.2.13 SURVEY REQUIREMENTS

Show ties on survey control or swing tie drawings to City monuments, Control Points and temporary benchmarks. All construction drawings shall be prepared in accordance with Chapter 2, Section 2.09, Construction Drawings.

3.2.14 PLAN AND PROFILE

Basic plan and profile sheets shall contain the following information:

1. Identify and label all existing and proposed lines in plan and profile view regardless of line type, including lot lines, property lines, easements, rights-of-way, and HCFCO outfalls.
2. Label each plan sheet as to street/easement widths, pavement widths, pavement thickness where applicable, type of roadway materials, curbs, intersection radii, curve data, stationing, existing utilities (type and location), and any other pertinent feature affecting design.
3. Show utility lines 4 inches in diameter or larger within the right-of-way or construction easement in profile view. Show utility lines, regardless of size, in the plan view, including communication and fiber optic cables.
4. Graphically show flow line elevations and direction of flow for existing ditches.
5. Label proposed top of curb grades except at railroad crossings. Centerline grades are acceptable only for paving without curb and gutters.
6. Show curb return elevations for turnouts in profile view.
7. Gutter elevations are required for vertical curves, where a railroad track is crossed.
8. For street reconstruction projects, show in profile the centerline elevation at the property line of existing driveways.
9. Show both existing and proposed station esplanade noses or the centerline of esplanade openings, including esplanade width.
10. The design of both roadways is required on paving sections with an esplanade.
11. Show in plan view station PCs, PTs, and radius returns. Show station radius returns and grade change PIs with their respective elevations in profile view.

12. All existing and proposed utilities and pavement shall be on the same plan and profile sheet for a given section.
13. Plan view and profile view shall be on the same sheet as long as the entire proposed design within the scope of the project can be shown clearly and legibly (i.e., depth of all utilities can be graphically viewed).
14. Each sheet of the plan and profile shall have a benchmark elevation and description defined. Refer to Chapter 2.09 for further specification.

Show natural ground profiles as follows:

1. For privately funded projects, centerline profiles are satisfactory except where a difference of 0.50 feet or more exists from one right-of-way or easement line to the other, in which case, dual profiles are required.
2. For City funded projects, provide natural ground profiles for each right-of-way line. For projects with existing (and/or proposed) roadside ditches, provide ditch flowline in profile view. Also show and label all driveway culverts.

SECTION 3 - LEADERS AND DIMENSIONS

3.3.01 LEADERS AND DIMENSIONS

1. Leaders shall use straight leader lines and closed, filled arrows.
2. The leader style shall attach the leader landing to the top of the multi-line text.
3. Leader lines shall be placed as close as possible to the object being identified.
4. Leader lines in the same area shall be parallel whenever possible.
5. Leader lines shall be avoided that are: horizontal or vertical. At the same angle as cross-hatching, at very small angles to the terminating surface, parallel to extension or dimension lines, curved, or crossed.

Table 3.1 Dimension Settings can be used as a general guide

Table 3.1 Dimension Settings		
Dimension Setting	Value for Proposed	Value for Existing
Associative Dimensions	2"	2"
Extension line beyond dimension line	0.05"	0.05"
Extension line offset from object	0.05"	0.05"
Arrow Size	0.10"	0.08"
Dimension Text Style	RomanS	RomanS
Dimension Text Height	0.10"	0.08"
Dimension Primary Units	2 (Decimal)	2 (Decimal)
Dimension Precision	0.00	0.00

3.3.02 LETTERING

Standard text height is 0.10 for most drawing annotation. A minimum height of 0.05 is acceptable when used for special purposes such as for symbols or stacked fractions. The standard text style shall use the upper-case RomanS font. Table 3.2 can be used as a general text property guide.

1. Text shall be in designated model space.
2. Text shall be placed readable from the bottom or right side of the page.
3. Text shall be justified Top Left, Top Right, or Middle Center as best applicable for each case.
4. Text strings shall not overlap one another.

- Where necessary, place text strings away from the features and use a leader.

Table 3.2 Text Properties			
Existing/Proposed	Text Style	Printed Height	Printed Width
Proposed text and dimensions	RomanS	0.10"	1.0
Existing text and dimensions	RomanS	0.08"	1.0
Major title block text	RomanS	0.30"	1.0
Survey spot elevations	RomanS	0.08"	1.0
Sheet numbers, detail titles, section or detail call outs, match line labels, table and location map sub-titles, and column headings	RomanS	0.20"	1.0
Stacked fractions, symbols, small detail annotation	RomanS	0.05"	1.0
Cover Sheet Title	COH CIP Cover	0.70"	1.0
Cover Sheet sub-titles	COH CIP Cover	0.40"	1.0

3.3.03 LINE WEIGHTS

The COH.CTB plot configuration file included with the City drawings specifies plotted line weights. No modifications are to be made to this file.

- Colors 1-10 have been reserved for unscreened elements such as proposed objects, annotations, text and dimensions in the COH.ctb file. The basic colors and corresponding weights can be located in Table 3.3.
- Colors 11-248 can be used as needed for the described typical use and each designated weight is represented by various colors within this color range.
- Colors 249-254 have been reserved for screening, ranging from 80-30%, in descending value in the COH.ctb file
- The following table is based on the National CAD Standard – V6, 2.0 line width guide and corresponds with colors 1-10 in the COH.ctb file.

Table 3.3 Line Weights				
Colors	Thickness	MM	IN.	Typical Use
1	Extra Fine	0.10	0.004	Hatch patterns, table and section grid lines, and sheet trim lines, existing object lines and text
2, 8	Fine	0.18	0.007	Proposed fine object lines
3, 7	Thin	0.25	0.010	Proposed thin object lines
4, 9	Medium	0.35	0.0138	Proposed medium object lines, proposed text, existing ROW
5	Wide	0.50	0.020	Sheet and title block borders, sheet dividers, major title underlines, outlines, location map outlines, section lines, proposed object lines requiring special emphasis, proposed design lines and elements
6	Extra Wide	0.70	0.028	Proposed Right of Way
10	XX Wide	1.20	0.048	Drainage Areas

3.3.04 LINE TYPE

1. The line weights shown in Table 3.3 are shown as a general guide. Some objects will need to be shown in a different line weight for clarity.
2. Custom line types can be located in the COH.lin file provided by the City and can be downloaded:
https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html

3.3.05 LAYERS

The layer standard is based on the drawing layer format by the National CAD Standard (NCS). The NCS format consists of four data fields (Discipline Designator, Major Group, and two Minor Groups), and a status field. Each field is separated by a dash for clarity. The Discipline Designator and Major Group fields are mandatory. The Minor Groups and Status field are optional.

	C	-	A	L	G	N	-	C	N	T	R	-	A	N	N	O	-	1
Discipline Designator (1-2 Letters)	Major Group (4 Letters)				Minor Group (4 Letters)				Minor Group (4 Letters)				Status Field (1 Letter)					

Below are lists of common layer fields. Not all field codes are represented. Refer to the [National CAD Standards](#) for layer field codes of disciplines not defined in this section. Layers may be created to provide additional clarity to the data placed in a drawing. The guidelines above shall be observed when creating layers not listed in the NCS. Layer names shall not exceed 18 characters.

Discipline Designators

Designator:	Description of Discipline Designator:
G	General
GR	General Record Drawings
V	Survey
VA	Aerial Survey
VF	Construction Field Survey
C	Civil
CD	Civil Demolition
CU	Civil Utilities
CP	Civil Paving
CT	Civil Transportation

Major Group

Major Field:	Description of Major Layer Field:
ALGN	Alignments
ANNO	Sheet annotation
BLDG	Buildings and Primary Structures
BLIN	Baseline
BORE	Test borings
BRDG	Bridge
CABL	Cable
COMM	Communications
CTRL	Control points
DETL	Details
DRIV	Driveways
ESMT	Easements
NGAS	Natural gas
PIPE	Pipes
PROP	Property
PVMT	Pavement
RAIL	Railway
ROAD	Roadways
RWAY	Right-of-Way
SIGL	Traffic signals
SSWR	Sanitary sewer
STRM	Storm Sewer

WETL	Wetlands
------	----------

Minor Group

Minor Field:	Description of Minor Layer Field:
ANNO	Annotation
ASPH	Pavement: asphalt
CNTR	All: Center lines
CONC	Pavement: Concrete
DATM	Datum notes
DIMS	Dimensions
EDGE	Channels, major water bodies, ponds, creeks and rivers
FDPL	Flood plain
FIBR	Fiber Optic
LABL	Annotation: Labels
LEGN	Sheets: Legends, symbols keys
NOTE	Sheets: Notes
NRTH	Sheets: North arrows
POLE	Utilities: Boxes / poles
ROAD	Pavement: Roadways
SECT	Sections
TTLB	Sheets: Border and title blocks
UTIL	Utilities

Status Group

Status Field:	Description of Status Field:
1	Phase 1
2	Phase 2
3	Phase 3
H	Horizontal (for profile grids)
V	Vertical (for profile grids)
F	Future Work

SECTION 4 –ELECTRONIC PLANS

3.4.01 ELECTRONIC PLAN REVIEW

The process for registering the Engineering firm with the iPermits Customer Portal for the Office of the City Engineer Plan Review, and the electronic plan review system is called Project Dox. The electronic plan review process is broken down into 10 key steps. The process utilizes two systems: iPermits and ProjectDox. The iPermits Customer Portal is used to submit applications and to make payments. ProjectDox is used to upload drawings, receive comments, and receive approvals. The Step-by-step user guide can be found here:

https://edocs.publicworks.houstontx.gov/documents/divisions/planning/hpc/hpw_oce_epr_user_guide.pdf

3.4.02 ELECTRONIC PLAN REVIEW FILE NAMING

File names are limited to 70 characters. Documents should be submitted in PDF format per the COH I-Permits and ProjectDox system requirements. File names should contain the sheet number, dash, and corresponding sheet title the following format: “### - XXXXXXX” add “00” to single digit page numbers to avoid the page jumping from 1, 11,12, etc. See table 3.5 below for some examples of common sheet files and corresponding file name to be used.

Table 3.5 File Naming		
Sheet Title	Sheet Number	File Name
Cover Sheet	01	001 – Cover Sheet
Sheet Index	02	002 – Sheet Index
Abbreviations	03	003 – Abbreviations
Symbols	04	004 – Symbols
General Notes	05	005 – General Notes
Overall Project Layout(s)	06	006 – Overall Project Layout(s)

SECTION 5 – REVISION PROCESS

Revisions required during the Construction Phase shall follow the revision process in this section. Revisions on plans are to be annotated and documented with the following guidelines:

3.5.01 FIRST REVISION PROCEDURES

1. All changes in each sheet that are pertinent to each revision shall be enclosed in revision “clouds”.
2. The number of the revision shall be placed inside of a triangle, commonly known as a “delta”.
3. Each revision delta shall be placed adjacent to the corresponding revision cloud(s).
4. It is acceptable to have multiple clouds with the same revision delta on a sheet if all changes apply to that revision.
5. It is acceptable to cloud an entire plan view area with a single revision cloud and delta, when a significant portion within the cloud has been revised or when clouding each revised item becomes impractical.
6. If an entire sheet is added to a plan set as a part of a revision, the sheet title and sheet number shall be clouded along with a delta.
7. The Sheet Index for each plan set shall also reflect revisions with the outlined procedures.

3.5.02 SECOND (AND SUBSEQUENT) REVISIONS PROCEDURES

1. The revision cloud(s) from any previous revision(s) shall be removed from each sheet.
2. The revision delta(s) from any previous revisions(s) shall remain in their original location on each sheet.
3. All of the new changes to each sheet shall follow the revision procedures outlines in the above narrative.

3.5.03 TITLE BLOCK / COVER SHEET ANNOTATION PROCEDURES

1. Each revision is to be documented on the title block area of each plan sheet or cover sheet, see below for examples.
2. All information is to be filled out, to include a brief description of the revision, starting from bottom to top or right to left.
3. Once the maximum amount of revision lines is completed, the oldest revision annotation will

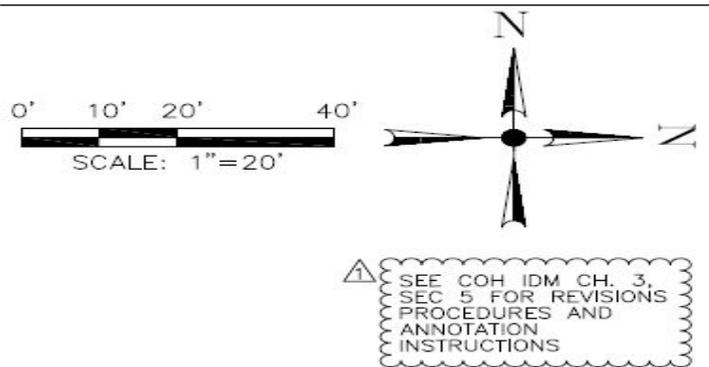
be removed to accommodate the newest current revision information.

- The oldest revision information will be located at the bottom or right, with the current information located at the top or left.

REVISION EXAMPLES

3	MM/DD/YY	BRIEF DESCRIPTION	XXX
2	MM/DD/YY	BRIEF DESCRIPTION	XXX
1	MM/DD/YY	BRIEF DESCRIPTION	XXX
NO.	DATE	REVISION	APP.

	MM/DD/YY	BRIEF DESCRIPTION	XXX
	MM/DD/YY	BRIEF DESCRIPTION	XXX
	MM/DD/YY	BRIEF DESCRIPTION	XXX
NO.	DATE	REVISION	APP.



SECTION 6 – EXAMPLE PLAN SET SHEETS

3.6.01 CAD STANDARDS APPLICABLE TO CITY AND PRIVATELY FUNDED PROJECTS

1. Provide a cover sheet for projects involving three or more design drawings (excluding standard City of Houston detail sheets).
2. The Example Sheets in the following subsections are to give the user an overall feel of how specific plans should appear and how they differ from each other. A few basic sample drawings are shown here:
 - Abbreviations
 - Symbols
 - Capital Projects Sheet Index
 - Capital Projects Cover Sheet
 - Non-Capital / Private Projects Cover Sheet
 - General Notes
 - Plan and Profile

3.6.02 ABBREVIATIONS

NO.	DATE	REVISION
1	07/01/2019	REVISED
2	07/01/2019	REVISED
3	07/01/2019	REVISED
4	07/01/2019	REVISED
5	07/01/2019	REVISED
6	07/01/2019	REVISED
7	07/01/2019	REVISED
8	07/01/2019	REVISED
9	07/01/2019	REVISED
10	07/01/2019	REVISED
11	07/01/2019	REVISED
12	07/01/2019	REVISED
13	07/01/2019	REVISED
14	07/01/2019	REVISED
15	07/01/2019	REVISED
16	07/01/2019	REVISED
17	07/01/2019	REVISED
18	07/01/2019	REVISED
19	07/01/2019	REVISED
20	07/01/2019	REVISED
21	07/01/2019	REVISED
22	07/01/2019	REVISED
23	07/01/2019	REVISED
24	07/01/2019	REVISED
25	07/01/2019	REVISED
26	07/01/2019	REVISED
27	07/01/2019	REVISED
28	07/01/2019	REVISED
29	07/01/2019	REVISED
30	07/01/2019	REVISED
31	07/01/2019	REVISED
32	07/01/2019	REVISED
33	07/01/2019	REVISED
34	07/01/2019	REVISED
35	07/01/2019	REVISED
36	07/01/2019	REVISED
37	07/01/2019	REVISED
38	07/01/2019	REVISED
39	07/01/2019	REVISED
40	07/01/2019	REVISED
41	07/01/2019	REVISED
42	07/01/2019	REVISED
43	07/01/2019	REVISED
44	07/01/2019	REVISED
45	07/01/2019	REVISED
46	07/01/2019	REVISED
47	07/01/2019	REVISED
48	07/01/2019	REVISED
49	07/01/2019	REVISED
50	07/01/2019	REVISED
51	07/01/2019	REVISED
52	07/01/2019	REVISED
53	07/01/2019	REVISED
54	07/01/2019	REVISED
55	07/01/2019	REVISED
56	07/01/2019	REVISED
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100	07/01/2019	REVISED

EXAMPLE ONLY
SEE WEBSITE FOR
CURRENT VERSION

ENGINEER NAME: _____
ADDRESS: _____
TELEPHONE NUMBER: _____
CITY: _____ STATE: _____
ZIP: _____

CITY OF HOUSTON
HOUSTON, TEXAS 77002

PROJECT TITLE
ABBREVIATIONS

SHEET NO. 16 OF 20

(For the most up to date sheet go to https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html)

3.6.04 COH SHEET INDEX

EXAMPLE ONLY
SEE WEBSITE FOR
CURRENT VERSION

SHEET NO.	SHEET TITLE	SHEET NO.	SHEET TITLE
1	GENERAL	1	GENERAL
2	CONTRACT	2	CONTRACT
3	CONTRACT NOTES	3	CONTRACT NOTES
4	CONTRACT SPECIFICATIONS	4	CONTRACT SPECIFICATIONS
5	CONTRACT DRAWINGS	5	CONTRACT DRAWINGS
6	CONTRACT SCHEDULE	6	CONTRACT SCHEDULE
7	CONTRACT BIDDING	7	CONTRACT BIDDING
8	CONTRACT ADMINISTRATION	8	CONTRACT ADMINISTRATION
9	CONTRACT CLOSEOUT	9	CONTRACT CLOSEOUT
10	CONTRACT WARRANTY	10	CONTRACT WARRANTY
11	CONTRACT AS-BUILT	11	CONTRACT AS-BUILT
12	CONTRACT RECORDS	12	CONTRACT RECORDS
13	CONTRACT ARCHIVES	13	CONTRACT ARCHIVES
14	CONTRACT LIBRARY	14	CONTRACT LIBRARY
15	CONTRACT BACKUP	15	CONTRACT BACKUP
16	CONTRACT RESTORE	16	CONTRACT RESTORE
17	CONTRACT SECURITY	17	CONTRACT SECURITY
18	CONTRACT COMPLIANCE	18	CONTRACT COMPLIANCE
19	CONTRACT AUDIT	19	CONTRACT AUDIT
20	CONTRACT REPORTING	20	CONTRACT REPORTING
21	CONTRACT TRAINING	21	CONTRACT TRAINING
22	CONTRACT SUPPORT	22	CONTRACT SUPPORT
23	CONTRACT IMPROVEMENT	23	CONTRACT IMPROVEMENT
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26	CONTRACT RESILIENCE	26	CONTRACT RESILIENCE
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98	CONTRACT REPORTING	98	CONTRACT REPORTING
99	CONTRACT TRAINING	99	CONTRACT TRAINING
100	CONTRACT SUPPORT	100	CONTRACT SUPPORT

DESIGN ENGINEER NAME	ADDRESS	TELEPHONE NUMBER	TX. FIRM NUMBER	ENGINEER'S SEAL
CITY OF HOUSTON HOUSTON PUBLIC WORKS				
PROJECT TITLE SHEET INDEX				
NO. DRAWER	X. DRAWING CODE	DRAWING SCALE	CITY OF HOUSTON IN	DATE FOR PLS.
SHEET NO. XX OF XX				

(For the most up to date sheet go to https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html)

3.6.05 CAPITAL PROJECTS COVER SHEET

**CITY OF HOUSTON
HOUSTON PUBLIC WORKS
CAPITAL PROJECTS**

PROJECT TITLE

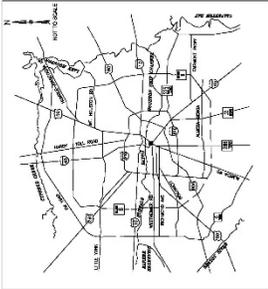
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EXAMINABLES ONLY

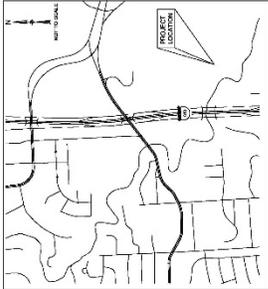
SEE WEBSITE FOR CURRENT VERSION

MAYOR
SYLVESTER TURNER

CONTROLLER
CHRIS BROWN



VICINITY MAP
KEY MAP NO ##X
GIS MAP NO ##X



LOCATION MAP

COUNCIL MEMBERS

BRENDA STAROIC DISTRICT A	JERRY DAVIS DISTRICT B	STEVE LE DISTRICT F	ROBERT GALLEGO DISTRICT I	ELEN R. COHEN DISTRICT C	GREG TRAVIS DISTRICT G	MIKE LASTER DISTRICT J	DWIGHT A. BOYKINS DISTRICT D	MARTHA CASTEX-TATUM DISTRICT K	MIKE KNOX POSITION 1	DAVID W. ROBINSON POSITION 2	MICHAEL KUBOSH POSITION 3	AMANDA EDWARDS POSITION 4	JACK CHRISTIE POSITION 5
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COUNCIL MEMBERS AT-LARGE

DAVID W. ROBINSON POSITION 2	AMANDA EDWARDS POSITION 4	JACK CHRISTIE POSITION 5
---------------------------------	------------------------------	-----------------------------

3 MM/20/YY BRIEF DESCRIPTION	XXXX	
2 MM/20/YY BRIEF DESCRIPTION	XXX	
1 MM/20/YY BRIEF DESCRIPTION	XXX	
NO. DATE REVISION		A.P.P.

DESIGN ENGINEER NAME _____

ADDRESS _____

TELEPHONE NUMBER _____

ENGINEER'S SEAL

DATE _____

PROJECT NO. _____

PROJECT NAME _____

PROJECT LOCATION _____

PARKS-FORESTRY DEPT. _____

METRC _____

HOUSTON WATER _____

TRANSPORTATION & DRAINAGE OPERATIONS _____

CAPITAL PROJECTS _____ SURVEY _____

FOR CITY OF HOUSTON USE ONLY

CITY ENGINEER _____ DATE _____

DIRECTOR OF HOUSTON PUBLIC WORKS _____ DATE _____

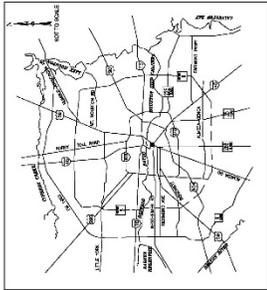
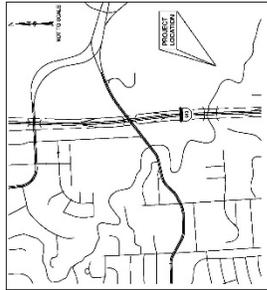
SHEET NO. XX OF XX SHEETS

(For the most up to date sheet go to https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html)

3.6.06 NON-CAPITAL / PRIVATE PROJECTS COVER SHEET

CONSTRUCTION PLANS FOR PROPOSED PROJECT TITLE

LOCATION (ADDRESS)

EXAMPLE ONLY

SEE WEBSITE FOR CURRENT VERSION

3. MM/DD/YY	BRIEF DESCRIPTION	XXX
2. MM/DD/YY	BRIEF DESCRIPTION	XXX
1. MM/DD/YY	BRIEF DESCRIPTION	XXX
NO. DATE	REVISION	APP.

DESIGN ENGINEER NAME

ADDRESS

CITY

STATE

ZIP

PHONE NUMBER

PROJECT NUMBER



NOTE: ALL SIGNATURES VALID FOR ONE YEAR ONLY AFTER DATE OF SIGNATURES

CITY OF HOUSTON
HOUSTON PUBLIC WORKS

STORM WATER	STORM WATER QUALITY
WASTE WATER	FACILITIES
STORM WATER	TRAFFIC & TRANSPORTATION/ STREET & BRIDGE

CITY ENGINEER	DATE	DIRECTOR OF HOUSTON PUBLIC WORKS	DATE
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SHEET NO. XX OF XX SHEETS
FOR CITY OF HOUSTON USE ONLY

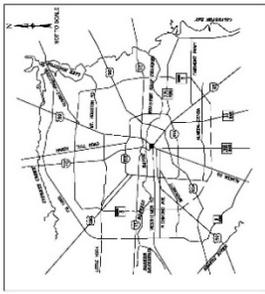
ILMS NO. ##-###-###

COH LOG NO. ##-###-###

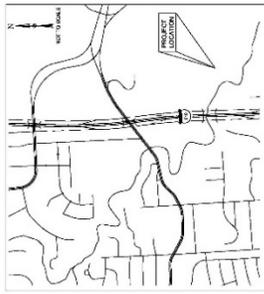
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3.6.07 TELECOMMUNICATION COVER SHEET

**CONSTRUCTION PLANS FOR PROPOSED
TELECOMMUNICATION PROJECTS
PROJECT TITLE
LOCATION (ADDRESS)**



LOCATION MAP



VICINITY MAP
KEY MAP NO ### X
GIMS MAP NO ### X

EXAMPLE ONLY
SEESITE FOR
CURRENT VERSION

3. IM/20/YY	B-1/E	D-DESCRIPTION	XXXX
2. IM/20/YY	B-1/E	D-DESCRIPTION	XXXX
1. IM/20/YY	B-1/E	D-DESCRIPTION	XXX
		REVISION	
			APP.



ENGINEER'S SEAL

ADDRESS _____ TELEPHONE NUMBER _____
 TELEPHONE NUMBER _____ FIRM NUMBER _____

NOTE: CITY SIGNATURES VALID FOR ONE YEAR ONLY AFTER DATE OF SIGNATURES

TELECOMMUNICATION _____ DATE _____

CITY ENGINEER _____ DATE _____ DIRECTOR OF HOUSTON PUBLIC WORKS _____

SHEET NO. XX OF XX SHEETS

FOR CITY OF HOUSTON USE ONLY

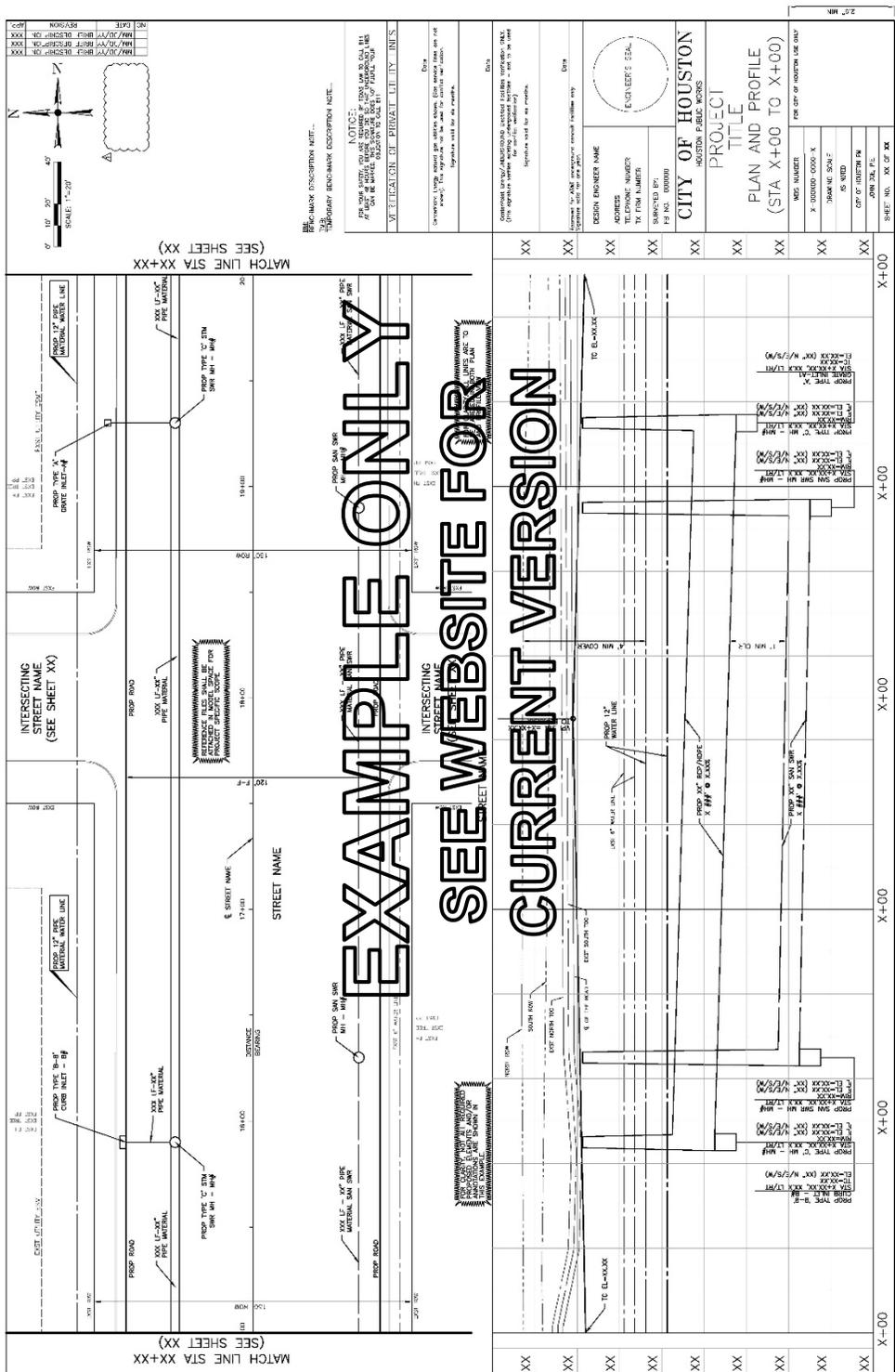
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11.5" x 17"

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COH_LOG NO. ##-###-###

(For the most up to date sheet go to https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html)

3.6.09 PLAN AND PROFILE



(For the most up to date sheet go to https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html)

SECTION 7 – RESOURCES

3.7.01 CAD TOOLS

Listed below are the files that are provided by the City for use along with all the sections of Chapter 3. The files can be found here:

https://www.publicworks.houstontx.gov/notices/engineering_standards_section.html

<u>File Name</u>	<u>Description</u>	<u>File Type</u>
1. COH	COH Custom Line Types	.LIN
2. COH	COH Plot Table	.CTB
3. COH Plan and Profile	COH Plan and Profile Template	.DWG / .PDF
4. COH Symbols	COH Standard Symbols	.DWG / .PDF

3.7.02 HELPFUL TEMPLATES

<u>File Name</u>	<u>Description</u>	<u>File Type</u>
1. coh_cp_title_block	COH Standard Title Block	.DWG / .PDF
2. coh_cp_cover_sheet	COH Standard Capital Projects Cover Sheet	.DWG / .PDF
3. coh_sheet_index	COH Standard Sheet Index	.DWG / .PDF
4. coh_abbreviations	COH Standard Abbreviations	.DWG / .PDF
5. coh_symbols	COH Standard Symbols	.DWG / .PDF
6. coh_cp_general_notes	COH Standard General Notes	.DWG / .PDF
7. coh_non_cp_cover_sheet	Non-CP/Private Cover Sheet	.DWG / .PDF
8. coh_non_cp_title_block	Non-CP/Private Title Block	.DWG / .PDF
9. coh_telecomm_cover_sheet	Telecommunication Cover Sheet	.DWG / .PDF

END OF CHAPTER

City of Houston

Design Manual

Chapter 4

PLATTING REQUIREMENTS

Chapter 4

PLATTING REQUIREMENTS

4.01 CHAPTER INCLUDES

- A. Coordination of platting requirements with the preparation of project drawings and specifications and their review and approval processing.

4.02 GENERAL PLATTING REQUIREMENTS

- A. Platting requirements are found in Chapter 42 of the Code of Ordinances.
- B. Refer to Figures 4.1 and 4.2 for flow charts of the process by which plats and related documents are submitted, reviewed, and approved by Houston Public Works. There are three classes of subdivision plat: a class I plat, a class II plat and a class III plat. Class I plats and class II plats are optional and may be used in lieu of a class III plat if the subdivision plat meets the qualifications of Sec. 42-23 b and c, Division I, Article II, Chapter 42, of the Code of Ordinances. Class I and class II plats do not propose the creation of any new streets; nor propose the dedication of any easements for public water, wastewater collection or storm sewer lines. A class I plat goes through an administrative review process within the Planning and Development Department. During that review questions may arise regarding the delivery of utilities that may be directed to Houston Public Works staff.
- C. All class II and class III plats submitted to the Planning and Development Department will be routed to the Department of Houston Public Works for review.
- D. Design drawings (when required) shall be submitted to Houston Public Works with the name of the proposed plat clearly identified on the cover sheet.

4.03 DESIGN REQUIREMENTS

- A. Class III Preliminary Plat
 - 1. The level of investigation to be performed for a class III preliminary plat is to identify major development impediments to water, wastewater collection and treatment, or storm drainage that are primarily the result of constraints external to the plat itself. Such constraints include, but are not limited to:
 - a. Water Lines:
 - (1) Long dead-end water lines.
 - (2) Single feed water lines.
 - (3) Inadequate capacity or pressure to the site.

- (4) Future plans for construction of major City facilities that will impact the site.
 - b. Wastewater Collection System:
 - (1) Inadequate right-of-way or wastewater easements.
 - (2) Limited wastewater service capacity for the area.
 - (3) Future plans for construction of major City facilities that will impact the site.
 - c. Storm Drainage System:
 - (1) Drainage outfall severely under capacity.
 - (2) Encroachment into flood-prone areas or floodway.
 - (3) Storm water detention or diversions of watershed drainage that impact the property.
 - (4) Future plans for construction of major City facilities that will impact the site.
2. Houston Public Works will review class III preliminary plats and take one or more of the following actions:
 - a. Pose no objection to the plat.
 - b. Request a meeting with the applicant to discuss design and construction requirements.
 - c. Request specific additional information, easements, or improvements to the plat or the land within the purview of the department.
 - d. Request one-line drawings be submitted prior to detailed engineering drawings and final plat submittal.
3. Approval of a preliminary plat by Houston Public Works does not infer approval of proposed infrastructure. Review of infrastructure will take place upon submittal of one-line drawings, if required, which may occur after preliminary plat approval and must occur prior to final plat approval.

B. Class II and Class III Final Plat

1. Houston Public Works will review class II and class III final plats and final design drawings, easement documents, and other data. Review will be for the following items, as a minimum:
 - a. Compliance with standards contained in this Design Manual.

- b. Adequacy of service availability for:
 - (1) Water
 - (2) Wastewater
 - (3) Storm sewer or storm water detention.
 - c. Other design standards of the Department of Public Works and Engineering.
- C. Comments resulting from reviews described in Paragraphs 4.03A and 4.03B will be reported to the Planning and Development Department for inclusion in CPC 101 Form.

4.04 DESIGN ANALYSIS

- A. For plats of land located inside the city limits, review of final design drawings and other documents required by Houston Public Works for final plat approval will address the following:
- 1. Resolution of conflicts with existing and proposed utilities.
 - 2. Layout of water lines for maximum circulation of water. The pattern shall allow at least two sources of water to be constructed within the public right-of-way or permanent easement. Side lot easements shall meet the requirements of Chapter 5, Easement Requirements, and Chapter 7, Water Line Design Requirements.
 - 3. Adequate capacity in water and wastewater facilities to be utilized. The City may require a current letter of utility commitment prior to approval of a plat.
 - 4. Adequacy of drainage facilities.
 - 5. Sizing and identification/designation of easements within the plat and required easements outside the plat boundary.
 - 6. Recordation of required off-site easements or lift station sites, their depiction on the site plan, and submittal to the City of record documents.
- B. For plats of land located outside the city limits, review of final design drawings and other documents required by Houston Public Works for final plat approval will address all items in Paragraph 4.04A plus the following:
- 1. When appropriate, a letter from the municipal utility district's president or board or from the property owner stating that all off-site easements that are not immediately obtainable (for example: those crossing fee strips, rail roads, or other areas under eminent domain) are in progress and that it is the intention of the municipal utility district or property owner to complete the acquisition of such easements. The letter will be accompanied by a certified survey plat and legal description of such easements.

2. That separately platted tracts requiring service are or will be directly served by public utilities located in or abutting public rights-of-ways or permanent access easements with overlapping public utility easements.
3. That necessary contracts and documents for inside the city limit and outside the city limit are approved and signed.
4. For a plat that includes portions both inside and outside the city limits and where there will be an imminent need for utility services, a current letter of utility commitment may be required prior to approval.

END OF CHAPTER

FIGURE 4.1
CLASS III PRELIMINARY PLAT

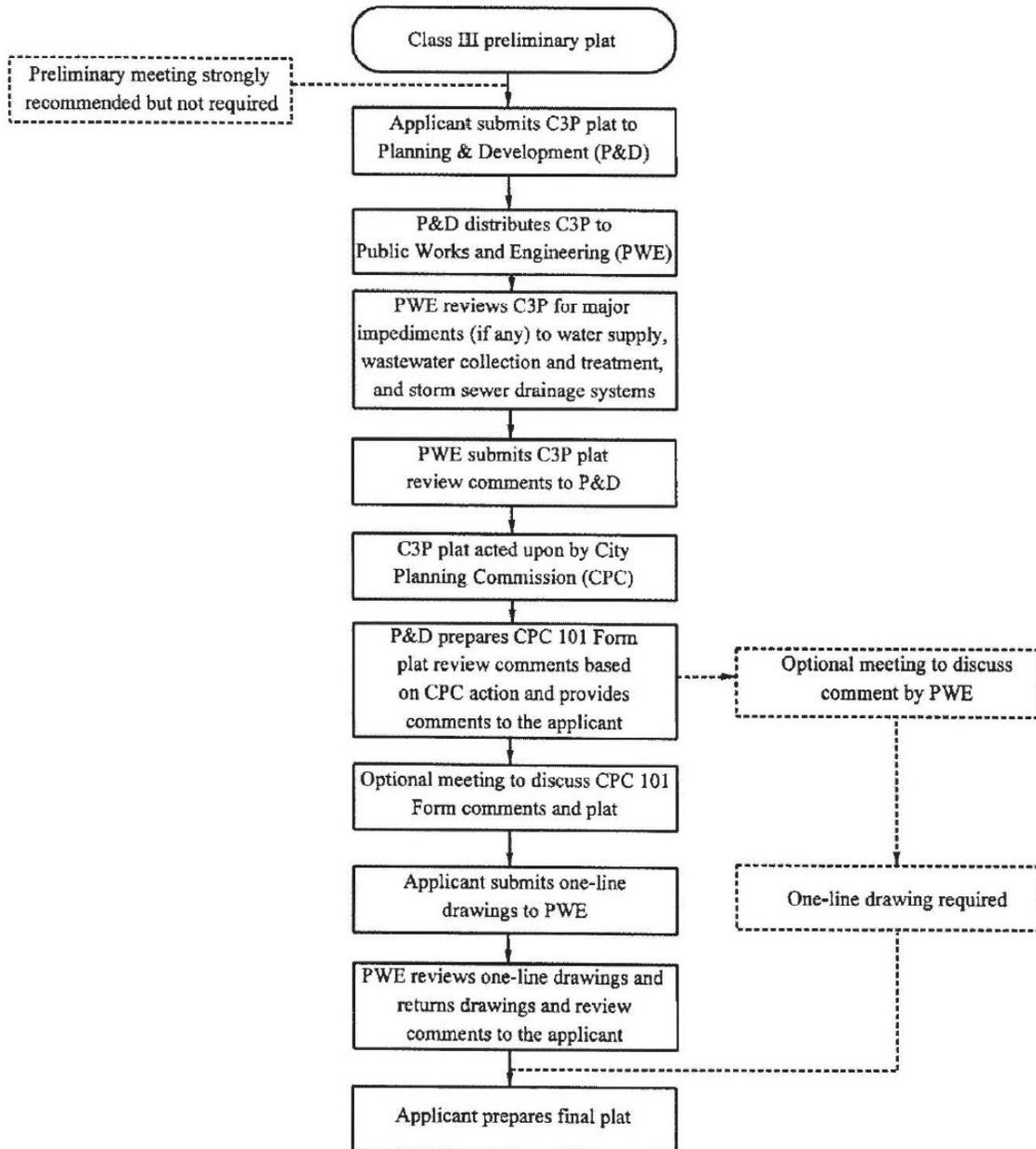
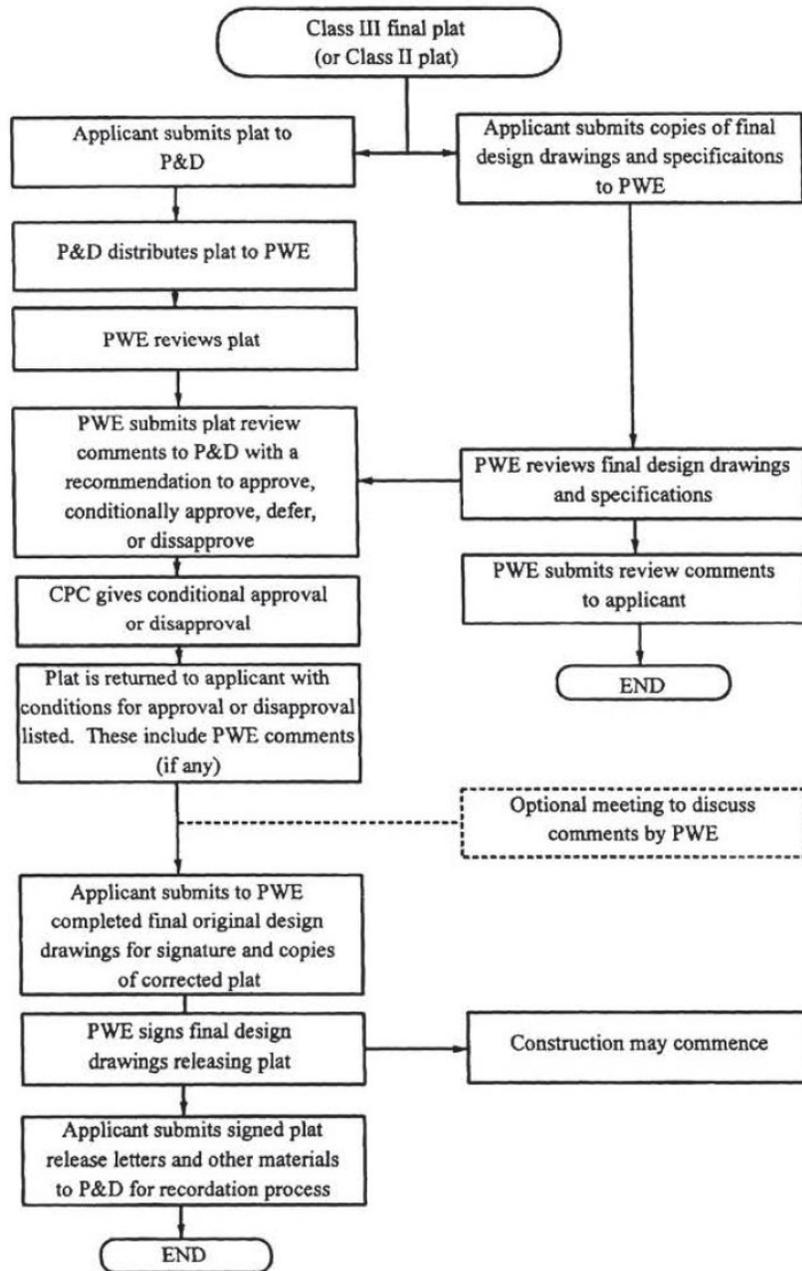


FIGURE 4.2
CLASS III FINAL PLAT (OR CLASS II PLAT)



City of Houston

Design Manual

Chapter 5

EASEMENT REQUIREMENTS

Chapter 5

EASEMENT REQUIREMENTS

5.01 CHAPTER INCLUDES

- A. Requirements for allocating and recording easements for water, wastewater, and storm drainage facilities located outside of public rights-of-way.

5.02 REFERENCES

- A. Utility Coordination Committee (UCC) for the Metropolitan Area-Typical utility location in 10-foot and 14-foot-wide easements, back-to-back lots, and perimeter lots.

5.03 DEFINITIONS

- A. Easements-Areas set aside for installation and maintenance of utilities by public and private utility operators.

5.04 DESIGN REQUIREMENTS

- A. Where public utilities are located in, along, across or adjacent to private drives, private streets or permanent access easements in platted single family residential lot subdivisions; such drives, streets or easements shall have an overlapping public utility easement to provide access and maintenance rights. Public utility easement rights shall be superior to permanent access easement rights allowing the City ingress and egress for maintenance of utilities.
- B. Easements for electrical and gas lines must comply with requirements of the UCC and are not covered under this Design Manual.
- C. Easements are to be defined and submitted as part of the recordable plat either shown on the plat or by metes and bounds description. The process for recording the plat is described in Chapter 4, Platting Requirements.

5.05 QUALITY ASSURANCE

- A. Recordable plats and metes-and-bounds descriptions of easements must be prepared under the direction of a Professional Surveyor. The surveyor must seal, sign, and date documents prepared under his supervision.

5.06 PLAT AND EASEMENT REQUIREMENTS

- A. Requirements for Platted Easements.

1. For construction inside city limits, submit a copy of the final plat accompanied by a CPC 101 Form together with the original engineering drawings for approval and signatures.
 2. For construction outside city limits but within Houston's ETJ.
 - a. Where no easements are required outside the plat boundary, follow the same requirements as for plats inside city limits given in Paragraph 5.06A.1.
 - b. Where easements are to be dedicated outside the plat boundary or through property under different ownership, follow the instructions in Paragraph 5.06A.1 for plats inside city limits and the additional requirements following:
 - (1) Submit a copy of the recorded instrument creating the easement or a metes-and-bounds description and a map of the easement, along with a letter from the Municipal Utility District Board or property owner stating the intent to obtain or dedicate necessary easements. The instrument shall be recorded prior to recordation of the plat.
 - (2) All off-site easements necessary to serve a proposed development must be shown on the face of the plat, or an acceptable reference tie between the plat and easements must be established between the two documents. Off-site easements must be recorded prior to recordation of the plat.
- B. Requirements for Easements Dedicated to the Public or to the City. Easements required for construction of a proposed project must be approved and accepted prior to approval of final design drawings or issuance of a permit for the proposed construction.
- C. Additional Requirements for Easements Dedicated to the City:
1. Easements shall be either a part of the dedication on the plat of a subdivision, dedicated to the City on standard forms provided by the City for that purpose, or on forms approved by the City Attorney.
 2. The person seeking to dedicate an easement to the City shall furnish the City with a Metes & Bounds description and map, signed and sealed by a Texas Registered Professional Land Surveyor, showing the easement and its location.
 3. A construction permit will be granted upon acceptance by the City of recordable instruments dedicating the easements.

5.07 DESIGN REQUIREMENTS

A. Easements for Water Lines and Appurtenances.

1. Water Lines:

- a. When outside a public street right-of-way or permanent access easement with overlapping public utility easements, easements must be dedicated and restricted for water lines only.
- b. When possible, easements should be contiguous with public rights-of-way. For water line located not adjacent to public rights-of-way shall have a minimum water easement width equal to twice the water line diameter plus the depth of the water line from natural ground or final ground elevation, whichever is greater; but not less than 20 feet on water line across open country (acreage) or commercial reserve.
- c. Provide all-weather access for water line easements not contiguous with public right-of-way.
- d. For water lines located outside of the public right-of-way:
 - (1) The easement shall be contiguous to the street right-of-way, or contiguous to a public utility easement that is contiguous to the street right-of-way.
 - (2) The minimum width of easement for lines 12 inches in diameter and smaller shall be 10 feet, and for lines 16 inches in diameter and larger shall be 20 feet.
- e. For water lines located inside of public right-of-way, less than 5 feet from right-of-way lines, the outside edge of a water line easement shall be located from the right-of-way line as follows:
 - (1) 12-inch diameter and smaller - minimum 5 feet
 - (2) 16-inch diameter and larger - minimum 10 feet
- f. Water lines along State rights-of-way shall be installed outside of the right-of-way in a separate contiguous easement. Width of easements shall be as provided in Paragraph 5.07.A.1.d.
- g. No backlot easements will be allowed for the installation of water lines.
- h. Commercial developments inside the City and in the ETJ requiring on-site fire hydrants must provide a minimum 20-foot water line easement for the water lines and fire hydrants.
- i. Water Lines shall be located in the center of the easement, where feasible.
- j. When using side lot easements, such easements shall be a minimum of 20 feet in width, located on one lot or centered between two lots. If centered between two lots, the water line may be centered within the 10 feet of one lot, or centered in the easement.

2. Fire Hydrants:
 - a. Use a minimum 10-foot by 10-foot easement for fire hydrants located outside of public rights-of-way.
 - b. Do not locate fire hydrants in 10-foot-wide water line or water meter easements.
 3. Meters and Valves:
 - a. Two-inch and smaller meters and shut-off valves (stop boxes) shall be set within public rights-of-way or water line easement if possible. Otherwise, they shall be set in 5-foot by 5-foot water meter easements contiguous with public right-of-way.
 - b. The minimum size of water meter easements contiguous with public right-of-way for three-inch through six-inch meters shall be 10-feet by 20-feet and for eight-inch and larger meters shall be 15-feet by 25-feet.
 - c. Water meter easements shall be located contiguous with public rights-of-way unless approved by the City. Access easements a minimum of 15 feet wide will be required when not contiguous with a public right-of-way.
- B. Easements for Wastewater Lines and Appurtenances.
1. Wastewater Collection Lines:
 - a. Easements adjacent to public rights-of-way, easements, or fee strips, including those owned by HCFCD, CenterPoint Energy, and pipeline companies.
 - (1) Easements for sanitary sewers 10 inches or less in diameter shall have a minimum width of 15 feet or a minimum width equal to the depth of the proposed sewer, whichever is greater.
 - (2) Easements for sanitary sewers 12 inches or greater in diameter shall have minimum width of 20 feet or a minimum width equal to the depth of the proposed sewer, whichever is greater.
 - (3) Easements for sanitary sewers 24 inches or greater in diameter that are to be installed by trenchless method of construction shall have a minimum width of 20 feet.
 - b. Sanitary sewer easements or other combined easements for sanitary sewers which meet the conditions below shall have a minimum width equal to twice the sewer's diameter plus the flow line depth of the sewer from natural ground, proposed fill elevation, or 100-year Floodplain Fill Elevation, whichever is greater; but not less than 25 feet. The qualifying conditions are:
 - (1) Runs through commercial reserves or across open country (acreage);

- (2) Serves other existing or proposed platted commercial reserves or non-platted acreage tracts; and
 - (3) Is not immediately adjacent to public rights-of-way, easements, or fee strips, including those owned by HCFCD, CenterPoint Energy, and pipeline companies.
 - c. Sanitary sewers shall be located in the center of the easement, where feasible.
 - d. Sanitary sewers less than 20 feet deep, which cannot be located in the center of easements shall be located a minimum distance of half the depth from the nearest side of the easement.
 - e. Sanitary sewers or force mains, installed in easements separated from public or semi-public rights-of-way by other private or utility company easements, shall be extended along or across the private utility company easement to provide access for maintenance of the sewer or force main.
 - f. Easements described in Paragraphs 5.07B.1.a through 5.07B.1.e shall be open-ended easements in conformance with City Codes, Ordinances and Planning Requirements. Such open-ended sanitary sewer easements shall be extended if necessary and shall be fully connected at both ends to public facilities including existing or proposed:
 - (1) Public road rights-of-way
 - (2) Wastewater treatment plant sites
 - (3) Wastewater pump station sites
 - (4) Public utility easement of adequate size for maintenance access.
2. Force Mains:
 - a. Force mains of all sizes shall have a minimum easement width of 20 feet for single lines which are not located adjacent to public or semi-public rights-of-way.
 - b. Force mains located in easements adjacent to public or semi-public rights-of-way shall have a minimum easement width of 10 feet subject to location and depth of the force main.
3. Service Leads: The minimum easement for building service leads is 6 feet.

C. Storm Drainage Lines and Appurtenances

1. Storm Sewer Lines:

- a. To the extent practical, storm sewers shall be placed in public road rights-of-way or permanent access easements with overlapping public utility easements in accordance with Chapter 6, Utility Locations.
- b. Storm sewers shall have a minimum 20-foot-wide easement. In the event of extreme depth or large sewers, additional width may be required to allow for proper maintenance operations.
 - (1) Maintenance operations require an easement width equal to the storm sewer width plus the depth rounded up to the nearest multiple of 5-feet.
- c. Storm Sewers shall be centered within the limits of the easement.

2. Storm Water Detention Basins:

- a. Easements for storm water detention basins shall be dedicated by plat or by separate instrument filed in conjunction with plat approval. Such easements shall be dedicated to the developer, owner, or water district.
- b. Such easements shall have a minimum 20-foot width for private basins surrounding the perimeter of the detention basin as measured from top of bank unless adjacent to a street right-of-way.

D. Easements for Combined Storm and Sanitary Sewer

1. Combined storm and sanitary sewer easement widths shall be as specified in 5.07C.1.b for storm sewer lines. The centerlines of sanitary sewer mains, trunks, or force mains shall be located in at least half the width of the easements defined in Paragraph 5.07B.1, but not less than 10 feet from the edge of the easement.
2. The centerline of sanitary sewers on the outside of combined storm and sanitary sewer easements adjacent to public or semi-public rights-of-way, shall be located in at least half the width of the easement defined in Paragraph 5.07B.1.d, but not less than 10 feet from the outside edge of the easement.

E. No variances will be approved by the City Engineer unless there are extenuating circumstances.

END OF CHAPTER

City of Houston

Design Manual

Chapter 6

UTILITY LOCATIONS

Chapter 6

UTILITY LOCATIONS

6.01 CHAPTER INCLUDES

- A. Location of utilities in rights-of-way and easements.

6.02 REFERENCES

- A. Typical utility location in 10-foot-wide and 14-foot-wide easements in back-to-back lots and perimeter lots as detailed in the most current drawing prepared by the Uniform Color Code (UCC).
- B. Typical utility locations within City rights-of-way.

6.03 DEFINITIONS

- A. Easements - Areas set aside for installation and maintenance of utilities by public and private utility companies.
- B. Private Utilities - Utilities belonging to, operated, and maintained by private entities.
- C. Public Utilities - Utilities belonging to, operated, and maintained by public entities
- D. Right-of-Way - Public property dedicated or deeded to a municipality for the purpose of public use.
- E. Storm Sewer Lines - Closed gravity (non-pressure) conduits designed to collect and transport storm water from inlet locations to an open conduit outfall, ditch, creek, stream, bayou, river, holding pond, or bay. Inlets are surface mounted basins designed to collect and funnel storm water to the collection system. Storm sewers from the inlets to the collection system are usually defined as inlet leads.
- F. Water Lines - Closed conduits designed to distribute potable water for human consumption and to provide fire protection. Line size and fire protection accessory locations are dependent on distance from primary source and quantity demand.
- G. Wastewater Sewer Lines - Closed conduits designed to collect and transport wastewater from residential, commercial, and industrial sites to plants for treatment prior to discharge into open conduits. Wastewater lines may be designed as gravity (non-pressure) flow lines or force (pressure) mains. Gravity flow lines usually fall into three categories in ascending size from service line to lateral line to main line. Service lines (source of wastewater) may discharge into a lateral line or main line.

6.04 DESIGN REQUIREMENTS

- A. Whenever practical, locate public storm sewer, wastewater collection lines, water mains, and appurtenances within public rights-of-way in the manner described by this and corresponding subject-specific chapters in this manual, as well as related details and specifications.
- B. Research and resolve known conflicts of proposed utilities with existing utilities according to subject-specific criteria developed by the utility owner(s).
- C. Locate back lot utilities in compliance with UCC recommendations.
- D. Identify all existing and proposed utilities and related appurtenances in the manner established by the subject-specific chapters in this manual.

6.05 SUBMITTALS

- A. Submittals are to be made according to the criteria established by the utility owner(s).

6.06 QUALITY ASSURANCE

- A. All existing utilities must be shown on project drawings. Sources of data include survey, record drawings, graphical information systems, and field visits. Field visits must be made to verify the project drawings accurately portray the existing conditions.

6.07 DESIGN

- A. Back Lot Utilities: Identify type of electrical service and select the appropriate width of the easement. For mixed overhead and underground service select the 14-foot-wide easement to provide versatility.
- B. No Utilities Lines on City of Houston Bridges

No Utility lines shall be placed on or attached to a City of Houston bridge without approval of the City Engineer. Approval shall be based on submittal of study of all alternatives resulting in no viable option.

- C. Water Lines.
 - 1. Water lines may be located within a public right-of-way, within a permanent access easement with overlapping public utility easements, within a dedicated easement adjacent to and contiguous with the right-of-way, or within separate dedicated water line easements, to meet the requirements of this manual. Water lines and related appurtenances shall be as specified in the subject-specific chapter(s) in this manual, as well as related details and specifications.

2. Water lines shall not be located in combination easements without approval of Houston Public Works. Water line easements shall not be combined with wastewater sewer easements.
3. Water lines, with the exception of transmission lines, shall be located within the right-of-way between the property line and back of curb or in a dedicated easement adjacent to and contiguous with the right-of-way.

D. Wastewater Lines.

1. Wastewater lines shall be located in a public right-of-way, within a permanent access easement with overlapping public utility easements or within a dedicated easement adjacent to the public right-of-way. Side lot easements may be used when required. Backlot easements shall not be utilized except in cases of pre-existing conditions and with approval of the City. Wastewater, force mains, and related appurtenances shall be as specified in the chapter (7, 8, and 9) in this manual, as well as related details and specifications.
2. Wastewater trunk or collector mains shall not be located in side lot easements without approval of the City.
3. Wastewater gravity sewer trunks, collector mains, and force mains shall be generally located on the opposite side of the right-of-way from the water main.
4. Wastewater force mains are generally located within the right-of-way between the property line and the back of curb, or in a dedicated easement adjacent and contiguous with the right-of-way.
5. When wastewater or force mains are parallel to the storm sewer, they shall not be constructed in the same theoretical trench widths.

E. Storm Water Lines.

1. Storm water lines shall be located within public rights-of-way, within a permanent access easement with overlapping public utility easements or approved easements. Approval of the location for storm water lines should be obtained from Houston Public Works prior to plan preparation.
2. Coordinate the proposed storm sewer alignment with water line location and future pavement widening.

F. Private Utility Lines.

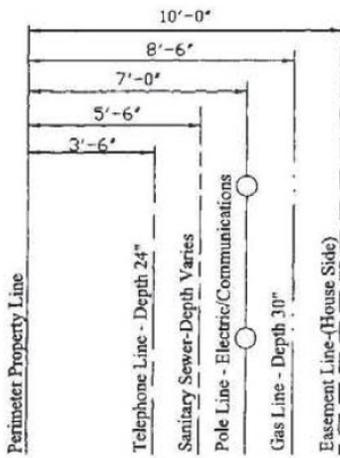
1. A minimum of three (3)-feet horizontal clearance when parallel, and two (2)-feet vertical clearance when crossing, shall be observed between the exterior of all private

utilities and public utilities, unless a greater clearance is required as stated in other portions of this design manual and/or related specifications or details.

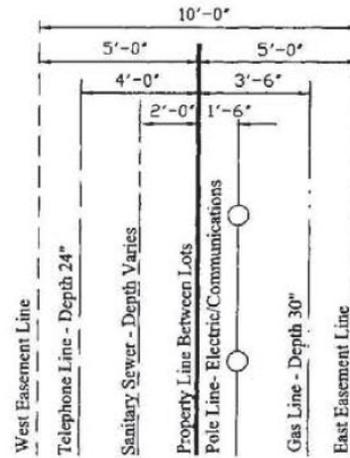
2. Structures shall not be imbedded within sidewalks.
3. All proposed work must be coordinated with the City of Houston Capital Improvement Program.
4. Above-ground utility structures and appurtenances shall have a minimum of three (3)-feet horizontal clearance from the right-of-way.

END OF CHAPTER

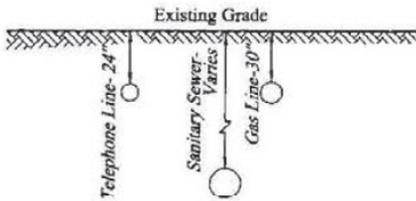
FIGURE 6.1
TYPICAL UTILITY LOCATIONS IN 10-FOOT-WIDE
RESIDENTIAL EASEMENT



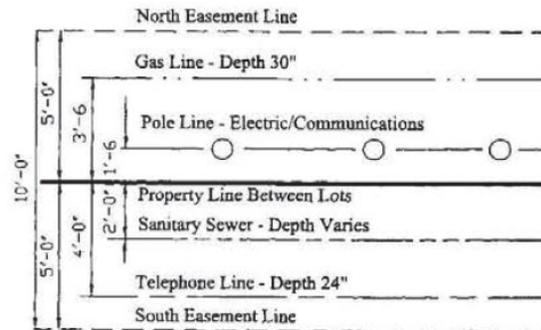
PERIMETER EASEMENT



BACK-TO-BACK EASEMENT



TYPICAL INSTALLATION
DEPTHS

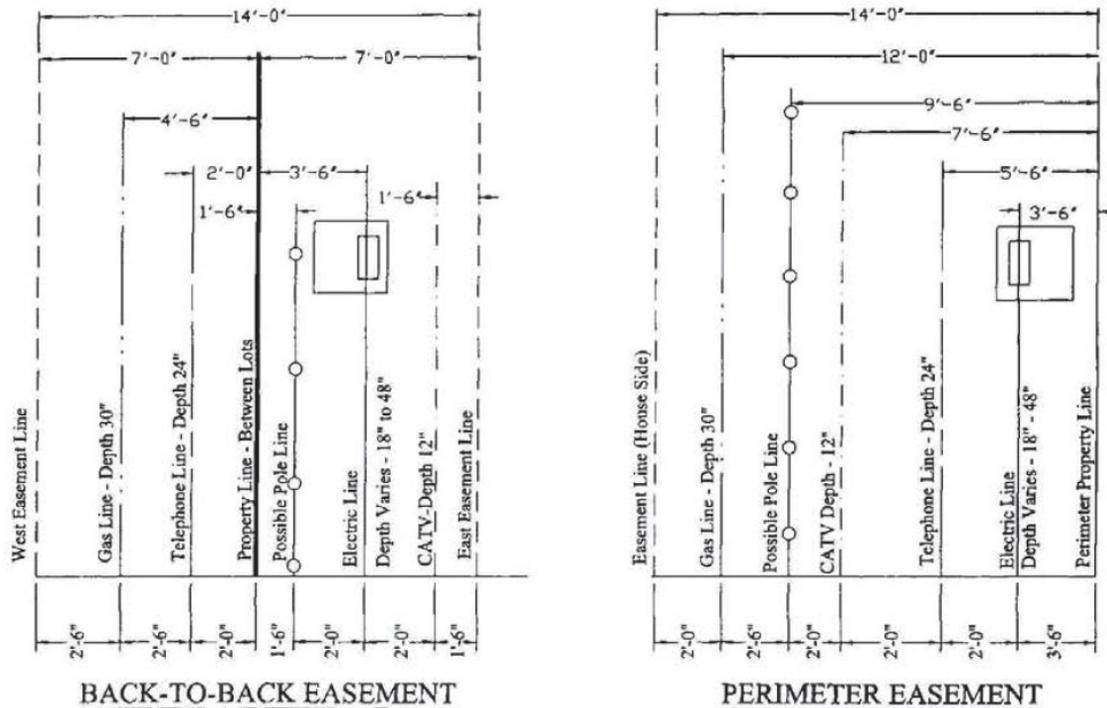


BACK TO BACK EASEMENT

NOTES:

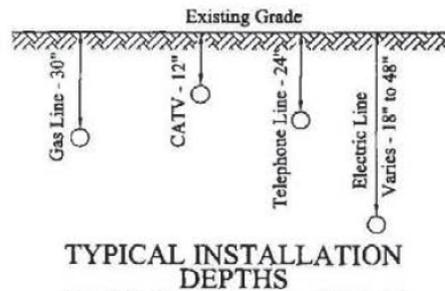
- (1) Utilities are normally installed as shown but depth may vary due to fill or cut by others.
- (2) Maintain minimum 4" clearance between utility lines extending from easement to house/building.
- (3) Flexible base shall be 8" minimum hot mix asphaltic concrete (hmac).

FIGURE 6.2
TYPICAL UTILITY LOCATIONS IN 14-FOOT-WIDE
RESIDENTIAL BACKLOT EASEMENT
(NO BACKLOT SEWER)



NOTES:

- (1) Utilities are normally installed as shown, but depth may vary due to fill or cut by others.
- (2) Maintain minimum 4" clearance between all utility lines extending from easement to house/building.
- (3) Always exercise extreme caution when digging in utility easements and on or across customer's property, because service lines extend from easement to house.
- (4) 10' Utility Easements may be granted if approved by the Utilities and City Council.



City of Houston

Design Manual

Chapter 7

WATER LINE DESIGN REQUIREMENTS

Chapter 7

WATER LINE DESIGN REQUIREMENTS

7.01 CHAPTER INCLUDES

- A. Criteria for the design of water lines.
- B. Criteria for 24-inch and larger water lines are in Appendix A of this Chapter.

7.02 REFERENCES

- A. American Water Works Association (AWWA).
- B. National Sanitation Foundation (NSF).
- C. Uniform Plumbing Code
- D. Refer to the list of references in Chapter 1, General Requirements.

7.03 DESIGN REQUIREMENTS

- A. Obtain approval from the Office of the City Engineer (OCE) for exceptions or deviations from these requirements. Exceptions or deviations may be granted on a project-by-project basis.
- B. Lines.
 - 1. Locate water lines within street rights-of-way, permanent access easements with overlapping public utility easements, easements adjacent to street rights-of-way, or recorded water line easements:
 - a. Pipe with 2-inch diameter is allowed only in rehabilitation projects where tie-ins to existing 2-inch lines are necessary.
 - b. Pipe with 4-inch diameter may be used within cul-de-sacs (permanent dead end) less than or equal to 200 feet in length.
 - c. Pipe with 6-inch diameter may be used if the line is less than 1000 feet in length and interconnected between 2 lines which are 8-inch diameter or larger, or if the 6-inch line terminates in a cul-de-sac or dead end street and meets the additional rule of this chapter. Only one fire hydrant or flushing valve is allowed on any length of 6-inch diameter line.

- d. Use minimum 8-inch diameter pipe for lines over 1000 feet long or when 2 or more fire hydrants or flushing valves are required.
- e. Pipe sizes are determined by the Professional Engineer and approved by the City. A minimum of 12-inch diameter pipe shall be used when parallel to a Railway Transit corridor for more than 300 feet.
- f. Dead-end lines within public right-of-way:
 - (1) In temporary dead end situations the water line shall be 6-inch diameter or larger, shall not exceed more than 200 feet in length from the closest interconnection water line, and shall terminate with a fire hydrant or blowoff valve. The terminus of the line shall end with a plug and clamp. The fire hydrant or blowoff valve shall be located considering adequate drainage to avoid flooding during flushing.
 - (2) In permanent dead ends situations the water line shall be 6-inch diameter or larger, shall not exceed more than 500 feet in length from the closest interconnection water line and shall terminate with a fire hydrant or blowoff valve. The terminus of the line shall end with a plug and clamp. The fire hydrant or blowoff valve shall be located considering adequate drainage to avoid flooding during flushing.
 - (3) Water lines within cul-de-sac:
 - (a) Reduce pipe sizes successively. Carry 8-inch and/or 6-inch and/or 4-inch diameter pipe in accordance with requirements found in paragraph 7.03. The water line shall terminate with a fire hydrant and/or blowoff valve. Carry 6-inch diameter pipe to the last fire hydrant. If the water line continues beyond the last fire hydrant, use 4-inch diameter pipe to end the water line. The water line shall terminate with a standard 2-inch blowoff valve and box at the end of a 4-inch diameter water line. Place last service as near as possible to the end of water line. The fire hydrant and/or blowoff valve shall be located considering adequate drainage to avoid flooding during flushing. The terminus of the line shall end with a plug and clamp.
 - (b) Use following alternate if approved or requested by OCE.
 1. Extend water line along both sides of the street and loop (connect both lines within the cul-de-sac turnaround).
 2. The diameter of the looped water line shall be of the same size as the diameter of water line perpendicular to the cul-

de-sac. The diameter of the water line shall not exceed 8-inch within the cul-de-sac without approval from OCE.

3. Discontinue water line along perpendicular street between entry and exit locations of the looped water line so that water flow will occur down one side of cul-de-sac street and up the other side without disrupting the continuity of water flow.
4. Fire hydrants to be spaced as if only a single line existed.
5. Alternatively, extend water line to an adjacent cul-de-sac under the following conditions:

- a. Obtain a separate 20-foot wide water line easement.

- b. Install water lines inside a continuous steel casing pipe. Extend the casing uninterrupted from R.O.W. to R.O.W. No horizontal or vertical deflections or connections are allowed. Construct encased water line of restrained joint bell and spigot pipe to prevent lateral movement. Provide casing spacers and end seals in accordance with Standard Specifications.

- c. Obtain approval from OCE.

- g. Install water lines that are located in side lot easements inside a continuous steel casing pipe. Extend the casing uninterrupted from R.O.W. to R.O.W. Diameter of pipe shall not exceed 12 inches. Provide isolation valves within 100 feet of each end. No horizontal or vertical deflections or connections are allowed. Construct encased water line of restrained joint bell and spigot pipe to prevent lateral movement. Provide casing spacers and end seals in accordance with Standard Specifications.
- h. Offsets through intersections shall span the width of the intersection whenever practical.
- i. The water line alignment shall have the minimum number of bends and appurtenances as is reasonable for the project scope.
- j. Restrained joint calculations shall be utilized at all such locations governed by Best Practices and shall be provided to the City upon request.

C. Location, Depth of Cover, and Separation Requirements

**Table 7.1
WATER LINE LOCATION WITHIN A STREET RIGHT-OF-WAY**

RIGHT-OF-WAY WIDTH & EXISTING OR ANTICIPATED CURB FACE TO FACE PAVING WIDTH	8" & SMALLER^{(1) (2) (4)}	12" THRU 20"^{(1) (2) (4)}
100-FOOT ROW (ALL STREETS):	8 feet	7 feet
80-FOOT ROW (ALL STREETS):	7 feet	6 feet
60-FOOT ROW:		
MAJOR THOROUGHFARE: 44 feet	5 feet	5 feet
COMMERCIAL, SCHOOL, PARK 40 feet	7 feet	6 feet
RESIDENTIAL: 27 feet	12 feet ⁽³⁾	12 feet ⁽³⁾
50-FOOT ROW:		
ALL STREETS: 35 feet	5 feet	5 feet
ALL STREETS: 27 feet	7 feet	7 feet

⁽¹⁾ The number listed below is the maximum allowable distance from the right-of-way to the nearest outside diameter of the proposed water line.

⁽²⁾ The minimum distance from the right-of-way to the nearest outside diameter of the proposed water line shall be 5 feet without a water line easement adjacent to the rights-of-way (see easement requirements for less than 5 feet).

⁽³⁾ Investigate the possibility of a future 35-foot face-to-face curb-and-gutter section to replace existing streets with roadside ditches.

⁽⁴⁾ The maximum and minimum distance from the right-of-way shall be applied in such a way as to preserve room in the right-of-way for future expansions and relocations, to the extent possible.

1. Boulevard streets: When necessary, water lines may be located within the esplanade. The lines should be located as near the centerline of street right-of-way as possible to avoid conflict with future pavement widening.
2. Locations within an easement: Locate water lines 12-inch diameter and smaller in the center of a 10-foot minimum width dedicated water line easement and water lines 16-inch diameter and larger in the center of a 20-foot minimum width dedicated water line easement. Do not locate lines 16-inch diameter and larger in side lot easements. For location within side lot easements, see Chapter 5, Easement Requirements. Obtain approval from OCE for lines to be located in wider or multi-use easements.
3. When a water line and appurtenances is placed parallel or adjacent to another utility line, other than a sanitary sewer, and is located above the other utility, water lines and appurtenances shall have a minimum of 4 feet horizontal clearance from outside wall to outside wall of the other utility.

4. Water lines and their appurtenances shall have minimum horizontal clearance of 4 feet as measured from each outside wall, to adjacent utilities, other than sanitary sewer.
5. When a water line is to be placed parallel to a railway corridor, maintain minimum 30 feet horizontal clearance from centerline of nearest outside track rail.
6. Do not place water line appurtenances in flow lines of the roadside ditches. The nearest outside diameter of any water line shall be no closer to a building line, building foundation or building slab than 10 feet for water lines 12 inches in diameter and smaller and no closer than 15 feet for water lines 16 inches in diameter and larger.
7. Depth of cover
 - a. Provide the following minimum depths of cover from the top of curb for curb-and-gutter streets or from mean elevation of the nearby ditch bottom and the nearby right-of-way for open-ditch section:

**Table 7.2
DEPTH OF COVER FOR WATER LINES**

SIZE OF LINE	DEPTH OF COVER		ABSOLUTE MINIMUM
	TOP-OF-CURB	OPEN-DITCH SECTION	
12-INCH & SMALLER	4 feet ⁽²⁾	5 feet	3 feet ⁽²⁾
16-INCH	5 feet ⁽²⁾	6 feet	3 feet ⁽²⁾
20-INCH	6 feet	8 feet	4 feet ^(1,2)

⁽¹⁾ Cement stabilized embedment required.

⁽²⁾ Minimum 6 feet of cover where crossing railway

- b. Whenever possible, changes in grade or alignment to clear utilities or underground features should be accomplished by deflecting the pipe joints. The use of regular bends for any change in grade will not be allowed without prior approval from OCE for variance.
- c. No vertical or horizontal offsets or bends allowed for water lines in casings.
- d. Use restrained joint pipe for lines 20-inch diameter and smaller with less than 4 feet or more than 8 feet of cover. The following direct bury alternates may be used:
 - (1) Ductile iron pipe pressure 250 psi with approved restrained joints.

- (2) PVC pipe with integral restrained joint system, or ductile iron restrained joints fittings, epoxy lined and coated. Use AWWA C900 DR 18 for PVC restrained joints. Use 250 psi AWWA C900 DR 14 for vertical offsets.
- (3) Use only ductile iron and PVC products listed on OCE approved products list and/or in accordance with City Standard Specifications.

D. Appurtenances

1. Do not place appurtenances under pavement.
2. Valves
 - a. Spacing - set at maximum distances along the line as follows:
 - (1) 4-inch through 12-inch diameter - 1000 feet.
 - (2) 16-inch and 20-inch diameter - 2000 feet.
 - b. Location:
 - (1) Normally, locate valves at street intersections along the street right-of-way lines projected across the water line. Tapping sleeves and valves are excluded from this requirement. Maintain a minimum of 30 feet from the centerline of the outside rail. Do not propose valves inside ramps or at curb.
 - (2) Isolate fire hydrants and flushing valves from the water line with a valve located in the fire hydrant or flushing valve branch. This valve shall not be located in the slope or flow line of roadside ditches.
 - (3) Intermediate valves, not located on the projection of the right-of-way line, shall be located on lot lines or 5 feet from fire hydrants but not set in driveways.
 - (4) Locate valves a minimum of 9 feet horizontally from sanitary sewer crossings and 4 feet horizontally from other utilities crossings.
 - (5) Valves located near reducers shall be located on the smaller diameter pipe.
 - (6) Provide flanged outlet and mount isolation valve directly on the flange on any branches to larger diameter water line.
 - c. Valve Type (Unless otherwise specified):
 - (1) 20-inch and smaller - Gate valves.
 - (2) Gate valves should be used for all meter installation.

- d. Number of Valves:
 - (1) Total number of valves at any water line intersection shall equal total number of lines leading out from the intersection point minus one, three valves for a cross, and two valves for a tee for 20-inch diameter lines and smaller.
3. Fire Hydrants and Flushing Valves

Fire hydrants should be designed to maintain sufficient water pressure for service to adequately protect public safety in residential area. The system must also be designed to provide fire fighting capability to maintain a minimum pressure of 20 psi under combined fire and drinking water flow conditions. The minimum fire flow for the residential area should be 1,500 gpm.

 - a. Spacing:
 - (1) Single-family residential development - 500-foot maximum spacing.
 - (2) All other developments - 350-foot maximum spacing.
 - b. Location in or along street right-of-way:
 - (1) Locate fire hydrants primarily at street intersections.
 - (2) Locate fire hydrants at PCS of the intersection curb radius, 3 feet behind curb or projected future curb.
 - (3) On streets with roadside ditches, set the fire hydrants within 5 feet of rights-of-way lines.
 - (4) Set intermediate fire hydrants on lot lines, as extended to pavement, when located between right-of-way intersections. These locations may be adjusted 5 feet either way to avoid driveways or obstructions. In either case, do not locate fire hydrants closer than 3 feet from curbed driveways or 5 feet from non-curbed driveways.
 - (5)
 - a. Fire hydrants may be set in the esplanade section of City streets when locations at back of curbs are not feasible. In such cases, the preferred location is 7 feet behind back of curb to provide access for parkway mower. In no instance shall the fire hydrant be closer than 3 feet from back of esplanade curb or closer than 10 feet from esplanade nose.
 - b. Fire hydrants shall not be located between parallel adjacent Rail Tracts in Railway Transit Corridor.
 - (6) For commercial building with fire service connections, place additional fire hydrant on the same side of the street as wet and dry connections. This hydrant is not counted in fire hydrant spacing.

- c. Location of fire hydrants or flushing valves outside and adjacent to street rights-of-way:
 - (1) The City Fire Marshall will establish and approve the location of fire hydrants and flushing valves in apartment complexes, platted private street developments, and other multi-family developments within the City.
 - (2) Locate fire hydrants and flushing valves in protected, easily-accessible areas behind curb lines.
 - (3) For fire hydrants or flushing valves which are located adjacent to water lines for fire protection constructed in 10-foot wide water line easements, the fire hydrant or flushing valve shall be centered in a minimum 10-foot by 10-foot separate easement.
 - d. For commercial developments inside the City and ETJ, provide isolation valves at each end of fire loops requiring on-site fire hydrants.
 - e. Fire hydrants shall be designed to have a 4-foot bury where possible. As a normal policy bends or offsets in fire hydrant branch will not be allowed. Bends may be used to maintain a 4-foot bury or to maintain 3-foot back of curb with prior approval from OCE. In case of conflict DIP fire hydrant leads may be used for a minimum of 3-foot of bury.
4. Fittings
- a. Normally use "all bell" (designated AB) for fittings. Properly designed thrust blocks shall be provided for each AB fitting for diameters 12-inch and smaller.
 - b. Provide fittings with approved restraint joints for diameters 16-inch and larger. Provide fittings with approved restraint joints for all diameters when crossing a railway. Provide calculations to determine limits of restrained joints for diameters 16-inch and larger. Show length of restrained joints on drawings in the profile view.
 - c. At dead end, use plugs with retention clamps and carrying the designation "plug and clamp" For 12-inch and smaller lines. Provide thrust blocks at end of plug, with polyethylene encasement as a bond-breaker between concrete blocking and pipe. For 16-inch and larger lines, use blind flanges or approved dished head plugs, and use restrained joint lengths in lieu of thrust blocking. When stubs are provided for future extensions, isolate the stub with a valve, and do not allow service connections to stub until extended.

E. Water Meter Service

1. Water meter service for lines in or along street rights-of-way. Locate in areas with easy access and with protection from traffic and adjacent to rights-of-way whenever possible. Do not locate meters in areas enclosed by fences. Obtain approval from OCE to locate meters within 30 feet from the center line of outside rail.
 - a. Meters 2 inches and smaller and Shut-off valves (stop boxes): Locate in rights-of-way, water line easements, or in a minimum 5-foot by 5-foot separate water meter easement contiguous with public right-of-way. Provide concrete meter boxes for meters located under sidewalks.
 - b. Meters 3 inches to 6 inches: Locate in minimum 10-foot by 20-foot separate water meter easement contiguous with public right-of-way. Provide Plan and Profile for OCE approval.
 - c. Meters 8 inches and larger: Locate in minimum 15-foot by 25-foot separate water meter easement contiguous with public right-of-way. Provide Plan and Profile for OCE approval.
 - d. Separate tap and service lead shall be designed for each domestic meter. Meter, line size, and appurtenances shall conform to the latest edition of the Uniform Plumbing Code.
 - e. All water meters must have the same size as of the service lines except 4-inch and 12-inch diameter service lines shall be installed for 3-inch and 10-inch water meters.
 - f. Irrigation meters are to be branched off the domestic service.
 - g. Double detector check valves allowed for use on un-metered fire lines for closed type systems in accordance to the City of Houston Ordinance Chapter 47.
 - h. 3 inches and larger meters set in right-of-way or any placement other than the dedicated easement will require approval from the OCE.
 - i. Meters larger than 10 inches, or applications in potential hazardous chemical environs must be installed in an above ground meter installation assembly.
2. Refer to Submittals Paragraph 7.04, and Drawings Paragraph 7.07 of this Chapter, for approval and drawing requirements for meter service leads 4-inch diameter and larger, and metered sprinkler connections.

3. For proposed apartments or townhomes in private street developments, provide one master meter sized for the entire development. Exceptions may be granted by OCE. If an exception is approved, do not interconnect multiple meters.
4. Provide a dedicated water main easement for commercial developments with on-site water mains (for fire protection) or, provide fire service meters adjacent to the public right-of-way. If a dual feed is desired, both feeds shall be metered. An above-ground, reduced pressure, zone-type backflow preventer shall be installed on the water line downstream from the meters.
5. Do not install stub outs for future water services.
6. The water meter report and survey shall be reconciled to verify that all meters are shown on the Drawings. Meters larger than 2-inch shall be called out and require connections to be designed.

F. Water Line Crossings

1. Public and private utility crossings other than sanitary sewer: Where a water line crosses another utility other than a sanitary sewer, a minimum of 6 inches of vertical clearance must be maintained between the outside wall of the water line and the outside wall of the utility.
2. Stream or ditch crossings
 - a. Elevated crossings, general:
 - (1) Elevated crossings are preferred to underground crossings.
 - (2) Design elevated crossings with the elevation of the bottom of the water line above the low chord of the nearest adjacent bridge or a minimum 1-1/2 feet above the 100-Year Floodplain Elevation, whichever is greater.
 - (3) Water lines shall be steel pipe and shall extend a minimum of 15 feet beyond the last bend or to the right-of-way line of the crossing, whichever is greater.
 - b. Elevated crossings on existing structures:
 - (1) 12-inch diameter and smaller water lines supported on existing or proposed bridges, must meet the following criteria. Coordinate location of lines, in advance, with OCE.
 - (a) Have adequate structural capacity.
 - (b) Have sufficient clearance above bent cap elevation for installation under the bridge.

- c. Elevated crossings on separate structures:
 - (1) Use a separate elevated supporting structure for 16-inch diameter and larger water lines unless otherwise approved by OCE. Locate separate structures a minimum of 10 feet clear from other existing or proposed structures.
 - (2) Support the line on columns spaced to accommodate structural capacity of the pipeline considering deflection and loading.
 - (3) Base column support design on soil capacity, spacing, loading, and structural requirements.
 - (4) Provide sufficient span length to accommodate the cross section of future widening of the stream or ditch, if available.
 - (5) Provide appropriately sized air release valves at the highest point of the water line.
 - (6) Provide pedestrian pipe guards on elevated crossings.
 - d. Underground Crossings:
 - (1) Provide a minimum 5-foot clearance above top of pipe to the ultimate flow line of the ditch.
 - (2) Provide sufficient length to exceed the ultimate future development of the stream or ditch.
 - (3) Water lines shall be restrained joint pipe in casing and shall extend a minimum of 15 feet beyond the last bend or to the right-of-way line of the crossing, whichever is greater.
 - (4) No water line underneath detention pond or amenity lake is allowed.
 - (5) Water line shall be installed with an isolation valve on both sides with a 40 foot minimum clearance from the end of casing on at least one side.
3. TxDOT and County Road Crossings
- a. Extend carrier pipe from right-of-way to right-of-way.
 - b. Use restrained joint pipe in steel casing under existing and future roadway from a point 5 feet outside of the service road or outside of pavement toward the right-of-way, to a similar point on the other side of the highway across the right-of-way. For highway or roadway crossings with open-ditch sections, extend restrained joint pipe in steel casing from right-of-way to right-of-way.
 - c. Where additional right-of-way has been acquired, or is being acquired, for future widening, the restrained joint pipe in steel casing shall extend to within 10 feet of each right-of-way line.

4. Railroad Crossings
 - a. For mainline and spurline railroad crossings, the water line material shall conform to Railroad requirements and have restrained joint pipe within a steel casing which extends no less than 30 feet from the center line of the outside rails within City of Houston right-of-way, and from right-of-way to right-of-way, on railroad owned property.
 - b. Install isolation valves on each side of rail crossings.
 - c. Crossings are to be made perpendicular to rail.
 - d. Design Engineer to use a Corrosion Consultant to evaluate pipe and casing materials and the effect to and from rail systems.
5. Additional Requirements
 - a. Use electrically isolated flange joints for transitions between two dissimilar metallic pipes. Electrically isolate water lines from casing pipe and supports.
 - b. The carrier pipeline shall extend a minimum of 1 foot beyond the end of the casing to allow flanged joints to be constructed.
6. Oil or Gas Pipeline Crossings: Do not use metallic pipe when crossing oil or gas lines unless a properly designed cathodic system is implemented or casing installed with OCE approval. Other pipe may be used, regardless of depth, subject to approval by OCE. Maintain a minimum 2-foot vertical separation between the pipeline and water line.
7. On-site Fire Loops within Commercial Developments
 - a. For commercial developments inside the City and in the ETJ requesting on-site water mains, comply with the following requirements to allow maintenance and future repair operations:
 - (1) Do not allow placement of structures, paved parking or equipment pads over the easement.
 - (2) Provide 20-foot-wide longitudinal pavement joints along easement lines where the water line is located under driveway.
 - (3) Fire loops should be placed under the unpaved and porous area except crossing driveways.
 - (4) Fire loops maybe placed in the Type 2 permanent access easement meeting all others requirements.
- G. Trenchless Construction: Use trenchless construction method by following the general criteria:

1. Improved streets - Use trenchless construction to cross a street regardless of surface. Trenchless length shall be computed as roadway width at proposed crossing location plus 5 feet to either side of roadway.
2. Driveways - Use trenchless construction to cross active driveways. Compute crossing length as driveways width plus 1 foot to either side. Where proposed lines are in close vicinity and parallel to culvert pipes along roadside ditch streets, the length of crossing shall be the same as the length of existing culvert plus 1 foot either end.
3. Trees - Use trenchless construction to cross within 10 feet of trees 6 inches and larger in diameter. Use an appropriate trenchless length to clear the tree canopy.
4. Transit Railways - Use trenchless construction to cross within 30 feet of center line of outside rails.

H. Circulation and Flushing for Water Quality:

1. The layout of the water distribution system shall provide maximum circulation of water to prevent future problems of odor, taste, or color due to stagnant water.
2. Provide a source of fresh water at each end or at multiple points of a subdivision. Provide ways to create circulation and place valves and fire hydrants to allow simple flushing of lines.

I. Interconnections

1. For interconnections between utility districts outside the City, written approval must be given by the TCEQ.
2. A written agreement between the districts must be approved by the City and recorded in the county records and furnished to the City.
3. Set meter at the point of connection in a separate easement sized to conform to requirements of Chapter 5. Meter to conform to requirements given in the City of Houston Standard Specifications and Standard Details.
4. Requirements for installation of a meter may be waived by the City, if provisions are made in the agreement between the districts. In this event, a separate easement, sized to conform to requirements of Chapter 5, and valves shall be provided for future meter installation.
5. Agreement between districts shall provide for annexation of the meter site by one district and shall require the installation of a meter. The installation and full cost shall be provided by the district not annexing the meter site.

6. For connection to City water lines serving districts or areas outside the City, written approval must be obtained from the TCEQ. No customer may take pump suction directly from City water lines. If a customer has his own well or other supply, an appropriate backflow preventer must be installed to prevent water from flowing into City water lines. Conform to the procedures for connection to City water lines in effect at the time of connection. Consult with the Public Utilities Division for current requirements.

J. Water Lines Separation from Sanitary Sewers

1. Water Lines Parallel to Gravity Sanitary Sewers and Force Mains:
Locate water lines a minimum of 9 feet horizontally apart, measured from outside wall to outside wall, when parallel to gravity sanitary sewers and force mains. Use the following procedure when stated separation cannot be achieved:
 - a. The existing sanitary sewer shall be replaced with lined ductile iron pipe or PVC pipe meeting ASTM specifications, having a minimum working pressure rating of 150 psi or greater and equipped with pressure-type joints.
 - b. The water lines, gravity sanitary sewers, or force mains, shall be separated by a minimum vertical distance of 2 feet, and a minimum horizontal distance of 4 feet, measured between the nearest outside walls of the pipes.

Following alternate shall be used only, if the above can not be achieved
 - c. Water line or sanitary sewer shall be constructed with approved restrained joints in an approved casing with at least two nominal sizes larger than the carrier pipe. The carrier pipe shall be supported at five-foot intervals with spacers or be filled to the springline with washed sand.
2. Water Lines Crossing gravity Sanitary Sewers and Force Mains. Conform to requirements of TAC § 290.44 Paragraph (e).
 - a. No protection is required if the sanitary sewer is 9 feet below the water line.
 - b. For all other cases, use Table 7.3 on the next page.

Table 7.3
PROTECTION REQUIREMENTS AT
WATER LINE (WL) - SANITARY SEWER (SS) CROSSINGS

	PROPOSED WATER LINE				PROPOSED SANITARY SEWER			
	OVER		UNDER		OVER		UNDER	
	EXISTING SS	PROP SS	EXISTING SS	PROP SS	EXISTING WL	PROP WL	EXISTING WL	PROP WL
Minimum 2 feet vertical clearance	√ ¹	√ ¹	√	√	√ ⁶	√	√ ¹	√ ¹
Place 1 full section (min 18 ft) of WL centered at SS Crossing. Provide restrained joints on WL, spaced at least 9 ft horizontally from centerline of SS	√	√	√	√	√ ⁶	√		√
Place 1 full section (min 18 ft) of SS centered at WL Crossing. Provide restrained joints on SS, spaced at least 9 ft horizontally from centerline of WL		√			√ ⁶		√	√
Replace 1 full section of existing SS with pressure-rated DIP or pressure-rated PVC pipe with adapters and restrained joints centered at WL crossing	√ ^{2,3}		√ ³		√ ⁶			
Provide DIP for small diameter WL (less than 24 inches), PVC pipe is only allowed if encased as per TAC § 290.44, and use restrained joints for both DIP and PVC pipe			√	√	√ ⁶	√		
Embed SS with CSS for the total length of 1 pipe segment plus 1 foot beyond the joints on each end	√ ^{2,3}	√ ⁴	√ ³	√ ⁴	√ ^{5,6}	√ ⁴	√ ⁴	√ ⁴
Place 1 full section (min 18 ft) of min 150 psi SS centered at WL crossing. Provide restrained joints on SS, spaced at least 9 ft horizontally from centerline of WL or encase in a joint of 150 psi pressure pipe (min 18 ft) two nominal sizes larger with spacers at 5 ft interval.				√	√	√		

1. Minimum clearance is 2 feet for non-pressure rated SS and 6 inches for pressure rated SS (with at least 150 psi pressure rating)
2. Minimum clearance is 2 feet for non-pressure rated SS and 1 foot for pressure rated SS
3. Required if existing SS is disturbed and/or there is evidence of leakage
4. Not required for augered WL unless there is evidence of leakage, completely fill augered hole with bentonite/clay mixture
5. Not required for augered SS, completely fill augered hole with bentonite/clay mixture
6. Not allowed requires approval of City Engineer
7. Both Waterline and Wastewater main or lateral must pass a pressure and leakage test as specified in AWWA C600 standards

3. Sanitary Sewer Manholes: Provide a minimum 9-foot clearance from outside wall of existing or proposed manholes unless manholes and connecting sewers can be made watertight and tested for no leakage. If a 9-foot clearance cannot be obtained, the water line may be located closer to the manhole when prior approval has been obtained from OCE by using one of the procedures below; however, in no case shall the clearance be less than 4 feet.
 - a. Water line shall be constructed with approved restrained joints in an approved casing with at least two nominal sizes larger than the carrier pipe. The carrier pipe shall be supported at five-foot intervals with spacers or be filled to the springline with washed sand.
4. Fire Hydrants: Do not install fire hydrants within 9 feet of sanitary sewers and force mains regardless of construction.
5. TCEQ Rules and Regulations for Public Water Systems, including any approved City variances shall apply if they are more strict than these guidelines or if they are not covered by these guidelines.

7.04 SUBMITTALS

- A. Conform to the following submittal requirements in addition to those of Chapter 1 - General Requirements.
- B. Water Line Sizes: Submit justification, calculations, and locations for proposed water lines, for approval by OCE.
- C. Water Meter Service
 1. For construction inside city limits, submit an application for meter services and metered sprinkler connections, to the Taps and Meters Section, prior to construction.
 2. Submit requests for more than one service meter for townhomes in proposed private street developments to OCE.
- D. Master Development Plan: For multiple phase developments, submit a master development plan. If within the ETJ, submit an overall district plan prior to the drawings being submitted for first phase construction.
- E. Interconnections
 1. Submit to the TCEQ requests for written approval of:
 - a. Connection of City water lines to serve districts or areas outside city limits.
 - b. Interconnections of districts.

2. Submit copies of approvals received from TCEQ to OCE.

7.05 QUALITY ASSURANCE

- A. Prepare calculations and construction drawings under the supervision of a Professional Engineer trained and licensed under the disciplines required by the drawings. The final design drawings must be sealed, signed, and dated by the Professional Engineer responsible for development of the drawings.

7.06 DESIGN ANALYSIS

- A. Water Line Sizes: Analyze system requirements to determine line sizes and obtain concurrence from the City.
- B. Water Distribution System: The system must be designed to maintain a minimum pressure of 35 psi at all points within the distribution network at flow rates of at least 1.5 gpm per connection. The system must also be designed to provide fire fighting capability to maintain a minimum pressure of 20 psi under combined fire and drinking water flow conditions.
- C. Elevated Stream, Ditch, or Aerial Crossings: Prepare appropriate design calculations for the supporting structure.

7.07 DRAWINGS

- A. Conform to the following drawing requirements in addition to those of Chapter 3, Graphic Requirements and the City's standard water line details and Standard Specifications.
- B. Provide a cross section drawing (plan and profile showing other utilities and pavement) of branch water lines that extend perpendicularly from main water lines when:
 1. Branch line extends 20 feet or more, and/or
 2. Branch lines have vertical bends.
 3. When proposed lines, including services larger than 2-inches, cross Railway Transit facilities.
 4. Any water taps size 4" or larger.
- C. Appurtenances: Identify, describe, and enclose proposed water line and appurtenances in rectangular box on drawings.
 1. Valves
 - a. Designate 2-inch through 16-inch gate valves with box as GV&B.

- b. Provide complete description and size for other valves.
 2. Water meters, service leads, and un-metered sprinkler connections
 - a. Show the location of service line tees, tapping sleeve and valves, valve boxes, and temporary plugs to be installed to serve future 3-inch diameter or larger meters.
 - b. Develop plan and profile sheets for 4-inch diameter and larger leads and connections.
- D. Construction Features
 1. Show special construction features required to complete the project in a safe, convenient, and economical manner.
 2. Trenchless Construction
 - a. If the construction is predominately open cut, all portions and locations of the street that must be trenchless constructed shall be clearly shown on drawings. Include designation for trenchless sections adjacent to trees with 6 inches or larger diameters located within 10 feet of water line.
 - b. If construction is predominately by trenchless construction:
 - (1) Clearly show on drawings, areas and locations in which trenchless pits will not be permitted.
 - (2) Clearly identify areas where special pipe material or offset sections are required to comply with these guidelines.
 3. Do not locate horizontal bends within street intersections between curb returns or within 30 feet of the centerline of the outside rail.
 4. Pedestrian Facilities: Include a requirement on drawings to replace any pedestrian facility that is disturbed, such as curb ramp, sidewalk, driveway or crosswalk in conformance with the latest edition of the City of Houston's Standard Details, American with Disabilities Act and Texas Accessibility Standards.
- E. Future Planned Improvements.
 1. When feasible, show planned improvements by City, County, TxDOT, Metro which could impact the proposed water line, or aspects of its design.

END OF CHAPTER

APPENDIX A
ADDITIONAL DESIGN REQUIREMENTS FOR LARGE DIAMETER WATER LINES

The following Appendix provides additional requirements to Chapter 7, related to the design of large diameter water lines (LDWL) which are defined as water lines 24-inches and larger. Unaltered portions of Chapter 7 shall remain in effect, but where conflicts exist, this appendix shall supersede requirements in Chapter 7.

1.01 DESIGN REQUIREMENTS AND CRITERA

A. Hydraulic Modeling:

1. Hydraulic modeling effort to be verified with Project Manager, and may be performed by Design Engineer, City, or another consultant. If model is to be provided by others, Design Engineer shall provide specific design information to modeler.
2. The following parameters shall be incorporated in the design:
 - a. Design Velocity:

Table A.1
Design Velocity

SIZE OF LINE	Desired (ft.sec)	Maximum (ft/sec) *
≥ 24-inch & ≤ 36-INCH	3	5
≥ 42-INCH & ≤ 96-INCH	5	7
> 96-INCH	7	12

* Maximum velocity may be adjusted with approval from Infrastructure Planning Branch (IPB).

b. Pipe Friction Factors:

Table A.2
HAZEN WILLIAMS "C" FACTOR

SIZE OF LINE	C (EXISTING LINES)	C (PROPOSED LINES)
≥ 24-inch & ≤ 36-INCH	110	120
≥ 42-INCH & ≤ 96-INCH	120	130
> 96-INCH	130	145

c. Maximum pressures anticipated are the greater of:

- (1) 150% of operating pressure regardless of pipe size. Operating pressure = 100 psi.
- (2) Other special design criteria as determined by modeling results, or specified by Project Manager.

Maximum system pressures are based upon the following equipment closing times:

- a. Pressure reducing valves: 2.0 - 5.0 seconds (max.)
 - b. Check valves: 2.0 - 5.0 seconds (max.)
 - c. Pump control valves: 30 seconds (min.)
3. Modeling effort shall identify location and sizing of other devices, including Air Valves, Pressure Reducing Valves, and Check Valves.
 4. Engineer to identify any shut down required of existing lines during construction of proposed project. Location, estimated duration, and timing of shutdown shall be provided to Project Manager and updated with each submittal milestone.

B. Transient (Surge) Analysis

1. Transient modeling effort to be verified with Project Manager, and may be performed by Design Engineer, City, or another consultant. If model is to be provided by others, Design Engineer shall provide specific design information to modeler.
2. In accordance with acceptable engineering practice (e.g. AWWA M51), air release, vacuum relief/air inlet, and/or combination air valves are to be installed at high points and such other intermediate points as determined during design. The water system is to be modeled under worst case transient scenarios to determine the effects of potential transients on the pipeline and to evaluate air valve placement and sizing.
3. General Criteria
 - a. Transient analysis shall, at a minimum, consider the following items to determine the appropriate surge protection methods and devices needed:
 - (1) Pipe material properties;
 - (2) Pipe wall thickness;
 - (3) Fluid properties; and

- (4) Existing waterline alignments. Existing as-built information and other available information shall be used to develop the computer model of existing conditions.
 - (5) Proposed waterline alignments. Proposed pipeline design shall be added to the model and modeled based upon "worst-case" scenarios. These scenarios shall be identified in the analysis.
- b. Computer modeling of the transient event scenario for each project shall be performed using the Liquid Transient (LIQT©) program or other modeling program acceptable to the City's Infrastructure Planning Branch (IPB).
 - c. Transient analyses shall include a table of recommended surge protection devices to be incorporated into the design drawings. The type of device and approximate station location for each device shall be identified in the table and incorporated into the Drawings.
 - d. The allowable surge pressure range for each analysis shall be -10 psi to 150 psi. Additional criteria and assumptions used in the analysis shall be identified in a Technical Memorandum signed and sealed by a licensed Professional Engineer registered in the State of Texas and submit to the Project Manager for review with each submittal milestone.

C. Alignment

1. Horizontal alignments shall be approved during preliminary engineering Phase I services. Evaluation of routes shall include factors including, but not limited to: traffic volumes, land use, width of right-of-way, existing utilities, pavement conditions, landscape features, proposed improvements along the route, and operational cost.
2. Proposed alignment shall minimize fittings and appurtenances, minimize impact with existing utilities and other site conditions. Remain on the same side of road within City Rights-of-Way to the extent possible. Where possible, manhole tops shall not be designed within the tire path along roadways.
3. Minimum depth of cover (depth to top of pipe) shall be 7 feet from top of curb in improved roadway areas or 9 feet measured at the water line centerline in roadways with open ditch drainage. Verify depth of cover will provide adequate space for air valve assembly and other appurtenances within manholes.
4. Normal depth of cover over tunnel shall be a minimum 1.5 x OD (outer diameter of tunnel). For shallower or deeper depths, a geotechnical analysis verifying adequacy of cover is required.

5. When a water line is placed parallel to another utility line, Water line should be designed with at least 4 feet horizontal clearance from OD to the OD of the other utility (additional requirements apply to sanitary sewer crossings). Engineer shall consider additional clearance based on material and condition of existing utility, and geotechnical conditions. Avoid overlapping of trench width of proposed water line with trench width of existing utility, to the extent possible.
6. Offsets/bends within 5 feet of a tunnel section are not allowed.
7. Locate drain line outlets at or near low point of elevation for water line, at areas that will permit draining a majority of the pipe. Place at least one drain line outlet between each set of in-line isolation valves. Design storm sewer leads from the drain line service manhole to a convenient drainage facility that is capable of accepting flow when draining the water line. System should be designed to drain by gravity, where possible.
8. To accommodate all approved pipe materials, the alignment plan and profiles (P&Ps) are to be based on the use of Prestressed Concrete Cylinder Pipe (PCCP), unless another material must be specified for sound engineering reasons.
9. In addition to graphical standards in Chapter 3, drawings shall include:
 - a. Station and elevation at bends, elevation changes, and beginning and end of each drawing sheet.
 - b. Arrow indicating normal direction of flow and slope of water line on the profile sheets.
 - c. Valves, manholes and other appurtenances related to the proposed water line.
 - d. Water line markers are to be installed where water line is placed in an easement. Markers shall be placed at a maximum spacing of 2000 feet, where there is a change in horizontal alignment, and when crossing property lines. Do not place markers within roadways.

D. Pipe Design Basis

1. Design shall be based upon combined loading conditions including operating, surge, vacuum and test pressures, as well as depth of backfill earth cover and live loads, and maximum velocity within the pipe.
2. Where different from standard specifications, design shall identify special features, such as: minimum wall thickness, special coatings, linings, shoring or joint

requirements. Unusual or unique considerations shall be described in details and/or project specifications as necessary.

3. Acceptable pipe materials for LDWL are listed below, based on currently approved diameters:

Table A.3
PIPE MATERIALS

TYPE	SIZE (INCHES)
Fiberglass Reinforced Pipe	≤ 30
High Density Polyethylene (HDPE)*	≤ 42
Ductile Iron	≤ 64
Prestressed Concrete Cylinder (PCCP)	≥ 24
Bar Wrap Concrete Cylinder	≤ 60
Steel	≥ 24

*Use of HDPE, or other materials not listed above, require City approval and additional project technical specifications.

4. Criteria used to evaluate pipe material for specific installation shall include: system flexibility, hydraulic efficiency, manufacturer and availability, surge protection, corrosion protection, special crossing requirements, operational cost, maintenance, susceptibility to environment and cost.

E. Corrosion Control

1. Corrosion control recommendations to be provided by a NACE International (formerly National Association of Corrosion Engineers) certified Cathodic Protection Specialist or certified Corrosion Specialist (referred to herein as Corrosion Engineer) in accordance with the technical standards, test methods and recommended practices of NACE International, ASTM, AWWA, and related technical societies.
2. Provide written Soil Corrosivity Study and include corrosion protection in the design.
3. Soil Corrosivity Study shall contain the following minimum elements:
 - a. Project name, project number and date of study;
 - b. Name and firm and signature of Corrosion Engineer;
 - c. Introduction to project and scope of work;

- d. Field results of soil resistivity;
 - e. Laboratory results of chemical analysis;
 - f. Interpretation of results/data;
 - g. Determination of likelihood of stray current;
 - h. Sources of AC power (when impressed current cathodic protection is recommended);
 - i. Soil corrosivity conclusions; and
 - j. Corrosion monitoring or corrosion control recommendations.
4. The following items shall be considered for corrosion monitoring and/or corrosion control recommendations. These shall not replace sound professional judgment on the part of Corrosion Engineer. The report shall be finalized upon completion of field work and laboratory testing and evaluation of results and data and appropriate corrosion control devices incorporated into the design.
- a. Buried metallic and concrete pipe and reinforced structures are subject to corrosion and deterioration. Corrosion Engineer shall consider:
 - (1) All pipe options available to the contractor.
 - (2) Options for protection (sacrificial or impressed current systems). The City's Drinking Water Operations (DWO) to review and approve protection method.
 - (3) Isolation from adjacent projects. Unless otherwise specified, each project should be designed to be isolated from adjacent projects.
 - (4) Impact to and from external current sources along the alignment.
 - (5) Testing locations. Test stations are to be placed in easily accessible locations.

F. Valves

1. Isolation Valves

- a. Valves shall isolate sections of water lines that may require repairs, maintenance or inspection or provide other operational functions.

- b. Lateral lines shall have a flanged isolation valve placed directly adjacent to tee connection, unless otherwise approved by Project Manager.
- c. Future accessibility to valves should be considered as part of the design. Actuator/operator manholes shall be located where they are accessible by truck-mounted mechanical valve operator, with minimal impact to traffic.
- d. Maximum spacing shall correspond to Table 1.4. Additional isolation valves may be required to provide operational flexibility of the overall system:

**Table A.4
ISOLATION VALVE TYPE AND SPACING**

TYPICAL TYPES*	SIZES	MAX SPACING (FEET)
Gate	24-inch	2,200
Butterfly*	30-inch to 42-inch	3,000
Butterfly	48-inch and larger	4,000

* Gate valves may be used as determined by the City at critical locations and connections; Design Engineer to confirm that adequate space and depth of cover exists.

- e. Foundation support details are required for pipe ends and valves. For butterfly valves, follow guidelines in AWWA C504/C516.
- f. Where blind flanges or internal dished head plugs are located close to a butterfly valve, adequate spacing shall be provided to allow valve to be fully opened.

2. Air Valves

- a. Inlet/outlet vent elevation shall be one foot above the 100-year floodplain elevation as established by the Federal Emergency Management Agency (FEMA), or four feet above natural ground, whichever is higher. Vent elevation greater than four feet above natural ground shall require design of support details.
- b. Valves that are designed to be exposed shall be located to minimize potential for tampering and/or damage.
- c. Drawings shall specify type of air valve at each location based on outcome of transient analysis. Air valve to be located within 10 feet from the bend.

3. Other Valves
 - a. Pressure Reducing Valves, Check Valves, or other special purpose valves may be required as determined by modeling or as instructed by the City.
- G. Accessibility
1. Manholes
 - a. Specialty manhole details are to be provided as required.
 - b. Extra depth manholes and details (greater than 20 feet) shall be identified on Drawings.
 2. Access Manways
 - a. Manways are required on water lines 30-inches in diameter and larger. Manways with air valves are counted as access locations.
 - b. Manways shall be no less than 24-inches in diameter and have a minimum 6-inch opening on top of each manway cover. Manway and flanges larger than 24-inches require the addition of appropriate mechanism to aid in lifting.
 - c. Manways shall be located on horizontal sections of the water line between isolation valves, such that access to the water line is provided at least every 1,000 feet, unless otherwise approved by Project Manager. Provide manways for access on both ends of tunnel if tunnel is deeper than 25 feet.
 - d. Where space permits, manways shall be designed within 10 feet on each side of the isolation valve in order to eliminate additional buried outlets for flushing and disinfection. Manholes shall not impact access to the valves or operator manhole.
 - e. Manways shall be placed at each end of the project limits where required to facilitate removal of dished head plugs, installed a maximum of 10-feet from the plug.
- H. Thrust Restraints
1. Thrust restraint for new lines shall be provided by means of restrained joints. In special cases, primarily at connections to existing lines, supplemental restraint or blocking may be necessary and should be evaluated to be included in the design.
 2. Thrust restraint calculations shall be performed to determine the minimum restrained joint lengths and be based on the use of Prestressed Concrete Cylinder Pipe (PCCP),

unless a specific pipe material is required, in which case the appropriate AWWA method for thrust restraint calculations should be used. Thrust restraint design calculations shall be signed and sealed by a professional Engineer, and provided to the Project Manager prior to final design submittal.

a. Thrust restraint calculations shall be based upon the following parameters:

(1) Internal Pressure = maximum pressure to which the pipe is subjected (including working, transient or field test pressures).

a. Working Pressure: 100 psi

b. Surge Pressure: 50 psi allowance (transient pressure total is 100 + 50 = 150 psi)

c. Field Test Pressure: 150 psi

(2) Soil Parameters: TRDP type IV soils as modified below:

a. Buoyant unit weight of soil as identified in project geotechnical report

b. Pipe to soil friction factor based on saturated soil conditions

i. PCCP, or other cement mortar coated pipe = 0.35

ii. Tape coated, polyurethane coated or epoxy coated pipe (including epoxy over cement mortar coated pipe) = 0.30

iii. For ductile iron pipe, reduce friction factor by 0.7 based on use of polyethylene encasement.

b. Calculations for specific pipe materials shall be based on the following:

(1) PCCP: AWWA M9 (latest edition) with design method as shown in the table below:

Table A.5

PCCP THRUST RESTRAINT DESIGN METHOD

Horizontal & Vertical Up Bends	Thrust Restraint Design Program (TRDP) (Latest Version)
Vertical Down Bends	AWWA M9 Eq 9-14
Dead End	TRDP Version 1.1 w/ Bend Angle = 0° or AWWA M9 Eq 9-11B
Minimum steel cylinder thickness and mortar coating thickness	AWWA C301

- (2) Ductile Iron Pipe: AWWA M41 or DIPRA Thrust Restraint for Ductile Iron Pipe (latest edition).
- (3) Steel Pipe: AWWA M11 (latest edition).
- (4) Fiberglass Reinforced Pipe: AWWA M45 (latest edition).

I. Plant Connections and Expansions

1. Direct-bury of couplings or other similar type connections shall be avoided when possible.
2. Water plant connections and expansions shall adhere to the requirements of the City's Groundwater Plant Design Guidelines, latest edition.

J. LDWL Crossings: Comply with Section 7.03 F of this Chapter, with the following additional requirements for LDWL (Note: For the portion of the alignment that is located within Rights-of Way or easements with differing design requirements than are contained herein, the differences shall be identified to the Project Manager, and the more stringent requirements shall govern.):

1. Restrained joints shall be utilized for the entire length for all water lines at crossings, except for dedicated joints for expansion/contraction. Proposed water line shall be perpendicular to the crossing, where practical.
2. Water line markers are required at each end of buried crossings, near ROW lines.
3. Design shall comply with requirements of the ROW/easement owner, and shall be incorporated into Contract Documents as necessary. Written approval or acceptance of water line crossing design from owning agencies or companies is required to be provided to the Project Manager prior to the final design submittal.
4. TxDOT and County Road Crossings
 - a. Steel tunnel liner is required for proposed LDWL.
 - b. Refer to Title 43 of the Texas Administrative Code, Part 1, Chapter 21, Subchapter C, entitled "Utility Accommodation".
5. Railroad Crossings
 - a. Refer to the Manual for Railway Engineering, latest edition, prepared by the American Railway Engineering and Maintenance-of-Way Association (AREMA) for the design of railroad crossings.

6. Oil and Gas Pipeline Crossings
 - a. Engineer shall coordinate with private utilities to determine the location of their facilities. Where necessary, the utility shall be probed in order to verify accuracy.
7. Harris County Flood Control District (HCFCD)
 - a. Design shall identify Ultimate Channel width and depth, and accommodate for future channel improvements.
 - b. Actual channel bottom elevation and geotechnical condition should be used to evaluate minimum depth of cover required for tunnels.
 - c. Engineer shall determine jurisdiction and if approval is required from USACE and/or Coast Guard, and perform work as required to obtain approvals.

1.02 INSTALLATION METHODS

A. Open Cut Installation

1. Limits of special shoring shall be identified on Drawings where the use of a typical trench box is not sufficient.
2. Where utilities extend across LDWL trench, plans shall indicate if utility is to be braced or removed and replaced.
3. Design shall account for groundwater dewatering, where necessary.

B. Trenchless Installation

1. Limits of proposed trenchless crossing shall be identified on plan and profile sheets of the Drawings with beginning and end station. Design must denote if a specific trenchless method is required, and appropriate details and specifications shall be provided.
2. Tunnel liner sizing shall be based on the largest part of the pipe, such as the bell or external restraining mechanism.
3. Provide minimum liner plate / casing diameter and thickness for all carrier pipe materials.
4. Design shall evaluate ability to dewater, potential for settlement in the zone of influence, and risk to adjacent structures and pavement.

- a. In areas where specific settlement criteria are necessary, a settlement monitoring plan is required and shall include types of devices, frequency and layout where recommended in geotechnical report.
5. Crossings with tunnel liner plates:
 - a. For railroad crossings, liner plate design shall be consistent with Chapter 1, Part 4 of the AREMA Manual for Railway Engineering.
 - b. For all other crossings using tunnel liner plates, the liner plate design shall be consistent with AASHTO LRFD Bridge Design Specifications, Section 12.
 - c. A minimum factor of safety of 3.0 for buckling and 2.0 for seam strength, with a maximum deflection of 2%, shall be used for liner plate calculations. Larger factors of safety may be required as determined by Design Engineer.
 - d. Liner plate shall be specified by material type and shall provide nominal diameter and wall thickness for 2-flange and/or 4-flange.
 - e. Annulus between the soil and the liner plates must be grouted.
 6. Crossings with smooth-wall, welded steel pipe casing:
 - a. For roadway crossings, live loads shall include minimum HS-20 loading conditions as defined by AASHTO.
 - b. Live loads at railroad crossings shall include minimum Cooper E-80 loading conditions as defined by AREMA.
 - c. A minimum factor of safety of 2.0 shall be used in the casing calculations. Larger factors of safety may be required as determined by the Design Engineer.
 - d. Casing pipe shall be specified by material type, inside diameter and wall thickness and meet the requirements of the City's Standard Specifications and AWWA standards.
 - e. Grouting of the annular space between the liner and carrier pipe is required for all water lines 36-inches in diameter and larger. Grouting of the annular space between the liner and carrier pipe is not required for all water lines that are 30-inches in diameter and less, so long as the liner is designed to carry all loads and the pipe and casing are covered by the cathodic protection design.

C. Above Grade Installation

1. Stand-alone bridge structures must be designed by a Structural Engineer registered in the State of Texas.
2. When the above-grade crossing structure is adjacent to an existing roadway bridge, the bridge columns shall be designed so that they are the same size and shape, and line up with the existing roadway bridge. The low and high chords of the water line bridge should fall within the limits of the roadway bridge high and low chords.
3. For bayou or channel crossings, the lowest structural member must not be less than 18-inches above the base flood elevation. If this requirement cannot be met, obtain a permit from City of Houston Floodplain Administrator per City of Houston Code of Ordinances, Section 19-43 (c)(1).
4. Pipe material for aerial crossing must be steel pipe with butt-welded joints. Thickness of steel wall to be designed based on span length.

2.01 ADDITIONAL SERVICES

A. For Geotechnical and Environmental requirements, refer to Chapter 11 of the City of Houston Infrastructure Design Manual, with the following additions.

1. Borings must be drilled on the centerline along the proposed alignment, except in areas where the LDWL will be installed by trenchless installations. In trenchless installation areas, soil borings shall be offset from the proposed water line alignment.
2. All excess core samples are to be maintained by the Geotechnical Consultant until corrosion monitoring and/or corrosion control recommendations are made. Geotechnical Consultant shall be instructed to provide excess core borings to the Corrosion Engineer when requested. The Corrosion Engineer may require samples at the proposed water line elevation and at the bottom of the boring. Geotechnical Consultant shall confirm the depth and number of samples required with the Corrosion Engineer.

B. Subsurface Utility Engineering (SUE)

1. General Criteria
 - a. SUE may be warranted where existing conditions are likely to significantly impact design and constructability of the proposed alignment.

2. SUE Results
 - a. SUE results for each location are required to be submit to the design Engineer and shall be signed and sealed by the SUE Professional Engineer, registered in the State of Texas.
 - b. SUE results shall provide sufficient information to ascertain the horizontal and vertical location of the existing utilities but should contain no less than the following items:
 - (1) Project name, location, date of field work;
 - (2) Owner of the utility;
 - (3) Type, size and material of the utility;
 - (4) Elevation of the top and at least one side of the utility;
 - (5) Elevation of existing grade over the utility at the test hole;
 - (6) Northing/Easting coordinates of the utility;
 - (7) General plan view of the utility with SUE location shown;
 - (8) Photographs of the site and the exposed utility; and
 - (9) General soil type and thickness of pavement within the test hole limits.

END OF APPENDIX A

City of Houston

Design Manual

Chapter 8

**WASTEWATER COLLECTION SYSTEM
DESIGN REQUIREMENTS**

Chapter 8

WASTEWATER COLLECTION SYSTEM DESIGN REQUIREMENTS

8.01 CHAPTER INCLUDES

- A. Criteria for the design of wastewater collection systems.
- B. This Chapter addresses the design of the wastewater collection systems within the public Right-Of-Way or a dedicated public easement. Sanitary sewers located on private property that are not in such a dedicated easement, are under the jurisdiction of the Plumbing Code, and will be reviewed by the Code Enforcement Branch.

8.02 REFERENCES

- A. Refer to the list of references in Chapter 1, General Requirements.
- B. City of Houston Engineering Design Guidelines Manual for Submersible Lift Stations.
- C. City of Houston Design Guideline Drawings for Submersible Lift Stations.
- D. Uniform Plumbing Code, latest edition adopted by the City.

8.03 DEFINITIONS

- A. Public Sewer - A closed conduit which conveys wastewater flow and which is located within the public Right-Of-Way or dedicated public sanitary sewer easement. A public sewer (or public sewer system) is intended to serve more than one residential, commercial, or industrial site.
- B. Private Sewer - A closed conduit which conveys wastewater flow and is constructed and maintained by a private entity (i.e. homeowner's association). Private sewers may be located in areas such as a private street or common area. Private sewers are subject to the design and construction requirements of the Plumbing Code and must discharge to a public sewer.
- C. Sewer Line - A public sewer located within public Right-Of-Way or Permanent Access Easement (PAE) I Public Utility Easement (PUE) that is maintained and operated by the City.
- D. Service Lead - The sewer pipe that connects a building sewer to a sewer line that is wholly located within the public Right-Of-Way or public easement. Such a line shall never exceed 150-feet in length, for lengths greater than 150-feet refer to definition for sewer line. No more than the equivalent of two single-family residences may be served at one time.
- E. Building Sewer - The sewer pipe that connects a building to a service lead that is wholly

located within the private property. If routed through another tract of land, it shall be located in a building connection easement. If located within a private easement, the City must be included as a third party in the easement documents. It will be owned and maintained by the owner of the property being served. Design shall adhere to the Design Manual or Plumbing Code, whichever is more stringent.

- F. Community sewer - A private sewer that serves more than 2 equivalent houses will adhere to this manual using an 8-inch pipe terminating in a manhole and will have an easement dedicated for the community sewer, which allows a property owner to extend a private sewer or service across adjacent property, or properties, to facilitate connection to a public sewer. If located within a private easement, the City must be included as a third party in the easement documents. It will be owned and maintained by the owner of the property being served by the private sewer.
- G. Project Area - The area in the immediate vicinity of a public sewer to be constructed. This includes the entire road Right-Of-Way and any adjoining easements used for the proposed wastewater line construction.
- H. Stack - A minimum 6-inch riser pipe, constructed on public sewer or lead, with a maximum of 6-feet of cover on the stack. A stack will be used for connecting service leads to a deep sewer line.
- I. Stub-Outs- A minimum 5-feet of sewer pipe extended from the manhole for future expansion and terminated with a sanitary sewer plug.
- J. Force Main- A pressure-rated conduit which conveys wastewater from one pump station to one discharge point.
- K. Central Business District- Area beginning at the centerline of U.S. 59 and the centerline of I.H. 45; thence in the northwesterly and northerly direction along the centerline of I.H. 45 to its intersection with the centerline of U.S. 59; thence in a southwesterly direction along the centerline of U.S. 59 to its intersection with I.H. 45, the point of beginning.

8.04 DESIGN REQUIREMENTS

- A. Drawings to be furnished
 - 1. To obtain a permit for the construction of a proposed sewer line or service lead crossing a public Right-Of-Way to an existing sewer line, a plan -and profile drawing of the proposed sewer shall be prepared and submitted to the City for approval.
- B. Drawing/Design Information
 - 1. The detailed drawings will show the exact location of the proposed line in the street, alley, or easement with respect to the edge of the particular Right-Of-Way, the transit base line, any nearby utilities, 100-year flood elevation within the project area, major landscaping, and other structures affecting construction.

2. Sewers and manholes shall be identified by number, letter, combination of, or other identification and shown on the sanitary sewer layout sheet.
3. Where sewers are to be placed between existing pavement and the street Right-Of-Way line (or interior easement line) show the existing ground line at both sides (or the closest side for sewers near the edge) of the Right-Of-Way or adjacent sewer easement. Prior approval will be required if proposed sewers are to be placed under existing pavements or toppings.
4. For connection to the City sanitary sewer system include one of the following: a copy of the City's Wastewater Capacity Reservation (WCR) letter or, a copy of the City's Wastewater short form, and a Wastewater Impact Fee Receipt for any proposed wastewater design.

C. Drawing Requirements

1. All sewers and connections must be shown in both plan-and-profile views.
2. The profile shall show other underground and surface utilities and facilities, both in parallel and at crossings; the size, grade of the proposed line, the elevations of the proposed line to hundredths of a foot at manholes, changes of grade and dead ends; and the proposed finished grade over the sewer. It shall show the actual ground line as it exists prior to construction of the sewer. Where proposed fill or cut is contemplated, the proposed new ground line shall be shown as a separate line from the actual ground line (label both lines and use contrasting line types to identify each). Type of pipe and bedding shall comply with City of Houston Standard Specifications and Standard Details.
3. Commercial sanitary sewer layout sheets for large areas and with a scale of 400 feet or more per inch must have an additional set of layout sheets at not more than 200 feet per inch, with match lines and a small index map showing which portion of the overall layout that the layout of each sheet represents.
4. A scale of not more than 200-feet per inch on the layout sheet will provide the following information:
 - a. All easements containing or adjoining sanitary sewers are shown and labeled (including recording information),
 - b. Label locations where pipe size or material change,
 - c. Identify manhole by letter and/or number,
 - d. The sewer alignment shall accurately reflect the relative location of the sewer as shown on the detailed plan view,
 - e. Service leads that cross street pavement or serve adjacent property are to be shown on the layout. The detail plans and profiles shall show the flow lines of

- service leads at the street or easement Right-Of-Way, as well as at manholes where private sewer connections are allowed or required,
- f. The number and size of the lots depicted on both the overall sewer layout sheet and the individual plan-and-profile drawings shall match the number and size of the lots depicted on the final plat after recordation,
 - g. The size and direction of flow for existing and proposed sewers shall be shown on the overall sanitary sewer layout sheet,
 - h. The location of the proposed sewer within the public Right-Of-Way, easement adjacent to the public Right-Of-Way, or side lot easement (if allowed by the City), and
 - i. The overall sanitary sewer layout sheet shall show the area, in acres, which the proposed sewer is designed to serve. Include a location map which references the acreage to nearby major thoroughfares and boulevard streets. The scale used for the project area location map shall be: 1" = 2000' or less and shall be shown on the map.
5. The plan view shall show, at a minimum, the following information for the project area:
- a. Topographical features,
 - b. Stationing for the proposed sewers,
 - c. Existing buried and overhead utilities (i.e. gas, electric, telecom, etc),
 - d. Any significant landscaping or other structures which might impact construction or construction-related activities,
 - e. The width and type of existing and proposed easements,
 - f. Proposed service leads,
 - g. The limits of the proposed bore or tunnel,
 - h. Locations where pressure pipe is to be installed for water line crossings, and
 - i. Terrain changes, retaining walls, overhangs, buildings, billboards and any other structure within 25 feet of the proposed line.
6. The profile view shall show, at a minimum, the following information for the project area:
- a. Underground and surface utilities/facilities which are either parallel to the proposed sewer or cross the proposed sewer,

- b. The proposed sewer's diameter, grade and length for each manhole section,
 - c. The flow line elevation for sanitary sewers and service leads at each manhole,
 - d. The rim elevation of existing and proposed manholes,
 - e. The flow line elevation at each sheet match line (i.e., from one sheet to another),
 - f. Type of pipe bedding and backfill shall be included in the Standard Details,
 - g. The finished grade for proposed and existing pavement. Where cut and fill are proposed, the proposed new ground line should be shown as a separate line from the existing ground line (label both lines and use contrasting line types to identify each),
 - h. The existing ground line for the near side of the public Right-Of-Way where a sewer is to be placed between the edge of existing pavement and the edge of the public Right-Of-Way,
 - i. The existing ground line at the centerline of the proposed sanitary sewer where a sanitary sewer is to be placed within an easement. Show any proposed cut and fill as described above. Show the finished grade of any proposed and existing pavement,
 - j. The flow line elevation of service leads where the service lead crosses the edge of the public Right-Of-Way or the dedicated easement adjacent to the public Right-Of-Way,
 - k. Locations where pressure pipe and/or casing is to be installed for water line crossings or special conditions (i.e. limited clearance, special protection requirements, etc.),
 - l. The limits of special backfill and proposed stacks shall be identified by stations indicated on the design plans, and
 - m. Vertical elevation breaks in profiles shall not be used without clearly identifying breaks on each sheet and dimension the break line elevation difference.
7. Drawings for single-family residential subdivisions shall show the proposed location, by stations, of all service leads, and stacks.

D. Service Leads

1. Service leads shall be located either at the side property line between two adjoining lots, or as directed by the City. A single 6-inch service lead located at the property line between two adjoining lots would serve two single-family residences with a wyes

placed at the end of the service lead. Do not extend the wyes beyond the edge of either the public Right-Of-Way or dedicated public easement.

2. Service leads measuring more than 50-feet in length and parallel to the street Right-Of-Way or public sewer easement shall be treated as a public sewer line having both a starting and ending manhole, except for cul-de-sac(s)'.
 3. Service leads for single-family developments shall not connect to a manhole unless otherwise stated in this manual. Private sewers from developments with more than 5000 gallons-per-day flow shall discharge into a proposed or existing manhole. Where the flow line of the private sewer is 24-inches or greater above the flow line of the manhole, provide a standard City of Houston outside drop to the manhole. Some design exceptions or additional requirements may be made for flow connections to large (36-inch and larger ID sewers) or deep (>20 feet flow line depth) sewer lines, depending on the individual circumstances.
 - a. Service leads shall be provided to serve every lot within a proposed development, whether inside the city limits or in the ETJ. Provide detail(s) for all typical near-side and far-side sewer connections, including 1-side or 2-sided stacks.
 - b. Service leads shall be 6-inches in diameter (minimum). If the length of a service lead exceeds 100-feet or the width of the public Right-Of-Way by more than 20-feet, the minimum diameter shall be 8-inches and a manhole shall be utilized for connection to the public sewer. Service leads exceeding 150-feet in length shall be designed as a sewer line.
 - c. Service leads with a diameter of 6-inches shall utilize full body fittings (extruded or factory-fabricated) for connection to a proposed public sewer or an approved saddle-type connector for connection to an existing public sewer.
 - d. Saddle-type connectors shall be installed with the stub oriented between the spring line (3 o'clock and 9 o'clock positions) and 45 degrees from the spring line (1:30 and 10:30 positions). Full body fittings used to connect a service lead to a proposed public sewer shall be oriented in the same manner.
 - e. The service lead shall be designed to minimize the use of bends as conditions permit.
 - f. Service leads exceeding the limits defined in Paragraph 8.04.D.2 shall have a manhole at each end; as well as a plan-and-profile drawing for each Right-Of-Way crossing. All or part of these service leads which are located in a public Right-Of-Way, alley or dedicated sanitary sewer or public utility easement(s) may be treated as a public sewer; depending upon the location of the terminal manhole and any intermediate manholes.

- g. For existing lots (which are not served in accordance with these guidelines) that requests a sewer connection and the distance to the nearest existing sewer is less than 50 feet, as measured parallel to the street Right-Of-Way, the sewer connection is under the jurisdiction of the Uniform Plumbing Code, (latest edition) provided that: a road bore is not required or a major thoroughfare (or collector) road is not being cut, both of which require City approval and an engineering drawing.
- h. The location where the service lead crosses the property line shall be shown on the plans and marked in the field. Provide a typical detail of the durable marker to be placed where the service lead crosses the property line.
- i. All private sewers, private force mains, and appurtenances, thereto, that is intended to be located inside the public Right-Of-Way must have an encroachment permit with plan and profile sheets.

E. General Requirements

1. Connect service leads to stacks, wyes or tees as shown on the City's Geographic Information Mapping System (GIMS). Where none are shown, a licensed plumber is responsible for placing a City approved saddle for connection to the public sewer and the City Inspector is responsible for determining that the saddle is watertight and properly installed.
2. Materials and construction shall conform to latest City of Houston Standard Specifications, including standard leak test.
3. Unless noted otherwise, all public sewers and service leads shall be embedded in cement-stabilized sand from 6-inches below the pipe to 12-inches above the pipe and for the full trench width. All such bedding shall be compacted to the density required by Standard Specifications. Cement-stabilized sand shall have a 48-hour compressive strength of 100 psi minimum. The cross-section described in this paragraph is defined as the pipe embedment zone.
4. Backfill excavated areas and trenches under or within one foot of existing or proposed pavement with cement-stabilized sand from the top of the pipe embedment zone up to one foot below the paving sub-grade. Cement-stabilized sand must develop 100 psi minimum compression at 48 hours. Backfill shall be compacted to 95 percent standard Proctor density.
5. The actual location of all special backfill and of proposed stacks shall be shown by stations on the drawings.
6. Public sewers and force mains shall be located in either the public Right-Of-Way or easements. Side lot easements may be used only with special approval. Back lot easements shall not be utilized except in the case of preexisting conditions or as approved by the City Engineer.

7. Generally, the location of the public sewer within a dedicated easement shall be along the centerline of the easement. However, in those instances where the easement is adjacent to the public Right-Of-Way, the location of the sanitary sewer and its manholes shall be approved on a case-by-case basis by the Director of Houston Public Works, or his designee. Required easement widths are addressed in Chapter 5, Easement Requirements. Additional information regarding the location of sanitary sewers is contained in Chapter 6, Utility Locations.
 8. The final determination as to that portion of a street, alley, or sanitary sewer easement to be occupied by a proposed sewer or force main rests with the City. The Director or designee will take into consideration existing, planned and proposed facilities such as manholes, pavement, pipes/conduits, along with existing trees and shrubs, or other unique surface conditions when arriving at a decision.
 9. There shall be no closed-end easements for public sanitary sewers and force mains.
 10. The drawings for the sewer shall show the location of any pipe, duct, other structure(s), hazardous obstacles and/or protected vegetation known to exist that might interfere with the construction of the sewer and call to the attention of the City any known obstacles that might be encountered in constructing the sewer in any location under consideration. The Professional Engineer of Record shall determine the existence of pipes, ducts, and any above stated obstacles by visually inspecting the site, researching all available public and private records, and conducting subsurface investigations when necessary.
 11. Manholes located within the 100-year floodplain shall be sealed and vented per TCEQ requirements. Engineering judgment and aesthetics should be considered.
 12. Manholes located within driveways shall be sealed and vented per TCEQ requirements.
 13. New manholes shall not be located between the top of banks for ditches or swales, unless approved by the City.
 14. Wastewater lines along State Right-of-Way shall be installed outside of the right-of-way in a separate contiguous easement; width of easement shall be as provided in Chapter 5.
- F. Line Size
1. The minimum pipe diameter for a public sanitary sewer shall be 8-inches.
 2. Service leads 4-inches in diameter shall be confined to the limits of the lot which they serve and shall serve only the equivalent of one single-family lot. No 4-inch sewer shall be laid in any street, alley, dedicated sewer easement or Right-Of-Way.

3. Service leads 6-inches in diameter shall not serve more than the equivalent of 2 single-family lots or other types of small land tracts.
 4. Service leads of 6-inch and 8-inch diameter for single-family residential lots shall have a minimum grades as shown in table 8.1.
 5. For all service leads that requires a street bore, submit a copy of the wastewater capacity letter to establish the required size of the line.
 6. For commercial service leads, the minimum size service lead shall be 8-inches in diameter for the Central Business District and 6-inches in diameter elsewhere. Connect all service leads within Central Business District directly to a manhole.
 7. Sewer lines shall be laid at a size and depth to conform to designs permitting an orderly expansion of the sewer system of the City and so as to avoid a duplication of lines in the future.
 8. The City shall be the final judge as to size and depth required and any exception to service leads as previously defined.
- G. Line Depth
1. Sewer line shall be laid with the top of the pipe a minimum of 3-feet below the surface of the natural ground without side ditches.
 2. Sewers laid in the street Right-Of-Way with curb and gutter paved streets shall have a minimum cover of 4-feet from the top of the pipe to top of the curb.
 3. Sewers laid in street Right-Of-Way with crowned roads and side ditches shall have a minimum cover of 6-feet from the average ground line at the adjacent street Right-Of-Way to the top of pipe.
 4. Where the minimum cover as specified in Paragraphs 8.04.G.1, 8.04.G.2, and 8.04.G.3 is not possible, the sewer shall be laid with Class 150 (150 psi) pressure pipe with cement-stabilized sand backfill as shown in Standard Details. Ductile iron pipe shall be lined with a material listed on the City of Houston Approved Product List and applied by either the pipe manufacturer or an approved applicator. Liners shall meet requirements of TCEQ 217.56(c)
 5. Maximum depth for 8-inch, through 12-inch diameter collection lines shall be 20-feet from average ground surface of the trench width to pipe invert. Depths greater than 20-feet are subject to approval by the City Engineer if justified for site-specific reasons during the preliminary engineering phase of the project design.

H. Line Grades

1. The following table lists the minimum grades for 6-inch to 27-inch diameter public sewers. (6-in. diameter is for service leads only). The minimum grade is based on a minimum full pipe velocity of 2.3 feet per second (fps). The maximum grade is based on a maximum full pipe velocity of 4.5 fps. In both cases, the Manning Formula has been used with an n coefficient of 0.013. The use of different pipe materials will not alter the use of 0.013 for the purposes of the Design Manual.

**Table 8.1
GRADES FOR WASTEWATER LINES**

NOMINAL INTERNAL PIPE DIAMETER (INCHES)	MINIMUM GRADE TO DEVELOP V= 2.3 FPS (PERCENT)	MAXIMUM GRADE TO DEVELOP V=4.5 FPS (PERCENT)
6	0.70	2.46
8	0.44	1.73
10	0.33	1.21
12	0.26	0.97
15	0.19	0.72
18	0.15	0.57
21	0.13	0.46
24	0.11	0.38
27	0.09	0.33

2. For sewers larger than 27-inches in diameter, the Professional Engineer of Record shall determine the appropriate grade utilizing the Manning Formula, n = 0.013 and a minimum full pipe velocity of 3.0 fps.

I. Line Alignment

1. Gravity sewers shall be laid in straight alignment with uniform grade between manholes. Deviations from straight alignment shall be justified by complying with the TCEQ requirements and approved by the City. Deviations from uniform grade without manholes shall not be allowed.

J. Manholes

1. Manholes shall be pre-fabricated or precast -, as per Standard Specifications and Details; unless the Professional Engineer of Record submits a cast-in-place manhole design for review and approval by the City. The Professional Engineer of Record shall determine the need for a liner or coating on concrete manholes. Liner or coatings will be as per Standard Specifications. Fiberglass manholes, per Standard

Details, are not allowed within the existing or proposed pavement allowed outside the street Right-of-Way. Precast manholes shall incorporate a boot-type connector for sewer diameters up to 24-inches. For sewer diameters greater than 24-inches, utilize either the boot-type connector (if available) or an integral gasket. Precast manholes shall conform to the latest ASTM requirements. Manhole covers shall be 32-inches as shown in the Standard Details.

2. Location: For public sewers, manholes shall be placed at changes in alignment, changes in grade, junction points, and either at street, alley, or easement intersections as designs may require.
 - a. Sewers laid in easements shall have a manhole in each street crossed by the sewer.
 - b. The maximum distance between manholes shall be determined from the following table for 8-inch to 48-inch pipe diameters. Spacing for manholes on mains with diameters larger than 48-inches installed by tunneling methods or open-cut methods shall be determined on an individual project basis.

Table 8.2
MAXIMUM DISTANCE BETWEEN
SANITARY SEWER MANHOLES

PIPE DIAMETER (I.D.) IN INCHES	MANHOLE MAXIMUM SPACING IN FEET
8-15	400
18-48	800
Greater than 48	As approved by the City

- c. A design objective is to have sewers with the same, or approximately the same, flow line elevation intersect each other at a 90-degree angle. However, where a true perpendicular intersection cannot be obtained, and where the entering sewer intersects the receiving sewer at, or about, the same flow line elevation, one or more manholes shall be located so that a minimum angle of 80 degrees at the point of intersection can be achieved for the sewer line. When the entering sewer is on the upstream side of the manhole, the minimum angle between the sewers may be reduced to a 45-degree angle provided:
 - (1) A distinct flow channel can be maintained within the manhole when the flow line elevations of the sewers are at or within one pipe diameter of the smaller pipe; or
 - (2) The flow line elevation of the entering pipe is above the crown of the primary sewer and clearance can be provided between the sewers.

- (3) The design is in compliance with City of Houston Standard Details (02082N-02 & 03)
- d. Place manholes at the terminal (most upstream) end of all public sewer lines. Clean-outs will not be utilized except at the end of each service lead.
- e. Existing manholes located within the city limit shall be identified by the alphanumeric system established by the Department. Refer to Department's "GIMS" map's "Wastewater Manholes" data layer for the 8-digit ID #s. If the manhole has no ID #, use the manhole's "Feature ID #" from the "Identify" query-generated pop-up database box.
- f. Criteria for Connections to and Utilization of Manholes:
 - (1) Connections between public sewers at the manhole shall adhere to the following criteria when possible:
 - (a) The elevation of the crown of the discharging sewer shall either match the elevation of the crown of the receiving sewer or be approved as a special case by the City.
 - (b) A standard outside drop connection as shown in City of Houston Standard Details is required when the difference in elevation between discharging sewer flow line and receiving sewer flow line is greater than 24-inches.
 - (2) The routing of a service connection directly to an existing manhole will be allowed only if:
 - (a) The flow line elevation of the existing sanitary sewer is more than 10 feet below grade and there is no available stack and the lot to be so connected is a single-family, owner-occupied, single lot residence connection to an existing manhole; or
 - (b) The lot to be so connected is a single-family, single lot connecting to a manhole in a cul-de-sac.
 - (c) Satisfies discharge requirements of service leads requiring manholes (see Paragraph 8.04.D.3).
 - (3) When routing an approved service lead to a manhole the wall penetration shall not be greater than 10-inches in diameter and shall be sealed using approved water stop and grout, see Paragraph 8.04.J.2.f.(2).
 - (4) When routing an approved service lead to an existing manhole with invert elevation more than 24-inches lower, the connections shall utilize an outside drop and shall adhere to the following criteria, see Paragraph 8.04.J.2.f.(3):
 - (a) The manhole wall penetration shall not be greater than 10-inches in diameter,

- (b) The outside drop shall be a minimum of 6-inches in diameter and shall be constructed of SDR 26 PVC pipe (ASTM D 3034),
 - (c) The outside drop shall be located 45-degrees from the upstream side of the sewer line,
 - (d) Usage of an internal drop will be reviewed on a case-by-case basis. A minimum of 48-inches of clear space shall be maintained inside the manhole between the drop and the opposing manhole wall. The drop pipe shall be firmly and frequently affixed to the manhole wall utilizing stainless steel bands and anchor bolts. All existing coatings shall be repaired per manufacturers recommendations upon completion,
 - (e) An internal drop shall terminate with a 45-degree bend. The 45-degree bend shall not extend below the top-of-pipe elevation of receiving sanitary sewer, and
 - (f) The wall penetration shall be sealed using an approved water stop and grout.
- (5) When the line is more than 20-feet below grade or the line is greater than 36-inch in diameter a site-specific design is required.
3. Benches and Inverts: The bottom of the manhole shall be provided with a "U" shaped channel that is a smooth continuation of the inlet and outlet pipes. The depth of the "U" shaped channel shall be at least equal to the largest pipe diameter. In manholes with pipes of different sizes, the tops of the pipes shall be placed at the same elevation and flow channels in the invert sloped on an even slope from pipe to pipe. The bench provided above the channel shall be smooth and uniformly sloped at a minimum of 1-inch per foot to a maximum of 1.5-inches per foot, from the wall to the top of the invert channel.
4. Large manholes: All manholes connecting pipes larger than 36-inch and junction boxes shall have the lower corners filleted to prevent solids deposition.

K. Lift Stations

1. Lift station design shall comply with the City of Houston Engineering Design Guidelines Manual for Submersible Lift Stations and Design Guideline Drawings for Submersible Lift Stations, latest revision. The designer shall submit a Final Design Submittal Checklist (available from the City), signed and sealed by the Design Engineer, to ensure that the lift station is designed in compliance with the requirements of applicable codes and regulations. Include a copy of the Engineering Design Report satisfying TCEQ criteria.

L. Metro Solutions - Guided Rapid Transit

1. Location of Sanitary Sewer Lines
 - a. Sanitary sewer lines crossing under tracks shall be in steel casing, with minimum pipe size of 10-inches.

- b. Sanitary service lines (building connections) shall not cross under tracks.
- c. Extend the sanitary sewer stub for a minimum of "depth of sanitary sewer cover + 5 feet" beyond pavement limits.
- d. Relocate existing sanitary sewer lines for a minimum of 15 feet from centerline of the nearest proposed track.
- e. SDR 35 PVC pipe is not allowed.
- f. Minimum cover of the pipe shall be determined by the Guided Rapid Transit Load Distribution calculations, use the greater of the calculated live or dead loads.

8.05 UNSERVED SITES REQUIRING ON-SITE SEWAGE FACILITIES (OSSF) (SEPTIC TANKS)

- A. Engineer shall conform to applicable County criteria.

8.06 SUBMITTALS

- A. Preliminary Design - Submit the following for review and comment:

1. Copies of any documents, which show approval or exceptions to the City design criteria.
2. Design calculations for line sizes and grades.
3. Contour map for overall area.
4. Plan-and-profile sheets showing proposed improvements (City projects only).
5. Geotechnical soils report for the project (City projects only).

- B. Final Design - Submit the following for approval:

1. Final documents of the above plus plan-and-profile sheets and geotechnical soils reports for non-City projects.
2. Review prints.
3. Original drawings.
4. Complete copy of project specifications.
5. A final engineering design report shall be developed following the latest edition of TCEQ Chapter 217 and submitted to the City for each project. This report shall bear the signed and dated seal of a Professional Engineer registered in the State of Texas who is responsible for the design.

8.07 QUALITY ASSURANCE

- A. Prepare calculations and construction drawings under the supervision of a Professional Engineer trained and licensed under the disciplines required by the drawings. The final construction drawings must be sealed, signed, and dated by the Professional Engineer responsible for the development of the drawings.

8.08 RESEARCH REQUIREMENTS

- A. Discuss project concepts outlining proposed features and usage with City of Houston, Department of Houston Public Works.
- B. Research existing utility and Right-Of-Way information.
- C. Verify that no restrictions exist that will deny approval of the project concept.

8.09 DESIGN ANALYSIS

- A. A calculation of design flows for the complete development project.
- B. Calculations for design of any treatment plant required for the development.
- C. Calculations for effect of the 25-year storm outfall from any proposed treatment plant.

8.10 DRAWINGS

- A. Drawings shall include layout sheets with contours, plan-and-profile sheets, and detail sheets for special items and treatment plants.

END OF CHAPTER

City of Houston

Design Manual

Chapter 9

STORMWATER DESIGN AND WATER QUALITY REQUIREMENTS

The City acknowledges that Harris County and Harris County Flood Control will be adopting new criteria based on Atlas 14.

The City is considering this data and will consider editing this document for future release.

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Chapter 9

STORMWATER DESIGN REQUIREMENTS

SECTION 1 - STORMWATER DESIGN OVERVIEW

9.1.01 CHAPTER INCLUDES

9.1.01.A. Criteria for the design of storm drainage improvements.

9.1.02 POLICY

9.1.02.A. Design Requirements.

1. Drainage criteria administered by the City of Houston and complemented by Harris County and the Harris County Flood Control District (HCFCD) for newly designed areas provides protection from Structural Flooding from a 100-year storm event. This is accomplished through application of various drainage enhancements, such as storm sewers, roadside ditches, open channels, detention and overland (sheet) run-off. The combined system is intended to prevent Structural Flooding from extreme events up to a 100-year storm.
2. Recognizing that each site has unique differences that can enhance the opportunity to provide proper drainage, the intent of these criteria is to specify minimum requirements that can be modified provided that the objective for drainage standards is maintained. For projects which require a site-specific approach and where unique engineering solutions will achieve drainage objective, a request for consideration of alternative standards (pipe flow, overland sheet flow, and detention storage) shall be submitted to the City of Houston, Houston Public Works, Office of the City Engineer (1002 Washington), for review and approval.

9.1.02.B. Ponding in streets and roadside ditches of short duration is anticipated and designed to contribute to the overall drainage capacity of the system. Storm sewers and roadside ditch conduits should be designed considering a balance of capacity and economics. These conduits should be designed to convey less intense, more frequent rainfalls with the intent of allowing for traffic movement during these events. When rainfall events exceed the capacity of the storm sewer system, the additional runoff is intended to be conveyed or stored overland in a manner that reduces the threat of structural flooding.

9.1.02.C. All proposed New Development, Redevelopment, or Site Modifications shall not alter existing or natural overland flow patterns and shall not increase or redirect existing sheet flow to adjacent private or public property¹. Where the existing sheet flow pattern is blocked by construction (i.e. raising the site elevation) of the Development, the sheet

¹ Texas Water Code 11.086 – Overflow Caused by Diversion of Water

(a) No person may divert or impound the natural flow of surface waters in this state, or permit a diversion or impounding by him to continue, in a manner that damages the property of another by the overflow of the water diverted or impounded.

flow shall be re-routed within the developed property to return flow to original configuration or to the public R.O.W. Except under special circumstances dictated by natural or existing drainage patterns no sheet flow from the developed property will be allowed to drain onto adjacent private property. No impact will be allowed onto adjacent property.

The estimated volume of displaced sheet flow shall be calculated, and the rerouted flow pattern shall have adequate volume to provide that adjacent property is not impacted by the development. No sheet flow from the developed property will be allowed to drain (via sheet flow) onto the adjacent ROW. Any increased quantity discharge should only be discharged to the ROW at the approved point of connection (which have enough capacity to handle the discharged) via a subsurface internal drainage system.

- 9.1.02.D. The City is a participant in the National Flood Insurance Program (NFIP). The flood insurance program makes insurance available at low cost where the municipal entity implements measures that reduce the likelihood of structural flooding. The design criteria in this chapter are provided to support the NFIP. All development located within the City limits shall comply with Chapter 19, FLOODPLAIN, of the Code of Ordinances.
- 9.1.02.E. Approval of storm drainage is a part of the review process for planning and platting of a New Development, site plan review process for Redevelopments, and the permitting process for Site Modifications. Review and approval of plats is conducted by the Department of Planning and Development. Review of storm drainage is conducted by Houston Public Works.
- 9.1.02.F. The City will consider joint project funding with a private entity for construction of drainage systems that improve existing drainage infrastructure. The City's first priority will be to fund those projects included in the Capital Improvement Plan (CIP). Where feasible, City funding will be leveraged with other funding sources including private entities, civic organizations, and other public agencies (Harris County, HCFCD, Corps of Engineers, Housing and Community Development, and other funding sources). For drainage systems that have been identified as deficient and are not scheduled to receive funding in the current CIP, the City will consider authorizing improvements performed by the private entity which comply with the City's objectives, and may be a candidate for a Developer Participation Contract (DPC) contract.
- 9.1.02.G. The criteria in this Chapter apply to all projects located in the City limits and to expanding utility districts and new utility districts located in the City's Extraterritorial Jurisdiction (ETJ). If the criteria conflicts with Harris County, HCFCD, Fort Bend County, Montgomery County or other jurisdictions, the more restrictive criteria shall govern.
- 9.1.02.H. Property owners and public agencies are responsible for not adversely impacting the community, neighbors, future property owners, or City facilities in terms of flood risks, erosion, infiltration and siltation.

9.1.03 REFERENCES

- 9.1.03.A. Refer to the list of references in Chapter 1, General Requirements.
- 9.1.03.B. National Weather Service Documents
 - 1. TP-40 Rainfall Frequency Atlas of the United States.
 - 2. Hydro-35; 5-to-60-Minute Precipitation Duration for the Eastern and Central United States.
 - 3. National Oceanic and Atmospheric Administration (NOAA) - Atlas - Precipitation - Frequency Atlas of the United States (Texas) – Current Edition.
- 9.1.03.C. Hydraulic Engineering Circular No. 22, (HEC-22), Current Edition, “Urban Drainage Design Manual”, Federal Highway Administration (FHWA).
- 9.1.03.D. ASCE Manual and Reports of Engineering Practice No. 77, Design and Construction of Urban Stormwater Management Systems, Current Edition.
- 9.1.03.E. HouStorm – The City of Houston’s version of The Texas Department of Transportation’s (TxDOT) software. The program is available from the City.
- 9.1.03.F. Harris County Flood Control District Policy, Criteria, and Procedure Manual (HCFCD Criteria Manual), Current Edition. <https://www.hcfcfd.org/>
- 9.1.03.G. Texas Department of Transportation. (2011). Hydraulic Design Manual.

9.1.04 DEFINITIONS AND ACRONYMS

9.1.04.A. Conduit – Any open or closed device for conveying flowing water examples, culverts, ditches, and storm sewers.

9.1.04.B. Continuity Equation:

$$Q = VA$$

Where: Q = discharge (cfs or cms)
V = velocity (ft/sec or m/sec)
A = cross sectional area of Conduit (square feet or square meters)

9.1.04.C. Critical Elevation - The maximum hydraulic grade line elevation a system is allowed to exhibit when conveying the design rainfall. This elevation is related to the level of service of the primary system.

9.1.04.D. Design Ponding Depth – The depth of water adjacent to an inlet during the design rainfall event. Depth is measured from the bottom of the inlet opening for curb opening or from the top of the grate openings. This depth is used in inlet capacity calculations.

9.1.04.E. Design Rainfall Event – Rainfall intensity upon which the drainage facility will be sized.

9.1.04.F. Development - (i) any activity that requires a subdivision plat or development plat pursuant to Code of Ordinances Chapter 42; (ii) the further subdivision of any reserve tract that is part of a subdivision plat approved by the city planning commission or pursuant to Article II of Chapter 42, the Code of Ordinances; or (iii) any activity that requires a construction permit. The term includes New Development and Redevelopment.

1. New Development – Development of an undeveloped parcel of land.
2. Redevelopment – A change in land use that alters the impervious surface from one type of Development to either the same type or another type, or green field, and alters the drainage patterns internally or externally to the Development.
3. Site Modifications - A site improvement that alters the area of impervious surface (e.g., an addition to an existing structure or creating additional parking), or a change in existing storm water collection, conveyance or runoff conditions for the developed site (e.g., replacing existing parking surface with pervious pavement).

9.1.04.G. Disturbed Area - means the existing surface has been altered by activity including, but not limited to, clearing, grubbing, demolition, grading, excavating and construction related activity (e.g. equipment staging, stockpiling of fill material and material storage areas), and construction support activity. This does not include altering the surface for routine maintenance that is performed to maintain the original line and grade, hydraulic

capacity, or original purpose of the site (e.g., the routine grading of existing dirt roads, asphalt overlays of existing roads, the routine clearing of existing right-of- ways, and similar maintenance activities).

- 9.1.04.H. Drainage Area - The surface area determined by topography that contributes rainfall runoff to a point of interception. The drainage area represents the drainage system service area and is not limited by the project boundary or street R.O.W. The possibility of overland flow contributions from adjacent drainage areas during certain extreme events shall be considered for accurate assurance of level of service.
- 9.1.04.I. Drainage Area Map - Service area map of the watershed or drainage system presented as specified in 9.4.01.A.8.
- 9.1.04.J. FEMA - Federal Emergency Management Agency.
- 9.1.04.K. FIS - Flood Insurance Study, the formal document and associated models used to define the floodplain boundaries. An appraisal of the community's flood problems in a narrative that describes; a) the purpose of the study; b) historic floods; c) the area and flooding sources studied; d) the engineering methods employed. FIS serve as the basis for rating flood insurance and for regulating floodplain development and carrying out other floodplain management measures.
- 9.1.04.L. HCFCD - Harris County Flood Control District.
- 9.1.04.M. HouStorm - The City's version of TxDOT's software. The program is available from the City.
- 9.1.04.N. Hydraulic Grade Line (HGL) - A line representing the pressure head available at any given point within the drainage system.
- 9.1.04.O. Impervious Surface - Impervious surface means any area that has been compacted or covered such that it does not readily absorb water or does not allow water to percolate through to undisturbed underlying soil strata. Surface materials considered impervious shall include, but not be limited to, bricks, pavers, concrete, asphalt, compacted oil-dirt, compacted or decomposed shale, oyster shell, gravel, or granite, and other similar materials. Surface features utilizing such materials and considered impervious shall include, but not be limited to, decks, foundations (whether pier and beam or slab), building roofs, parking and driveway areas, sidewalks, compacted or rolled areas, paved recreation areas, swimming pools, dry or wet detention ponds that don't allow percolation, and other features or surfaces that are built or laid on the surface of the land and have the effect of increasing, concentrating, or otherwise altering water runoff so that runoff is not readily absorbed.

9.1.04.P. Manning's Equation:

$$V = (K/n) R^{2/3} S_f^{1/2}$$

Where: K = 1.49 for English units,
1.00 for metric units

V = velocity (ft./sec or m/sec)

R = hydraulic radius (ft. or m) (area/wetted perimeter)

S_f = friction slope (head loss/length) (101)

n = 0.012 for corrugated profile-wall polyethylene pipe
0.013 for concrete pipes,
0.015 for concrete boxes,
0.024 for CMP pipes

9.1.04.Q. Overland Flow - Flow resulting from a rainfall event that is routed along surface streets or surface channels in a defined manner.

9.1.04.R. Rainfall Frequency - Probability of a rainfall event of defined characteristics occurring in any given year at a given location. Information on Rainfall Frequency is published by the National Weather Service. For the purpose of storm drainage design, the following frequencies are applicable:

1. 2-year frequency - a rainfall intensity having a 50 percent probability of occurrence in any given year, that occurs on the average every 2 years over a long period of time.
2. 3-year frequency - a rainfall intensity having a 33 percent probability of occurrence in any given year, that occurs on the average every 3 years over a long period of time.
3. 5-year frequency - a rainfall intensity having a 20 percent probability of occurrence in any given year, that occurs on the average every 5 years over a long period of time.
4. 10-year frequency - a rainfall intensity having a 10 percent probability of occurrence in any given year, that occurs on the average every 10 years over a long period of time.
5. 25-year frequency - a rainfall intensity having a 4 percent probability of occurrence in any given year, that occurs on the average every 25 years over a long period of time.
6. 100-year frequency - a rainfall intensity having a 1 percent probability of occurrence in any given year, that occurs on the average every 100 years over a long period of time.
7. 500-year frequency – a rainfall intensity having a 0.2 percent probability of

occurrence in any given year, that occurs on the average of every 500 years over a long period of time.

- 9.1.04.S. Rational Method - A method for calculating the peak runoff for a drainage system using the following equation for runoff:

$$Q = I \times (CA)$$

Where:

C	=	watershed coefficient
A	=	Area (acres)
I	=	rainfall intensity (inches)

- 9.1.04.T. Sheet Flow - A shallow depth of runoff on a sloping and/or relatively flat surface that does not have a precisely defined bounding condition.
- 9.1.04.U. Spread - Calculated only for design rainfall. The width of flow in the gutter, measured laterally from the roadway curb, approaching an inlet. In HouStorm this value is called the ponding width.
- 9.1.04.V. Storm Sewer Junction Box - Precast or cast-in-place concrete, square or rectangular structure used to merge upstream pipes, accommodate changes in pipe size or direction, or provide service access to the storm sewer system by the addition of a circular manhole structure to the top of the junction box.
- 9.1.04.W. Structural Flooding - The Water Surface Elevation (WSE) from the storm event exceeds the finished slab elevation of the building (for pier and beam construction the top of first floor elevation), resulting in water entering the residential or commercial structure.
- 9.1.04.X. Undeveloped Parcel - a parcel on which there are no structures at the time that a construction permit, subdivision plat or other city approval is applied for or required.

SECTION 2 - DESIGN REQUIREMENTS

SECTION 2A - STORM WATER DESIGN REQUIREMENTS

9.2.01 DESIGN REQUIREMENTS

Projects shall meet the standards of this chapter. The Office of the City Engineer (OCE) may grant exceptions or deviations from these requirements on a project-by-project basis.

9.2.01.A. Construction of drainage facilities designed per this chapter shall meet requirements of the City of Houston Standard Specifications and Standard Details. HouStorm shall be used to perform 2-year and inlet design analysis and design of storm drainage systems as follows:

1. City CIP Projects – In conjunction with design analysis using HouStorm, designs shall comply with guidelines provided in Technical Paper No. 100 (TP-100), Storm Sewer Design Applications for the City of Houston, Texas, CIP Projects, February 2005, or the latest published date.
2. Private Projects within City Limits which include City funding participation.
3. 100% Privately-funded Project located in City Limits – HouStorm preferred but alternative equivalent analysis procedures will be accepted.
4. Projects in New or Expanding Utility Districts located in City's ETJ - HouStorm preferred but alternative equivalent analysis procedures will be accepted.

9.2.01.B. Determination of Runoff.

1. Design Rainfall Events.

a. Rainfall Intensity:

(1) Intensity Duration Frequency (IDF) Curves. Figure 9.1, City IDF Curves, depicts the intensity-duration curves to be used for storm sewer and roadside ditch design in the City and the ETJ. These curves were derived from the National Weather Service publications referenced in this Chapter.

(2) Calculate Intensity: The intensity calculation is based on duration equal to the time of concentration. The intensity is calculated as follows:

$$I=b/(d + T_C)^e$$

Where b, d, and e are coefficients dependent on the rainfall event, as provided in Table 9.1, below and are based on City depth- duration-frequency values.

9.2.01(B)(1)(a)(2)

continued

Table 9.1
Rainfall Intensity Parameters²

Rainfall Frequency	b	d	e
2-year	75.01	16.2	0.8315
3-year	77.27	17.1	0.8075
5-year	84.14	17.8	0.7881
10-year	93.53	18.9	0.7742
25-year	115.9	21.2	0.7808
100-year	125.4	21.8	0.7500

Note: The rainfall data presented above is the latest available as of the date of Ch 9 issuance. The City may adopt revised data not reflected in this table. It is the engineer’s responsibility to ensure that current accepted rainfall intensity calculations are being utilized for the analysis.

2. Application of Runoff Calculation Models.

- a. Rational Method: The Rational Method will be used to estimate peak flows for individual drainage areas up to 200 acres in size, and for project areas up to 640 acres in size. Project areas greater than 200 acres must be broken down into smaller drainage areas for analysis, with each drainage area being less than 200 acres in size. The Rational Method will be used for design on areas served by storm sewers up to 640 acres in size.
- b. Runoff Watershed Modeling: For areas greater than 640 acres, use the methodology specified in the HCFCFCD H&H Manual.
- c. Hydrograph Development Dynamic Conditions – For development of runoff hydrograph for use in dynamic modeling utilize Clark Unit Hydrograph Method.
- d. Hydrograph Development Static Conditions – For evaluation of detention volume the approved methodology for hydrograph development shall be based upon the NRCS Dimensionless Unit Hydrograph or Malcolm’s Small Watershed Method.

3. Coefficients for the Rational Method.

- a. Calculation of Runoff Coefficient.

(1) The runoff coefficient C values in the rational method formula will vary based on the land use. Land use types and C values which can be used are as follows:

² The City acknowledges that Harris County and Harris County Flood Control have adopted on June 4, 2019, new data based on Atlas 14. The City is considering this data and will consider editing this information for future release.

9.2.01(B)(3)(a)(1)

continued

<u>Land Use Type</u>	<u>Runoff Coefficient (C)</u>
Residential Districts	
Lots more than 1/2 acre	0.35
Lots 1/4 - 1/2 acre	0.45
Lots less than 1/4 acre	0.55
Townhomes	0.60
Multi-Family areas	
Less than 20 Service Units/Acre	0.65
20 Service Units/Acre or Greater	0.80
Business Districts	0.80
Industrial Districts	
Light Areas	0.65
Heavy Areas	0.75
Railroad Yard Areas	0.30
Parks/Open Areas	0.18
Pavement/ROW	0.90

(2) Alternatively, the runoff coefficient C in the Rational Method formula can be calculated from the equation:

$$C = 0.6Ia + 0.2$$

Where: C = watershed coefficient
Ia = impervious area/total area

(3) If the alternate form is to be submitted, the calculation of C shall be provided as part of the drainage calculations.

b. Determination of Time of Concentration.

Time of concentration can be calculated from the following formula:

$$TC = 10A^{0.1761} + 15$$

Where: TC = time of concentration (minutes)
A = subarea (acres)

c. Sample Calculation Forms.

(1) Figure 9.2, City of Houston Storm Sewer Calculation Form, is a sample calculation form for storm sewer systems.

(2) Figure 9.3, City of Houston Roadside Ditch Worksheet, is a sample calculation form for roadside ditch systems.

4. Hydrograph Development.

Where necessary to calculate runoff hydrographs, the peak flow of the hydrograph should match the Rational Method peak flow as calculated above. The hydrograph should be calculated using the entire drainage area, the FIS rainfall distribution, Green & Ampt loss rates, and the Clark Unit Hydrograph (TC&R) methodology.

These methodologies are described in the HCFCO H&H Manual. For design and impact analyses, Green & Ampt parameters as included in the effective hydrologic model for the watershed, rather than using the values from the FIS models. Selection of the Clark Unit Hydrograph parameters will be done as follows: T_C will be calculated as described above, with a minimum value of 10 minutes, and the storage coefficient (R) will be selected such that the peak flow matches the rational method peak flow. There will be a different R value for each rainfall event.

9.2.01.C. Design of Storm Sewers.

1. General Considerations

- a. Drainage systems for curb-and-gutter pavement shall consist of underground closed conduits.
- b. City CIP Projects or New Development that is anticipated to become City infrastructure and R.O.W.: The City's Comprehensive Drainage Plan (CDP) may indicate that a larger diameter storm sewer is planned in the area proposed for paving improvements. The Transportation and Drainage Operations of HPW has information on proposed improvements and should be consulted for impact on New Development.

Private Drainage Systems: Storm sewers for private drainage systems should conform to the City Uniform Building Code for development within the City limits. The City recommends the contents of this chapter as a guideline for best practices for all storm sewers within the City or its ETJ.

2. Design Frequency.

- a. New Development: The Design Rainfall Event for sizing storm sewers in newly developed areas will be at minimum a 2-year rainfall event.
- b. Redevelopment: The existing storm drain (sewer, ditch) shall be evaluated using a 2-year rainfall event, assuming no development takes place. The storm drain shall then be evaluated for the 2-year rainfall event design with the Development in place.
 - (1) If the proposed Redevelopment has an equal or lesser amount of impervious surface and the existing storm drain (sewer, ditch) meets 2- year level of service, then no modifications to the existing storm drain are required.
 - (2) If the proposed Redevelopment results in the hydraulic gradient of the existing storm drain below the gutter line, no improvements to the existing storm drain are required.
 - (3) If the analysis of the existing conditions finds that the existing storm drain is deficient (i.e. the hydraulic grade line is above the gutter line), the

9.2.01(C)(2)(b)(3)

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applicant should check with the City to see if a CIP or a DPC project is proposed that will require a capital contribution.

3. Velocity Considerations.

- a. Storm sewers should be constructed to flow in subcritical hydraulic conditions if possible.
- b. Minimum velocities should not be less than 3 feet per second with the pipe flowing full, under the design conditions.
- c. Maximum velocities at the storm sewer system outfall should not exceed 8 feet per second without use of energy dissipation at the outfall.
- d. Maximum velocities within storm sewers should not exceed 12 feet per second.

4. Pipe Sizes and Placement.

- a. Use storm sewer and inlet leads with at least 24 inches inside diameter or equivalent cross section. Single Family Residential projects, without sharing storm outfall with others, shall be permitted to use the point of connection through a curb via a 4 inch schedule 40 pipe or to connect to the ditch with 12 inch schedule 40 pipe within the R.O.W. Box culverts shall be at least 3 feet by 2 feet. Closed conduits; circular, elliptical, arch pipe, or box, shall be selected based on hydraulic principles and economy of size and shape.
- b. Larger pipes upstream should not flow directly, or indirectly (via inlet, junction box, manhole) into smaller pipes downstream unless construction constraints prohibit the use of a larger pipe downstream, or the improvements are outfalling into an existing system, or the upstream system is intended for use as detention.
- c. Match crowns of pipe at any size change unless severe depth constraints prohibit.
- d. Locate public storm sewers in public street R.O.W. or in approved easements. Back lot easements are discouraged and will require a variance from the City design standards.
- e. Follow the alignment of the R.O.W. or easement when designing cast in place concrete storm sewers.
- f. Conduits shall connect to manholes and inlets preferably on a straight alignment, however angled connections no greater than 10 degrees normal to the wall will be provided.
- g. Center culverts in side lot storm sewer easements.
- h. Minimum horizontal clearance between the exterior of any storm pipe or box

9.2.01(C)(4)(h)
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culvert shall be at least 48 inches from the exterior of the existing or proposed public or private utility and other appurtenances (i.e., inlet or manhole).

- i. Minimum vertical clearance between the exterior of any storm pipe or box culvert or other appurtenances (i.e., manhole or inlet) shall be at least 18 inches from exterior of the existing or proposed public or private utility and other appurtenances.
 - j. Siphon design connection shall not be allowed.
 - k. Conflict manhole shall not be allowed.
5. Starting Water Surface and Hydraulic Gradient.

- a. Tailwater elevation selections for Hydraulic Gradient Line (HGL) analysis:

(1) If the receiving channel for the storm system being analyzed is less than 2,000-feet from the project limits, then the starting tailwater shall be determined from outfall at the receiving channel according to criteria.

- For the 2-year design rainfall event with non-submerged outfall to the receiving channel, the starting tailwater shall be the top of pipe.
- For the 100-year extreme rainfall event and outfall to the receiving channel, the starting tailwater shall be the 10-year water surface elevation (WSE) or 2-feet below the top of bank.

(2) If the receiving channel for the storm system being analyzed is greater than 2,000-feet from the project limits, then the starting tailwater may be determined from an outfall point, or truncation, downstream of the project interconnect point, as noted below:

- For the 2-yr design rainfall event the starting HGL, shall be the top of pipe 2,000-feet downstream of the project interconnect point assuming pipes are connected at soffit. If pipes are connected at flow line, the top of the larger receiving pipe must be used. If a starting tailwater other than the top of pipe is chosen, the consultant shall analyze the storm system from outfall at the receiving channel upstream to the point of interconnect to demonstrate the alternate starting HGL value.
- For the 100-year extreme rainfall event the starting HGL shall be 2-feet above the top of pipe 2,000-feet downstream of the project interconnect point. If a starting tailwater other than 2-ft above the top of pipe is chosen, the consultant shall analyze the storm system from outfall at the receiving channel upstream to the point of interconnect to demonstrate the alternate starting HGL value.

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- (3) For the hydraulic impact analysis a variable tailwater at the downstream end of the model may be used (reference to TP-100). A variable tailwater condition is recommended for use for detention analyses.
 - b. At drops in pipe invert, where the top of the upstream pipe be higher than the HGL, then the HGL shall be recalculated assuming the starting water surface to be at the top of pipe at that point.
 - c. For the Design Rainfall Event, the hydraulic gradient shall at all times be below the gutter line for all newly developed areas.
6. Manhole Locations.
- a. Use manholes at the following locations:
 - (1) Size or cross section changes.
 - (2) Inlet lead and conduit intersections.
 - (3) Changes in pipe grade.
 - (4) A maximum spacing of 700 feet measured along the conduit run.
 - b. Use manholes for existing monolithic-concrete storm sewers at the same locations as above except for intersections of inlet leads unless a manhole is needed to provide maintenance access at those intersections.
 - c. Do not place manholes in driveways or in the street in front of or immediately adjacent to a driveway.
7. Inlets.
- a. Locate inlets at low points in the gutter.
 - b. Valley gutters across intersections are not permitted.
 - c. Inlet spacing is a function of gutter slope. The minimum gutter slope shall comply with Chapter 10, Street Paving Design Requirements.
 - (1) For minimum gutter slopes, the maximum spacing of inlets shall result from a gutter run of 700-feet from high point in pavement or the adjacent inlet on a continuously graded street section, with a maximum of 1400-feet of pavement draining towards any one inlet location.
 - (2) Inlet location should be spaced to ensure that spread does not exceed one lane of the roadway for the design rainfall event.

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- (3) Residential Development: Maximum spacing of inlets shall result from a gutter run of 700-feet from high point in pavement to the adjacent inlet on a continuously graded street section, with a maximum of 1400-feet of pavement draining towards any one inlet location.
- (4) Commercial Development: Maximum spacing of inlets shall result from a gutter run of 400-feet from high point in pavement to the adjacent inlet on a continuously graded street section with a maximum of 600-feet of pavement draining towards any one inlet location.
- (5) Spread: Calculate 2-year rainfall flow approaching each inlet from each direction. Additional inlets may be required if the Spread exceeds the maximum allowable value. The Spread in a typical prismatic curb-and-gutter street may be calculated using the following relationships:

$$Q = (K_g/n)(S_x^{1.67})(S_o^{0.5})(T^{2.67}), \text{ and}$$

$$T = y/S_x$$

Where: K_g = 0.56 (US Customary Units) or 0.376 (SI Units)

n = Manning's roughness coefficient

S_x = Transverse slope (or cross slope) (ft/ft),

S_o = Longitudinal pavement slope (gutter slope) (ft/ft)

T = Spread (ft), and

y = Ponded depth (ft)

(6) Allowable Spread:

- (a) On a residential street, the Spread shall be no greater than the distance from the curb to the center crown of the roadway.
- (b) For a roadway with two or more lanes in each direction, the Spread shall be no greater than the distance from the curb to the inside edge of the outside lane.
- (c) The Spread adjacent to an inlet shall be no greater than the point of intersection of the transverse pavement slope with the top of curb elevation (i.e., the maximum Design Ponding Depth).
- d. Use only City of Houston standard inlets (See Table 9.2).

Table 9.2*
STANDARD STORM SEWER INLETS

INLET	APPLICATION	NOMINAL CAPACITY CFS	DWG. NOS.
Type A	Driveway, parking lots, small areas (curb and gutter system not available area). Please note inlets shall not allowed on travel lanes.	5.00	02632-01
Type B-B (with solid plate or grate)	Curb and gutter system within collector streets (major collector, minor collector), transit corridor street, residential and commercial area.	5.00	02632-04
Modified B-B (with solid plate or grate)	Driveway, parking lots, small areas (with no curb and gutter system). Please note grates shall not allowed on travel lanes.	N/A	
Type C	Curb and gutter system within collector streets (major collector, minor collector), transit corridor street, residential & commercial area.	2.50	02632-06
Type C-1	Curb and gutter system within major thoroughfare, collector streets (major collector, minor collector), transit corridor street & commercial area.	5.00	02632-06
Type C-2	Curb and gutter system within major thoroughfare & commercial area.	10.00	02632-06
Type C-2A	Curb and gutter system within major thoroughfare & commercial area.	10.00	02632-06
Type D	Driveway, parking lots, small areas (curb and gutter system not available area). Please note inlets shall not be allowed on travel lanes.	4.00	02632-07
Type D-1	Driveway, parking lots, small areas (curb and gutter system not available area). Please note inlets shall not be allowed on travel lanes.	3.00	02632.08
Type E	Road side ditch connect with storm sewer system.	10.00	02632-09,-10
Precast Area Zone Drain (PAZD)	Low profile roadside ditch in residential and commercial area	Varies TBD by Engineer	Styles 'RG' and 'FG' on TxDOT detail prestd08.dgn

* The nominal capacity values provided in Table 9.2 are to be used for initial sizing only. The actual Inlet size all shall be based on hydraulic analysis of the required inlet capacity. Inlet capacities are calculated using either orifice and or weir equations depending upon their location and a type of inlet openings with or without plates.

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- e. Do not use beehive grate inlets or other specialty inlets.
 - f. Do not use grate top inlets in unlined roadside ditch.
 - g. Do not place inlets in the circular portion of cul-de-sac streets unless justification based on special conditions can be provided.
 - h. Place inlets at the end of proposed pavement, if drainage will enter or leave pavement.
 - i. Do not locate inlets adjacent to esplanade openings.
 - j. For new residential development, locate inlets at the center of lots and drainage system with lot site layout such that inlets are not located within the driveway between the radius end points as defined by the driveway radius intersection with the curb or edge of pavement.
 - k. Place inlets on side streets intersecting major streets, unless justification based on special conditions can be provided.
 - l. For private development with internal site drainage, only one connection is permitted to any one inlet, and that connection (lead) shall be made to the back of the inlet. Connection shall not be made to the front face and to the short sides of the inlet unless approved by the City. Design the connection not to exceed the pipe capacity minus either the capacity listed in Table 9.2, Standard Storm Sewer Inlets, or calculated inlet inflow.
 - m. For all new construction, convey public or private alleyway drainage to an inlet prior to entering the public street drainage system.
 - n. For all new connections, the engineer shall be required to demonstrate that inlets for design storm events have adequate capacity based on ponding and available opening. For New Development, Redevelopment, or Site Modification or connections to curbside inlets, existing B inlets along or immediately downstream of said development shall be enlarged to BB inlets.
 - o. For inlet calculations reference the TXDOT Hydraulic Design Manual Chapter 10, Section 5, Storm Drain Inlets at <http://onlinemanuals.txdot.gov/txdotmanuals/hyd/index.htm>
 - p. Grate inlets shall not be allowed on travel lanes other than the gutter.
 - q. Do not use inlets without top manhole lip in major streets (i.e. Type BB inlet).
8. Pipe materials and installation shall conform to latest City of Houston Standard Specification 02631.

9.2.01.D. Extreme Event Analysis

1. The design frequency for consideration of overland sheet flow will consider extreme storm events (up to 100-year storms). These events, which exceed the capacity of the underground storm sewer system and result in ponding and overland sheet flow, shall be routed to drain along street ROW or open areas and through the development to a primary outlet.
2. An overland flow analysis of the proposed drainage system shall be prepared by the design engineer. The design engineer shall submit supporting calculations, exhibits, and drawings, which define the conveyance capacity of the roadway, define the flow paths of overland sheet flow and define the ponding depths of overland sheet flow.
 - a. Three analysis methods as presented in Technical Paper No. 101, Simplified 100-year Event Analyses of Storm Sewers and Resultant Water Surface Elevations for Improvement Projects in the City of Houston, Harris County, Texas Region will be acceptable to the City.
 - (1) Method 1: Hydraulic Grade Line (HGL) Analysis A simplified approach to analyze and control the 100-year water surface elevation (WSEL) can be achieved by designing the storm sewer system for the 2-year frequency rainfall event; imposing a 100-year frequency storm event on the proposed design; calculating the hydraulic grade for the 100-year frequency event for the proposed design; and adjusting the position of the HGL to not exceed the critical elevation by increasing the size of the proposed storm sewer for selective reaches.
 - (2) Method 2: $Q_t = Q_o + Q_c$
where Q_t is the total flow conveyed,
 Q_o is the overland flow component, and
 Q_c is the calculated flow in the conduit for the 2-year design event. The overland flow component (Q_o) is computed by applying Manning's Equation to calculate the flow across the critical street cross-section along the R.O.W. This method accounts for flow in the storm sewer and overland flow across the street crest, but does not account for street ponding or storage.
 - (3) Method 3: $Q_t = Q_o + Q_c + \Delta S/T$
where Q_t , Q_o , and Q_c are as defined above, and
 $\Delta S/T$ is the change in storage volume relative to time provided in the streets and adjacent area upstream of the point of interest being analyzed. This method uses a volumetric calculation based on a 100-year frequency storm event with a duration of 3-hours for developments less than 200 acre and 6-hours duration for developments over 200 acres. The Soil Conservation Service, TR-20 method is used to set a peak triangular hydrograph shape. This method accounts for flow in the storm sewer, overland flow across the

9.2.01(D)(2)(a)(3)

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street crest, and storage within the street and adjacent area.

- b. Analysis using the U.S. Environmental Protection Agency’s Stormwater Management Model (SWMM) will be acceptable to the City.
3. Relationship of Structures to Street: All structures shall be above the maximum ponding elevation anticipated resulting from the extreme event analysis.
 - a. Barring conditions listed in 9.2.01.D.3.a and b, the maximum ponding elevation for the 100-year event at any point along the street shall not be higher than the natural ground elevation at the R.O.W. line.
 - b. For City CIP Projects, the maximum ponding elevations shall be no higher than 12 inches below the finished slab elevations, or, if the finished slab elevations are less than 12 inches above the natural ground elevations at the R.O.W., the ponding elevations shall be no higher than the natural ground elevations at the R.O.W. In instances where the maximum ponding elevation for the 100-year event is not within the natural ground elevation at the R.O.W. line, the engineer will add a note on the drawings indicating the rainfall frequency event is designed to be conveyed within the R.O.W.
 - c. For Development or Redevelopment by private entities, the post- project maximum WSE shall be no higher than the pre- project maximum WSE in surrounding areas, and proposed finished slab elevation shall be above the post-project maximum WSE. The Maximum Ponding Elevation is determined from the physical characteristics of an area, and may change as a result of the proposed Development. Where existing topographic conditions, project location within a special flood hazard area, and/or other site conditions preclude achieving this objective, the City will consider waiver of this requirement upon submittal of documentation and analysis prepared, signed, and sealed by a professional engineer, registered in the State of Texas. Analysis shall demonstrate that structural flooding will not occur and will identify the rainfall frequency event that will be conveyed within the R.O.W. The limiting parameter will depend on project-specific conditions, and the most restrictive condition (the lowest ponded water elevation) shall govern.
4. Design Considerations:

Streets shall be designed so that consecutive high points in the street will provide for a gravity flow of drainage to the ultimate outlet. If a detention facility is designed to mitigate peak flows from the extreme event, the overland flow path shall carry the extreme event sheet flow to the detention facility. If the extreme event sheet flow must enter a receiving channel, the overland flow path shall carry the extreme event sheet flow to the channel. In the event that there is no overland flow path, or the overland flow path is insufficient to carry all of the extreme event sheet flow, the inlets and storm sewer at the downstream end of the overland flow path shall be sized to carry the extreme event sheet flow from the end of the overland flow path into the detention facility or receiving channel.

- a. The maximum depth of ponding at high points shall be 6 inches above top of curb.
- b. The maximum depth of ponding at low points shall be 18 inches above top of curb.
- c. Provide a minimum 20-foot easement to accommodate sheet flow that is routed between lots or across reserve tracts in accordance with Section 5.07.C. Fence lines and other improvements shall not be constructed on or across dedicated drainage easements.
- d. A drawing(s) shall be provided to delineate extreme event flow direction through a Development and how this flow is discharged to the primary drainage outlet.

The extreme event flow path(s) shall be identified on a plan view drawing(s) such as the drainage area map. There will be multiple extreme event flow paths for most projects. A profile for each path should be shown. Where secondary paths join a primary path, the secondary path profile should extend at least one street high/low point downstream along the major flow path, until the maximum ponding elevation downstream of the confluence is lower than the maximum ponding elevation upstream of the confluence.

- e. The drawing for each path shall show a profile of the roadway (or overland flow path) from the upper reach of the drainage area to the primary drainage outlet. The drawing(s) shall be exaggerated vertical scale and shall include roadway profile at the gutter, ground profile at the R.O.W., all the parameters used to determine the maximum ponding elevations, the maximum ponding elevations, and the hydraulic gradient for the extreme event, or an alternative equivalent drawing accepted by the City. The drawing(s) should be separate from the plan and profile sheets, and should include the entire overland flow path on one sheet, if possible. The drawings are not required to include the storm sewer profile.
5. Evacuation Routes and Emergency Service Routes. This standard applies to routes designated by HPW for emergency evacuation and for routes where access by the emergency service vehicles is a public safety need. Ponding of surface runoff is not allowed in the highest travel lane (each direction) for the 100-year event. Exceptions to this standard based on technical infeasibility or cost limitations will require approval of the Director, Houston Public Works, or his designated representative. This standard may be modified or exempted for locations in the 100-year floodplain.

9.2.01.E. Design of Open Channels.

1. Design Requirements and General Criteria.
 - a. Open channels shall be designed according to methods described in the HCFCD

9.2.01(E)(1)(a)
continued

Criteria Manual which can be accessed at www.hcfcd.org/dl_manuals.html and shall convey 100 year event.

- b. Design standards for channel construction shall follow the requirements specified in the HCFCFCD Criteria Manual which can be accessed at www.hcfcd.org/dl_manuals.html.
- c. Design standards for outfalls into channels shall conform to those in the HCFCFCD Criteria Manual which can be accessed at www.hcfcd.org/dl_manuals.html.

2. Determination of Water Surface Elevation (WSE).

- a. WSE shall be calculated using Manning's Equation and the Continuity Equation.
- b. For the Design Rainfall Event, the water surface shall be calculated to remain 1' below the top of banks.

3. Design of Culverts.

- a. Head losses in culverts shall conform to TxDOT Hydraulics Manual, Chapter 8, and Culverts.
- b. Corrugated metal pipe will be approved only for railroad crossings.
- c. For proposing Street Parking Pads (only allowed in projects approved by planning commission) over an existing ditch, the submitted plans must include the following:
 - (1) Include upstream and downstream ditches/area of the proposed culvert as necessary for drainage analysis.
 - (2) Include overall drainage area and sub-drainage areas, culvert type, size, slope, length and flow velocities (for 2 and 100-year event).
 - (3) Include a culvert hydraulic calculation and identify headwater elevations for 2-year and 100-year design events.
 - (4) Include a calculation for the existing and proposed ditch/culvert flows for 2-year and 100-year design events.
 - (5) Identify max ponding elevation (MPE with location) and provide a calculation for the existing and proposed ditch/culvert hydraulic grade lines (HGLs) for 2-year, 10-year, 25-year, and 100-year design events. Show no adverse impact to the area.
 - (6) Include a calculation for the existing and proposed ditch/culvert capacity (volume) for 2-year, 25-year, and 100-year design events. Show no adverse impact to the area.

(7) Proposed enclosed system should match the existing ditch storage capacity.

(8) Drawing(s) must be sealed and signed by a professional Engineer Licensed in the State of Texas.

9.2.01.F. Design of Roadside Ditches.

1. Design Frequency.

- a. Roadside ditch design is permissible only for single family residential lots or commercial areas equal to or larger than 0.5 acres.
- b. The Design Rainfall Event for the roadside ditches shall be a minimum of 2-year rainfall.
- c. Design capacity for a roadside ditch shall be to a minimum of 0.5 feet below the edge of pavement or 0.5 feet below the natural ground at R.O.W. line, whichever is lower, including head loss across the culvert. Design Capacity calculations shall include head loss calculations for driveway and roadway culverts that are placed along the roadside ditch.
- d. The design must include an extreme event analysis to indicate that structures will not be flooded, and that maximum ponding elevation for the extreme event complies with Paragraph 9.2.01.D.3.

2. Velocity Considerations.

- a. For grass-lined sections, the maximum design velocity shall be 3.0 feet per second during the design event.
- b. A grass-lined or unimproved roadside ditch shall have side slopes no steeper than three horizontal to one vertical (3:1), or as soil conditions will permit.
- c. Minimum grades for roadside ditches shall be 0.1-foot per 100 feet.
- d. Calculation of velocity will use a Manning's roughness coefficient (n) of 0.045 for earthen sections and 0.025 for ditches with paved inverts.
- e. Use erosion control methods acceptable to the City when design velocities are expected to be greater than 3 feet per second.
- f. The top of bank shall not encroach beyond the City R.O.W. or within 2 feet of the edge of pavement.

3. Driveway and Roadway Crossings
 - a. Culverts will be placed at all driveway and roadway crossings, and other locations where appropriate.
 - b. Culverts shall be evaluated for inlet and outlet control, as well as normal depth. The highest of the three shall be designated as the computed headwater for design of the culvert section.
 - c. Roadside culverts are to be sized based on hydraulic analysis. The minimum culvert size shall be 24 inches inside diameter or equivalent 'cross section'. For example, if the ditch is deeper than or equal to 29 inches, the elliptical pipe with inside diameter of 19 inches x 30 inches can be used. Calculations shall be provided for review. In the ETJ, the Regulations for Harris, County, Texas for the Construction of Driveways and/or Culverts on County Easements and R.O.W. shall govern.
 - d. Design capacity calculations shall include head loss calculations for driveway and roadway culverts that are placed along the roadside ditch.
 - e. Stormwater discharging from a ditch into a storm sewer system must be received by an appropriate structure (i.e., stubs with ring grates or Type E inlets).
 - f. Install appropriate structures (i.e., headwall) at both sides of inlet and outlet of a culvert.
4. Invert Protection.
 - a. Ditch invert protection shall be used when velocities exceed 3 feet per second.
 - b. Ditch invert protection will be used at the upstream and downstream ends of all culverts.
5. Depth and Size Limitations.
 - a. Maximum depth shall not exceed 4 feet from adjacent edge of pavement.
 - b. Roadside ditch bottoms shall be at least 2 feet wide, unless design analysis will support a narrower width.
 - c. Ditches in adjoining and parallel easements shall have top of bank not less than 2 feet from the outside easement line.

9.2.01.G. Design of Outfalls: Outfalls from storm sewers or detention facilities that discharge directly into a channel or other HCFCD facility shall be designed and constructed in

accordance with HCFCD criteria.

9.2.01.H. Stormwater Detention.

1. The intention of Stormwater detention is to mitigate the effect of New Development, Redevelopment, or Site Modifications on an existing drainage system. Stormwater detention volume requirements are based on the acreage of the disturbed area that results in impervious surface. Stormwater detention volumes are calculated at the minimum rates set forth in Paragraph 9.2.01.H.3.

2. Application of Detention.

a. The use of on-site detention is required for all Developments within the City and for new or expanding utility districts within the City's ETJ. Detention may not be required if the City has developed detention capacity for a drainage watershed, and/or infrastructure improvements, to serve the drainage watershed in compliance with the requirements of this Chapter. Under these conditions, the City will consider a funding contribution in lieu of on-site detention volume constructed by the owner.

b. Stormwater detention requirements are invoked for redevelopments that include disturbed area resulting in impervious surface.

c. If the drainage system outfalls directly into a channel maintained by HCFCD, and the requirements of HCFCD include payment of an impact fee, then no further impact fee will be required by the City.

d. A waiver of detention requirements may be requested if the following conditions are satisfied:

Development is located in an area determined by the City to not need detention due to (1) the geographic location in the watershed, (2) the Development's proximity to regional facilities, or (3) the capacity of the receiving outfall facilities. Such conclusion by the City shall be supported by submittal of a Hydraulic Report prepared, signed, and sealed by a professional engineer, registered in the state of Texas, to demonstrate compliance with the conditions stated in this Chapter. The hydraulic analysis shall consider (1) the current developed condition of the watershed of the Stormwater conveyance system, and (2) the fully developed condition of the watershed. The probable land use for the fully developed condition will be determined by the design engineer for review and approval by the City. The hydraulic analysis shall demonstrate no negative impact to upstream or downstream conditions.

3. Calculation of Detention Volume.

a. Detention volume for Development areas is calculated on the basis of disturbed area that results in impervious surface, as defined in 9.1.04.O, associated with

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the project development.

- b. Single family residential (SFR) lots of 15,000 square feet in area or less: SFR Lots are not required to provide detention if the Impervious area is less than or equal to 65%. Detention volume of 0.20 acre feet per acre is required for Impervious area in excess of 65% of the lot.

(1) Detention Requirement = 0.2 acre feet per acre of impervious cover (including all disturbed area that results in impervious surface) surface exceeding over 65% of the project area;

(2) No sheet flow to the ROW is allowed. Without sharing storm outfall with others, a point of connection through a curb via a 4-inch PVC pipe within the ROW shall be permitted.

- c. SFR lots of 15,000 square feet or less utilizing a shared driveway are required to provide detention at a volume of 0.20 acre feet per acre. The individual lots will be required to detain based on area in excess of 65% impervious. The entire shared driveway (access road, permanent access easement (28' PAE), private alley, public alley, or common driveway) will be required detention; no 65% reduction will be allowed. The total detention for the development will be a combination of these two volumes.

(1) Detention Requirement =

[0.2 acre feet per acre of impervious cover surface (including all disturbed area that results in impervious surface) in excess of 65%]

+

[0.2 acre feet per acre] x [The area of the common or shared driveway, the access easement, a permanent access easement (28'PAE) access road, private alley or public alley, or similar access way by any other name, must be included in the calculation of the project area.]

- d. Tract size less than one acre and not subject to 9.2.01.H.3.b or 9.2.01.H.3.c: Detention volume will be required at 0.20 acre-feet per acre of disturbed area that results in impervious surface. Additionally, detention volume will be required to offset redevelopment of existing impervious surfaces.

If shared driveway is used, detention volume of 0.20 acre feet per acre is required. In other words, for projects that are platted to contain more than one lot and access to these individual lots is to be provided by a common or shared driveway, such as an access agreement, an access road, a permanent access easement (28' PAE) private alley or public alley, the detention requirements shall be calculated as this section:

The area of the common or shared driveway, the access easement, a permanent

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access easement (28'PAE) access road, private alley or public alley, or similar accessway by any other name, must be included in the calculation of the project area.

Any project when a shared driveway is used, subsurface drainage system is required. No sheet flow to the ROW is allowed.

Total Detention Volume required is calculated as follows:

$$V_T = [43,560 \times (0.20 \times A_{II})]$$

V_T = Total Detention Volume for the proposed project (Cubic Feet)

A_{II} = Area of impervious surface (including all disturbed area resulting in impervious surface) (Acres)

Subdividing of larger tracts (greater than 1 acre) into smaller tracts of 1.0 acre or less to reduce stormwater detention requirements will not be permitted.

- e. Tract size equal or greater than 1 acre and less than or equal to 50 acres: Detention volume will be required at 0.50 acre-feet per acre of disturbed area that results in impervious surface.

Total Detention Volume required is calculated as follows:

$$V_T = [43,560 \times (0.50 \times A_{II})]$$

V_T = Total Detention Volume for the proposed project (Cubic Feet)

A_{II} = Disturbed area that results in impervious surface (Acres)

- f. Tract size greater than 50 acres: Detention calculation will be per the most current version of the HCFCFCD PCPM. Refer to http://www.hcfcd.org/downloads/manuals/HCFCFCD_PCPM_Dec2010.pdf
- g. Private parking areas, private streets, and private storm sewers may be used for detention provided the maximum depth of ponding does not exceed 9 inches directly over the inlet, and paved parking areas are provided with signage stating that the area is subject to flooding during rainfall events.
- h. Private transport truck only parking may be used for detention provided the maximum depth of flooding does not exceed 15 inches directly above the inlet and signage is provided stating that the area is subject to flooding during rainfall events.
- i. All mitigation facilities shall be located within or adjacent to the project area except for roadway projects or projects where impacts are mitigated in a regional stormwater detention facility. Engineer shall provide calculations indicating receiving stormwater system was designed to have conveyance capacity to non-adjacent detention facilities.

9.2.01(H)(3)

continued

- j. Low Impact Development (LID) techniques that are considered acceptable for achieving detention are Bioretention, Infiltration Trenches, Porous Pavement, Vegetative Swales, Green Roof, Hard Roof, and Rain Barrels. See section 9.10.01 for LID design guidelines.

Review and approval of engineering calculations demonstrating the volume of detention achieved for each LID feature will be required.

If LID techniques are considered for achieving detention, review and approval of a maintenance and Life Cycle plan are required per this section and section 9.2.01(H) of this chapter. Review and approval of engineering calculations demonstrating the volume of detention achieved for each LID feature will be required. This plan shall be signed and sealed by a professional registered engineer and included as part of the review and approval process.

- k. For any new development or any part of an existing development that is still undeveloped, the most recent detention requirements would apply.

4. Calculation of Outlet Size.

- a. Detention pond discharge pipe into an existing storm sewer line or existing City of Houston ditch:

- (1) If the maximum pool elevation is at or below the design hydraulic grade at the drainage system outfall, the discharge line shall be sized for the Design Rainfall with the discharge pipe flowing full. The pond will float on the drainage system to provide maximum benefit.

- (2) If the maximum pool elevation is at or above the hydraulic grade at the drainage system outfall, provide a reducer or restrictor pipe to be constructed inside the discharge line. The discharge line shall be sized for the Design Rainfall with the discharge pipe flowing full.

- b. Reducer or Restrictor Pipes shall be sized as follows:

- (1) Allowable Discharge Rate – Use the lowest of the discharge rates described below:

- (a) Restrictor pipes will provide a combination of low level and high level controlled release from the detention basin. The low level restrictor pipe (primary orifice) shall be sized to provide a release rate of 0.5 CFS/acre when the detention basin water depth is 25% of capacity. The low level restrictor pipe (primary orifice) shall be located at the bottom of the basin to provide complete drainage of the pond. The high level restrictor pipe (secondary orifice) shall be sized to provide a combined release rate (from the primary orifice and secondary orifice) of 2.0 CFS/acre at full basin depth. The high level restrictor secondary orifice) shall begin

9.2.01(H)(4)(a)

continued

releasing flow when detention basin water depth reaches 75% of capacity. The combined rate of 2.0 CFS/acre is the approximate discharge from an undeveloped tract for the 100-year storm. The basin is considered 100% full when it reaches its maximum volume during the 100-year storm.

(b) Flow discharged to the storm drain shall not exceed the proportional amount of pipe capacity allocated to the Development. The proportional amount of pipe capacity allocated to the Development shall be determined by the ratio of the area (acres) of the Development (in storm drain watershed) divided by the total drainage area (acres) of the storm drain multiplied by the capacity of the storm drain.

(2) Use the following equations to calculate the required outflow orifice:

$$Q = CA \sqrt{2g} \sqrt{h}$$

$$D = Q^{1/2} / (2.25h^{1/4})$$

Where:

Q = outflow discharge (cfs)

C = coefficient of discharge

= 0.8 for short segment of pipe

= 0.6 for opening in plates, standpipes, or concrete walls

A = orifice area (square feet)

g = gravitational factor (32.2)

h = head, water surface differential (feet)

D = orifice diameter (feet)

(3) For rectangular weir flow calculation:

$$Q = CLH^{3/2}$$

Where:

Q = weir discharge (cfs)

C = weir coefficient

L = horizontal length (ft)

H = head on weir (ft)

The value of the weir coefficient, C, depends on the weir shape (i.e., broad crested or sharp crested) and if the weir is submerged or not. See Brater and King's Handbook of Hydraulics or other applicable references.

(4) Restrictor shall be either of the required diameter or of the equivalent cross-sectional area. The orifice diameter D shall be a minimum of 0.5 feet.

c. In addition to a pipe outlet, the detention basin shall be provided with a gravity spillway that will protect structures from flooding should the detention basin be overtopped.

5. Ownership and Easements.

9.2.01(H)(5)
continued

a. Private Facilities:

- (1) Pump discharges into a roadside ditch requires the submittal of pump specifications on the design drawings.
- (2) The City reserves the right to prohibit the use of pump discharges where their use may aggravate flooding in the public R.O.W.
- (3) Responsibility for maintenance of the detention facility must be confirmed by letter submitted to the City as part of the design review.
- (4) All private properties being served have drainage access to the pond. Dedicated easements may be required.
- (5) No public properties may drain into the detention area.
- (6) A private maintenance agreement must be provided when multiple tracts are being served.

b. Public Facilities:

- (1) Facilities will only be accepted for maintenance by the City within the City limits in cases if public drainage is being provided.
- (2) The City requires a maintenance work area of 20-foot width surrounding the extent of the detention area. Public R.O.W. or permanent access easements may be included as a portion of this 20- foot width. See table 9.3 below from the HCFCD PCPM for minimum berm widths around a detention basin.

Table 9.3: Minimum Berm Width around a Detention Basin

Detention Basins That Are	The Minimum Berm Width Is
Grass-lined with a depth > 7 feet	30 feet
Grass-lined with a depth ≤ 7 feet	20 feet ¹
Grass-lined where side slopes are 8(horizontal):1(vertical) or flatter	10 feet ²
Grass-lined with the 20-foot maintenance access on a bench	10 feet
Lined with riprap or articulated concrete blocks or partially concrete-lined	Same as grass-lined channel
Fully concrete-lined	20 feet ¹

¹Backslope swale system not needed.

²Maintenance access is on the side slope.

- (3) A dedication of easement shall be provided by plat or by separate instrument.

9.2.01(H)(5)(b)
continued

- (4) Proper dedication of public access to the detention pond must be shown on the plat or by separate instrument. This includes permanent access easements with overlapping public utility easements.
- (5) Backslope drainage systems are required where the natural ground slopes towards the drainage basin. A basin that is within 30 feet of a parking lot or roadway with berms that drain away from the basin does not require a backslope swale. Comply with criteria provided in HCFCDC Criteria Manual.

SECTION 2B - STORM STRUCTURAL DESIGN REQUIREMENTS

9.2.02 STRUCTURAL DESIGN REQUIREMENTS

The engineer of record is responsible for the design of all structural components within the proposed storm water design. This includes but is not limited to pipe, box sewers, manholes and junction boxes.

Cast in place and precast structural elements are both allowed given that each design is signed and sealed by a professional engineer.

SECTION 3 - EASEMENT AND RIGHTS-OF-WAY

9.3.01 EASEMENT AND RIGHTS-OF-WAY

Storm sewer easement and R.O.W. requirements are described in Chapter 5 Easement Requirements.

SECTION 4 – SUBMITTALS

9.4.01 SUBMITTALS

9.4.01.A. Submittal for review and comments:

1. Approximate definition of lots and street patterns.
2. Stormwater Information Form.
3. Any proposed drainage easements.
4. Floodplain information, including floodplain boundary, if any; FEMA map number, effective map date and zone.
5. Copies of any documents which show approval of exceptions to the City design criteria.
6. Design calculations for time of concentration, storm line sizes and grades, and for detention facilities, if any.
7. Design calculations for the Hydraulic Grade Line of each line or ditch, and for detention facilities, if any.
8. Drainage Area Map with the following information:
 - a. Existing contour map.
 - b. Existing and Proposed drainage area and sub-drainage area boundaries.
 - c. Existing and Proposed drainage area (acres) and flow quantity (cfs) draining to each inlet and each pipe segment from manhole to manhole.
 - d. Extreme event (100-year) Sheet Flow direction.
 - e. Existing condition and proposed condition Sheet Flow direction for the surrounding properties.
9. Plan and profile sheets showing Stormwater design (public facilities only).

Projects located within a floodplain boundary or within a floodplain management area shall:

- a. Show the floodplain boundary or floodplain area, as appropriate, on the Drainage Area Map.
- b. Comply with all applicable submittal requirements of Chapter 19, Code of Ordinances.

- c. Review and approval of this project by the City of Houston Floodplain Management Office (FMO) is required.
 10. Profile drawing of roadway (or overland flow path) with exaggerated vertical scale from the upper reach of drainage area to the primary drainage outlet. Show roadway profile at gutter, ground profile at the public R.O.W., and hydraulic gradient lines for the 2-year and 100-year extreme event; or an alternative equivalent drawing accepted by the City.
 11. Calculation for proportional amount of pipe capacity allocated to the Development along with the drainage area map used for these calculations.
 12. If the detention has been provided by other projects, a Memorandum should be provided to explain how the existing detention facility serves this proposed project.
- 9.4.01.B. Signature Stage - Submit the following for approval:
1. Review prints with all comments.
 2. Original drawings
 - a. Provide Stormwater Information Form log number on the cover sheet.
 - b. Provide all information requested in section 9.4.01A.
 3. Stormwater detention maintenance agreement letters.
 4. All required permits from other agencies or departments (i.e., HCFCDD approval, Floodplain Management Office (FMO) approval, etc.)

SECTION 5 - QUALITY ASSURANCE

9.5.01 QUALITY ASSURANCE

Prepare calculations and design drawings under the supervision of a Professional Engineer trained and licensed under the disciplines required by the project scope. The final design drawings and all design calculations must be sealed, signed, and dated by the Professional Engineer responsible for the development of the drawings.

SECTION 6 – SURVEY

9.6.01 SURVEY

Projects shall be tied to National Geodetic Survey (NGS) datum adjustment which matches the Federal Emergency Management Agency (FEMA) rate maps or the most current NGS datum which matches the FEMA rate maps. In the event GPS surveying is used to establish bench marks, at least two references to bench marks relating to the rate maps shall be identified. Equations may be used to translate other datum adjustments to the required adjustment.

SECTION 7 - LOW IMPACT DEVELOPMENT

9.7.01 LOW IMPACT DEVELOPMENT

Design requirements for Low Impact Development techniques are included in section 9.10.01. Only three techniques may be considered to have impact on impervious surface: Hard Roof, Green Roof, and Porous Pavement.

STORMWATER QUALITY DESIGN REQUIREMENTS

SECTION 8 - STORMWATER QUALITY OVERVIEW

9.8.01 SECTION INCLUDES

- 9.8.01.A. Criteria for the design of Stormwater pollution prevention procedures and controls for construction activities.
- 9.8.01.B. Criteria for the design of permanent Stormwater pollution prevention facilities and controls to minimize impacts for new development and decrease impacts for redevelopment on tracts of land of one acre or more.

9.8.02 REFERENCES

- 9.8.02.A. Stormwater Management Handbook for Construction Activities, City of Houston, Harris County, Harris County Flood Control District, 2006 or Current Edition.
- 9.8.02.B. Stormwater Quality Management Guidance Manual, City of Houston, Harris County, Harris County Flood Control District, 2001 or current edition.
- 9.8.02.C. Minimum Design Criteria (MDC) for Implementation of Certain Best Management Practices for Stormwater Runoff Treatment Options, 2001 edition, City of Houston.
- 9.8.02.D. Article XII of Chapter 47 Water and Sewers of the City of Houston Code of Ordinances.
- 9.8.02.E. National Pollutant Discharge Elimination System Permit Number TXS001201.
- 9.8.02.F. Texas Pollutant Discharge Elimination System (TPDES) Permit No. WQ0004685000 (known as the Municipal Separate Storm Sewer System - MS4 permit)
- 9.8.02.G. Texas Pollutant Discharge Elimination System (TPDES) General Permit No. TXR150000 (known as the Construction Stormwater General Permit)
- 9.8.02.H. Texas Pollutant Discharge Elimination System (TPDES) General Permit No. TXR050000 (known as the Industrial Stormwater Multi-Sector General Permit)
- 9.8.02.I. Texas Pollutant Discharge Elimination System Permit Number WQ0004685000
- 9.8.02.J. International Stormwater Best Management Practices (BMP) Database, www.bmpdatabase.org

9.8.03 DEFINITIONS

- 9.8.03.A. Applicant - The owner of the land on which the new development or significant redevelopment will occur, or authorized agent.

- 9.8.03.B. Best Management Practice (BMP) - Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. Stormwater management BMP to control or abate the discharge of pollutants when authorized under section 402(p) of the Clear Water Act (CWA) for the control of Stormwater discharges.
- 9.8.03.C. Best Management Practices (BMP) - A number of Stormwater structural and non-structural control strategies that have become the national focus for the mitigation of Stormwater pollution. BMP types include ponds, bio retention facilities, infiltration trenches, grass swales, and filter strips (Ref EPA.gov- TMDL 2007).
- 9.8.03.D. Detention - A feature meant to collect a site's stormwater and slowly release it at a control rate to not significantly impact downstream areas.
- 9.8.03.E. Development - (i) Any activity that requires a subdivision plat or development plat pursuant to Chapter 42 of this Code; (ii) the further subdivision of any reserve tract that is part of a subdivision plat approved by the city planning commission or pursuant to article II of Chapter 42 of this Code; or (iii) any activity that requires a construction permit.
- 9.8.03.F. Dwelling Unit - A structure, or a portion of a structure, that has independent living including provisions for non-transient sleeping, cooking and sanitation.
- 9.8.03.G. Engineered Soil - Cement-Based Engineered Soil technology used to stabilize the soil on a work site where it is not solid enough to safely support a building or roadway. Portland cement is blended with soil (sometimes including aggregate) and water and then compacted. The resulting mix, known as soil cement provides a secure and stable base for construction. It is also used for flood control structures.
- 9.8.03.H. Engineered Soil Media – Low Impact Design (LID) practice used to reduce storm runoff volume and loading of pollutants in the discharge from its contributing drainage area. Engineered soil incorporate a growing media with the native soil to create a functional soil designed for high infiltration, filtration, and plant sustainability. The layer should be compacted as minimally as possible to allow for surface percolation through the engineered soil layer and into the surrounding native soil or underdrain.
- 9.8.03.I. Impervious Surface - Any area that does not readily absorb water, including, but not limited to, building roofs, parking and driveway areas, sidewalks, compacted or rolled areas, and paved recreation areas.
- 9.8.03.J. Low Impact Development (LID) - A land planning and engineering design approach to managing Stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to replicate the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. LID based practices are used to reduce Stormwater runoff volume and pollutant loading from developed sites.

- 9.8.03.K. Notice of Intent (NOI) - A written submission to the executive director from an applicant requesting coverage under general permit, reference definition 9.8.03.G.
- 9.8.03.L. NPDES - National Pollutant Discharge Elimination System
- 9.8.03.M. Regulated Construction Activity - Construction activities, including clearing, grading, and excavation that disturb either one acres or more, or less than one acre if the activities are part of a larger plan of development or sale.
- 9.8.03.N. Residence Time - The length of time that runoff remains in a pond, which is known as the pond's Hydraulic Residence Time (HRT). Removal efficiency is primarily dependent on the HRT.
- 9.8.03.O. Significant New Development - Development on a currently undeveloped parcel of land one acre or larger without regard to the amount of land that will actually be disturbed, except for development on an existing undeveloped and undivided parcel of one acre or more of one single-family dwelling unit and/or the types of non-commercial building(s) typically associated with a single-family dwelling unit, including, but not limited to, a garage, carport or barn. If the occupancy for any structure excluded under the foregoing exception at any time changes to a commercial use, the owner of the property will at that time have to comply with all requirements of this program. The term also does not include a Stormwater detention basin that includes a water quality feature. The required Stormwater quality permit must include Detention.
- 9.8.03.P. Significant Redevelopment - Increase of 0.2 acre or more to the impervious surface on one acre or larger developed parcel, but does not include a Stormwater detention basin that includes a water quality feature. The required Stormwater quality permit must include Detention.
- 9.8.03.Q. SWQMP - Stormwater Quality Management Plan.
- 9.8.03.R. Stormwater Pollution Prevention Plan (SWPPP) - A site-specific, written document that: Identifies potential sources of Stormwater pollution at the construction site; describes practices to reduce pollutants in Stormwater discharges from the construction site. Reduction of pollutants is often achieved by controlling the volume of Stormwater runoff (e.g., taking steps to allow Stormwater to infiltrate into the soil). Identifies procedures the operator will implement to comply with the terms and conditions of a construction general permit.
- 9.8.03.S. Stormwater Quality permit or SWQ permit - shall mean a current, valid permit issued pursuant to Article XII, Chapter 47, Division 2 of the City Code of Ordinances. A SWQ permit shall be obtained for all new development and significant redevelopment sites that will construct or modify their detention features. This requirement applies only to the detention feature if the facility has or will have permit coverage for stormwater discharges from industrial activity issued by the state.

9.8.03.T. TPDES – Texas Pollutant Discharge Elimination System

9.8.03.U. Undeveloped Parcel - A parcel on which there are no structures at the time that a construction permit, subdivision plat or other city approval is applied for or required.

SECTION 9 - DESIGN REQUIREMENTS

9.9.01 DESIGN REQUIREMENTS

9.9.01.A. Obtain approval from the Office of the City Engineer (OCE) for exceptions or deviations from these requirements. Exceptions or deviations may be granted on a project-by-project basis.

9.9.01.B. Construction Activity:

1. SWPPPs and BMPs will be developed in accordance with the Stormwater Management Handbook for Construction Activities (9.8.02 Reference A), for sites that are less than one acre the SWPPP can be as simple as the Stormwater Pollution Prevention Plan Detail (DWG No. 01571-01).
2. Construction plans will include a note requiring contractor to comply with the Construction Stormwater General Permit including preparation of a SWPPP and to provide a copy of the Site Notice, NOI, and maintenance checklist to City Engineer or Building Official five (5) work days prior to commencement of any construction activity.

9.9.01.C. New Development and Significant Redevelopment:

1. All designs must be consistent with the Stormwater Quality Guidance Manual³ (SWQGM) and the Minimum Design Criteria for Certain Stormwater Runoff Treatment Options⁴ (MDC), 2001 edition.
2. Pollutants expected from the site must be identified in the SWQMP. BMPs must be designed and selected to remove the pollutants identified.
3. At a minimum, the system must be designed to treat the first 1/2 inch of runoff, except as noted in the SWQGM or the MDC.
4. BMPs listed in the SWQGM but not in the MDC may be acceptable for implementation pending review of design calculations and site applicability. BMPs not listed in the SWQGM may be considered on a case by case basis. Acceptance of these BMPs will require not only review of design calculations and site applicability, but also review of case studies or other data provided by an uninterested third party indicating the effectiveness of the BMP. All calculations and literature must be provided as part of the plan submittal.
5. In addition to meeting the Stormwater quality requirements of this section, the Stormwater system must also meet the requirements of the rest of this Chapter.

³ The Stormwater Quality Guidance Manual developed jointly by City of Houston, Harris County, and Harris County Flood Control District can be found at http://www.cleanwaterways.org/downloads/professional/guidance_manual_full.pdf

⁴ The Minimum Design Criteria Manual developed jointly by City of Houston, Harris County, and Harris County Flood Control District can be found at http://www.cleanwaterways.org/downloads/criteria_2001_edition.pdf

SECTION 10 - DESIGN STANDARDS

9.10.01 DESIGN STANDARDS

9.10.01.A. When design approaches included in this section are incorporated in designs requiring City Engineer approval, the standards of this section will apply.

9.10.01.B. Low Impact Development (LID):

1. Bioretention

a. Overview

Bioretention is a terrestrial-based (up-land as opposed to wetland), water quality and water quantity control practice using the chemical, biological and physical properties of plants, microbes and soils for removal of pollutants from Stormwater runoff. Some of the processes that may take place in a bioretention facility include: sedimentation, adsorption, filtration, volatilization, ion exchange, decomposition, phytoremediation, bioremediation, and storage capacity. Bioretention may also be designed to mimic predevelopment hydrology.

b. Design Criteria

- (1) Determine volume of bioretention area below maximum design water surface. Depth of ponding limited to a maximum of 6 inches.
- (2) Demonstrate that sufficient area contributes stormwater runoff to the bioretention area to fill the area to its maximum design water surface for the design storm under consideration.
- (3) Using in-situ or new soils, design the bioretention area to empty within 48 hours. This may be accomplished through infiltration, evapotranspiration, and/or the design of a subsurface drainage system.
- (4) Mitigating detention volume requirements can be reduced by the volume in the bioretention area below its maximum design water surface.
- (5) Runoff from commercial areas and parking lots require pretreatment; grass buffer strip or vegetated swales, prior to draining into bioretention area.
- (6) Infiltration rates less than 0.5 inches per hour will require a subsurface drainage system.
- (7) Geotechnical testing is required to confirm infiltration rates.
- (8) The cross section for typical Porous Bioretention Basin is shown on

*9.10.01(B)(1)(b)(8)**continued*

Figure 9.6.

c. Inspection and Maintenance Requirements

- (1) Verify presence of vegetation considered in design computations (if any) quarterly.
- (2) Verify the bioretention area has adequate volume quarterly by checking whether sedimentation has encroached on design volume. This can be done by comparing actual maximum depth against design maximum depth.
- (3) Verify ability of bioretention area to drain within 48 hours twice yearly after rainfall event.
- (4) Correct deficiencies related to items 1-3 above as needed.

2. Infiltration Trenches

a. Overview

Trenches or basins that temporarily detain a design water quality volume while allowing infiltration to occur over a prescribed period of time. Trenches are applicable for both water quality and water quantity control practices.

b. Design Criteria

- (1) In-situ subsoil shall have a minimum infiltration rate of 0.5 inches per hour. Geotechnical testing including one boring per 5,000 square feet or two per project is required to confirm infiltration rate.
- (2) Subsurface drainage systems are required where the in-situ subsoil rate is less than 0.5 inches per hour or where the project is constructed on fill soils.
- (3) Avoid placement on slopes greater than 15% in fill areas.
- (4) Design of the trench area to empty with 48 hours.
- (5) Backfill using clean aggregate larger than 1.5 inches and smaller than 3 inches surrounded by engineered filter fabric.
- (6) Provide overflow structure or channel to accommodate larger runoff events.
- (7) Provide 4 inches PVC observation well into subgrade.
- (8) Runoff from commercial areas and parking lots require pretreatment;

9.10.01(B)(2)(b)(8)

continued

grass buffer strip or vegetated swales, prior to draining into infiltration trench.

- (9) Locate bottom of facility at least 4 feet above seasonal high water table elevation.
- (10) Locate at least 100 feet from any water supply well.
- (11) Maximum contributing drainage area is 5 acres.
- (12) Mitigating detention volume can be reduced by the amount of infiltration into the subsoil and the volume of voids within the trench area.

c. Inspection and Maintenance Requirements

- (1) Inspect observation well for water level and drainage times.
- (2) Conduct landscaping, mowing, and desilting of facility.

3. Porous Paver Systems and Porous Pavement

a. Overview

Porous Pavement consists of a permeable surface course (typically, but not limited to, pavers, asphalt or concrete) that allows infiltration of stormwater runoff into a permeable layer of uniformly graded stone bed. The underlying permeable layer serves as a storage reservoir for runoff and/or infiltration. Porous Pavement is applicable for both water quality and water quantity control practices.

b. Design Criteria

Minimum requirements for porous paver system

- (1) Design details for Porous Paver Systems are shown in Figure 9.7 and for Porous Pavement Systems are shown in Figure 9.8.
- (2) Restricted to Single Family Residential Construction or Commercial Construction on private property when the system is covered by a Stormwater Quality Permit.
 - a. Residential Porous Pavers Systems without a subsurface drainage system may be determined as pervious for up to 10% of the lot area for a Single Family Residential (SFR) lot: (1) qualifying for exemption from detention under 9.2.01.H.3 and (2) for basis of City Drainage Utility charges

9.10.01(B)(3)(b)(2)

continued

- b. Commercial Porous Paver Systems without a subsurface drainage system that have a Stormwater Quality Permit may be determined as pervious for commercial areas designed for heavy traffic volume and/or vehicles.
- (3) In-situ subsoil shall have a minimum infiltration rate of 0.5 inches per hour. Geotechnical testing including one boring per 5,000 square feet or two per project is required to confirm infiltration rate.
- (4) Subsurface drainage systems are required for stormwater detention where the in-situ subsoil rate is less than 0.5 inches per hour or where the project is constructed on fill soils.
- (5) Subsurface drainage systems are required to be drained in 48 hours.
- (6) If the volume of storage within the voids of the subsurface drainage system's stone bed meets the detention volume rate of 0.5 acre-feet per acre of development or 0.2 acre-feet per acre for tracts less than one acre, the area of the porous pavement is considered undeveloped. Otherwise, the total voids storage volume will be credited toward the required detention volume.
- (7) If the time of concentration (Tc) from a project site that includes porous pavement and subsurface drainage system, is equal to the undeveloped time of concentration, the development of the project site is considered undeveloped.
- (8) Soft porous pavement area shall be considered undeveloped.
- (9) The cross-section typically consists of four layers, as shown in Figure 9.8. The aggregate reservoir can sometimes be avoided or minimized if the sub-grade is sandy and there is adequate time to infiltrate the necessary runoff volume into the sandy soil without by-passing the water quality volume. Descriptions of each of the layers are presented below:

Porous Pavement Layer – The porous pavement layer consists of an open graded pavement mixture, concrete or asphalt, specifically designed to be porous with binding agents that create a cohesive wearing surface. The thickness of this layer is based on the design of the pavement section and the loading requirements associated with the intended use. It is important to note that porous asphalt is not to be confused with Open Graded Friction Course (OGFC) that is used as a driving surface on highways which should not be used in this particular application except as an overlay wearing course over the porous concrete or asphalt. Porous pavement may be considered to contain 18% voids (typical range is 16% to 22%). Technical reference for porous concrete is FHWA-HIF-13-006. Technical reference for porous asphalt is FHWA-HIF-15-009.

9.10.01(B)(3)(b)(9)

continued

Top Filter Layer – Consists of a 0.5 inch diameter crushed stone to a depth of 1 to 2 inches. This layer serves to stabilize the porous concrete layer. Can be combined with reservoir layer using suitable stone.

Reservoir Layer – The reservoir gravel base course consists of washed, bank-run gravel, 1.5 to 2.5 inches in diameter with a void space of about 40 %. The depth of this layer depends on the desired storage volume, which is a function of the soil infiltration rate and void spaces, but typically ranges from two to four feet. The layer must have a minimum depth of nine inches. The layer shall be designed to drain completely in 48 hours. The layer shall be designed to store at a minimum the water quality volume (WQv). Aggregate contaminated with soil shall not be used. A porosity value (void space/total volume) of 0.32 shall be used in calculations unless aggregate specific data exist.

Bottom Filter Layer – The surface of the subgrade shall be a 6 inch layer of sand (ASTM C-33 concrete sand) or a 2 inch thick layer of 0.5 inch crushed stone, and be completely flat to promote infiltration across the entire surface. This layer serves to stabilize the reservoir layer, to protect the underlying soil from compaction, and act as the interface between the reservoir layer and the filter fabric covering the underlying soil.

Filter Fabric – It is very important to line the entire trench area, including the sides, with filter fabric prior to placement of the aggregate. The filter fabric serves a very important function by inhibiting soil from migrating into the reservoir layer and reducing storage capacity. Fabric shall be MIRFI # 14 N or equivalent.

Underlying Soil – The underlying soil shall have an infiltration capacity of at least 0.5 in/hr, but preferably greater than 0.50 in/hr. as initially determined from NRCS soil textural classification, and subsequently confirmed by field geotechnical tests. The minimum geotechnical testing is one test hole per 5,000 square feet, with a minimum of two borings per facility (taken within the proposed limits of the facility). Infiltration trenches cannot be used in fill soils. Soils at the lower end of this range may not be suited for a full infiltration system. Test borings are recommended to determine the soil classification, seasonal high ground water table elevation, and impervious substrata, and an initial estimate of permeability. Often a double-ring infiltrometer test is done at subgrade elevation to determine the impermeable layer, and for safety, one-half the measured value is allowed for infiltration calculations.

c. Inspection and Maintenance Requirements

- (1) Initial inspection of porous pavement shall be monthly for the first three months post construction.
- (2) Semi-annual inspection to ensure pavement surface is free of sediment.

9.10.01(B)(3)(c)

continued

- (3) Vacuum sweep hard porous pavement followed by high pressure hosing to keep voids free of sediment quarterly.
 - (4) Annually inspect pavement surface and subsurface drainage system (if any) for deterioration, spalling or malfunctioning.
- d. Additional provisions regarding use as a pervious cover. Approval of plans considering the SFR exemption in cases including porous pavement will include the following condition:

Approval of the proposed development is based in-part on capacity for proposed porous pavement to mitigate increased stormwater runoff.

As condition of approval, applicant is required to provide notice to the owner/buyer of the property of the stormwater quality permit and that maintenance of porous paver system or porous pavement is necessary for continued functionality, that requirements for routine maintenance have been published by Houston Public Works and may be revised in the future, and that failure to fulfill maintenance actions and reporting may result in citations or an increase of drainage utility charges for the property pursuant to City of Houston Ordinance Chapter 47 Water and Sewers, Article XV Drainage Impact Fees.

4. Vegetated Swales

a. Overview

Vegetated Swales (dry or wet) are earthen, planted stormwater conveyances designed to filter a shallow depth of runoff (<4 inches) for water quality improvement and to infiltrate stormwater. There are two types, dry or wet. Dry swales include an underdrain system. Wet swales do not. Swales are typically designed to convey runoff from larger storm events, however, treatment and infiltration is reduced during high flows. Infiltrative soils or an engineered porous subgrade is required for infiltration use. Vegetated Swales are applicable for both water quality and water quantity control practices.

b. Design Criteria for Dry Swale

- (1) Soil infiltration rate of 0.27 to 0.50 inches/hour.
- (2) Trapezoidal or parabolic cross section.
- (3) Bottom width shall be 2 feet wide minimum or 6 feet wide max.
- (4) Longitudinal slope shall range from 1% to 6%.
- (5) Flow depth shall be less than 4 inches for water quality treatment.

*9.10.01(B)(4)(b)**continued*

- (6) Flow velocity shall be less than 1 fps for water quality, less than 5 fps for 2-yr storm (non-erosive velocities for grass and soils).
 - (7) Length shall yield a 10 minute residence time.
 - (8) Side slopes shall be flatter than 3:1.
 - (9) Maximum ponding time shall be 48 hours.
 - (10) Use proper vegetation (grass or wetland plants) consistent with climate, ecoregion, soils, and hydric conditions.
 - (11) Provide at least 3 inches of free-board during design storm.
 - (12) Provide pretreatment of runoff into the swale.
 - (13) Design details are shown in Figure 9.9.
- c. Design Criteria for Wet Swale
- (1) Soil infiltration rate of 0.27 to 0.50 inches/hour.
 - (2) Trapezoidal or parabolic cross section.
 - (3) Bottom width shall be 2 feet wide minimum or 8 feet wide max. to avoid gullyng or channel braiding.
 - (4) Longitudinal slope shall range from 1% to 6%.
 - (5) Flow depth shall be less than 4 inches for water quality treatment.
 - (6) Flow velocity shall be less than 1 fps for water quality, less than 5 fps for 2-yr storm (non-erosive velocities for grass and soils).
 - (7) Length shall yield a 10 minute residence time.
 - (8) Slide slopes shall be flatter than 3:1.
 - (9) Maximum ponding time shall be < 48 hours.
 - (10) Use proper vegetation (grass or wetland plants) consistent with climate, ecoregion, soils, and hydric conditions.
 - (11) Provide at least 3 inches of free-board during design storm.
 - (12) Provide pretreatment of runoff into the swale.
 - (13) Design details are shown in Figure 9.10.

9.10.01(B)(4)
continued

d. Inspection and Maintenance Requirements

- (1) Mow dry swales as required during growing season to maintain grass heights in the 4 to 6 inch range. Wet swales, employing wetland vegetation or other low maintenance ground cover do not require frequent mowing. Remove sediment when 25% of the original water quality volume has been exceeded.

5. Green Roof

a. Overview

A green roof, in the simplest terms, is a vegetated roof. The vegetation varies, but must be suitable to the local climate and be drought tolerant unless a method of irrigation is also installed. Installation generally consists of a waterproof membrane installed over a suitably constructed roof deck. For in-situ installations, an under-drain drainage system is installed over the membrane. A lightweight engineered soil is installed on top of the under-drain, as fill dirt or topsoil is typically too heavy to use in rooftop applications. The engineered soil is then planted with select vegetation. If a modular system is selected, the drainage system may already be incorporated into the design, along with the soil and vegetation, depending on the manufacturer. The substrate material and depth are also factors that influence the efficiency of the green roof to store and/or treat stormwater. Roofs consisting of relatively thin soil layers, called extensive roofs, are not as heavy as the intensive roofs, which are covered with thicker soil layers.

b. Design Criteria

- (1) Vegetation suitable to the climate and preferably a species that is drought tolerant, unless a method of irrigation is provided, shall be installed. The effect of wind on the vegetation shall also be considered when selecting the roof foliage, as wind velocities are typically higher at rooftop elevations.
- (2) The amount of credit given for the rainfall amount stored shall be as prescribed by the manufacturer for a modular system.
- (3) The amount of credit given for the rainfall amount stored for non-modular systems shall be calculated for the engineered soil media. The rate shall be derived by in-situ porosity testing. The porosity test shall be performed four times with the first time results being discarded and the three remaining results averaged. The test shall require the first sample remain wet a minimum of 1 hour. The subsequent porosity tests shall be performed the same day. In no case shall the storage volume be credited more than 33% of total volume, as that is the assumed volume of clean graded washed gravel.

9.10.01(B)(5)(b)

continued

- (4) The roof membrane must be sufficiently designed and installed to pond a minimum of 1 inch of water at the most shallow point on the roof for 24 hours without leaks. This shall be tested in the same manner as shower pans are tested under the building code. Additionally, special consideration shall be given for the plant root structure and prevention of soil migration during membrane selection. A root barrier may also be required to protect the waterproof membrane integrity.
 - (5) The under-drain drainage system shall be designed for the selected plant's tolerance for drought and varying soil moisture contents by maintaining the proper balance of moisture and aerobic conditions within the soil media for optimum vegetation sustainability. Design provisions shall address higher volume rainfall events to keep excessive amounts of water from ponding on top of the soil, to prevent erosion, and to prevent soil media saturation for extended periods. Structural calculations shall be submitted that demonstrate the structure's ability to sustain the additional loading of the green roof appurtenances plus the maximum water weight that could be stored.
- c. Inspection and Maintenance Requirements
- (1) A maintenance plan for the green roof system shall be developed in accordance with the membrane manufacturer's instructions and plant species selected. At a minimum, maintenance inspections shall be performed at least four times per year. The maintenance plan shall include provisions for vegetation maintenance and replacement as needed to maintain a minimum 80% coverage/survival rate in order to sustain Stormwater quality and/or detention credits. Irrigation may be required initially in order to establish the roof vegetation and to supply water under severe drought conditions. Any requirements for initial or intermittent use of fertilizer and pesticides for disease or insect control shall be identified in the plan. Plant species shall be carefully selected to minimize intermittent fertilizer and pesticide applications.
 - (2) Each green roof installation shall be inspected by the agency responsible for issuing the Stormwater quality or detention credits to check compliance with the approved drawings before final acceptance is issued and the proper credits are approved. At a minimum, the following items shall be checked during the inspection:
 - (a) Results from porosity testing (for non-modular installations).
 - (b) Certification from a registered Professional Engineer or registered Architect that the green roof, including membrane, drain system and engineered soil media system, was installed per the approved (permitted) drawings and operates as designed.
 - (c) Drawings of the green roof installation.

9.10.01(B)(5)(c)

continued

- (3) Once the green roof is installed and established, additional inspections will be required in order to properly maintain the vegetation, drainage system and roof membrane. Routine inspections shall be conducted and associated maintenance activities performed on the following:
 - (a) Joints at adjoining walls, roof penetrations for vents, electrical and air conditioning conduits shall be inspected regularly for leaks. The ceilings located directly below the green roof installation shall also be visually inspected for signs of water staining or leaking.
 - (b) Designated drainage paths and drainage system components shall be inspected to ensure proper surface drainage is maintained and that the soil layer is drained to prevent excessively saturated soils. Vegetation selected to tolerate drought conditions may rot or die if the soil is allowed to become saturated for extended periods.
 - (c) Vegetation shall be visually inspected to identify weeds, accumulated trash or debris, dead or dying vegetation, disease or other infestation problems requiring maintenance attention. Weeds and dead vegetation shall be removed on a regular basis, especially right after the roof is planted. If a certain plant or grass species continues to die, that plant or grass shall be removed and replaced with a more tolerant species. Certified professionals shall only be used to apply chemical applications for the control of disease or insects at trouble spot locations.
 - (d) Trimming and pruning shall be done in accordance with horticulture practices to keep vegetation aesthetically groomed.

6. Hard Roof

a. Overview

Horizontal roof surfaces can be used to attenuate peak runoff associated with rainfall and effectively detain flow resulting from smaller rain events.

The detention volume can be controlled in several ways, but typically a simple drain ring is placed around the roof drains. As stormwater begins to pond on the roof, flow into the roof drains is controlled by orifices or slits in the drain ring. Extreme flows can be designed to overflow the ring and drain directly to the roof drains or be directed to openings in the parapet walls to prevent structural and flood damage to the roof. The roof deck must be designed to withstand the live load and be properly waterproofed.

b. Design Criteria

- (1) The structural capability of the roof system must be considered when designing a temporary rooftop storage system. For example, a 3 inch water depth is equivalent to a load of 15.6 lbs/sq.ft., which is less than

9.10.01(B)(6)(b)(1)

continued

most current building code requirements for live loads.

- (2) Consideration must be given to the placement of electrical devices on the roof, such as air conditioning or ventilation systems and lights, and proper measures shall be taken to protect the electrical devices from the collected water.
- (3) Overflow mechanisms shall be provided so that there is no danger of overloading the roof storage system during major storms. Additionally, roof slopes shall be designed to drain positively toward the roof drains to help minimize localized roof ponding or ‘bird bath’ formation after the detained water volume is released.
- (4) It is recommended that Chapter 16 of the International Building Code, Current Edition be used for additional structural criteria along with ASCE Standard Reference Number 7, Minimum Design Loads for Buildings and Other Structures.
- (5) The amount of credit given for detention volume for rooftop storage shall take into account that many flat roofs already pond significant amounts of water; although not by design. Therefore, when measuring credit given for hard roof detention volume, it is recommended that only credit be given for the total rooftop storage volume less the rooftop storage volume associated with the first inch of rain. Typically, rooftop storage volumes are only effective during the smaller, more frequent rainfall events as the larger, less frequent storms typically exceed the rooftop storage capacity.

c. Inspection and Maintenance Requirements

- (1) Each hard roof installation shall be inspected by the agency responsible for issuing the detention credits to check compliance with the approved drawings before final acceptance is issued and the proper credits are approved. At a minimum, the following items shall be checked during the inspection:
 - (a) Roof penetrations for ventilation, electrical or plumbing connections to verify proper sealing against leaks.
 - (b) The overflow system that drains excessive rainfall off of the hard roof once the maximum storage volume is captured.
 - (c) Certification from a registered Professional Engineer or registered Architect that the hard roof, drain system and appurtenances have been installed and operate as designed.
 - (d) Drawings of the hard roof installation.
- (2) Once the hard roof is installed, additional inspections will be required in order to properly maintain the drainage system and roof membrane.

9.10.01(B)(6)(c)(2)
continued

Routine inspections shall be conducted and associated maintenance activities performed on the following:

- (a) Designated drainage paths and drainage system components shall be inspected to ensure proper surface drainage is maintained and that the roof is draining properly after the collected stormwater volume is released from a rainfall event.
- (b) Routine inspections to collect and remove any trash or debris from the roof shall be conducted to prevent clogging of the roof drains and overflow drainage system.
- (c) Visible cracks in the roof surface shall be identified and repaired in accordance with the roof manufacturer's recommendations in order to maintain roof integrity.

7. Rain Barrels

a. Overview

A cistern ("rain barrel"), ranging from 55 gallons to several hundred gallons in capacity, is placed near the down spout of a house and is used to collect rain water runoff from the roof of the house. The captured water is then typically used as a pure water source for plants and lawns.

b. Design Criteria

- (1) Gutters and downspouts carry water from the rooftops to rain barrels as shown on Figure 9.11.
- (2) Screens are required on gutters to prevent clogging.
- (3) Rain barrels shall be equipped with a drain spigot.
- (4) Overflow outlet must be provided to bypass rain barrel from large rainfall events.
- (5) Rain barrel must be designed with removable, child resistant covers and mosquito screening.
- (6) Minimum rain barrel capacity equal to 1 inch of runoff from roof top surface area.

c. Maintenance and Inspection

- (1) Empty rain barrel after each rainfall event.
- (2) Rain barrel shall be inspected annually.

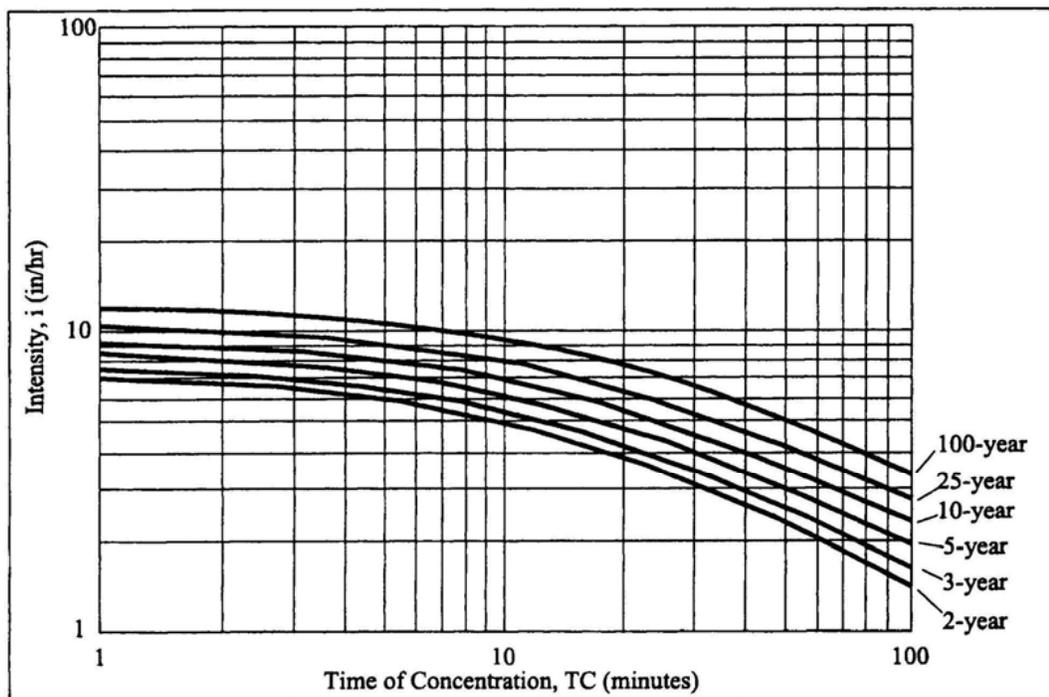
SECTION 11 - QUALITY ASSURANCE

9.11.01 QUALITY ASSURANCE

Final design drawings, BMPs, SWPPPs, and SWQMPs will be sealed, signed, and dated by the Professional Engineer registered in the State of Texas responsible for their development.

END OF CHAPTER

FIGURE 9.1
City of Houston IDF Curves
Intensity vs. Time of Concentration vs Rainfall Frequency
Source: Hydro 35/TP-40



$$i = \frac{b}{(d+TC)^e}$$

$$TC = 10A^{0.1761} + 15$$

$A = \text{area in acres}$

Rainfall Frequency	b	d	e
2-year	75.01	16.2	0.8315
3-year	77.27	17.1	0.8075
5-year	84.14	17.8	0.7881
10-year	93.53	18.9	0.7742
25-year	115.9	21.2	0.7808
100-year	125.4	21.8	0.7500

The City acknowledges that Harris County and Harris County Flood Control have adopted on June 4, 2019, new data based on Atlas 14. The City is considering this data and will consider editing this information for future release.

FIGURE 9.4 DETENTION AND RESTRICTOR CALCULATION SAMPLE

DETENTION:

Tract size =acres
 Disturbed area =acres to four decimal places or SF
 Proposed (final) Impervious area =acres to four decimal places or SF
 Please provide your calculations:
 Required Detention Volume =acre-feet (Show calculations, refer to 9.2.01.H)
 Provided Detention Volume = acre-feet (must show calculations)

RESTRICTORS:

Low Level Restrictor (25% flow):

Total Drainage Area =acres
 Outflow Rate Allowed for Low Flow QL1 = cfs (based on 0.5 cfs/ac)
 Head HL1 (water surface differential) for Low Flow =ft
 Calculated Low Level Restrictor Size DL = inches
 Provided/Designed Low Level Restrictor Size DL1 =inches (min. 6 inches)

High Level Restrictor (75% flow):

Total Drainage Area =acres
 Total Outflow Rate Allowed (100%) Q =cfs (based on 2 cfs/ac)
 Re-calculated Head HL2 (water surface differential) for Low Level Restrictor =ft
 Re-calculated Low Flow Q L2 for Low Level Restrictor =cfs (based on DL1 and HL2)

Outflow Rate Allowed for High Flow Qh1 (75%) =cfs (based Q and Q L2)
 Head Hh2 (water surface differential) for High Level Restrictor =ft
 Calculated High Level Restrictor Size Dh =inches
 Provided/Designed High Level Restrictor Size Dh1 (75%) =inches
 Outflow Rate Provided for High Flow Qh2 =cfs (based on Dh1, must < Qh1)

To explain your design above, please provide information below to the plan:

- The location of the restrictor(s) on the plan(s)
- The cross section for the restrictor(s) with the water surface elevations for 25%, 75%, and full detention capacity.
- The location and elevation of the overflow structure.

FIGURE 9.5 STORMWATER INFORMATION FORM



CITY OF HOUSTON

Houston Public Works

Stormwater Information Form



FOR OFFICE USE ONLY					
Log Number:		Private Building ILMS Project #:		Public Plan ILMS Project #:	PW Record Drawing #:

The Office of the City Engineer reviews and approves development plans to ensure the proper design and construction of storm sewer utilities in addition to enforcing private storm design criteria and parameters as stated in City of Houston Code of Ordinances and the current City of Houston Infrastructure Design Manual. When a property owner proposes new development or redevelopment of property, the applicant must submit this form with their plans. *Completion of this form does not represent an approval or commitment by the City of Houston. This form is informational only to assist in the review and approval of your plans.*

Fee Simple Title Owner Information		Authorized Representative Information	
Name		Name	
Company		Company	
Address		Address	
City, State ZIP		City, State ZIP	
Phone		Phone	
Email		Email	
Signature*		Signature	

** As the fee simple owner of the property referenced in this form, I hereby authorize the referenced representative on this form (if applicable) to submit this form on my behalf. My authorized representative is also approved to make changes or corrections.*

Property Information					
Service Address					
City		State		ZIP Code	
Property Tax Account Number(s)					
Lot(s)		Block		Reserve	
Subdivision		Section			

Development Information				
Provide description of development with associated footprint (in square feet).				
	Single Family Residential Development	Multiple Family Residential Development	Commercial Development	Other
Existing Development:				
Development to be Removed:				
Proposed Development:				

Flood Plain Information						
FIRM Panel Number:						
Property is located within the following FEMA Flood Zone:						
<input type="checkbox"/> X (shaded)	<input type="checkbox"/> X (unshaded)	<input type="checkbox"/> AE	<input type="checkbox"/> A	<input type="checkbox"/> AO	<input type="checkbox"/> Other:	

CITY OF HOUSTON - STORMWATER INFORMATION FORM

Impervious Cover Information			
Improvements	Area of Existing Impervious Cover (Sq Ft.)		Area of Final Impervious Cover (Sq Ft.)
Building			
Parking Lot/Driveway			
Sidewalk/Patio			
Detention Pond			
Pool			
Total Area			

Tract Size (Square Feet)		Total Impervious Cover (Square Feet)		Percentage of Impervious Cover (%)	
------------------------------------	--	---	--	---	--

Storm Sewer Information			
Storm Infrastructure Is Maintained By:			
<i>NOTE: Any infrastructure maintained by outside agencies will require their respective approval prior to final City plan approval.</i>			
City of Houston	HCFC	TXDOT	
Clear Lake City Water Authority	Fort Bend County	Montgomery County	
Other:			
Proposed Storm Connection Development Will Be Connected To:			
Existing on-site storm sewer system that outfalls to:	(STREET NAME / PIPE SIZE)		
Public storm sewer located in:	(STREET NAME)	Pipe Size:	
Public roadside ditch located in:	(STREET NAME)		
Off-Road Ditch/Watershed:			

Detention Criteria					
Stormwater detention volume was determined utilizing City of Houston Infrastructure Design Manual:					
9.2.01.H.3(b)	9.2.01.H.3(d)	9.2.01.H.3(e)	9.2.01.H.3(f)	9.2.01.H.3(g)	

Documentation			
This form must be accompanied with:			
A recorded deed or title report in the owner's name	HCAD printout	survey and/or recorded plat	
The applicant can also provide the following documentation if applicable to their project:			
Previous Stormwater Letter of Availability	Copy of outside agency approval		
Storm Water Quality Permit: <i>Per Section 47-631 of the City of Houston Ordinance, SWQ permit is required when the development is meeting the definition of "new development" or "significant redevelopment".</i>			
Drainage Study/Hydraulic Analysis: <i>Please submit Drainage Study when you have more than one (1) section or a larger commercial or subdivision tract. Hard copy must be accompanied with a CD or USB Flash Drive containing the drainage study file.</i>			

Developer Drainage Impact Fee Rate Information			
<i>Service Area Rate is per service unit (1 service unit = 1,000 sf of impervious area) of increased impervious area. Please select one.</i>			
Clear Creek \$0.39	Greens Bayou \$13.41	Buffalo Bayou \$16.38	Addicks Reservoir \$0.00
Brays Bayou \$8.63	Hunting Bayou \$10.24	Sims Bayou \$17.72	Barker Reservoir \$0.00
San Jacinto \$0.00	Ship Channel \$0.00	Vince Bayou \$17.72	White Oak Bayou \$16.38

FOR OFFICE USE ONLY	
Employee:	Comments:

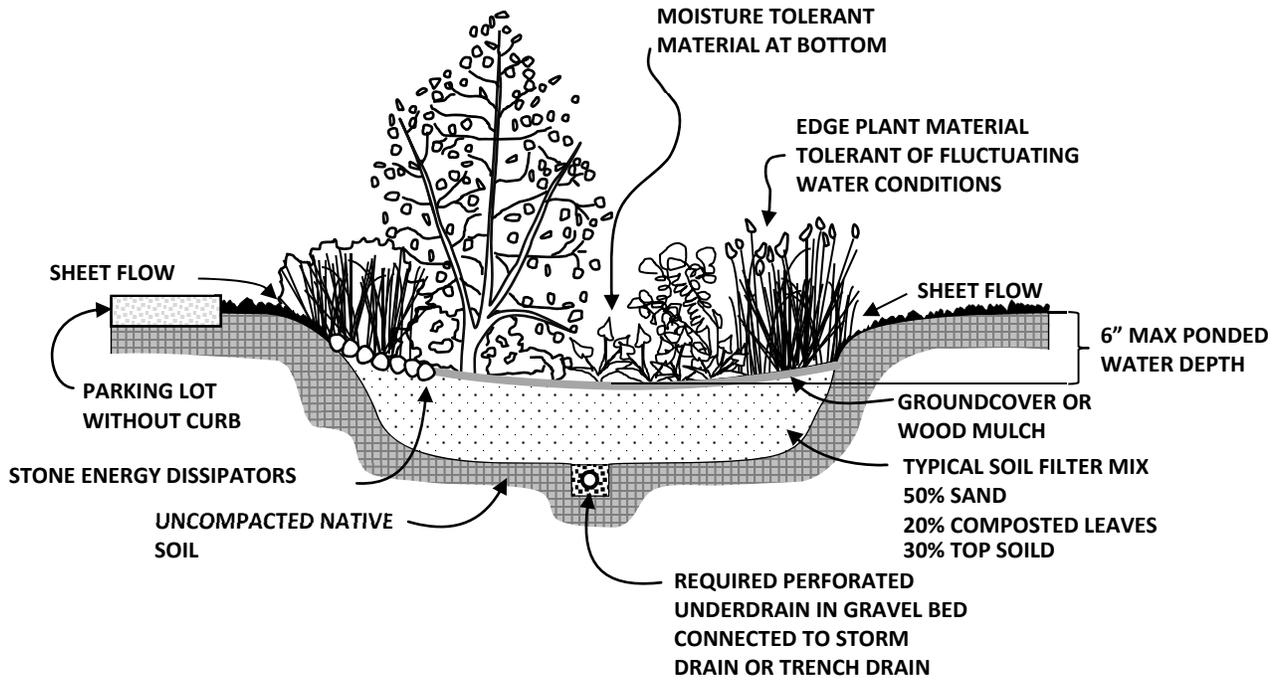
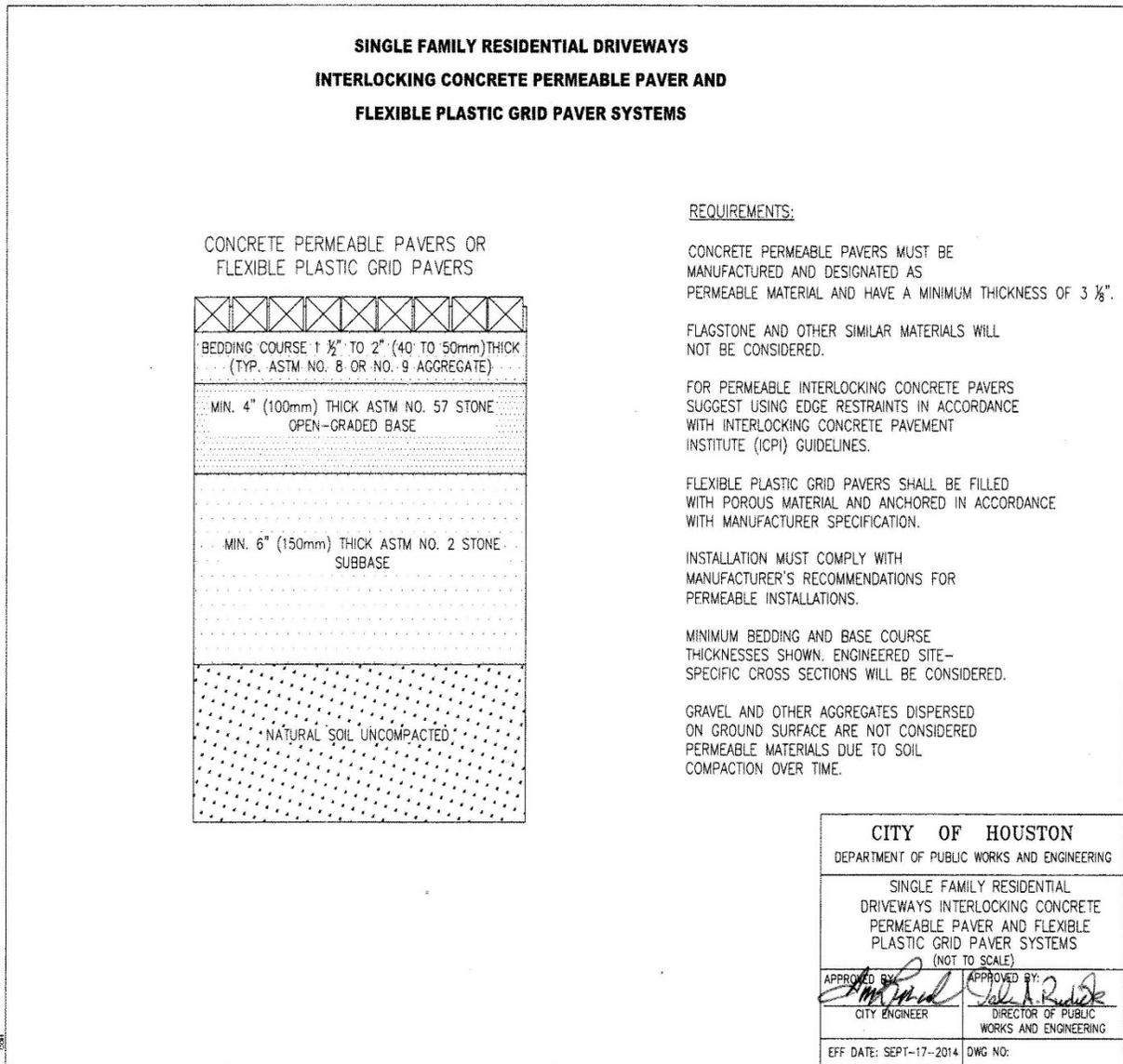


FIGURE 9.6
POROUS BIORETENTION BASIN



**FIGURE 9.7
SINGLE FAMILY RESIDENTIAL DRIVEWAYS INTERLOCKING
CONCRETE PERMEABLE PAVER AND FLEXIBLE PLASTIC
GRID PAVER SYSTEMS**

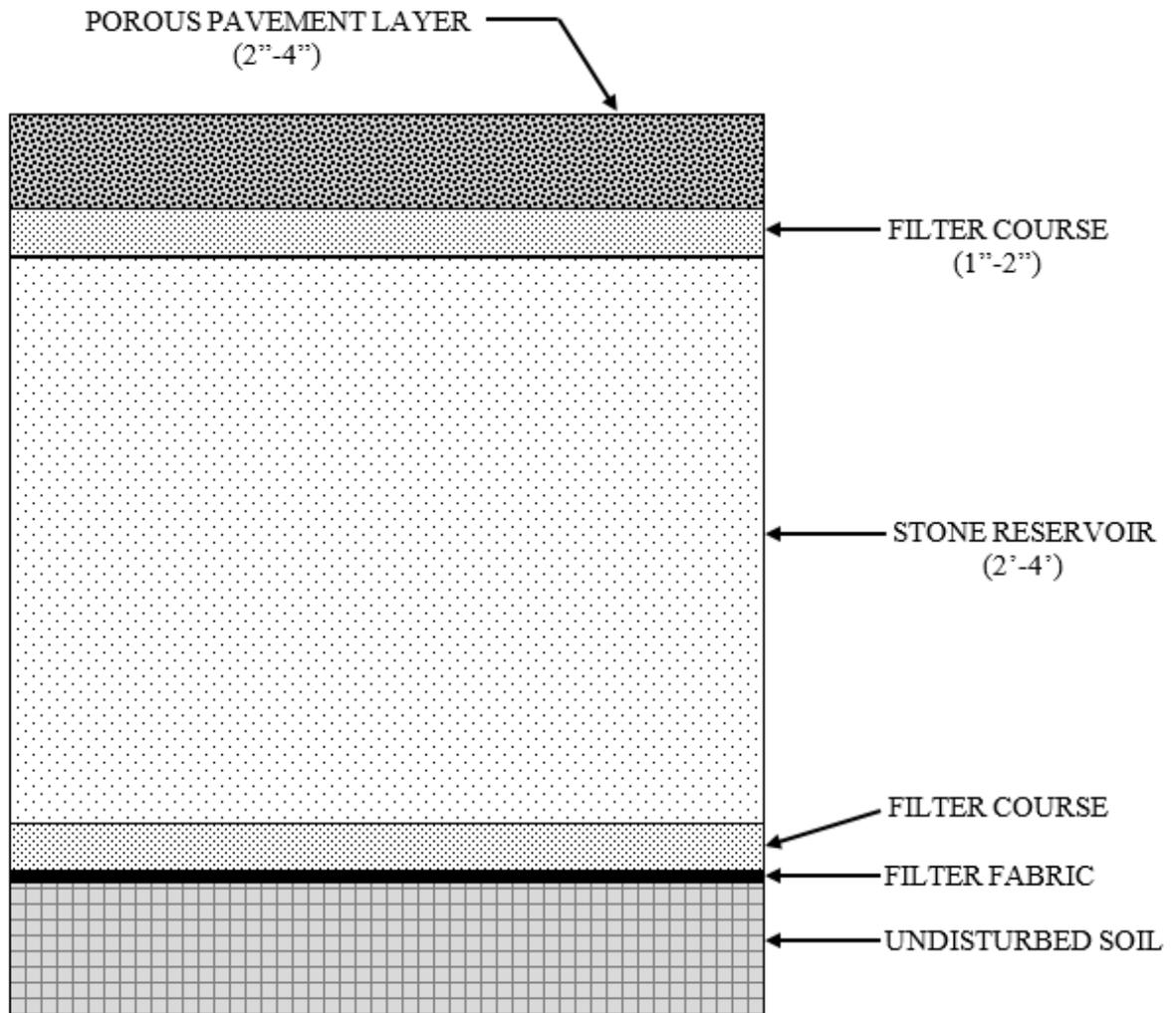


FIGURE 9.8
POROUS PAVEMENT TYPICAL SECTION

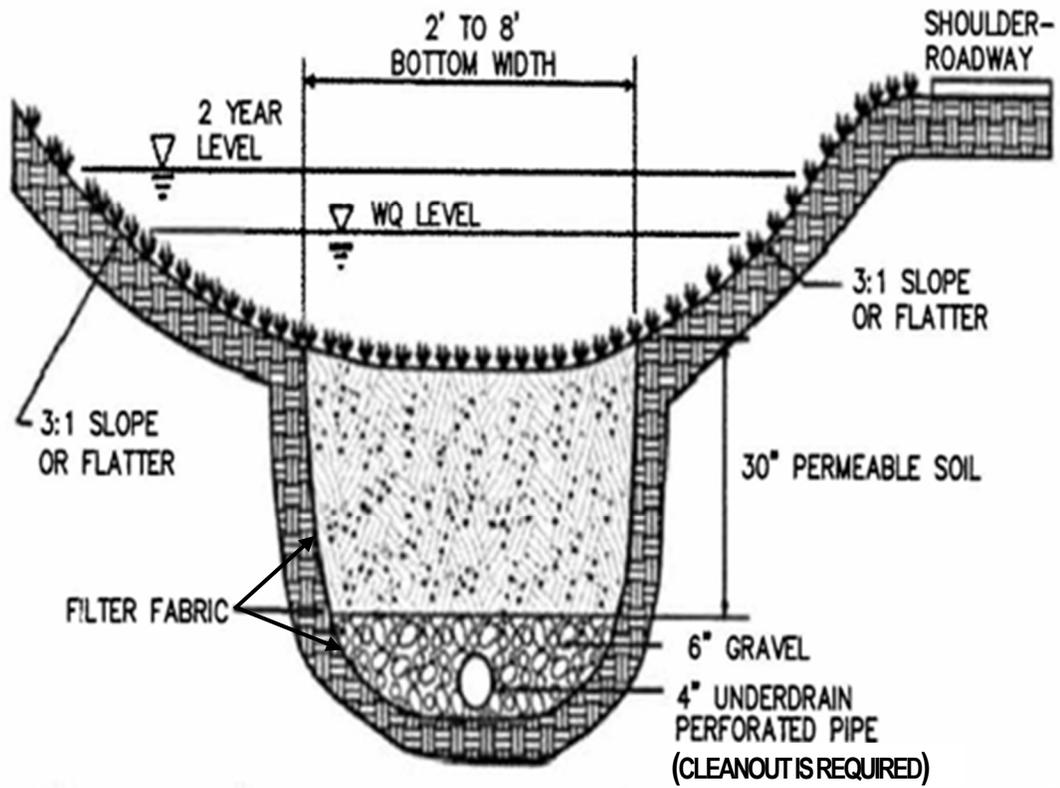


FIGURE 9.9
DRY SWALE CROSS SECTION

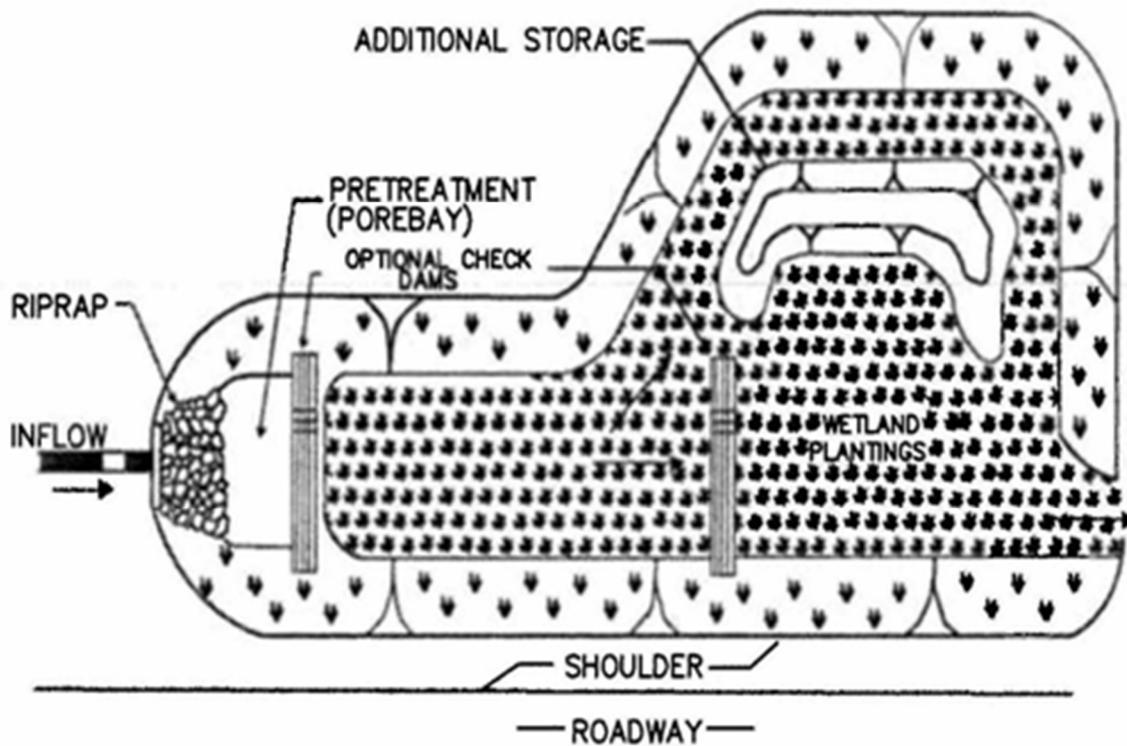


FIGURE 9.10
WET SWALE PLAN

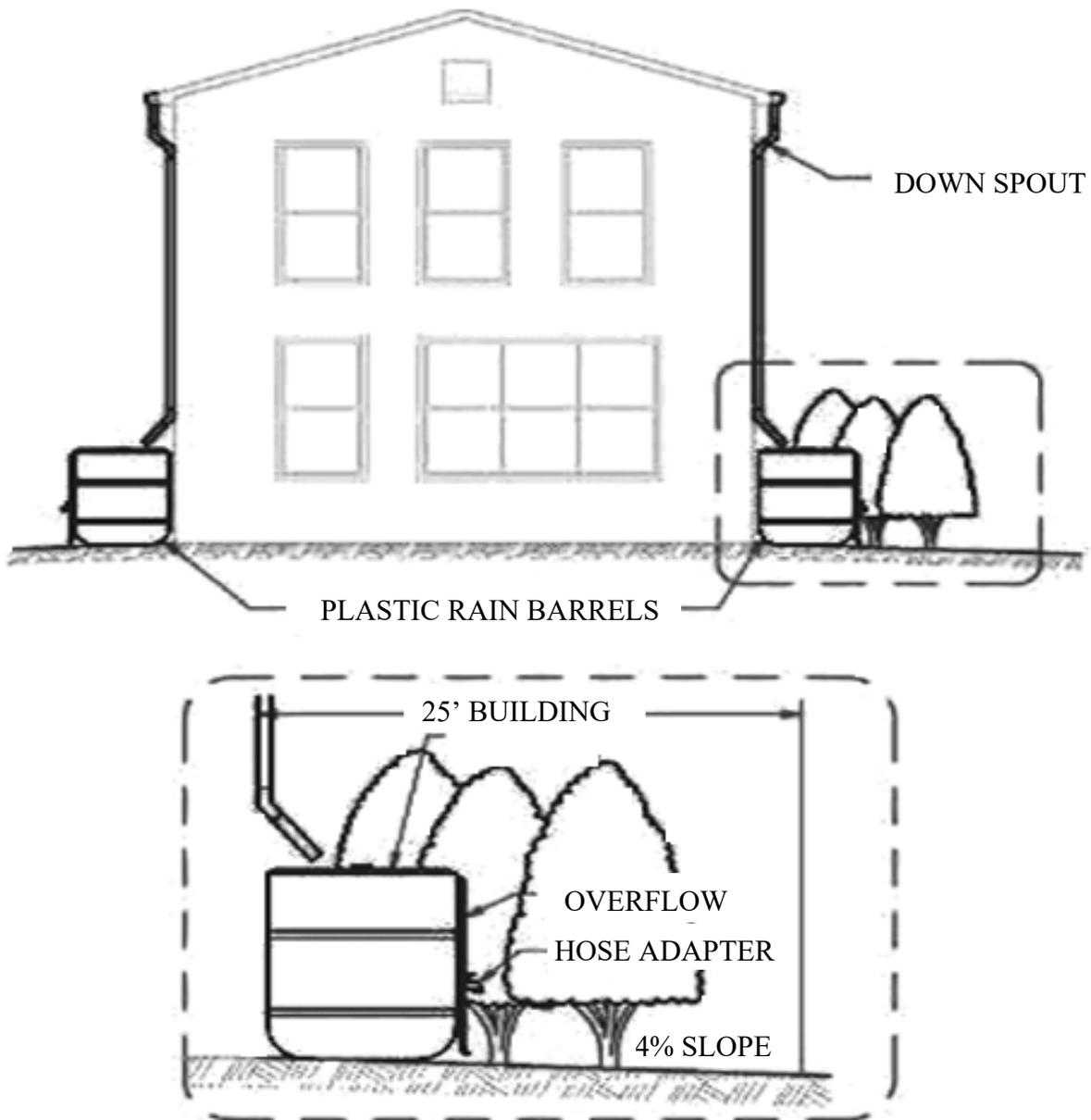


FIGURE 9.11
TYPICAL RAIN BARREL

City of Houston

Design Manual

Chapter 10

STREET PAVING DESIGN REQUIREMENTS

Chapter 10

STREET PAVING DESIGN REQUIREMENTS

10.01 CHAPTER INCLUDES

- A. Geometric design guidelines for streets, criteria for street paving, and standard paving notes for drawings.

10.02 REFERENCES

- A. Access Management Manual, TRB, current edition
- B. Houston Complete Streets and Transportation Plan
- C. Designing Walkable Urban Thoroughfares: A Context Sensitive Approach, ITE, current edition
- D. Geometric Design of Highways and Streets ("The Green Book"), AASHTO, current edition
- E. Guide for the Development of Bicycle Facilities, AASHTO, current edition
- F. Guide for the Design of Pavement Structures, AASHTO, current edition
- G. Highway Capacity Manual (HCM), TRB, current edition
- H. Highway Safety Manual, AASHTO, current edition
- I. International Building Code (IBC), current edition
- J. Department of Houston Public Works Infrastructure Design Manual Chapter 1, General Requirements.
- K. Roadside Design Guide, AASHTO, current edition
- L. Scenic Houston Streetscape Resource Guide
- M. Texas Manual on Uniform Traffic Control Devices (TMUTCD), TXDOT, current edition
- N. Traffic Engineering Handbook, ITE, current edition
- O. Trip Generation, ITE, current edition
- P. Urban Bikeway Design Guide, NACTO, current edition

- Q. Urban Street Design Guide, NACTO, current edition

10.03 DEFINITIONS

- A. AASHTO - American Association of State Highway and Transportation Officials
- B. AC - asphaltic concrete.
- C. ASTM - American Society for Testing and Materials
- D. CMP - The City Mobility Plan is joint initiative between Planning & Development Department and HPW to examine a range of land development and growth issues by evaluating multi-modal transportation network needs and adjacent land development in the city.
- E. Complete Streets - Complete streets are streets that are designed using context sensitive design principles.
- F. Context Sensitive Design - Context sensitive design takes into account all roadway users, their interactions with one another, and overall effect on the land uses and neighborhoods for which a corridor serves to move people in a safe, effective and predicible manner. Roadway users include people who are driving or riding in cars, using mass transit, riding bicycles, walking, using wheelchairs, driving or riding in trucks, driving or being transported by emergency vehicles, and being served at their residence or property by other users. Context sensitive design principles are flexible and sensitive to community values. Context sensitive design principles take the following variables in account:
 - 1. People being served at their residence or property by other Right-of-Way users.
 - 2. People of all ages and abilities, including children, older adults, and persons with disabilities.
 - 3. The functional classification of the road (e.g. local, collector, and thoroughfare), the level of comfort for pedestrian and bicycle traffic, as well as vehicle volumes and speeds of the roadway.
 - 4. Multi-Modal Classification Street Type - A public street type classification that takes into account the functional classification (MTFP designation) and land use context, inclusive of right-of-way width, number of lanes and traffic volume. The context of the land use adjacent to the road comprises population and job densities (present and future), projected land use types (residential, commercial community facility or industrial), and modes of operation (pedestrian, bicycle, transit, rail, freight and vehicle lanes) can be used as a determinant in identifying Multi-Modal Classifications.

- a. Complete Streets and Transportation Plan - A plan that, at a minimum, includes the Major Thoroughfare and Freeway Plan, Bikeway/Pedestrian Plan, Rail Plan, Multi-Modal Classification Street Type, Master Parking Plan, Bayou Greenway Initiative, Context Report and METRO's Transit Plan.
 - b. Major Thoroughfare - Divided into two classifications; Principal Thoroughfare and Thoroughfare. Major Thoroughfares are those streets designed for fast, heavy truck traffic, high traffic volumes and are intended to serve as traffic arteries of considerable length and continuity throughout the community.
 1. Principal Thoroughfare - Public streets that accumulate traffic from Collector streets and other Major Thoroughfares for distribution to the freeway system. They may be a highway and typically provide a high degree of mobility for long distance trips.
 2. Thoroughfare - Public streets that accumulate traffic from Collector streets and local streets for distribution through the thoroughfare and freeway system. These streets distribute medium to high volume traffic and provide access to commercial, mixed use and residential areas.
 - c. Collector Streets - Public streets that accumulate traffic from local streets for distribution to the Major Thoroughfare streets. A Collector Street may be a Minor Collector or a Major Collector.
 1. Major Collector - Public streets that accumulate traffic from local streets and Minor Collectors for distribution to the Major Thoroughfare. A Major Collector Street may have commercial, residential or have mixed uses abutting.
 2. Minor Collector - A public street that accumulates traffic from local streets for distribution into a thoroughfare or major collector. A minor collector typically serves residential uses. Although in some circumstances, it may serve commercial or mixed uses.
 - d. Transit Corridor Streets - Rights-of-way or easements that METRO has proposed as a route for a guided rapid transit or fixed guide way transit system and that is included on the City's MTFP.
- G. Curb-and-gutter Sections - Full width concrete pavement with doweled on six (6)-inch curbs or monolithic curb-and-gutter sections for asphaltic concrete pavement. Curb-and-gutter sections require inlets and underground storm sewers.
- H. Geotechnical Engineer - A licensed Professional Engineer in the State of Texas who is practicing in the field of geotechnical engineering.
- I. Houston Complete Street and Transportation Plan- A plan that, at a minimum, includes the Major Thoroughfare and Freeway Plan, Bikeway/Pedestrian Plan, Rail Plan, Multi-Modal Classification Street Type and Master Parking Plan, Bayou Greenway Initiative, Context Report and METRO's Transit Plan.
- J. Intersection Sight Distance - Provides an unobstructed line of sight in each direction at

intersections. The unobstructed line of sight allows for vehicles on side streets to observe approaching traffic on the main roadway and to safely enter an intersection from a side street. The unobstructed line of sight allows for vehicles on the main roadway sufficient distance to observe vehicles entering from side streets.

- K. ITE - Institute of Transportation Engineers
- L. Local Streets - Provide access to individual single-family residential lots, multifamily or commercial developments, provide entry and exit to the neighborhood, and provide connectivity to collectors and thoroughfares.
- M. MTFP - Major Thoroughfare and Freeway Plan
- N. NACTO - National Association of City Transportation Officials.
- O. Roadside Ditch Sections - Ditch sections adjacent to either full width reinforced concrete pavement or asphaltic concrete pavement. Roadside ditch sections do not require underground storm sewers; however, the ditch sections must be designed to accommodate storm runoff.
- P. Roadway Context - The roadway context includes adjacent land uses, traffic volumes, and multimodal components taken into consideration when determining roadway design features. Although each roadway will have a unique set of characteristics that define its specific context, five major categories of roadway context are defined: commercial, residential, mixed use, industrial and transit. Each category of roadway context has specific design features, standards, and cross sections that must be considered.
 - a. Commercial Street - The primary land uses adjacent to the street is commercial (with limited amounts of light industrial), and the Planning and Development Department has classified the roadway context as commercial.
 - b. Mixed-Use Street - The land use is a mix between commercial and residential (either single or multi-family), and the Planning and Development Department has classified the roadway context as mixed-use.
 - c. Residential Street - The primary land use is residential (typically single-family, potentially with some multi-family), and the Planning and Development Department has classified the roadway context as residential.
 - d. Industrial Street - The adjacent land uses are predominantly industrial with some commercial land uses, and the Planning and Development Department has classified the roadway context as industrial.
 - e. Transit Street - The typical adjacent land uses are those of a Mixed-Use Street with the addition of a fixed guideway or other high-capacity rapid transit system, and the Planning and Development Department has classified the roadway context as transit-related.
- Q. Soils
 - a. Cohesive Soils are those that have 50% or more (by weight) passing the No. 200 Sieve and Plasticity Index greater than seven (7).
 - b. Granular Soils are those that have 50% or more (by weight) retain on the No. 200 Sieve.

- R. TRB - Transportation Research Board
- S. Type 1 Permanent Access Easement - A permanent access easement at least 50-feet in width that is designed and constructed like a public street in accordance with the design manual and contains one or more public utilities in an unpaved portion of the easement. Refer to Chapter 42 of the Code of Ordinances No. 1999-262.
- T. Type 2 Permanent Access Easement - A permanent access easement at least 28-feet in width that is designed and constructed like a private street serving a development that has no public utilities other than a public water line, connected to one or more fire hydrants, that provides no domestic water services. All private utilities within a Type 2 permanent access easement must be designed to public utility standards outlined in the Infrastructure Design Manual. Refer to Chapter 42 of the Code of Ordinances No. 1999-262.

10.04 ASPHALTIC CONCRETE PAVEMENT DESIGN REQUIREMENTS:

- A. AC Surface Minimum Thickness - Pavement design shall be prepared by a Professional Engineer based on current AASHTO design methodology (Guide for the Design of Pavement Structure). Minimum thickness shall be as shown on City of Houston Standard Detail 02741-01.
- B. Base Minimum Thickness - Pavement design shall be prepared by a Professional Engineer based on current AASHTO design methodology (Guide for the Design of Pavement Structure). Minimum thickness shall be as shown on City of Houston Standard Detail 02741-01. Alternative design may be approved by HPW.
- C. Subgrade Treatment
 - 1. Type, depth, and percentage of subgrade stabilization, stabilization design, and type of stabilization shall be determined by a geotechnical engineer.
 - 2. For subgrade conditions of cohesive soils, subgrade treatment or stabilization shall be no less than eight (8)-inches unless otherwise prescribed in this document or specified by a geotechnical engineer.

10.05 CONCRETE PAVEMENT DESIGN REQUIREMENTS:

The following requirements are applicable to pavement within City street rights-of-way.

- A. Minimum Pavement Thickness, Reinforcing, and Subgrade Stabilization Requirements:
 - 1. Pavement thickness and reinforcement shall be designed by a Professional Engineer based on a current soils analysis, roadway use, traffic loadings, and minimum 50 year life span of proposed pavement. Pavement design shall be prepared by a Professional Engineer based on current AASHTO design methodology (Guide for the Design of Pavement Structure). However, in no event shall the pavement thickness be less than the minimums stated below.

2. For Residential Roadway Concrete Pavement:
 - a. Minimum concrete slab thickness shall be six (6)-inches.
 - b. Minimum concrete strength shall be $f'c = 4000$ psi.
 - c. Minimum reinforcing steel strength shall be $f_y = 60,000$ psi.
 - d. Refer to City of Houston Standard Detail 02751-01 for concrete reinforcement details.
 - e. Minimum stabilized subgrade thickness shall be six (6)-inches for granular soils and eight (8)-inches for cohesive soils.
 - f. The type and depth of subgrade and base shall be as determined by a geotechnical engineer.
3. Collector Roadway with Concrete Pavement
 - a. Minimum concrete slab thickness shall be nine (9)-inches.
 - b. Minimum concrete strength shall be $f'c = 4000$ psi.
 - c. Minimum reinforcing steel strength shall be $f_y = 60,000$ psi.
 - d. Refer to City of Houston Standard Detail 02751-01 for concrete reinforcement details.
 - e. Minimum stabilized subgrade thickness shall be six (6)-inches for granular soils and eight (8)-inches for cohesive soils.
 - f. The type and depth of subgrade and base shall be as determined by a geotechnical engineer.
4. For Major Thoroughfares Constructed With Concrete Pavement
 - a. Minimum concrete slab thickness shall be 11-inches.
 - b. Minimum concrete strength shall be $f'c = 4,000$ psi.
 - c. Minimum reinforcing steel strength shall be $f_y=60,000$ psi.
 - d. Refer to City of Houston Standard Detail 02751-01 for concrete reinforcement details.
 - e. Minimum stabilized subgrade thickness shall be eight (8)-inches.

- f. The type and depth of subgrade and base shall be as determined by a geotechnical engineer.
 5. Paving headers shall be placed at the end of all concrete pavements.
- B. Curb Requirements:
1. Six (6)-inch Vertical Curb:
 - a. Six (6)-inch vertical curb is the standard curb design and shall be in accordance with City Standard Details.
 - b. Collector streets and higher volume residential streets where traffic calming measures are in place require construction of six (6)-inch vertical curb.
 2. Laydown Curb:
 - a. Laydown curb shall be in accordance with City Standard Details.
 - b. Shall be four (4)-inches in height.
 - c. Is only allowed as an option for street projects on single family residential streets within the City.
 - d. Laydown curb shall not be permitted if sidewalk is to be constructed immediately adjacent to the curb.
 - e. Laydown curb construction shall provide for necessary transition lengths at curb inlets to go from laydown curb to standard vertical curb section.
 - f. Transition from standard six (6)-inch to four (4)-inch vertical curb shall be extended a minimum of ten (10)-feet beyond curb inlets before beginning transitions.

10.06 GEOMETRIC DESIGN REQUIREMENTS:

A. Design Guidance

1. The design of streets within the City of Houston shall consider all users.
2. Roadway designs shall require context sensitive solutions such as those included in the ITE Recommended Practice: Designing Walkable Urban Thoroughfares: A Context Sensitive Approach; the NACTO Urban Bikeway Design Guide; AASHTO; or any other reference documents as defined in Chapter 17.

3. Minimum standards should be exceeded, to enhance safety and comfort for all roadway users. The minimum standards set in this chapter are not intended to be the only values used for design. The design values should be based on the context of the roadway and engineers may choose to use values that vary from the minimums set in this chapter. Use of the minimums shall be properly communicated and coordinated with Houston Public Works Staff.
4. Alternative Cross Section:

Project designs should consider roadway context, including adjacent land uses; nearby destination and infrastructure; and existing and potential bicycle, pedestrian, and transit traffic. Designers are encouraged to consider alternative cross sections as defined in Appendix 1 of this chapter to support the roadway context. Additional information regarding potential enhanced pedestrian environments and bicycle facilities can be found in Chapter 17.

B. Roadway Classifications

- a. Principal Thoroughfare
- b. Thoroughfare
- c. Major Collector
- d. Minor Collector
- e. Transit Corridor
- f. Local Street Classifications (not applicable in the ETJ)
 - (1) Residential Standard Density - Provides access to individual lots equal to or greater than 40-feet in width.
 - (2) Residential High Density - Provides access to individual lots less than 40-feet in width.
 - (3) Residential Main - Serves multiple streets and can be described as the "neighborhood feeder / collector."
 - (4) A summary of the design characteristics for the three local street classifications above is included in Table 10.06-01. Traffic volumes shown in column "Traffic ADT" are provided as general guidelines.

Table 10.06-01

LOCAL STREET CLASSIFICATION FOR CURB AND GUTTERED STREETS

	Gross		Min.
Street	Density	Traffic	Pavement
Classification	DU/AC ⁽⁴⁾	ADT ⁽¹⁾	Width (ft)
Residential Std ⁽²⁾	0-6	250 - 5000	26
Residential HD ⁽³⁾	6-27	350 - 5000	32
Residential Main	0-27	≥ 1500	36

Notes:

1. ADT - average daily traffic.
2. Lot widths equal to or greater than 40-feet.
3. Lot widths less than 40-feet.
4. DU/AC - dwelling units (DU) peracre.

C. Design Considerations

1. Context factors that may influence roadway design include, but are not limited to:
 - a. Number of dwelling units per acre (density).
 - b. Location of services within or near the neighborhood.
 - c. Pedestrian and bicycle facilities within the neighborhood.
 - d. Connectivity to the collector and thoroughfare network.
 - e. Connectivity to pedestrian, bicycle, and transit networks.
 - f. Traffic volume guidelines (ADT) are based on full development density.
 - g. Level of Comfort for bicyclists and pedestrians, as defined in Chapter 17.
 - h. Transit stop locations, destinations, ridership and appropriate facility design for high comfort boarding and alighting, transitions and access to platforms.
2. Design Speed
 - a. For purposes of design, design and target speed shall be synonymous.
 - b. The design speed shall be set by City Ordinances regulating speed limits.
 - c. The minimum design speed for a roadway shall be 30-mph.

3. Design Vehicles

- a. A WB-50 design vehicle shall be used for the following intersection types:
 - (1) Thoroughfare/Thoroughfare
 - (2) Thoroughfare/Major Collector
 - (3) Major Collector/Collectors
- b. A B-40 (Bus 40-foot) design vehicle will be generally used for all other intersections.
 - (1) If the design engineer feels that a design vehicle larger than a B-40 is applicable for other intersections, they should use the appropriate larger vehicle.
 - (2) In no case shall a smaller design vehicle be used without a variance, from the City Engineer.
- c. Where bicyclist and pedestrian needs must be considered, the following design vehicles shall apply.
 - (1) A DL-23 (Delivery Truck) shall be used at intersections involving only neighborhood/residential streets.
 - (2) A SU-30 shall be used at intersections on streets within Downtown or designated commercial districts.

D. Horizontal Geometric Requirements

1. Lane Widths

- a. The standard lane width on a City street will be 11-feet.
- b. On thoroughfares with heavy truck traffic documented (greater than 5% of total volume) or transit agencies designated bus routes, the use of a 12-foot outside lane is recommended.
- c. If a permanent parking lane is provided, an outside lane width of 20-feet is recommended.
- d. Lane widths other than 11-feet shall require a variance signed by both the City Engineer and the City Traffic Engineer, unless otherwise specified within this chapter.

2. Curve Radii

- a.
 - (1) Curve radii design shall be based on the design speed of the roadway and any super-elevation that may be considered for the design.
 - (2) Minimum curve radii for major collectors/thoroughfares is 500-feet.
 - (3) Minimum curve radii for local streets and minor collectors is 300-feet.

- b. Reverse curves for roadways should have a minimum 100-foot tangent between curves excluding turn lane transitions.
 - c. Maximum super elevation rate will be 4%.
 - d. Reverse super elevations shall not be allowed on any city roadways.
 - e. For super elevation design criteria, refer to City of Houston Standard Drawing 10.06-12.
3. Curb Radii
- a. Cul-de-Sac Curb Radii:
 - (1) For approved cul-de-sac curb radii, refer to City of Houston Standard Drawing No. 10.06-09.
 - (2) Curb radii around cul-de-sacs shall be 42-feet for single family areas.
 - (3) Curb radii around cul-de-sacs shall be 50-feet for cul-de-sacs in areas other than single family areas.
 - b. Street Intersection Curb Radii:
 - (1) For approved street intersection curb radii, refer to City of Houston Standard Drawing No. 10.06-04.
 - (2) Variances to the standard presented in City of Houston Standard Drawing No. 10.06-04 require approval by the City Engineer.
 - (3) Street intersection curb radii are a composite of needs to serve pedestrian and vehicular traffic.
 - (4) Bicycle/Pedestrian consideration: See Chapter 17.
4. Right-of-Way Corner Cut-Backs:
- a. For approved right-of-way corner cut-back dimensions, refer to City of Houston Standard Drawing No. 10.06-04.
 - b. Right-of-way shall be dedicated for corner cut-backs on principal thoroughfares, thoroughfares, transit corridor streets, major collectors, collectors and local streets as a requirement for subdivision platting of adjacent properties under Chapter 42 of the City of Houston Code of Ordinances.
 - c. When right-of-way corner cut-backs are not feasible on local streets, visibility easements will be required.
 - d. For Type 1 Permanent Access Easements, visibility easements shall be provided.
 - e. Corner cut-backs of right-of-way at street intersections are necessary to provide sufficient public space for pedestrian sidewalk facilities and ramps (compliant with Americans with Disabilities Act - ADA and Texas Accessibility Standards-

TAS), traffic control devices, street signs, street lighting, traffic signal equipment, and all surface encroachments which could prevent the future installation of such equipment within the cut-back area.

- f. Bicycle/Pedestrian consideration: See Chapter 17.

5. Objects in Right-of-Way

- a. Utilities (especially those above ground), trees, and other obstacles shall not be placed within the sidewalk or where they will interfere with pedestrian movements on existing and future side walk location. Minimum of 5' clearance pedestrian.
- b. Utility poles shall be placed within two (2)-feet of the ROW Lines unless approved the City Engineer.

6. Intersection Sight Distance:

- a. Dedicated right-of-way or easements are required to meet the intersection sight distance triangle requirements.
- b. Design Basis
 - (1) Design Vehicle - Passenger Car
 - (2) Design Standard - AASHTO "A Policy on Geometric Design of Highway and Streets"
 - (3) Lane Widths - 11-foot wide travel lanes; 10' may be considered based on engineering judgment and appropriate based on area context and multimodal use of a corridor inclusive of bicycles as defined in Chapter 17.
 - (4) Vertical obstructions and elevations must be considered for all users of the corridor including pedestrians and bicyclists.
 - (5) Sight Distance - Is measured to the center of the outside lane on main roadway approaching from the left and to the center of the inside lane of traffic on the main roadway approaching from the right.
 - (6) The intersection of local streets serving residential properties only, meeting at an angle of 85° degrees or more. Within 250-feet of the intersection, each of the uncontrolled approaches to the intersection of two local residential streets will have:
 - i. land uses adjacent to the street that are exclusively single family residential lots (or unoccupied reserves of limited size, such as landscape reserves, drainage reserves or utility reserves).
 - ii. Residential lots with driveway access to the uncontrolled approach street.
 - iii. A posted (or prima facie) speed limit of 30-mph or less.

- c. Design Procedures:
 - (1) Determine design speed of main roadway based on section 10.06.C2 of this chapter.
 - (2) For the appropriate design speed, determine the minimum sight distance from the following Table 10.6-02:

TABLE 10.6-02 Triangle Applicability

Triangle Applicability		
Highest classification/greater width street	Sight triangle driver's eye setback distance	Sight triangle dimension on uncontrolled street
High speed major thoroughfare (≥ 45 mph posted speed)	25-foot	sight-specific analysis
Major thoroughfare or major collector on MTFP map	25- feet	500- feet
Divided streets and 41 ft. streets	15-foot	500- feet
26 ft. local and collector streets	15- feet	390- feet
26 ft., single family residential frontage on both streets	N/A	N/A

- (3) Develop a scaled drawing depicting the sight triangle based on the design criteria. Refer to the City of Houston Standard Drawing No. 10.06-05.
- d. Exceptions
 - (1) Replats and partial replats at the intersections of a local/local street, local/major collector street, and major collector/major collector street are exempt from providing intersection sight distance rights-of-way or easements where existing site conditions for abutting properties preclude compliance.
 - (2) Variances or deviations to these guidelines will be considered on a site-by-site basis. An engineering analysis should be prepared to support the proposed sight triangle dimensions, based on criteria in the AASHTO "Green Book", latest edition. Where the uncontrolled street is existing, design speeds should be based on an analysis of the 85th percentile operating speed.

7. Median Design:

Median design should accommodate bicycle and pedestrian movements across a street where the need has been established. Midblock crossing standards for bicycle and pedestrian access are defined in Chapter 17.

a. Minimum Median Width:

- (1) For local streets, refer to City of Houston Standard Table No. 10.06-04.
- (2) Paved medians shall be at least four (4)-feet (face to face) in width.
- (3) The desired width of reverse median is six (6)-feet (face to face).

b. Minimum Median Length:

- (1) Median lengths are based on functional street classification of the main roadway and intersecting street. Median Openings should only be installed where the need for an opening exists. Before a median opening is closed, the need to continue pedestrian and bicycle movements across the corridor shall be evaluated per Chapter 17 guidance.
- (2) Refer to City of Houston Standard Drawing No. 10.06-06 for minimum median length requirements. The minimum median spacing is 660-feet. Designs should adhere to the desirable spacing when in the vicinity of major signalized intersections.

c. Median Geometry - Refer to City of Houston Standard Drawing No. 10.06-07.

d. Street Taper Geometry - Refer to City of Houston Standard Drawing No. 10.06-08 for subdivision street taper geometrics.

8. Left Turn Lanes:

a. Left Turn Lanes are Required:

- (1) At all signalized intersection approaches.
- (2) At all median openings.
- (3) Overlaps between opposing and adjacent left turn tracking paths should be checked and shown in the intersection review design submittal.

b. Left Turn Lane Design Standards:

- (1) Refer to City of Houston Standard Drawing No. 10.06-07 for left turnbay geometrics.
- (2) The design of a left turn lane shall not result in an offset greater than three (3)-feet crossing the intersection for the adjacent through lanes.
- (3) The volume of left turn movements shall be based on projections developed in the City Mobility Plan or based on traffic studies reviewed and approved by the City Engineer.
- (4) At median openings; openings may be directional but whenever possible, left turn lanes should be provided for both directions.

- c. Dual Left Turn Lanes:
 - (1) Are required when left turn movement exceeds 300 vehicles for the peak hour, or when traffic analysis of the intersection indicates existing or projected left turn storage space requires dual left turn lanes before the volume threshold is reached.
 - (2) Where dual left turn lanes are required, right of way for the intersection shall be based on the width required for dual left turns, through lanes, a right turn lane, and minimum landscape/pedestrian zone of ten (10)-feet (dimension S) as shown in City of Houston Standard Drawing No. 10.06-02.
 - d. Special conditions or other constraints may require design criteria other than shown herein.
 - (1) Exceptions to the requirements must be demonstrated by submittal of a traffic study encompassing AASHTO criteria.
 - (2) Approval by City Engineer is required for all variances to standard.
- E. Roadway Cross Sections:
- 1. The City of Houston utilizes the basic roadway cross sections shown in City of Houston Standard Drawing Numbers 10.06-01, 02 and 03, respectively. With the growing emphasis on Context Sensitive Design, roadway cross section variations will be considered by the Office of the City Engineer.

Table 10.06-03 Roadway Geometric Design Criteria

Item	Desirable	Minimum
Width of Travel Lanes (ft)	11	11
Width of Turn Lanes (ft)	11	11
Horizontal Curve Radii	Varies ⁵	500
Non-Dedicated Bike Lane	*11-14	*11-14
Standard Bike Lane Width (ft)	*6	*5
Median Width at turn lanes (ft)	17 ¹	15
Median Width face of the curb to the face of curb outside the turn lanes (ft)	*6-10	4
Center Turn Lane Width (ft)	11	11
Pedestrian Realm Width ² (ft)	15 ³	10
Total Buffer to Sidewalk with Tree Well ²	6	4
Total Buffer to Sidewalk w/o Tree Well ²	4	2
Sidewalk Width (ft)	*6-10	5/6 ⁵
Transit Sidewalk Width (ft) By Transit Corridor Ordinance	>6	6
Sidewalk adjacent to curb	>6	6
Shared use path/trail	10	8
Shared use path/trail easement	20	15

1. Desirable Median width may be higher based on available right-of-way, see dwg. 10.06-02
2. Buffer to sidewalk includes buffer to tree grate and tree grate width
3. Figure 10.06.02 show typical sections only, not minimum or desirable widths.
4. Curve design radii shall be based on the design speed of the roadway and any super-elevation that may be considered for the design. Where bicycle facility is present, curve radii should provide for highest visibility of a person on a bike by motor vehicle users.
5. On thoroughfares and above.

* See Chapter 17 for more information.

F. On-Street Parking

1. Permanent on-street parking cannot occur in a traffic lane.
 - a. At the discretion of the City Traffic Engineer, parking may be allowed in a traffic lane if current traffic volumes do not warrant the need for the additional lane. The City Traffic Engineer may allow this parking to occur all day or may restrict it to certain times of the day as needed for mobility purposes. All parking allowed to occur within a traffic lane shall be considered to be temporary and can be removed at any time.

2. Permanent on-street parking can be provided assuming that sufficient right-of-way exists. When a permanent parking lane is provided, it shall be at least eight (8)-feet in width. Where on-street ADA accessible parking is provided, the minimum required width is 13-feet.
 3. As required by the City of Houston Code of Ordinances, all on-street parking shall be parallel to the curb or edge of pavement unless approved by the City Traffic Engineer. Lateral parking shall be treated on a case by case basis.
 4. As required by the City of Houston Code of Ordinances, all parking within the public right-of-way behind the curb (curb cutback parking) requires the approval of the Director of Houston Public Works. Parking behind the curb shall be considered on a case by case basis.
- G. Vertical Geometric Requirements:
1. For Curb and Gutter Pavement Sections:
 - a. Minimum grade line shall be 0.30 percent.
 - b. Minimum grade line shall be 1.00 percent for radii of 35-feet or less around intersection turnouts. Grades for larger radii shall be determined on an individual basis.
 - c. Super elevation - Major thoroughfares shall be super elevated in accordance with AASHTO requirements.
 - d. Vertical Curves:
 - (1) Shall be installed when the algebraic difference in grades exceeds 1.00 percent.
 - (2) Elevations shall be shown at 10-foot intervals through vertical curves.
 - (3) Maintain a minimum of 0.03-foot elevation change at 10-foot intervals by altering calculated elevations.
 - (4) Determine minimum vertical curve lengths based on AASHTO design criteria (minimum shall not be less than 3 times design speed).
 - e. Minimum grade line around a cul-de-sac shall be 0.70 percent.
 - f. Pavement Cross Slopes:
 - (1) Cross slopes for pavement shall be a minimum of 1/4-inch per foot.
 - (2) Cross slopes for left-turn lanes and esplanade openings shall be 1/8-inch per foot minimum.

2. Railroad Crossings

- a. Maximum Tangent Grade to Vertical Curves at Railroad Crossings:
 - (1) 8.0 percent for local streets
 - (2) 3.5 percent for major thoroughfares
- b. Roadway grades at railroad crossings shall be zero percent from centerline of the track to ten (10)-feet either side of the track's centerline, and should not cause a drop of more than six (6)-inches from the top-of-rail elevation at a distance of 30-feet either side of the track's centerline.
- c. For concrete roadways, the roadway shall terminate at a railroad header, six (6)-feet from the centerline of the track and the roadway cross slope shall be zero (0) from the railroad header to four (4)-feet before the railroad header.
- d. Railroad crossings are shown in Standard Drawing No. 10.06-13.
- e. All roadway crossings of a railroad shall include a six (6)-feet pedestrian walkway. See Standard Drawing No. 10.06-13.
- f. At railroad track approaches, decrease curbs from six (6)-inches to zero (0)-inches in two (2)-feet, at a distance of ten (10)-feet from the nearest track centerline.
- g. All roadway crossings of a railroad that involve bicycle facilities shall include appropriate crossing angles and signage for bicyclists as defined in Chapter 17.

H. Pedestrian Realm (Sidewalks, Accessibility Ramps, and Bus Pads):

1. Minimum Sidewalk Width - five (5)-feet and should be wider where appropriate. For Transit Streets see section 10.6.I.3. Minimum sidewalk width for Major Thoroughfares shall be six (6)-feet.
2. Accessibility ramps shall be constructed at all intersections, when the right-of-ways leading to those intersections have existing sidewalks.
3. Sidewalks constructed along Type A Streets - for Transit Corridor Streets shall have a minimum width of six (6)-feet. Ramps, approaches and sidewalks shall comply with ADA and TAS requirements. Sidewalks for Transit Corridor Street and Type A Streets:
 - a. Chapter 42, Article IV - Transit Corridor Development, of the Code of Ordinances regulates improvements constructed in the public right of way within 1,320 feet of each transit station (Ch. 42, Sec 401-406).

- b. Mandatory requirements are summarized below and shown in Standard Detail 02775-08. These requirements are required under IBC, Section 3110).
 - (1) Minimum Sidewalk Width - six (6)-feet (must be located within the public right of way or sidewalk easement).
 - (2) Minimum Vertical Clear Zone, a continuous obstacle free path, for a minimum width of six (6)-feet and a minimum height of seven and one-half (7 ½)-feet.
- c. Performance Standards - Refer to Chapter 42 Sections 401-406:
 - (1) Minimum Pedestrian Realm - 15-foot distance from back of curb to a building's facade or other improvements (can be entirely within public right of way or a combination of public right of way and public access easement).
 - (2) Maximum Softscape area in the pedestrian realm is 20% of the surface area of the pedestrian realm excluding any driveways and shall be located at least two (2)-feet from the back-of-curb of any street area used for parking.
4. Sidewalks at intersections are to be provided with unobstructed areas as shown in Standard Drawing No. 10.06-04 and are to be free of obstructions and surface encroachments such as sign posts, power poles and down guy wires within that area.
5. Approved sidewalk/ramp details are shown in the City's Standard Details. Use of these details are specific to certain field conditions such as ramp direction, driveway crossings, crosswalk locations and the location of the sidewalk with respect to the curb.
6. Where use of standard sidewalk/ramp details is not possible due to field conditions, engineer shall submit proposed design drawings to City Engineer for approval. Design drawings shall include site field survey conditions.
7. Accessibility ramps should cross street at 90 degrees to centerline of street.
8. All ramps constructed on an intersection corner should be interconnected for pedestrian access continuity.
9. Mid-block crosswalks shall be installed where appropriate based on area context and associated justification provided by the design engineer. Mid-block crossings for side paths, off-street trails as well as other considerations are discussed in Chapter 17.
10. Sidewalks traversing rail lines shall be at 0% slope for a distance of five (5)-feet from the Center Line of the track.
11. Alternative methods of sidewalk construction may be used in places where tree preservation is of concern. Alternative materials may be but are not limited to decomposed granite and checkered plate.

12. When right-of-way contains a Bus Stop, the engineer will use the following Bus Pad and Landing Design Guidance to appropriately integrate the bus landing pad with the sidewalk.
 - a. Each bus stop area will be composed of three elements per City of Houston Drawing Number 10.06-14:
 - (1) Bus Pad (one): 15'6" (typical) by eight (8)-feet (minimum) (all slopes maximum 2%)
 - (2) Bus Landing Area (two): Five (5)-feet by eight (8)-feet (minimum) (front door landing), and seven (7)-feet (recommended) by eight (8)-feet (minimum) (back door landing) (all slopes maximum 2%)
 - (3) Transitions (two): Five (5)-feet (minimum) by eight (8)-feet aligning with the landing and tapering to the sidewalk width (maximum longitudinal slope of 5%)
 - b. As additional right-of-way is available beyond the minimum nine (9)-feet S-dimension:
 - (1) Pad will shift back, maintaining a one-foot distance to the edge of right-of-way.
 - (2) Landings may extend in width from the curb to one foot from the right-of-way. The width will be extended in order to always maintain an ADA and TAS accessible route between the pad and landing.
 - (3) Engineer will use their judgement to specify the proposed surface of the remaining portion between the pad and curb (ex. paving, grass, etc.).
 - c. Context factors that may influence the design of Standard Bus Pad and Landings.
 - (1) Distance from the curb to the right-of-way (or bus pad easement) is less than nine (9)-feet.
 - (2) Location of bus pad longitudinally along the roadway will need to account for the Critical Shelter Obstruction (as identified in City of Houston Drawing Number 10.06-14) when verifying safe Intersection Sight Distances (as prescribed by per City of Houston Drawing Number 10.06-05). If the stop location needs to change due to sight distance requirements, the engineer will contact METRO at 713-615-6195 for coordination and approval.
 - d. Where use of standard bus pad and landings details is not possible due to field conditions (ex. driveways, trees, etc.), engineer shall contact METRO at 713-615-6195 for proposed variations and approval.

I. Alleys:

1. Design standards for a Public Use Alley are shown in City of Houston Standard Drawing No. 10.06-10.
2. All Public Use Alleys should not drain across sidewalks without approval by City Engineer.
3. An offer of dedication of right of way to the public is required for a Public Use Alley and such offer must be formally accepted by the City for implementation of public maintenance services.
4. The minimum design standards for a Private Use Alley are shown in City of Houston Standard Drawing No. 10.06-11.
5. The right of way for a Private Use Alley is owned and maintained by the abutting property owners.
6. Signs shall be erected by the developer at the entrance to the alley (or by the abutting property owners for existing alleys) which state "PRIVATE ALLEY - NOT A PUBLIC WAY". See City of Houston Standard Drawing 10.06-11 for sign details.

J. Street Terminations:

1. Where cul-de-sac streets are approved, design geometrics shall comply with City of Houston Standard Drawing No. 10.06-09. Bicycle and pedestrian access to nearby existing or proposed bicycle facility or trail shall be provided where feasible.
2. Where termination of a private street or Type 2 Permanent Access Easement is approved, design geometrics shall comply with City of Houston Standard Drawing No. 10.06-09. Bicycle and pedestrian access to nearby existing or proposed bicycle facility or trail shall be provided where feasible.
3. Dead-End Streets - Standard City of Houston barricades shall be placed at the end of dead-end streets not terminating in cul-de-sacs. Refer to City of Houston Standard Detail No. 01580-01. Bicycle and pedestrian access to nearby existing or proposed bicycle facility or trail shall be provided where feasible.
4. Temporary Street Termination - Temporary termination of streets (for future extension into adjacent development) shall include construction of street barricades as shown in City of Houston Standard Detail No. 01580-01.

K. Roundabout Intersections:

1. Design standards for Roundabouts are shown in 10.06.5.
2. Roundabouts are limited to collector-collector street intersections and four leg approaches without prior consideration and approval of the City Engineer and City Traffic Engineer.
3. No direct driveway access shall be allowed to the roundabout.
4. Roundabouts will have raised center island treatment.
5. Landscaping in the central island will conform to Chapter 15 visibility requirements.
6. For general layout of Roundabouts refer to details 10.06-15 and 10.06-16.

Table 10.06.4 Roundabout Design Parameters

Parameters	Local or Collector	Boulevard or Arterial
Maximum Entry Speed	20 mph	25 mph
Design Vehicle	B - 40	WB - 50
Roadway Type	Collectors or lower	Major Collectors and above
Inscribed Circle Diameter	90 to 150 FT	150 to 180 FT
Maximum Number of Entering Lanes	1	2
Typical Capacity (all approaches)	< 20,000	< 40,000
Median Treatment	Raised Curb with Truck Apron	Raised Curb with Truck Apron

1. Driveways shall not be located where vehicles must take direct access to a roundabout or splitter island. Fastest paths must be drawn for all approaches and all movements, including left-turn and right-turn movements. If required, unobstructed visibility easement(s) shall be provided to conform with required sight distances.
2. All landscaping shall be designed to minimize roadside hazards and maintain required stopping and intersection sight distance throughout the roundabout.
3. Conflicting leg sight triangle decision point is located 50 ft. from the yield line. Safe stopping sight distances for the approach shall be evaluated from both the yield line and marked crosswalk.

10.07 STREET CONNECTIONS AND TRANSITIONS:

A. Street Transition Requirements:

1. Concrete Streets:

- a. When transitioning from a proposed concrete street to an existing concrete street, the transition shall consist of concrete, and shall equal the existing concrete pavement thickness with a minimum thickness of eight (8)-inches.
- b. Refer to City of Houston Standard Detail 02751-01.

2. Streets Other Than Concrete Pavement:

- a. When transitioning from a proposed street to an existing street constructed of material other than concrete, the transition shall consist of asphaltic concrete paving.
- b. Refer to City of Houston Standard Drawing No. 10.06-03.

B. Proposed Curb and Gutter Street Connecting to an Existing Roadside Ditch Street:

1. The standard transition length for meeting a roadside ditch street is:

- a. 50-feet for street widths less than or equal to 26-feet F-F(face to face of curb).
- b. 75-feet for street widths equal to 36-feet F-F(face to face of curb).
- c. 100- feet for street widths equal to 40-feet F-F(face to face of curb).

C. Proposed Curb and Gutter Street Connecting to an Existing Curb and Gutter Street:

1. When meeting an existing curb-and-gutter street, top-of-curb elevations shall be designed to meet an elevation six (6)-inches above the existing gutter.
2. At existing inlets, top-of-curb elevations shall be designed to match existing top-of-curb elevations.

D. Construction Requirements for Connecting a Proposed Concrete Street with an Existing Concrete Street:

1. When meeting existing concrete streets at right angles, the existing street should be saw cut in a V-shape extending from the curb returns to a point where the centerline of the proposed pavement intersects the quarter point of the existing concrete street to create a crowned intersection. In the event this construction creates a situation in

which traffic on the existing street, at design speed, will bottom out when crossing the proposed street intersection, a special design will be allowed to eliminate this potentially dangerous condition.

2. Remove concrete either to an existing joint or a sawed joint. The groove of the sawed joint shall be cut to a minimum depth of two (2)-inches along the line designated by the Professional Engineer.
3. When meeting existing concrete pavement, horizontal dowels shall be used if no exposed reinforcing steel exists. Horizontal dowels shall be Grade 60 bars, 24-inches long, drilled and embedded 12-inches into the center of the existing slab with PO ROC, or approved equal. Dowels shall be 12-inches center-to-center, unless otherwise specified.
4. When concrete is removed for connection with proposed concrete pavement, the pavement shall be saw cut and existing concrete removed to expose a minimum of 15-inches of reinforcing steel. If no reinforcing steel exists, use horizontal dowels per Paragraph 10.07 D.3.

E. Pavement Connection Special Requirements:

1. At a T-intersection with a street that has not been improved to its ultimate width, concrete shall be stopped either at the right-of-way line or the end of the curb return. The option that will require the least concrete removal at a future date should be chosen.
2. For roadway turnouts placed at an existing cross street intersection, the turnout should be designed to fit the ultimate pavement width of the intersecting cross street and then transitioned to the existing roadway.

F. L - Type Street

The minimum grade line around the longest radius on an L-type street shall be 0.40 percent.

10.08 Bicycle Facilities

A. Bicycle Master Plan

1. All City of Houston maintained bicycle facilities shall be shown on the City's Bikeway Plan.
2. On-Street bicycle facilities will not be provided on roadways having a posted speed limit above 35 mph.
3. If an On-Street Bike Lane is provided, the minimum width of the Bike Lane shall be five (5)-feet with a desired width of six (6)-feet.

B. Types of Bicycle Facilities

1. Bike Routes are signed routes primarily along collector streets, local streets, and occasionally along thoroughfares. They consist of Bike Route signs (D11-1) only with no pavement markings or reserved area for bicycles. Bike routes typically require a minimum lane width of 11-feet.
2. Buffered Bike Lanes can be provided on collectors and major thoroughfares assuming that sufficient right-of-way exists for these facilities. A Buffered Bike Lane is simply a Bike Lane that is separated from the adjacent traffic while still existing as a part of the roadway. The buffer can be provided through the use of either a raised or painted median. If painted the buffer shall be a minimum of three (3)-feet in width and shall consist of two six (6)-inch solid white lines with six (6)-inch diagonal white cross-hatching. If a raised median is provided, it will follow the minimum guidelines for raised medians found elsewhere in this manual. Bicycle pavement markings will be provided in the bike lanes and Bike Lane signs (R3-17) will be provided along the route.
3. Cycle Tracks can be provided on collectors and major thoroughfares assuming that sufficient right-of-way exists for these facilities. Cycle tracks can be one or two way and are similar in nature to Buffered Bike Lanes. Cycle Tracks will be treated on a case by case basis and additional information can be found in the NACTO Urban Bikeway Design Guide. For Cycle Tracks design criteria, refer to City of Houston Standard Drawing 10.06-13.
4. Off-Street facilities within the right-of-way can be provided along any facility and the speed of adjacent traffic is not of concern. Due to maintenance issues associated with off-street facilities, they will be considered on a case by case basis to determine the best design standards for the project. Typically, off-street facilities will be two-way and will be at least eight (8)-feet in width and shall be at least five (5)-feet from the back of curb.
5. Bicycle Parking or "Corrals" can be provided; however, they must occur within a permanent parking space, not in a travel or mobility lane or within the sidewalk. If the sidewalk exceeds ten (10)-feet in width, bicycle parking may be considered within the pedestrian realm.

C. Bike Trails

1. Bike trails should be designed using AASHTO Guidelines for Development of Bicycle Facilities, current edition or alternate with approval of the City Engineer.

10.09 SPECIAL REQUIREMENTS:

- A. Pavement Crossing Pipelines - A Letter of agreement between the City and pipeline company is required when paving is placed over a transmission pipeline.
- B. Bridges: attaching utilities to bridges shall be prohibited whenever practical, unless all other ways have been explored.

a. Design Requirement

- (1) Research and resolve known conflicts of proposed utilities before establishing design to structure. Any exceptions that are permitted will be handled per the design conditions. These exceptions will be considered on an individual basis and does not set a precedent for granting subsequent requests.
- (2) It may be beneficial to carry lines across an obstruction using a utility structure rather than an attachment to a structure.
- (3) The City Engineer's Office and the Bridge Maintenance Office will conduct a structural review and review of the details of the design. Exhibits submitted should include the following:
 - 1. Details on how the line is attached to the bridge.
 - a. Show proposed location of the attachment on elevation view of bridge layout.
 - b. Show specific detail of attachment to bridge with appropriate notes to contractor.
 - c. The Utility Attachment Exhibit must be signed and sealed by a licensed professional engineer.
 - 2. Copies of bridge layout and pertinent details of existing bridge as-built plans (if available).
- (4) Bridge design should include a high comfort bicycle facility where a bicycle facility exists or is proposed. See Chapter 17 for details on high comfort bicycle facilities.

Note: All requirements can be referenced from The Texas Department of Transportation Bridge Project Development Manual; Chapter 4: Advanced Planning, Section 4: Utility Attachments; December 2012 Edition

b. Design Guidelines

- (1) No gas or liquid fuel line may be attached to a bridge structure without approval from Public Works.
- (2) Power lines are not permitted on bridges under any condition with the exception of low voltage distribution lines, lines that carry 600 volts or less.
- (3) When a utility company request permission to attach a utility to an existing bridge, sufficient information should be furnished to allow a stress analysis to determine the effect of the added load on the structure. Other details of the proposed attachment as they affect safety and maintenance should also be presented. If the bridge structure is not of adequate strength to carry the increased weight or forces with safety, permission will not be granted.

- (4) Bridge attachments should not be made to any bridge rail or rail hardware, including anchor bolts.
- (5) Do not hang lines from the bottom of beams.
- (6) Maintenance of utility attachments to a bridge is the responsibility of the utility.

C. Thoroughfare Construction Considerations:

1. When the full section of a thoroughfare is located within the city limits and is dedicated on a final plat, the esplanade and all lanes of the thoroughfare shall be constructed at the time of initial construction of the roadway.
2. If approved by the City Engineer, lanes contained within a plat, left-turn lanes, bicycle facilities, and the esplanade to the centerline of the right-of-way shall be constructed at the time of initial construction of the roadway when only one side of a thoroughfare is located on a final plat. The remaining lanes, left-turn lanes, bicycle facilities and esplanade shall be constructed at the time the final plat containing the opposite side of the thoroughfare is approved.

D. Inlets and Manholes

1. The inlet spacing and the maximum allowable curb run to an inlet shall be provided in accordance with Chapter 9.
2. City approved inlets shall be used on all curbs and gutter sections within the city limits and in the ETJ.
3. Keep proposed inlets away from esplanade opening and out of major thoroughfare intersections. For intersections between a major thoroughfare and minor street, locate inlets at the end of return (E/R) of the side street.
4. Inlets shall be placed at the end of pavement in order to eliminate drainage from the pavement gutter into a road ditch.
5. When curb and gutter streets connects to roadside ditches street, place inlets at end of curb and gutter street with reinforced concrete pipe stubs with rings to collect ditch storm water. See standard detail 02632-11- Side Street Ditch Reception
6. Use only City standard grates for curb inlets.
7. Adjust existing manhole frames and covers within the limits of the proposed pavement to meet the proposed top-of-slab elevation.
8. Adjust existing manhole frames and covers outside the limits of pavement to conform to the final grading plan.

- E. When a curb and gutter street intersects a drainage ditch, the gutter elevation shall be above the designed water surface elevation of the ditch.
- F. Fill/Cut For Proposed Pavement:
1. Fill Placement For Curb and Gutter Pavement Sections:
 - a. Fill shall be placed to ensure a minimum of 3/8-inches per foot transverse slope toward the curb from the property line. Fill shall be placed between the curb and a point two (2)-feet outside of the right-of-way.
 - b. Where fill as described above is required, and the pavement is adjacent to a nonparticipating property owner, fill easements shall be obtained, filed, and a copy of the easement shall accompany the final drawings.
 - c. Construction of this nature will require back-slope drainage design to prevent trapping storm runoff.
 - d. When pavement or curb grades are established below natural ground, slopelines shall be shown on the drawings.
- G. Drawings
1. Construction drawings shall be prepared in accordance with Chapter 3, Graphic Requirements.
 2. Top-of-curb grade for the outside lanes shall be labeled except at railroad crossings where gutter grades shall be labeled. Centerline grades are acceptable for sheets with roadside ditch sections.
 3. For proposed driveways, call out centerline stations, widths, and radii.
- H. Transit Shelters
1. Engineers shall coordinate with METRO or other Transit groups in regards to placement and design of Bus or other Transit Shelters when designing or rebuilding roadways for the placement of pads and other appurtenances. See Chapter 17 for more information regarding transit, pedestrian and bicycle facilities.

END OF CHAPTER

APPENDIX 1

CHAPTER 10

Appendix 1 presents a "Street Design Menu" with examples of optional roadway corridor sections that are a result of the 2009 City of Houston Mobility Planning Study. Figure 1 is provided to cross reference the street classifications in the Major Thoroughfare and Freeway Plan to the corridor sections within the City Mobility Plan. These corridor sections can be utilized for development of roadway systems within the City limit of Houston. These roadway sections are not applicable in the ETJ of the City. The tables identify the right-of-way requirements and element dimensions associated with each corridor section.

The design engineer, in consultation with the City, shall determine the appropriate Multimodal Street Classification is applicable for each street using context sensitive design principles. While full right-of-way dedication may not be required under Chapter 42 of the City of Houston Code of Ordinances, it is expected that developer's utilizing these alternative sections will make available the necessary public right-of-way dimensions at no cost to the City of Houston.

NOTES

1. Sidewalk dimensions shown are options. Minimum sidewalk dimension for Transit Street designations and Major Thoroughfare is six (6)-feet and five (5)-feet for all others.
2. TW - Tree Wells will be considered for use in lieu of a green space dimension where shown in Tables.

CITY MOBILITY PLAN (CMP)				MAJOR THOROUGHFARE AND FREEWAY PLAN (MTFP)				
MULTIMODAL STREET CLASSIFICATION				EXISTING CLASSIFICATION				
	Proposed Right-of-Way	Number of Lanes	Typical Design Avg Daily Traffic Vol (vpd)	Principal		Major	Minor	Local
				Thoroughfare	Thoroughfare	Collector	Collector	Street
BOULEVARD								
Commercial	80' - 140'	4 - 8	15,000 - 80,000					
Mixed Use	80' - 140'	4 - 6	15,000 - 50,000					
Residential	80' - 120'	2 - 6	15,000 - 30,000					
Transit	120'	4 - 6	15,000 - 30,000					
Industrial	80' - 140'	4 - 6	15,000 - 50,000					
AVENUE								
Commercial	80' - 100'	2 - 4	1,500 - 30,000					
Mixed Use	80' - 100'	2 - 4	1,500 - 30,000					
Residential	80' - 100'	2 - 4	1,000 - 20,000					
Transit	100'	2	1,500 - 15,000					
Industrial	80' - 100'	3 - 5	5,000 - 35,000					
COUPLET								
Commercial	60' - 100'	2 - 5	1,000 - 45,000					
Mixed Use	60' - 100'	2 - 5	1,000 - 45,000					
Residential	60' - 100'	2 - 3	1,000 - 25,000					
Transit	60' - 100'	2 - 4	1,000 - 35,000					
Industrial	60' - 100'	2 - 5	1,000 - 45,000					
STREET								
Commercial	60'	2	1,000 - 15,000					
Mixed Use	60'	2	1,000 - 15,000					
Residential	60'	2	500 - 5,000					
LOCAL STREET								
Residential Main	60' - 70'	2	≥ 1,500					
Residential High Density	55' - 65'	2	350 - 5,000					
Residential Std. Density	50' - 65'	2	250 - 5,000					

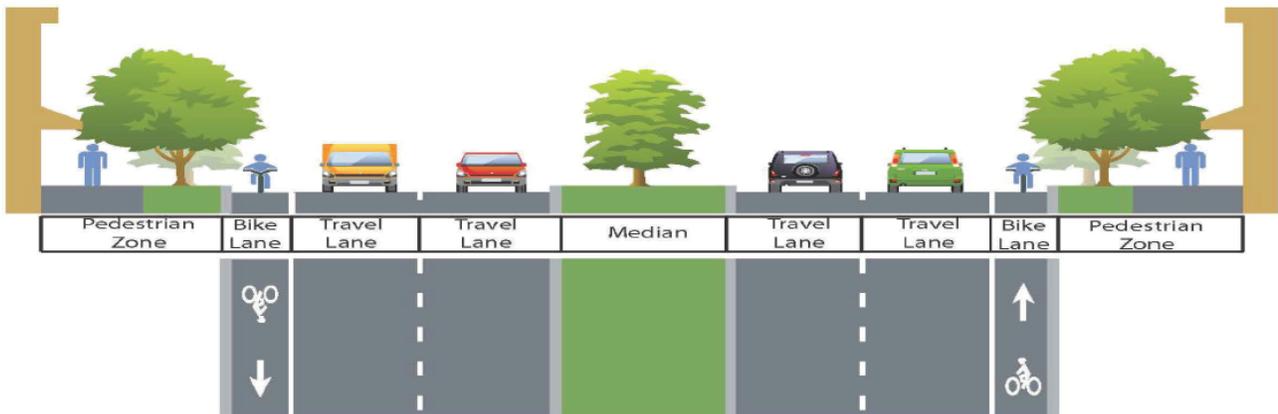
 Indicates Shared Classification

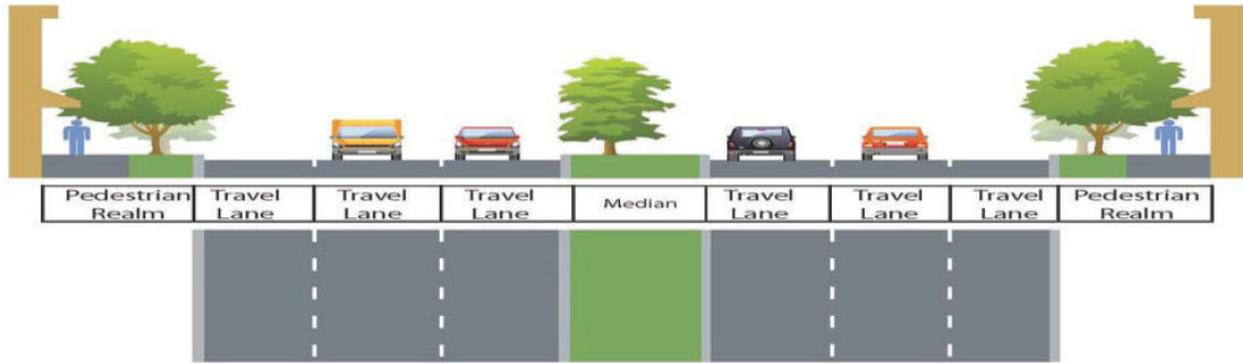
Figure 1

Commercial/Mixed Use Boulevard Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 x 10 = 20	TW	N/A	N/A	16	4 x 11 = 44	15,000 - 30,000
100	2 x 18 = 36	TW	N/A	N/A	20	4 x 11 = 44	15,000 - 30,000
	2 x 12 = 24	TW	N/A	2 x 6 = 12	20	4 x 11 = 44	15,000 - 30,000
	2 x 10 = 20	TW	2 x 8 = 16	N/A	20	4 x 11 = 44	15,000 - 30,000
	2 x 13.5 = 27	TW	N/A	2 x 6 = 12	17	4 x 11 = 44	15,000 - 30,000
	2 x 10 = 20	TW	N/A	N/A	14**	6 x 11 = 66	15,000 - 40,000
120	2 x 17 = 34	TW	N/A	N/A	20	6 x 11 = 66	15,000 - 30,000
	2 x 11 = 22	TW	N/A	2 x 6 = 12	20	6 x 11 = 66	15,000 - 30,000
	2 x 12.5 = 25	TW	N/A	2 x 6 = 12	17	6 x 11 = 66	15,000 - 30,000
	2 x 10.5 = 21	TW	2 x 8 = 16	N/A	17	6 x 11 = 66	15,000 - 30,000
140	2 x 16 = 32	TW	N/A	N/A	20	8 x 11 = 88	20,000 - 50,000
	2 x 11.5 = 23	TW	N/A	2 x 6 = 12	17	8 x 11 = 88	20,000 - 50,000

* - Minimum Sidewalk width is a minimum of 5 feet.

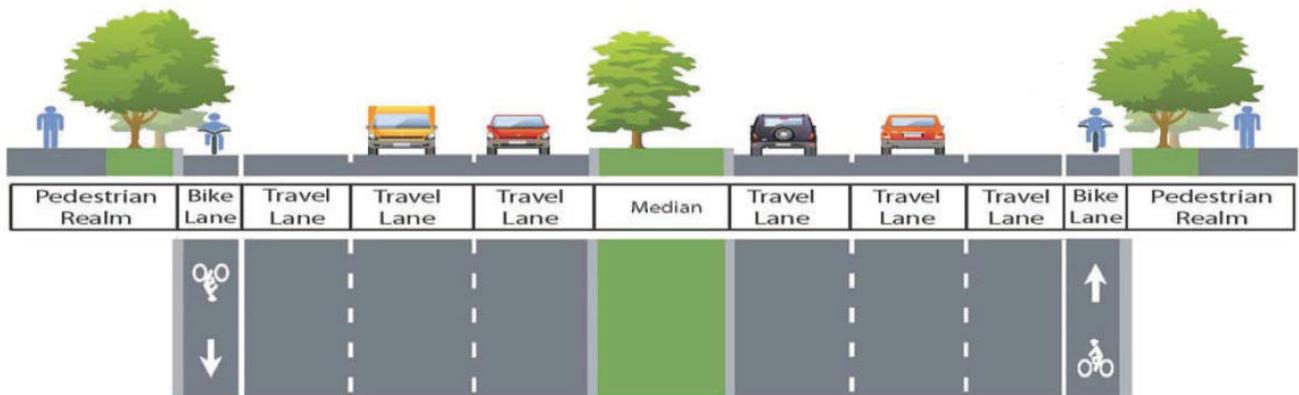
** - Not recommended. Requires the concurrence of the City Engineer and the City Traffic Engineer.

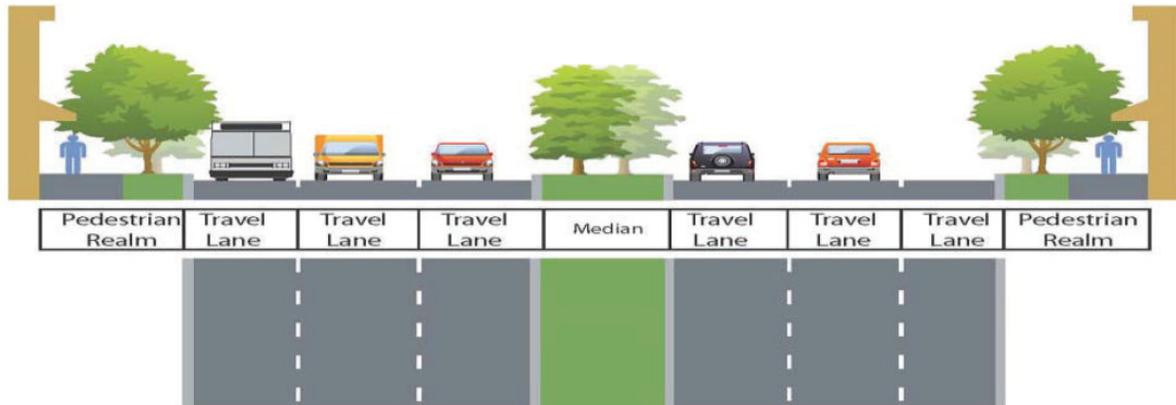




Residential Boulevard Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 x 11 = 22	TW	2 x 8 = 16	N/A	20	2 x 11 = 22	5,000 - 15,000
	2 x 13 = 26	TW	N/A	2 x 6 = 12	20	2 x 11 = 22	5,000 - 15,000
	2 x 10 = 20	TW	N/A	N/A	16	4 x 11 = 44	15,000 - 30,000
100	2 x 10 = 20	2 x 12.5 = 25	2 x 8 = 16	N/A	17	2 x 11 = 22	5,000 - 15,000
	2 x 10 = 20	2 x 14.5 = 29	N/A	2 x 6 = 12	17	2 x 11 = 22	5,000 - 15,000
	2 x 12 = 24	TW	N/A	2 x 6 = 12	20	4 x 11 = 44	15,000 - 30,000
	2 x 11.5 = 23	TW	2 x 8 = 16	N/A	17	4 x 11 = 44	15,000 - 30,000
120	2 x 10 = 20	2 x 12 = 24	N/A	2 x 6 = 12	20	4 x 11 = 44	15,000 - 30,000
	2 x 12.5 = 25	TW	N/A	2 x 6 = 12	17	6 x 11 = 66	15,000 - 50,000
	2 x 10 = 20	2 x 7 = 14	N/A	N/A	20	6 x 11 = 66	15,000 - 50,000

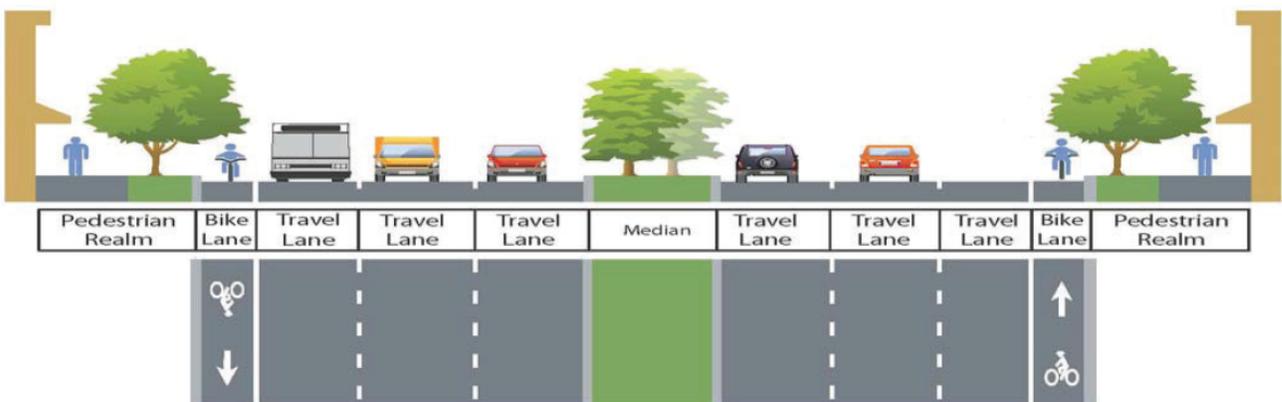
* - Minimum Sidewalk width is a minimum of 5 feet.

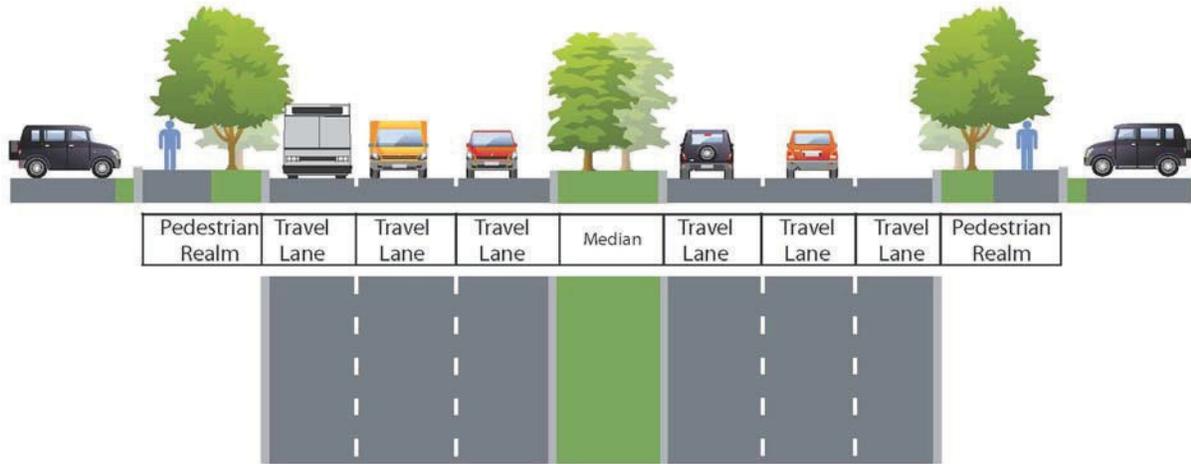




Transit Boulevard Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
100	2 x 13 = 26	TW	N/A	N/A	28	2 x 12 = 24 2 x 11 = 22	15,000 - 30,000
110	2 x 18 = 36	TW	N/A	N/A	28	2 x 12 = 24 2 x 11 = 22	15,000 - 30,000
120	2 x 17 = 34	TW	N/A	2 x 6 = 12	28	2 x 12 = 24 2 x 11 = 22	15,000 - 30,000
	2 x 16 = 32	TW	N/A	N/A	20	2 x 12 = 24 4 x 11 = 44	15,000 - 40,000

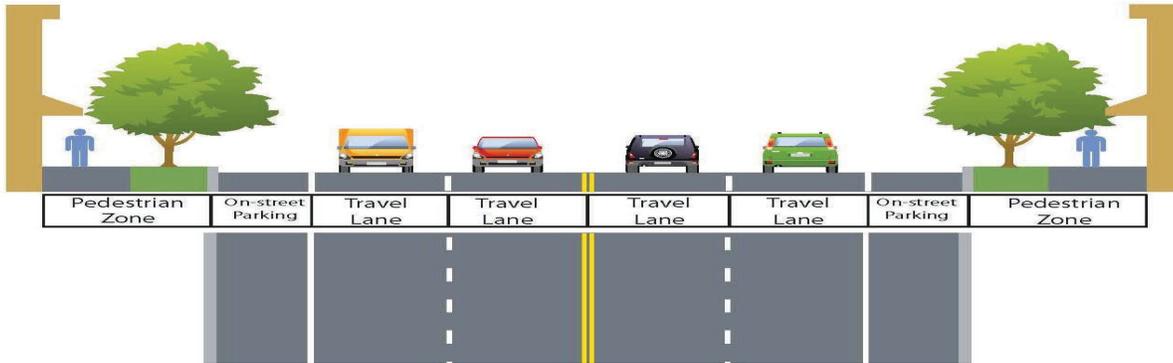
* - Minimum Sidewalk width is a minimum of 6 feet.





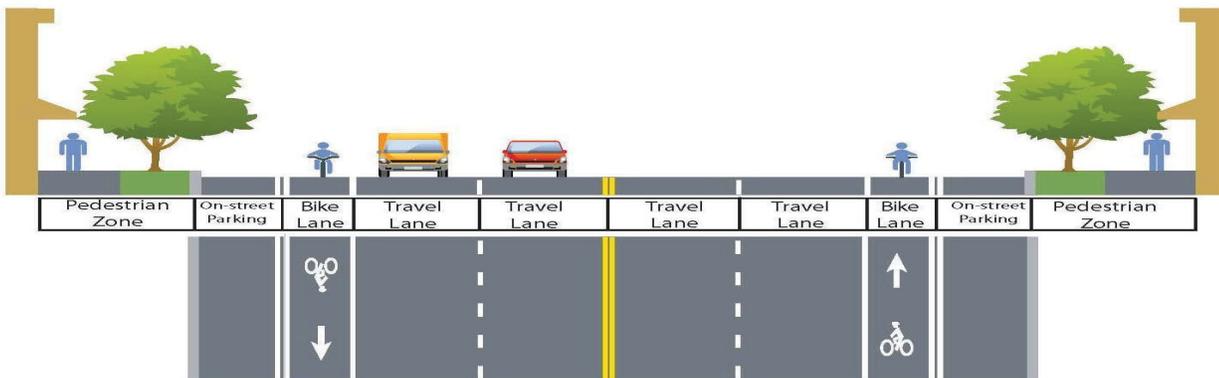
Industrial Boulevard Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
100	2 X 17 = 34	TW	N/A	N/A	20	2 X 11 = 22 2 X 12 = 24	15,000 - 30,000
	2 X 11 = 22	TW	N/A	2 X 6 = 12	20	2 X 11 = 22 2 X 12 = 24	15,000 - 30,000
	2 X 10.5 = 21	TW	2 X 8 = 16	N/A	17	2 X 11 = 22 2 X 12 = 24	15,000 - 30,000
120	2 X 16 = 32	TW	N/A	N/A	20	4 X 11 = 44 2 X 12 = 24	15,000 - 50,000
	2 X 10 = 20	TW	N/A	2 X 6 = 12	20	4 X 11 = 44 2 X 12 = 24	15,000 - 50,000

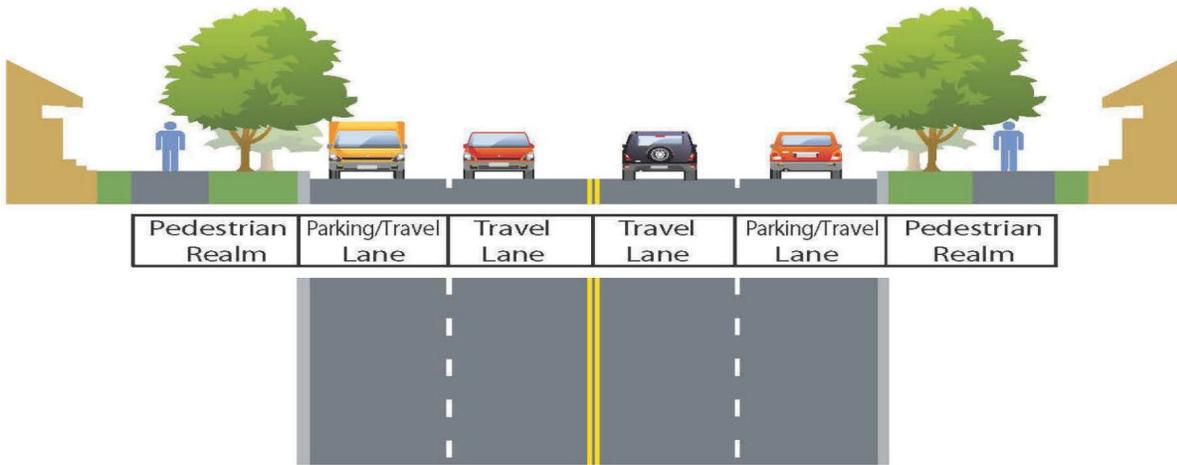
* - Minimum Sidewalk width is a minimum of 5 feet.



Commercial/Mixed Use Avenue Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 X 21 = 42	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,500 - 15,000
	2 X 11 = 22	TW	2 X 18 = 36**	N/A	N/A	2 X 11 = 22	1,500 - 15,000
	2 X 15 = 30	TW	2 X 8 = 16	2 X 6 = 12	N/A	2 X 11 = 22	1,500 - 15,000
	2 X 15 = 30	TW	N/A	2 X 6 = 12	N/A	2 X 11 = 22	1,500 - 15,000
	2 X 22 = 44	TW	N/A	N/A	N/A	2 X 11 = 22 + 1 X 14 (CLTL***) = 36	5,000 - 20,000
	2 X 14 = 28	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22 + 1 X 14 (CLTL***) = 36	5,000 - 20,000
	2 X 16 = 32	TW	N/A	2 X 6 = 12	N/A	2 X 11 = 22 + 1 X 14 (CLTL***) = 36	5,000 - 20,000
	2 X 18 = 36	TW	N/A	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 X 10 = 20	TW	2 X 8 = 16	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 X 12 = 24	TW	N/A	2 X 6 = 12	N/A	4 x 11 = 44	10,000 - 30,000
100	2 x 28 = 56	TW	N/A	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 22 = 44	TW	N/A	2 x 6 = 12	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 20 = 40	TW	2 x 8 = 16	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 10 = 20	TW	2 x 18 = 36**	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 14 = 28	TW	2 x 8 = 16	2 x 6 = 12	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 17 = 34	TW	N/A	N/A	N/A	6 x 11 = 66	10,000 - 30,000
	2 x 11 = 22	TW	N/A	2 x 6 = 12	N/A	6 x 11 = 66	10,000 - 30,000

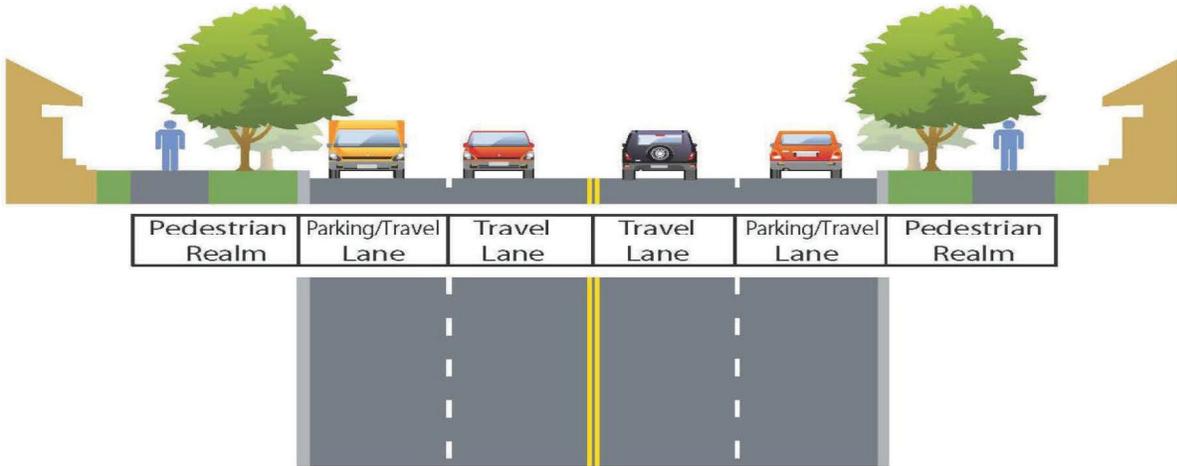
* - Minimum Sidewalk width is a minimum of 5 feet.
 ** - Angle Parking. Requires permission from the City Traffic Engineer.
 *** - CLTL = Continuous Two-Way Left Turn Lane.





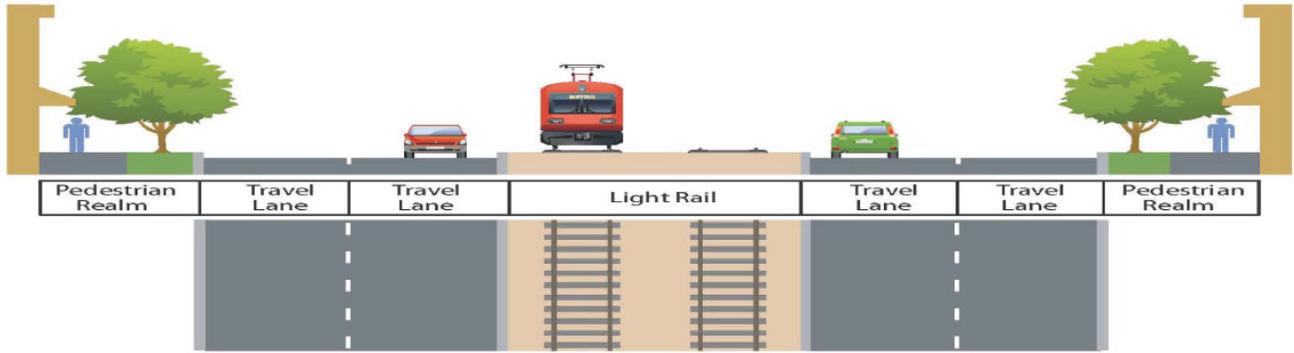
Transit Avenue Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 x 11 = 22	2 x 10 = 20	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 8 = 16	2 x 7 = 14	2 X 8 = 16	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	2 x 10 = 20	N/A	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 X 8 = 16	2 x 10 = 20	N/A	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 10 = 20	TW	2 X 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 12 = 24	TW	N/A	2 X 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000
100	2 x 18 = 36	2 x 10 = 20	N/A	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 12 = 24	2 x 10 = 20	N/A	2 x 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 10 = 20	2 x 10 = 20	2 x 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 14 = 28	TW	2 x 8 = 16	2 x 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000

* - Minimum Sidewalk width is a minimum of 5 feet.



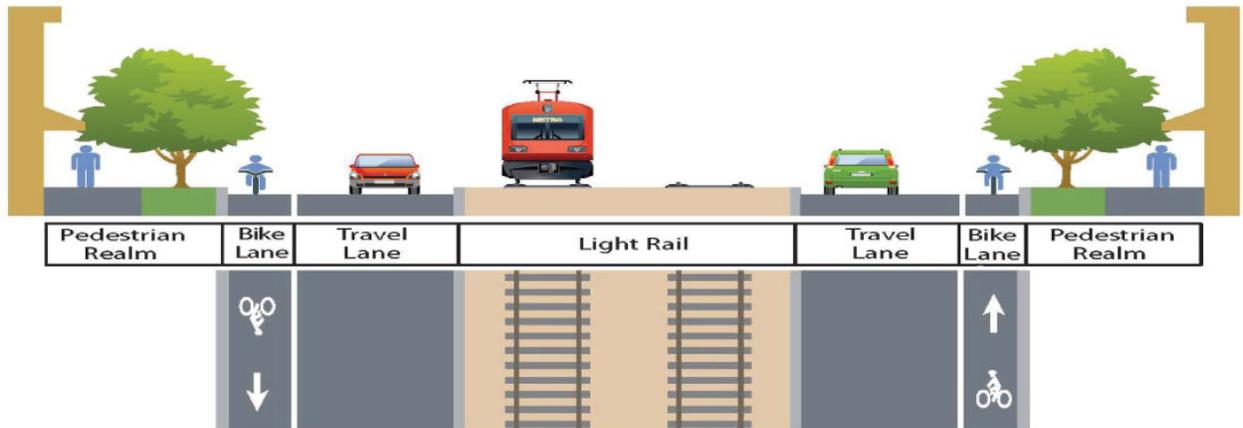
Residential Avenue Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 x 11 = 22	2 x 10 = 20	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 8 = 16	2 x 7 = 14	2 X 8 = 16	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	2 x 10 = 20	N/A	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 X 8 = 16	2 x 10 = 20	N/A	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 10 = 20	TW	2 X 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 12 = 24	TW	N/A	2 X 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000
100	2 x 18 = 36	2 x 10 = 20	N/A	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 12 = 24	2 x 10 = 20	N/A	2 x 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 10 = 20	2 x 10 = 20	2 x 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 14 = 28	TW	2 x 8 = 16	2 x 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000

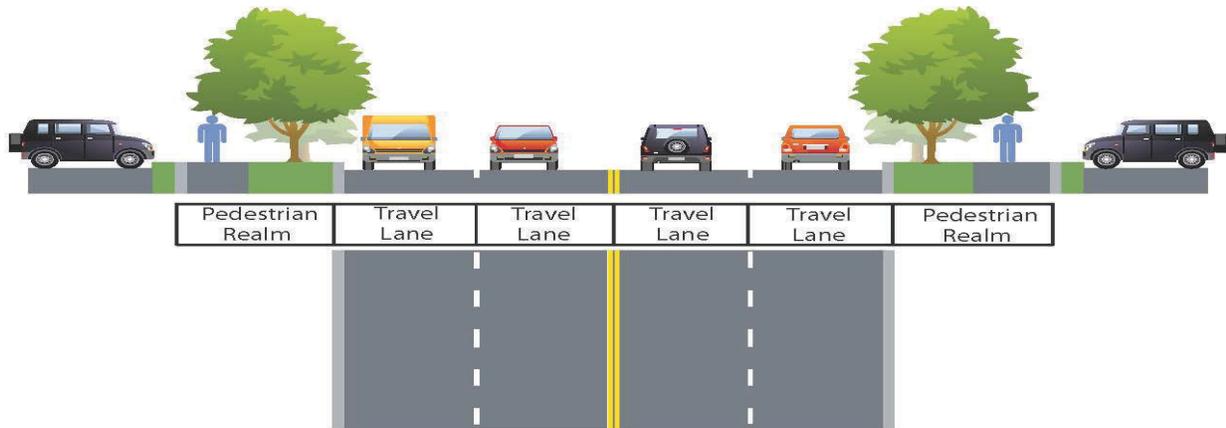
* - Minimum Sidewalk width is a minimum of 5 feet.



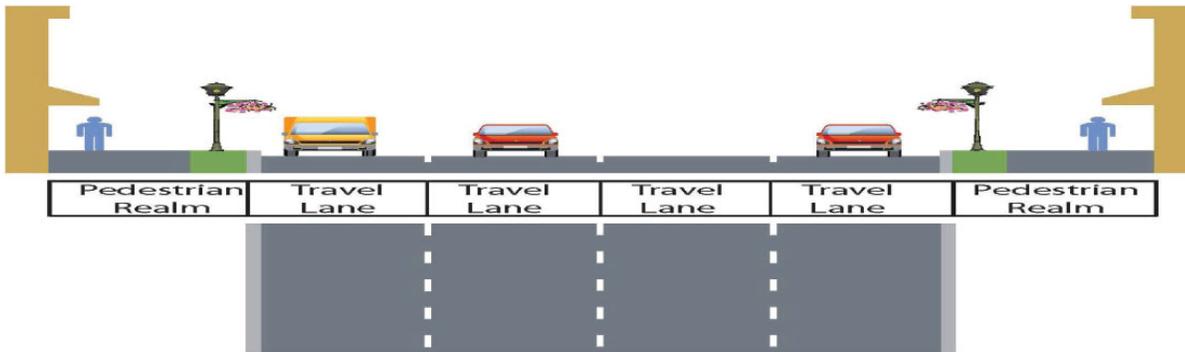
Transit Avenue Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Transit Lanes** (ft)	Lane Widths (feet)	ADT (vpd)
100	2 x 27 = 54	TW	N/A	N/A	2 x 12 = 24	2 x 11 = 22	1,000 - 15,000
	2 x 21 = 42	TW	N/A	2 x 6 = 12	2 x 12 = 24	2 x 11 = 22	1,000 - 15,000
	2 x 19 = 38	TW	2 x 8 = 16	N/A	2 x 12 = 24	2 x 11 = 22	1,000 - 15,000
	2 x 13 = 26	TW	2 x 8 = 16	2 x 6 = 12	2 x 12 = 24	2 x 11 = 22	1,000 - 15,000

* - Minimum Sidewalk width is a minimum of 6 feet.
** - Transit lanes may be transit vehicle only or allow for mixed traffic.



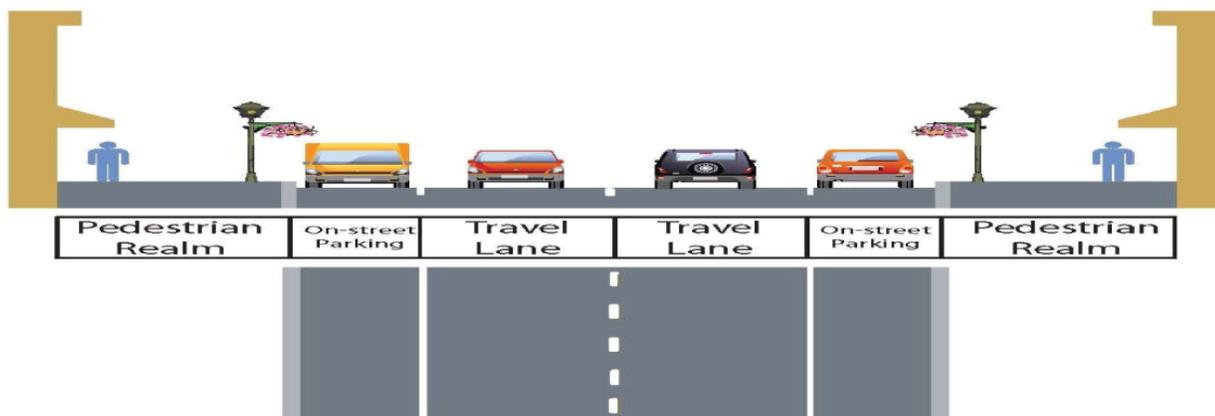


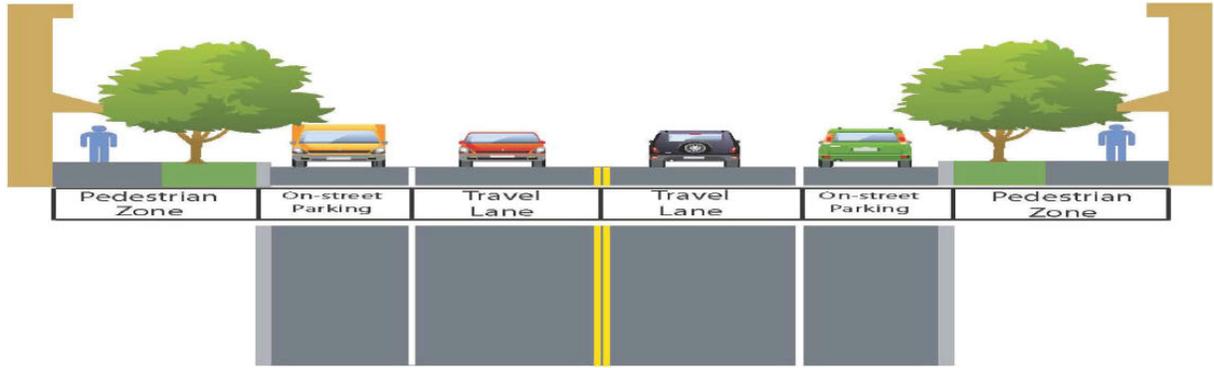
Industrial Avenue Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 x 10 = 20	2 x 7 = 14	N/A	N/A	N/A	2 x 11 + 2 x 12 = 46	10,000 - 25,000
	2 x 11 = 22	2 x 10 = 20	N/A	N/A	N/A	1 x 14(CLTL**) + 2 x 12 = 38	5,000 - 15,000
90	2 x 18 = 36	TW	2 x 8 = 16	N/A	N/A	1 x 14(CLTL**) + 2 x 12 = 38	5,000 - 15,000
100	2 x 10 = 20	2 x 10 = 20	N/A	N/A	N/A	1x14(CLTL**) + 2x12+2x11= 60	10,000 - 35,000
* - Minimum Sidewalk width is a minimum of 5 feet.							
** - CLTL = Continuous Two-Way Left Turn Lane.							



Commercial/Mixed Use Couplet Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
60	2 x 11 = 22	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	TW	N/A	1 x 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
80	2 x 21 = 42	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 23 = 46	TW	N/A	1 X 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 15 = 30	TW	2 x 8 = 16	1 X 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 15.5 = 31	TW	2 X 8 = 16	N/A	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 17.5 = 35	TW	N/A	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 9.5 = 19	TW	2 X 8 = 16	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 10 = 20	TW	2 X 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 12 = 24	TW	N/A	1 X 6 = 6	N/A	4 x 11 = 44	5,000 - 20,000
100	2 x 12.5 = 25	TW	N/A	N/A	N/A	5 x 11 = 55	10,000 - 25,000
	2 x 14 = 28	TW	2 x 8 = 16	1 x 6 = 6	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 14.5 = 29	TW	2 x 8 = 16	N/A	N/A	5 x 11 = 55	10,000 - 25,000
	2 x 15.5 = 31	TW	N/A	1 x 6 = 6	N/A	5 x 11 = 55	10,000 - 25,000
	2 x 9.5 = 19	TW	2 x 8 = 16	1 x 5 = 5	N/A	5 x 11 = 55	10,000 - 25,000

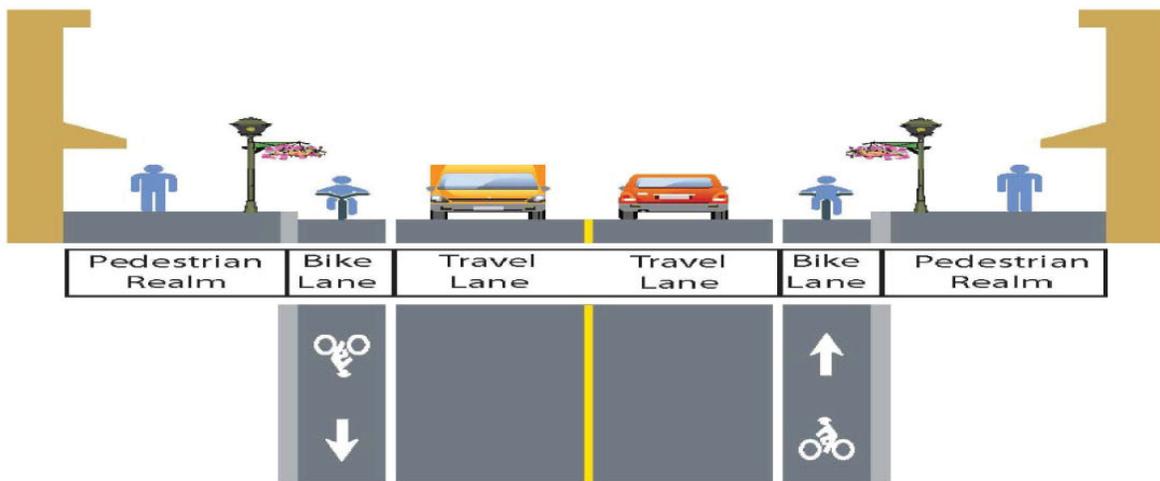
* - Minimum Sidewalk width is a minimum of 5 feet.

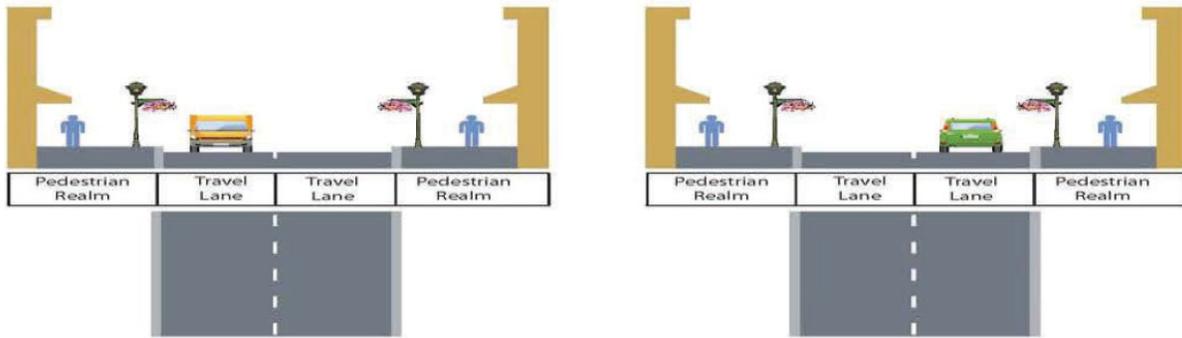




Commercial/Mixed Use Street Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
	2 x 19 = 38	TW	N/A	N/A	N/A	2 X 11 = 22	1,000 - 10,000
60	2 x 11 = 22	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	TW	N/A	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 X 12 = 24	TW	N/A	N/A	N/A	2 X 11 = 22 + 1 X 14 (CLTL**) = 36	1,000 - 15,000

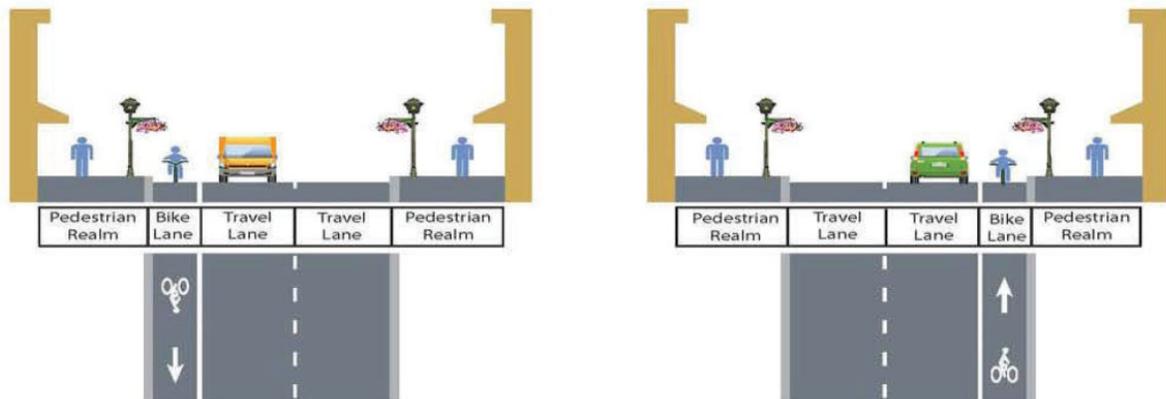
* - Minimum Sidewalk width is a minimum of 5 feet.
** - CLTL = Continuous Two-Way Left Turn Lane.

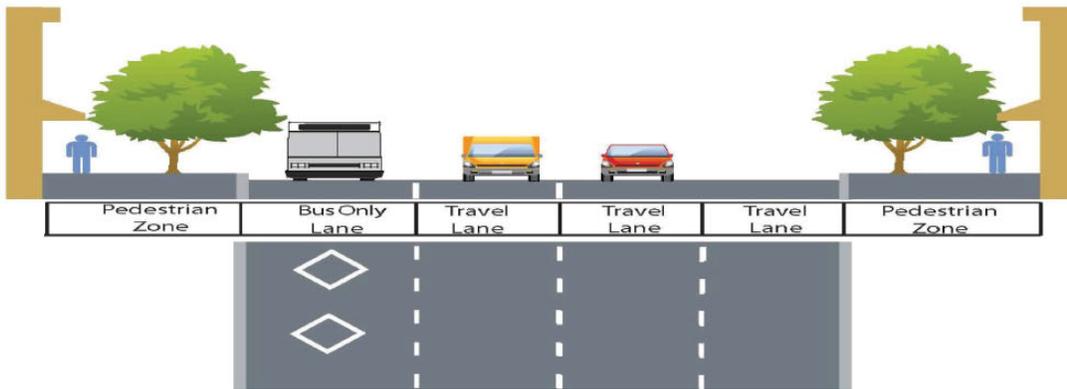




Residential Couplet Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
60	2 x 11 = 22	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	TW	N/A	1 x 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
80	2 x 10 = 20	2 x 10.5 = 21	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 10 = 20	2 x 13 = 26	N/A	1 X 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 15 = 30	TW	2 x 8 = 16	1 X 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 15.5 = 31	TW	2 X 8 = 16	N/A	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 17.5 = 35	TW	N/A	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 9.5 = 19	TW	2 X 8 = 16	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 9.5 = 19	TW	2 X 8 = 16	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000

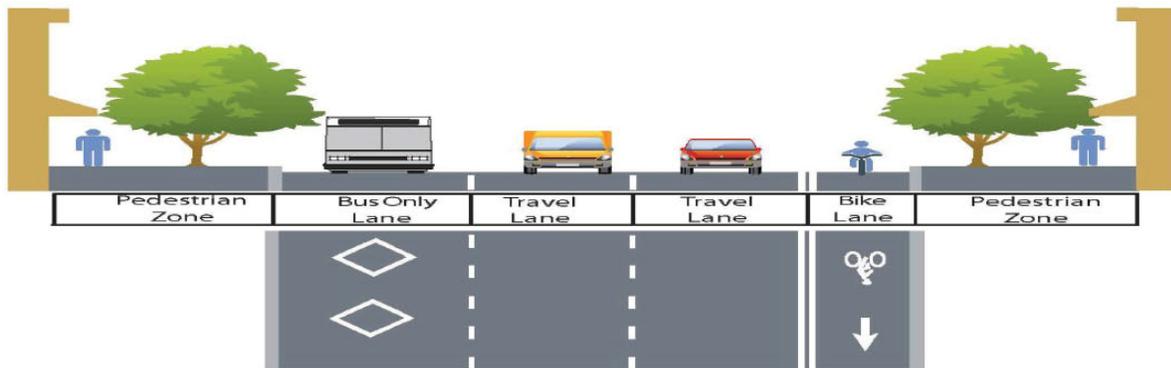
* - Minimum Sidewalk width is a minimum of 5 feet.

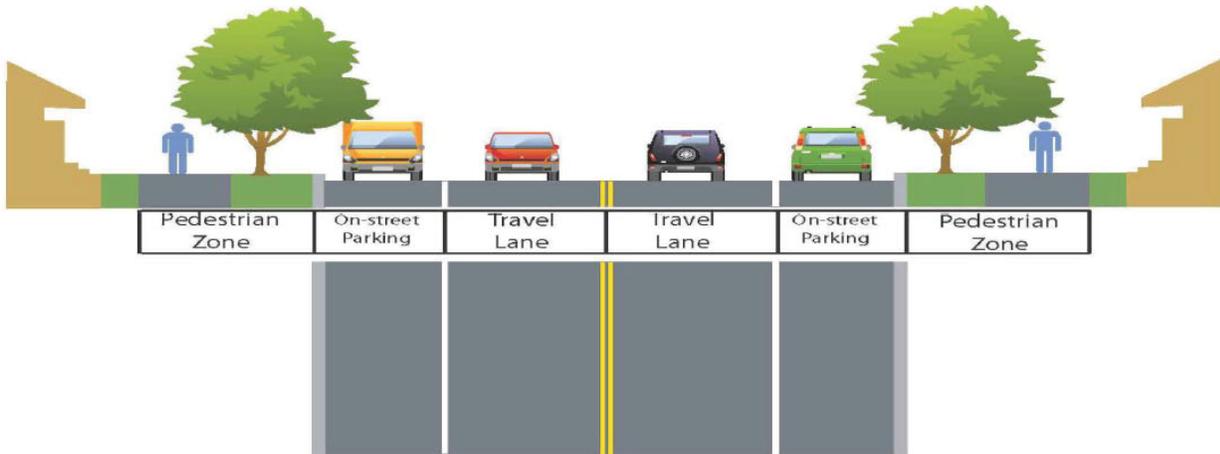




Transit Couplet Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
60	2 x 10.5 = 21	TW	2 X 8 = 16	N/A	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
	2 x 12.5 = 25	TW	N/A	1 x 6 = 6	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
80	2 x 20.5 = 41	TW	2 X 8 = 16	N/A	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
	2 x 22.5 = 45	TW	N/A	1 X 6 = 6	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
	2 x 14.5 = 29	TW	2 x 8 = 16	1 X 6 = 6	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
	2 x 15 = 30	TW	2 X 8 = 16	N/A	N/A	1 x 12 + 2 x 11 = 34	1,500 - 15,000
	2 x 17 = 34	TW	N/A	1 X 6 = 6	N/A	1 x 12 + 2 x 11 = 34	1,500 - 15,000
	2 X 11.5 = 23	TW	N/A	1 X 6 = 6	N/A	1 x 12 + 3 x 11 = 45	5,000 - 20,000
	2 x 12 = 24	TW	N/A	N/A	N/A	5 x 11 = 55	10,000 - 25,000
100	2 x 13.5 = 27	TW	2 x 8 = 16	1 x 6 = 6	N/A	1 x 12 + 3 x 11 = 45	5,000 - 20,000
	2 x 14 = 28	TW	2 x 8 = 16	N/A	N/A	1 x 12 + 4 x 11 = 56	10,000 - 25,000

* - Minimum Sidewalk width is a minimum of 6 feet.

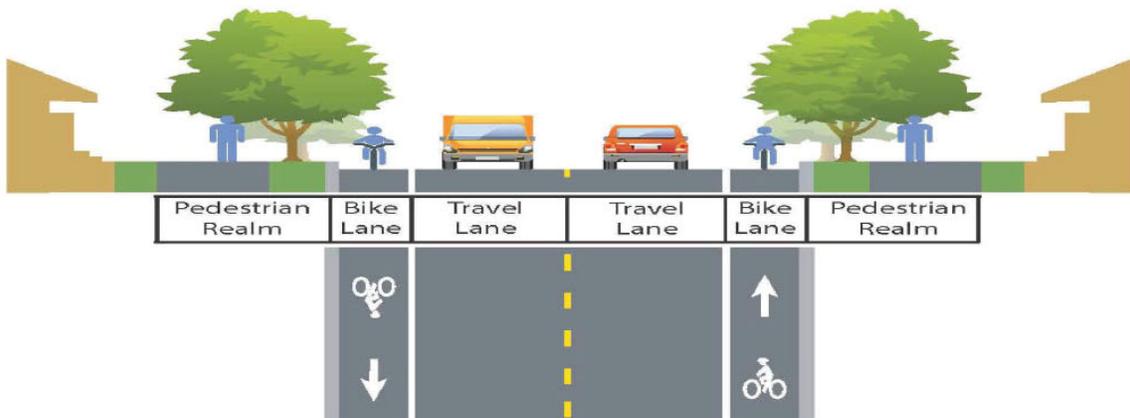




Residential Street Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
50	2 x 12 = 24	TW	N/A **	N/A	N/A	2 x 13 = 26	500 - 5,000
60	2 x 9 = 18	2 x 8 = 16	N/A **	N/A	N/A	2 X 13 = 26	500 - 5,000
	2 x 11 = 22	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	500 - 5,000
	2 x 13 = 26	TW	N/A	2 X 6 = 12	N/A	2 X 11 = 22	500 - 5,000

* - Minimum Sidewalk width is a minimum of 5 feet.

** - While space is not specifically set aside for parking, parking may be allowed on a 26' wide residential street.



APPENDIX 2

CHAPTER 10

GEOMETRIC DESIGN GUIDELINES FOR SUBDIVISION STREETS

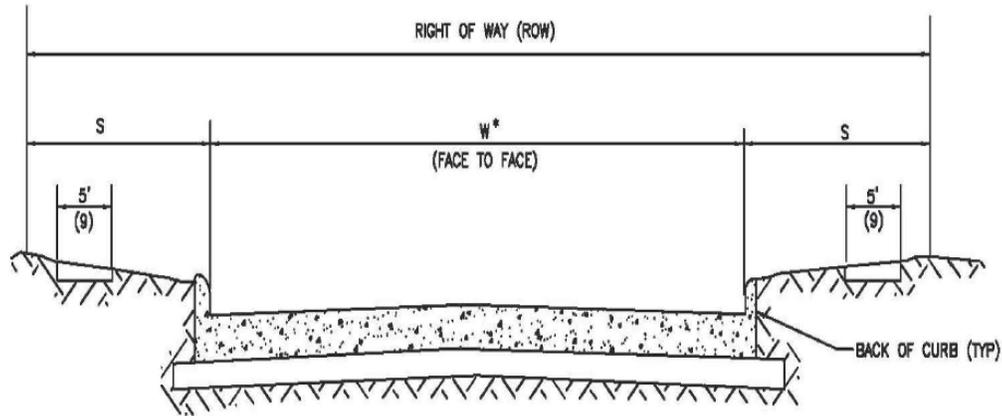
CITY OF HOUSTON

The Guidelines presented in Appendix 2 include the most often requested information regarding geometric design of subdivision streets. All streets within the City of Houston shall be considered for special design features such as presented in Appendix 1 of this Chapter. Design features not shown in Appendix 2 should be considered special design features. Agency Engineer as used throughout this section shall mean City Engineer for the City of Houston. The average daily traffic volumes presented in Standard Drawing No. 10.06-01, 02, and Appendix 1 Figure 1 are provided as general guidelines to define each street classification. Professional engineering experience and judgment should be used in application of the guidelines to a specific project.

It is advisable to consult with the City and review the most recent edition of the following publications to determine adequate thoroughfare requirements and special design features.

- Recommended Guidelines for Subdivision Streets, Institute of Transportation Engineers
- Guidelines for Urban Major Streets Design, Institute of Transportation Engineers
- A Policy on Geometric Design of Highways and Streets, American Associations of State Highway and Transportation Officials (AASHTO)
- Texas Manual on Uniform Traffic Control Devices (TMUTCD), Texas Department of Transportation
- Urban Street Design Guide, National Association of City Transportation Officials (NACTO)
- Urban Bikeway Design Guide, National Association of City Transportation Officials

**THE GUIDELINES IN THIS APPENDIX ARE HEREBY APPROVED AS BASIC REQUIREMENTS FOR FUTURE STREET PLANNING AND DEVELOPMENT
JULY 2015**



UNDIVIDED STREET DIMENSIONS (FEET)

	LOCAL STREET SINGLE FAMILY RESIDENTIAL (SFR)					Commercial/Mixed Use		
	STANDARD DENSITY LOT(2)	HIGH DENSITY LOT(3)	RESIDENTIAL MAIN WITHOUT MEDIAN		WITH MEDIAN	APT/ COMM (+)(θ)	MAJOR (θ)(θ)	
ADT(1)	250-350	350-750	≥1500		≥1500	500-5000	1500-5000	
ROW	50	60	55	60	60	60	70	80
W*	26	26	32	36	36	40	44	44
S	12	17	14	12	12	10	13	18

SEE DWG. NO 10.06-02

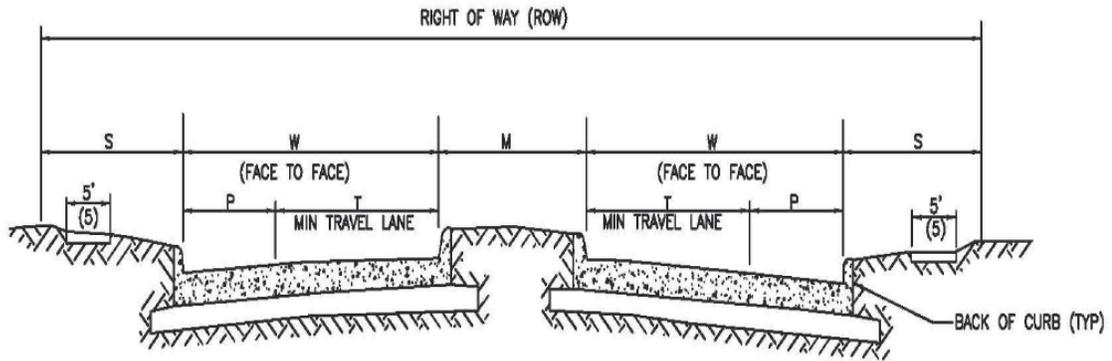
W* WIDTH (W) INCLUDES ON STREET PARALLEL PARKING WHERE APPROVED BY AGENCY ENGINEER.

NOTES:

1. AVERAGE DAILY TRAFFIC. REFER TO GUIDELINES PRESENTED IN SECTION 10.06A.
2. STANDARD LOT: LOT WIDTHS 40 FEET OR GREATER.
3. HIGH DENSITY LOT: LOT WIDTHS LESS THAN 40 FEET.
4. APARTMENT/COMMERCIAL: ANY PROPERTY USE OTHER THAN SINGLE FAMILY, RESIDENTIAL.
5. MAJOR: ANY ROADWAY DESIGNATED AS A MAJOR COLLECTOR ON THE MAJOR THOROUGHFARE AND FREEWAY PLAN.
6. ABUTTING LAND USE: AS REQUIRED BY CHAPTER 42 OF THE CODE OF ORDINANCES.
7. WIDTH (W) DOES NOT INCLUDE WIDTH FOR BICYCLE LANES. REFER TO APPENDIX 1 FOR MINIMUM REQUIREMENTS. REQUIRES APPROVAL OF CITY ENGINEER.
8. REQUESTS FOR ALTERNATIVE STREET CROSS SECTION SHALL BE SUBMITTED TO CITY ENGINEER FOR REVIEW.
9. 5' MINIMUM WIDTH IS CITY OF HOUSTON STANDARD FOR NON-TRANSIT CORRIDOR STREETS. MINIMUM WIDTH FOR TRANSIT CORRIDOR STREETS IS 6'.

<p>CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING</p>	
<p>UNDIVIDED STREET TYPICAL CROSS SECTION</p>	
<p>(NOT TO SCALE)</p>	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: JUN-16-2015	DWG NO: 10.06-01

PREVIOUS NO: CH 10 FIG 02



DIVIDED STREET DIMENSIONS (FEET)

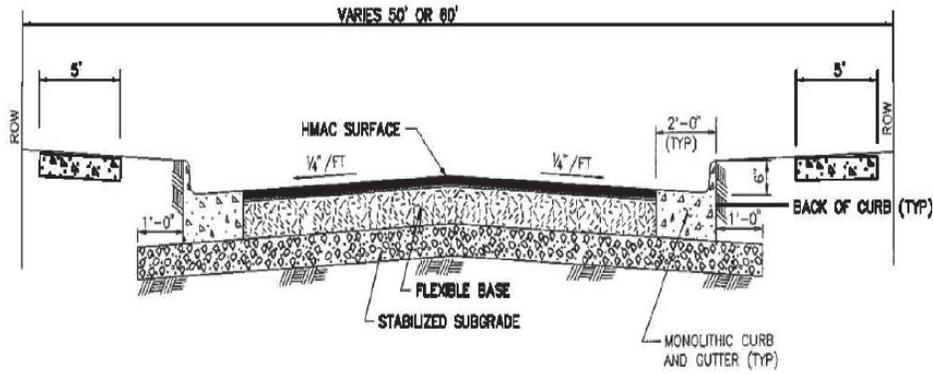
	LOCAL STREET SINGLE FAMILY RESIDENTIAL		MAJOR STREET				
	RESIDENTIAL MAIN		PRINCIPAL THOROUGHFARE, THOROUGHFARE, MAJOR COLLECTOR, COLLECTOR (4)				
	STD SW	CENTER SW(3)					
ADT (1)	>1500	>1500	5000-50,000				
ROW (2)	70	80	80	90	100	100	>100
W	20	20	22	22	22	33	SEE AGENCY ENGINEER
M	8	16	17	20	20	16	
S	11	12	9.5	13	18	9	
T	11	11	22	22	22	33	
P	9	9	0	0	0	0	

NOTES:

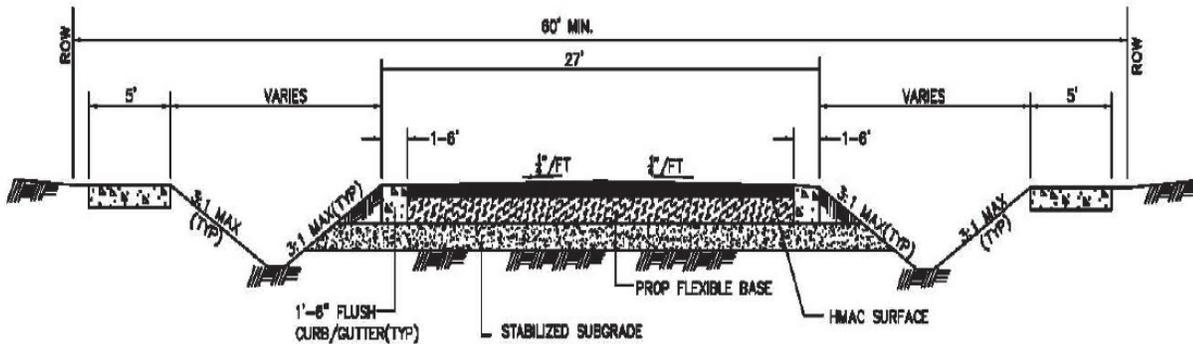
1. AVERAGE DAILY TRAFFIC. REFER TO GUIDELINES PRESENTED IN SECTION 10.06A.
2. ANY RIGHT-OF-WAY DIMENSIONS DIFFERENT FROM THOSE SHOWN SHALL REQUIRE SPECIAL GEOMETRIC DESIGN AS DETERMINED BY CITY ENGINEER.
3. SIDEWALK LOCATED IN CENTER MEDIAN ONLY (MIN. SW WIDTH-6')
4. REFER TO CITY MOBILITY PLAN (INFRASTRUCTURE DESIGN MANUAL, CHAPTER 10, APPENDIX 1) FOR OPTIONAL DESIGNS TO SERVE SPECIAL MOBILITY NEEDS, PEDESTRIAN NEEDS, BICYCLE LANES, OR OTHER REQUIREMENTS. APPROVAL BY CITY ENGINEER REQUIRED.
5. 5' MINIMUM WIDTH IS CITY OF HOUSTON STANDARD FOR NON-TRANSIT CORRIDOR STREETS. MINIMUM WIDTH FOR TRANSIT CORRIDOR STREETS IS 6'.

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
DIVIDED STREET TYPICAL CROSS SECTION (NOT TO SCALE)	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: JUN-16-2015	DWG NO: 10.06-02

PREVIOUS NO: CH 10 FIG 01



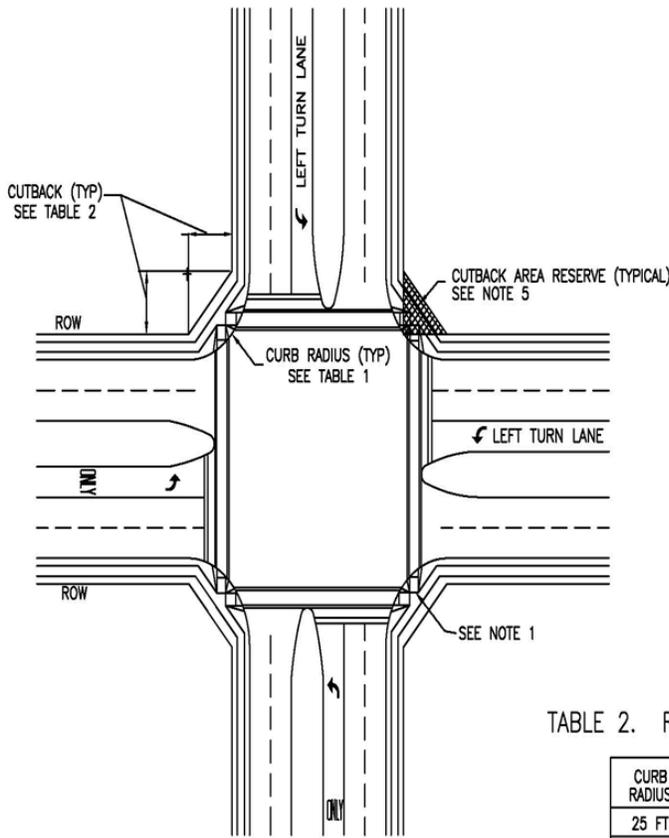
FLEXIBLE BASE PAVEMENT - CURB & GUTTER SECTION



FLEXIBLE BASE PAVEMENT - DITCH SECTION

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
FLEXIBLE PAVEMENT TYPICAL CROSS SECTIONS	
(NOT TO SCALE)	
APPROVED BY: <hr/> CITY ENGINEER	APPROVED BY: <hr/> DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: JUN-18-2015	DWG NO: 10.06-03

PREVIOUS NO: 02741-01



NOTES:

1. ALL RAMPS AND SIDEWALKS SHALL BE CONSTRUCTED IN ACCORDANCE WITH AGENCY STANDARD DETAILS, AMERICANS WITH DISABILITIES ACT (ADA) AND TEXAS DEPARTMENT OF LICENSING AND REGULATION (TDLR) REQUIREMENTS.
2. ALL PAVEMENT MARKINGS SHALL BE INSTALLED IN ACCORDANCE WITH AGENCY STANDARD DETAILS AND THE TEXAS MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (TMUTCD).
3. CURB RADII SHALL BE DESIGNED TO ACCOMMODATE THE TYPE OF VEHICLES ANTICIPATED TO USE THE FACILITY, (I.E., BUSES, TRUCKS, ETC.) IN ACCORDANCE WITH AASHTO CRITERIA FOR TURNING VEHICLES.
4. WHERE ALTERNATIVE MINIMUM CURB RADIUS IS REQUIRED TO SERVE MOBILITY, PEDESTRIAN, OR OTHER SPECIAL NEEDS, SUBMIT DESIGN LAYOUT AND SUPPORTING CALCULATIONS TO AGENCY ENGINEER FOR REVIEW AND APPROVAL.
5. THE CORNER CUT AREA IS RESERVED FOR TRAFFIC SIGNAL EQUIPMENT AND SHALL BE KEPT FREE OF SIGNS, POLES, PRIVATE UTILITY CONTROL CABINETS AND ALL SURFACE ENCROACHMENTS WHICH COULD PREVENT THE FUTURE INSTALLATION OF SUCH EQUIPMENT WITHIN THE AREA.
6. WHERE A NEW ROADWAY OR DRIVEWAY IS CONNECTING TO AN EXISTING SIGNALIZED INTERSECTION, THE APPLICANT SHALL BE RESPONSIBLE FOR DESIGNING AND CONSTRUCTING THE NECESSARY MODIFICATIONS TO THE EXISTING SIGNAL SYSTEM AS REQUIRED BY AGENCY ENGINEER.

TABLE 2. ROW CUTBACK REQUIREMENTS

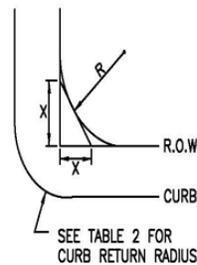
CURB RADIUS	MINIMUM ROW CUTBACK "X"	ROW RADIUS R(1)
25 FT	15 FT X 15 FT	25 FT
30 FT	20 FT X 20 FT	30 FT
35 FT	25 FT X 25 FT	35 FT
40 FT	30 FT X 30 FT	40 FT
45 FT	35 FT X 35 FT	45 FT

1. BASED ON RIGHT ANGLE INTERSECTION (*)
2. FOR ACUTE ANGLE USE 25 FOOT RADIUS (MIN)
3. FOR OBTUSE ANGLE, USE ROW RADIUS R. (*)

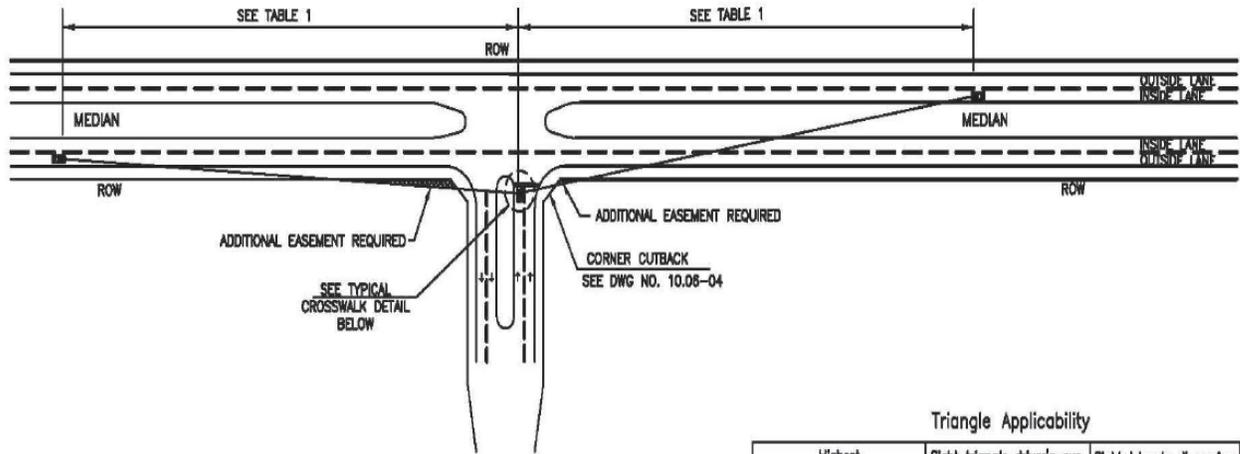
TABLE 1. INTERSECTION CURB RADIUS REQUIREMENTS

INTERSECTION TYPE	MINIMUM CURB RADIUS BY INTERSECTION ANGLE		
	90 DEG.	85-90 DEG.	80-85 DEG.
LOCAL - LOCAL	25 FT	30 FT	30 FT
COLLECTOR - LOCAL	25 FT	30 FT	30 FT
COLLECTOR - COLLECTOR	30 FT	30 FT	35 FT
THOROUGHFARE - COLLECTOR	30 FT	35 FT	35 FT
THOROUGHFARE - THOROUGHFARE	35 FT	35 FT	40 FT
PRINCIPAL THOROUGHFARE - THOROUGHFARE	35 FT	35 FT	40 FT
PRIN. THOROUGHFARE - PRIN. THOROUGHFARE	35 FT	35 FT	40 FT

(*) SKETCH SHOWS ACCEPTABLE PROPERTY CUTBACK DISTANCE X AS SUBSTITUTE FOR ROW RADIUS R.

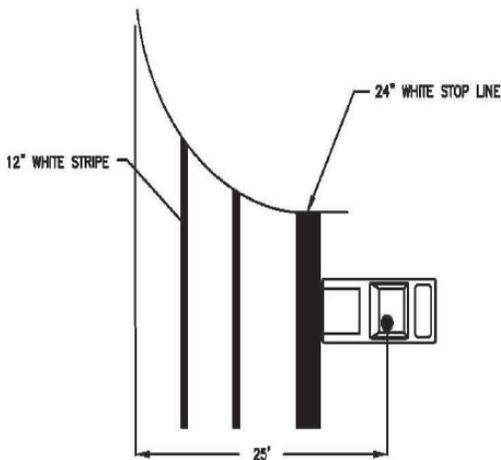


CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
INTERSECTION GEOMETRY CURB RADIUS AND CORNER CUTBACK (NOT TO SCALE)	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: FEB-13-2015	DWG NO: 10.06-04



Triangle Applicability

Highest classification/greater width street	Sight triangle driver's eye setback distance	Sight triangle dimension on uncontrolled street (Design speed)
High speed major thoroughfare (>45 mph posted speed)	25 ft	sight-specific analysis
Major thoroughfare or major collection on MTP map	25 ft	500 ft (45 mph)
Divided streets and 41 ft. streets	15 ft	500 ft (45 mph)
28ft local and collector streets	15 ft	390 ft (35 mph)
28ft., single family residential frontage on both streets (1)	N/A	N/A

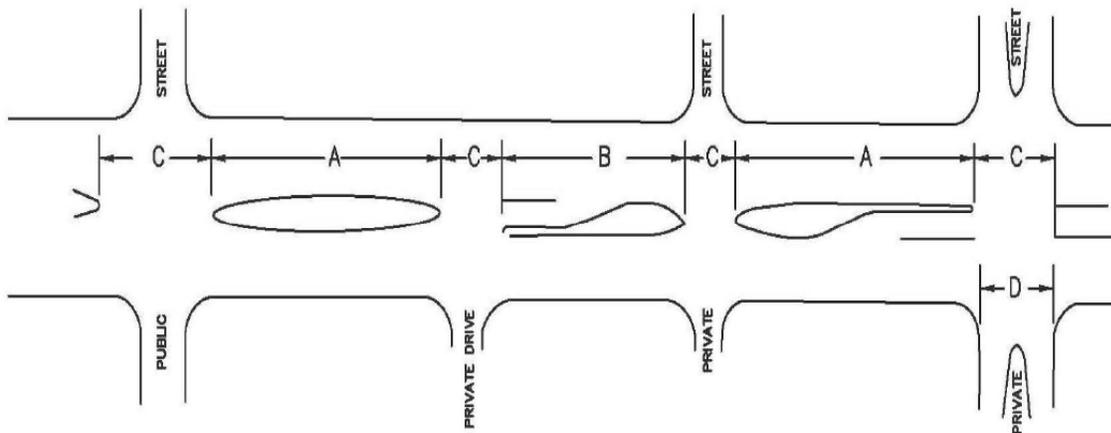


NOTES:

1. INTERSECTION SIGHT DISTANCES ARE BASED ON AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) CRITERIA FOR INTERSECTION SIGHT DISTANCE.
2. IF ROADWAY BEING CROSSED OR TURNED ONTO HAS A MEDIAN THAT IS 25 FEET OR GREATER, SIGHT DISTANCE TO THE RIGHT MAY BE MEASURED FROM THE POINT AT WHICH A VEHICLE CAN SAFELY STOP WITHIN THE MEDIAN OPENING.

TYPICAL CROSSWALK AND STOP BAR PLACEMENT DETAIL

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
INTERSECTION GEOMETRY SIGHT DISTANCE TRIANGLE (NOT TO SCALE)	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: FEB-13-2015	DWG NO: 10.06-05



TYPICAL MEDIAN OPENING C

MINIMUM MEDIAN LENGTH A, B

MEDIAN INTERRUPTION FOR	(1)	
	1 LTB	2 LTB
PRIVATE DRIVE	52.5'	60'
UNDIVIDED STREET <40' 44'	52.5' (1) 55' (2)	60' 80'
DIVIDED STREET ALL	D+22'	D+22'

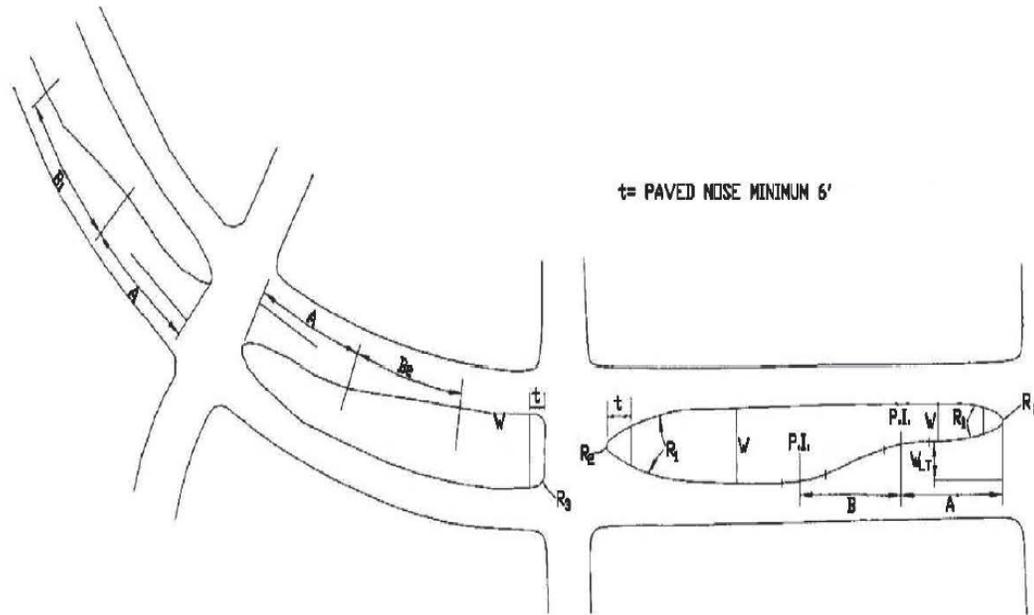
IF DIVIDED STREET IS:	INTERSECTING STREET CLASSIFICATION			
	MAJOR STREET/ THOROUGHFARE (A)	COLLECTOR STREET (A)	LOCAL STREET (A)	PRIVATE STREET OR DRIVEWAY (B)
PRINCIPAL THOROUGHFARE/ THOROUGHFARE	660'	660'	660'	660'
COLLECTOR STREET	660'	500'	350'	350'
LOCAL STREET	300'	300'	300'	300'

NOTE:

- (1) LTB—LEFT TURN BAY.
- (2) DISTANCE FROM CENTERLINE OF OPENING TO MEDIAN NOSE WITH LEFT TURN LANE IS 30' FOR RIGHT ANGLE INTERSECTIONS. FOR INTERSECTIONS OTHER THAN 90°, APPLY DESIGN VEHICLE TURNING TEMPLATE TO DETERMINE DIMENSION TO MEDIAN NOSE CUT OFF.

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
MEDIAN DESIGN MEDIAN LENGTH AND OPENING (NOT TO SCALE)	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: FEB-13-2015	DWG NO: 10.06-06

PREVIOUS NO: CH 10 FIG 3



MEDIAN DIMENSIONS

W	R ₁	R ₂	R ₃
≤10'	NONE	W/2	NONE
>10' < 40'	90	2'	NONE
>40'	NONE	NONE	15

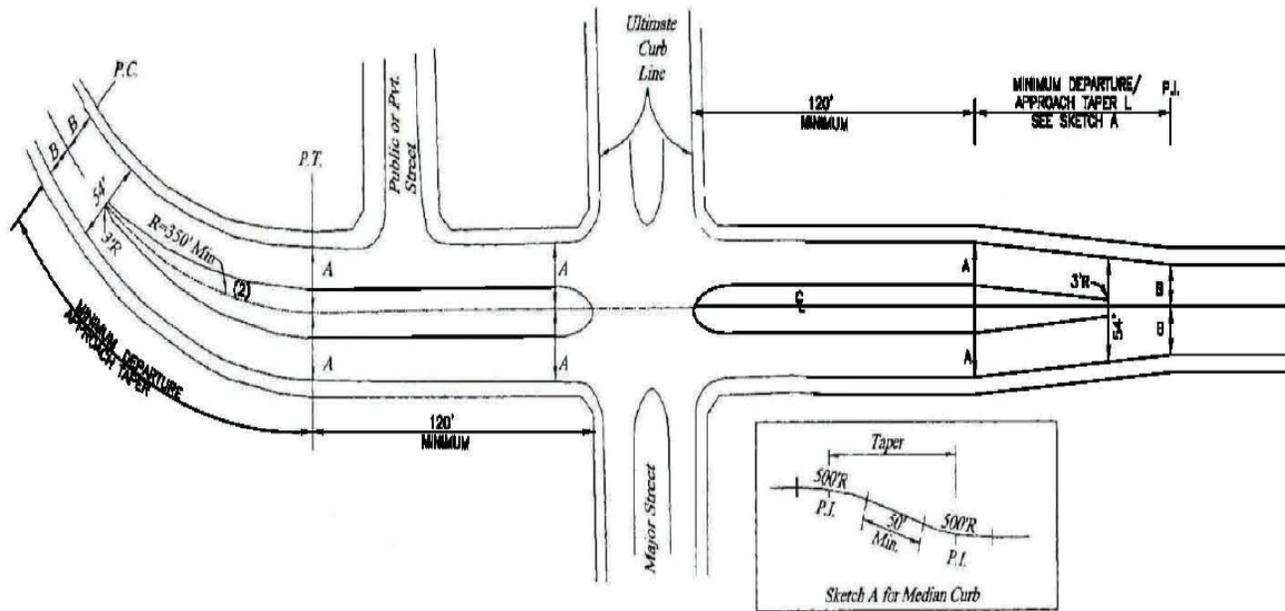
LEFT TURN BAY DIMENSIONS

INTERSECTION TYPE	DESIGN SPEED	A	B	R _(rc)	W _(LT)
THOROUGHFARE - THOROUGHFARE	< 35 MPH	150'	86'	150'	11'
	> 35 MPH	150'	118'	300'	11'
THOROUGH - MAJOR COLLECTOR	< 35 MPH	150'	86'	150'	11'
	> 35 MPH	150'	118'	300'	11'
ALL OTHER	< 35 MPH	100'	86'	150'	11'
	> 35 MPH	100'	118'	300'	11'

R_(rc) - REVERSE CURVE RADIUS

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
MEDIAN DESIGN MEDIAN NOSE AND LEFT TURN BAY (NOT TO SCALE)	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: FEB-13-2015	DWG NO: 10.06-07

PREVIOUS NO: CH 10 FIG 4

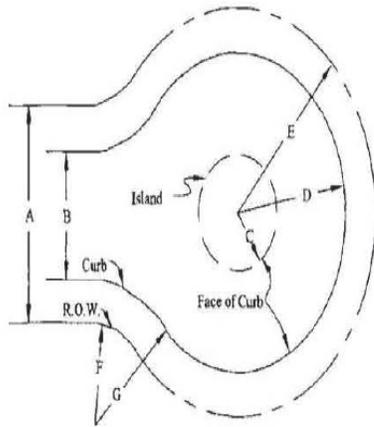


NOTES:

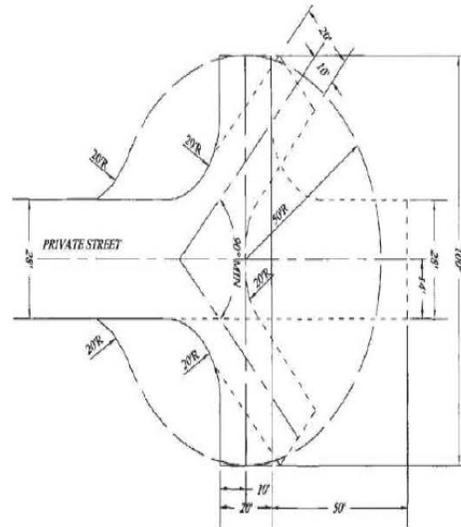
- 1) APPROACH AND DEPARTURE TAPER REQUIREMENT:
 $L = \frac{WS^2}{80}$ WHERE L = LENGTH IN FEET
 S = SPEED IN M.P.H.
 W = LATERAL OFFSET IN FEET
 S = 30 M.P.H. MINIMUM DESIGN SPEED FOR SUBDIVISION STREETS
 W = A-B
- 2) 350' MINIMUM CENTERLINE RADIUS FOR HORIZONTAL CURVE WITH APPROACH OR DEPARTURE TAPERS.
- 3) REFER TO STANDARD DRAWING NO. 10.06-06 FOR MEDIAN LENGTHS AND MEDIAN OPENING.

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
MEDIAN DESIGN ROADWAY TAPERS FOR MEDIAN DESIGN (LOCAL STREETS) (NOT TO SCALE)	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: JUN-16-2015	DWG NO: 10.06-08

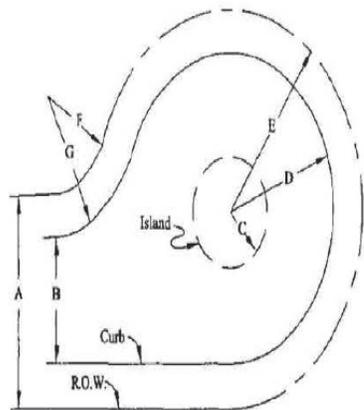
PREVIOUS NO: CH 10 FIG 7



SYMMETRICAL CUL-DE-SAC



TYPE 2 PERMANENT ACCESS EASEMENT (PAE)



OFFSET CUL-DE-SAC

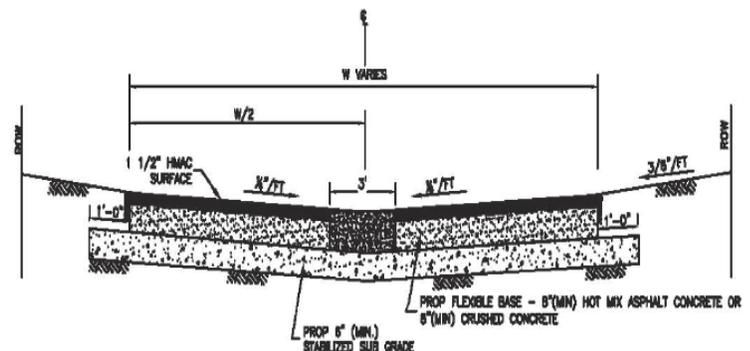
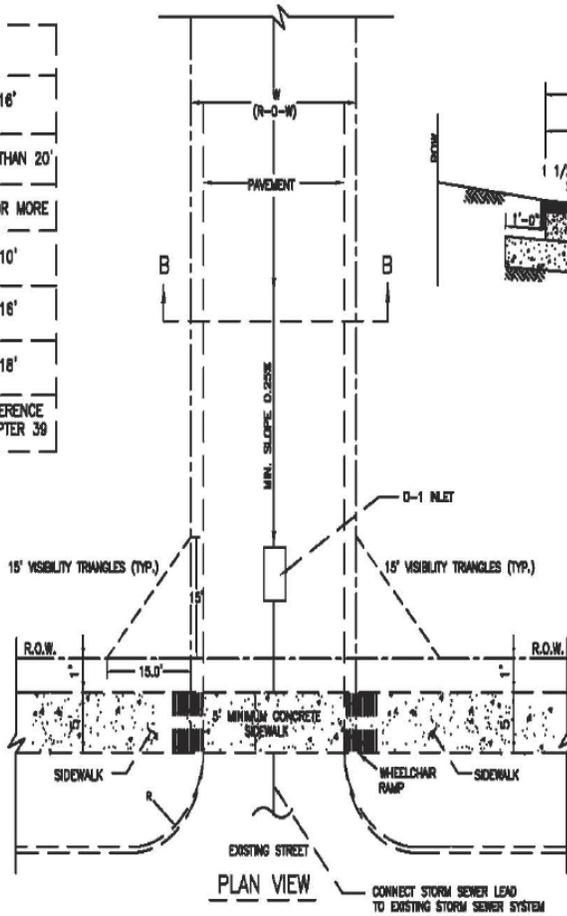
CUL-DE-SAC		
ABUTTING LAND USE		
	SINGLE FAMILY	ALL OTHER
A	ALL WIDTHS	60'
B	ALL WIDTHS	40'
C (MIN)	0	0
C (MAX)	20'	15'
D	42'	50'
E	50'	60'
F	25'	25'
G	35'	35'

CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
STREET TERMINATION CUL-DE-SAC AND TYPE 2 PAE (NOT TO SCALE)	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: FEB-13-2015	DWG NO: 10.06-09

PREVIOUS NO: CH 10 FIG 6

PUBLIC USE ALLEYWAY		
MINIMUM RIGHT-OF-WAY WIDTH IS:		16'
	ONE-WAY TRAFFIC	LESS THAN 20'
	TWO-WAY TRAFFIC	20' OR MORE
MINIMUM PAVING WIDTH IS:	ONE-WAY TRAFFIC	10'
	TWO-WAY TRAFFIC (residential)	18'
	TWO-WAY TRAFFIC (commercial)	18'
	ELIGIBLE FOR SOLID WASTE SERVICE	REFERENCE CHAPTER 39

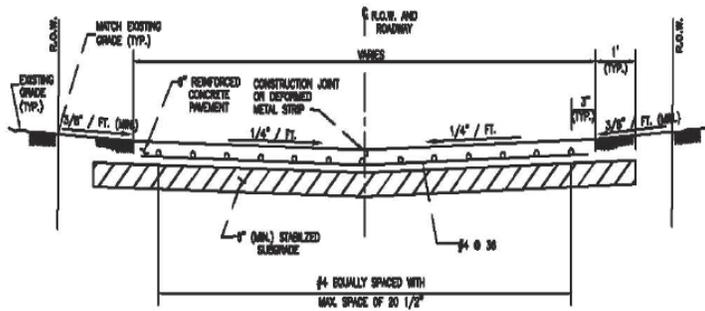
MINIMUM CURB RADIUS (R)	
RESIDENTIAL	15'
COMMERCIAL	25'
ELIGIBLE FOR SOLID WASTE SERVICE	25'



SECTION
FLEXIBLE BASE PAVEMENT-GUTTER SECTION

NOTES:

1. PROPOSED ALLEY PAVEMENT DESIGN MUST BE SUBMITTED BY A TEXAS P.E. FOR ENGINEERING REVIEW
2. POROUS PAVEMENTS ARE ALLOWED IN RESIDENTIAL ALLEYS BUT NOT COMMERCIAL
3. ALLEY DRAINAGE MUST COMPLY WITH CHAPTER 9 OF THE COH INFRASTRUCTURE DESIGN MANUAL
4. REFER TO ORDINANCE CHAPTER 39 FOR MINIMUM REQUIREMENTS FOR ELIGIBILITY FOR SOLID WASTE SERVICE
5. ACCEPTED BY CITY FOR MAINTENANCE. REFERENCE CHAPTER 40 CODE OF ORDINANCES
6. ALLEY DRAINAGE SHALL COMPLY WITH CHAPTER 9 OF THE INFRASTRUCTURE DESIGN MANUAL
7. ALLEY SHALL NOT CONNECT TO PRINCIPAL THOROUGHFARE OR THOROUGHFARE.



SECTION B-B
CONCRETE PAVEMENT

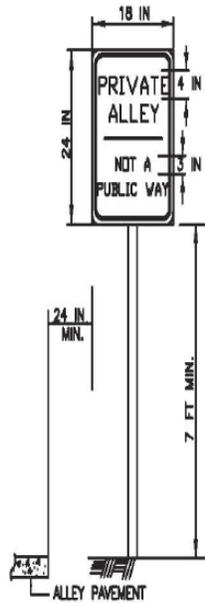
CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

PUBLIC USE ALLEY
(NOT APPLICABLE IN ETJ OF CITY)

(NOT TO SCALE)

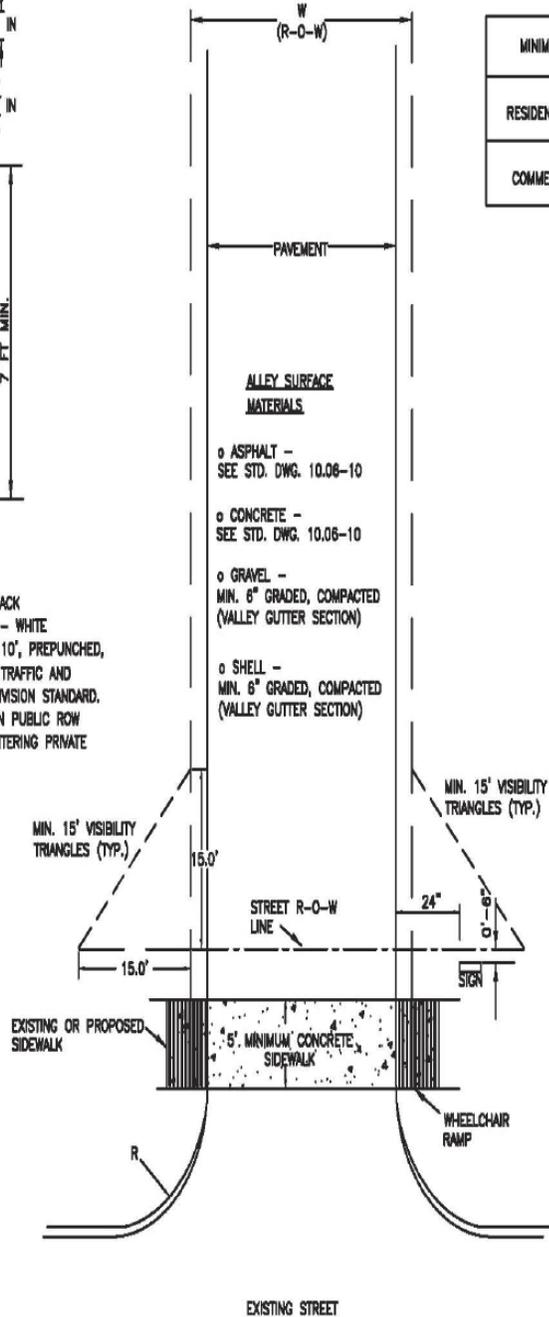
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: FEB-13-2015	DWG NO: 10.06-10

PREVIOUS NO: CH 10 FIG 9



NOTES:

1. FONT-GOTHIC C, BLACK
2. SIGN BACKGROUND - WHITE
3. POST - 2 3/8" X 10', PREPUNCHED, CITY OF HOUSTON TRAFFIC AND TRANSPORTATION DIVISION STANDARD.
4. SIGN LOCATION - IN PUBLIC ROW FACING TRAFFIC ENTERING PRIVATE ALLEY.



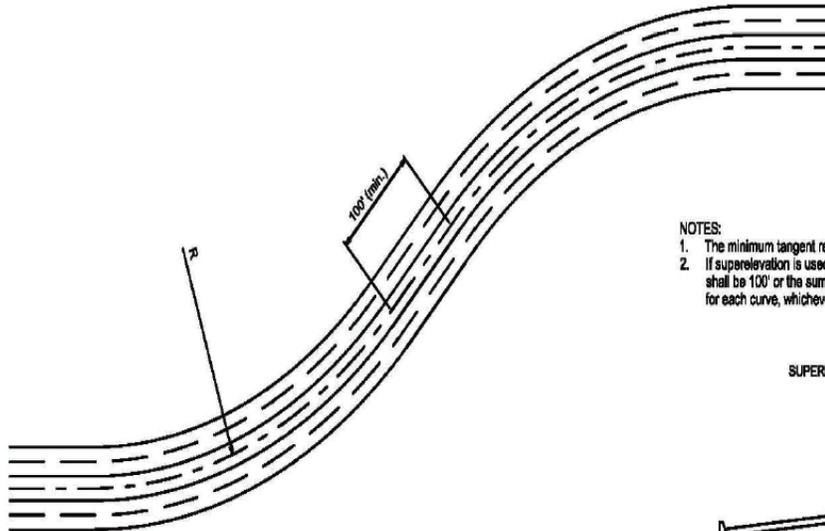
MINIMUM CURB RADIUS (R)	
RESIDENTIAL	15'
COMMERCIAL	25'

PRIVATE USE ALLEYWAY (LOW TRAFFIC)		
MINIMUM RIGHT-OF-WAY WIDTH IS:		12'
	ONE-WAY TRAFFIC	LESS THAN 20'
	TWO-WAY TRAFFIC	20' OR MORE
MINIMUM PAVING WIDTH IS:	ONE-WAY TRAFFIC	10'
	TWO-WAY TRAFFIC	18'

NOTES:

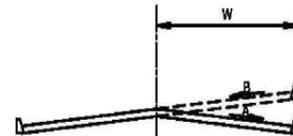
- 1) MAINTENANCE OF THE ALLEY IS THE RESPONSIBILITY OF THE ADJUTING PROPERTY OWNER(S)
- 2) CITY DOES NOT PATROL THE ALLEY OR ENFORCE PARKING REGULATIONS
- 3) CONSTRUCTION AND MAINTENANCE OF STORM WATER DRAINAGE FACILITIES ARE THE RESPONSIBILITY OF THE ADJUTING PROPERTY OWNERS
- 4) PROPOSED ALLEY PAVEMENT DESIGN MUST BE SUBMITTED BY A TEXAS P.E. FOR ENGINEERING REVIEW
- 5) POROUS PAVEMENTS ARE ALLOWED IN RESIDENTIAL ALLEY BUT NOT COMMERCIAL
- 6) ALLEY DRAINAGE SHALL COMPLY WITH CHAPTER 9 OF THE INFRASTRUCTURE DESIGN MANUAL
- 7) ALLEY SHALL NOT CONNECT TO PRINCIPAL THOROUGHFARE OR THOROUGHFARE

<p>CITY OF HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING</p>	
<p>PRIVATE USE ALLEY (NOT APPLICABLE IN ETJ OF CITY) (NOT TO SCALE)</p>	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF DATE: FEB-13-2015	DWG NO: 10.06-11



- NOTES:
1. The minimum tangent required between curves shall be 100'.
 2. If superelevation is used, the minimum tangent between curves shall be 100' or the sum of the required superelevation runout for each curve, whichever is greater.

SUPERELEVATION RUNOUT

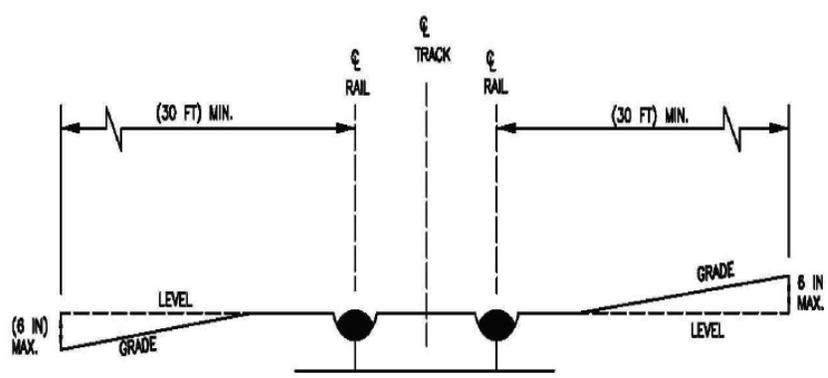
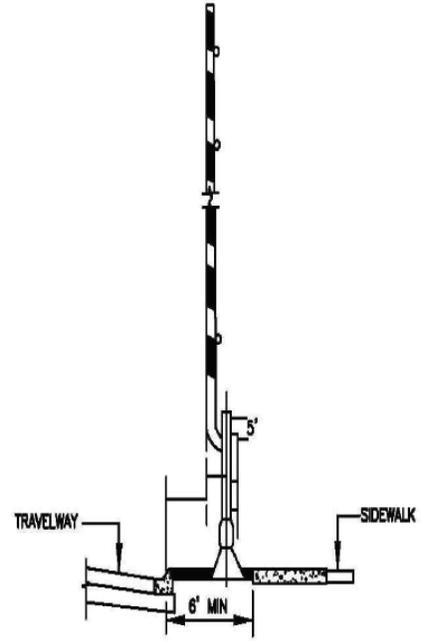
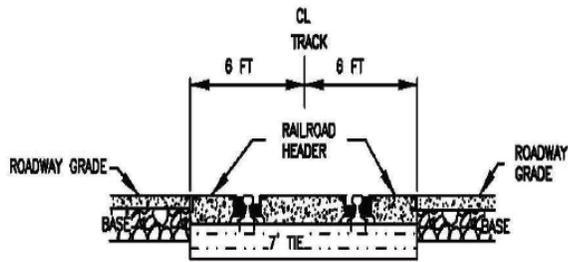


L = SUPERELEVATION RUNOUT LENGTH
 D = ALGEBRAIC DIFFERENCE IN THE CROSS SLOPES
 G = MAXIMUM RELATIVE GRADIENT (AASHTO TABLE 111-14, P177)
 W = WIDTH OF THE ROADWAY TO BE SUPERELEVATED
 D = A% - B%
 L = DW/G

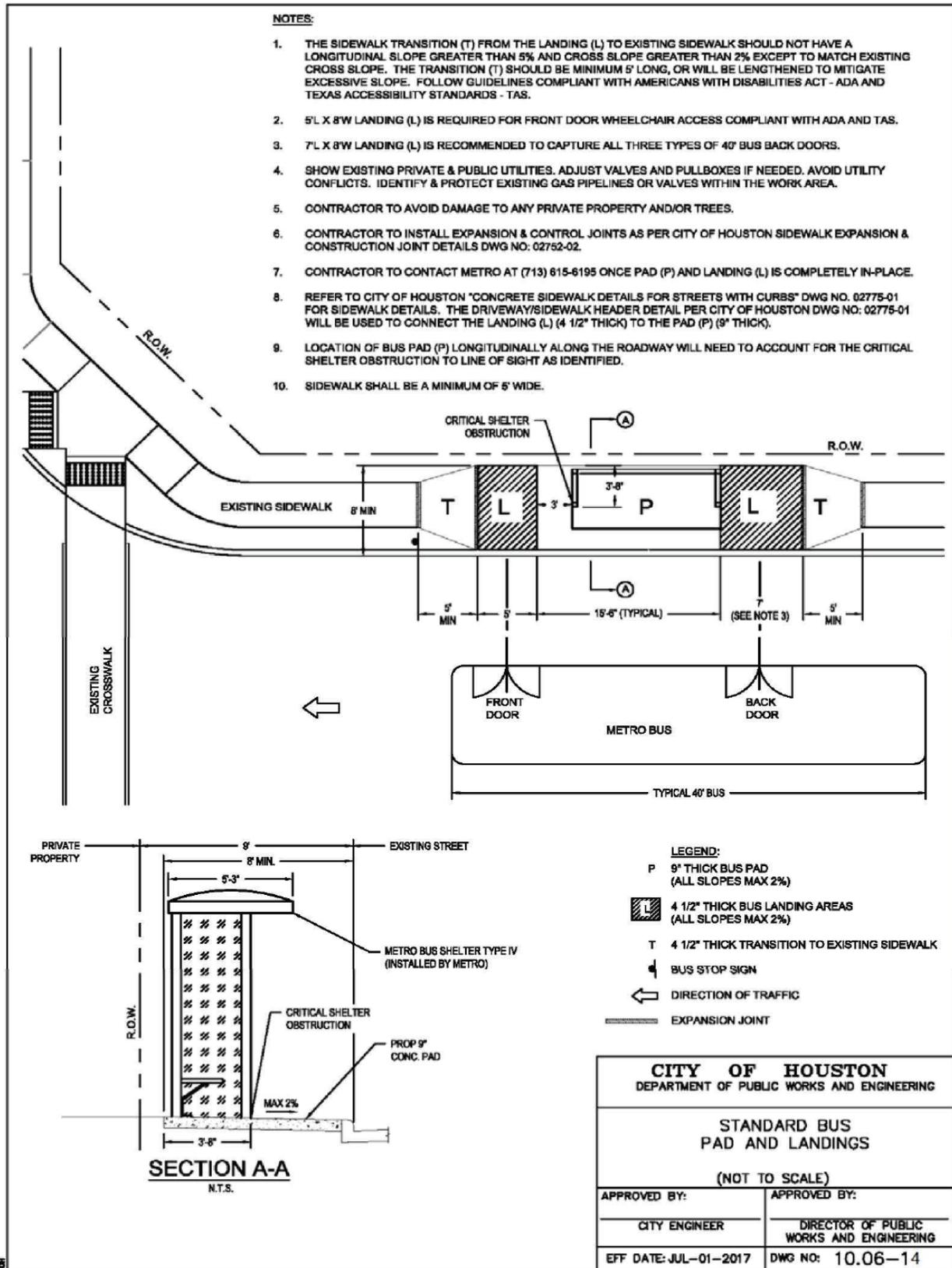
Roadway Classification	City of Houston		Harris County	
	R (minimum)	e (maximum)	R (minimum)	e (maximum)
Thoroughfares & Major Collectors (with superelevation)	500'	4%	N/A	N/A*
Thoroughfares & Major Collectors (without superelevation)	2000'	N/A	2000'	N/A*
Minor Collectors & Local Streets	300'	N/A	300'	N/A*

* - The use of superelevation is not allowed on roadways maintained by Harris County.

CITY OF HOUSTON	
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
SUPERELEVATION	
(NOT TO SCALE)	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF. DATE: JUN-18-2015	DWG. NO: 10.06-12



CITY OF HOUSTON	
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING	
RAILROAD CROSSING	
(NOT TO SCALE)	
APPROVED BY:	APPROVED BY:
CITY ENGINEER	DIRECTOR OF PUBLIC WORKS AND ENGINEERING
EFF. DATE: FEB-13-2015	DWG. NO: 10.06-13



City of Houston

Design Manual

Chapter 11

**GEOTECHNICAL AND ENVIRONMENTAL
REQUIREMENTS**

Chapter 11

GEOTECHNICAL AND ENVIRONMENTAL REQUIREMENTS

11.01 CHAPTER INCLUDES

- A. Section I: Includes minimum Geotechnical Investigation Requirements for projects inside the city limits of Houston and within its extra territorial jurisdiction (ETJ).
- B. Section II: Includes minimum Phase I Environmental Site Assessment (ESA I) and Phase II Environmental Site Assessment (ESA II) Requirements for land involved in the City of Houston real estate transactions, interdepartmental transfers, ETJ, and rights-of-way which will be involved in the construction projects.

11.02 REFERENCES

The latest versions of the following references shall be reviewed in conjunction with this chapter:

- A. The American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures.
- B. The American Society for Testing and Materials (ASTM) standard test methods and environmental site assessments processes.
- C. The City of Houston's Standard Construction Specifications.
- D. The Harris County Flood Control District's (HCFCD) Geotechnical Investigation Guidelines.
- E. The Houston Geological Society (HGS) requirements for conducting fault studies.
- F. Rules and regulations published by the Occupational Safety and Health Administration (OSHA).
- G. Rules and regulations published by the Texas Commission on Environmental Quality (TCEQ).
- H. Rules and regulations published by the Texas Department of Licensing and Regulation (TDLR) including Texas Administrative Code (TAC) Chapter 76 - Water Well Drillers and Water Well Pump Installers.
- I. Rules and regulations published by the Texas Board of Professional Engineers (TBPE).
- J. Geotechnical Manual issued by the Texas Department of Transportation (TxDOT).

- K. The Texas Manual on Uniform Traffic Control Devices (TMUTCD).

11.03 DEFINITIONS

- A. Engineer of Record - Project Civil Design Consultant.
- B. Project Manager - An authorized representative of the City of Houston who manages the project or the Engineer of Record for private development.
- C. Geotechnical Consultant - A consultant who is practicing in the field of Geotechnical Engineering in the State of Texas and has a valid status with the TBPE.
- D. Environmental Consultant - An environmental professional who is meeting the education, training, and experience requirements as set forth in 40 CFR 312.10(b).
- E. Licensed Engineer - An engineer currently licensed to practice engineering in the State of Texas and is in good standing with the TBPE.
- F. Licensed Geoscientist - A geoscientist currently licensed to practice geosciences in the State of Texas and is in good standing with the Texas Board of Professional Geoscientists.

SECTION I

11.04 GEOTECHNICAL REQUIREMENTS

- A. A detailed Geotechnical Investigation (by borings) is required for the completion of the design of the proposed facilities. Subsurface information from the earlier project design activities shall be incorporated if it is sufficient and reliable for the current project as determined by the Project Manager in consultation with the Geotechnical Consultant.
- B. The purpose of the Geotechnical Requirements is to outline the minimum recommended procedures for implementing a uniform approach for the preparation of the Geotechnical Investigation Reports on the City of Houston projects including its ETJ.
- C. The scope of the Geotechnical Investigation may need to be expanded or modified on a case by case basis as determined necessary and appropriate by the Project Manager. It is not the intent of the Geotechnical Requirements to specify methods or scope of Geotechnical Investigation for individual projects, or to supplant the judgment of the Licensed Engineer. No provision in these requirements should be construed to constitute a statute, ordinance, or regulation, unless stipulated elsewhere.
- D. In the event that any part of the Geotechnical Requirements should be found to be in conflict with laws or regulations of competent jurisdiction or ruled to be invalid by a court authority of competent jurisdiction, the remainder of the Geotechnical Requirements shall remain in full force and effect, and the conflicting section or item shall be deleted or revised as required and as determined necessary by the City of Houston.

- E. These Geotechnical Requirements are not applicable when another agency (like the HCFCD) will maintain the facility, or the funding source (like the TxDOT) has specific requirements that must be met in order to receive funding for the project. In which case, another agency's requirements shall be applicable.
- F. Not all of the information in this chapter will be applicable to every project, but the investigative scope should be consistent with the sensitivity of the intended use and the physical constraints of the project.

11.05 ENGINEER OF RECORD'S EFFORTS

- A. The Engineer of Record, at the proposal stage of the project, shall work with the Geotechnical Consultant to develop the proper scope of the project.
- B. The Engineer of Record shall inform the Geotechnical Consultant for any changes in the project related to Geotechnical Investigation as soon as possible.
- C. The Engineer of Record shall assist the Geotechnical Consultant in obtaining required permits for drilling, if requested by the Geotechnical Consultant.
- D. The Engineer of Record shall provide survey information of the borings (after drilling) to the Geotechnical Consultant to be used in the Geotechnical Investigation Report.
- E. The Engineer of Record shall provide a base map using engineering scale (showing the alignments and/or structures) of the project to the Geotechnical Consultant that can be used as a Plan of Borings.
- F. The Engineer of Record shall verify the Geotechnical Investigation performed by the Geotechnical Consultant for the conformance with the Geotechnical Requirements and for conformance with project specific conditions and design requirements.
- G. The Engineer of Record shall review the Geotechnical Investigation Report and attach their review comments with the Geotechnical Investigation Report prior to submittal to the City of Houston.

11.06 GEOTECHNICAL CONSULTANT'S EFFORTS

- A. The Geotechnical Consultant shall confirm with the Engineer of Record that the proper scope of the project is proposed in the proposal.
- B. The Geotechnical Consultant shall include the project description, location, and Key Map Number(s) in the geotechnical proposal. Also, a proposed Plan of Boring(s) may be included in the geotechnical proposal, if available.

- C. The Geotechnical Consultant has a responsibility to obtain the latest information of the project from the Engineer of Record before starting the field investigation. If modifications are required in the original Geotechnical Investigation scope, then the Project Manager shall be contacted by Engineer of Record before commencement of the field investigation.
- D. The planning of field investigation, laboratory testing, engineering analyses, and close supervision of the work shall be performed by a Licensed Engineer of the Geotechnical Consultant who has experience in this type of work.
- E. All Geotechnical Laboratory tests shall be conducted by the Geotechnical Consultant with current accreditation by the American Association of Laboratory Accreditation (A2LA) or any other accreditation agency approved by the City of Houston.
- F. The Geotechnical Consultant is responsible for adhering to all pertinent federal, state, and local regulations and laws throughout the Geotechnical Investigation.

11.07 SITE ACCESS

- A. When the Geotechnical Investigation will be within the public right-of-way and easement, the Geotechnical Consultant shall obtain necessary permits and arrange for access to boring locations from the appropriate governmental agency.
- B. When the Geotechnical Investigation will require entry onto a private property, the Geotechnical Consultant may require assistance from the Engineer of Record in obtaining permission to enter in the private property.
- C. It shall be the ultimate responsibility of the Geotechnical Consultant to ensure necessary permits are obtained before commencement of drilling for the project.

11.08 TRAFFIC CONTROL

- A. The Geotechnical Consultant is responsible for the safety of drilling work area during field operations, including traffic control commensurate with the traffic while working in the street right-of-way.
- B. Traffic control shall be in accordance with the TMUTCD.
- C. Provide a Certified Flagman to control movement of vehicular and pedestrian traffic when field investigation encroaches on public traffic lanes. Provide a Uniformed Peace Officer for work along major thoroughfares and at signalized intersections.

11.09 FAULT INVESTIGATION

- A. As a part of the Geotechnical Investigation, geologic fault maps, aerial photographs, and literature available in Geotechnical Consultant's library shall be reviewed to evaluate the potential for known active faults that may impact the project.

- B. If a review of available existing information suggests that a known fault may impact the project, a Phase I Geological Fault Study shall be performed as defined by the current HGS guidelines.
- C. At a minimum, the Phase I Geological Fault Study shall consist of a detailed literature review, a remote sensing study with examination of historical aerial photographs (including LiDAR and false color infra-red imagery), a study of subsurface geologic structure maps, topographic maps, and a detailed field reconnaissance.
- D. If the project is part of a larger tract for which a Phase I, II, or III Geological Fault Study is available, the results of the study on the larger tract may satisfy this requirement. In this circumstance, the necessity of a Phase I Geological Fault Study shall be decided by the Project Manager.
- E. The Phase I Geologic Fault Study may also be conducted on areas where no faults appear in published literature and maps but when there is evidence that surface faults and possibly blind faults could exist in that area. In this circumstance, the necessity of a Phase I Geological Fault Study shall be decided by the Project Manager.
- F. When required, the Phase I Geological Fault Study shall be performed as a separate study to supplement the Geotechnical Investigation.
- G. The entire Phase I Geological Fault Study, when required, shall be performed by a licensed geoscientist or a Licensed Engineer in the State of Texas who has substantial experience and training in investigating surface faults in the Greater Houston area. At the least, such experience and training should include a general knowledge of the location of known surface faults in the Gulf Coast, an understanding of fault mechanics, and a familiarity with the many subtle ways that surface faults manifest themselves.

Additional criteria that shall be met by a licensed geoscientist or a licensed engineer are as follows:

1. Ability to recognize surface faults on aerial images and topographic maps.
 2. Ability to distinguish surface faults from other natural and man-made features.
 3. Ability to distinguish ground deformation caused by expansive clay soils from that caused by active faults.
 4. Ability to determine and map the width of the zone of disturbed ground along an active fault.
- H. At a minimum, the Phase I Geologic Fault Study shall determine the likelihood of a surface fault impacting the project. If a fault is determined to be present at the project, it should be delineated on a map. In the event that the fault is clearly visible at the Earth's surface, the

width of the fault's associated deformation zone should be determined and mapped. The mapping shall be considered as an additional study.

- I. When a fault is not clearly visible at the surface, its delineation and mapping may require an investigation employing Phase II and III subsurface methods. In this circumstance, the necessity of the Phase II or Phase III shall be decided by the Project Manager.
- J. The qualifications, including specific geologic fault project experience, of the professional performing the Phase I Geological Fault Study shall be included in the fault report.
- K. The draft report of the Phase I Geological Fault Study report shall be submitted before the final report.
- L. The final report of the Phase I Geological Fault Study shall be signed and may be stamped by the professional conducting the study.
- M. The Phase I Geological Fault Study Report, when required, shall be included in the appendix of the Geotechnical Investigation Report.

11.10 GENERAL INVESTIGATION

- A. Some of the facilities in which Geotechnical Investigation may be required are given below:
 - 1. Above ground water storage tanks and associated structures.
 - 2. Bridges (roadway, pedestrian, and pipe support).
 - 3. Clarifiers and associated structures.
 - 4. Detention/Retention basins.
 - 5. Lift stations and associated structures.
 - 6. Open channels.
 - 7. Retaining walls.
 - 8. Street pavement.
 - 9. Traffic signal foundations.
 - 10. Tunnels.
 - 11. Underground utilities using open cut or trenchless methods.
- B. Geotechnical Investigation may also be required for:

1. Construction that could affect the integrity of adjacent structures (with the exception of interconnections such as service connections and meter vault installations).
2. Proposed construction work near ground slopes, such as drainage channels or natural waterway.

11.11 PROTECTION OF UNDERGROUND UTILITIES AND STRUCTURES

- A. On the public rights-of-way and easements, it shall be the responsibility of the Geotechnical Consultant to have existing utility lines marked and boring locations cleared prior to drilling.
- B. On private properties, it shall be necessary to employ the property owner's assistance to estimate the locations of the underground utilities and structures.
- C. Drilling shall not begin until clearance has been provided or notification that all underground utility lines are marked has been received by the Geotechnical Consultant.
- D. If there is any reason to believe that an underground facility exists in an area to be drilled, and its location cannot be determined with reasonable accuracy, then that boring shall be moved from the area of concern.

11.12 FIELD INVESTIGATION NOTIFICATIONS

- A. The Project Manager shall be informed (via email) about the start date of drilling approximately 48 hours prior to beginning drilling.
- B. If any unusual conditions are encountered during the field investigation (e.g., signs of contamination in the boring, cavity, underground utilities, loose or soft soils at the bottom of the planned boring depth, etc.), then the Project Manager shall immediately be informed.

11.13 FIELD INVESTIGATION

- A. The field logging of the soil samples shall be performed by an experienced soils technician of the Geotechnical Consultant.
- B. For the proposed open cut utility construction, the borings shall be drilled along or as close as possible to the center line of the alignment.
- C. For the proposed trenchless construction, the borings shall be drilled outside the planned utility alignment but within 20 feet of the centerline of the alignment.
- D. Soil Sample Methods and Intervals:
 1. Undisturbed cohesive soils samples should be recovered by using a thin-walled tube sampler in general accordance with ASTM D1587. For granular soils, Split-Barrel samplers should be used in general accordance with ASTM D1586.

2. Continuous soil sampling shall be performed at about 2-foot depth intervals to a minimum depth of about 20 feet of the borings and at about 5-foot interval thereafter to the termination depth of borings with the exception for bridge, retaining wall, lift station, and tunnel borings. If the boring depth is less than 20 feet, then continuous sampling shall be performed to the termination depth of the boring.
3. If a soil boring for bridge or retaining wall is within the TxDOT right-of-way, then the current TxDOT guidelines shall be followed including performing Texas Cone Penetration (TCP) testing.
4. If a soil boring for bridge or retaining wall is outside the TxDOT right-of-way, then the TCP testing is not required. However, TxDOT sampling interval guidelines shall be followed.
5. For lift stations, continuous soil sampling shall be performed at 2-foot depth intervals from natural ground to 5-foot below the depth of the excavation.
6. For tunnels, continuous soil sampling shall be performed from one bore diameter (or minimum of 6 feet) above the bore crown to one bore diameter (or minimum of 6 feet) below the bore invert level and at about 5-foot intervals in the remainder of the boring.
7. If unusual soils are encountered (e.g., loose or soft soils, etc) after the depth of 20 feet, then the intermittent soil sampling shall be changed to continuous soil sampling through the anomalous layer.

E. Boring Spacing

1. Soil borings shall be conducted in order to obtain sufficient information about the subsurface soil stratigraphy and water level conditions.
2. The recommended boring spacing is given in Table 11.1 (Page 11-9), unless waived by the Project Manager in writing.
3. For geotechnical features that are not mentioned in Table 11.1, the Project Manager shall be contacted.
4. Based on the reliability of soil information available to the City of Houston from the previous project design activities, the recommended boring spacing may be modified by the Project Manager in consultation with the Geotechnical Consultant.

F. Boring Depth

1. The minimum boring depths are given in Table 11.1, unless waived by the Project Manager in writing.

2. For geotechnical features that are not mentioned in Table 11.1, the Project Manager should be contacted.
3. Boring depth shall be increased by the Geotechnical Consultant if unusual soil conditions are encountered during field investigation (e.g., loose or soft soil at the bottom of the planned boring depth, etc).
4. The depth of borings for paving in conjunction with utility work is governed by utility requirements.

Table 11.1

BORING SPACING AND DEPTH

Project Type	Approximate Spacing	Minimum Depth
FACILITIES		
Above Ground Water Storage Tank	At center: One (1) boring at the center. At periphery: At a minimum spacing of 100 feet.	At center: one tank diameter. At periphery: 0.75 tank diameter.
Electrical or Other Building	Depends on the size of the building and loading.	20 feet.
Clarifier	At center: One (1) boring at the center. At periphery: At a minimum spacing of 100 feet.	At center: one clarifier diameter. At periphery: 0.75 clarifier diameter.
Lift Station (Less than 30-foot diameter)	At least one (1) soil boring within the footprint.	Proposed Lift Station depth plus:
Lift Station (30-foot or larger diameter)	At center: One (1) boring at the center. At periphery: At a minimum spacing of 100 feet.	<ul style="list-style-type: none"> ○ At center: diameter of lift station ○ At periphery: 0.75 times diameter of lift station.

Project Type	Approximate Spacing	Minimum Depth
DRAINAGE		
Detention / Retention Basin	The HCFCD guidelines should be followed.	
Open Channel	The HCFCD guidelines should be followed. In addition, one boring with a minimum depth of 30 feet to be drilled on each side of the channel and as close as safely possible to the channel.	
UNDERGROUND UTILITIES		
Open Cut	Minimum distance of 500 feet.	<ul style="list-style-type: none"> ○ 15 feet for trenches up to 10-foot deep. ○ Trench depth plus ten feet for trenches between 10-foot and 25-foot deep. ○ One and one half times the trench depth for trenches greater than 25-foot deep.
Augered	Minimum distance of 500 feet.	5-foot below the proposed invert level.
Tunnels and Microtunnels	Minimum distance of 500 feet.	Minimum one tunnel diameter or 15-foot below the proposed invert level (whichever is greater).
Shafts for Tunnels	Each Location.	1.5 times the shaft diameter below the bottom of the shaft but not less than 30 feet.
STREET & BRIDGE		
Pavement (Street) only along each street	Maximum distance of 250 feet.	5 feet.
Pedestrian and Pipe Bridge	Each side of drainage channel.	40 feet below the bottom of drainage channel.

Project Type	Approximate Spacing	Minimum Depth
Retaining Walls	The TxDOT guidelines should be followed.	
Roadway Bridge	The TxDOT guidelines should be followed.	
Traffic Signal Foundation	Each location.	20 feet.
OTHER		
Discretion of Geotechnical Consultant, Engineer of Record, and the City of Houston.		

G. Piezometers

1. Piezometers may be included in the scope of the Geotechnical Investigation if the project includes any of the following:
 - a. Excavation exceeding 15 feet in depth.
 - b. Crossing underneath a major drainage channel.
 - c. Crossing underneath a major TxDOT or the Harris County Toll Road Authority corridor.
 - d. Tunneling (hand or Tunnel Boring Machine) or Microtunneling installation for an extended length.
2. Piezometers shall be installed in accordance with the applicable rules and regulations of TDLR.
3. A minimum of two water level readings are required on each piezometer. The Geotechnical Consultant shall read water levels at 24 hours and 30 days (long term) after the installation of the piezometer, unless otherwise approved by the Project Manager.
4. For utility lines, spacing between piezometers shall be no greater than 2,500 feet in any direction.
5. One piezometer shall be installed within the footprint of a proposed deep structure, such as wet well or access shaft.

6. The Piezometer Installation Report (as shown on Figure 11.1) shall be included in the Geotechnical Investigation Report.

11.14 SITE RESTORATION

- A. The Geotechnical Consultant shall be responsible for clean up and site restoration upon completion of the field investigation.
- B. If for any reason the borehole must remain open, then appropriate measures shall be taken by the Geotechnical Consultant to protect the safety of the public.
- C. Plugging of Piezometer(s).
 1. The Geotechnical Consultant shall plug piezometer(s) installed for the project in accordance with the TDLR (Chapter 76 of TAC) soon after measuring long term water level readings. A copy of Piezometer Installation and Plugging Reports (submitted to the TDLR) shall be included in the Geotechnical Investigation Report.
- D. Backfilling of Borings.
 1. All borings under the existing or proposed pavement shall be backfilled with cement bentonite grout using the tremie method.
 2. In unpaved areas where boring depth exceeds 10 feet (or if free water is encountered) boreholes shall be backfilled with cement bentonite grout using the tremie method. For depths of 10 feet or less, soil backfill tamped into the borehole is acceptable.
 3. Boreholes in known contaminated areas, or in which contamination otherwise has been detected, shall be backfilled with cement-bentonite or non-shrink grout using tremie method.
- E. Restoration of Pavement Cores.
 1. Boreholes or cored pavements shall be restored for the full depth of pavement using cold patch in asphalt paved areas and ready-mix concrete in concrete paved areas. Larger penetrations shall be repaired following the current City of Houston guidelines.
 2. The pavement shall not be restored until the borehole grout has taken initial set to allow for any settlement or shrinkage of the grout.

11.15 SURVEY REQUIREMENTS

- A. The locations and elevations of boreholes and piezometers shall be surveyed by the Engineer of Record or another member of the project team.

- B. The elevation and coordinates shall be shown on boring and piezometer logs by the Geotechnical Consultant.
- C. The station and offset of boreholes and piezometers may also be shown on boring and piezometer logs (in addition to coordinates) by the Geotechnical Consultant.

11.16 LABORATORY TESTING

- A. The purposes of the laboratory testing are to define the soil classification, soil stratigraphy, and the relevant engineering properties of the soils.
- B. The laboratory tests shall be performed in general accordance with the latest revision of the ASTM standards.
- C. The laboratory tests may include but not limited to the following:
 - 1. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Modified Unified Soil Classification System)
 - 2. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
 - 3. ASTM D1140 - Standard Test Methods for Amount of Material in Soils Finer Than the No. 200 (75- μ m) Sieve
 - 4. ASTM D2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
 - 5. ASTM D2166 - Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
 - 6. ASTM D2850 - Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
- D. The selection of appropriate laboratory tests beyond the above tests is left to the discretion of the Geotechnical Consultant in consultation with the Project Manager.
- E. To assist in properly classifying the soils in general accordance with ASTM D2487, the laboratory testing program shall include a minimum of one set of Liquid and Plastic Limits (ASTM D4318) and Percent Passing Number 200 Sieve (ASTM D1140) tests on a representative cohesive soil sample in each boring.
- F. The water content test (ASTM D2216) shall be performed on all cohesive soil samples to determine the moisture profile.

- G. The Unconfined Compression Strength test (ASTM D2166) shall not be performed on a soil sample containing seams or slickensides.
- H. If the invert level of the utility is greater than 5 feet, a minimum of one Unconsolidated-Undrained Triaxial test (ASTM D2850) shall be performed on a representative cohesive soil sample in each boring.
- I. Aggressivity tests (Sulfates, Chlorides, pH, and Electric Resistivity) shall be performed on soil and/or water samples on projects where metallic pipes are used. Geotechnical Consultant shall not discard soil samples without ensuring from Engineer of Record that corrosion monitoring and/or corrosion control recommendations are made and soil samples are not needed.
- J. All the test results shall be summarized in the report in a table format. The Geotechnical Consultant shall include the summary of the test results on the most updated template format (or approved equal), as provided by the City of Houston (as shown on Figure 11.2).

11.17 BORING LOG FORMAT

- A. The Geotechnical Consultant shall submit the boring log on the most updated template format (or approved equal), as provided by the City of Houston and shown on Figure 11.3.
- B. The City of Houston project number shall be written on all boring logs.
- C. Any test data that is not included in boring log shall be reported separately in general accordance with the reporting guidelines mentioned in the ASTM standard of that test.

11.18 BORING LOG PROFILE

- A. When more than one borings are drilled for the project, boring log profile(s) along the project alignments(s) shall be included in the Geotechnical Investigation Report as shown on Figure 11.4.
- B. If the invert depths of utility line are known, then utility line shall be plotted on the boring log profile(s) as shown on Figure 11.4.

11.19 ENVIRONMENTAL CONCERNS

- A. The Geotechnical Consultant shall look for obvious signs of visual staining of the soil samples, note any odors (specifically of hydrocarbon nature) during drilling, and summarize this information in the report.

11.20 GEOTECHNICAL INVESTIGATION REPORT - GENERAL REQUIREMENTS

- A. The Geotechnical Investigation Report shall be an in-depth evaluation that entails a review of available pertinent literature, geologic fault information, field subsurface investigation,

laboratory testing, engineering analysis of the data obtained, and recommendations concerning the proposed facilities.

- B. The content of the Geotechnical Investigation Report shall be project specific.
- C. The Geotechnical Consultant shall review any soil information (provided by the Project Manager) that may be available from the previous project design activities. The summary is to be included in the Subsurface Conditions section of the Geotechnical Investigation Report. The boring logs and the plan of borings shall be included in the appendix of the Geotechnical Investigation Report.
- D. Any illustration containing copyright information (e.g., aerial views from the Internet or Key Map for Plan of Borings, Vicinity Map, etc.) shall have proper reproduction permission and credits written on the illustration.
- E. All drawings (including drawings for the slope stability analyses) shall be at a scale available on a standard engineering scale.
- F. The pavement design shall be in accordance with the latest edition of the AASHTO Guide for Design of Pavement Structures.
- G. The Geotechnical Consultant shall perform a quality control review of the Geotechnical Investigation Report before its submittal. The Engineer of Record shall provide a separate review of the Geotechnical Investigation Report prior to its submittal.
- H. For the City of Houston projects, the Geotechnical Consultant shall submit a Draft Geotechnical Investigation Report (hard copy) to the City of Houston for review prior to submitting the Final Geotechnical Investigation Report. The title of the report shall identify if the report is a draft or final report.
- I. The Final Geotechnical Investigation Report shall be signed and sealed by a Licensed Engineer.

11.21 GEOTECHNICAL INVESTIGATION REPORT - RECOMMENDATIONS

The minimum geotechnical recommendations shall address the following:

- A. Open-Cut Installation: Bedding, backfill, excavation wall and bottom stability, thrust restraint, dewatering, and pipe design parameters.
- B. Auger Installation: Soil design parameters, ground stability, auger pit excavation stability, and dewatering.
- C. Tunnels and Shafts: External pressures on primary and permanent liners, wall and bottom stability, and dewatering.

- D. Open Channel: Slope angle or slope ratio, setback distance for structures or appurtenances included in the project, and erosion protection.
- E. Detention Pond: Slope angle or slope ratio, setback distance for structures or appurtenances included in the project, and erosion protection.
- F. Paving:
 - 1. The requirements in Chapter 10 "Street Paving Design Requirements" of the City of Houston Infrastructure Design Manual shall be followed.
 - 2. For rigid paving: At a minimum, the pavement thickness and minimum subgrade treatment shall be included. All the selected design parameters used in obtaining the pavement thickness shall be provided in the report.
 - 3. For flexible paving: At a minimum, the design Structural Number (SN), recommended pavement section and its SN, and subgrade treatment shall be included. All the selected design parameters used in obtaining the pavement thickness shall be provided in the report.
 - 4. For overlay projects, recommendations for rehabilitation shall be provided.

11.22 GEOTECHINCAL INVESTIGATION REPORT - TABLE OF CONTENTS

- A. The Geotechnical Investigation shall be presented in report including the text sections, tables, illustrations, and appendices as shown below:

Transmittal Letter - The transmittal letter in accordance with the TBPE rules.

Executive Summary - Summarize the work performed for the project including findings and recommendations.

Table of Contents (with page numbers)

- 1. Introduction
 - a. General
 - b. Authorization
 - c. Location and Description of the Project
 - d. Purpose
 - e. Scope
- 2. Field Investigation
 - a. General

- b. Geotechnical Borings
 - c. Piezometer Installation
3. Laboratory Testing
4. Subsurface Conditions
 - a. Geology
 - b. General Fault Information
 - c. Soils Stratigraphy
 - d. Soils Stratigraphy from the Previous Project Design Activities (if applicable)
 - e. Water Levels
5. Engineering Analyses and Recommendations
6. Construction Considerations
7. Limitations
8. Tables
 - a. Summary of Boring Information (Number, depth, survey information with baseline and datum). The survey coordinates shall be as per Texas South Central Zone No. 4204 State Plane Grid (not surface) Coordinates (NAD83).
 - b. Geotechnical Design Parameters
 - c. Summary of Test Results
9. Illustrations (varies based on the project requirements, using 8.5 x 11 pages)
 - a. Vicinity Map
 - b. Fault Map
 - c. Plan of Borings
 - d. Boring Log Profile (showing utility lines)
 - e. Earth Pressure Diagrams
 - f. Thrust Force
 - g. Liner Load
 - h. Vertical Stress on the Pipe
 - i. Stability of Bottom for Braced Cut
 - j. Uplift Resistance
 - k. Pile/Shaft Capacity Curves
 - l. Any other relevant illustration
10. Appendices (several of the following may be combined in one appendix)
 - a. Boring Logs
 - b. Piezometer Installation Report (Figure 11.1 and report submitted to the TDLR)
 - c. Piezometer Plugging Report (report submitted to the TDLR)
 - d. Grain Size Distribution Curves (if applicable)
 - e. CU, Pinhole, or any other test results (if applicable)
 - f. Slope Stability Analyses Information (if applicable)

- g. Fault Study Report (if applicable)
 - h. Pavement Design Calculation
 - i. Information from the Previous Project Design Activities (if applicable)
 - j. Any other relevant information
- B. When required, a separate Trench Safety Report shall be provided for the City of Houston projects. The Trench Safety Report shall satisfy statutory requirements for contracting for trench safety construction.
- C. The Geotechnical Consultant shall provide an electronic version (in pdf format) of the entire Final Geotechnical Investigation Report (one file).
- D. The Geotechnical Consultant shall also provide electronic files of the final boring logs. The files must be compatible with input files used by "gINT" LogWriter software.

(Continued on next page)

**FIGURE 11.3
BORING LOG FORMAT**

LOG OF BORING NO. B-												
PROJECT :					PROJECT NO. :							
LOCATION : N xx,xxx.x, E xx,xxx.x See Plan of Borings (Figure no)					COMPLETION DEPTH : FT.							
SURFACE ELEVATION : FT.					DATE : MM-DD-YY							
ELEVATION, FEET	DEPTH, FEET	SYMBOL	SAMPLES	SAMPLER : Shelby Tube/Split Spoon	STANDARD PENETRATION TEST, BLOWS PER FOOT	PERCENT PASSING NO. 200 SIEVE	DRY UNIT WEIGHT, PCF	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, TSF
				DRY AUGER : TO FT.								
	0											
	5											
	10											
	15											
	20											
	25											
	30											
	35											

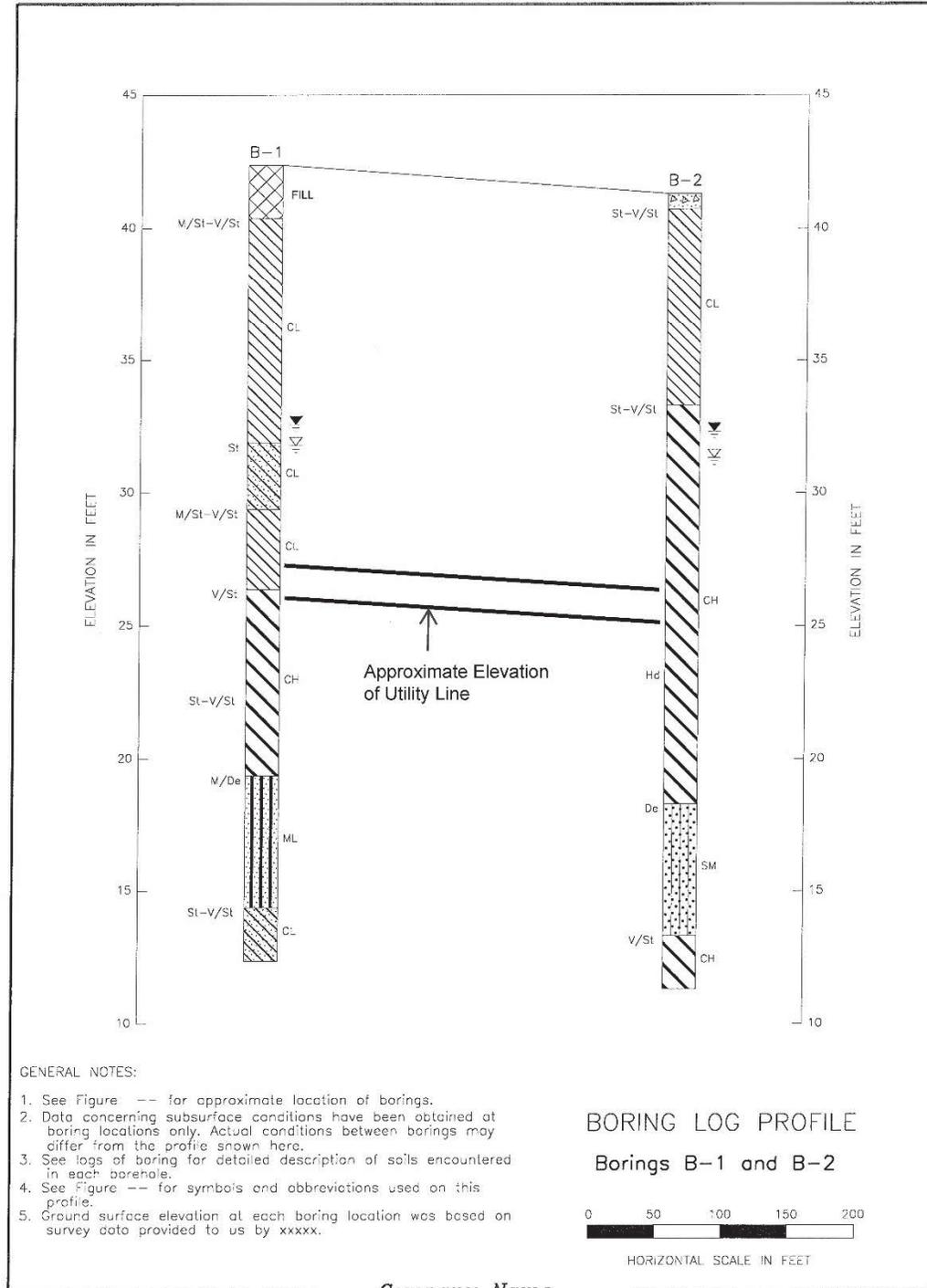
DEPTH TO WATER IN BORING :
 * : FREE WATER 1st ENCOUNTERED AT 10.0 FT. DURING DRILLING; AFTER 15.0 MIN. AT 8.0 FT.
 * : WATER DEPTH AT 7.5 FT., HOLE OPEN TO 35.0 FT. ON mm-dd-yy.

Drilled By: _____ Logged By: _____

Company Name

FIGURE

**FIGURE 11.4
BORING LOG PROFILE FORMAT**



FIGURE

Chapter 11 (Continued)

SECTION II

11.23 PHASE I ENVIRONMENTAL SITE ASSESSMENT (ESA I) REQUIREMENTS

This section categorizes various types of projects that require an ESA I and sets a minimum scope of work for:

- A. Property to be acquired by the City of Houston and property involved in divestitures and inter-departmental transfers; and
- B. The City of Houston construction projects.

11.24 PROPERTY TO BE ACQUIRED BY THE CITY OF HOUSTON AND PROPERTY INVOLVED IN DIVESTITURES AND INTER-DEPARTMENTAL TRANSFERS

The ESA I conducted on property to be acquired by the City of Houston shall conform to the latest ASTM Standard Practice E1527 with the following stipulations:

- A. The sources of historical data reviewed for a site shall include, at a minimum, historical aerial photographs, fire insurance maps (where available), local city street directories (where available), and United States Geological Survey (USGS) maps. The chain-of-title search is not required as an historical search. Applicable copies of these sources shall be presented in the report. Since City Directories are copyright protected, copies of these should not be presented in the report. One aerial photograph for every five to ten years interval from approximately 1950 to the present shall be obtained of an appropriate scale (1" = 500', or shall not exceed 1" = 700') to clearly indicate site details. Sites inside the IH-610 Loop shall have property usage identified from the present, back a minimum of 100 years (where available), or to the property's obvious first development, whichever is earlier.
- B. If regulatory records indicate that Leaking Petroleum Storage Tank (LPST) facilities are located within approximately 500 feet of the site, the latest comprehensive assessment or monitoring report maintained on the facility by the TCEQ (Houston District Office) shall be reviewed and summarized in the ESA I report. Any review of records shall be conducted during the ESA I.
- C. If regulatory records indicate that a federal/state superfund facility is located within approximately ¼ mile of the site, the files maintained on that facility by the TCEQ shall be reviewed and summarized in the ESA I report.
- D. The TCEQ's Voluntary Cleanup Program (VCP) database shall be searched for facilities that are located within approximately 500 feet of the site.
- E. If the project includes demolition/renovation of buildings/structures, the ESA I report shall include recommendation for asbestos survey.

- F. If the project includes renovation of buildings/structures constructed before 1978, the ESA I report shall include recommendation for lead based paint survey.
- G. If the site includes undeveloped property, available wetlands maps shall be obtained and reviewed, the presence of hydric soil types shall be reviewed using published information, and the presence of standing or flowing water shall be investigated during the site inspection. The environmental professional shall make a statement in the report concerning the potential for the presence of wetlands on the site and whether or not full wetlands determination delineation is needed.
- H. If the site is in an area of known oil and gas production operations, a record search for oil and gas exploration and production wells on or adjacent to the site shall be included in the ESA I.
- I. Flood Insurance Rate Maps (FIRM) available from the Federal Emergency Management Agency (FEMA) shall be reviewed to identify areas of the subject site located within flood plains.
- J. A minimum of five interviews (where applicable) shall be conducted in accordance with the latest ASTM E1527 Standard Practice.
- K. The environmental professional who conducted the ESA I shall make recommendations for an ESA II, as appropriate, which shall be thorough enough to support an ESA II.

11.25 THE CITY OF HOUSTON CONSTRUCTION PROJECTS

The ESA I conducted on rights-of-way which will be involved in City construction projects shall conform to the latest ASTM Standard Practice E1527 with the following stipulations:

- A. The approximate minimum search distance for Standard Environmental Record Sources may be reduced, pursuant to ASTM E1527, to a radius of 500 feet unless there is a justifiable reason to maintain a larger radius; except the minimum search distance for Federal National Priorities List (NPL), Federal Resource Conservation and Recovery Act - Treatment, Storage, and/or Disposal (RCRA TSD) Facilities, and Texas Hazardous Waste Sites (HWS)/Texas State Superfund Sites shall be maintained at the ASTM specified distance of 1.0 mile.
- B. The sources of historical data reviewed for a site shall include, at a minimum, historical aerial photographs, fire insurance maps (where available), local city street directories (where available), and United States Geological Survey (USGS) maps. The chain-of-title search is not required as an historical search. Applicable copies of these sources shall be presented in the report. Since City Directories are copyright protected, copies of these should not be presented in the report. One aerial photograph for every five to ten years interval from approximately 1950 to the present shall be obtained of an appropriate scale (1" = 500', or shall not exceed 1" = 700') to clearly indicate site details.

- C. If the project includes demolition/renovation of buildings/structures, the ESA I report shall include recommendation for asbestos survey.
- D. If the project includes renovation of buildings/structures constructed before 1978, the ESA I report shall include recommendation for lead based paint survey.
- E. If the site includes undeveloped property, available wetlands maps shall be obtained and reviewed. The environmental professional shall make a statement in the report concerning the potential for the presence of wetlands on the site and whether a full wetlands determination or delineation is recommended.
- F. If the site includes undeveloped property, the environmental professional shall make a statement in the ESA I report that "Threatened and Endanger Species", and "Historical, Cultural, and Archeological" surveys are warranted.
- G. If the project involves construction of any infrastructure crossing or within a waterway easement, the environmental professional shall make a statement in the ESA I report the jurisdictional authority should be consulted prior to construction.
- H. If the site is in an area of known oil and gas production operations, a record search for oil and gas exploration and production wells on or adjacent to the site shall be included and discussed in the ESA I.
- I. The FIRM available from the FEMA shall be reviewed and discussed to identify areas of the subject site located within flood plains.
- J. A minimum of five interviews, where applicable, shall be conducted in accordance with the latest ASTM E1527 Standard Practice.
- K. The environmental professional who conducted the ESA I shall make recommendations for an ESA II, as appropriate, which shall be thorough enough to support an ESA II.
 - i. A regulated site listed in the database with impacted soil and/or groundwater shall be considered for ESA II provided it is located adjacent to the alignment/parcel.
 - ii. A historical site (gasoline, filling, and service stations, and dry cleaners) not currently listed in the database shall be considered for ESA II provided it is located adjacent to the alignment/parcel.
 - iii. A regulated site distant for the alignment/parcel can be considered for ESA II provided TCEQ (Houston office) has documents indicating that regulated site has impacted a large area including the alignment/parcel.

- L. The Environmental Consultant shall submit a Draft Environmental Site Assessment Report (hard and an electronic copies) to the City of Houston for review prior to submitting the Final Environmental Site Assessment Report. The title of the report shall identify if the report is a draft or final report. At minimum, hard copies of the executive summary section of the database including radius map and pages pertinent to the sites of recognized environmental conditions (REC) discussed shall be included in the ESA I report. The ESA I report and the complete set of the database should be in the enclosed electronic copy.

- M. The Environmental Consultant shall provide an electronic version (in pdf format) of the entire Final Environmental Site Assessment Report (one file).

(Continued on next page)

Chapter 11 (Continued)

11.26 PHASE II ENVIRONMENTAL SITE ASSESSMENT (ESA II) REQUIREMENTS

The primary objective for performing an ESA II is to evaluate the recognized environmental conditions (REC) identified in the ESA I for the purpose of providing information regarding the nature and extent of contamination to assist in engineering design process. The ESA II shall conform to the latest ASTM Standard Practice E1903 with the following stipulations.

11.27 FIELD INVESTIGATION NOTIFICATIONS

The Environmental Consultant or Engineer of Record shall inform the Project Manager (via email) about the start date of drilling approximately 48 hours prior to beginning drilling.

11.28 PROCEDURES

The following are the minimum requirements for an ESA II to be conducted for the City of Houston projects, land acquisitions, and inter-departmental transfers.

A. Field Activities

The location and depth of borings shall be based on the proposed construction activities, and any previous environmental reports pertaining to the project location, if reasonably available.

1. *Frequency of samples* -
 - a. For linear project, the boring shall be advanced incrementally (every one foot) to allow continuous sampling. Three (3) or more borings (approximately 150 feet apart for a rough delineation) shall be drilled along the proposed excavation at each REC location.
 - b. For non-linear project, the frequency and spacing of the borings should be determined by the environmental consultant in consultation with the Project Manager.
2. *Termination of boring* - Borings shall be advanced to a maximum depth of five (5) feet below the planned excavation. Borings may be advanced to greater depths if warranted by site-specific circumstances. If borings are terminated due to field conditions (e.g., obstructions), borings should be relocated at the discretion of the environmental professional.
3. *Cross-contamination* - To prevent cross-contamination, sampling and boring equipment shall be decontaminated prior to drilling each soil boring /collecting samples. Environmental consultant shall follow applicable federal, state, and local regulations to prevent cross-contamination between soil samples.

4. *Sampling procedure:*
 - a. Soil
 - i. Obtain a minimum of one soil sample from each boring for laboratory analysis. Additional soil samples may be collected as deemed necessary by the environmental professional.
 - ii. Perform field screening of all soil samples collected from borings.
 - iii. The sample for laboratory analysis shall be collected from the zone exhibiting the highest Photoionization Detector/Organic Vapor Analyzer (PID/OVA) reading. If the PID/OVA readings are non-detected, the sample shall be collected from the soil-groundwater interface. If no saturated zone exists, then the sample shall be collected from the bottom of the boring.
 - iv. Place all samples in clean pre-labeled containers composed of materials with the appropriate preservatives as required by the respective analytical method. To prevent volatilization, place samples on ice in an insulated cooler prior to and during transportation to the analytical laboratory for analysis.
 - b. Groundwater

If groundwater is encountered during drilling, one (1) groundwater sample shall be collected from each REC location. The groundwater sample shall be collected from a temporary installed sampling well.
 - c. Each boring log shall include the following:
 - i. Soil classification according to ASTM D2488.
 - ii. Detection of hydrocarbon or other odors.
 - iii. Visible hydrocarbon or other contamination (if present, including degree, location, and extent of staining).
 - iv. PID/OVA readings.
 - v. Other field screening as required by the type of contaminations.
 - vi. The depth at which groundwater was first encountered.
 - vii. Location of boring based on GPS X,Y coordination. The coordinates shall be as per Texas South Central Zone No. 4204 State Plane Grid (not surface) Coordinates (NAD83).
 - viii. Boring identification.
 - ix. City project number.
5. *Site Clean up and Restoration* - The environmental professional is responsible for the site clean up upon completion of field operations, commensurate with site conditions.

a. Generation of Waste

- i. Wastes may be generated during the assessment implemented as part of the ESA II (for example, drill cuttings and purged groundwater, etc.). The wastes generated during the assessment should be collected and stored in tightly fitted container(s).
- ii. Wastes should be categorized according to the regulatory requirements and disposed at an approved facility within a 60-day time frame. All completed waste manifests are to be included in the ESA II final report or returned to the Project Manager.
- iii. Techniques that minimize the generation of waste shall be utilized to the extent feasible, consistent with the information and data quality objectives of the planned assessment and applicable regulatory requirements.

b. Backfill of Borings

Completed borings shall be backfilled with cement-bentonite or non-shrink grout. Boreholes or other cored penetrations of pavements shall be restored with the same or equivalent materials as the existing pavement.

B. Laboratory Analysis

1. Environmental Consultant shall perform analytical testing in accordance with applicable United States Environmental Protection Agency (USEPA) and the TCEQ procedures.
2. Laboratory Documentation
 - a. Chain of Custody

A completed chain of custody record shall accompany each shipment of samples to the analytical laboratory, and shall be included in the report.

- b. Laboratory Results

Laboratory results for samples shall include the following:

- i. Date of collection.
- ii. Date of extraction, analysis, and report.
- iii. Extraction and analytical methods used.
- iv. Method detection limits.
- v. Standard utilized in the analysis.
- vi. Sample identification and depth.
- vii. Laboratory QA/QC report.

C. Report

1. Site Characterization

- a. The soil characteristics of significance to the design and construction work shall be described with particular emphasis on the occurrence of transmissive soils at or below the elevation in which contamination was detected, or which have potential for providing pathways for contaminant migration. Geologic characteristics, which affect the migration potential of a contaminant, shall be addressed.
- b. Potential sources of contamination shall be clearly described in the report. Areas of contamination within or adjacent to the project alignment/site which were confirmed, and their spatial relationship to the planned construction activity, shall also be clearly identified.

2. Type of Contamination

- a. The report shall address the basis for determining which contaminants were potentially present and the methods that were used to verify their presence or absence. Where specific contaminants are present, the report is to describe the concentrations and indicate whether or not they are above relevant action levels.

3. Impact of Planned Construction

- a. The report shall describe, based on the available information, the estimated vertical extent and lineal extent (station-to-station) of the PPCA at the REC location. The determination of probable extent should be based on reasonable interpretation of both analytical and geological data. The report shall clearly address the following:
 - i. Comparison of contaminant concentration to regulatory criteria.
 - ii. Potential for contaminated runoff entering the work area.
- b. The report shall address the potential impact of the contamination on the planned construction including the potential for contaminant impact on construction dewatering. Specifically, the report shall address the potential for migration of contamination from the investigated sources and plumes into the construction area, and due to groundwater withdrawal.
- c. A quality control review of the Environmental Report shall be performed by the Engineer of Record, where applicable, before its submittal to the City of Houston.

4. Recommendations

The report shall provide recommendations for construction phase monitoring which should take into account:

- a. Vertical extent and Lineal extend (station-to-station) of PPCA and action plan.
- b. Worker protection and general health and safety.
- c. Potential contaminated media screening, testing, handling, and disposal consistent with Federal, State, and City Regulations and Specifications.

5. Exhibits

- a. Site plan identifying the location of the REC's and boring locations.
- b. Boring logs for each boring with GPS X,Y coordination. The coordinates shall be as per Texas South Central Zone No. 4204 State Plane Grid (not surface) Coordinates (NAD83).
- c. Analytical results including tables summarizing analytical results.
- d. Photographs of drilling activities.

6. The Environmental Consultant shall submit a Draft Environmental Site Assessment Report (hard and electronic copy) to the City of Houston for review prior to submitting the Final Environmental Site Assessment Report. The title of the report shall identify if the report is a draft or final report.

7. The Environmental Consultant shall provide an electronic version (in pdf format) of the entire Final Environmental Site Assessment Report (one file).

(Continued on next page)

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Chain of Custody

END OF CHAPTER

City of Houston

Design Manual

Chapter 12

STREET CUT REQUIREMENTS

Chapter 12

STREET CUT REQUIREMENTS

12.01 CHAPTER INCLUDES

- A. Criteria for street pavement cuts, excavation, backfill, and pavement restoration in Public Ways.
- B. This chapter applies to excavation under paved surfaces in Public Ways which have been improved for street, sidewalk, surface drainage, or related public transportation infrastructure.

12.02 References

- A. Refer to the list of references in Chapter 1, General Requirements.
- B. City of Houston Procedural Guidelines for Planning and Permitting of Excavations in Public Ways, latest revision.

12.03 DEFINITIONS

- A. Excavation - An activity that disturbs, alters, or penetrates any portion of the public way that has been improved for street, driveway, sidewalk, surface drainage, or related public transportation infrastructure purposes. The term includes but is not limited to cutting, tunneling, jacking and boring, backfilling, restoring, and repairing the public way. The term does not include a transportation improvement or maintenance of publicly owned utility systems, such as water and wastewater lines and facilities.
- B. Backfill - Excavation fill material that meets city specified quality requirements or the placement thereof.
- C. Facility - Any structure device or other thing whatsoever that may be installed or maintained in, or, within, under, over or above a public way by an excavation.
- D. Five - Year CIP - Street improvement projects included in a Capital Improvement Program by the City of Houston, Harris County, METRO, TxDOT, or other organization for construction.
- E. Hole - Excavation in the Public Way with the excavation having a length less than the width of the pavement.

- A. Patch - Method of pavement replacement that is temporary in nature. A patch consists of: (1) the compaction of the subbase and aggregate base, and (2) the replacement, in kind, of the existing pavement for a minimum of two feet beyond the edges of the excavation in all directions. A patch is full restoration only when the pavement is included in the City of Houston's Five Year Capital Improvement Plan.
- B. Public Way - Any public street right-of-way located in the city, including the entire area between the boundary lines of every way (including but not limited to roads, streets, alleys, highways, boulevards, bridges tunnels, or similar thoroughfares), whether acquired by purchase, grant, or dedication and acceptance by the city or by the public that has been opened to use of the public for purpose of vehicular travel.
- C. Restoration - The process by which an excavated public way and surrounding area, including pavement and foundation, is returned to the same condition that existed before excavation.
- D. Trench - An excavation in the pavement with the excavation having length equal to or greater than the width of the pavement.

12.04 DESIGN REQUIREMENTS

- 1. Design project so that restoration returns public way to the same condition that existed prior excavation. Base minimum limits and methods required for restoration on City Standard Details.
- B. Comply with requirements of 6.08A, Open Cut Construction in Street Pavement, for all open-cut construction including excavation for auger or directional drilling insertion pits.
 - 1. Saw cut existing pavements along lines parallel to and perpendicular to traveled way center lines unless otherwise approved by the City Engineer.
 - 2. For concrete pavements, conform to requirements of Paragraphs 10.04, K., 5., 10., and 11.
- C. Prepare plan view drawings for all excavations that identify and locate existing underground facilities. The drawings, or verification statements, shall confirm that the underground facilities have been identified, located, and marked by the following organizations:
 - 1. Texas Underground Facility Notification Corporation,
 - 2. City of Houston Public Utilities (water and sewer), and
 - 3. City of Houston Traffic Signal Section.

- D. The City may require plan and profile drawings for complex projects or when the constructing agency has demonstrated previous non-compliance with underground facility location procedures.
- E. Plan view drawings shall show, at a minimum, the following information for the project area:
 - 1. Topographical features.
 - 2. Existing public and private utilities.
 - 3. Significant landscaping or other structures which might impact construction or construction related activities.
 - 4. Location and dimensions of proposed surface cuts.
 - 5. Location and depth of existing and proposed mains, cables, conduits, switches, and related equipment and facilities.
 - 6. Use baseline offsets from property lines, centerline of the public way, or curb lines; or a coordinate system acceptable to the City.
- F. Final drawings shall include a list City of Houston Standard Specifications and related standard details for excavation, bedding, backfilling, and pavement repair and resurfacing.

12.05 QUALITY ASSURANCE

- A. For projects which include conduits, duct banks or pipelines over 1", have final design drawings sealed, signed, and dated by the Professional Engineer responsible for development of the drawings.

END OF CHAPTER

City of Houston

Design Manual

Chapter 13

NOT USED

City of Houston

Design Manual

Chapter 14

FACILITY DESIGN REQUIREMENTS

Chapter 14

FACILITY DESIGN REQUIREMENTS

14.01 CHAPTER INCLUDES

- A. Incorporation of Houston Public Works Guidelines for water and wastewater related facilities.

14.02 REFERENCES

- A. Groundwater Plant Design Guidelines
- B. Engineering Design Guidelines Manual for Submersible Lift Stations.
- C. Design Guidelines Drawings for Submersible Lift Stations.

14.03

- A. Conform to design requirements of the latest published edition of each reference document available online.

END OF CHAPTER

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).



CITY OF HOUSTON

ACCESS MANAGEMENT

DATA SUMMARY

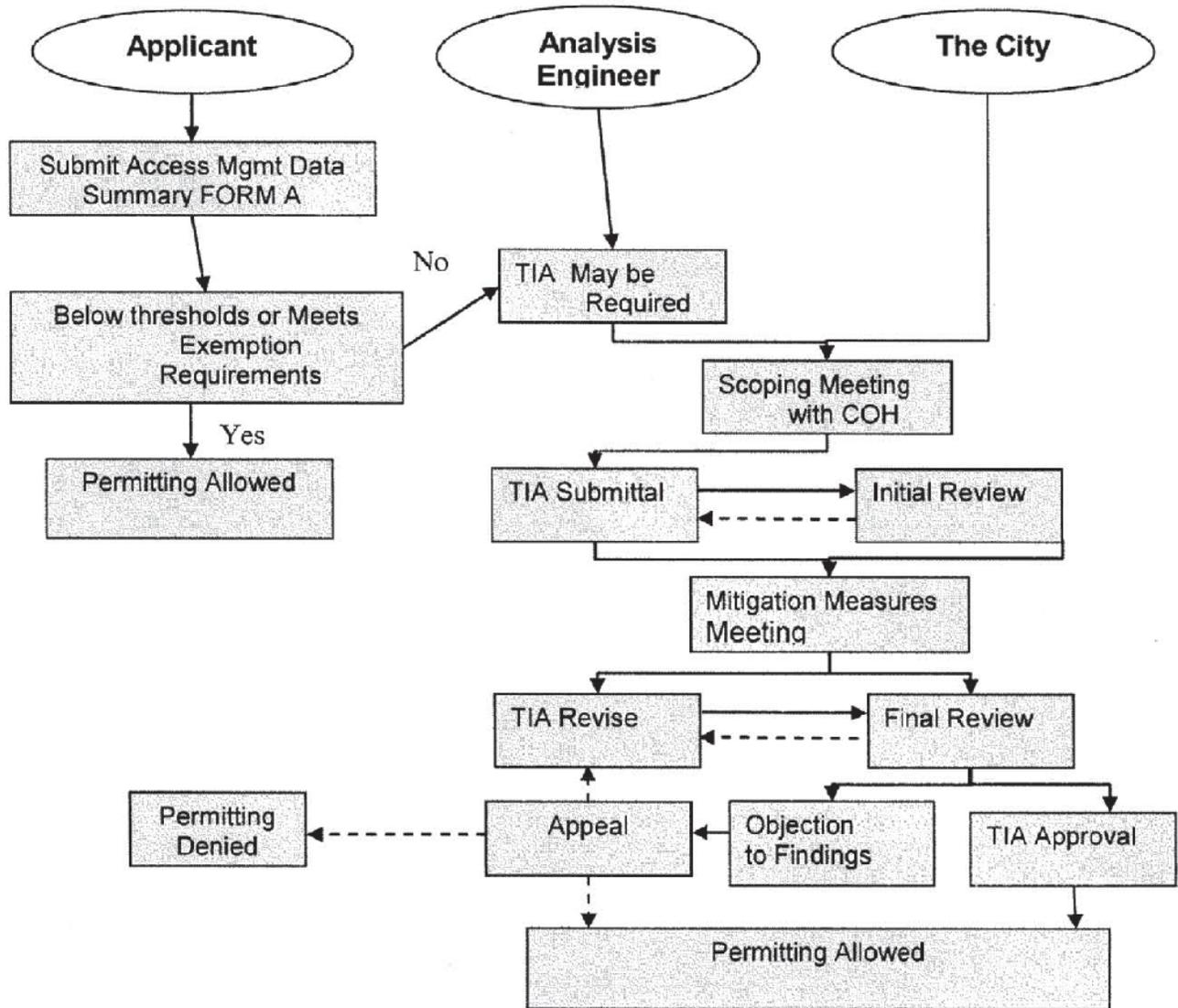


Figure 15.04.01 Overview of Traffic Impact Analysis Process



CITY OF HOUSTON

ACCESS MANAGEMENT DATA SUMMARY

Applicant Information:

Property Owner

Name: _____

Address: _____

City/State/Zip: _____

Telephone: _____

Email Address: _____

Agent

Name: _____

Firm Name: _____

Address: _____

City/State/Zip: _____

Telephone: _____

Email Address: _____

All responses and/or questions should be directed to (check one or both):

Property Owner

Agent

- a. Form to be accompanied by a scalable site plan layout with driveway locations indicating the extent of the access which the private property has or (is planned) to public streets. On site traffic related features (loading docks, emergency lanes, driveway entrance/exits should be depicted on site plan.
- b. Forms may be submitted at any time prior to or during Preliminary Plat submittal and Final Site Plan Permitting
- c. Results of review/analysis will result in "Interpose no objection to Permitting" or "Requires submittal and approval of additional information prior to Permitting"

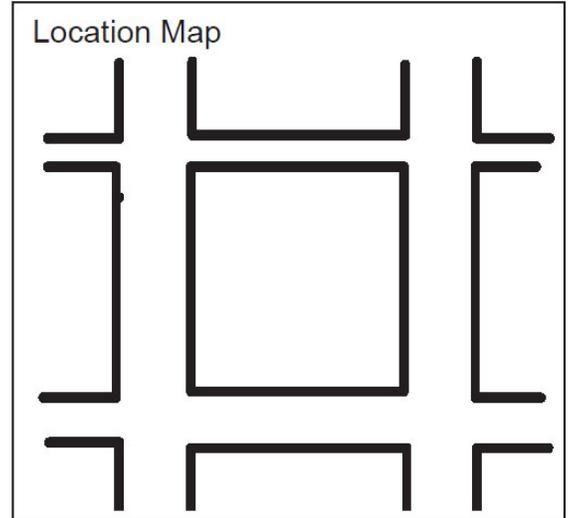
SITE INFORMATION:

Street Address (Primary Access): _____

Legal Description (if no street address) _____

Key Map Page No. _____

Zip Code _____



The dimensions of the private property, and the type and location of improvements thereon or to be placed thereon:

Tract Size (Sq Ft or Acres): _____

Current Land Use (include # of units, square footage of improvements, etc.) _____

Current Trip Generation Rates (Based on ITE Trip Generation Handbook or COH approved local rate)

ITE Land Use Classification: _____ AM Trip Rate: _____ PM Trip Rate: _____
(Code & Description)

AM Peak Hour Trips: _____ PM Peak Hour Trips: _____ Average Daily Traffic : _____
(Provide Trip Generation supporting documentation as applicable.)

Proposed use to be made of the private property: (include proposed # of units, square footage of improvements, etc.) _____

Proposed Trip Generation Rates (Based on ITE Trip Generation Handbook or COH approved local rate)

ITE Land Use Classification: _____ AM Trip Rate: _____ PM Trip Rate: _____
(Code & Description)

AM Peak Hour Trips: _____ PM Peak Hour Trips: _____ Average Daily Traffic: _____
(Provide Trip Generation supporting documentation as applicable)

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. 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.
 - 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 between the preliminary plat submittal and before the final site plan approval. 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 or redevelopment 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.

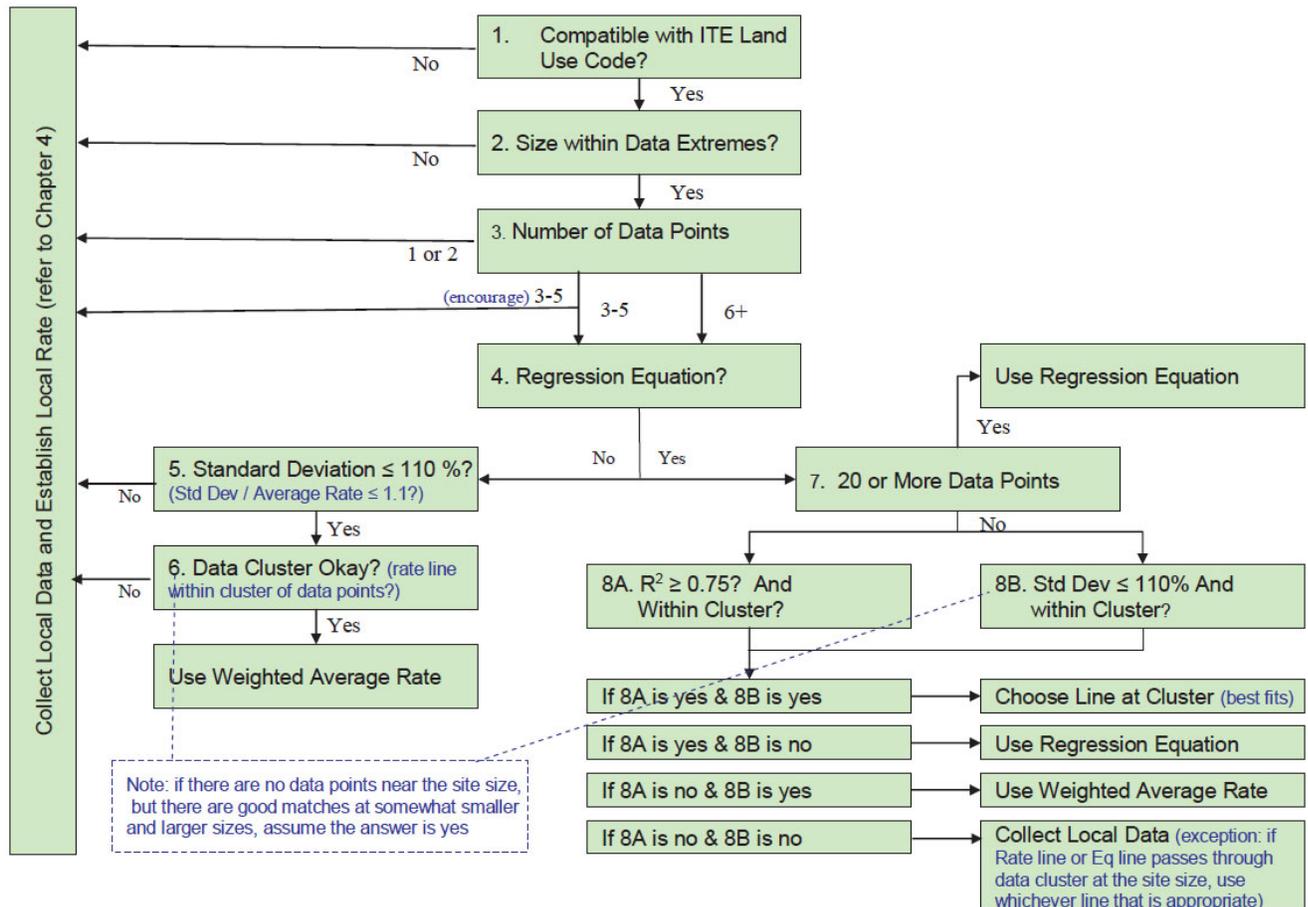


Figure 15.04.02 Recommended Procedure for Estimating Trip Generation

- 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

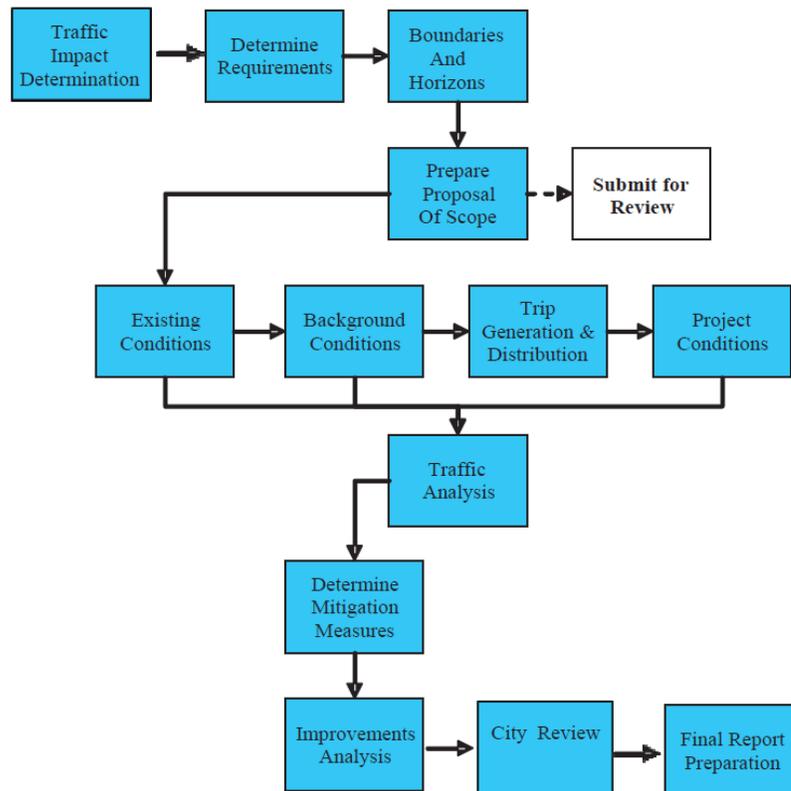
Requirements		Category I	Category II	Category III	Category IV
General	Access Management Data Summary Form	X	X	X	X
	Meeting with the City Traffic Engineer		X	X	X
	Proposed Scope		X	X	X
Horizon	Opening Year		X	X	X
	Full Build-Out Year			X	X
Limits	Analysis Area (From boundaries of development) ⁽¹⁾		¼ Mile	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) 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.

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 LOSD.

- 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).

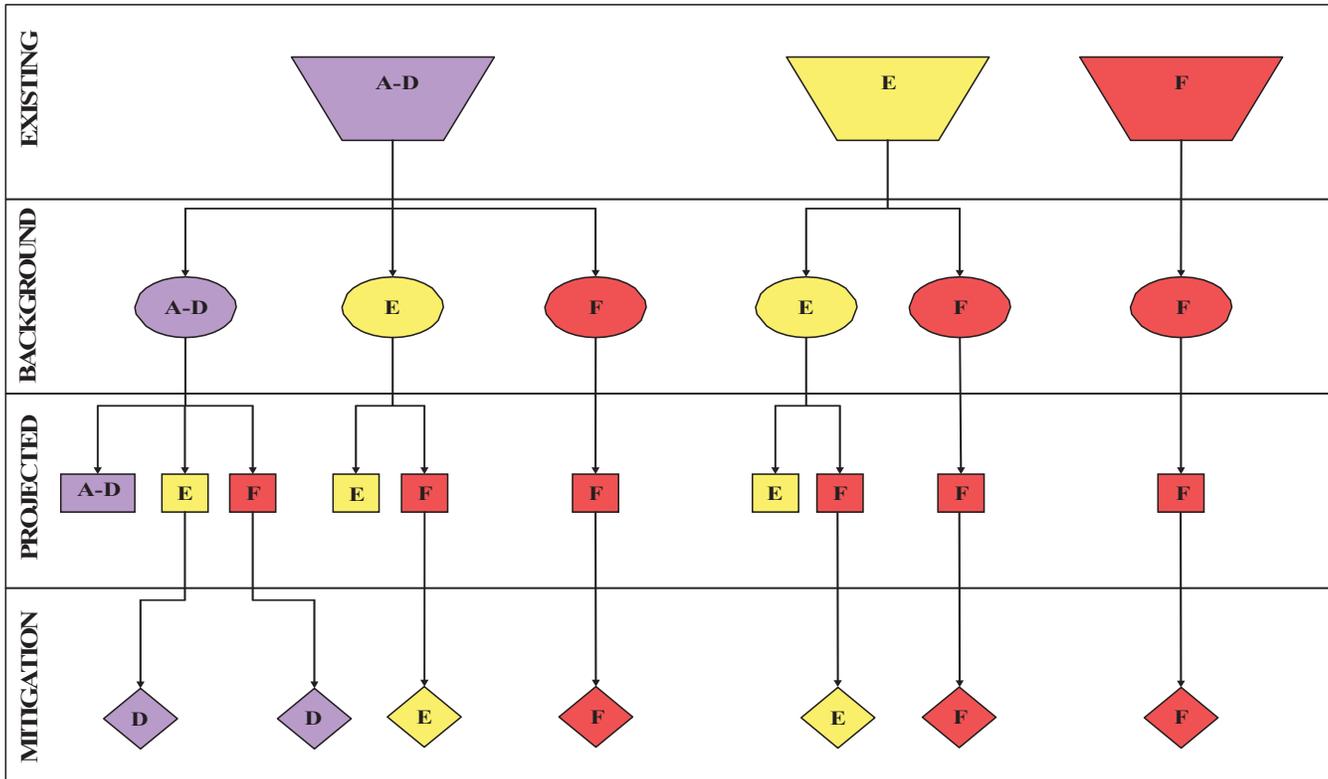


Figure 15.04.04 Mitigation Decision Tree (Collector and Local Roadways)

- 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 GIMS portal:
<http://www.gims.houstontx.gov/portalWS/MainPortal.aspx>

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):

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

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.

$$PHF = \frac{HourlyVolume}{4V_{15}}$$

3. K Factors (design hour factor)
 - a. 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).
 - b. 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)
 - a. The percentage of the total, two-way design hour traffic traveling in the peak direction.
 - b. 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

- A. 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.
- B. 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.
- C. 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://edocs.publicworks.houstontx.gov/division-files/traffic-operations-division/school-coordination-program/80-school-zone-installation.html>.

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.

15.07.02 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.

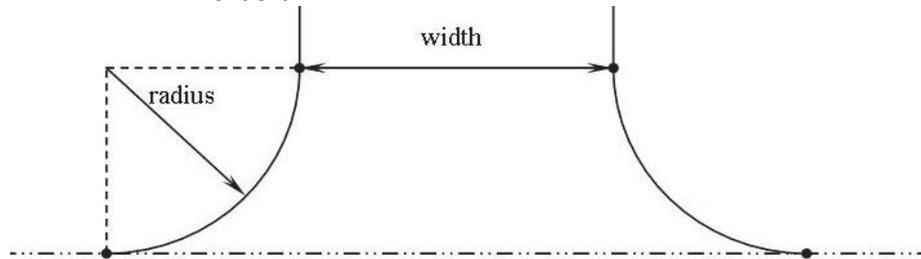


Figure 15.08.01 Driveway Radius and Width

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
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

* Verify radius and width using turning templates for trucks.

** If the number of townhomes/condos exceeds twelve (12) units, the development will be considered a 'commercial' development.

- g. General Driveway Design Criteria
 - (1) One-way driveways must intersect city streets between 45 and 90 degrees.
 - (2) Skewed, one-way drives are permitted only on one-way streets and divided streets with no median opening.
 - (3) Two-way driveways must intersect city streets at approximately 90 degrees.
 - (4) Where situations permit, AASHTO design vehicles may be used to justify driveway radii.
 - (5) No driveway radius shall encroach on abutting property or corner radius.
 - (6) 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.)
 - (7) For one-way driveways, the entry driveway shall precede exit driveways (in direction of adjacent travel lane).
 - (8) Driveway must remain tangential for a minimum of 20 feet past the property line.
 - (9) 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.

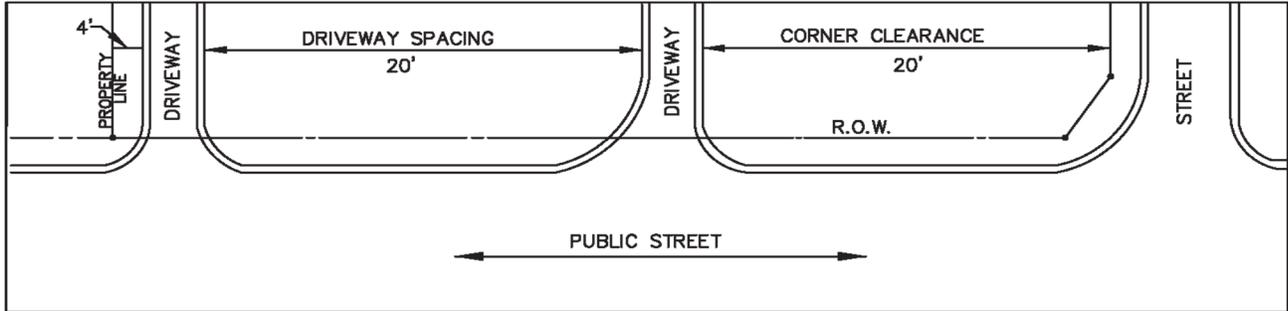


Figure 15.08.02 Residential Driveway Spacing

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.

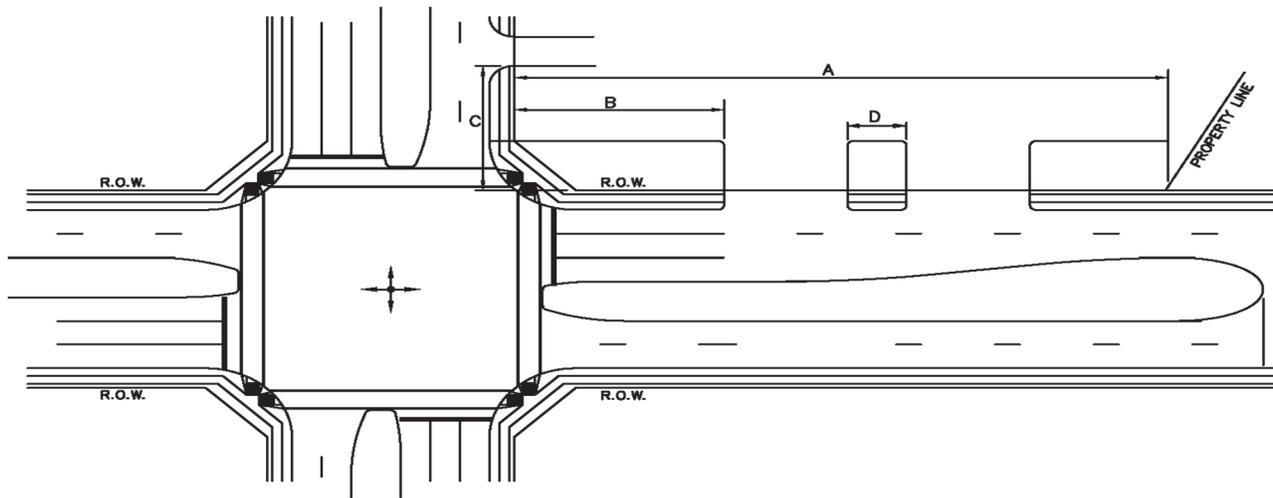


Figure 15.08.03 Driveway Placement

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.

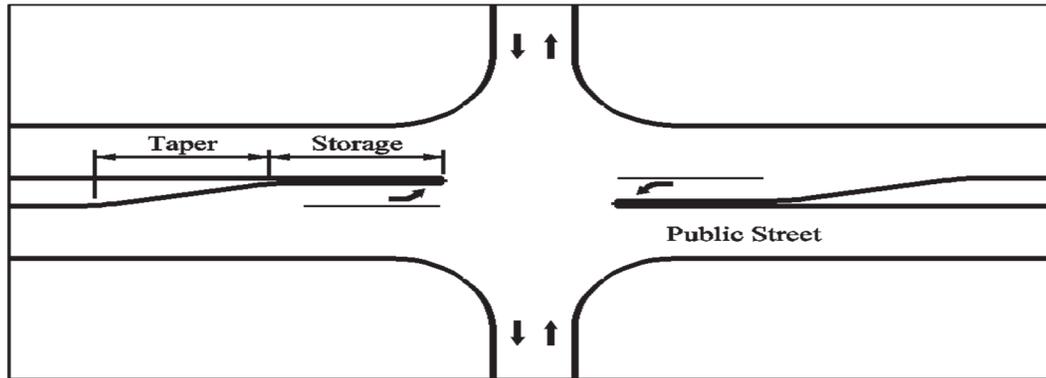


Figure 15.08.04 Turn Lane Details

- 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 for 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.

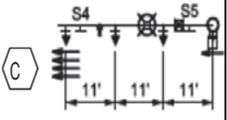
ITEM BY DIRECTION	STREET 1 STATION OF APPROACH EDGE	OFFSET FROM CONST. CL TO CL OF DETECTOR	ITEM BY DIRECTION	STREET 2 STATION OF APPROACH EDGE	OFFSET FROM CONST. CL TO CL OF DETECTOR
EASTBOUND: STOP LINE:	STA. XX+XX		SOUTHBOUND: STOP LINE:	STA. XX+XX	
PHASE 2 PULSE LOOP	STA. XX+XX	CENTERED IN LANE	PHASE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

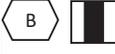
A pole schedule shall be provided showing the pole and its identifier, the pole type, information on the mast arm(s), signal heads, luminaire, pedestrian pushbuttons and signs, pole location, communications system, and relative City standards. Each pole will have its own row within the schedule. The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

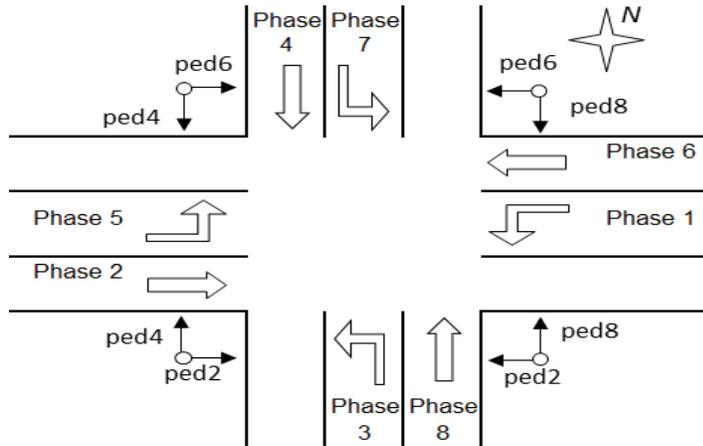
1. Controllers

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.

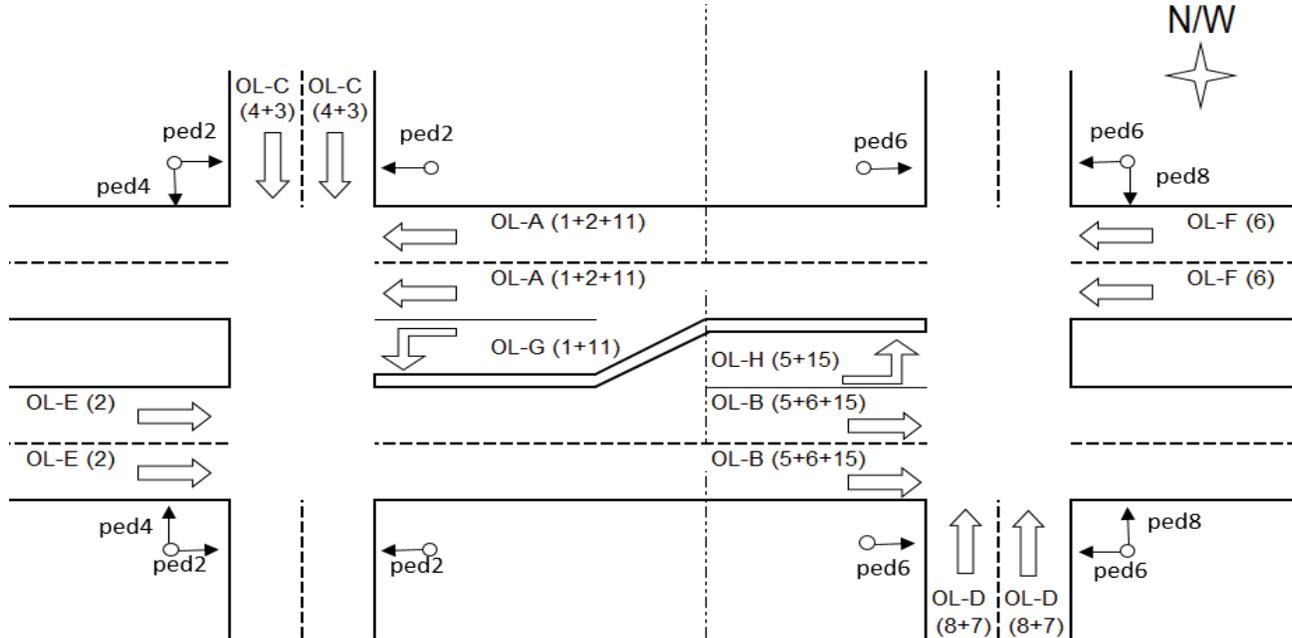
2. Phasing

- 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 volumestreet.
 - 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

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.

- e. 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.
- f. No device serving purposes different than 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 require 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.

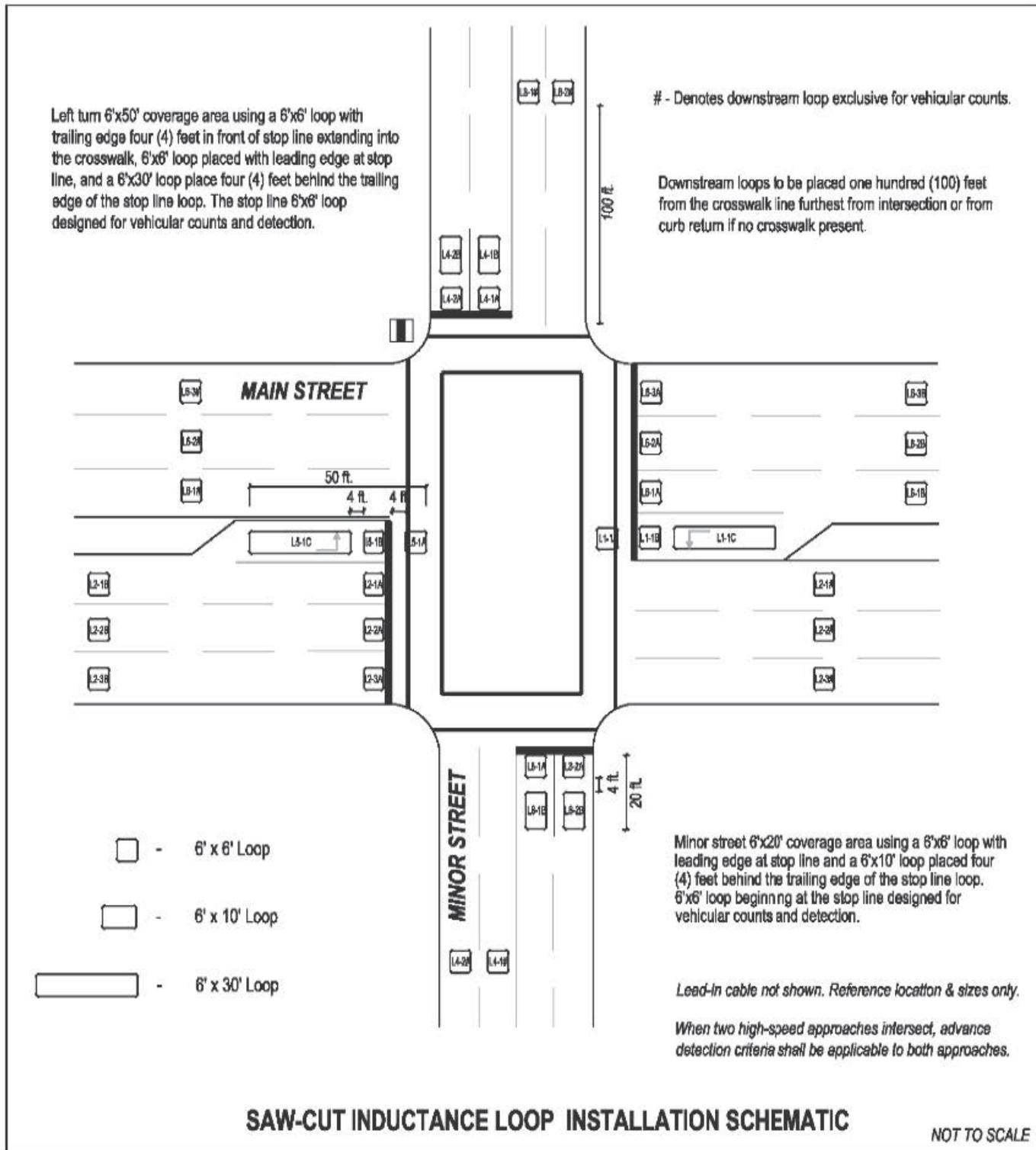


Figure 15.11.01a Saw-Cut Inductance Loop Installation Schematic

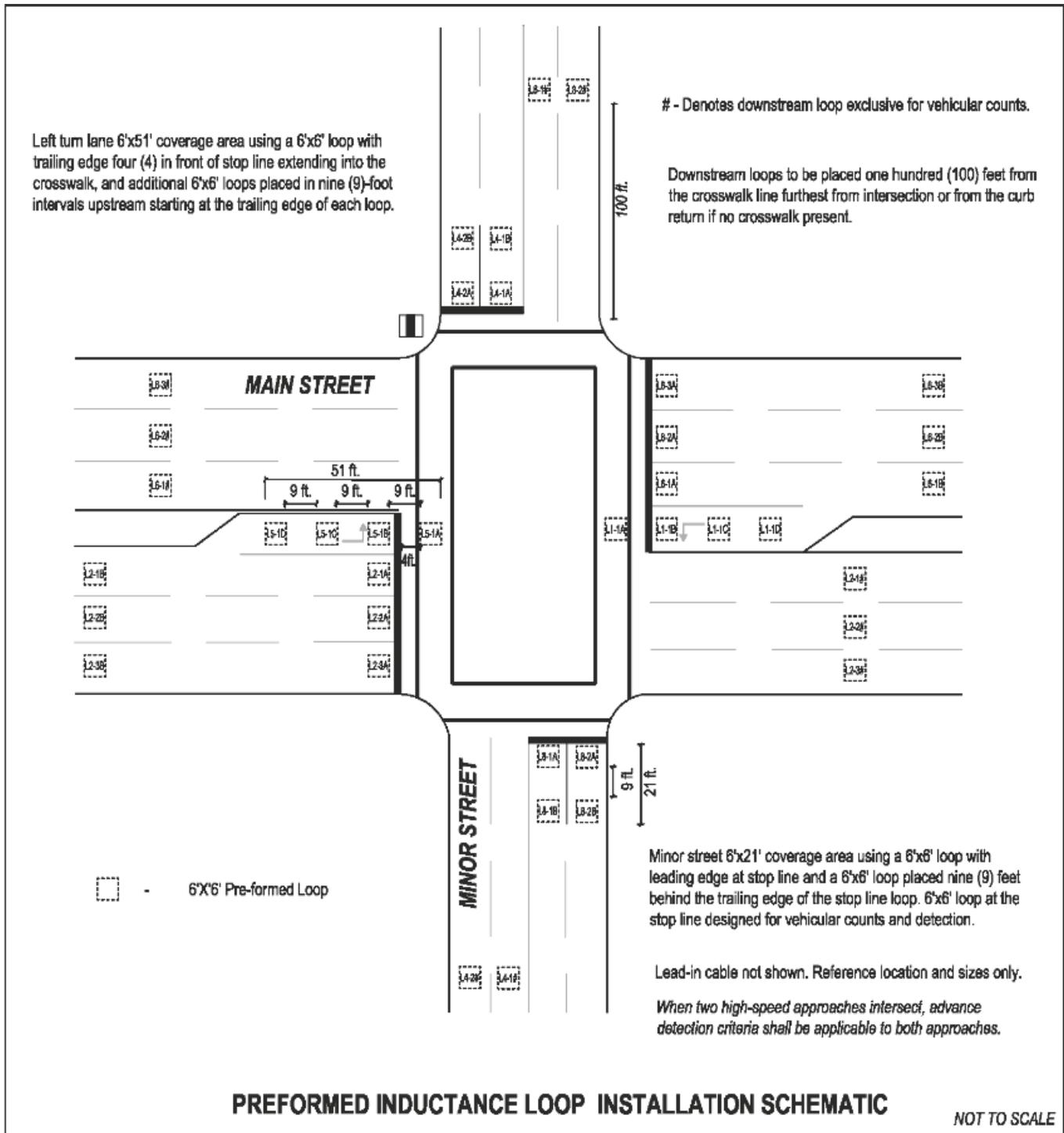


Figure 15.11.01b Pre-Formed Inductance Loop Installation Schematic

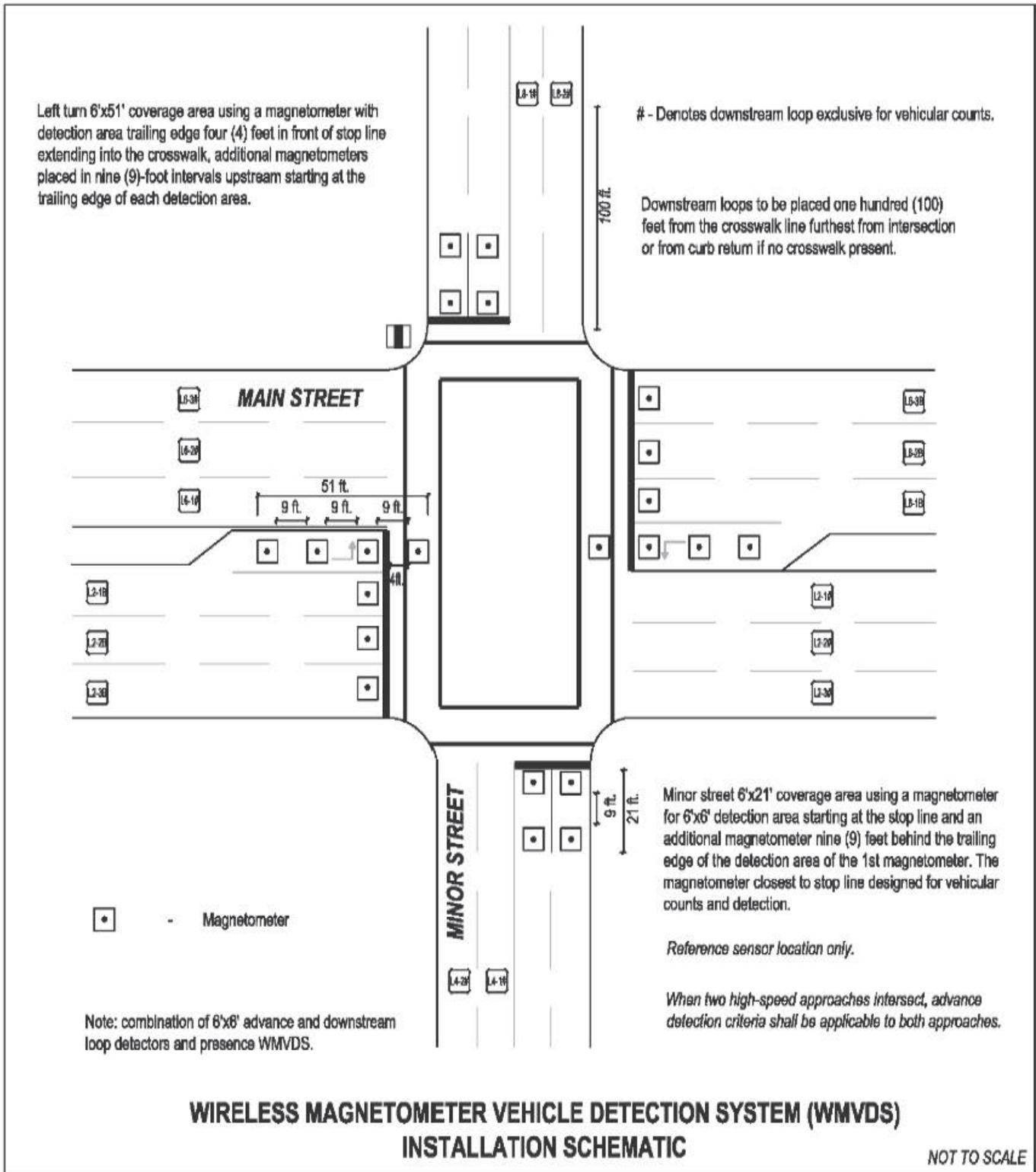


Figure 15.11.01c Wireless Magnetometer Vehicle Detection System (WMVDS) Installation Schematic

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 ½" 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 (Mobility Permit Section at <http://www.gims.houstontx.gov/portalWS/MainPortal.aspx>) before implementing the traffic control plan. 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).
- (17) When entering or leaving roadways carrying public traffic, the Contractor 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 <http://www.publicworks.houstontx.gov/tod/programs.html>. 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.

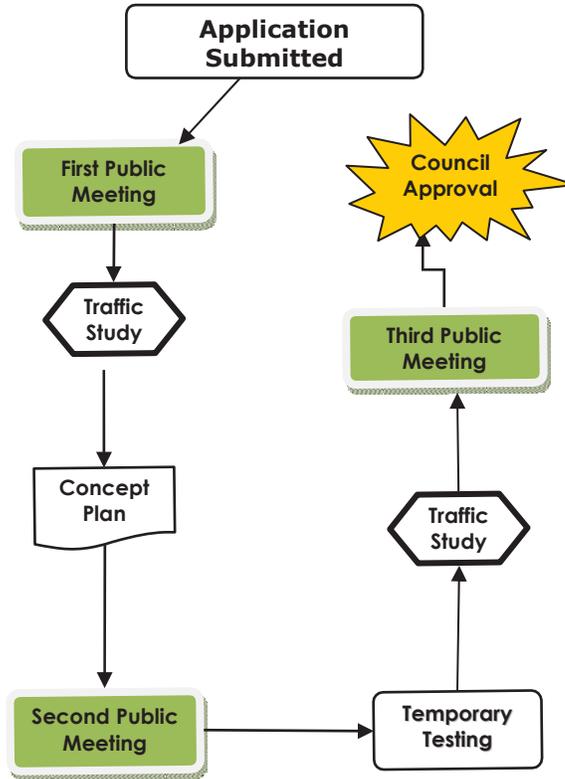


Figure 15.15.01 - Summarized NTMP Process - Volume Control Program

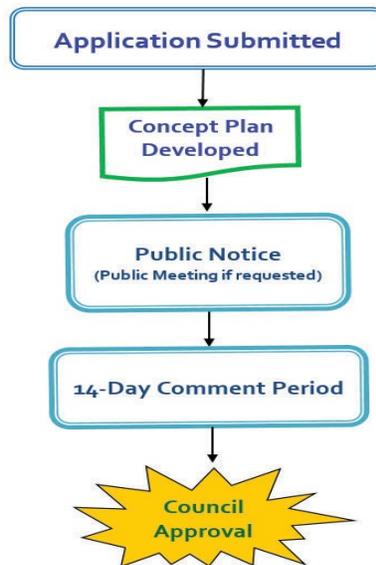


Figure 15.15.02 - Summarized NTMP Process - Speed Control Program

- 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://edocs.publicworks.houstontx.gov/division-files/traffic-operations-division/programs.html>) 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/notices/joint-referral-committee.html> .
- 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 SECTION

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.

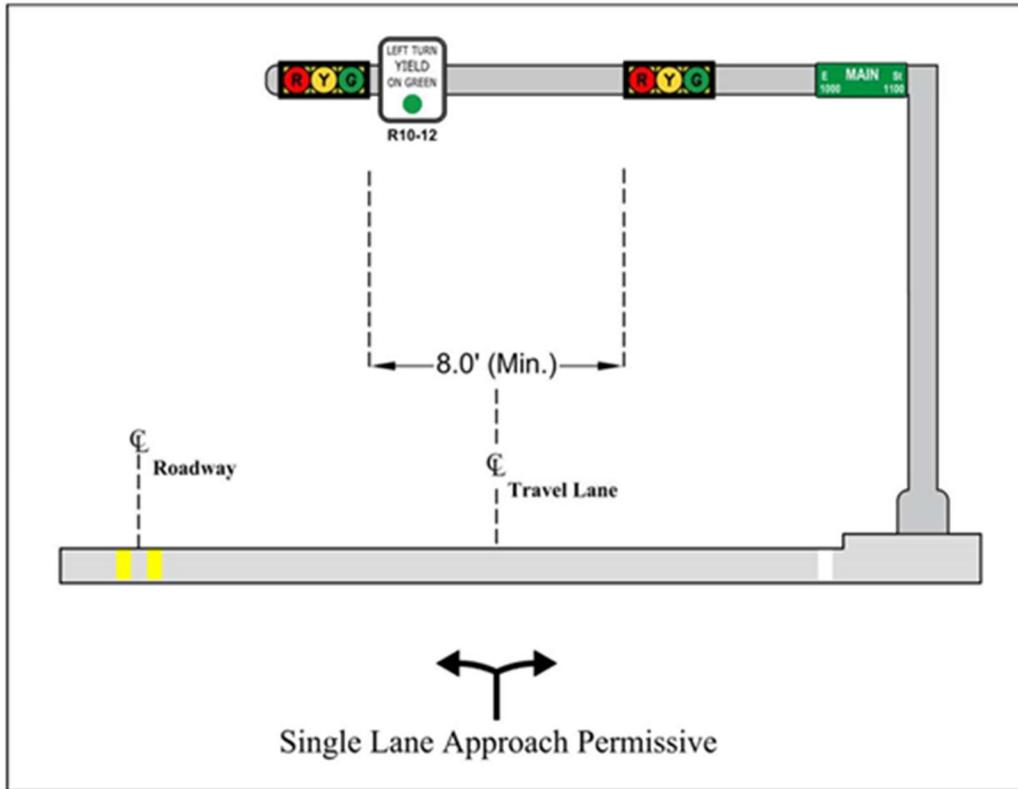


Figure 1

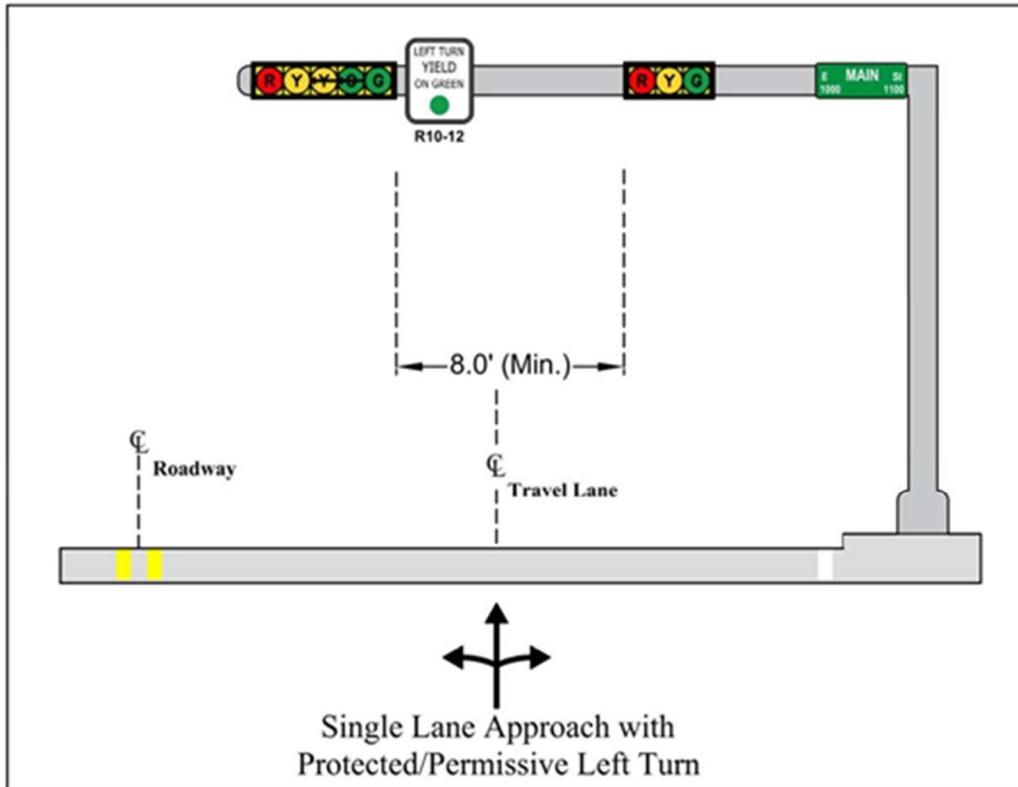


Figure 2

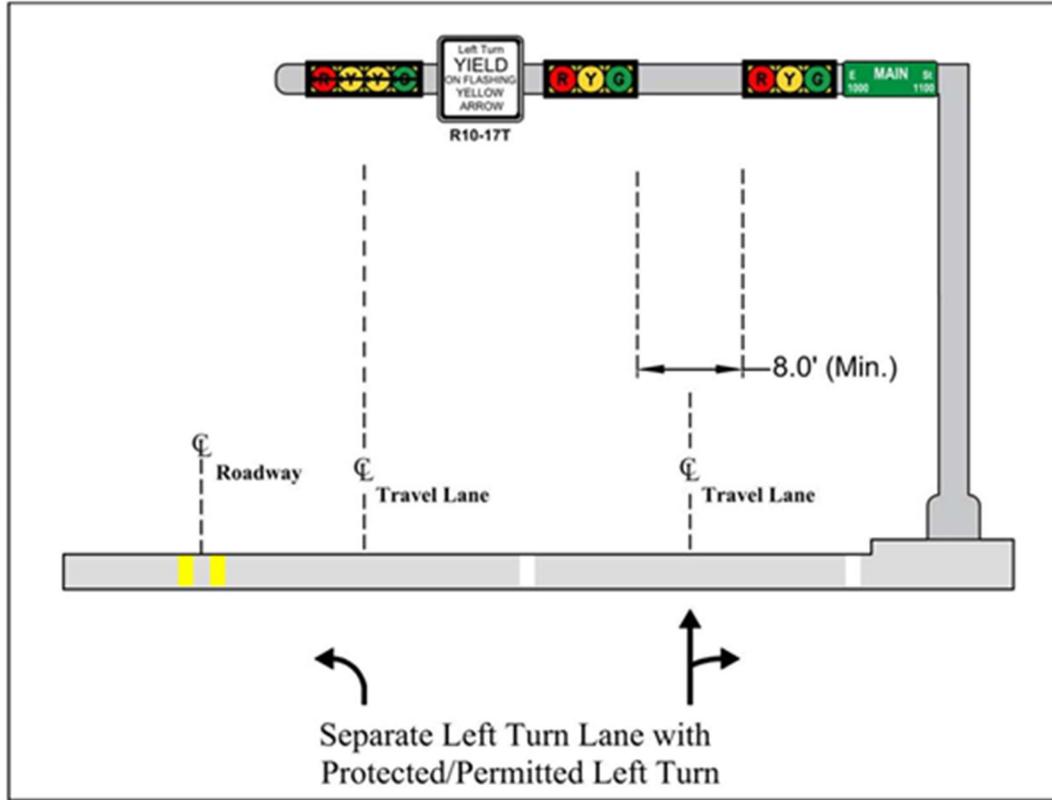


Figure 3

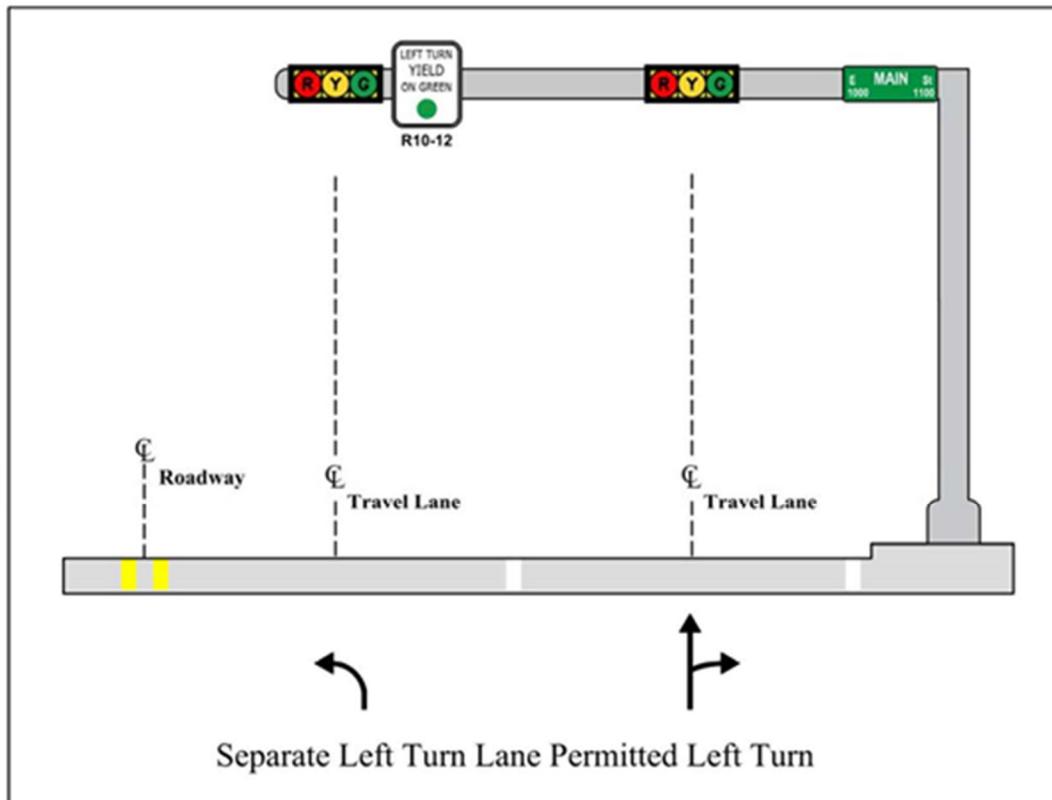


Figure 4

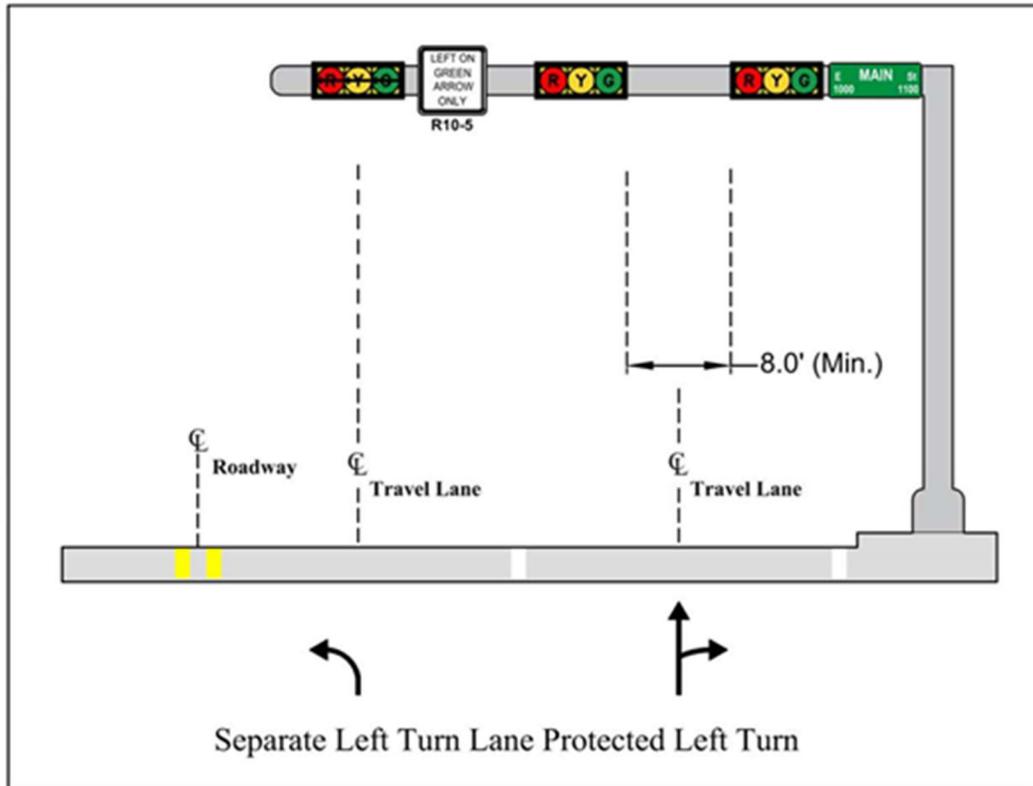


Figure 5

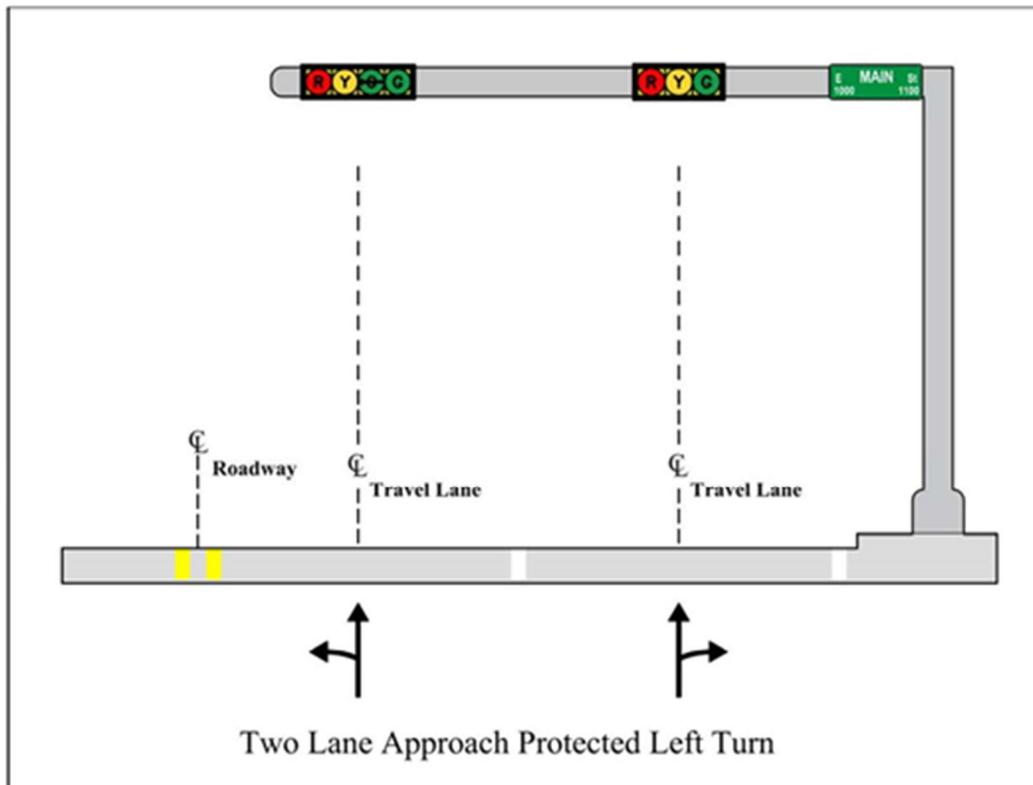


Figure 6

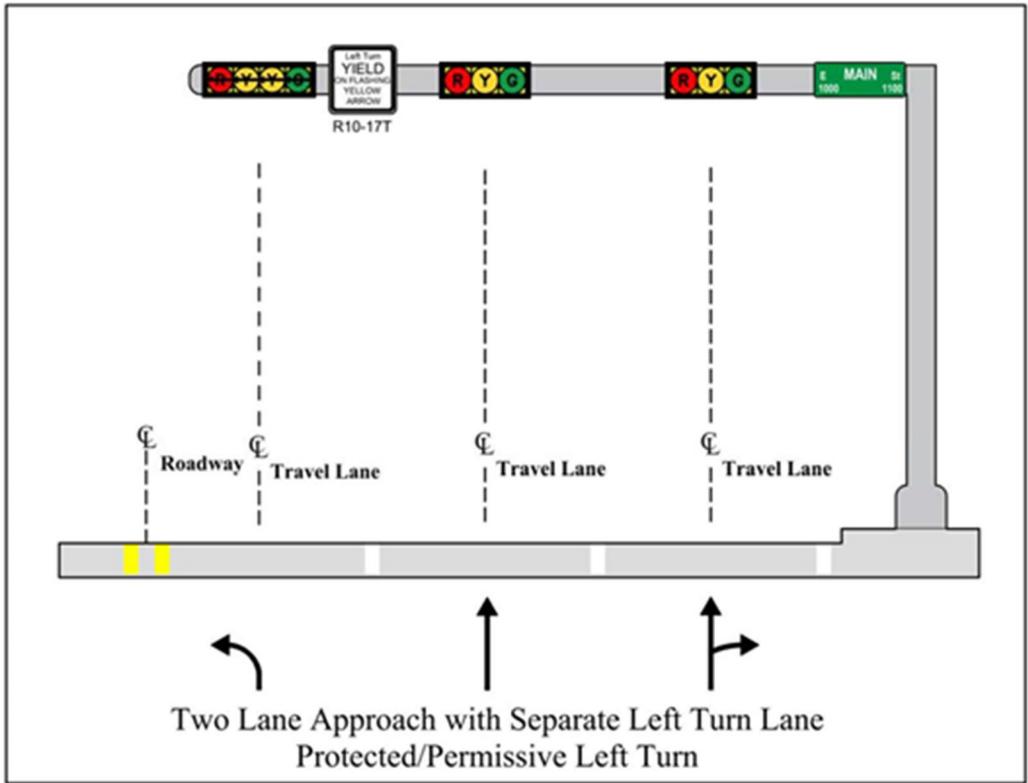


Figure 7

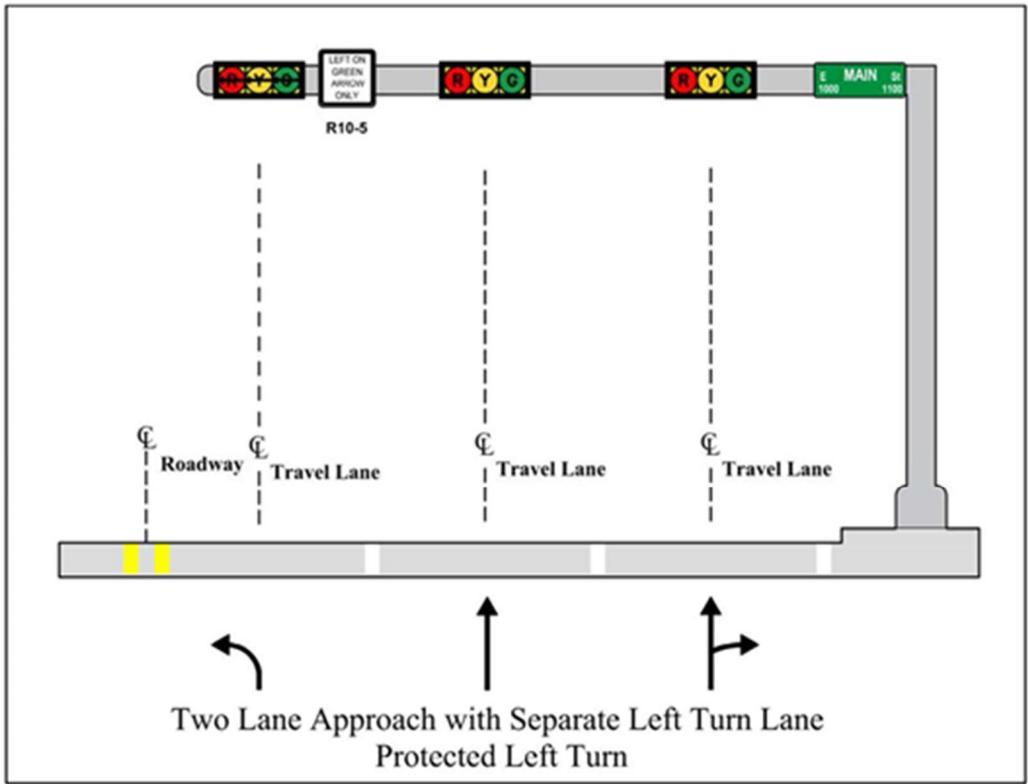


Figure 8

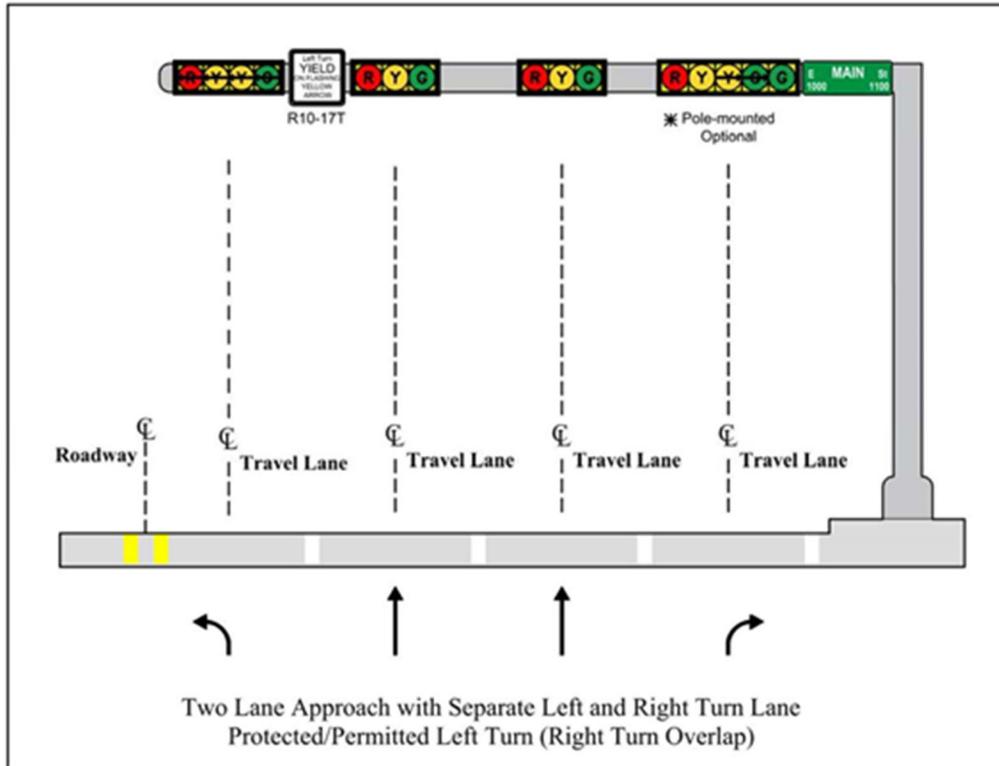


Figure 9

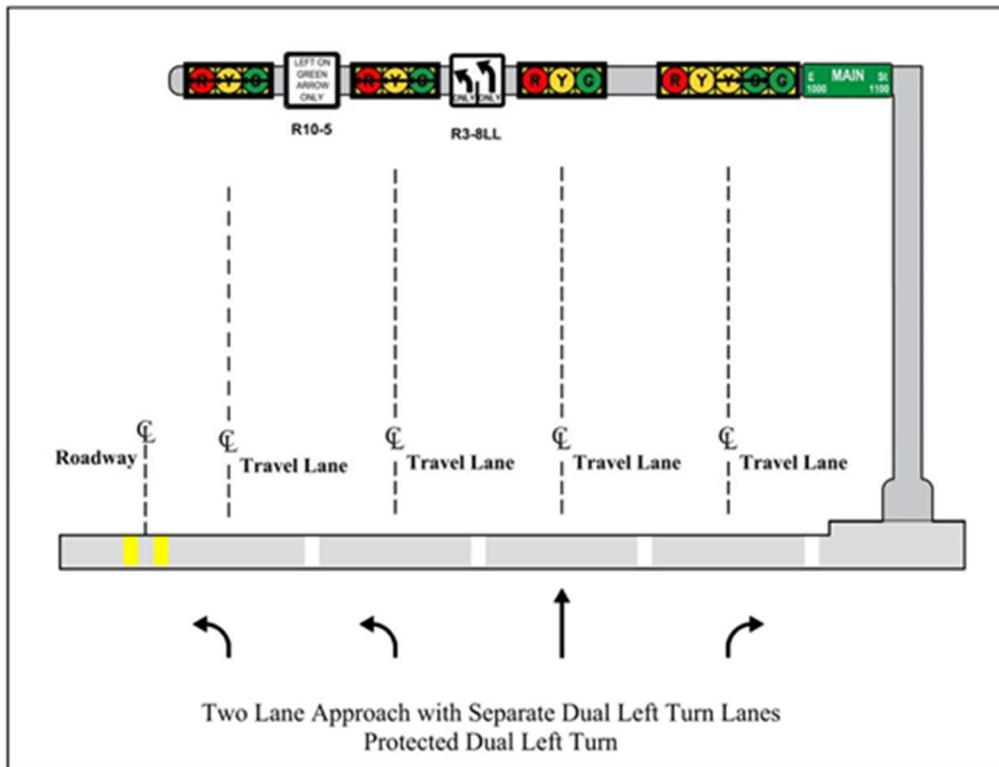


Figure 10

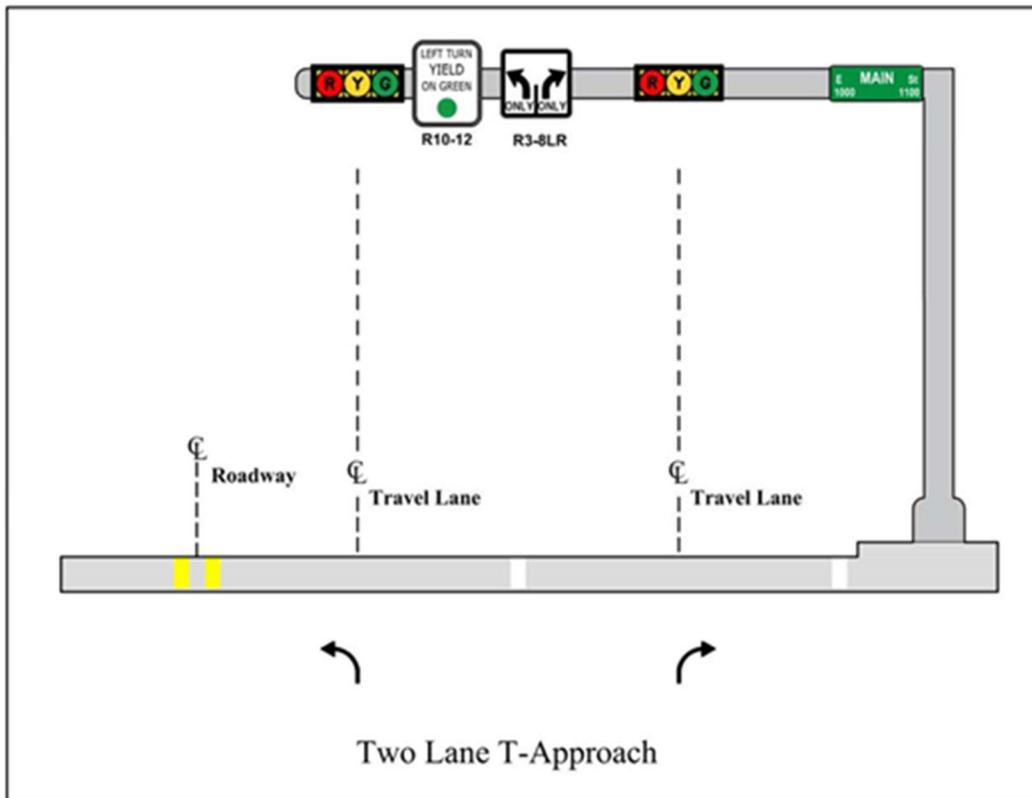


Figure 11

PROPOSED TRAFFIC SIGNAL POLE SCHEDULE										
POLE NUMBER	POLE TYPE	MAST ARM		SIGNALS		LUMINAIRE TYPE	PED PB TYPE/SIGN	REMARKS	LOCATION	STANDARDS
		SIGNAL	LUMINAIRE	MOUNTING	FACE					
	TYPE 2	40'	15'	3 - ASTROBRAC 1 - SIDE OF POLE	1 - H3L 2 - H3 1 - V3L	106-WATT SYSTEM MAX LED COBRA HEAD LUMINAIRE	-	PRE-EMPT SENSOR (DUAL TURRETS) WIMAX ANTENNA SPP RADIO SIGNS: S10 = R10-5L (30"x36") S11 = STREET NAME S12 = R10-5L (30"x36")	AT APPROX: POLE C: STA. 2+88, 51' RT RICHMOND AVE. CONST ☑	02893-02 02893-03 02893-04A 02893-04B 02893-05 02893-09
	TYPE 2	40'	15'	3 - ASTROBRAC 2 - SIDE OF POLE	1 - H3L 2 - H3 1 - V3L 1 - GDP	106-WATT SYSTEM MAX LED COBRA HEAD LUMINAIRE	POLARA NAVIGATOR R10-3F (R)	PRE-EMPT SENSOR (DUAL TURRETS) SIGNS: S1 = R10-5L (30"x36") S2 = STREET NAME S3 = R10-5L (30"x36")	AT APPROX: POLE D: STA. 2+83, 52' LT RICHMOND AVE. CONST ☑	02893-02 02893-03 02893-04A 02893-04B 02893-05 02893-09
	TYPE 2	40'	15'	3 - ASTROBRAC 2 - SIDE OF POLE	1 - H3L 2 - H3 1 - V3L 1 - CDP	106-WATT SYSTEM MAX LED COBRA HEAD LUMINAIRE	POLARA NAVIGATOR R10-3E (R)	PRE-EMPT SENSOR (DUAL TURRETS) SPP RADIO (UJUL IURH:1S) SIGNS: S4 = R10-5L (30"x36") S5 = STREET NAME S6 = R10-5L (30"x36")	AT APPROX: POLE E: STA. 3+92, 56' LT RICHMOND AVE. CONST ☑	02893-02 02893-03 02893-04A 02893-04B 02893-05 02893-09
	TYPE 1	35'	15'	3 - ASTROBRAC 1 - SIDE OF POLE	1 - H3L 2 - H3 1 - V3L	106-WATT SYSTEM MAX LED COBRA HEAD LUMINAIRE	-	PRE-EMPT SENSOR (DUAL TURRETS) SIGNS: S7 = R10 6L (30"x36") S8 = STREET NAME S9 = R10-5L (30"x36")	AT APPROX: POLE F: STA. 4+14, 46' RT RICHMOND AVE. CONST ☑	02893-02 02893-03 02893-04A 02893-04B 02893-05 02893-09
	PED POLE 15'	-	-	1 - SIDE OF POLE	1 - GDP	-	POLARA NAVIGATOR R10-3E (L)	-	AT APPROX: POLE H: STA. 3+92, 54' RT RICHMOND AVE. CONST ☑	02893-02 02893-03 02893-06 02893-07
	PED POLE 15'	-	-	1 - SIDE OF POLE	1 - CDP	-	POLARA NAVIGATOR R10-3E (L)	-	AT APPROX: POLE G: STA. 3+95, 43' RT POLE L: STA. 2+78, 49' RT POLE N: STA. 2+88, 51' LT POLE Q: STA. 4+03, 51' LT RICHMOND AVE. CONST ☑	02893-02 02893-03 02893-06 02893-07
	PED POLE 15'	-	-	2 - SIDE OF POLE	2 - CDP	-	POLARA NAVIGATOR R10-3E L (R)	-	AT APPROX: POLE J: STA. 3+38, 50' RT POLE M: STA. 2+78, 49' RT POLE P: STA. 3+46, 54' LT POLE R: STA. 4+94, 03' RT RICHMOND AVE. CONST ☑	02893-02 02893-03 02893-06 02893-07
	PED POLE 15'	-	-	1 - SIDE OF POLE	1 - CDP	-	POLARA NAVIGATOR R10-3E (R)	-	AT APPROX: POLE K: STA. 2+90, 59' RT RICHMOND AVE. CONST ☑	02893-02 02893-03 02893-06 02893-07
TRAFFIC SIGNAL CONTROLLER										
CABINET	TYPE	CONTROLLER	AUX. CONTROL	REMARKS	LOCATION	STANDARDS				
	METERED PEDESTAL SERVICE UL TYPE 3R	METERED PEDESTAL SERVICE WITH ONE 30 AMP AND ONE 60 AMP BREAKER AND PHOTOCCELL	-	PROVIDE METER SOCKET WINDOW 4" H X 6" W	AT APPROX: STA. 2+92, 75' LT (CENTER OF CABINET) RICHMOND AVE. CONST ☑	02893-14				
	TYPE 340 ITS	2070LX CONTROLLER UNIT W/ 2075-1C CPU MODULE WITH GPS SERIAL COMMUNICATIONS MODULE & UPS BATTERY BACK-UP SYSTEM	-	STANDARD SPECIFICATION 16730 & 16731 UNINTERRUPTIBLE POWER SUPPLY - STANDARD SPECIFICATION 16732 FIELD HARDENED ETHERNET SWITCH (SIX COPPER PORTS ONLY) - STANDARD SPECIFICATION 16733 WIMAX - STANDARD SPECIFICATION 16734 GPS SERIAL COMMUNICATIONS MODULE - STANDARD SPECIFICATION 16785	AT APPROX: STA. 2+86, 57' RT (CENTER OF CABINET) RICHMOND AVE. CONST ☑	02893-10C				

STOP LINE AND PREFORMED LOOPS LOCATIONS		
ITEM BY DIRECTION	STATION S. DAIRY ASHFORD RD.	OFFSET
SOUTHBOUND		
STOP LINE @ GUTTER	4+32	39' LT
STOP LINE @ CENTERLINE	4+32	01' LT
SOUTHBOUND (THRU LANES)		
PHASE 4 CALL (6'X6') LOOP L4-1A, L4-2A	4+33	
PHASE 4 PULSE LOOPS		
L4-1B LEADING EDGE (6'X6')		CENTERED IN LANE
L4-2B LEADING EDGE (6'X6')		
PHASE 2 DOWNSTREAM LOOPS		
L4-1C, L4-2C (6'X6')	2+15.62	
SOUTHBOUND (LEFT TURN LANE)		
PHASE 7 PRESENCE LOOPS		
L7-1A (6'X6') LOOP	4+18	CENTERED IN LANE
L7-1B (6'X6') LOOP	4+33	
L7-1C (6'X6') LOOP	4+48	
L7-1D (6'X6') LOOP	4+63	
NORTHBOUND		
STOP LINE @ GUTTER	3+18	39' RT
STOP LINE @ CENTERLINE	3+18	03' RT
NORTHBOUND (THRU LANES)		
PHASE 8 CALL (6'X6') LOOPS L8-1A, L8-2A	3+14	
PHASE 8 PULSE LOOPS		
L8-1B LEADING EDGE (6'X6')		CENTERED IN LANE
L8-2B LEADING EDGE (6'X6')		
PHASE 2 DOWNSTREAM LOOPS		
L8-1C, L8-2C (6'X6')	5+27	
NORTHBOUND (LEFT TURN LANE)		
PHASE 3 PRESENCE LOOPS		
L3-1A (6'X6') LOOP	3+26	CENTERED IN LANE
L3-1B (6'X6') LOOP	3+11	
L3-1C (6'X6') LOOP	2+96	
L3-1D (6'X6') LOOP	2+81	
ITEM BY DIRECTION	STATION RICHMOND AVE.	OFFSET
EASTBOUND		
STOP LINE @ GUTTER	2+84	39' RT
STOP LINE @ CENTERLINE	2+84	01' RT
EASTBOUND (THRU LANES)		
PHASE 2 CALL (6'X6') LOOPS L2-1A, L2-2A	2+76	
PHASE 2 PULSE LOOPS		
L2-1B LEADING EDGE (6'X6')		CENTERED IN LANE
L2-2B LEADING EDGE (6'X6')		
PHASE 2 DOWNSTREAM LOOPS		
L2-1C, L2-2C	5+28	
EASTBOUND (LEFT TURN LANE)		
PHASE 5 PRESENCE LOOPS		
L5-1A (6'X6') LOOP	2+91	CENTERED IN LANE
L5-1B (6'X6') LOOP	2+76	
L5-1C (6'X6') LOOP	2+61	
L5-1D (6'X6') LOOP	2+46	
WESTBOUND		
STOP LINE @ GUTTER	3+98	40' LT
STOP LINE @ CENTERLINE	3+98	05' LT
WESTBOUND (THRU LANES)		
PHASE 6 CALL (6'X6') LOOPS L6-1A, L6-2A	4+00	
PHASE 6 PULSE LOOPS		
L6-1B LEADING EDGE (6'X6')		CENTERED IN LANE
L6-2B LEADING EDGE (6'X6')		
PHASE 6 DOWNSTREAM LOOPS		
L6-1C, L6-2C	1+80	
WESTBOUND (LEFT TURN LANE)		
PHASE 1 PRESENCE LOOPS		
L1-1A (6'X6') LOOP	3+85	CENTERED IN LANE
L1-1B (6'X6') LOOP	4+00	
L1-1C (6'X6') LOOP	4+15	
L1-1D (6'X6') LOOP	4+30	

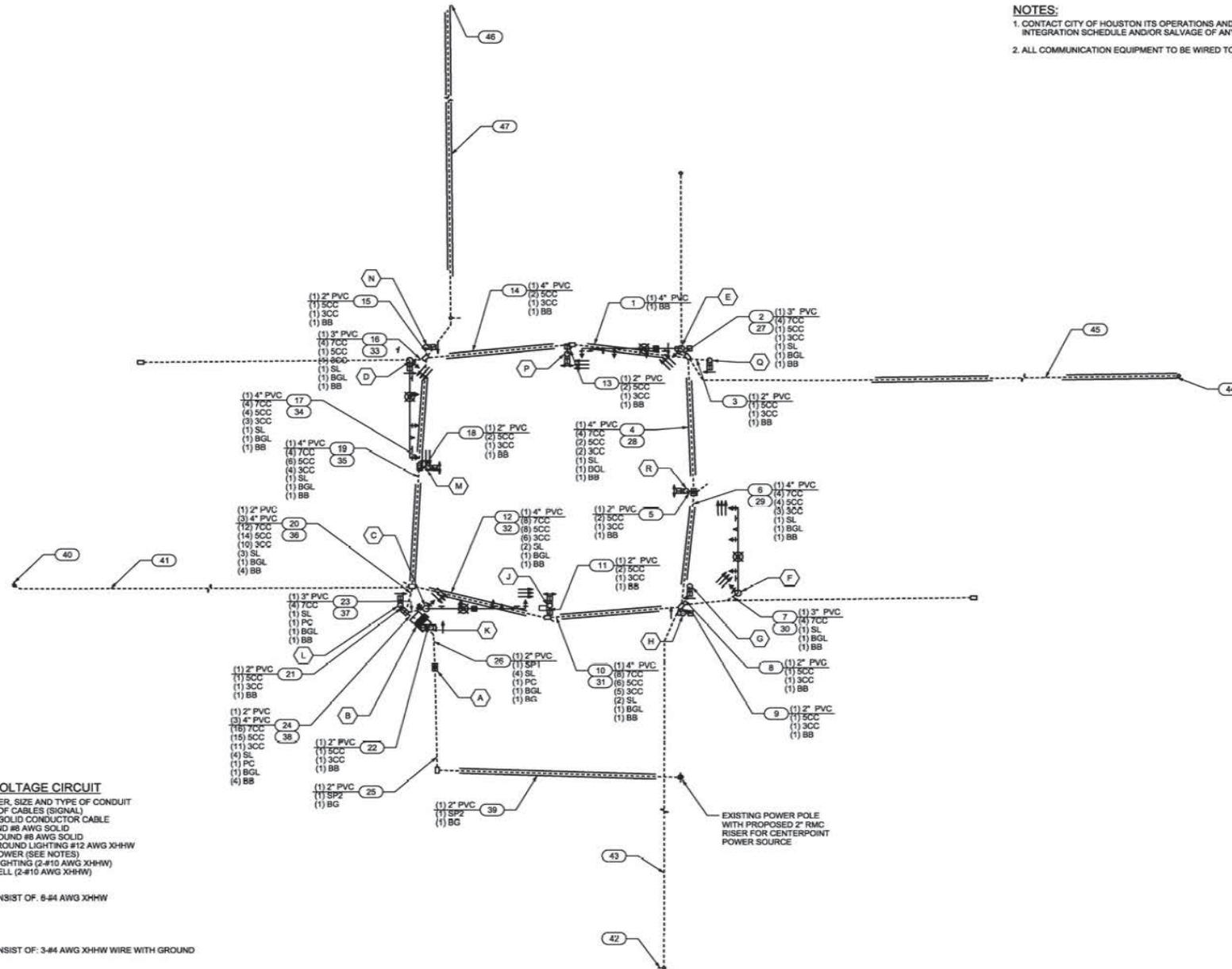
No.	Date	Description	App.

CITY OF HOUSTON	
HOUSTON PUBLIC WORKS	
CITYWIDE TRAFFIC SIGNAL REBUILD PACKAGE	
TRAFFIC SIGNAL POLE SCHEDULE	
S. DAIRY ASHFORD ROAD AT RICHMOND AVENUE	
WGS NUMBER	
N-XXXX-XXX-X	
DRAWING SCALE	
NOT TO SCALE	
CITY OF HOUSTON PW	
SHEET NO. 30 OF 78	

- NOTES:**
- ALL SIGNAL HEADS WILL BE 12" WITH LOUVERED BLACK BACK PLATES AND YELLOW HOUSING
 - POLES G, K, L, M AND Q WILL HAVE CONCRETE FOUNDATION
 - POLES H, J, N, P AND R WILL HAVE SCREW-IN ANCHOR FOUNDATION

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\"/>

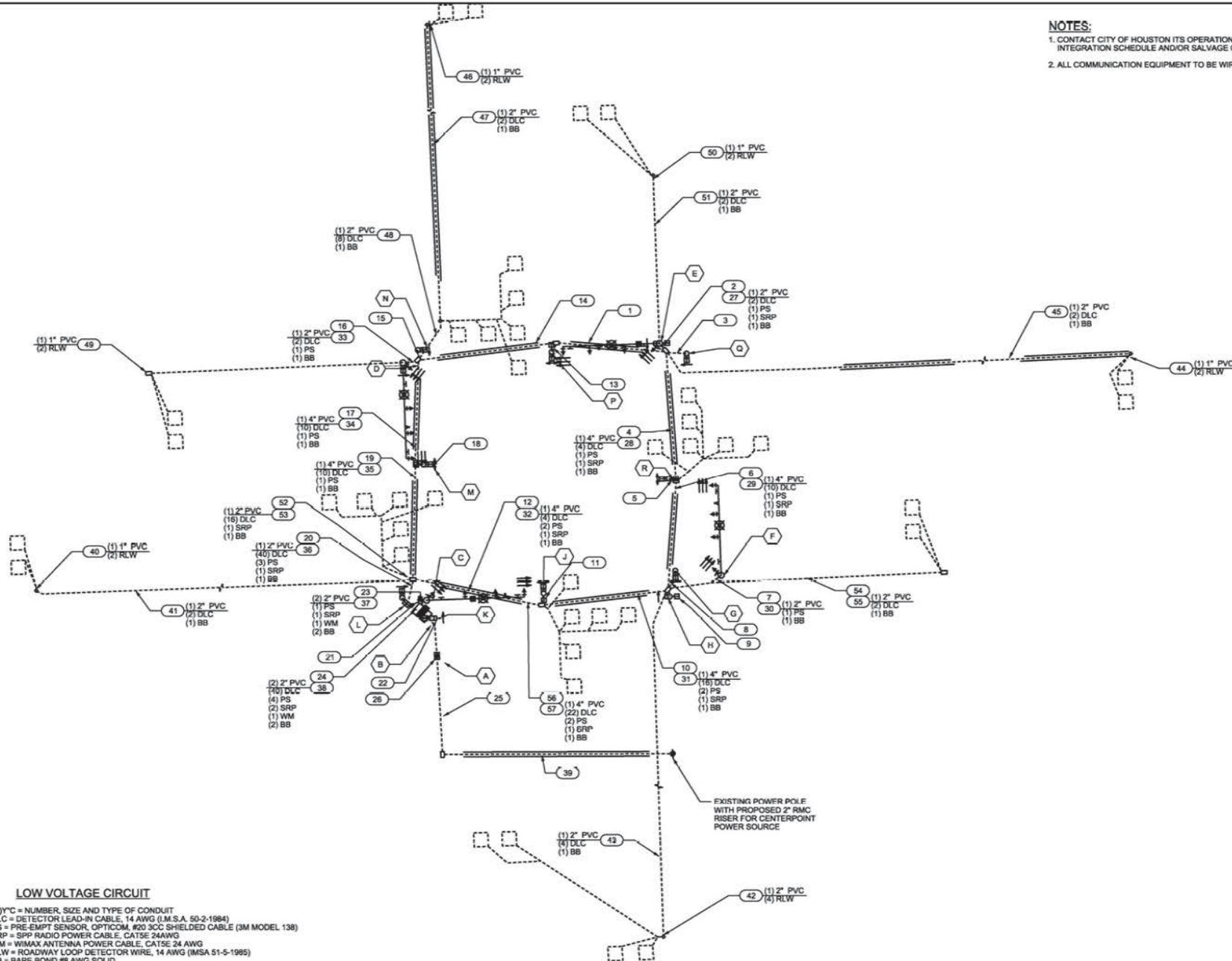
- NOTES:**
 SP1 SHALL CONSIST OF: 6-#4 AWG XHHW
 2 - WHITE
 1 - BLACK
 1 - RED
 2 - GREEN

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			
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)Y\"/>

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			

City of Houston

Design Manual

Chapter 16

MISCELLANEOUS

Chapter 16

MISCELLANEOUS

16.01 CHAPTER INCLUDES

- A. Criteria for miscellaneous facilities within the public right of way including:
 - 1. Tree protection
 - 2. Residential subdivision markers
 - 3. Sky bridges
 - 4. Wireless Facility, Ground Equipment, and/or Licensee Pole

16.02 REFERENCES

- A. Refer to list of references in Chapter 1, General Requirements
- B. City of Houston Code of Ordinances
- C. American Standard for Nursery Stock (ANSI Z60.1).

16.03 DEFINITIONS

- A. Drip line - Imaginary circle drawn around a tree, extending to the tree's branching limit.
- B. Entrance marker - Ornamental gate(s), column(s), or other ornamental works of wood, iron, masonry, earth or other materials denoting the entrance to a platted and recorded single family residential subdivision.
- C. Esplanade - Unpaved area between two paved roadway sections.
- D. Parkway - Area lying between the street curb or edge of roadway paving and the adjacent property line.
- E. Protected Tree - Corridor tree, designated tree, green corridor tree or parkway tree as defined by Chapter 33 of the City of Houston Code of Ordinances.
- F. Street Right-of-Way - Entire width between the boundary lines of every way which is held by the city, county, state or otherwise by the public in fee or dedication when any part thereof is open to the use of the public for purposes of vehicular travel.

- G. Tree-any evergreen or deciduous tree which at the time of planting has a caliper equal to or greater than 1 1/2 inches as measured six inches above the root collar, which is not less than six feet in height as measured from the root collar, and which meets the Standard for Nursery Stock Specifications.

16.04 TREE PROTECTION

A. Tree Protection Requirements

Tree protection requirement is designed to protect trees in a time of any construction activity, including, without limitation, construction or repair of buildings or other structures, installation or repair of utilities, or installation or repair of streets or sidewalks within the drip line circle area of any protected tree that is not to be removed, without complying with the applicable provisions.

1. Trees to be preserved must be clearly tagged in the field with ribbon.
2. Protection barrier shall be composed of wood, wire, snow fence and braces of similar non injurious material.
3. Tree wells shall be made of a durable material and set a minimum of four feet from any tree they are designed to protect.
4. Retaining walls of a durable material, i.e., stone, or treated lumber, are to be constructed around each tree immediately after the grade is lowered. A retaining wall must be at least four feet from the tree it is designed to preserve.
5. Any under story clearing within six feet of existing tree trunks should be done by hand.
6. No building materials are to be stacked or stockpiled within the drip line or within six feet of any tree to be preserved, whichever is greater.
7. Topsoil shall not be stockpiled within the drip line or within six feet of any tree to be preserved, whichever is greater.
8. Selective thinning of dead or dying vegetation, tree stumps and other undesired growth is required in buffer areas. Supplemental vegetation shall comply with the landscape buffer requirements.
9. Tree boarding should be used if work is required with in construction fencing.
10. Where possible, utility lines shall be tunneled beneath tree roots in order to protect feeder roots, rather than trenched or open cut.

B. Tree Root Barriers

1. Tree root barriers will be used for planting of new trees, to prevent the uncontrollable spread of tree roots, following root pruning, to protect land and hardscapes from root damage.
2. It can be designed for surround or linear application depends on the hardscape to be protected, distance from surrounding trees, the aggressiveness of the tree, rooting depth of the tree(s).
3. Holes for the tree should be excavated two feet greater in width than the diameter of the soil ball.
4. The size of root barriers should be three times the diameter of the root ball.

16.05 RESIDENTIAL SUBDIVISION MARKERS

A. General Considerations/Restrictions

1. Subdivision markers may display the name of the subdivision or neighborhood but shall not contain any commercial advertising, announcement, or other signage.
2. An electronic sign or marker is not allowed.
3. Subdivision markers may not be located on, extend on to, nor:
 - a. Intrude upon any portion of a roadway.
 - b. Intrude upon any portion of a sidewalk or pedestrian pathway in the public right of way.
 - c. Create any hazardous condition or obstruction for vehicular or pedestrian travel upon a public street.
 - d. Be located within five (5) feet of underground storm, sanitary sewer, water lines and all appurtenances.
 - e. Be located within 25 feet of a fire hydrant.
 - f. Restrict or block driver's visibility or sight line of traffic, pedestrians, bikeway travelers, or other public user within the right of way.
 - g. Be located within the visibility triangle.

B. Locations

1. Subdivision markers may be located at the main entrance to a subdivision and at secondary entrances.
2. The subdivision marker must be within the boundaries of the subdivision or single family residential development they identify.
3. Locations where multiple subdivisions interface will be reviewed on a first come, first serve basis for purposes of establishing allowable subdivision marker locations.
4. The City Engineer's approval will be required for installation of more than two markers to identify a single subdivision.
5. The following are minimum allowable entrance marker location guidelines:
 - a. 50 feet from the median nose for mid-block median openings,
 - b. 75 feet from the median nose for intersection openings,
 - c. 100 feet from the median nose of median for left turn lanes,
 - d. Seven (7) feet from the inside median curb (this dimension may be reduced if community has entered into maintenance or Adopt-an-Esplanade agreement with Houston Parks and Recreation Department and does not create a hazardous condition),
 - e. Within right-of-way adjacent to property line.

C. Size

1. Maximum height above the ground surface shall not be greater than six (6) feet.
2. Height shall be limited to not obstruct sight lines of vehicular and pedestrian traffic.
3. Maximum horizontal width shall not exceed eight (8) feet.
4. Maximum display area shall not exceed 36 square feet.
5. Width shall be limited to not obstruct sight lines of vehicular and pedestrian traffic.
6. Variances to the size requirements for a proposed subdivision marker must be granted by the City Engineer.

D. Materials

1. Materials for base structure shall be permanent, durable, and weather resistant.
2. Marker shall provide pleasing aesthetic elements, clarity, and professional design appearance.
3. Marker letters and/or other elements should be of non-corrosive and non-staining materials, and coated properly to prevent staining and discoloration.
4. Material selections should be capable of clean-up from graffiti mark ups.

E. Utilities

1. Marker shall be of size and location to not impede or restrict the City's ability to maintain, repair, or replace the existing utility line(s).
2. Existing utilities shall be field located prior to the construction of the entrance marker. It is recommended that existing utilities shall be field located prior to preparation of the measured drawings for the entrance marker and its location.

F. Plan Reviews/Permits

1. Drawings shall be submitted to the office of City Engineer for review and approval.
2. Drawings shall show existing surface and buried facilities within the right of way or easements in plan view.
3. If entrance marker design includes landscaping, the growth characteristics of the plants shall be submitted with the drawings.
4. Subdivision markers are considered encroachments in the public right-of-way and shall meet the encroachment requirements set out for subdivision markers in Chapter 41 of the City of Houston Code of Ordinances.
5. A construction permit will be required prior to construction of a subdivision marker within the public right of way or public easement. The construction permit will be obtained by the applicant from the Houston Permitting Center, Traffic/Paving Permits Section, upon submittal of approved plans and appropriate encroachment permit.

16.06 SKYBRIDGES

A. General Requirements

1. A skybridge, as defined in this Chapter, permits pedestrian and other access between two adjacent structures (not necessarily under the same property ownership) via an elevated structure or bridge within the public right of way.
2. Skybridges may be open air or conditioned space depending upon the specific location and application.
3. Skybridges shall not interfere with the operation of the public right of way across which it traverses and is subject to following height restrictions:
 - a. The bottom of the lowest portion of the skybridge over the public right of way must be a minimum of 18.5 feet above the roadway surface.
 - b. Clearances less than 18.5 feet require review a variance and approval of the City Engineer.
4. Skybridges proposed to traverse an intersection of two public street rights of way requires approval of the City Engineer.
5. Skybridges are considered encroachments in the public right-of-way and shall meet the encroachment requirements set out in Chapter 41 of the City of Houston Code of Ordinances including all administrative, permitting and fees.

16.07 WIRELESS SERVICE FACILITIES

A. Definitions as follows are a partial list of those defined in Local Government Code 284 – Deployment of Network Nodes in Public Right-of-Way and are repeated here for clarity:

1. “Design District” means an area that is zoned, or otherwise designated by municipal code, and for which the city maintains and enforces unique design and aesthetic standards on a uniform and nondiscriminatory basis.
2. “Historic District” means an area that is zoned or otherwise designated as a historic district under municipal, state, or federal law.
3. “Network Provider” means a) a wireless provider; or b) a person that does not provide wireless services and that is not an electric utility but builds or installs on behalf of a wireless service provider.

B. Wireless Service Facilities shall comply with Local Government Code 284 – Deployment of Network Nodes in Public Right-of-Way and City Ordinance Chapter 40, Article XXI – Facilities in the Public Right-of-Way.

- C. A Network Provider shall comply with the design and aesthetic standards of a Historic or Design District and explore the feasibility of using certain camouflage measures to improve the aesthetics of the new network nodes, new node support poles, or related ground equipment, or any portion of the nodes, poles, or equipment, to minimize the impact to the aesthetics in a historic district or on a design district's decorative poles.
- D. Prior to submitting drawings to the City of Houston, the Network Provider shall coordinate with the Historic or Design District. Submit the evidence of coordination with the design drawings to the Houston Permitting Center located at 2nd floor of 1002 Washington Ave, Houston TX 77002.
- E. Wireless Service Facilities and related equipment shall be placed in accordance with the following requirements:
1. Within 2 feet of the right-of-way line
 2. Not within 10 feet of a driveway.
 3. Not within 50 feet (measure from the right-of-way line) of a local street intersection and 100 feet (measure from the right-of-way line) of a major street intersection.
 4. Not within any sidewalk area or within 3 feet of the centerline of a sidewalk which is less than 5 feet in width.
 5. If unable to place within 2 feet of right-of-way line, then Wireless Service Facilities shall be placed no closer than 2 feet of the back of curb of any roadway.
 6. Poles shall be installed along arterials or residential collectors.
 7. For any public right-of-way that is not more than 50 feet wide:
 - (a) No new node support pole shall be installed on either side of the right-of-way that border a street that is next to a municipal park.
 - (b) No new node support pole shall be installed on either side of the right-of-way that border a street that is next to residential areas (single-family, multifamily, town home, duplex, apartment, or any other residential configuration) or undeveloped land that is platted for residential use.
 8. Pole(s) can be installed at the side of commercial areas across the street from residential areas (single-family, multi-family, town home, duplex, apartment, or any other residential configuration), when the public street right-of-way is more than 50 feet wide.
 9. Pole(s) can be installed in residential areas (single-family, multi-family, town home, duplex, apartment, or any other residential configuration) but must be installed at the lot line when the public street right-of-way is more than 50 feet and both sides of the

street are residential.

10. No pole(s) are to be installed in front of the front door or entry way of any single-family, multi-family, town home, duplex, apartment, or any other residential configuration, either on the same side of the street or directly across from the structure's door or entry way.
11. Proposed equipment (i.e. power supply and cabinets) associated with the Wireless Service Facilities can be placed in line with existing poles if the proposed node is co-located on the existing pole. The edge of the equipment shall not be any closer to the curb than the associated pole.
12. Sidewalk, public utilities and other public infrastructure can be relocated if the proposed pole(s) or equipment installation cannot meet required clearances.
13. The use of City infrastructure is prohibited without the approval of the City Engineer and the City Bridge Engineer/Traffic Engineer or the Director of the operations unit responsible for its maintenance. The standard approval is dependent on the type of City infrastructure.

END OF SECTION

City of Houston

Design Manual

Chapter 17

**BICYCLE, TRANSIT AND PEDESTRIAN DESIGN
REQUIREMENTS**

Chapter 17

BICYCLE, TRANSIT AND PEDESTRIAN DESIGN REQUIREMENTS

17.01 CHAPTER INCLUDES

- A. Geometric design guidelines for bicycle, pedestrian, and transit facilities.

17.02 REFERENCES

- A. Bicycle Master Plan (Houston Bike Plan), current edition
- B. Bicycle Parking Guidelines, Association of Pedestrian and Bicycle Professionals (APBP), current edition
- C. Designing for All Ages and Abilities - Contextual Guidance for High-Comfort Bicycle Facilities, NACTO, current edition
- D. Designing Walkable Urban Thoroughfares: A Context Sensitive Approach, ITE, current edition
- E. Houston Complete Streets and Transportation Plan
- F. Implementing Context Sensitive Design on Multimodal Thoroughfares, ITE, current edition
- G. Geometric Design of Highways and Streets ("The Green Book"), AASHTO, current edition
- H. Guide for the Development of Bicycle Facilities, AASHTO, current edition
- I. Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations, FHWA, current edition
- J. Parks Master Plan, current edition
- K. Roadside Design Guide, AASHTO, current edition
- L. Scenic Houston Streetscape Resource Guide
- M. Separated Bike Lane Planning and Design Guide, Federal Highway Administration Bicycle and Pedestrian Program, current edition
- N. Texas Manual on Uniform Traffic Control Devices (TMUTCD), TXDOT, current edition
- O. Transit Street Design Guide, NACTO, current edition

- P. Trail Sponsor Guidance Document, Harris County Flood Control District (HCFCD), current edition
- Q. Urban Bikeway Design Guide, NACTO, current edition
- R. Urban Street Design Guide, NACTO, current edition
- S. Accessibility Guidelines for Pedestrian Facilities in the Public Right Of Way (PROWAG)

17.03 DEFINITIONS

- A. Bicycle Master Plan - Also called the Houston Bike Plan, this is a planning document that outlines the City's vision for bicycling in the City and associated goals for achieving the stated vision.
- B. Bike Routes - A bicycle route can be designated along any bikeway type with signing and can provide guidance along a series of different styles of bicycle facilities.
- C. Bicycle Facility - parts of a bikeway which may be dedicated, non-dedicated or off-street.
 - 1. Dedicated On-Street Bicycle Facilities provide dedicated space for bicyclists separate from vehicle lanes within the roadway. These facilities can be located on the right side or left side of the road as appropriate based on engineering judgment to accommodate roadway conflicts such as transit vehicles, driveways, and turn movements. Examples include Standard Bike Lane, Buffered Bike Lane, Separated Bike Lane, and Side Path.
 - 2. Non-Dedicated On-Street Bicycle Facilities are on-street are on-street bikeways where bicyclists share the street with motor vehicle traffic. They can be high-comfort facilities on roadway with certain characteristics such as low traffic volumes and speeds.
 - 3. Off-Street Bicycle Facilities provide dedicated space for bicyclists separate from vehicle lanes outside of the roadway.
 - a. Trail: A facility for bicyclists and pedestrians outside of street right-of-way. For trails in Harris County Flood Control District rights-of-way, refer to the HCFCD "Trail Sponsor Guidance Document."
 - b. Side Path: A facility for bicyclists and pedestrians within the street right-of-way but outside the roadway. May consist of a sidewalk widened sufficiently to also support bicycle travel.

- D. Bicycle Parking:
1. Bicycle Parking Station: An area on or projecting on any public right-of-way upon which one or more bicycle racks may be affixed. Amenities may include bicycle fixit stations, bicycle lockers, etc.
 2. Bike Rack: A fixture upon which one or more bicycles may be parked.
 3. Specifications and guidelines for bike racks and their installation are provided in the Houston Bike Racks Application.
- E. Cycle Track - see Separated Bike Lane
- F. Conflict Zone - Space where one mode's primary path crosses another, and can occur at points of transition such as at intersections, bus stop, primary commercial driveways, etc. Pavement markings and signage should be used to define the space and communicate proper use by facility user whether a pedestrian, bicycle, car, or bus.
- G. Contraflow Bike Lanes - are typically separated bike lanes that flow against vehicle traffic on a one-way street. They can be used where the contraflow path closes an important gap in the network and other alternatives are not feasible. They can be installed in conjunction with a separated bicycle facility or non-dedicated bicycle facility on the opposite side of the road that flows in the same direction as vehicle traffic. Contraflow Bike Lanes may be located on the left side of a corridor.
- H. Delineator - treatment or object used to physically separate a bike facility from vehicular traffic or bike traffic from pedestrian traffic. They provide the comfort and safety that make separated bike lanes attractive facilities. The selection of separation type(s) should be based on the presence of on-street parking, overall street and buffer width, cost, durability, aesthetics, traffic speeds, emergency vehicle and service access, and maintenance. Example of delineators include but are not limited to:
1. Armadillo: Oblong low delineator that creates the physical separation for separated bike lanes.
 2. Raised curb buffer: Precast or concrete unit raised and spaced appropriately for continued maintenance and drainage that creates the physical separation for separated bike lanes.
- I. Desired Bicycle Width - Desirable width of a bicycle facility, based the facility's bicycle level of comfort as it relates to roadway traffic volumes, posted speeds and number of vehicular lanes.

- J. Houston Bike Plan Map - Map of all existing and planned City of Houston maintained bicycle facilities. The primary purpose of the map is to define a connected network of bicycle facilities that is updated on a regular basis. Additional facilities may be proposed based on individual project, neighborhood, and connectivity needs.
- K. Level of Comfort - A qualitative measure of the ability of a bicycle facility to provide an experience that the target user considers safe and comfortable. Elements that impact the level of comfort include volume and speed of adjacent automobile traffic, width of bicycle facility, number of driveway and intersection crossings, quality of pavement, and type and width of buffer provided between the bicycle facility and adjacent vehicle travel and parking lanes.
- L. Minimum Width - Alternative width to be considered where ROW is constrained. Values lower than the provided minimum result in a Low-Comfort facility and require review and approval of Houston Public Works staff.
- M. Transit Lane Configurations - Special roadway configurations that dedicate lanes/space to specific modes of transportation.
1. Transit Only Lane - Roadway lanes dedicated to transit vehicles, typically using signs and pavement markings. Vehicles and bicycles may use said lanes if necessary to make a turn or reach a business front or curbside parking (aka Business Access/Transit (BAT) lanes).
 2. Transit and Bicycle Shared Lane - Roadway lanes dedicated to bicycles and transit, ideal for low speed, low traffic roadways.
 3. Bus Turn Radii - Buses require more space on roadway infrastructure due to larger turning radii (20-40 ft). This factor must be considered when designing intersections and station/stop areas as well as the route alignment.
- N. Transit Stations/Stops - A designated location for boarding/alighting of a transit vehicle. Stations/stops may also provide transit users shelter to wait for vehicles.
1. Bus Stop - Any location designated as a boarding/alighting zone within a bus transit route.
 - a. Far Side Stop - A bus stop located beyond an intersection. It requires that buses cross the intersection before stopping to serve passengers.
 - b. Near Side Stop - A bus stop located on the approach side of an intersection. The buses stop to serve passengers before crossing the intersection.

- c. Mid-Block Stop - A bus stop located between two intersections. Traditionally, these stops are located next to a mid-block pedestrian crossing for safe crossing.
 2. Bypass Lane - Transit only lane or right turn lane at the near side of an intersection that allows transit vehicles to pass queued automobiles without a specific transit only signal.
 3. Transit Shelter - Infrastructure installed at transit stop locations to provide protection from the weather.
 4. Bus Boarding Pad - A rectangular slip resistant concrete pad connected to adjacent sidewalks and sidewalk ramps and provide access to transit vehicles.
 5. Bus Pullout - A dedicated space adjacent to roadway infrastructure that brings transit vehicles completely out of traffic into a dedicated space. Provides increased safety during the boarding/alighting process.
 6. Floating Bus Stop - A bus stop whose specific layout allows pedestrian and bicycle right-of-way to locate behind the bus boarding pad, safely separating different modes of transportation. Generally used when a dedicated/protected bike lane travels through a bus stop area.
 7. BRT Station - A transit station for bus rapid transit and its passengers.
 8. Rail Station - A transit station for trains. It is typically an off-street facility where passengers wait for, board, alight, or transfer between transit units (vehicles or trains). A station usually provides information and a waiting area and may have boarding and alighting platforms, ticket or farecard sales, fare collection, and other related facilities. Rail stations can be both at-grade or grade separated (for elevated guideways).
- O. Pedestrian Clear Zone - The primary, accessible area along a roadway where pedestrian travel is prioritized. Additional pedestrian clear zone widths are required within transit areas.
- P. Public Transit - Any form of publicly provided passenger transportation containing fixed/non-fixed routes and an established fare system.
1. Bus Transit - A form of public transit that uses bus fleets to provide fixed route and non-fixed route service.
 2. Bus Rapid Transit (BRT) - High capacity bus service with dedicated lanes and upgraded stations. BRT systems are characterized by several of the following components: exclusive transitways, enhanced stations, easily identified vehicles,

high frequency, all-day service, simple route structures, simplified fare collection, and ITS technologies.

3. Light Rail Transit (LRT) - A metropolitan electric railway system characterized by its ability to operate single cars or short trains along exclusive rights-of-way at ground level, on aerial structures, in subways, or occasionally, in streets, and to board and discharge passengers at track or car floor level.

Q. Retrofit Bicycle Facility - A bicycle facility provided through the reallocation of existing roadway pavement by reducing the width or number of existing vehicle or parking lanes or by using excess, unused pavement. Retrofits typically do not require the roadway widening or median reduction.

R. Separated Bike Lane - Dedicated on-street space for bikes separated from vehicle traffic with a buffer and a physical delineation device. Facilities can be one or two-way where a one-way facility is similar in nature to buffered bike lanes. Sometimes called a "Cycle Track."

S. Wayfinding - Directional signage to certain destinations such as libraries, parks, schools, trail entry points, and other attractions.

17.04 BICYCLE GEOMETRIC DESIGN REQUIREMENTS

A. General Design Guidance

1. The design of streets within the City of Houston shall consider options for high-comfort bicycle design solutions to improve bikeway connectivity and expansion of the planned bicycle network.
2. Low-comfort bicycle facilities should be avoided wherever possible. Proposed design of any facilities that would be considered low-comfort shall require prior approval from the Transportation and Drainage Operations.
3. The design of bicycle facilities shall accommodate the design bicyclist. The dimensions of a bicycle and associated operating space are summarized in Figure 17.1 and interpreted from the Guide for the Development of Bicycle Facilities, AASHTO.
4. Bicycling is an increasing component of multimodal thoroughfares. Bicycle facilities may be placed at sidewalk level, between sidewalk and pavement level, against the curb, between the curb and the parking lane, or between the parking lane and the vehicle travel lane. Bicycling facilities can benefit pedestrians by providing a buffer between the walking area and the vehicle traveled way.

- 5. Bicycle design speed for bicycle facilities is 12 mph.
- 6. Visibility of bicycle crossings may be emphasized by the use of bicycle-green pavement markings.

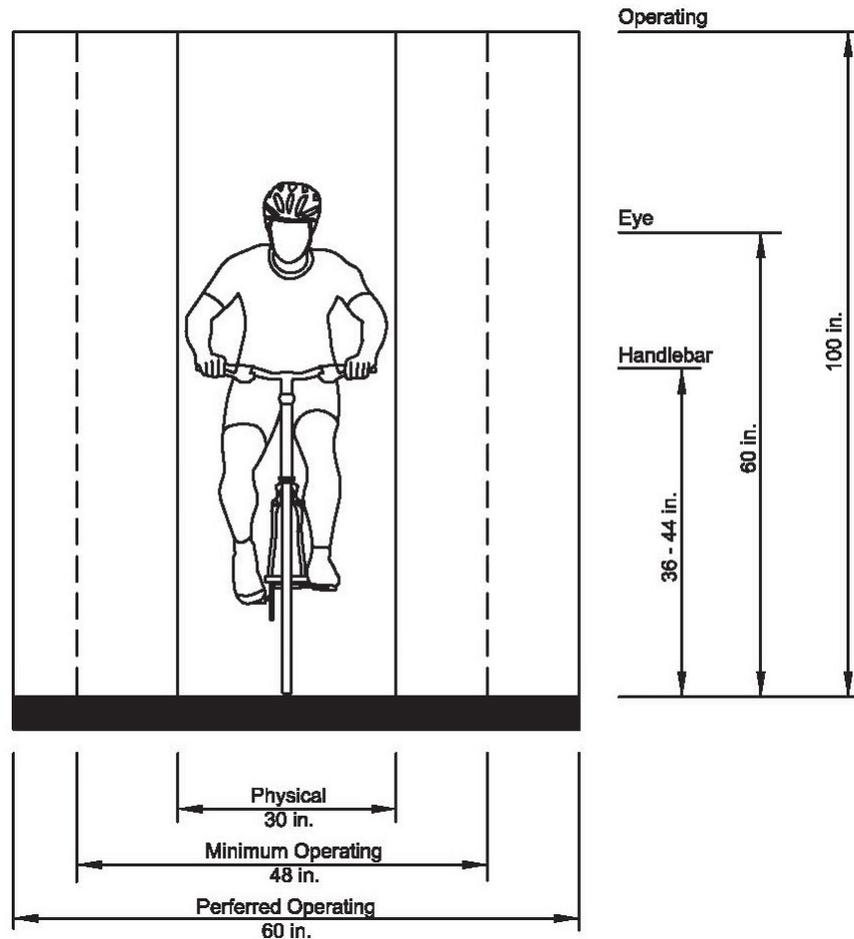


Figure 17.1 Design Bicyclist

B. Design Considerations

1. Bikeway facilities can be implemented as part of roadway reconstruction projects, through retrofit projects, or in the case of facilities outside of the roadway pavement, through special capital projects or other.
2. **Bicycle Retrofit Projects:** In some cases, retrofit bicycle facilities can be provided by reallocating existing pavement or by utilizing unused, excess pavement. A traffic study shall be required to determine the impact to other modes of travel on the roadway where an existing vehicular lane of traffic is removed. The traffic study shall be reviewed and approved by Houston Public Works staff before the retrofit can proceed. Houston Public Works may require a public meeting to gauge the public input on a proposed retrofit project. The flowchart below outlines the questions to be addressed by the traffic study.
3. Where delineator is being considered, the designer should evaluate its impacts on accessibility for other road users such as a bus accessing a bus stop, driveway ingress and egress, street sweeper, garbage collection truck, etc.

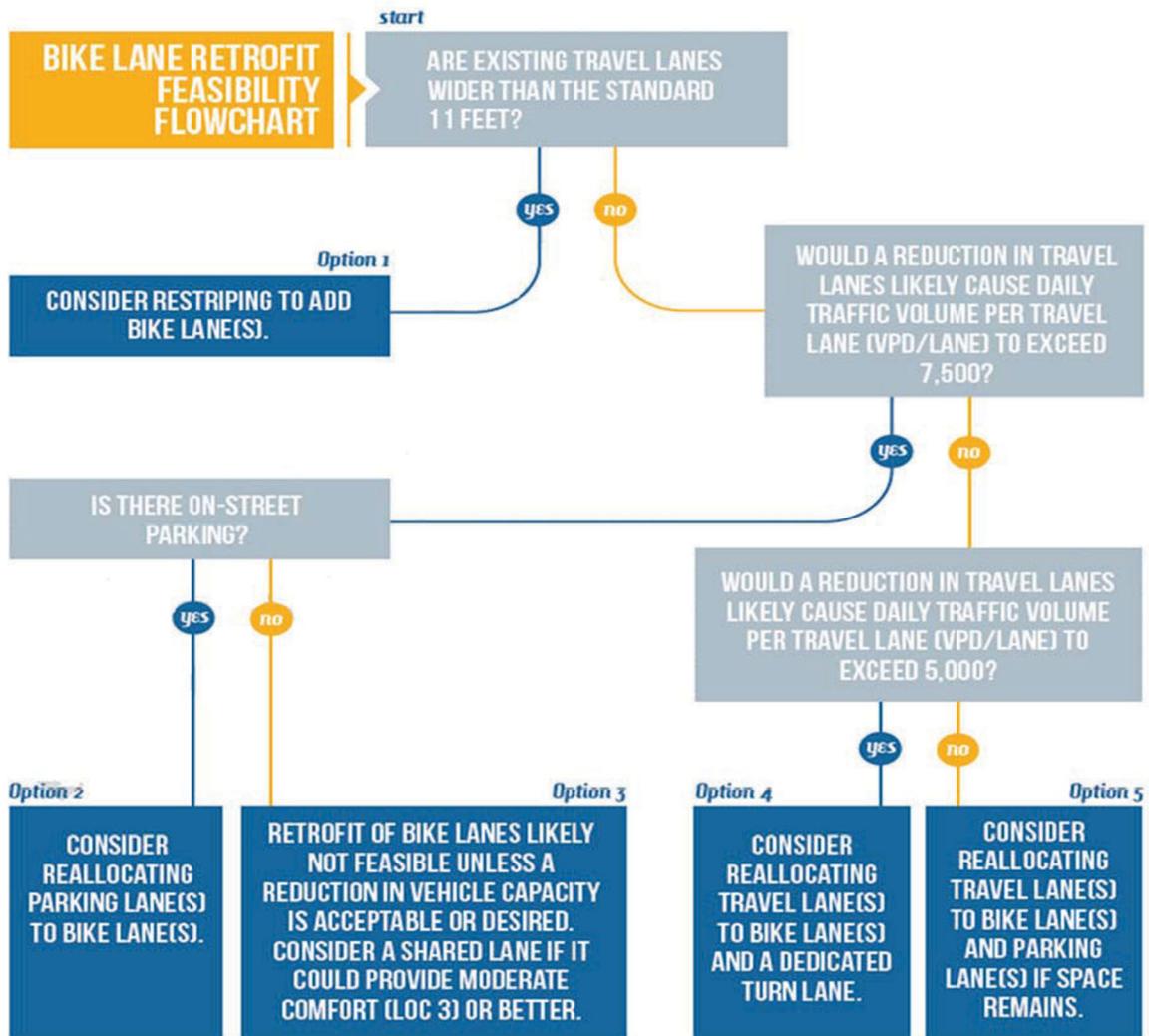
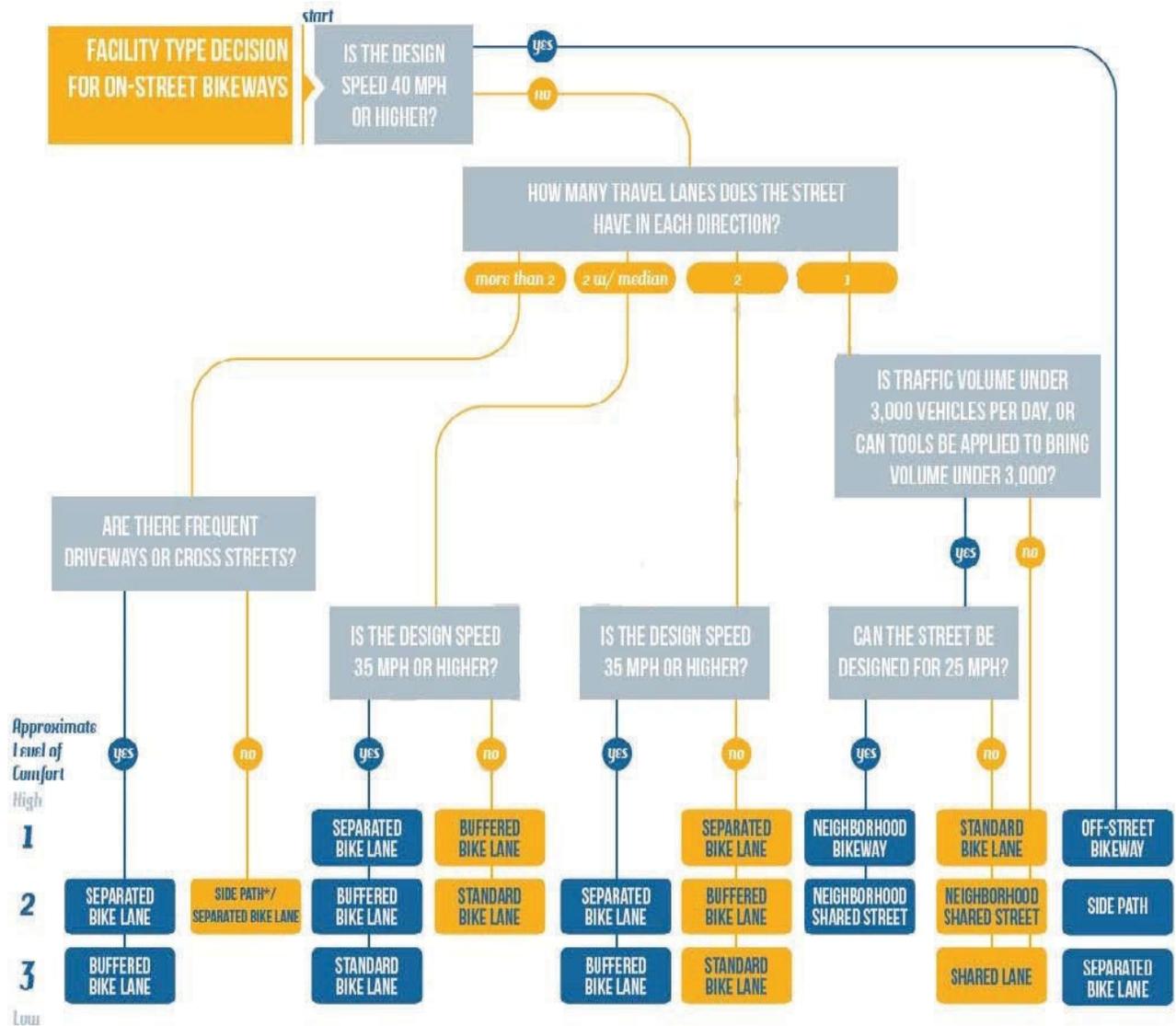


Figure 17.2 Bike Lane Retrofit

C. Selection of Bicycle Facility Type

New bicycle facilities shall provide as high a level of comfort for bicycle traffic as possible within the constraints of a given project. The flowchart below can be used to determine what type of bicycle facility may be appropriate for achieving a desired level of comfort with the specific roadway and traffic characteristics of a given project.



* Consideration should be given to designating Side paths as one way bikeways and providing them on both sides of a street corridor.

Figure 17.3 Bicycle Facility Type

D. Facility Type Standards and Guidelines

1. Dedicated Bicycle Facilities

- a. Standard Bike Lanes are delineated from vehicular traffic with pavement markings and do not provide a buffer.
 - i. Dimensions: Standard width is six (6)-ft (minimum five (5)-ft).
 - ii. Pavement Markings (Longitudinal): A six (6) inch solid white stripe shall be used to separate the bicycle lane from the adjacent vehicle lane.
 - iii. Pavement Marking (Symbols): In accordance with the Texas MUTCD Section 9c.04, a bicycle symbol and arrow markings shall be used to define bicycle lanes and should be placed at the beginning of a bike lane facility and the start of every block or at regular intervals as necessary to reinforce the intended use. See Standard Detail 01510-04 for pavement marking details.
 - iv. Signage: Bike lane signs (R3-17) and plaques (R3-17aP and R3-17bP) are required and should be placed at the beginning of a bike lane facility and at the start of every block or at regular intervals as necessary to reinforce the intended use.

For standard bike lanes design criteria, refer to City of Houston Standard Detail 01510-09.

- b. Buffered Bike Lanes can be provided on local streets, collectors and major thoroughfares. They are standard bike lanes with additional striped, delineated space separating the bicycle lane from the adjacent vehicle travel lane and/or parking lane. Buffered bike lanes can provide a higher level of comfort in given traffic conditions than standard bike lanes. Buffered bike lanes are generally preferred over of standard bike lanes for increased bicyclist comfort where ROW is sufficient.
 - i. Dimensions: The lane and buffer together shall be at least eight (8)-ft wide. Buffer may be reduced if a raised delineator is provided as approved by Houston Public Works. The minimum bicycle lane width is five (5)-ft.
 - ii. Pavement Markings (Buffer): The buffer shall consist of two six (6)-inch solid white lines, with six (6)-inch diagonal white hatching if three (3) -ft in width or wider. Spacing of hatching should be between 10 and 40 -ft as determined by the engineer to increase motorist compliance.
 - iii. Delineator: A raised, physical delineator shall be provided where buffer space is less than 2-ft between vehicles and bicycles and should be used for increased comfort based on engineering judgment. Examples include armadillos and raised curb buffer. Delineator selection should consider impacts on drainage, bus stops, street

- sweeping and where not specified here shall require approval from Houston Public Works.
- iv. Pavement Marking (Symbols): In accordance with the Texas MUTCD Section 9c.04, a bicycle symbol and arrow markings shall be used to define bicycle lanes and should be placed at the beginning of a bike lane facility and at the start of every block or at regular intervals as necessary to reinforce the intended use. See Standard Detail 01510-04 for pavement marking details.
 - v. Signage: Bike lane signs (R3-17) and plaques (R3-17aP and R3-17bP) are required and should be placed at the beginning of a bike lane facility and at the start of every block or at regular intervals as necessary to reinforce the intended use.

For buffered bike lanes design criteria, refer to City of Houston Standard Detail 01510-09.

- c. Separated One-way Bike Lanes can be provided on collectors and major thoroughfares. It is a dedicated on-street space for bikes, wide enough to allow for one-way bicycle traffic, separated from vehicle traffic with a buffer and, where applicable, a physical delineation device.
 - i. Dimensions: The buffer shall be designed to accommodate and complement the selected delineator device but should typically be at least three (3) -ft. Buffer may be reduced if raised delineators are provided as approved by Houston Public Works staff. The minimum bicycle lane width is five (5) -ft.
 - ii. Delineator: A raised, physical delineator shall be provided where the bike lane runs against the vehicular traffic (contra flow) or buffer space is less than 2-ft between vehicles and bicycles and should be used for increased comfort based on engineering judgment. Examples include armadillos and raised curb buffer. Delineator selection should consider impacts on drainage and street sweeping and where not specified here shall require approval from Houston Public Works staff.
 - iii. Pavement Markings (Buffer): Should complement the delineator type selected. For delineators utilizing a series of discrete elements (e.g. armadillos), a striped buffer shall be utilized and shall consist of two six (6)-in solid white lines, with six (6)-inch diagonal white hatching if three (3)-ft in width or wider. Spacing of hatching should be between 10 and 40-ft as determined by the engineer to increase motorist compliance.
 - iv. Pavement Marking (Symbols): In accordance with the Texas MUTCD Section 9c.04, a bicycle symbol and arrow markings shall be used to define bicycle lanes and should be placed at the beginning of a bike lane facility and at the start of every block or at regular intervals as necessary to reinforce the intended use. See Standard Detail 01510-04 for pavement marking details.

- v. Signage: Bike lane signs (R3-17) and plaques (R3-17aP and R3-17bP) are required and should be spaced at the beginning of a bike lane facility and at the start of every block or at regular intervals as necessary to reinforce the intended use.

For one-way separated bike lanes design criteria, refer to City of Houston Standard Detail 01510-09.

- d. Separated Two-way Bike Lanes: can be provided on collectors and major thoroughfares. It is a dedicated on-street space for bikes separated from vehicle traffic with a buffer and a physical delineation device wide enough to allow for two-way bicycle traffic.
 - i. Dimensions: The buffer shall be designed to accommodate and complement the selected delineator device but should typically be at least three (3)-ft. The minimum bidirectional bicycle lane width is ten (10)-ft.
 - ii. Delineator: A raised physical delineator shall be provided as additional buffer. Examples include armadillo and raised curb buffer. Delineator selection should consider impacts on drainage and street sweeping and shall require approval from Houston Public Works staff.
 - iii. Pavement Markings (Buffer): Should complement the delineator type selected. A striped buffer shall be utilized and shall consist of two six (6)-inch solid white (or yellow if contra flow) lines, with six (6)-inch diagonal white (or yellow) cross-hatching if three (3) -ft in width or wider. Spacing of hatching should be between 10 and 40 -ft as determined by the engineer to increase motorist compliance. Delineators are generally placed in the center of the striped buffer.
 - iv. Pavement Markings (Longitudinal): A dashed yellow line should be used to separate two-way bicycle traffic.
 - v. Pavement Marking (Symbols): In accordance with the Texas MUTCD Section 9c.04, a bicycle symbol and arrow markings shall be used to define bicycle lanes and should be placed at the beginning of a bike lane facility and at the start of every block or at regular intervals as necessary to reinforce the intended use. See Standard Detail 01510-04 for pavement marking details.
 - vi. Signage: Bike lane signs (R3-17) and plaques (R3-17aP and R3-17bP) are required and should be placed at the beginning of a bike lane facility and at the start of every block or at regular intervals as necessary to reinforce the intended use.
 - vii. If physical delineators are used, access should be considered for driveways, solid waste collection, bus stops, and mail delivery.

For two-way separated bike lanes design criteria, refer to City of Houston Standard Detail 01510-09.

- e. Side Paths are bike facilities that run alongside a roadway within the ROW. Side paths may be slightly raised from the street level or at the same grade as the sidewalk. Side paths may provide single or bidirectional bicycle traffic flow. Side paths may be designed as shared use space for bicycles and pedestrians or as dedicated single or double lane bicycle facilities separate from both pedestrian and vehicular traffic. Bicycle-dedicated side paths can be separated from pedestrian traffic physically with a buffer or simply with contrasting pavement materials or colors. Maintenance responsibilities for side paths should be determined before implementation. Side paths can be provided along any roadway regardless of the speed of adjacent traffic. However, they can present challenges when there are an abundance of driveways, intersections, and other conflict points.
 - i. Dimensions.
 - 1. A two-way, bidirectional side path should maintain a standard width of ten (10)-ft (minimum eight (8)-ft), and can be more if separated pedestrian traffic is desired.
 - 2. A buffer of at least three (3)-ft should be provided between the side path and the adjacent motor vehicle lane, and tree plantings incorporated for increased shading.
 - 3. Where pedestrian traffic and bicycle traffic are both heavy, a portion of the side path cross section should be designated for exclusive bicycle use. Designation may include unique pavement texture and/or colors, bike lane pavement markings, and/or signage. For two-way bicycle travel the width of this area is ten (10)-ft; minimum eight (8)-ft. For one-way bicycle travel the width of this area is six (6)-ft; minimum five (5)-ft. This is in addition to the width of the pedestrian travel area.
 - ii. Pavement Markings (Longitudinal): A dashed yellow line may be used to separate two-way bicycle traffic on bidirectional side paths.
 - iii. Pavement Marking (Symbols): For bicycle-exclusive side paths, a bicycle symbol and arrow markings may be used to define bicycle lanes and, if used, should be placed at the beginning of a bike lane facility and every block or at regular intervals as necessary to reinforce the intended use. See Standard Detail 01510-04.
 - iv. Signage: Signage should be provided to designate intended use of the side path. At a minimum, "Bike Route" signs should be provided at the start of the facility and at regular intervals.
 - v. Access Drives: Shall incorporate design considerations for enhanced visibility of the bicycle facility to motorized vehicle users. Prioritized mode at crossing should be clearly defined by signage and/or pavement markings. See E. CORRIDOR DESIGN CONSIDERATIONS of this section.

- vi. Ramps: Width of curb ramps that incorporate pedestrian and bicycle movements shall be equal to the width of the shared use path. Detectable warning surfaces shall extend the full width of the ramp run (excluding any flared sides).

For side path design criteria, refer to City of Houston Standard Detail 01510-09.

2. Non-Dedicated Bikeway Facilities

- a. Neighborhood Shared Streets are low speed, low volume, and typically residential streets shared by motor vehicles and bikes and marked with "Bike Route" signs and potentially wayfinding signage. This designation does not include additional treatments to manage vehicle speed or volume.
 - i. Pavement Markings: No special pavement markings are required. Shared Lane Markings may be used if the shared nature of the roadway should be emphasized to encourage driver compliance.
 - ii. Signage: Bike Route signs (D11-1) should be placed at regular intervals based on engineering judgment to inform bicyclists of bicycle route direction changes and to confirm route direction. Bikes May Use Full Lane signs (R4-11) may be used. Wayfinding can be used to provide direction to other high comfort bicycle facilities, trails, or neighborhood destinations and amenities such as schools.
- b. Neighborhood Bikeway: also known as "Bicycle Boulevards," are similar to Neighborhood Shared Streets but provide a more regional connector and may be provided on local streets or collectors where the speed limit does not exceed 30 mph. They have three essential elements:
 - 1. Street design elements that enhance bicycle and pedestrian safety and comfort while maintaining vehicle traffic speeds at levels appropriate to the neighborhood context.
 - 2. Intersection treatments to assist bicyclists crossing roadways with high traffic volumes and/or speeds.
 - 3. Bicycle signage and wayfinding
 - i. Pavement Markings: Shared Lane Markings should be used to emphasize the shared nature of the roadway. See Standard Detail 01510-04. for shared lane marking placement and design consideration. On-street parking may but is not required to be delineated. Parking delineation may be appropriate in dense urban or commercial contexts.
 - ii. Signage: Bike Route signs (D11-1) should be placed at regular intervals based on engineering judgment to inform bicyclists of bicycle route direction changes and to confirm route direction. Bikes May Use Full lane signs (R4-11) shall be used to emphasize the shared nature of the roadway. Wayfinding should be used to provide direction to other

- high comfort bicycle facilities, trails, or neighborhood destinations and amenities such as schools. Stop sign placement and direction should provide priority to the bikeway over intersecting local streets to minimize bicycle stops.
- iii. Optional Treatments: Bicycle safety enhancements, such as speed cushions, neighborhood traffic circles, chicanes, and bike-only through movements at intersections can be considered based on engineering judgment and shall require Houston Public Works approval.
- c. Shared Lanes can be located on minor collector, major collector and certain major thoroughfares where there is insufficient ROW for dedicated facilities. They represent roadway travel lanes shared by vehicles and bicyclists on thoroughfares. They do not provide the highest level of comfort for bikes and are appropriate only where ROW is insufficient to provide a dedicated bikeway. They may be used in combination with higher-quality bike facilities to accommodate ROW pinch points. Shared lanes are restricted to roadways with posted speed limits 35 mph or less. Shared Lanes should not exceed 12-ft where no on-street parking is present. Signage and pavement markings are used to provide a visual indicator to vehicle traffic of the dual use and nature of the roadway
 - i. Pavement Markings: Shared Lane Markings shall be used to encourage bicycle travel in the middle or most visible portion of the travel lane. If on-street vehicular parking is not present, pavement markings should be placed far enough from the curb to direct bicyclists away from gutters, seams, and other obstacles. Minimum Placement:
 - 1. Shared Use Vehicular Lane Defined: 6-ft from the lane line of the shared use lane
 - 2. Shared Use Lane Not Defined: 6-ft from the center of the roadway where roadway lines do not exist.
 - ii. Signage: Bike Route signs (D11-1) should be placed at regular intervals based on engineering judgment to inform bicyclists of bicycle route direction changes and to confirm route direction. Bikes May Use Full lane signs (R4-11) shall be used to emphasize the shared nature of the roadway.

E. CORRIDOR DESIGN CONSIDERATIONS:

- 1. Overview: Bicycle facilities should provide a safe, high-comfort experience for the user as it traverses a corridor from intersection to intersection. Elements along a corridor may present unintended obstacles for bicyclists if not properly designed.

Design considerations presented in this section are not exhaustive. Additional considerations for review should be raised based on engineering judgment and approved by Houston Public Works.

2. General:
 - a. Gutter seams, drainage inlets, and utility covers should be flush with the pavement and oriented to prevent conflicts with bikes. Bicycle facility width should not include the gutter pan because people on bikes are typically unable to use this space.
 - b. Bicycle facilities are intended to be flexible to maximize comfort and can transition between facility types to accommodate corridor elements. Bicycle facility transitions (e.g., a bike lane to an off-street side path) should be logical and smooth. Abrupt facility transitions can be confusing, decrease bicycle predictability and increase vehicle conflicts.
 - c. Where possible, bicycle facilities should connect to other bicycle facilities, and facility termination should be minimized. Where bicycle facilities terminate, clear signing and striping shall be provided to communicate the termination to bikeway users and other roadway users. Where appropriate, on-street bicycle facilities may transition to a shared space with pedestrians (i.e. side path/trail) or to a non-dedicated bicycle facility type. Bicycle facilities should not terminate in areas that abruptly force bicyclists to merge with high-speed or high-volume vehicular traffic or heavy pedestrian activity.
 - d. Ramps may be used to transition bicycles on and off the street and shall not compromise pedestrian realm minimum standard widths.
 - e. All signs, signals, and markings related to bicycle facilities shall have maintenance responsibilities established and, if relevant, approved by Houston Public Works.
 - f. The design of bicycle facilities and associated physical delineation shall not restrict curbside access for solid waste trucks on streets with curbside trash and/or recycling pickup.
 - g. The design of bicycle facilities and associated physical delineation shall not restrict curbside access for transit vehicles at designated transit stops. Physical delineators should be stopped prior to transit stops. On streets where frequent breaks in physical delineation would be required, alternative bicycle facility designs that do not require physical delineation should be considered.

3. On-Street Parking:
 - a. Bike lanes may be provided between the parking lane and the curb or between the parking lane and travel lane.
 - b. Where on-street parallel parking would otherwise be allowed, No Parking in Bike Lane signs (R7-9) may be considered.
 - c. A 3-ft buffer should be provided between a bike lane and an adjacent parking lane to accommodate the door zone when high parking turnover is expected.
4. Railroad Crossings:
 - a. General: Bicycle tires can become stuck in rail flanges when they cross tracks at a small angle. Where bicycle facilities cross a street-surface rail track, bicyclists should be directed to cross tracks at a safe angle (60 degrees minimum, 90 degrees desirable).
 - b. If desired crossing angle is not possible, a warning sign (W10-1 or W10-12) shall be placed in advance of the rail crossing alerting bicyclist of skewed railroad crossing.
 - c. In presence of uneven railroad tracks warning sign (W10-6) should be installed.
5. Bridge Crossings and Tunnels:
 - a. Bridges and tunnels shall accommodate multimodal transportation usage.
 - b. When the approach roadway has an existing or planned bicycle facility, the quality and comfort of bicycle facility on the bridge/tunnel shall equal or exceed that of the facility on the approach roadways.
 - c. When the approach roadway does not have an existing or planned bicycle facility, 10-ft or greater sidewalks should be considered for multimodal consideration on the bridge/tunnel. The absence of an existing bicycle facility on the approach roadway does not justify failure to accommodate bicyclists on the bridge or tunnel.
 - d. Bridge sidewalks and shared-use paths shall be raised above the vehicular pavement level.

- e. Railing/Delineator:
 - i. Exterior bridge railings adjacent to a pedestrian/bicycle facility:
 - 1. Minimum height: 42 inches.
 - 2. Height of 48 inches should be considered in the following cases:
 - Speed of adjacent traffic exceeds 35 mph
 - Width of pedestrian/bicycle facility is less than 10-ft
 - 3. The railing design should minimize opportunities for bicycle handle bars to get caught in the railing.
 - ii. A railing may be used to separate bicycle traffic from pedestrian traffic to improve bicycle/pedestrian safety and comfort where appropriate.
6. Loading/Commercial Zones:
- a. Dedicated loading/commercial zones shall not impede bicycle traffic or encroach on a bicycle facility. Where possible, dedicated bicycle facilities should be placed behind loading zones and adjacent to the pedestrian zone whether on or off-street.
 - b. To avoid conflicts with loading/commercial zones bicycle facility may be transitioned to the adjacent sidewalk where a minimum 10-ft separate pedestrian realm is maintained.
 - c. A painted crosswalk may be provided across the bikeway facility to accommodate loading and unloading of commercial vehicles.
7. Midblock Crossings
- a. General: Midblock crossings are legal pedestrian and bicycle street crossing locations that are not located at roadway intersections. Intersection crossings are generally preferred, but occasionally midblock crossing locations are acceptable. Examples of potentially acceptable midblock crossing locations include a trail in a utility easement that crosses a street at a distance that is farther from the nearest signalized intersection than a trail user would be expected to traverse.
 - b. Midblock crossings shall require Houston Public Works approval.
 - c. Midblock crossings shall be designed at minimum with the following considerations:
 - i. Midblock crossings shall be located at least 100-ft from adjacent intersections.
 - ii. Street name signs should be placed at Major Thoroughfare crossings and should be considered on Collector and Local Street crossings.

- iii. The width of curb ramps serving a midblock crossing shall be equal to the width of the approaching pedestrian or bicycle facility. Detectable warning surfaces shall extend the full width of the ramp.
- iv. Pavement markings shall be used to define all midblock crossing locations.
 - 1. For pedestrian-only midblock crossing, white high visibility crosswalk markings shall be used.
 - 2. For shared-use midblock crossings, Dual Use Markings shall be used, consisting of a series of white stripes flanked by square bicycle-green pavement markings (see Standard Detail 01510-09A).
- d. Midblock Enhancements: Additional treatments should be considered for increased visibility and refuge at midblock crossings. Enhancements shall require justification per engineering judgment and approval by Houston Public Works. Potential enhancements may include:
 - i. Raised crossing (a.k.a. raised crosswalk). Raised crossings elevate people in the crossing above the road level, thereby increasing their visibility. Raised crossings are not permitted on corridors with design speeds greater than 35 miles per hour.
 - ii. Curb extensions. Curb extension reduce crossing distance and increase visibility of people in the crossing. This treatment can be used when on-street parking exists or where excess pavement exists such that a curb extension can be constructed without decreasing roadway capacity.
 - iii. Median refuge islands. Median refuge islands are located in the center of the roadway to permit a two-stage crossing of the roadway. Median refuges should be considered where center turn lanes are present and are encouraged on corridor with 4 or more lanes, or where roadway configuration is reconfigured from a 4-lane corridor to a 3-lane corridor.
 - iv. Street lighting at midblock trail crossings where feasible and approved by Houston Public Works.
- e. Selection of Midblock Treatments:

Midblock treatments shall be selected to maximize safety of people crossing the street at the midblock location. Selection of treatments should consider the corridor speed, number of lanes and average daily traffic in addition to area context. Several levels of treatment based on these factors are presented below. Standard treatments are required for each level. Optional treatments may be used based on engineering judgment and with Houston Public Works approval. **Table 1-B** provides guidance for the selection of treatment level.

Table 1-B Criteria for Midblock Crosswalk
(Levels A, B, C, D are defined below)

ADT	Speed Limit	4 lanes with median	2 lanes without median	4 lanes without median
≤ 5,000	≤ 30 mph	A	A	A
	> 30 mph	A	B	C
5,000 - 15,000	≤ 30 mph	B	B	B
	> 30 mph	C	C	D
>15,000	≤ 30 mph	C	D	D
	> 30 mph	D	D	D

Level A: Midblock crossing pavement markings

1. Standard: Install, as appropriate, white high-visibility crosswalk markings (pedestrian-only crossing) or Dual Use Markings (shared-use crossing).
2. Optional:
 - a. Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-9P AHEAD (plaque) mounted on the side of the roadway in advance of the crossing.
 - b. Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-7PL diagonal downward arrow plaque mounted on the side of the roadway at the crossing.

Level B: Level A + advance warning signage

1. Standard:
 - a. Install, as appropriate, white high-visibility crosswalk markings (pedestrian-only crossing) or Dual Use Markings (shared-use crossing).
 - b. Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-9P AHEAD (plaque) mounted on the side of the roadway in advance of the crossing.

- c. Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-7PL diagonal downward arrow plaque mounted on the side of the roadway at the crossing.

2. Optional:

- a. Install "PED XING" (pedestrian-only crossing) or "BIKE XING" (shared-use crossing) advanced pavement marking.

Level C: Level B + additional pavement markings

1. Standard:

- a. Install, as appropriate, white high-visibility crosswalk markings (pedestrian-only crossing) or Dual Use Markings (shared-use crossing).
- b. Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-9P AHEAD (plaque) mounted on the side of the roadway in advance of the crossing.
- c. Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-7PL diagonal downward arrow (plaque) mounted on the side of the roadway at the crossing.
- d. Install "PED XING" (pedestrian-only crossing) or "BIKE XING" (shared-use crossing) advanced pavement marking.
- e. On four-lane roadways, install R1-5 "Yield Here to Pedestrians" (pedestrian-only crossing) or R1-5PB "Yield Here to Pedestrians and Bicyclists" (shared-use crossing) signage and yield lines consisting of isosceles triangles pointing toward oncoming vehicles (see Standard Detail 01510-09A).

2. Optional:

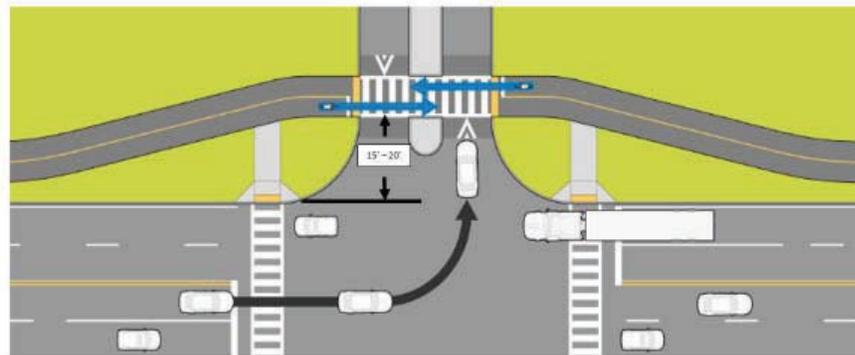
- a. Raised crossing
- b. Curb extension
- c. Median refuge island

Level D: Level C + crossing enhancements

1. Standard:
 - a. Install, as appropriate, white high-visibility crosswalk markings (pedestrian-only crossing) or Dual Use Markings (shared-use crossing).
 - b. Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-9P AHEAD (plaque) mounted on the side of the roadway in advance of the crossing.
 - c. Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-7PL diagonal downward arrow plaque mounted on the side of the roadway at the crossing.
 - d. Install "PED XING" (pedestrian-only crossing) or "BIKE XING" (shared-use crossing) advanced pavement marking.
 - e. On four-lane roadways, install R1-5 "Yield Here to Pedestrians" (pedestrian-only crossing) or R1-5PB "Yield Here to Pedestrians and Bicyclists" (shared-use crossing) signage and yield lines consisting of isosceles triangles pointing toward oncoming vehicles (see Standard Detail 01510-09A).
 - f. Consider a traffic signal or hybrid pedestrian beacon if the appropriate warrants in the TMUTCD are satisfied. Requires approval of City Traffic Engineer.
 - g. Enhancements are strongly encouraged where appropriate, including:
 - i. Raised crossing
 - ii. Curb extension
 - iii. Median refuge island

8. Driveways:
 - a. Driveways shall be designed to safely accommodate bicyclists, pedestrians and motorized vehicle users. Where a driveway crosses a dedicated on-street or off-street bikeway, the driveway should be designed to enhance the visibility of the bikeway user.
 - b. Signage:
 - i. Stops signs (R1-1) should be placed on primary commercial driveways to indicate a full stop by motor vehicles before entering and crossing a bicycle facility. Where the bicycle facility is in or immediately adjacent to the roadway, the stop sign should be placed before the bicycle facility.
 - ii. Where a stop sign is not provided on the driveway approach, Bicycle Crossing Warning Sign (W11-1) or dual Combination Bike and Ped Crossing Warning Sign (W11-15) should be considered.

- c. **Pavement Markings:** Where bicycle facilities cross driveways, the design should clearly communicate that bicyclists have the right-of-way by defining the bicycle facility width and associated placement across the driveway. Green bicycle pavement markings should be used across primary commercial driveways.
- d. **Curb Radius:** Driveway curb radius should be selected to encourage slower vehicular movements across the bicycle facility. Based on engineering judgment, the smallest feasible curb radius should be selected based on AASHTO design vehicles. Additional curb radius design considerations are discussed in Chapter 15.08.
- e. **Driveway Spacing:** Driveway consolidation should be considered where bike facilities are present. Each driveway presents an additional vehicle-bicycle conflict point. Refer to Chapter 15.08 for driveway spacing standards.
- f. **Vehicle Parking** should be prohibited at least 20-ft from the edge of a driveway along the roadway.
- g. **Landscaping and other street-side elements** shall not reduce sight distance across the bicycle facility below AASHTO minimums.
- h. **Optional Treatments:** Bicycle safety enhancements such as raised crossings and recessed driveway crossings can be considered based on engineering judgment and shall require Houston Public Works approval prior to implementation. Recessed driveway crossings should be between 15-ft to 20-ft from the edge of the roadway pavement to enable one vehicle to queue between the roadway and the bicycle facility. See figure below:



F. INTERSECTION TREATMENTS

1. Overview: Intersections present significant challenges to bicyclists, and specific accommodations should be provided to ensure bicyclist safety and comfort. These accommodations may include additional signing and striping, signal modifications, and deliberate transitions from one type of bicycle facility to another.
2. Standard Intersection Treatments for Bicycles Facilities
 - a. General:
 - i. Bicyclists are required by law to obey traffic control devices at intersections; therefore, traffic control devices shall be designed to account for identified bicycle needs.
 - ii. Intersections shall be designed to logically position bicyclists through an intersection from an approaching bicycle facility to the receiving bicycle facility.
 - iii. Wayfinding signage should be included wherever two designated bicycle facilities intersect or where a bicycle facility changes direction.
 - iv. Green bicycle pavement markings may be used to increase bicycle facility visibility and identify potential conflict areas and increased cyclist/vehicular awareness. Green bicycle pavement markings should not be used in lieu of but in addition to white pavement markings.
 - b. Traffic signal considerations:

General standards for signalized intersections are defined in Chapter 15 and include bicycle accommodations. Bicycle-related signal options are summarized below.

 - i. Signal timing and actuation shall consider the needs of bicyclists.
 - ii. Bicycle signal heads may be installed at signalized intersections to provide guidance for bicyclists at intersections where movements may not be apparent or where bicycle-specific signal strategies (e.g. bicycle-only phases) are employed.
 - iii. Bicycle detection should be used along high-comfort bicycle facilities at actuated traffic signals to alert the signal controller of bicyclist demand.
 - iv. When bicycle detection is used, a Bicycle Signal Actuation Sign (R10-22) should be used, and a Bicycle Detection Marking (Standard Detail 01510-09A) shall be placed on the pavement indicating the optimal position for a bicyclist to actuate the signal.
 - v. Visibility-limited signal faces shall be adjusted to ensure bicyclists can see the signal indications. If the visibility-limited signal faces cannot be aimed to serve the bicyclist, then separate signal faces shall be provided for bicyclists.

- c. On-street bicycle facilities:
 - i. On-street bicycle facilities generally do not include crossing markings through intersections. However, crossing markings should be considered when additional guidance is needed to direct bicyclists through the intersection or when increased awareness of bicyclists activity is desired.
 - ii. Intersection crossing markings are shown on Standard Detail 01510-09A and may consist of:
 - 1. Dashed white pavement markings aligned with the lateral extensions of the approach bicycle facility.
 - 2. A combination of dashed white pavement markings and green bicycle pavement markings may be considered when additional guidance is needed to direct bicyclists through the intersection or when increased visibility is desired.
 - iii. If used, intersection crossing markings shall define a space through the intersection with a width that is the greater of 1) the width of the approaching bicycle facility or 2) the standard width for a corresponding high-comfort bicycle facility.
 - iv. On approaches to intersections without dedicated right-turn lanes, on-street bicycle facilities should be extended to the STOP bar with the typical characteristics of the facility.
 - v. On approaches to major intersections without dedicated right-turn lanes and with high right-turn volumes or with a transit stop, on-street bicycle facilities should be extended to the STOP bar. Any buffer should be dropped approximately 50-200-ft from the STOP bar, and from that point the bicycle facility should be defined by dot striping to emphasize the movements of right-turn vehicles across the bicycle facility.
 - vi. Bicycle facilities should not generally terminate at intersections. Where on-street bicycle facilities end at an intersection, signage should be sufficient to provide bicyclists an opportunity to safely make necessary accommodations. At a minimum, "Bike Lane Ends" signage (R3-17, R3-17b) signage shall be used.
 - vii. At intersections where on-street, high-comfort bicycle facilities cannot be extended to the intersection because of geometric or ROW constraints, off-street bicycle facility transitions should be explored.
 - viii. When transitioning between off-street bicycle facilities and on-street bicycle facilities, the grade should be smooth and comfortable, without significant longitudinal pavement joints or sharp changes in direction. Maximum slope should be 1:7.

- d. Separated on-street bicycle facilities:
 - i. For two-way separated on-street bicycle facilities (i.e., cycle tracks), bidirectional bicycle traffic shall be designated through the intersection with a center yellow dash and corresponding white dash on the vehicle side lateral extension of the bicycle facility.
 - ii. Bicycle-green pavement markings may be considered when additional guidance is needed to direct bicyclists through the intersection or when increased visibility is desired.
 - e. Off-street bicycle facilities:
 - i. People riding bicycles on off-street facilities may not utilize standard pedestrian crosswalks, whether the crosswalks are marked or unmarked. Bicycle crossings must provide bicycle-specific crossing markings.
 - ii. Where off-street bicycle-only facilities cross a road, bicycle-green continental pavement markings should designate the bicycle crossing area. These markings should be placed adjacent to the white pedestrian continental pavement markings if present. These roadway crossings may be midblock, at unsignalized intersections, or at signalized intersections.
 - iii. Where off-street shared bicycle/pedestrian facilities cross a road, Dual Use Markings shall be used. These roadway crossings may be midblock, at unsignalized intersections, or at signalized intersections.
 - iv. Dual Use Markings shall consist of white 24-inch continental pavement markings flanked by 24-inch by 24-inch square green bicycle pavement markings. The width of the white markings shall be greater of 8-ft or the width of the approach facility. See Standard Detail 01510-09A.
3. Special Case Intersection Accommodations for Bicycle Facilities
- a. Dedicated Right-Turn Lanes
 - i. General:
 - 1. Dedicated right-turn lanes present crossing challenges for bicycle facilities and should be designed to highlight the crossing maneuver and prioritize bicyclists.
 - 2. The need for dedicated vehicular turn lanes at intersections should be based on vehicular capacity requirements. Where capacity requirements are satisfied by multiple lane assignment combinations, a dedicated right-turn lane should be considered when bicycle/right-turn conflicts are projected to be high (more than approximately 5 bike/turning-vehicle conflicts/peak hour).
 - ii. Design:
 - 1. See Standard Detail 01510-09A for design details.
 - 2. Where a dedicated right-turn lane is used, an adjacent on-street bike lane should continue through to the intersection on the left side of the right-turn lane.

3. An on-street bike lane shall not be located on the right side of a dedicated right-turn lane.
 4. Where a dedicated right-turn lane crosses a bike lane, the bike lane shall not be required to shift more than 3-ft. This is intended to clarify the requirement for vehicles crossing into the dedicated right-turn lane to yield to bicyclists in the bicycle lane.
- iii. Markings:
1. The width of an on-street bike lane adjacent to the left side of a dedicated right-turn lane shall be a minimum of 5-ft (desirable 6-ft).
 2. The bike lane through the bike/right-turn conflict zone shall be delineated with combination white/bicycle-green dashed pavement markings.
 3. The defined conflict zone should end a minimum of 20-ft from the intersection. Within the section of the bike lane past the conflict zone, the lane shall be fully demarcated with green bicycle pavement markings between two 6-in solid white lines and shall include bike lane symbol and arrow pavement markings.
- iv. Signage:
1. A "Right Lane Must Turn Right" sign shall be used at the intersection, and a "Begin Right Turn Lane / Yield to Bikes" sign shall be used at the beginning of the bike lane/right-turn conflict zone.
- b. Two-Stage Turn Queue Boxes
- i. General:
1. Two-Stage Turn Queue Boxes are an intersection improvement consisting of pavement markings and signage that simplify turn movements for bicyclists across adjacent lanes of traffic or to accommodate two stage crossings. They are most frequently used to facilitate left-turn movements for bicyclists in a bike lane without requiring bicyclists to first merge with adjacent traffic into the appropriate turn lane. Instead, bicyclists make the turn in two movements: first, proceeding through the intersection in the bike lane, then turning ninety degrees within the Queue Box to face in the desired direction in front of motorists on the cross street. Two-Stage Turn Queue Boxes should be considered at intersections for roadways with heavy traffic volumes and when designated on-street bicycle facilities are provided on both intersecting streets.
 2. Shall require approval by Houston Public Works.
 3. Should only be installed along roadways with designated on-street bicycle facilities.

- ii. Design
 1. Shall be green bicycle pavement markings with an approved material that provides adequate surface traction.
 2. Shall include a bicycle symbol and turn arrow pavement markings to designate the space for turning bicycle use only.
 3. Shall be placed in a protected zone that will not be encroached upon by vehicles along the origin street. Depending on the intersection geometry, this zone can be located between the lateral extension of the bicycle facility and the adjacent travel lane on the origin street when a buffer exists or between the pedestrian crosswalk and the bicycle lane.
 4. Shall include a "No Turn on Red" sign mounted on the signal assembly directed towards the vehicles on the cross street that would stop behind the turn box.
 5. Should be positioned to orient the bicyclist towards the receiving bicycle facility on the cross street.
 6. May utilize Intersection Crossing Markings to indicate desired path of bicyclists across the intersection in relation to the Two-Stage Turn Queue Box.

- c. Bicycle Box:

- i. Purpose: Bike boxes are an intersection design component consisting of pavement markings and signage that enables bicyclists to queue at a red light in front of stopped vehicles in adjacent lanes. Bike boxes promote bicyclist safety by positioning bike riders in front of vehicular traffic improving bicyclist visibility and reducing potential conflicts between bicyclists and turning vehicles. They should be considered at locations where the volume of turning traffic in conflict with an adjacent bicycle facility is high.
- ii. Suitability and approvals
 1. Shall require approval by the City Traffic Engineer.
 2. Shall be allowed only at signalized intersections.
 3. Shall only be used in conjunction with on-street bicycle facilities, including standard bike lanes, buffered bike lanes, and separated bicycle lanes.
 4. Shall only be approved across a single direction of general purpose lanes. A single bike box will not be approved across bidirectional travel lanes.
 5. A bike box may extend across multiple adjacent lanes to accommodate bicycle left-turn movements.

- iii. Design
 1. See Standard Detail 01510-09A for design details.
 2. Shall be filled with bicycle-green pavement markings that provides adequate surface traction.
 3. Shall be located between the pedestrian crosswalk and the vehicular STOP bar.
 4. Shall include a bicycle symbol pavement marker to designate the space for bicycle use only.
 5. Shall include a R10-11A "No Turn on Red" sign mounted on the signal assembly when those movements would be otherwise allowed across the bike box.
- d. Roundabouts
 - i. Purpose: See Chapter 15 regarding general Roundabout Considerations for all roadway users. Bicycle considerations are discussed here.
 - ii. Bicycle lanes shall not be provided within the circulatory roadway.
 - iii. Where bicycle lanes or shoulders are used on approach roadways, they should be terminated at least 100-ft from the edge of the circulatory roadway.
 - iv. Bicyclists may choose to merge with traffic and travel like other vehicles, or a ramp may be provided to allow them to exit the roadway onto the sidewalk (or shared use path) and travel as pedestrians.
 - v. If a ramp is provided for bicyclists to access the sidewalk, the slope shall not exceed 7:1. Lighting should be considered for increased facility safety at transition point.
- 4. Side-of-street Transitions
 - a. General: Side-of-street transitions provide options for transitioning a bicycle facility from one side of the street to the other. For example, a bidirectional cycle track that transitions to a pair of standard one-way bicycle lanes at a traffic signal.
 - b. Two Stage Crossings
 - i. General
 1. Accommodate bicyclist transitions from one side of the roadway to the other at a signalized intersection by requiring bicyclists to cross each road on a separate signal phase.
 2. Shall require approval by Houston Public Works.
 3. Shall require bicycle-specific signals and/or signal timing consideration for each stage of the crossing.

4. A designated staging zone shall be provided in which bicyclists can safely wait for the second crossing phase. Staging locations may be located on or off-street based roadway geometrics, available pavement width, presence of on-street parking, lane assignments, and turning movements.
 5. This staging zone shall not place the bicyclist in conflict with vehicular traffic.
 6. Appropriate pavement markings should be provided to define each crossing.
- ii. Design
 1. Shall use bicycle-green pavement markings with an approved material that provides adequate surface traction.
 2. Shall include a bicycle symbol and turn arrow pavement markings to designate the space for turning bicycle use only.
 3. Shall be placed in a protected zone that will not be encroached upon by vehicles along the origin or cross street.
 4. May utilize Intersection Crossing Markings to indicate desired path of bicyclists across the intersection.
- c. Diagonal Crossing Phase
 - i. General: Bicyclists transition from one side of the road to the other in a single, independent signal phase at a signalized intersection.
 - ii. Shall require approval by Houston Public Works.
 - iii. Is, when feasible, the preferred method of transitioning bicycle travel from one side of the roadway to the opposite side.
 - iv. Shall require a traffic study to determine feasibility of a diagonal crossing phase. The study shall utilize existing traffic counts and bicycle counts or, if bicycle counts are unavailable, a projection of bicycle usage to determine existing and projected intersection level-of-service (LOS) under NO-BUILD and BUILD scenarios. The LOS shall be computed using Highway Capacity Manual methodology, as detailed in Chapter 15: Traffic Studies.
 - v. Shall utilize a bicycle-specific signal head, pointing diagonally across the intersection from the receiving bicycle facility towards the originating bicycle facility.
 - vi. Shall utilize a specific bicycle crossing signal phase that allows bicycles to travel diagonally across the intersection without vehicular conflicts.
 - vii. Shall require bicycle detection of a type approved by Houston Public Works to call the diagonal signal phase. The diagonal signal phase shall not be called without a detected bicyclist.
 - viii. May utilize individual signal phases for the different directions of bicycle travel (when applicable) so that the diagonal signal phase is only called when a bicycle is traveling in that direction.

- ix. Shall utilize Intersection Crossing Markings to delineate diagonal path of travel across intersection.
- x. Should utilize a Bicycle Pavement Marking Symbol and an Arrow Pavement Marker to indicate the diagonal direction of bicycle travel.
- xi. Shall utilize signage to indicate the diagonal crossing for the bicycle approach.

G. BIKEWAY AMENITIES

- 1. Bike Parking: Bicycle parking and associated bicycle racks placed within the public right of way should not impede the flow of traffic (vehicular, pedestrian, or other) or cause any unnecessary obstruction within the right of way. Bike rack spacing and placement shall be approved by Houston Public Works staff. General Spacing standards include:

Spacing Standards:			
Location	Orientation	Minimum (in)	Standard (in)
Between Racks	Side-by-Side	36"	48"
	End-to-end	72"	96"
From Curb	Perpendicular	36"	-
	Parallel	24"	-
From Wall	Perpendicular	48"	-
	Parallel	36"	-
From Tree	Parallel	36"	48"

- 2. Wayfinding: Wayfinding provide direction, destination, and distance information as needed for bicycle travel. If several destinations are to be shown at a single location, they may be placed on a single sign with an arrow (and the distance, if desired) for each name. If more than one destination lies in the same direction, a single arrow may be used for the destinations.
 - a. A Bike Route sign (D11-1) may be used along any type of bicycle facility as a wayfinding sign.
 - b. The D1 series of wayfinding signage may be used in conjunction with a Bike Route sign (D11-1).

- c. Wayfinding signage, if used, should be placed at logical intervals, especially prior to and at bicycle network decision points.
- d. Alternative wayfinding signage design may be provided on off-street trails.
- e. Listed Destinations: Requires coordination with and approval by Houston Public Works. Wayfinding should indicate directions to neighborhood amenities and destinations. Wayfinding within the public right-of-way shall not promote the use of any one private or for-profit business (except for grocery stores). Examples of acceptable destinations include:
 - i. Management District (i.e. Downtown, Montrose, EaDO, etc.),
 - ii. Transit station (i.e. Park-n-Ride, light rail platform)
 - iii. Government service centers
 - iv. Trail access points
 - v. School/University
 - vi. Library,
 - vii. Grocery Store
 - viii. Bikeway amenities (bike parking, bike shop, bike service center.
 - ix. Bicycle Parking Area - D4-3

H. BIKE DETOURS

- 1. Bicycle detours shall be provided wherever a bicycle facility is obstructed.
- 2. Bicycle detours shall provide a level of user comfort that is equivalent to or superior to that of the obstructed facility.
- 3. Bicycle detours shall be provided for trail obstructions that reroute trail users to a public street.

17.05 RESERVED FOR TRANSIT DESIGN REQUIREMENTS

- A. TRANSIT OVERVIEW: TRANSIT OVERVIEW: Reserved
- B. TRANSIT SECTION INTRODUCTION: Reserved
- C. TRANSIT STOP TYPOLOGIES, STANDARD DIMENSIONS: Reserved
- D. TRANSIT STOP PLACEMENT: Reserved
- E. TRANSIT STOP CONFIGURATIONS: Reserved
- F. TRANSITWAYS: Reserved

G. PAVEMENT MARKINGS/SIGNAGE: Reserved

17.06 PEDESTRIAN DESIGN REQUIREMENTS

A. Design Guidance

1. Minimum Sidewalk Width - six (6)-ft or more shall be installed along major thoroughfares and five (5)-ft or more shall be installed along all other streets. Where appropriate sidewalks may be split or reduced in width at pinch points to preserve mature street trees, and should remain ADA compliant. For Transit Streets see section 10.6.I.3.
2. The pedestrian realm shall be a minimum of 10 (ten)-ft which includes the sidewalk and associated pedestrian amenities such as a pedestrian buffer, tree plantings, or furniture zone. Pedestrian zones should be greater than ten (10)-ft where appropriate and may include additional amenities such as a METRO bus shelter and/or bike parking.
3. Sidewalk width should exceed the minimum when ROW is available.
4. A buffer between the sidewalk and roadway is desirable for sidewalks less than ten (10)-ft in width. The desirable minimum width is four (4)-ft, with an absolute minimum width of two (2)-ft.
5. If a sidewalk is used by bicyclists and pedestrians, it should be designed as an off-street bicycle facility or trail as defined in 17.04 BICYCLE GEOMETRIC DESIGN REQUIREMENTS.
6. All curb ramps shall comply with ADA and Texas Accessibility Standards (TAS) requirements.
7. Curb ramps shall be constructed at all signalized intersections and at any legal crossing points for existing or planned sidewalks.
8. Sidewalks constructed along Type A Streets - for Transit Corridor Streets shall have a minimum width of six (6)-ft. Ramps, approaches and sidewalks shall comply with ADA and Texas Accessibility Standards (TAS) requirements. Sidewalks for Transit Corridor Street and Type A Streets:
 - a. Chapter 42, Article IV - Transit Corridor Development, of the Code of Ordinances regulates improvements constructed in the public right of way within 1,320 -ft of each transit station (Ch. 42, Sec 401-406).

- b. Mandatory requirements are summarized below and shown in Standard Detail 02775-08. These requirements are required under IBC, Section 3110). (1) Minimum Sidewalk Width - six (6)-ft (must be located within the public right of way or sidewalk easement). (2) Minimum Vertical Clear Zone, a continuous obstacle free path, for a minimum width of six (6)-ft and a minimum height of seven and one-half (7 ½)-ft.
- c. Performance Standards - Refer to Chapter 42 Sections 401-406:
 - i. Minimum Pedestrian Realm - Fifteen (15)-ft distance from back of curb to a building's facade or other improvements (can be entirely within public right of way or a combination of public right of way and public access easement).
 - ii. Maximum softscape area in the pedestrian realm is 20% of the surface area of the pedestrian realm excluding any driveways and shall be located at least two (2)-ft from the back-of-curb of any street area used for parking.
- 9. Sidewalks at intersections should be free of obstructions and surface encroachments such as sign posts, power poles and down guy wires.
- 10. Where use of standard sidewalk/ramp details is not possible due to field conditions, engineer shall submit proposed design drawings to City Engineer for approval. Design drawings shall include site field survey conditions.
- 11. Curb ramps should cross street at 90 degrees to centerline of street. At skewed intersections, curb should be adjusted to allow for high visibility crossing. Stop bars and signage may be used to further alert motor vehicles of crossing.
- 12. All ramps constructed on an intersection corner should be designed such that a person walking can turn the corner without entering the street.
- 13. Midblock crossings shall be considered on a case-by-case basis and in coordination with Houston Public Works based on engineering judgment. The design of pedestrian midblock crossings shall follow the requirements in the Midblock Crossing discussion in Section 17.04.
- 14. Sidewalks traversing rail lines shall be at 0% slope for a distance of five (5)-ft from the Center Line of the track.
- 15. Alternative methods of sidewalk construction may be used in places where tree preservation is of concern. Alternative materials may be but are not limited to decomposed granite and checkered plate.

END OF CHAPTER