



WACO METROPOLITAN AREA

Master Thoroughfare Plan

Roadway Design Guidelines



July 2012



Waco Metropolitan Planning Organization

Waco Master Thoroughfare Plan

Context-Sensitive Roadway Design Guidelines

Table of Contents

1. Introduction	1
1.1 Purpose of the Design Guidelines	1
1.2 About the Context-Sensitive Solutions Approach	1
1.3 How to Use This Document.....	3
2. Thoroughfare System	4
2.1 Proposed Thoroughfare Network	4
2.1 Thoroughfare Types.....	6
Expressways	6
Arterials	6
Collectors and Local Streets	6
3. Area Types	8
3.1 City Center Area	9
3.2 Urban Area	9
3.3 Suburban Area	9
3.4 Rural Area.....	9
4. Context Zones	11
4.1 City Center Context Zone.....	11
4.2 Commercial Center Context Zone	11
4.3 Village Center Context Zone	12
4.4 Neighborhood Center Context Zones.....	12
4.5 Mixed Use Neighborhood Context Zone	13
4.6 Conventional Suburban Neighborhood Context Zone	13
4.7 Rural Agriculture Context Zone	14
4.8 Special Districts	14
Regional Center	14
Institutional Campus.....	15
Industrial Center.....	15
5. Thoroughfare Design Elements and Cross Sections	18
5.1 Matching Thoroughfare Type With Community Context	18
5.2 Potential Thoroughfare Design Elements for Different Area Types	20
5.3 Thoroughfare Design Elements.....	24
Sidewalks and Pedestrian Areas.....	24
Bicycle Lanes.....	24
Raised Medians.....	24
Lane Width	25
Trees and Landscape	25
5.4 Cross Sections.....	30
Suburban Principal Arterial	30
Urban Principal Arterial	31



Two-Lane Minor Arterial	31
Four-Lane Minor Arterial.....	32
Two-Lane Urban Collector	32
Four-Lane Urban Collector.....	33
Two-Lane Major Rural Collector	33
Four-Lane Major Rural Collector.....	34
6. Designing Context-Sensitive Streets	35
6.1 <i>Throughway Corridor</i>	36
Vehicle Travel Speeds (Design Speed, Target Speed and Posted Speed)	36
Design Vehicle	39
Travel Lane Width.....	39
Horizontal Clearance	40
Lane Reductions.....	41
Lane Reductions on One-way Streets.....	42
Four-lane to Three-lane Conversions.....	42
Raised Medians.....	43
On-Street Parking	45
On-street Parking Placement and Design.....	45
Back-in Angled Parking	46
Curb Extensions.....	47
Accessible On-Street Parking	47
Bicycle Lanes.....	47
Shared Use Paths	49
6.2 <i>Sidewalk Corridor</i>	50
Americans with Disabilities Act	50
The Curb Zone (Edge Zone).....	50
The Furniture Zone	52
The Pedestrian Zone.....	52
The Frontage Zone	52
Bicycle Parking	53
Pedestrian Lighting	54
Transit Stop Location	54
Far Side Stops	55
Near Side Stops	55
Mid-block Stops.....	55
Transit Stop Design.....	56
Bus Stop Infrastructure and Amenities	56
Bus Bay.....	57
Bus Bulbs	58
Personal Safety (Crime Prevention Through Environmental Design).....	59
6.3 <i>Intersections</i>	61
Corner Radii	61
Curb Extensions	62
Right-turn Channelized Islands	65
Signalized Intersections	66
Placement of Signal Structures within the Sidewalk Corridor.....	67
Pedestrian Crosswalks	67
Crosswalk Placement.....	67



Crosswalk Spacing	68
Marked Crosswalks.....	69
Signalized Crosswalks.....	69
Raised Medians and Crossing Islands	70
Advance Stop Line	71
Mid-block Crossings.....	71
Other Crossing Enhancements	71
Roundabouts	72
Interchanges.....	74
Endnotes	75

Tables

Table 1: Typical Thoroughfare Network Characteristics.....	7
Table 2 Compatibility Among Area Types, Context Zones, and Thoroughfares.....	19
Table 3 Pedestrian and Bicycle Design Elements by Area Type.....	21
Table 4 Design Elements to Help Reduce Travel Speeds or Volumes by Area Type.....	22
Table 5 Other Design Elements by Area Type	23
Table 6 Thoroughfare Design Elements For City Centers.....	26
Table 7 Thoroughfare Design Elements for Urban Areas	27
Table 8 Thoroughfare Design Elements For Suburban Areas.....	28
Table 9 Thoroughfare Design Elements For Rural Areas.....	29
Table 10 Bus Stop Locations and Spacing.....	54
Table 11 Recommended Bus Stop Features	56



Figures

Figure 1: Proposed Thoroughfare Network.....	5
Figure 2: Area Types	10
Figure 3 Context Zones.....	17
Figure 4 Suburban Principal Arterial	30
Figure 5 Urban Principal Arterial	31
Figure 6 Two-Lane Minor Arterial	31
Figure 7 Four-Lane Minor Arterial.....	32
Figure 8 Two-Lane Urban Collector	32
Figure 9 Four-Lane Urban Collector	33
Figure 10 Two-Lane Major Rural Collector	33
Figure 11 Four-Lane Major Rural Collector	34
Figure 12 Vehicle Speed and Pedestrian Crash Severity	37
Figure 13 Vehicular Speed and Crash Avoidance.....	38
Figure 14 Street Width and Vehicle Type	40
Figure 15 Minimum Horizontal Clearances in Constrained Areas	41
Figure 16 Lane Reduction and Roadway Improvements.....	43
Figure 17 Objects in the Median.....	44
Figure 18 On Street Parking Layouts	46
Figure 19 Bicycle Lanes Adjacent to Curb and Unpaved Shoulder	48
Figure 20 Typical Shared Use Path	49
Figure 21 Sidewalk Corridors in Suburban and Some Urban Areas	51
Figure 22 Sidewalk Corridors in City Center and Some Urban Areas	51
Figure 23 Bus Stops and On-Street Parking	58
Figure 24 Bus Stops and On-Street Parking	59
Figure 25 Intersection Corner Radii Comparison.....	62
Figure 26 Curb Extensions.....	63
Figure 27 Curb Extension and Parking Integrated Into Sidewalk Corridor	64
Figure 28 Curb Extension and Parking Integrated Into Sidewalk Corridor	64
Figure 29 Channelized Right-turn Lane	66
Figure 30 Crosswalks and Ramps.....	68
Figure 31 Center Median Refuge Island.....	70
Figure 32 Advance Stop Line	71
Figure 33 Roundabout Elements.....	73



1. Introduction

1.1 Purpose of the Design Guidelines

The purpose of the Waco Thoroughfare Plan Context Sensitive Roadway Design Guidelines document is to provide guidance on roadway features and design approaches that enhance the experience of people using various transportation modes along County thoroughfares. This document supplements the information provided in the Waco Master Thoroughfare Plan by describing the roadway features that planners and designers should be considering to improve the transportation network in a context-sensitive manner. These Guidelines provide specific recommendations for planning, designing, and constructing these features on various types of roadways in order to accommodate all types of roadway users.

Designing livable communities requires employing multi-modal transportation planning recommendations that support the community context of each roadway. To serve this purpose, this document provides guidance for design elements appropriate to the surrounding area. The result will be a transportation system that provides an appropriate balance between all modes of transportation, ensuring that roads are safe, comfortable and aesthetically pleasing for all users, and that they add value to the communities they serve.

It is the intention of this document to set forth guidelines consistent with federal, state, and local standards and to highlight best practices for context-sensitive roadway design. The desired outcome is to inspire a new approach to roadway design, emphasizing that our communities' streets are significant public spaces for all types of travelers, embracing the concept of moving people, not just cars, to enhance the 'livability' of roadways throughout McLennan County.

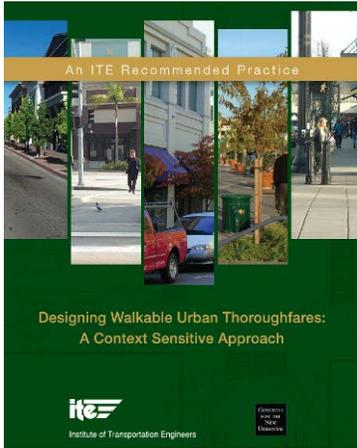
The Guidelines are not intended to supplant existing policies and practices regarding project planning, development and coordination, or roadway design. There are many opportunities, within adopted standards, to employ flexibility in design and to address issues that warrant tailored approaches, such as constrained right-of-way, limited funds, community character, economic development, and natural preservation.

1.2 About the Context-Sensitive Solutions Approach

The Context Sensitive Solutions (CSS) transportation planning approach helps planners, engineers, and local stakeholders work together to envision and design roadways that support all users and that enhance community character. CSS design guidelines provide specific methods for designing thoroughfares that address the needs of all types of travelers and, at the same time, complement the surrounding land uses. The resulting roadway network is intended to be safer and more attractive for all users, including motorists, transit riders, bicyclists, and pedestrians, as well as people of all ages and abilities. It also enhances the value of roadway corridors as public spaces that enhance the vitality and attractiveness of the places they serve, from urban downtowns and suburban neighborhoods to rural villages. ⁱ

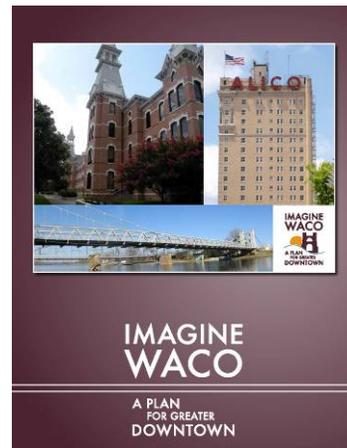


A key resource for the 2012 Thoroughfare Plan Update and Design Guidelines is a 2010 publication by the Institute for Transportation Engineers (ITE) entitled *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*. The ITE manual, developed in coordination with the Congress for New Urbanism with funds from US DOT and US EPA, provides detailed guidance on how to “promote a collaborative, multidisciplinary process that involves all stakeholders in planning and designing transportation facilities that meet the needs of users and stakeholders; are compatible with their setting and preserve scenic, aesthetic, historic and environmental resources; respect design objectives for safety, efficiency, multimodal mobility, capacity and maintenance; and integrate community objectives and values relating to compatibility, livability, sense of place, urban design, cost and environmental impacts”ⁱⁱ



An important local resource is the 2010 *Imagine Waco* downtown plan. The plan presents a detailed vision for the streets and blocks of Downtown Waco, including cross-sections for proposed multi-modal street types such as Urban Boulevards and Gateways. Design guidance for the City Center Area and City Center Context Zone developed in this 2012 Waco MPO Thoroughfare Plan was based, in part, on information from *Imagine Waco*.

The 2012 Thoroughfare Plan is also consistent with the 2009 Texas Department of Transportation Project Development Process Manual which recommends the use of Context Sensitive Solutions in the construction and improvement of roadways.ⁱⁱⁱ



1.3 How to Use This Document

CSS guidelines focus on including all transportation users in the development of thoroughfares while at the same time complementing the surrounding land uses. This approach is intended to increase safety and improve the transportation experience for all users, including motorists, transit riders, bicyclists, pedestrians, or persons with disabilities. Transportation systems that follow CSS guidelines complement and enhance urban form. These systems accommodate the needs of different travelers while integrating with the surrounding land uses. Corridor design elements balance accessibility and mobility for different contexts and types of users. These specific design elements are described in this document.

The Master Thoroughfare Plan provides recommended criteria for considering design treatments and techniques for the types of major thoroughfares that are found within urban, suburban, and rural land use contexts throughout McLennan County. The Plan and Design Guidelines are intended to support a regional process for coordinating the development of roadway design plans during the initial and final engineering phases of the project development process. Communities that wish to employ a CSS approach for the design and development of roadway improvements within their area can get underway by taking the following steps:

Step 1: Identify the relevant Thoroughfare Type (Expressway, Arterial, or Collector) as defined by the 2012 Thoroughfare Plan. Section 2 of this document provides a Thoroughfare Plan Map and descriptions. The differences between Thoroughfare Types are primarily based upon their function (i.e. to provide higher-speed regional mobility and/or lower-speed local accessibility).

Step 2: Identify the Area Type(s) served by the thoroughfare, as described in Section 3. The four basic Area Types provide broad definitions of urban, suburban, and rural land use contexts that help planners and engineers discuss and determine key design criteria such as the predominant types of roadway users (high- or low-speed drivers, pedestrians, transit riders, cyclists, etc); potential multi-modal design elements (sidewalks, bike lanes, transit facilities, etc); and appropriate ranges for target design speed and overall roadway dimensions (lane width, number of lanes, medians, etc).

Step 3: Identify the Context Zone(s) served by the thoroughfare. The Context Zones, described in Section 4, are pinpointed subareas throughout the County that provide land use contexts to guide discussions and decisions about the location and design of specific design treatments for different types of roadway users (sidewalk widths and furnishings; crosswalk signals and median pedestrian refuges; bus pullouts and transit shelters; etc). These design treatments should support safe, convenient travel for all types of roadway users, as well as enhancing the vitality and character of the surrounding community.

Step 4: To support discussions and decisions regarding thoroughfare dimensions, elements, and design treatments, use the cross-sections and design guidance provided in Sections 5 and 6 of this document.



2. Thoroughfare System

2.1 Proposed Thoroughfare Network

Figure 1 identifies the recommended future thoroughfare network. It includes proposed new roadway segments and major improvements identified in local and regional plans such as *Connections 2035*.

The thoroughfare system provides the skeletal framework within which communities grow. Much like the physical skeleton of a person, the scale and connectivity of the street network determine, to a great degree, the dimensions and functionality of the community. The basic thoroughfare system should be considered as the structuring framework for future growth within McLennan County. The preponderance of regional vehicular traffic movement within the County should be concentrated on the arterial system, while the collector street system should complement the major arterials by supporting a variety of local traffic, including cars, bicycles, buses and pedestrians. Through better pre-planning of neighborhood areas and with developer cooperation, it may be possible to achieve this basic arrangement of primary and secondary thoroughfares.

These Design Guidelines are intended to help planners and engineers to design transportation networks that support cohesive, logically organized neighborhoods, towns, and cities. They include descriptions of the compatibility among the thoroughfare types and context zones; provide detailed tables outlining design recommendations and cross sections of the thoroughfare types; and offer guidance for the various elements of a roadway, including the throughway, sidewalk, bicycle facilities, transit infrastructure, and intersections.

Consulting the Roadway Design Guidelines and, where appropriate, incorporating them into area plans and policies will help local, regional and state agency staff and decision-makers to work collaboratively toward implementing the policies and recommendations set forth in this Thoroughfare Plan. It is the intent of the Design Guidelines not to supersede or contradict local and regional plans, but instead to promote flexibility and context-sensitivity within the roadway design process through techniques and strategies aimed at:

- Establishing a balanced array of multi-modal facilities;
- Increasing the level of safety, real and perceived, for all roadway users
- Improving the functionality of roadways;
- Accommodating a variety of roadway types and adjacent land use conditions; and
- Making roadway improvements that support local goals for economic, aesthetic, safety, and environmental benefits.



Figure 1: Proposed Thoroughfare Network



2.1 Thoroughfare Types

Expressways

Expressways are high speed (greater than 45 mph), controlled access thoroughfares with no pedestrian access and grade separated interchanges. This thoroughfare classification includes a range of roadway types such as expressways, freeways, toll ways, and parkways, with varying transportation characteristics. These facilities typically do not necessitate context sensitive solutions and are managed by the Texas Department of Transportation, therefore design guidance is not provided.

Arterials

The system of major arterials and expressways is designed primarily for higher-speed vehicle traffic. However, in Areas and Context Zones where major arterials also serve local traffic (such as downtown areas of cities and towns) the design of the roadway may be modified to support more types of roadway users, such as transit riders, bicyclists and pedestrians, and to promote the development of a more vibrant urban center.

Principal Arterials function to facilitate higher speeds and regional mobility (longer distance trips) across all modes while responding to the surrounding physical context in a non-obtrusive manner. Within urban areas, arterials are often marked by wide, planted medians that provide for separation of traffic flow, as well as generous sidewalks and furnishing zones within the right-of-way.

Minor Arterials also facilitate higher speeds and increased regional mobility but also provide greater local accessibility than principal arterials. These facilities usually have medians and sidewalks with a smaller buffer between the road than principal arterials.

Collectors and Local Streets

The system of collectors and local streets provides accessibility to, from, and within local communities and activity centers. The interconnected, multimodal networks provided by this system make collectors and local streets far preferable to arterials and expressways for making local and intra-regional trips.

A well-designed, multimodal collector system helps to reduce the congestion and safety problems along arterials that can occur when local drivers routinely use segments of high-speed roads for short trips. Making the flow of traffic smoother on higher-speed roads, in turn, reduces the temptation for regional truck drivers and automobile travelers to use local streets as de facto bypasses for overcrowded arterials. As with arterials in the Thoroughfare Plan, the design guidelines for collectors and local streets vary depending upon the “context zone” of the area that each roadway segment serves.

As new development occurs, new collectors and local street segments above and beyond those shown on the Thoroughfare Plan map may be needed. The alignment and capacity of these streets should be determined as part of any action on a preliminary plat or a final plat. The MPO recommends that each local city and the County consider updating local construction standards and subdivision regulations to reflect the context-sensitive roadway design standards contained within these Design Guidelines. This will help to



ensure a consistent approach to developing, over time, a complete network of local and regional thoroughfares.

Urban Collectors serve to carry traffic from larger thoroughfares to local roads, and typically provide a high level of access to adjacent parcels. They serve to connect neighborhoods to each other and to regional roadways. It is very unlikely that a street on the State Highway System will be classified as an urban collector.

Major Rural Collectors facilitate local and regional traffic movement in rural context zones and connect to local streets as well as regional roadways.

Table 1: Typical Thoroughfare Network Characteristics

Thoroughfare Type	Number of Lanes	Right of Way	Design Speed	Vehicles Per Day	Functions Within Different Areas
Principal Arterial	4-6	100-120 ft	35-65 mph	15,000-40,000	Regional mobility in undeveloped areas; accessibility to minor arterials and collectors in urban centers.
Minor Arterial	2-4	60-110 ft	25-65 mph	15,000-30,000	Regional mobility in undeveloped areas; regional and local accessibility in villages, towns, and cities.
Urban Collector	2-4	50-70 ft	25-45 mph	<10,000	Local accessibility in cities and towns.
Major Rural Collector	2-4	40-100 ft	35-65 mph	10,000-15,000	Regional mobility in undeveloped areas; local accessibility in towns and villages.



3. Area Types

Appropriate roadway design characteristics are defined by the surrounding community and neighborhood context as well as the intensity, density, and mix of adjacent land uses. In order to apply a Context-Sensitive Solutions approach to thoroughfare planning, the MPO stratified the County into a few broadly defined Area Types that reflect urban, suburban, and rural settings. Within each Area, the Plan further identifies pinpointed subareas called “Context Zones,” which range from high-density city centers to low-density agricultural areas.

The four general Area Types provide overarching land use contexts that help planners to identify typical roadway functions and overall dimensions such as overall right-of-way, lane width, and design speed. (See Figure 2) For example, the function of a Major Arterial in a Rural Area may be to provide regional mobility, which generally calls for more right-of-way, wider lanes, and higher design speeds. Within Suburban and Urban contexts, however, the functions of this example Major Arterial might change to include both regional mobility and local accessibility. To make the roadway better serve the overarching land use contexts and functions in these Area Types, it may be appropriate to lessen the Major Arterial’s overall roadway footprint and reduce the design speed.

The seven Context Zones are associated with roadway design elements that help planners and engineers to design roadway sections that support a variety of desired development settings. To build upon the example in the previous paragraph, it may be appropriate to reduce the overall dimensions and design speed of a Rural Area Major Arterial when it passes through a Village Center Context Zone, and to add design elements such as sidewalks, crosswalks, angled on-street parking, and landscaped medians. These design elements would support economic development goals such as enhancing the village gateway and encouraging drivers to stop and shop. Within a dense City Center Context Zone, the same Major Arterial may feature wide sidewalks, count-down pedestrian signals, and bus pullouts with attractive shelters, all of which encourage the higher numbers of pedestrians and transit riders found in vital urban areas.

Used together, the Area Types and Context Zones can help planners and engineers determine appropriate roadway design techniques to complement the surrounding built environment by enhancing community character and supporting desired economic development. The Area Types and Context Zones are described briefly in this section. More details about these designations are included in the Roadway Design Guidelines that accompany this Thoroughfare Plan.



3.1 City Center Area

The City Center Area Type is reserved for the highest intensity area in the region and typically represents a balanced mix of high density residential and employment uses. Within McLennan County, the City Center Area is comprised of downtown Waco, and is consistent with the geography and desired characteristics of the Imagine Waco downtown plan. It is a regional hub for entertainment, civic and cultural uses. The parcels in these areas are usually built to the public frontage with little or no setbacks, forming a continuous street wall. The buildings are typically four or more stories high. The streets in city center areas are strongly oriented towards pedestrian and transit activity with emphasis on public spaces such as parks, plazas, and squares.

3.2 Urban Area

The Urban classification is oriented towards residential uses, typically a range of housing types including attached, semi-detached and detached units. Commercial and civic activity in these areas is focused along major corridors and/or neighborhood and community centers. Buildings are typically two to three stories tall and attached or semi-detached with minimal or no front and side setbacks. Public spaces are mostly parks and other recreational open spaces that are oriented towards residential uses.

3.3 Suburban Area

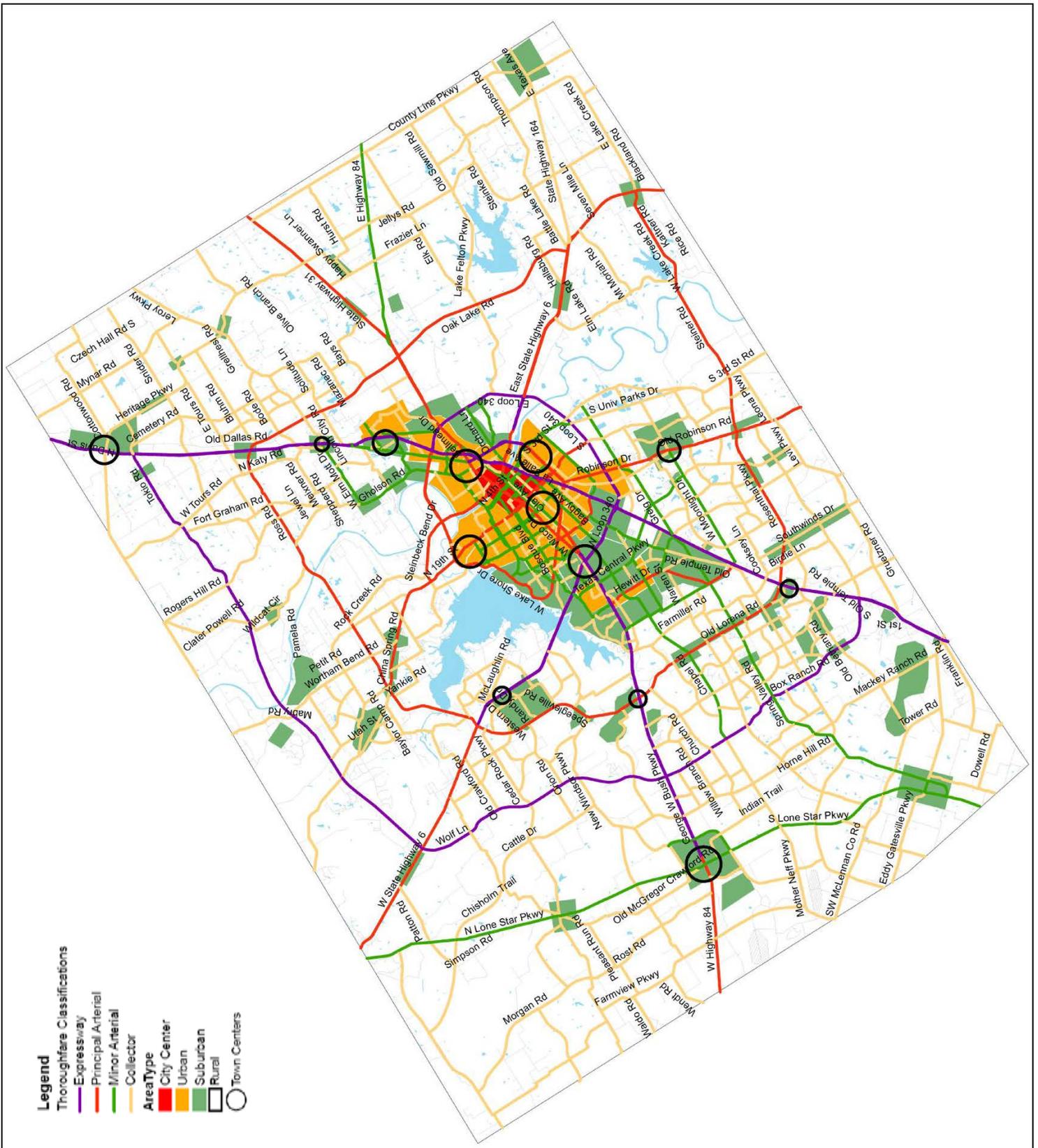
The Suburban classification is oriented towards single family residential uses. Commercial and civic activity in these areas is usually limited to commercial/retail centers. The buildings are typically one to two stories high and detached with varying front and side yard setbacks and parking in front of buildings. Open spaces are usually landscaped as lawns, yards, parks and other recreational green spaces.

3.4 Rural Area

The Rural classification is predominantly agricultural with scattered residential development and little or no commercial activity. Building heights, type, and setbacks are highly variable.



Figure 2: Area Types



4. Context Zones

As shown in Figure 3, a variety of locations within each development area can be further characterized as belonging to one of seven basic context zones: City Center, Commercial Center, Village Center, Neighborhood Center, Traditional Neighborhood, Conventional Neighborhood, and Rural Agriculture). Additionally, there are three special districts represent areas of high thoroughfare activity but do not fit cleanly within any of the basic zones. These special districts include Regional Center, Institutional Campus, and Industrial Center.

4.1 City Center Context Zone

The City Center Context Zone has essentially the same Downtown Waco geography as the City Center Area Type. The purpose of also including a Context Zone classification for this area is to provide a finer-grained level of detail regarding design elements and characteristics. Many desired elements for various thoroughfares and the built environment are described in the Imagine Waco Downtown Plan.

Typical City Center design characteristics include, but are not limited to, the following:

- Vehicle travel speeds should be low to moderate
- On-street parking is important to serve the high vehicle access demand
- Wide sidewalks (at least 15') should be included with a minimum 8' walk zone
- Bicycle lanes can be incorporated into the right-of-way
- Driveways should be infrequent so as not to impede pedestrian movement
- Signals or stop signs at intersections
- Bus stops located at the curb
- Pedestrian and street lighting required; 1.5' from curb

Imagine Waco is a downtown development plan created by the City of Waco Planning and Zoning Department for the purpose of articulating a vision for Greater Downtown Waco and providing a tool to guide development towards that vision. It includes a vision map that provides recommendations for transportation improvements, land uses, and amenities. Many of the downtown plan's recommendations involve creating context sensitive solutions to improve the vitality of Greater Downtown Waco.

4.2 Commercial Center Context Zone

Commercial Centers are a dominant form throughout Waco. These areas often lack a recognizable "center", but are important economic generators. They serve multiple neighborhoods as destination retail locations. Residents must drive to and between buildings for access. Franklin Avenue is an example of a Commercial Center in Waco.

Typical Commercial Center design characteristics include, but are not limited to, the following:

- Typically four travel lanes
- On-street parking is important due to the high vehicle traffic of visitors to surrounding businesses



- Multimodal access should be incorporated, including bicycle lanes and bus stops
- Buildings should be set back from street to provide ample walking space for pedestrians
- Buildings may or may not be oriented toward the street
- Vehicle travel speeds are typically moderate to high
- Where there is a low signal density, crossings need to be included for pedestrians
- Bus stops located at back of sidewalk
- 12' to 15' sidewalk with a minimum 8' walk zone
- Pedestrian and street lighting required

4.3 Village Center Context Zone

Discrete villages are scattered throughout McLennan County. Although many of these village centers are located in rural areas, their general characteristics group them into the urban centers area types. These villages are compact, offer high internal accessibility, and have moderately dense commercial cores. Within the Waco city limits, small urban village centers are also present. These tend to be more scattered in form, but have great potential to undergo revitalization and become a community focal point in the future. Village Centers in McLennan County include McGregor, Lorena, Crawford, China Springs, and small urban neighborhood centers.

Typical Village Center design characteristics include, but are not limited to, the following:

- On-street parking is important
- Multimodal access should be incorporated, including bicycle lanes and bus stops
- Buildings should be set back from street to provide ample walking space for pedestrians
- Street network is well-connected
- Vehicle travel speeds are typically low to moderate
- Signals or stop signs at intersections
- Bus stops located at back of sidewalk
- 12' to 15' sidewalk with a minimum 8' walk zone
- Pedestrian and street lighting required

4.4 Neighborhood Center Context Zones

A Neighborhood Center includes civic facilities, such as libraries, schools, parks, and churches. A neighborhood center may become the focal point of a community where residents convene for mutual purpose. Accessibility by multiple modes is key to its success. Examples of Neighborhood Centers are Dean Highland Elementary School, Crestview Elementary School and Mitchell Park.

Typical Neighborhood Center design characteristics include, but are not limited to, the following:

- On-street parking is important
- Multimodal access should be incorporated, including bicycle lanes and bus stops



- Buildings should be set back from street to provide ample walking space for pedestrians
- Street network is well-connected
- Vehicle travel speeds are typically low to moderate
- Signals or stop signs at intersections
- Bus stops located at back of sidewalk
- 12' to 15' sidewalk with a minimum 8' walk zone
- Pedestrian and street lighting required

4.5 Mixed Use Neighborhood Context Zone

A traditional neighborhood consists of single or multi-family houses at about 3-5 du/acre. Smaller blocks are created by a tight, interconnected urban street network. Sidewalks are usually present. Examples include North and north-west downtown Waco.

Typical Mixed Use Neighborhood design characteristics include, but are not limited to, the following:

- The street network is well-connected
- Multimodal access is moderate, with sidewalks and trails connecting to transit stops and other context zones
- May use bike shoulders or shared lanes instead of bike lanes
- On-street parking is feasible and appropriate
- Vehicle speeds are low to moderate, although congestion may occur due to frequent signal spacing
- Curb radii are small and curb extensions are appropriate
- Signals or stop signs at intersections
- Bus stops located at back of sidewalk
- 6' to 8' wide sidewalks recommended
- Street lighting required

4.6 Conventional Suburban Neighborhood Context Zone

A conventional neighborhood is distinguished by its pattern of curvy streets and cul-de-sacs. The network breaks down and prevents through traffic from traversing a neighborhood. Houses typically are larger and on larger lots. Sidewalks may or may not be present. Areas around Lake Waco, West Waco, and McLennan County are examples of conventional neighborhoods.

Typical Conventional Suburban Neighborhood design characteristics include, but are not limited to, the following:

- The street network is less-connected than mixed use neighborhoods, with many streets ending in cul-de-sacs
- Multimodal access is moderate, with sidewalks and trails connecting to transit stops and other context zones
- May use bike shoulders or shared lanes instead of bike lanes



- On-street parking is feasible and appropriate
- Vehicle travel speeds are low, as lanes are narrow
- Curb radii are small and curb extensions are appropriate
- Stop signs at intersections
- Bus stops located at back of sidewalk
- Sidewalks are a minimum 5' recommended
- Street lighting required
- Cul-de-sacs are strongly discouraged

4.7 Rural Agriculture Context Zone

The Rural context zone is predominantly agricultural with scattered residential development and little or no commercial activity. Building heights, type, and setbacks are highly variable. Low density farmsteads are easily distinguished by their surrounding open space or farmland. Densities are often below 1 dwelling unit for every 20 acres. These areas are mostly located outside of the Waco urbanized area. Farmstead is an example of Rural Agriculture context zone in McLennan County.

Typical Rural Agriculture design characteristics include, but are not limited to, the following:

- Sidewalks are not typical
- Bicycle lanes or shoulders may be included in the throughway
- Vehicle travel speeds are moderate to high
- There is no need for on-street parking
- Building density is very low
- Stops signs at intersections
- Bus stops not typically included
- Sidewalks not typically included
- Street lighting not required except safety lighting at the intersections of principal arterials or expressways

4.8 Special Districts

Regional Center

Centers that serve populations on a regional scale are called Regional Centers. These centers are accessible from major highway networks and offer vast areas of parking. Buildings are typically accessed from parking lots and offer internal pedestrian circulation. The most successful Regional Centers offer connections with local street networks in addition to the regional network. Creating connections helps to diversify the types of uses within the center and offers opportunities for compatible development that benefits the local community. Two examples of Regional Centers in McLennan County include Providence Health Center and Richland Mall.

Typical Regional Center design characteristics include, but are not limited to, the following:



- The street network accommodates a high amount of traffic and connects to regional roadways
- Vehicle travel speeds are moderate to high
- Buildings should be set back from street to provide ample walking space for pedestrians
- Internal multimodal access should be incorporated, including wide sidewalk, bicycle lanes and bus stops
- On-street parking is typically not necessary due to the ample parking provided at the regional center destinations
- Signals or stop signs at intersections
- Bus stops located at back of sidewalk
- Sidewalks are a minimum 5' recommended
- Street lighting required

Institutional Campus

Campus style institutions are a unique place type in the spectrum of context zones. Buildings may be organized in a compact or a disperse pattern. Access from regional highways is important for these locations that draw from a regional population. Access to local streets is important to serve students and local commuters. Finally, internal circulation is important where walking is the primary form of transportation between buildings. Baylor University exemplifies this context zone.

Typical Institutional Campus design characteristics include, but are not limited to, the following:

- On-street parking is important
- Multimodal access should be incorporated, including bicycle lanes and bus stops
- Buildings should be set back from street to provide ample walking space for pedestrians
- Street network is well-connected
- Vehicle travel speeds are typically low
- Signals or stop signs at intersections
- Bus stops typically located at curb
- Sidewalks with a minimum 5' width recommended
- Pedestrian and street lighting required

Industrial Center

Industrial Centers are another unique context zone. Built form most often resembles that of the Commercial Center with larger building footprints, vast areas of surface parking and an auto-orientation. Facilitating truck traffic into and through industrial centers is essential to the success of these centers on both a regional and local level.

Typical Industrial Center design characteristics include, but are not limited to, the following:

- Buildings are widely dispersed to allow ample maneuvering space for trucks and on-site parking



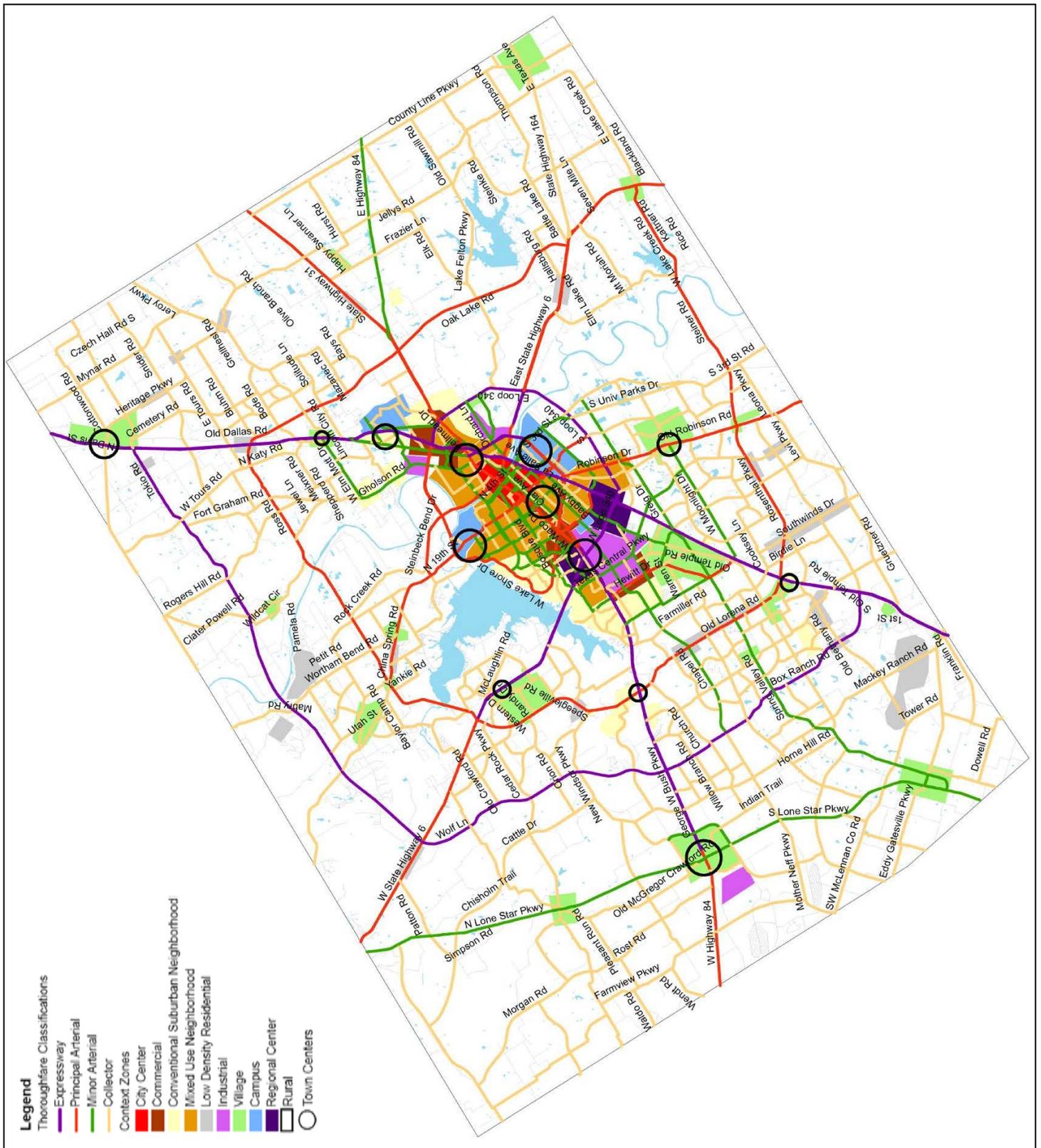
- Street network connectivity varies, but is typically focused on main streets with cross streets providing additional access
- Bicycle lanes and sidewalks can be incorporated into the street design
- On-street parking may not be feasible
- Sidewalks and bicycle lanes are encouraged to increase multimodal safety
- Signals or stop signs at intersections
- Bus stops placed where employment densities warrant
- Sidewalks not typically included, but if so, are a minimum 5' recommended
- Street lighting required

In addition, the following design elements accommodate high volumes of truck traffic:

- Curb radii are typically larger to accommodate the turning movements of freight trucks
- Outside lanes are wider for freight trucks to utilize
- Stop bars are set further back to avoid collisions of turning trucks with vehicles stopped at intersections
- Tapered curbs and multiple radius curbs may be used in areas where wider turn radii are needed



Figure 3 Context Zones



5. Thoroughfare Design Elements and Cross Sections

5.1 Matching Thoroughfare Type With Community Context

These Guidelines aim to develop an alternate set of roadway types that can accommodate all modes of transportation. This requires a shift from the conventional auto-oriented functional classification system to a system based on the surrounding context through which the roadway travels. The new classification system shifts the focus of roadway design from vehicular mobility to consideration of all modes of travel.

The design of a thoroughfare is intrinsically connected to its functional classification and context. The elements of a roadway, how they are designed, and how they relate to each other are dependent on the traffic patterns on the roadway and adjacent land uses. The following paragraphs outline compatibilities among area types, context zones, and thoroughfare types.

A thoroughfare is defined by its function and its role in the street network as well as the area type and context zone surrounding the road. Principal Arterials, Minor Arterials, and Urban Collectors are predominantly found in urban and suburban area types and context zones, although variations of these thoroughfare typologies can exist in rural areas and zones. Table 2 describes the compatibility between specific thoroughfare types and area types as guidance for assigning thoroughfare types to specific roadways based on their location.



Table 2 Compatibility Among Area Types, Context Zones, and Thoroughfares

Area Type	City Center	Urban	Suburban	Rural
Context Zones	City Center	Commercial Center, Village Center, Neighborhood Center, Special Districts: Regional Center, Institutional Campus, & Industrial Center	Mixed-use Neighborhood, Conventional Neighborhood	Industrial Center, Rural Agriculture
Thoroughfare Types	Expressway, Principal Arterial, Minor Arterial, Urban Collector	Expressway, Principal Arterial, Minor Arterial, Urban Collector	Minor Arterial, Major Rural Collector, Urban Collector	Minor Arterial, Major Rural Collector
Block Length	400' – 600'	400' – 800'	200' – 400'	N/A
Frontage	Commercial, Storefront, Porch Front	Commercial, Storefront, Porch Front	Storefront, Porch Front, Residential Yard	Residential Yard, Agricultural Land
Setbacks	0 – 10'	0 – 50'	10 – 50'	N/A
Parking	Structured, On-street, Interior Block Surface	Structured, On-street, Interior Block Surface	On-Street, Interior Block Surface, Residential, Alley	Residential



5.2 Potential Thoroughfare Design Elements for Different Area Types

In the following tables, various roadway design elements are rated for each area type as follows:

Desirable - those techniques which should be included on all projects unless there are compelling reasons not to do so.

Appropriate - those techniques that should be employed, but must be evaluated relative to context of the particular project.

May be Appropriate – those techniques that should be employed only if there is a specific need or problem that can be addressed by their inclusion in the project design. They also could conflict with required roadway elements in some conditions and should not be used in those cases.

Not Appropriate—those techniques that should not be considered.

The issue of desirability is important to both the nature of guidelines and the idea of designing for livability. These guidelines are advisory, but intentionally emphasize roadway design features and techniques that would enhance multi-modal safety and travel flow while also enhancing the surrounding community character.

These tables are intended to provide the reader with an initial sense of design techniques that could be considered in order to advance community goals for different area types. More detailed information about these design elements for various thoroughfare types, including cross-sections, is contained in the next two sections of the document.



Table 3 Pedestrian and Bicycle Design Elements by Area Type

STRATEGIES	CITY CENTER	URBAN	SUBURBAN	RURAL
Adding sidewalks where none are present	D	D	A	M
Sidewalks on both sides of the street	D	D	D	M
Sidewalks wider than six feet	D	A	M	N
Setting back sidewalks from edge of pavement	D	D	D	D
Automatic pedestrian signals (non-actuated)	D	D	D	A
Countdown pedestrian signals	D	D	A	M
Median refuge areas	A	A	A	N
Reduced corner radius	D	A	M	N
Curb extensions	M	M	N	N
Right-turn channelized islands	N	N	M	M
Midblock crossings	M	M	A	M
Midblock pedestrian signals	M	M	N	N
Illuminated pedestrian crossings	M	M	N	N
Bicycle lanes	D	D	A	M
Paved shoulders	N	N	M	D
Expanded shared lanes	M	M	M	M
Signed bicycle routes	A	A	A	M
Independent shared use paths	N	M	A	A
Bicycle parking	D	D	M	M

- D Desirable
- A Appropriate
- M May be appropriate
- N Not appropriate



Table 4 Design Elements to Help Reduce Travel Speeds or Volumes by Area Type

STRATEGIES	CITY CENTER	URBAN	SUBURBAN	RURAL
Lower speed limits	N	N	N	N
Increased use of stop signs	M	M	N	N
On-street parking	D	A	M	N
Conversion of one-way streets to two-way	A	A	M	N
Limit or reduce number of lanes	A	M	M	M
Speed humps	N	N	N	N
Speed tables and raised intersections	M	M	A	N
Traffic chokers	N	N	N	N
Compact intersections	A	A	A	M
Curvilinear, continuous alignment	M	M	A	N
Street closing or route relocation	M	M	M	N
Traffic roundabouts	M	A	D	D

- D Desirable
- A Appropriate
- M May be appropriate
- N Not appropriate



Table 5 Other Design Elements by Area Type

STRATEGIES	CITY CENTER	URBAN	SUBURBAN	RURAL
Wayfinding maps or signs	D	M	M	N
Landscaped right of way	A	D	D	M
Innovative storm water facilities	A	A	A	A
Street furniture	D	A	M	N
Pedestrian lighting	D	A	M	N
Minimal horizontal clearance (trees and poles)	D	D	M	N
Alternative paving materials	A	M	M	N
Pedestrian-friendly interchange ramps	D	D	M	M
Safety and personal security amenities	A	A	M	M
Space through-streets a half mile apart max	D	D	A	N
Space through-streets a mile apart max*	N	N	M	M*

- D Desirable
- A Appropriate
- M May be appropriate
- N Not appropriate

*Separation distance may be further in rural areas depending upon the context.



5.3 Thoroughfare Design Elements

Sidewalks and Pedestrian Areas

Sidewalks should be considered on all projects, including some types of rural areas, because they perform a vital mobility function for the community and are essential to certain user groups. Although the standard sidewalk width is five feet, it is desirable to create wider sidewalks in business districts, near schools, transit stops, or where there are other significant pedestrian attractors. Sidewalks that have a buffer strip along the roadway must be a minimum of five feet wide. A two-foot buffer is acceptable, but a six-foot landscape buffer is preferred to improve the pedestrian experience and eliminate the need to narrow or reroute sidewalks around driveways. Roadways that cannot accommodate a landscape strip must have a minimum six-foot wide sidewalk. Roadways with flush shoulders should locate the sidewalk as far from the roadway as practical in the following priorities:

- At or near the right-of-way line.
- Outside of the clear zone.
- Five feet from the shoulder point.

Section 6 of this document includes recommendations for the “sidewalk corridor” dividing this area into four distinct zones that ensure that there is room for pedestrian travel as well as street furniture and other features. The pedestrian areas include the sidewalk corridor and crosswalks. The sidewalk corridor is divided into four zones below:

- The curb zone provides the edge between the traveled way and the sidewalk corridor;
- The furniture zone is where elements such as street trees, bicycle racks, signs, parking meters, driveway aprons, utilities, signal poles and other street furniture are located;
- The pedestrian zone is the area specifically reserved for pedestrian travel; and
- The frontage zone offsets the pedestrian zone from the property line to allow maintenance of the sidewalk, and provide some distance from vertical elements placed at the property line.

Bicycle Lanes

Bicyclists are an expected common user group in all contexts and for all projects, except for the main lanes of expressways. Appropriate bicycle facilities shall be considered on all projects. Basic design criteria and standards for bicycle facilities are provided in Section 6 of this document. However, additional details about the design of bicycle facilities can be found in other documents including the AASHTO Guide for the Development of Bicycle Facilities.

Raised Medians

Raised medians are often the single most valuable geometric feature for retrofitting a street as part of a CSS project. Four- and six-lane undivided roadways typically have very poor safety records given unrestricted turn movements, no storage lane for left turning vehicles, and no refuge for pedestrians. A two-way center left turn lane can



improve traffic flow and reduce may the incidence of rear-end crashes by providing a storage area for left-turning vehicles. However, the frequently chaotic vehicle maneuvers and lack of positive separation present in continuous center turn lanes can provoke more crashes than turn lanes on median-divided roadways. By restricting left turn movements to clearly defined, specific locations, raised medians improve vehicle safety by reducing the incidence of left turn crashes, which are among the most severe types of crashes.

Raised medians also provide a refuge for pedestrians, allowing them to cross major roadways one or two single-direction lanes at a time. As a result, raised medians have been shown to reduce pedestrian crossing crashes at unsignalized locations by as much as 40 percent. This safety benefit is similar at marked, designated crossing locations. Raised medians also discourage the dangerous tendency of pedestrians to dash across multiple lanes of traffic in random mid-block areas, especially on corridors that lack designated, conveniently located crossings.

Raised medians with landscape features may also improve the roadway character by encouraging slower operating speeds, narrowing long vistas, and providing opportunities for landscaping enhancement. Where a continuous raised median is not feasible, sections of raised median should be provided to enhance vehicular and pedestrian safety and to help delineate key areas such as urban centers and village gateways.

Lane Width

The use of narrow travel lanes supports livability and should be encouraged on McLennan County thoroughfare projects. Wide roadways, fostered in part by wider lanes, can act as barriers to pedestrians, discouraging pedestrian crossings and decreasing pedestrian safety. The use of narrow lanes also encourages lower operating speeds and reclaims rights-of-way for wider sidewalks, bicycle lanes, street trees, on-street parking, wider medians, and other features. A study by the national Transportation Research Board ^{iv} found that there is no significant difference in overall vehicle crash rates on urban arterial streets with travel lanes of ten feet versus twelve feet.

Trees and Landscape

Street trees provide shade, separate sidewalks from roadways, and break down the scale of the street. In order to provide continuous shade coverage, street trees should be planted 30' apart. Typically an 8' vertical clear zone between the tree canopy and the sidewalk should be maintained in order to ensure clear visibility and security for pedestrians and motorists. In intensely developed areas, this zone may be increased in order to enhance readability of storefronts and signage. Tree grates are encouraged in commercial areas, while planting strips are more often recommended in non-commercial areas or residential streets. Tree species with tap roots should be selected to prevent sidewalk breakage. Drought tolerant, native tree species are also encouraged in order to minimize watering requirements and the need for irrigation.



Table 6 Thoroughfare Design Elements For City Centers

DESIGN ELEMENTS		Principal Arterial	Minor Arterial	Urban Collector	Neighborhood Collector
Posted speed		25 to 35 MPH	25 to 35 MPH	20 to 30 MPH	15 to 30 MPH
Right-of-way width		80'-100'	60'-80'	50'-70'	40'-60'
Number of through-lanes		4	2-4	2-4	2
Raised median width		6'-10'	6'-10'	6'-10'	Not typical
Lane width		10'-11'	10'-11'	10'-11'	9-10'
Bicycle lane (where striped lane is recommended over shared lane)		5'-6'	5'-6'	5'-6'	5'-6'
Paved shoulder width		N/A	N/A	N/A	N/A
Parking width		N/A	8'	7'-8'	Not striped
Sidewalk corridor width	Furniture Zone	3'-5'	3'-5'	5'-8'	5'-8'
	Pedestrian Zone	7'-10'	7'-10'	6-10'	6'-8'
	Frontage Zone	0'-5'	0'-5'	0'-5'	N/A
Curb		6"	6"	6"	6"
Drainage		Curb + gutter	Curb + gutter	Curb + gutter	Curb + gutter
Trees in median		N/A	N/A	N/A	N/A
Trees in Furniture Zone		Optional	Desirable	Desirable	Desirable



Table 7 Thoroughfare Design Elements for Urban Areas

DESIGN ELEMENTS		Principal Arterial	Minor Arterial	Urban Collector	Neighborhood Collector
Posted speed		35 to 40 MPH	25 to 40 MPH	20 to 30 MPH	15 to 30 MPH
Right-of-way width		80'-120'	60'-100'	50'-70'	40'-60'
Number of through-lanes		4-6	2-4	2-4	2
Raised median width		10'-12'	10'-12'	6'-10'	N/A
Lane width		10'-12'	10'-12'	10'-11'	9'-10'
Bicycle lane (where striped lane is recommended over shared lane)		5'	4'-5'	4'-5'	4'-5'
Paved shoulder width		N/A	N/A	N/A	N/A
Parking width		N/A	8'	7'-8'	Not striped
Sidewalk corridor width	Furniture Zone	3'-5'	2'-6'	2'-8'	5'
	Pedestrian Zone	5'-8'	5'-10'	5-10'	5-6'
	Frontage Zone	0'-5'	0'-5'	0'-5'	N/A
Curb		6"	6"	6"	Optional
Drainage		Curb + gutter	Curb + gutter	Curb + gutter	Curb + gutter or swale
Trees in median		Optional	Desirable	Desirable	Desirable
Trees in Furniture Zone		Optional	Desirable	Desirable	Desirable



Table 8 Thoroughfare Design Elements For Suburban Areas

DESIGN ELEMENTS		Principal Arterial	Minor Arterial	Urban Collector	Neighborhood Collector
Posted speed		35 to 50 MPH	25 to 50 MPH	20 to 35 MPH	15 to 30 MPH
Right-of-way width		100'-120'	60'-120'	50'-70'	40'-60'
Number of through-lanes		4-6	2-4	2-4	2-4
Raised median width		12'-16'	10'-16'	6'-10'	12'-16'
Lane width		11'-12'	10'-11'	10'-11'	9'-11'
Bicycle lane (where striped lane is recommended over shared lane)		5'	5'	4'-5'	4'-5'
Paved shoulder width		N/A	N/A	N/A	5'-8'
Parking width		N/A	8'	7'-8'	Not striped
Sidewalk corridor width	Furniture Zone	5'-8'	2'-6'	2'-8'	5'
	Pedestrian Zone	5'-8'	5'-8'	5-8'	5'-6' or optional 12' shared use path
	Frontage Zone	1'	1'	1'	1'
Curb		Optional	Optional	Optional	None
Drainage		Curb + gutter or swale	Curb + gutter or swale	Curb + gutter or swale	Swale
Trees in median		Optional in lower speed areas	Optional in lower speed areas	Optional	Optional
Trees in Furniture Zone		Optional in lower speed areas	Optional in lower speed areas	Optional	Optional



Table 9 Thoroughfare Design Elements For Rural Areas

DESIGN ELEMENTS		Principal Arterial	Minor Arterial	Rural Collector	Neighborhood Collector
Posted speed		45 to 70 MPH	40 to 65 MPH	20 to 45 MPH	15 to 45 MPH
Right-of-way width		100'-120'	60'-120'	50'-80'	40'-80'
Number of through-lanes		4-6	2-4	2-4	2-4
Raised median width		12'-16'	10'-16'	12'-16'	12'-16'
Lane width		11'-12'	10'-12'	10'-11'	9'-10'
Bicycle lane (where striped lane is recommended over shared lane)		N/A	N/A	4'-5'	4'-5'
Paved shoulder width		8'	8'	5'-8'	5'-8'
Parking width		N/A	N/A	N/A	N/A
Sidewalk corridor width	Furniture Zone	N/A	2'-6'	2'-8'	5'
	Pedestrian Zone	Optional 12' shared use path	5'-6' or optional 12' shared use path	5'-6' or optional 12' shared use path	5'-6' or optional 12' shared use path
	Frontage Zone	1'	1'	1'	1'
Curb		Optional	Optional	Optional	None
Drainage		Curb + gutter or swale	Curb + gutter or swale	Curb + gutter or swale	Swale
Trees in median		N/A	Optional in lower speed areas	Optional in lower speed areas	Optional in lower speed areas
Trees in Furniture Zone		N/A	Optional in lower speed areas	Optional in lower speed areas	Optional in lower speed areas



5.4 Cross Sections^v

The purpose of the thoroughfare cross sections is to define the thoroughfare elements and their organization based on the function, capacity and speed of the roadway. To provide for vehicular mobility while maintaining multi-modal access on thoroughfares, roadways are organized into areas for vehicular traffic (including transit and bicyclists), and pedestrian traffic. The vehicular areas include lanes for through traffic and turning traffic (sometimes shared by motor vehicles and bicycles), bicycle lanes, and parking lanes. Shared use paths or trails are a more suburban or rural condition and could be designed to allow for pedestrians and/or bicycle traffic.

Suburban Principal Arterial

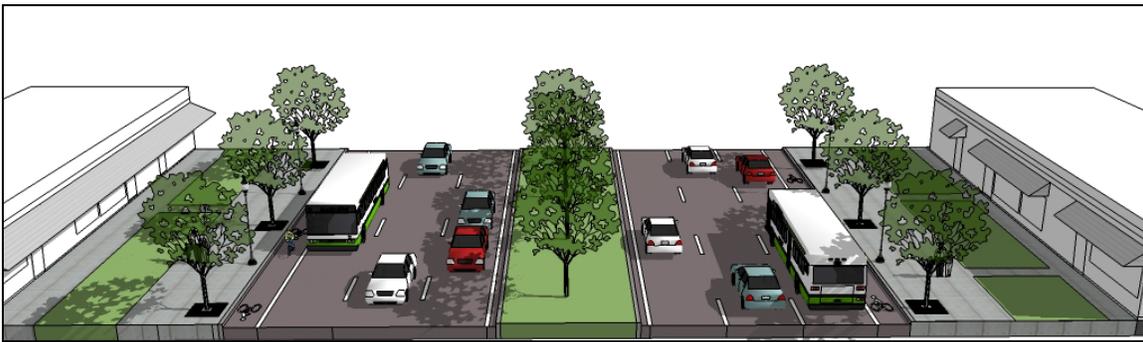


Figure 4 Suburban Principal Arterial

The primary function of Suburban Principal Arterials is mobility, typically with two or three lanes for through motor vehicle traffic in each direction. Suburban Principal Arterials typically contain no-parking lanes, and bicycle lanes are included unless right-of-way is severely restricted. The opposing lanes of through traffic are separated using a landscaped median, and pedestrian traffic is separated from vehicular traffic by a landscaped furniture zone. Parking on Suburban Principal Arterials can be accommodated on frontage roads along each side of the Arterial that sometimes include a single one-way lane for vehicular traffic and one lane for parking.

Urban Principal Arterial



Figure 5 Urban Principal Arterial

The primary function of Urban Principal Arterials is multi-modal accessibility with lower mobility and capacity needs for motor vehicles. Urban Principal Arterials typically include two (or occasionally 3) lanes for through motor vehicle traffic in each direction, on-street parking, and bicycle lanes. Pedestrian traffic is accommodated on a sidewalk, typically separated from the vehicular and bicycle traffic using a landscaped furniture zone. The opposing lanes of through traffic are separated by a landscaped median.

Two-Lane Minor Arterial

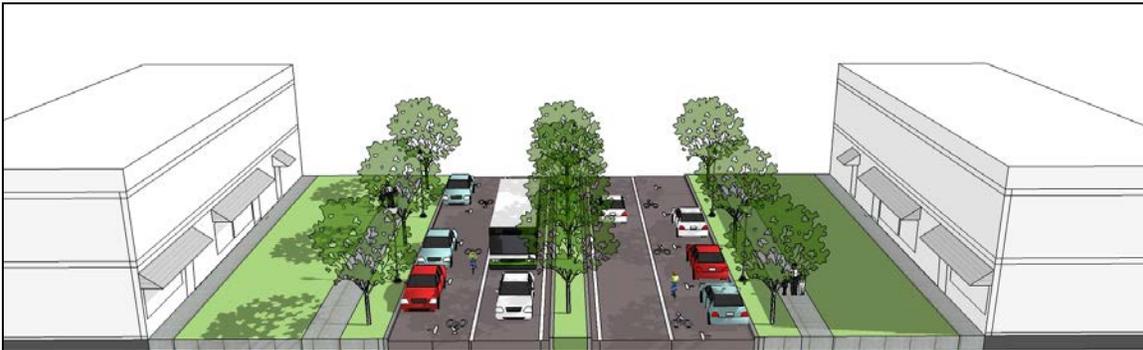


Figure 6 Two-Lane Minor Arterial

The primary function of Minor Arterials is mobility with a high level of local connectivity and accessibility. Minor Arterials typically include one lane for through motor vehicle traffic in each direction with parking lanes and bicycle lanes. With only one lane in each direction, the opposing lanes are not separated, and turn lanes are typically included as continuous left turn lanes or by eliminating parking lanes at intersections. In the City Center context zone, the sidewalk corridor typically includes a paved furniture zone with trees in tree grates, light poles, and other street furniture separating pedestrians from vehicular traffic. In Urban contexts, especially those bordering on Suburban, pedestrian traffic is separated from vehicular traffic using a landscaped furniture zone.

Four-Lane Minor Arterial



Figure 7 Four-Lane Minor Arterial

Where needed for higher traffic volumes, minor arterials can have two lanes for through motor vehicle traffic in each direction. The opposing lanes of through-traffic should be separated by a median and turn lanes should be provided at intersections. In City Center context zones, the sidewalk corridor typically includes a paved furniture zone with trees in tree grates, light poles, and other street furniture separating pedestrians from vehicular traffic. In Urban contexts, especially those bordering on Suburban, pedestrians are accommodated on sidewalks that may or may not be separated from vehicular traffic using a landscaped furniture zone.

Two-Lane Urban Collector

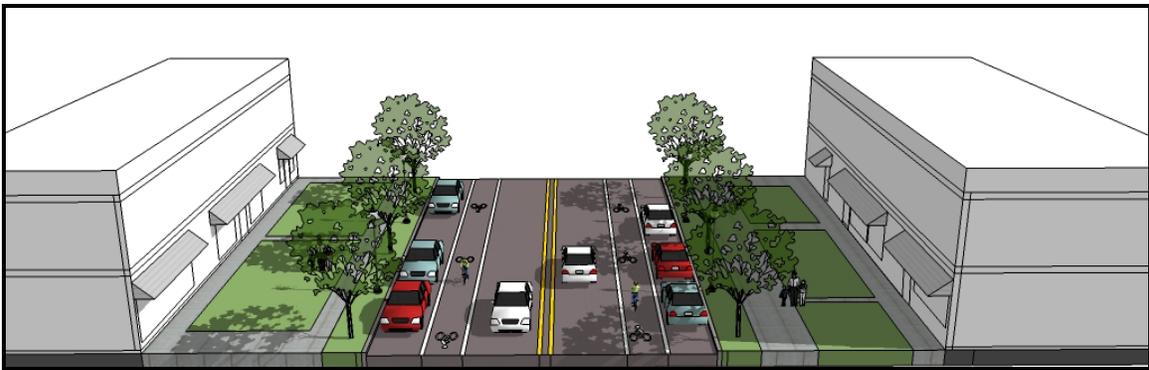


Figure 8 Two-Lane Urban Collector

Urban Collectors typically include one lane for through motor vehicle traffic in each direction with parallel or angled parking. Turn lanes and bicycle lanes are optional based on the existing right-of-way constraints and the context of the street. The sidewalk corridor nearly always includes a paved furniture zone where trees in tree grates, light poles, and other street furniture are placed. The sidewalk corridor is often wider than other thoroughfare types, taking up more of the available right-of-way.

Four-Lane Urban Collector

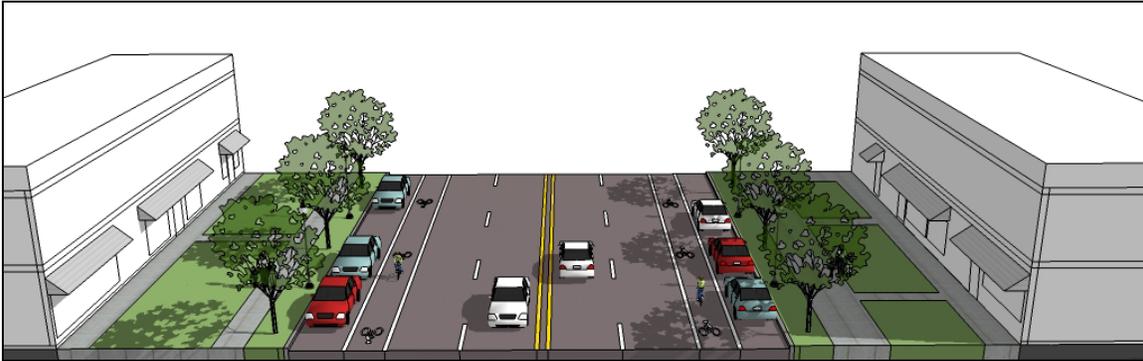


Figure 9 Four-Lane Urban Collector

Urban collectors can have two lanes for through motor vehicle traffic in each direction. The opposing lanes of through-traffic should be separated by a median and turning lanes should be provided at intersections. Medians on urban collectors may need to be narrower than on other thoroughfare types to allocate more of the available right-of-way for other elements of the roadway, such as the sidewalk corridor. The sidewalk corridor nearly always includes a paved furniture zone where trees in tree grates, light poles, and other street furniture are placed. The sidewalk corridor is often wider on urban collectors than for other thoroughfare types, taking up more of the available right-of-way.

Two-Lane Major Rural Collector

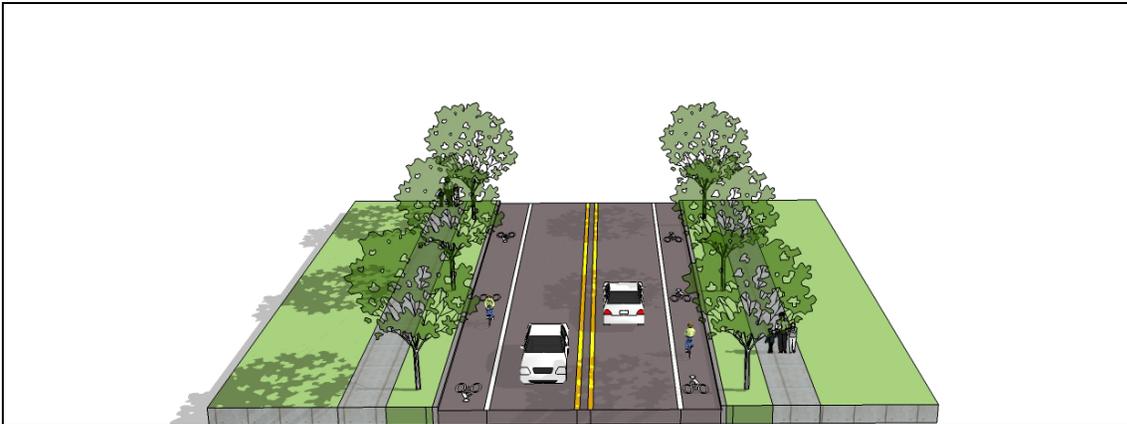


Figure 10 Two-Lane Major Rural Collector

The primary function of rural collectors is rural connectivity and access. Rural Collectors typically include a single lane in each direction for through motor vehicle and bicycle traffic with optional parking lanes. Since Streets accommodate mostly slow speed and low volume traffic, bicycles lanes and turn lanes are not required. Pedestrian traffic is typically accommodated on sidewalks that may have a paved or landscaped furniture zone based on adjoining land uses and setbacks.

Four-Lane Major Rural Collector

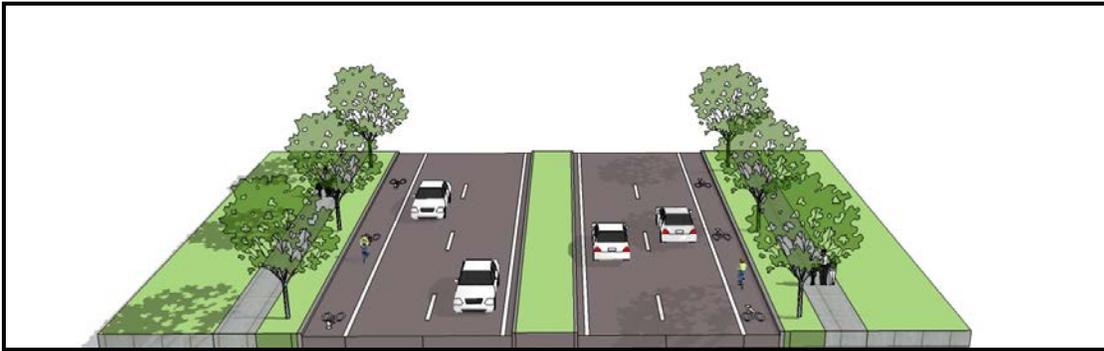


Figure 11 Four-Lane Major Rural Collector

The primary function of major rural collectors is to provide access in low density rural context zones. Major rural collectors typically accommodate one lane of through-traffic in each direction with shoulders to accommodate special needs such as bus stops and mail delivery. On rural highways with higher traffic, shoulder width of approximately ten feet is recommended. Turn lanes may be included at major intersections but rarely at driveways. Pedestrian and bicycle traffic, if any, is accommodated on the shoulders or optionally on a shared use path with some separation from motor vehicle traffic. A combination of sidewalks and designated bicycle lanes may be appropriate in some rural areas.

6. Designing Context-Sensitive Streets

Thoroughfares may serve, along their length, one or more Area Types and Context Zones. The previous sections focused on broad considerations for identifying the general characteristics of thoroughfares given their overall area type. This Section focuses on more fine-grained transportation design elements that are appropriate to consider for corridor segments within context zones that serve livable communities. It covers approaches to multi-modal roadway design that are essential to balancing the mobility needs of all users of the transportation system and creating streets that suit the community context.

The following discussions and illustrations of potential design elements are organized around the major roadway sections, as follows:

6.1 Throughway Corridor: This is the area “between the curbs” of the roadway. Elements addressed in this section include strategies to design travel lanes for cars, trucks, bicycles, and buses as well as medians, on-street parking lanes, and pedestrian crossings.

6.2 Sidewalk Corridor: This is the area bordering the roadway. It principally serves pedestrians (including people pushing strollers and in wheelchairs), and that sometimes includes outdoor cafes, landscaping, benches, and other amenities that promote urban vitality and attractiveness. This section discusses several sub-areas of the Sidewalk Corridor including the Curb Zone, Frontage Zone, Pedestrian Zone, and Furniture Zone. It also includes information about bicycle parking, pedestrian lighting, the location and design of transit stops, and personal safety design strategies developed by experts in Crime Prevention Through Environmental Design (CPTED).

6.3 Intersections: Often the most challenging elements of context-sensitive corridor design are located around intersections. This section discusses intersection geometry issues such as curb radii and channelized right-turn lanes as well as the location and design of pedestrian crossings. The section concludes with a brief discussion of roundabouts and interchanges.



6.1 Throughway Corridor

Vehicle Travel Speeds (Design Speed, Target Speed and Posted Speed)

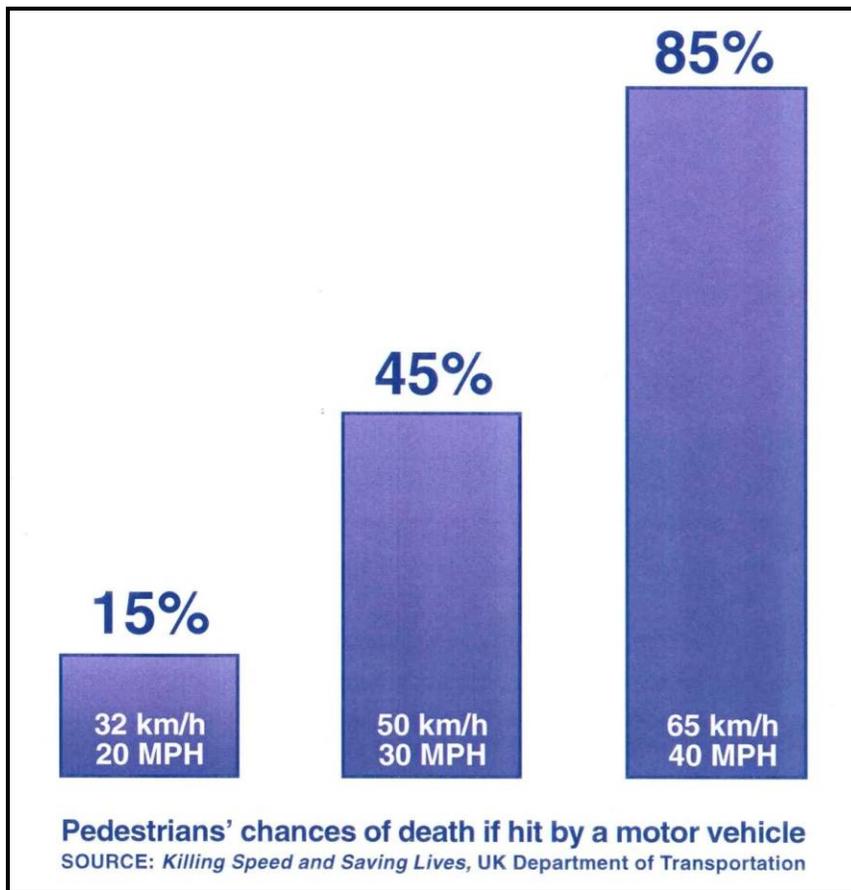
Vehicle travel speeds are an important consideration for a project that successfully promotes livability. Traditional thoroughfare design has maximized the design speed to provide more roadway capacity, with a goal of improving motor vehicle safety. For CSS projects, the street context and travel experience are important considerations, while the needs and safety of non-motorized users as well as drivers, should be a priority objective.

In general, the comfort and safety of pedestrians and bicyclists increases as actual motor vehicle travel speeds decrease. Slower driver speeds have a significant positive effect on pedestrian safety for several reasons, such as the following:

- At slower speeds, drivers do not need to look as far down the road and are better able to see activity on the side of the road including pedestrians walking along or crossing the road;
- At slower speeds, drivers' perception and reaction distance is much shorter, which means that they are better able to avoid a crash if there is a potential conflict with pedestrians or other road users (See Figure 12); and
- Slower speeds can mean significantly lower crash severity, particularly for pedestrian/vehicle crashes. The chance of pedestrian injury and fatality rises dramatically when speeds increase. (See Figure 13)



Figure 12 Vehicle Speed and Pedestrian Crash Severity



This figure shows the chance of a pedestrian fatality at various speeds

To provide a comfortable and safe environment for pedestrians and bicyclists, design speeds on context sensitive projects should be based on a “target speed” that is appropriate for the specific context of each roadway. Target Speed is the speed at which vehicles should operate on a thoroughfare in a specific context, consistent with the level of multimodal activity generated by adjacent land uses to provide both mobility for motor vehicles and a safe environment for pedestrians and bicyclists.^{vi} The target speed is usually the same as the posted speed limit. Design speed is the speed that governs geometric features of the roadway.

Consistent with the *ITE Designing Walkable Urban Thoroughfares: A Context Sensitive Approach Manual*, the design speed should never be lower than the posted speed or target speed. To achieve the appropriate target speed on most context sensitive projects, the design speed should normally be equivalent to the posted speed and not greater than five miles per hour (mph) over the posted speed, except on roads posted at 20 mph or below. The following minimum and maximum posted speeds and design speeds are recommended:

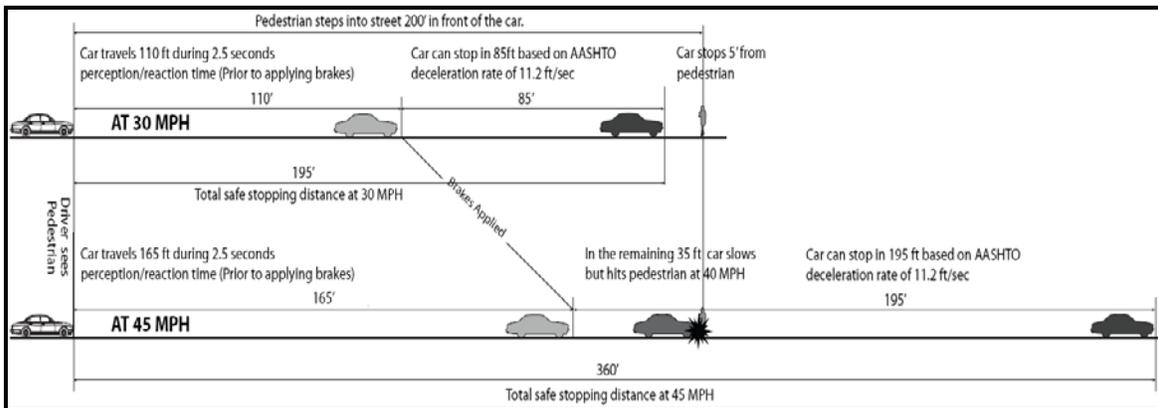
- Maximum posted (target) speed = 35 mph;
- Maximum design speed = 40 mph; and



- Minimum design speed = 30 mph.

On Suburban Arterials and Rural Roads, the desire for vehicular mobility may be high enough that it may be appropriate to allow for a posted speed of 40 mph and a design speed of 45 mph, even on a context sensitive project. In urban areas, design or posted speed is not necessarily directly related to capacity. A high-capacity street does not necessarily require a high design speed. Under interrupted flow conditions typical on major urban thoroughfares in urban areas, intersection operations and delay are the major determinant of capacity.

Figure 13 Vehicular Speed and Crash Avoidance



Drivers are better able to avoid crashes at lower speeds

Setting a target speed and posted speed that are artificially low relative to the design of the roadway will result in operating speeds that are higher than desirable and difficult to enforce. The following design features have the potential to reduce travel speeds:

- Narrow lane widths (appropriate for the design speed and design vehicles);
- Minimal or no horizontal offset or shoulder between inside travel lane and raised medians;
- No super-elevation;
- Smaller corner radii at intersections and elimination or reconfiguration of high-speed channelized right-turns;
- Signals spaced and synchronized to obtain the desired speed;
- On-street parking;
- Street trees and other landscaping; and
- Close proximity of buildings and other development features that suggest an urban setting where slower speeds are appropriate.



Design Vehicle

The design vehicle influences several geometric design features including lane width, corner radii, median nose design, and other intersection design details. Designing for a larger vehicle than necessary is undesirable on CSS projects, due to the potential negative impacts that pedestrian crossing distances and the speed of turning vehicles have on pedestrian safety. On the other hand, designing for a vehicle that is too small can result in operational problems if larger vehicles frequently use the facility.

For many thoroughfares, the single unit truck (SU-30) is appropriate unless larger vehicles are common. On bus routes designing for the bus (CITY-BUS or WB-40, which is similar) is appropriate. On arterials, a large truck (WB-50 or WB-62) may be appropriate. On truck routes, the mainline geometry should accommodate the largest trucks where possible (WB-65 or WB-67).

The chosen design vehicle for a given roadway should directly influence the lane width. For the design of intersection geometry features such as corner radii, it may be appropriate to use different design vehicles for each intersection or even each geometric feature based on the frequency of large vehicles that are anticipated to make specific turns at each intersection. The design vehicle should be accommodated without encroachment into opposing traffic lanes. It is generally acceptable to have encroachment onto multiple same-direction traffic lanes on the receiving roadway.

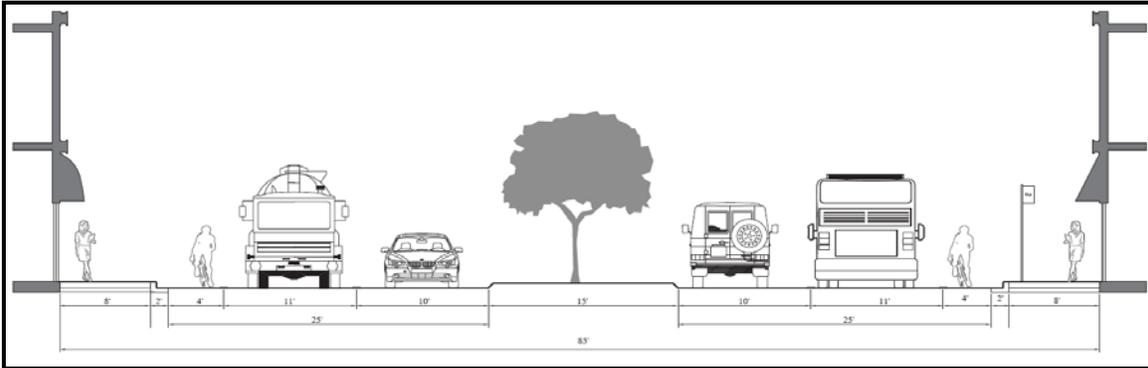
Furthermore, it may be appropriate to consider under-designing a facility by using a larger “control vehicle”, which uses a facility infrequently, or infrequently makes turns at a specific location. An example of a control vehicle is a vehicle that makes no more than one delivery per day at a business. Depending on the frequency, by under-designing, the control vehicle can be allowed to encroach on opposing traffic lanes or make multiple-point turns.

Travel Lane Width

On CSS projects, which typically have right-of-way constraints, the minimum through lane and turn lane width should be eleven or twelve feet on streets with design speeds of 35 mph or less.^{vii} The recommended maximum lane width for Waco thoroughfare projects is eleven feet. On bus routes and where the truck percentage is higher than ten percent, the outside travel lane should be eleven feet, but the inside travel lanes can still be ten feet (see Figure 14), unless significant truck or bus traffic typically uses lanes other than the outside lane. Streets with a design speed of 40 mph should have eleven-foot travel lanes throughout.



Figure 14 Street Width and Vehicle Type



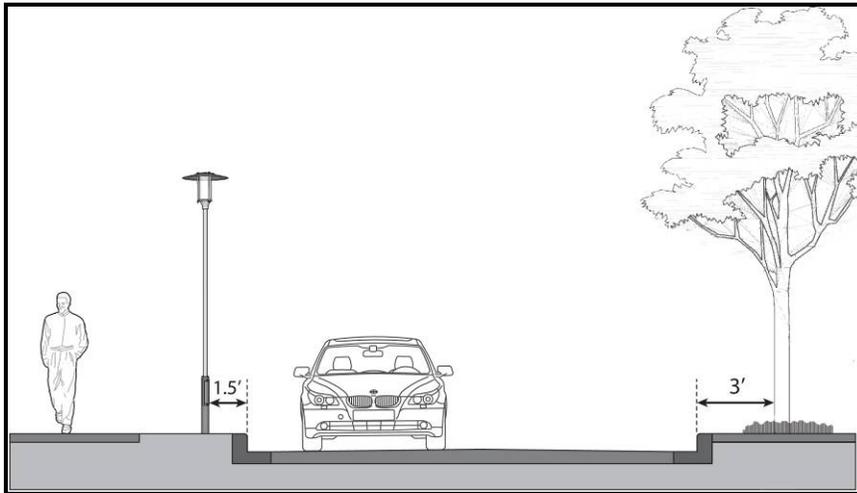
Large vehicles can safely operate in smaller travel lanes in a low speed environment. Narrowing inside lanes to 10' allows for wider outside lanes. This example shows an 11' outside lane.

Horizontal Clearance

Horizontal clearance is defined as the distance between the traveled way and fixed objects such as trees and light poles. This is a critical element for livable communities because objects like trees, other landscaping, and street furniture provide an important buffer between pedestrians and moving vehicles and contribute to “livable” roadway character.

For CSS projects, the horizontal clearance to fixed objects should be a minimum of one and a half feet from the face of curb at the roadside and three feet from the inside travel lane at raised medians. The minimum horizontal clearance for trees (over four inches in diameter) is four feet to the face of curb at the roadside and six feet from the inside travel lane at raised medians. As shown in Figure 15, the four foot minimum clearance at the roadside should not be used to require that trees be placed behind the sidewalk in constrained conditions. Trees are a very important component of CSS projects in part because they act as a buffer between pedestrians and the roadway. In other words, if there is not enough width to place trees between the sidewalk and the road and obtain four feet of clearance, then the border width is “constrained” and the one and a half foot minimum clearance should be used.

Figure 15 Minimum Horizontal Clearances in Constrained Areas



Lane Reductions

Lane reductions are frequently used to improve the livability of a street or thoroughfare corridor. Many configurations of lane reductions are possible, but before undertaking any lane reduction, a traffic study should be completed. Every time a lane reduction is proposed, the potential livability benefits should be weighed against the potential impacts to motor vehicle travel time and delay. These benefits should be built into the traffic study and considered alongside the effects on traffic operations the conversion would have. The following factors should be considered in the analysis for the conversion:

- Potential for lower operating speeds;
- Logical termini for the one-way and two-way segments that effectively process vehicle traffic;
- The ability for pavement markings to appropriately serve vehicle traffic, pedestrians, bicycles and transit
- Reclaimed rights-of-way for other features:
 - Bicycle lanes;
 - Wider sidewalks;
 - Street trees;
 - On-street parking; and
 - Raised medians.
- Safer pedestrian facilities:
 - Opportunity for buffer zone between sidewalk and street;
 - Reduced crossing width and complexity; and
 - Increased potential for raised medians to be used as a refuge.

Lane Reductions on One-way Streets

The potential for lane reduction on one-way streets is high, including where a State roadway becomes a one-way couplet in a city center or built up area. In many cases, the existing street width was converted to through travel lanes when the one-way conversion was completed. Removing one of three, four, or even five travel lanes on a one-way street can often have only a minor effect on overall level of service and capacity.

Four-lane to Three-lane Conversions

One common lane reduction strategy is to change the roadway configuration from four lanes (two through-lanes in each direction) to three lanes (one through lane in each direction and a center turn lane, with a raised median to restrict uncontrolled turning movements). Figure 16 shows the resulting roadway configuration. This concept is often called a “road diet” and can result in the following safety benefits:

- Speeds are generally reduced with the three-lane configuration;
- Fewer rear-end crashes, as motorists wait to make a left turn in a dedicated, well-delineated turn lane, instead of a through lane;
- Fewer sideswipe crashes, as motorists no longer swerve around another motorist waiting to turn left in a through lane;
- Fewer left turn crashes, as turning motorists face only one lane of oncoming traffic; and
- Improved pedestrian crossings; with a median island in the center turn lane; pedestrians only need to cross one lane of traffic (which is going in one direction) at a time instead of all three lanes at once.

The four- to three-lane road diet also includes the following operational benefits:

- Fewer delays from traffic stacked behind a car waiting to turn left;
- Easier to negotiate right-turns, as the curb lane is offset from the curb; and
- More people using bicycles for transportation.

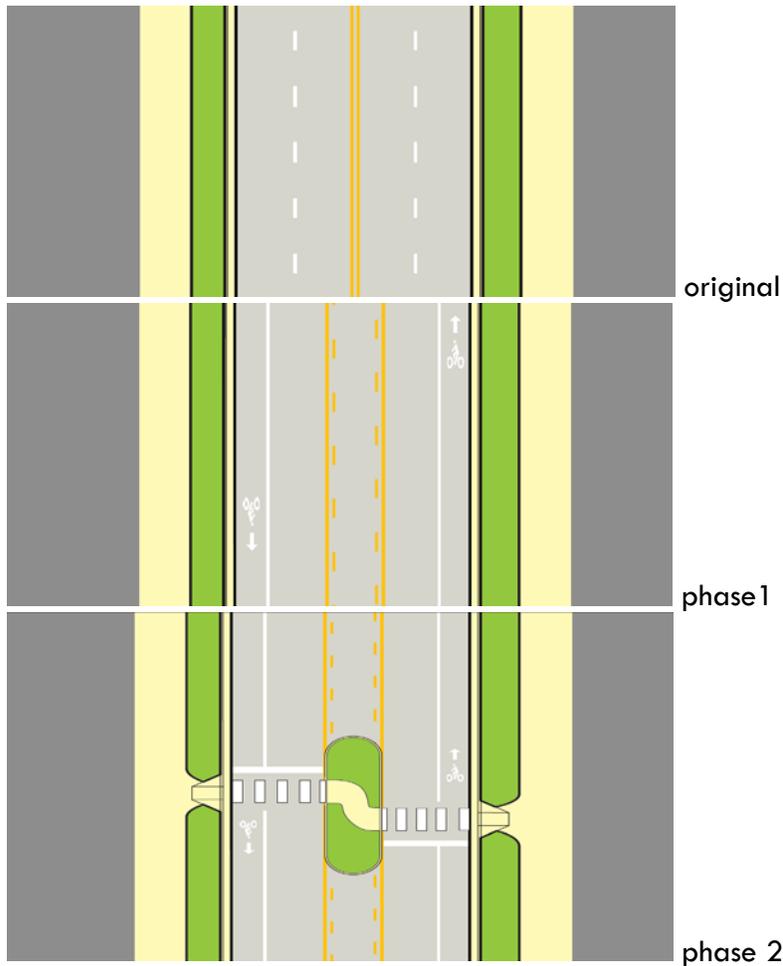
Road diets also include the following livability benefits:

- Greater separation from traffic for pedestrians; and
- More space for street furniture and landscaping.

In general, road diets can be easily implemented with traffic volumes up to 15,000 vehicles per day. These conversions can also be successful on roads with up to 27,000 vehicles per day where there are parallel roads and a good roadway network, but the operations at controlled intersections must be closely scrutinized during the traffic study.



Figure 16 Lane Reduction and Roadway Improvements



Reducing the number of travel lanes in each direction and adding a two way left turn lane provides space for signed and striped bicycle lanes (phase 1) as well as a continuous raised median or median islands that can serve as pedestrian refuges and to reduce travel speeds (phase 2).

Raised Medians

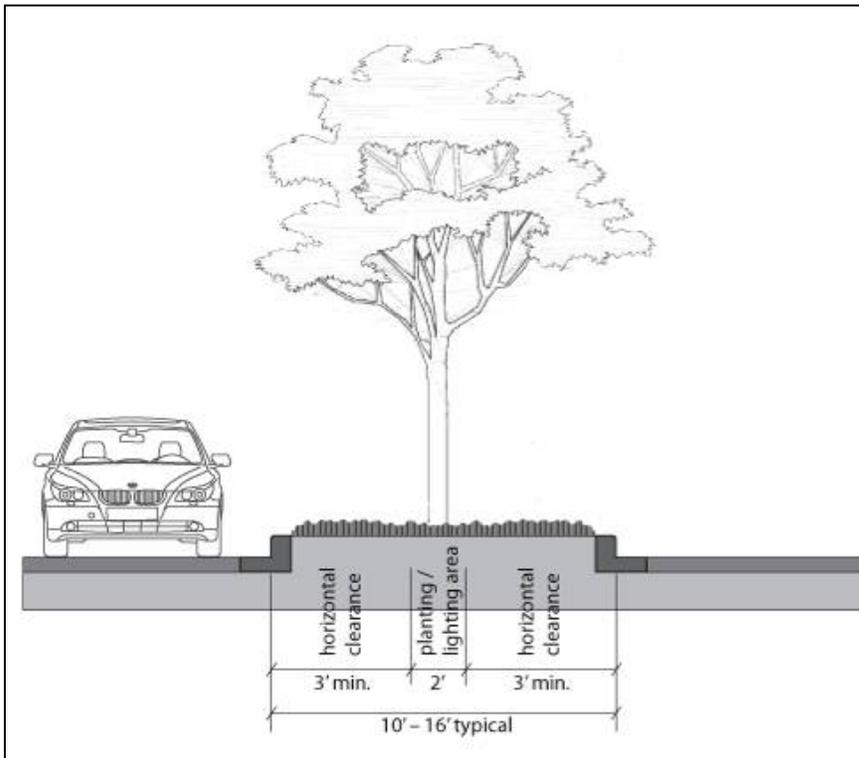
For the purposes of these Design Guidelines, the critical measurement is the width of the raised median, measured from curb face to curb face. In order to provide raised medians in the constrained environment of a typical thoroughfare project, guidelines for minimum and recommended raised median width are as follows:

- Fourteen feet to sixteen feet recommended where feasible; this width provides room for a ten-foot to twelve foot turn lane and a four-foot traffic separator;
- Twelve feet minimum where left turn lanes are provided and a median nose is necessary for access control (assumes ten-foot turn lane and two-foot traffic separator);

- Ten feet minimum where the median is terminated at left turn lane locations (assumes ten-foot striped left turn lane with no traffic separator); and
- Six feet minimum where no turn lanes are provided – this is the minimum needed to adequately provide pedestrian refuge.
- If trees are planted or if any other objects that are not crashworthy are placed in the raised median, a width of at least eight feet is necessary to obtain the minimum horizontal clearance (See Figure 17). This topic is more thoroughly covered in the Horizontal Clearance subsection of Section 6.

On normal crown sections of road, concrete gutter pans are not necessary at the median curb. For design speeds of 35 mph or less, no offset should be provided between the median curb and the left side of the inside travel lane. The maximum offset on any thoroughfare project should be two feet.

Figure 17 Objects in the Median



Medians eight feet wide allow for trees that grow up to 24" in diameter with a three foot offset. Ten to sixteen foot medians are typical, allowing ample room for trees, light poles and other objects within the median.

On-Street Parking

On-street parking provides important functions beyond providing parking supply for local businesses and residences. Even where there are ample supplies of off street parking, on-street parking may be desirable to provide the following benefits:

- Provides a significant buffer between pedestrians and traffic, increasing pedestrian comfort;
- Encourages slower traffic speeds which improves livability and makes it safer for pedestrians to cross the street; and
- Increases activity on the street since people walk from their parked vehicles to destinations.

The following potential negative effects should be evaluated when considering the provision of on street parking:

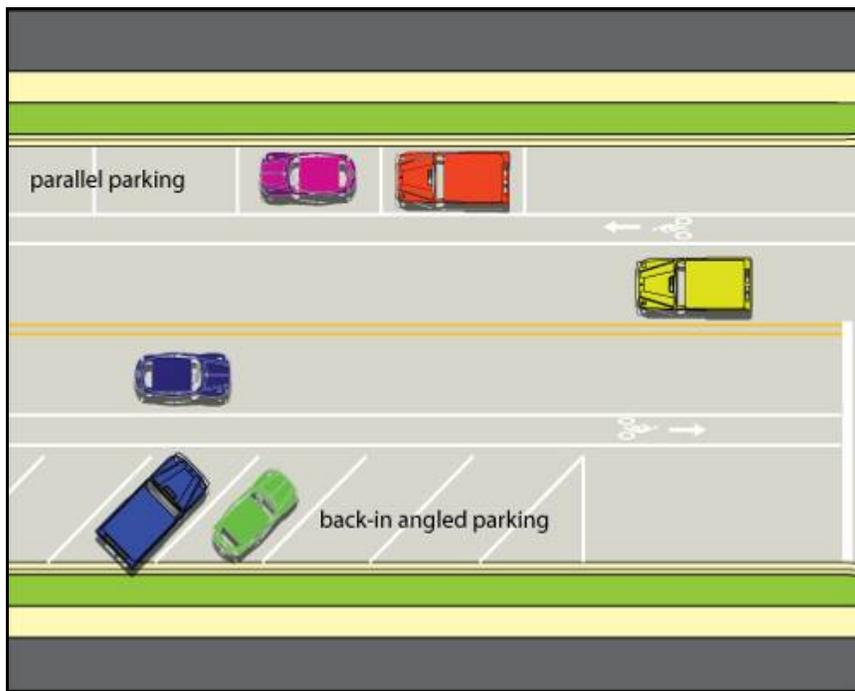
- Parallel parking increases the potential for car occupants to open their car doors into the path of approaching bicyclists;
- On-street parking usually results in a minor reduction in the capacity of the nearest motor vehicle lane, depending on the number of lanes and the frequency of parking maneuvers; and
- Crashes occasionally occur between moving vehicles and vehicles making parking maneuvers. However, this crash increase is offset somewhat by the potential for a reduction in the overall crash numbers and severity associated with the decrease in speed.

On-street Parking Placement and Design

Parking should only be used on streets where speed limits are 35 mph or less and operating speeds for the 85th percentile of traffic do not exceed 35 mph. Parallel parking lanes should normally be eight feet wide. In residential areas parking lanes can be as narrow as seven feet wide. In non-residential areas with restricted right-of-way, parking lanes as narrow as seven feet wide can be considered, especially in areas with low parking density and turnover.



Figure 18 On Street Parking Layouts



Parallel parking is fairly typical on CSS projects. In areas where parking demand is high and adequate space can be obtained, back in angled parking is a potential alternative to parallel parking.

Back-in Angled Parking

Where space permits and parking demand is high, back-in angled parking can be used as an alternative to parallel parking on any road where parking is appropriate. Parking lane dimensions for back-in angled parking should be calculated based on the parking angle and available space for vehicle overhang. Front-in angled parking is not recommended on any facility. There are many advantages of back-in angled parking:

- Up to 90% more parking can be added compared to parallel parking.
- Parking maneuvers are simpler for back in angled parking than parallel parking.
- Drivers making parking maneuvers can easily see other users when entering and exiting a back-in angled parking space. In contrast, drivers cannot see down the street when exiting a front-in angled parking space.
- Vehicle occupants are directed toward the curb upon exiting. This is especially important for children as open car doors will preclude them from walking out into the travel lane.
- Trunk access is from the sidewalk.

The only potential disadvantages of back-in angled parking are unfamiliarity for drivers, and exhaust fumes on the sidewalk, which is a particular concern where outdoor dining is allowed.

Curb Extensions

Wherever on-street parking is allowed, curb extensions should be installed at intersections, midblock crosswalks, and even at non-crossing locations to provide landscaping areas. Curb extensions “protect” on-street parking, and help provide a “narrow” feel to the street even when no vehicles are parked. For more information about curb extensions, see Intersections subsection of this document.

Accessible On-Street Parking

To comply with draft federal guidelines on accessible public rights of way, for every 25 marked or metered parking spaces in a block perimeter, one accessible parking space should be provided. Where parallel parking is provided and there is sufficient room in the furniture zone, a 5’ wide access aisle should be provided adjacent to the accessible parking space at street level, with a ramp to the sidewalk. Where there is not sufficient room in the furniture zone for an access aisle, the accessible parallel parking spaces should be placed at the end of the block so that users can access the curb ramps at the crosswalks. Where back-in angled parking is provided, the accessible parking spaces should have an 8’ wide access aisle adjacent to the space, with a ramp connecting the access aisle to the sidewalk.

Bicycle Lanes

Bicycle Lanes are the primary bicycle facility that should be used on CSS projects. They should be the standard facility for new construction and are desirable for resurfacing and reconstruction projects. On resurfacing and reconstruction projects, bicycle lanes should be built when sufficient width exists, but widening the curbed roadways to provide bicycle lanes is not required. Therefore, wide curb lanes are sometimes the only practical option for these types of projects. On existing multilane facilities without bicycle lanes, if truck volumes are 10% or less, consideration shall be given to reducing traffic lane widths to provide bicycle lanes or wide curb lanes. Bicycle lanes can also be provided by widening existing roadways, paving shoulder areas, eliminating parking, or using emergency lanes normally provided for disabled vehicles.

Bicycle lanes are striped lanes in the traveled way adjacent to the outside vehicle lane. Wherever motor vehicle travel speeds are 25 mph or greater, bicycle lanes should be included. Where motor vehicle travel speeds are less than 25 mph, bicycle lanes may still be necessary if the traffic volumes are especially high, or other conditions make it difficult for motorists and bicyclists to share travel lanes. However, on many streets with motor vehicle speeds less than 25 mph, bicyclists fare well sharing travel lanes, especially where there are two lanes in each direction and motorists can use the left lane to pass bicyclists in the right lane. Shared lanes are more likely to be appropriate in City center areas.

Appropriately designed and located bicycle facilities play an important role in encouraging safe bicycle travel. Bicycle facility needs include bicycle lanes, route systems, and separate paths with the appropriate signs, control devices, parking facilities, etc. Measures that can considerably enhance a route’s safety and capacity for bicycle traffic

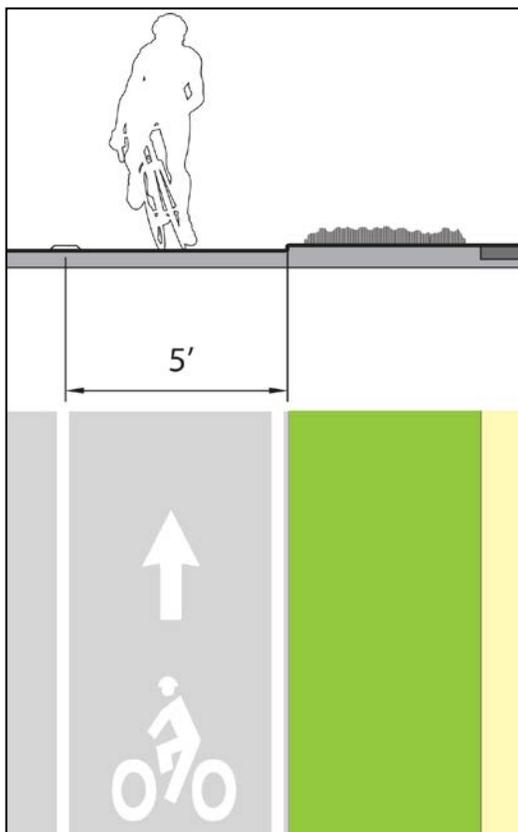


are: bicycle lanes, paved shoulders, bicycle-safe drainage grates, manhole covers flush with grade, maintaining a smooth, clean riding surface, and appropriate traffic control devices.

Continuity and connectivity are very important in the provision of bicycle lanes and other bicycle facilities. Where bicycle lanes exist beyond both ends of a roadway segment under consideration, every effort should be made to provide bicycle lanes on the project. Bicycle lanes should not be discontinued at intersection approaches. If a bicycle lane is placed on the approach to an intersection, there should always be a receiving bicycle lane on the other side.

Bicycle lanes should be a minimum width of four feet measured to the lip of the gutter, which typically provides a 5.5-foot width to the face of curb. Bicycle lanes should be five feet wide when adjacent to a parking lane, right turn lane, guardrail, barrier, or curb without a gutter pan. On streets with curb but within 1 mile of an urban area, the paved shoulder should be marked as a bicycle lane and it should be five feet wide; on RRR projects, existing four-foot shoulders can remain four feet and can be marked as bicycle lanes.

Figure 19 Bicycle Lanes Adjacent to Curb and Unpaved Shoulder

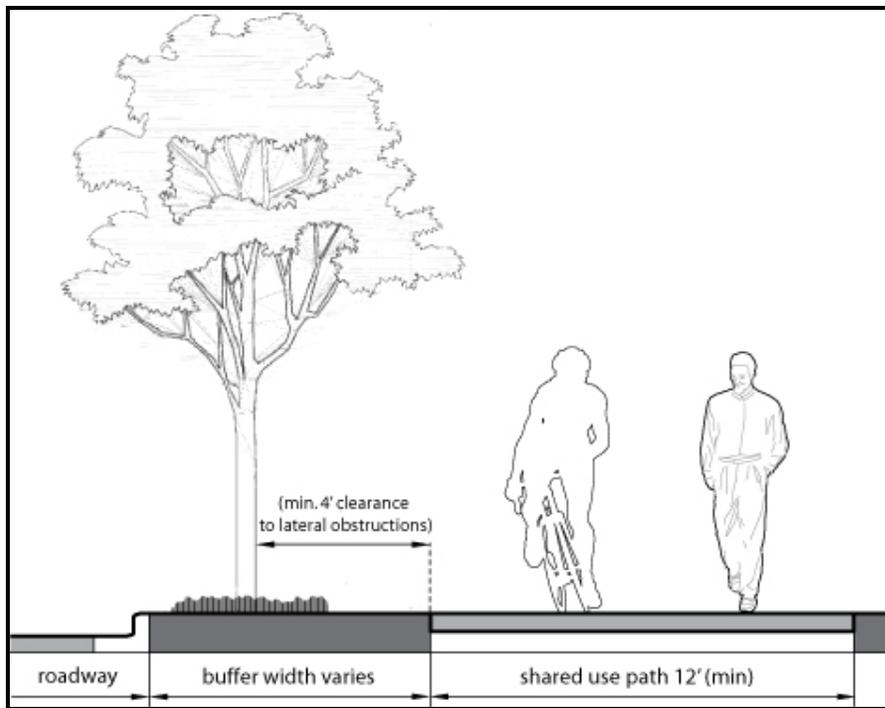


Shared Use Paths

Shared use paths are most useful in independent rights-of-way. At times, these paths will cross roadways. These crossings need to be designed carefully and at most high-volume roadways, signalized crossings are most appropriate.

It is also possible to place shared use paths within the right-of-way of a roadway. However, on most CSS projects, it is undesirable to encourage bicycling within the pedestrian environment and sidewalk corridor between the roadway and the right-of-way line. In rare circumstances a path along a roadway might be included, for example, where the path provides continuity in a regional path by connecting sections of path in independent corridors. Where a path is placed along a roadway, it is critical that the intersections with cross streets be designed to minimize the conflicts between path users and motor vehicles making turns at the intersection.

Figure 20 Typical Shared Use Path



6.2 Sidewalk Corridor

To provide a safe and comfortable pedestrian environment, the designer needs to think beyond the simple implementation of a six foot concrete sidewalk adjacent to the road. The entire roadside portion of the right-of-way should be considered as the “sidewalk corridor”, which contains four distinct zones. (See Figure 21 and Figure 22) In a suburban environment, the sidewalk corridor does not need to be especially wide in most cases, and the furniture zone is typically a landscaped buffer. The furniture zone may need to be wider where there are large trees, on higher-speed roadways to provide more separation for pedestrians. Where ample right-of-way exists, the furniture zone can be expanded to fill the available right-of-way width.

In an urban environment, the sidewalk corridor typically includes a wider paved furniture zone that accommodates more types of street furniture, as well as a wider pedestrian zone to better accommodate higher levels of pedestrian activity.

The use of the “zone system” adequately addresses all the needs of pedestrians and harmonizes this area with other modes of transportation. The four zones are the curb zone, the furniture zone, the pedestrian zone, and the frontage zone.

Americans with Disabilities Act

Complying with the Americans with Disabilities Act (ADA) is a requirement in the design and construction of roadways and is an especially important consideration for the design of the sidewalk corridor. The guidelines for implementing CSS features have been written to be consistent with accessibility guidelines, but are not intended to provide specific guidance on how to comply with the ADA.

The Curb Zone (Edge Zone)

The curb zone provides the edge between the traveled way and the sidewalk corridor. Curbs keep water from the gutter off of the sidewalk, discourage vehicles from driving or parking on the pedestrian area, and help define the pedestrian environment. Curbs also help pedestrians, especially those with visual impairments, identify the street edge. The curb should normally be six inches wide. This width should never be included in the measured sidewalk width. Total curb-and-gutter width varies and should be based on normal gutter design standards and drainage needs. Where sidewalks connect to crosswalks, curb ramps should be provided to provide accessibility to pedestrians with disabilities.

In a suburban environment, the sidewalk corridor does not need to be especially wide in most cases, and the furniture zone is typically a landscaped buffer. The furniture zone may need to be wider where there are large trees, on higher-speed roadways to provide more separation for pedestrians. Where ample right-of-way exists, the furniture zone can be expanded to fill the available right-of-way width.

In an urban environment, the sidewalk corridor typically includes a wider paved furniture zone that accommodates more types of street furniture, as well as a wider pedestrian zone to better accommodate higher levels of pedestrian activity.



Figure 21 Sidewalk Corridors in Suburban and Some Urban Areas

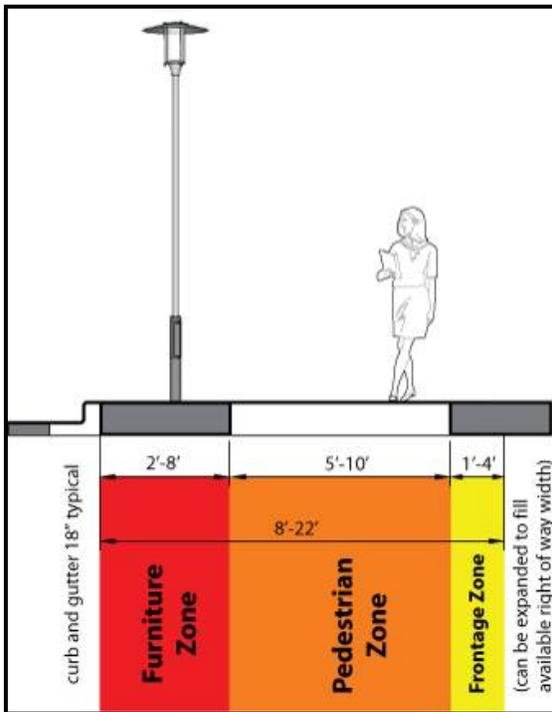
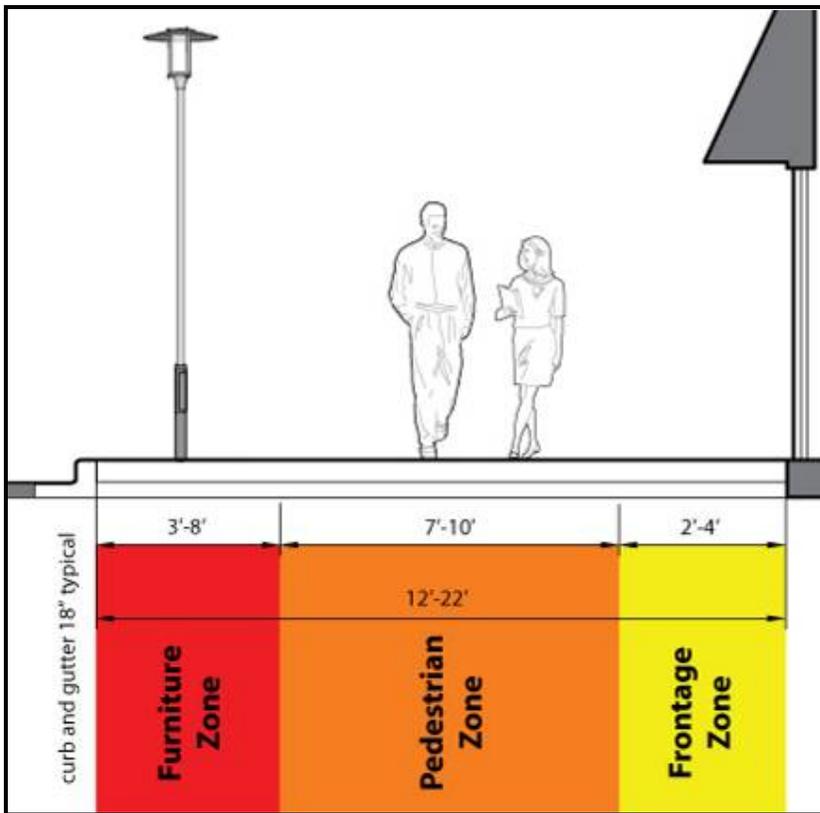


Figure 22 Sidewalk Corridors in City Center and Some Urban Areas



The Furniture Zone

The Furniture Zone is where elements such as street trees, bicycle racks, signal poles, utility poles, street lights, controller boxes, hydrants, signs, parking meters, driveway aprons, grates, hatch covers, and other street furniture are properly located. By placing all of these items in the furniture zone, the pedestrian zone is kept free of obstacles. This zone serves as a buffer between motor vehicles and pedestrians making the sidewalk a more comfortable place to walk. The furniture zone also serves as a location for sloped concrete driveway aprons, allowing the pedestrian zone to be level and at full height.

Wherever it is wide enough to obtain appropriate horizontal clearance, the furniture zone should include street trees. In residential areas and low-density commercial areas, the furniture zone generally includes ground cover, grass, or shrubs. In commercial areas, this zone is often paved with concrete, bricks, or pavers with tree wells or planters for trees, flowers, and shrubs. The furniture zone can be as narrow as two feet to accommodate signs and small poles. Four feet is the minimum necessary for small caliper trees, but five feet is the preferred minimum width. More width is needed where larger trees are desired or where a significant amount of street furniture is to be accommodated. On high speed, high volume roads, the function of the furniture zone as a buffer is very important, and more width provides more comfort for pedestrians.

The Pedestrian Zone

The Pedestrian Zone is the area specifically intended for pedestrian travel. On streets without a paved furniture zone or frontage zone, this area is what is commonly called the sidewalk. This zone should be entirely free of permanent and temporary obstacles. The pedestrian zone should be a minimum of five feet. At pinch points created by obstructions that cannot be relocated, at least four feet minimum clear width must be provided to meet accessibility guidelines. Where a furniture zone is not provided, the pedestrian zone should be at least six feet wide to provide a small buffer from traffic and to allow space for minor encroachment of obstructions like signs or poles at the front or back of the pedestrian zone.

In commercial areas and other areas with significant pedestrian use, the pedestrian zone should be wider in order to accommodate the higher pedestrian volume. In these areas, a minimum width of 7' is desirable to allow two people to walk comfortably side by side while a third person passes in the other direction. The Highway Capacity Manual Pedestrian Level of Service model should be used in areas of high pedestrian use to determine an appropriate sidewalk width.

The Frontage Zone

The Frontage Zone is located between the pedestrian zone and the property line. Pedestrians tend to “shy away” from vertical elements such as building fronts, fences, and hedges. Allocating some space for the frontage zone allows for full use of the pedestrian zone. This zone provides space for entering and exiting buildings and allows room for additional street furniture. In areas where sidewalk dining or other business activities are permitted in the public right-of-way, these activities should normally be conducted in the frontage zone.



The frontage zone should be a minimum of one-foot wide to provide room for maintenance of the sidewalk and to ensure that fences or hedges are not installed right at the back of the sidewalk. In most areas, two feet is a more practical width for the frontage zone. A frontage zone used for these purposes may be paved or unpaved.

In dense commercial areas where buildings are at or near the right-of-way line, the frontage zone should be four feet or wider to provide space for menu boards, sidewalk cafés, and opening doors. A frontage zone used for these purposes should be paved.

Bicycle Parking

Context Sensitive Solutions projects will typically have adjacent land uses that are likely destinations for bicyclists, and secure bicycle parking is critical to complement the linear facilities that cyclists use to travel. Like motorists, bicyclists expect convenient and secure parking at their destinations. Bicycle parking at destinations often comes in two forms: on-site bicycle parking provided by the building owner or private developer, typically regulated by local land use code; and bicycle parking in the right-of-way. Even where bicycle parking is provided on site, it is appropriate to consider implementation of bicycle parking in the public right-of-way. The provision of bicycle parking in the public right-of-way is important:

- At all locations where on-street motor vehicle parking is provided;
- Where street-front retail or other destinations are accessed by front doors directly on the sidewalk; and/or
- Where on-site parking is not provided.

The placement of bicycle parking in the public right-of-way must be such that the bicycle racks and locked bicycles do not obstruct sidewalks. This is typically accomplished by placing the bicycle racks within the furniture zone, and possibly the frontage zone. Another solution is to increase the size of curb extensions at crosswalk locations, or add additional mid-block curb extensions, providing enough space for bicycle racks. Bicycle racks should normally be placed in a manner that encourages users to lock their bicycles parallel to the sidewalk. Bicycle racks should be designed so that they:

- Support the bicycle frame in two places;
- Don't bend wheels or damage other bicycle parts;
- Enable the frame and one or both wheels to be secured; and
- Allow both front-in parking and back-in parking to allow the user to either lock the front wheel and the down tube or lock the rear wheel and seat tube of the bicycle.

A simple, easy to install, and effective bike rack is the “inverted U” design, which meets all of the above design guidelines. However there are other rack designs that meet these guidelines. Creative rack designs are encouraged, and can easily be built to follow these guidelines. For more information on rack design and placement, see the [Bicycle Parking Guidelines](#) from the Association of Pedestrian and Bicycle Professionals.



Pedestrian Lighting

Existing lighting conditions on many roadways are adequate to illuminate the vehicular way, but do not do an adequate job of illuminating the pedestrian environment. Pedestrian facilities need special consideration when it comes to lighting. The primary issues are safety and personal security. In addition, pedestrian lighting and higher levels of street lighting in general are desirable in neighborhood commercial centers, activity centers, transit corridors, main streets and any other areas where there is significant pedestrian activity at night. The scale of pedestrian lighting used should be compatible with community context, predominant building design characteristics and adjacent land uses.

When considering pedestrian lighting needs for a typical commercial corridor, the designer should provide adequate lighting overall. There should also be a focus on areas where additional lighting or lighting levels has the most impact. These areas include the sight triangle at signalized intersections and intersections with crosswalks, transit stops, especially those with transit shelters, and areas with a history of personal or property crime.

When considering pedestrian lighting needs for areas with a significant amount of nighttime pedestrian traffic, such as a center, the MPO should coordinate with local governments and other stakeholders early in the project development process. Since the successful implementation of pedestrian street lighting includes a sound financial plan for capital costs and operations and a thorough consideration of design issues, the coordination should occur as early in the project development process as possible. Pedestrian and other street lighting should be considered in light of local dark skies initiatives to reduce the amount of light pollution from roadway and site lighting.

Transit Stop Location

Waco Transit uses a flag stop system where users can hail the bus at any point along the existing route. While fixed stops are not part of the system at present, the following provides guidance on different types of stops, their placement and the infrastructure and facilities that should accompany them.

The recommended spacing between stops based on area type is illustrated in the following table:

Table 10 Bus Stop Locations and Spacing

AREA TYPE	TYPICAL SPACING IN FEET
City Center	300 – 1,000
Urban	500 - 1,000
Suburban	600 - 2,500
Rural	650 - 2,640



One extremely important consideration in selection of transit stop locations is the fact that most transit stops will have a high level of pedestrian activity, including the need to cross the street. Bus stops should be located at least five feet from crosswalks and fifteen feet from on-street parking (unless a “bus bulb” is used).

Far Side Stops

Far-side bus stops are generally preferred to near side stops because they result in:

- Fewer traffic delays;
- Better sight lines between vehicles and pedestrians and between buses and other vehicles;
- Improved access for patrons who can reach the crosswalk by walking to the rear of the bus; and
- Fewer conflicts among buses, cars, pedestrians and bicyclists.

Far side bus stops are especially desirable under the following circumstances:

- Motor Vehicle traffic volume is greater on the near side than on the far side of the intersection;
- Heavy volumes of right turns occur at the intersection;
- Traffic conditions and signal patterns may cause delay at the intersection;
- Transit signal priority treatments exist at the intersection;
- The intersection is unsignalized, especially where there is a non-stop traffic configuration; and
- Where a route alignment requires the bus to turn left before stopping.

Near Side Stops

A near side bus stop may be preferred when the following conditions exist:

- The near side location has potential for the addition of a shelter and bus stop amenities and the far side location does not;
- The bus route requires a left turn at a subsequent intersection that is very close to the intersection with the stop;
- Motor vehicle traffic volume is greater on the far side than on the near side of the intersection;
- Pedestrian access on the near side is better than on the far side;
- Significant pedestrian-generating land uses exist on the near side;
- The bus route directs the bus to turn right at the intersection; and
- When the bus must stop in the travel lane because of curb-side parking in order for the front door of the bus to access an intersection and crosswalk.

Mid-block Stops

Mid-block bus stops should generally be avoided due to the fact that pedestrians want to cross the street at every transit stop. Mid-block stops are appropriate under the following conditions:



- The mid-block location has potential for the addition of a shelter and bus stop amenities and the far side location does not;
- Traffic or street/sidewalk conditions at the intersection are not conducive for a near side or far side stop;
- The distance between intersections and the prior and post stops is unusually long;
- Major transit passenger generators are located mid-block and cannot be served at the nearest intersection; and
- A marked mid-block pedestrian crossing is present or can be installed to serve the bus stop.

Transit Stop Design

Bus Stop Infrastructure and Amenities

Bus Stop infrastructure and amenities can be designated as minimum, desirable, or optional according to the number of daily boardings, at transfer points, and by the mobility needs of its passengers. Table 11 summarizes the recommended facilities:

Table 11 Recommended Bus Stop Features

	NUMBER OF DAILY BOARDINGS					SPECIAL AREAS		
	<10	11-20	21-50	51-100	>100	TRANSFER POINTS	TRANSIT DEPENDENT AREAS	HEALTHCARE FACILITIES
INFRASTRUCTURE								
Sign and Pole	D	D	D	D	D	D	D	D
5 x 8 pad	D	D	D	D	D	D	D	D
Lighting	M	D	D	D	D	D	D	D
AMENITIES								
Shelter	M	M	A	D	D	A	M	A
Route map	M	A	D	D	D	D	A	A
System Map	M	A	D	D	D	D	A	A
Landscaping	M	M	A	D	D	D	A	A
Bike Rack	M	M	M	A	D	M	M	M
Trash Receptacle	M	M	A	A	D	A	A	M
ITS applications	M	M	M	M	A	A	M	M
Expanded Sidewalk	M	M	M	A	A	A	M	M

D – Desirable A – Appropriate M – May be Appropriate



Provide bus stop signs at all stops. Sheltered bus stops must be fifteen feet from a fire hydrant, twelve feet from the intersection point of curve/tangent and fifteen feet from a utility pole. Provide seating at stops:

- That are major transfer points, major trip generators and points of interest;
- That serve the elderly or disabled;
- Where headways are twenty minutes or longer; and
- That are adjacent to properties that have features that attract leaning or sitting, such as retaining walls, stairs, and low fences.

Provide a shelter, with or without seating at:

- Any stop with more than twenty-five boardings per day;
- Major transfer points; and
- Stops that attract typically transit-dependent populations, such as near schools, recreation centers, and housing for older adults or people with disabilities.

Provide bike racks or lockers at:

- Stops that are on routes where bike racks on buses are at or near capacity;
- Major transfer points or hubs;
- Express route stops; and
- Any transit stops where automobile parking is provided for park and ride purposes.

Bike racks and lockers should be placed in areas of high visibility to avoid vandalism and theft.

Bus Bay

On projects, bus bays may detract from the livable nature of the area, by adding additional roadway area and increasing travel speeds. Bus bays should be considered where several of the following conditions exist:

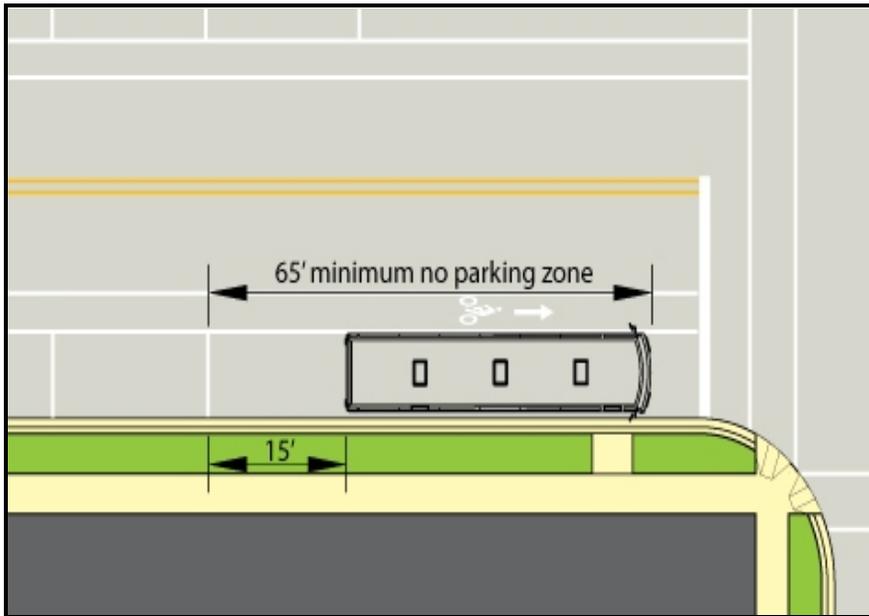
- High traffic volumes and high traffic speeds;
- Areas where rear end crashes with buses are common;
- Areas where a high volume of passengers embark or alight from the bus or where dwell time exceeds 30-seconds during peak hours;
- Traffic in the “curb” lane exceeds 1000 vehicles during peak hours;
- Bus volumes exceed ten buses per hour during the peak hour;
- Right-of-way is available and the geometry of the road is suitable; and
- Buses are expected to layover at the end of a route or at transfer locations.

A bus bay can also be designed into roads with on-street parking (See Figure 23). Bus bays should be avoided when traffic volumes exceed 1,000 vehicles per hour per lane and in high density commercial areas that have on-street parking. At signalized intersections, bus bays at far-side stops can be more effective because the signal provides gaps in traffic that permit bus re-entry into the travel lane. Near-side bus bays should be



avoided because of conflicts with right-hand turning vehicles and delays in service resulting from the difficulty associated with bus re-entry into the travel lane. Bus bays may be appropriate at mid-block stops, especially those associated with destinations that are major transit trip generators. Where articulated buses are in service or are planned to be in service, the design of bus bays needs to accommodate the larger buses.

Figure 23 Bus Stops and On-Street Parking



If a bus stop is placed where a bus needs to pull to the curb in an on-street parking lane, a 65' minimum no parking zone (about 3 parking spaces) is necessary.

Bus Bulbs

Where bus stops are located on streets with on street parking, curb extensions or “bus bulbs” (See Figure 24) can be built out into the parking area. This eliminates the need for buses to pull back into traffic, which can significantly reduce dwell time and improve transit operations along an entire route if implemented on a regular basis. In addition, about three more parking spaces can be provided if a bus bulb is used. The major disadvantage of bus bulbs is that buses will stop in the travel lane and/or parking lane, although this is partially mitigated by the reduced dwell time.

Figure 24 Bus Stops and On-Street Parking



By providing a “bus bulb”, only one parking space is lost, room for a bus shelter is provided, and transit operations are significantly enhanced by the reduced dwell time at the bus stop.

Personal Safety (Crime Prevention Through Environmental Design)

Since the 1970’s, law enforcement agencies and planners have been working together to develop community design methods that help to improve public safety. This approach, dubbed Crime Prevention Through Environmental Design (CPTED), is based upon four guiding principles:^{viii}

Natural Surveillance - A design concept directed primarily at keeping intruders easily observable. Promoted by features that maximize visibility of people, parking areas and building entrances: doors and windows that look out onto streets and parking areas; pedestrian-friendly sidewalks and streets; front porches; adequate nighttime lighting.

Territorial Reinforcement - Physical design can create or extend a sphere of influence. Users then develop a sense of territorial control while potential offenders, perceiving this control, are discouraged. This is promoted by features that define property lines and distinguish private spaces from public spaces using landscape plantings, pavement designs, gateway treatments, and non-sight limiting fences.

Natural Access Control - A design concept directed primarily at decreasing crime opportunity by denying access to crime targets and creating in offenders a perception of risk. This is gained by designing streets, sidewalks, building entrances and neighborhood gateways to clearly indicate public routes and discouraging access to private areas with structural elements.

Target Hardening - This is accomplished by features that prohibit entry or access: window locks, dead bolts for doors, interior door hinges.



Specific CPTED design principles that are applicable to street design include:

- Ensuring that hedges and shrubs are no taller than three feet for maximum visibility;
- Keeping lower branches of existing trees at least ten feet off the ground;
- Providing lighting systems that make pedestrians more visible to motorists and can illuminate other vehicles and objects that should be avoided;
- Providing visibility for parking areas from windows and doors, having side parking areas visible from the street;
- Providing lighting that is even, uniform and does not produce dark areas or sharp contrasts for concealment;
- Considering the type of light fixture, the height of the poles, the direction the light needs to go and the spacing of the fixtures;
- Using angled parking in front of stores, rather than parallel, to allow greater visibility between cars; (See On-street parking subsection for more information regarding on-street parking)
- Avoiding exterior walls devoid of windows;
- Clearly defining public entrances with walkways and signage;
- Accentuating building entrances through architectural elements, lighting, landscaping and/or paving stones;
- Locating windows that face rear parking lots for increased visibility; and
- Maintaining clear visibility from the store to the street, sidewalk, parking areas and passing vehicles.



6.3 Intersections

Since most conflicts between roadway users occur at intersections where travelers cross each other's path, good intersection design is critical for livability. Applying the following basic intersection geometry principles will generally improve safety and livability:

- Avoid unusual conflicts;
- Provide compact intersection designs and consider the implications for intersection scale when contemplating lane additions, lane width, and turn lanes;
- Provide simple, right angle intersections and avoid skewed or multi-legged intersections;
- Avoid free-flowing turning movements; and
- Apply access management techniques to remove unnecessary conflict points near intersections.

Corner Radii

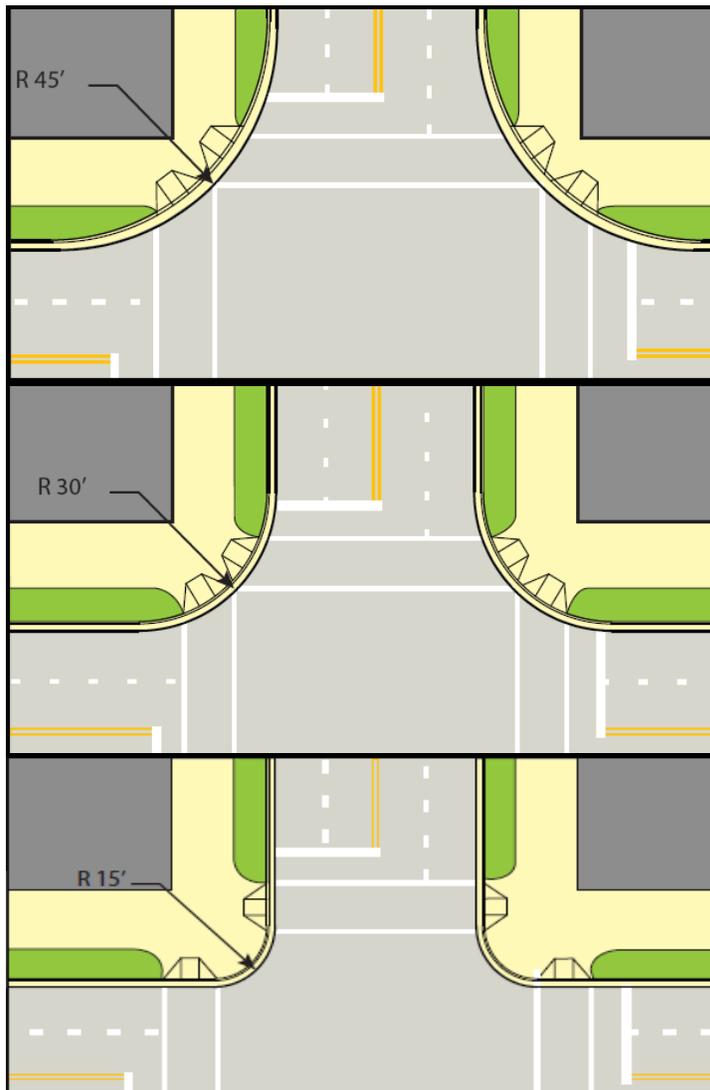
This seemingly minor intersection geometry feature can have a significant impact on the comfort and the safety of non-motorized users. Small corner radii provide the following benefits:

- Smaller, more pedestrian-scale intersections;
- Slower vehicular turning speeds;
- Reduced pedestrian crossing distance and crossing time (See Figure 25); and
- Simpler, more appropriate crosswalk placement.

For designing corner radii on projects, the default design vehicle should be the passenger (P) vehicle. The default corner radius on projects is fifteen feet. Larger design vehicles should only be used where they are known to regularly make turns at the intersection, and corner radii should be designed based on the larger design vehicle traveling at crawl speed. In addition, designers should consider the effect that bicycle lanes and on-street parking have on the "effective radius", increasing the ease at which large vehicles can turn. Encroachment by large vehicles is acceptable onto multiple receiving lanes. On projects, whenever a design vehicle larger than the passenger (P) vehicle is used, the truck or bus should be allowed to turn into all available receiving lanes. As described in the Design Vehicle subsection of this document regarding design vehicles, larger, infrequent vehicles (the "control vehicle") can be allowed to encroach on multiple departure lanes and opposing traffic lanes.



Figure 25 Intersection Corner Radii Comparison



Tighter corner radii reduce crossing distance and slow turning traffic.

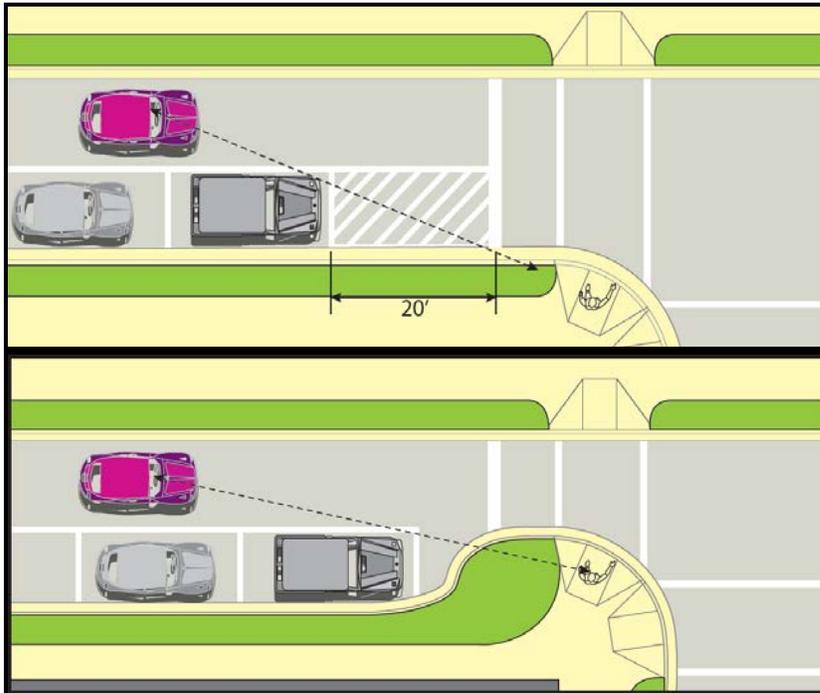
Curb Extensions

Curb extensions can be provided in the parking lane at crosswalks. Curb extensions have many benefits related to livability:

- Reduced pedestrian crossing distance resulting in less exposure to vehicles and shorter pedestrian clearance intervals at signals;
- Improved visibility between pedestrians and motorists (See Figure 26);
- Narrowed roadway, which has a potential traffic calming effect;
- Additional room for street furniture, landscaping, and curb ramps; and

- Additional on-street parking potential due to improved sight lines at intersections. Since curb extensions allow pedestrians to walk out toward the edge of the parking lane without entering the roadway, they will be located where they can more easily see vehicles and motorists can more easily see them (See Figure 26).

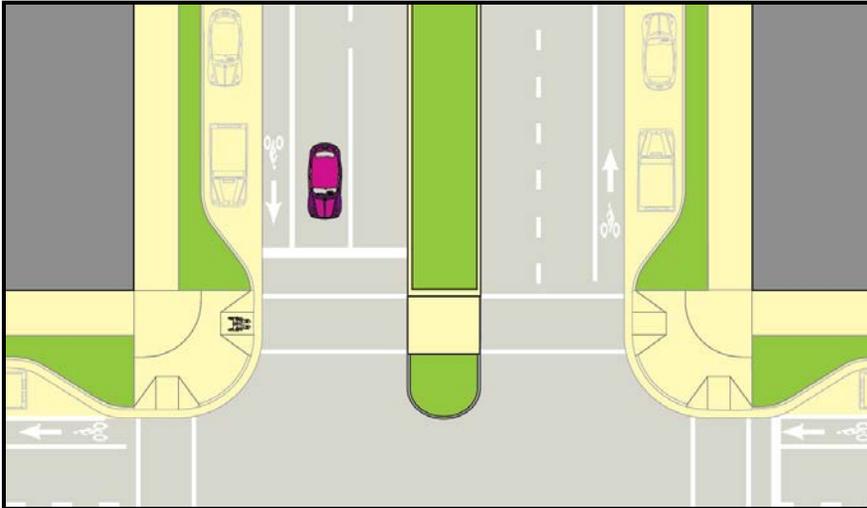
Figure 26 Curb Extensions



Curb extensions reduce pedestrian crossing distance and improve visibility between pedestrians and motorists. In some cases, curb extensions allow for parking to be placed closer to the crosswalk.

Whenever on-street parking is allowed, curb extensions should be included on projects (See Figure 27). The appropriate corner radius should be applied based on the corner radii guidance in the Intersections subsection. Due to reduced road width, the corner radius on a curb extension will likely need to be larger than if curb extensions were not installed. To fully achieve livability goals, the curb extension and parking area can be integrated into the sidewalk corridor. This technique involves using similar surface materials for the curb extension, parking area, and the sidewalk. Instead of the curb extensions appearing to jut out into the street, the parking appears as “parking pockets” in the furniture zone.

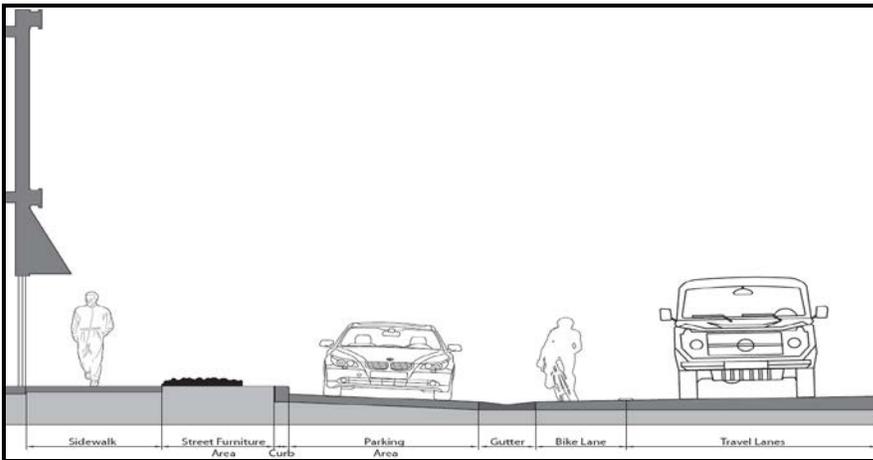
Figure 27 Curb Extension and Parking Integrated Into Sidewalk Corridor



Integrating curb extensions and on-street parking into the sidewalk corridor enhances pedestrian safety and the walking experience.

To reinforce this design where street grades permit, the gutter line and drainage grates should be placed between the travel lane and the parking lane/curb extensions (See Figure 28). This creates a stronger visual cue separating the parking lane from the bicycle lane or travel lane, and can sometimes allow existing drainage infrastructure to be left in place.

Figure 28 Curb Extension and Parking Integrated Into Sidewalk Corridor



This figure shows one example of integrating curb extensions and parking into the sidewalk corridor by placing a valley gutter between the parking and the traveled way

Right-turn Channelized Islands

For CSS projects, right-turn lanes should generally be avoided as they increase the size of the intersection, increase pedestrian crossing distance, and increase the likelihood of right-turns on red by inattentive motorists who do not notice pedestrians on the right side. However, where there are heavy volumes of right-turns (approximately 200 vehicles per hour), a right-turn lane may be the best solution to provide additional vehicle capacity without adding additional lanes elsewhere in the intersection. For turns onto roads with only one through lane, and where truck turning movements are rare, providing a small corner radius at the right-turn lane often provides the best solution for pedestrians' safety and comfort. This slows motorists down and also helps older drivers with limited neck movements to better see oncoming traffic and pedestrians.

At intersections of multi-lane roadways where trucks make frequent turns, a raised channelization island between the through lanes and the right-turn lane can enhance livability and pedestrian safety at right-turn lanes. If designed correctly, these raised islands can achieve the following objectives:

- Allow pedestrians to cross fewer lanes at a time;
- Allow motorists and pedestrians to judge conflicts separately;
- Reduce pedestrian crossing distance, which can improve signal timing for all users;
- Balance vehicle capacity and truck turning needs with pedestrian safety; and
- Provide an opportunity for landscape and hardscape enhancement.

To provide for livability and safety for pedestrians, bicyclists, and motorists, the following design practices for right-turn lane channelization islands should be used:

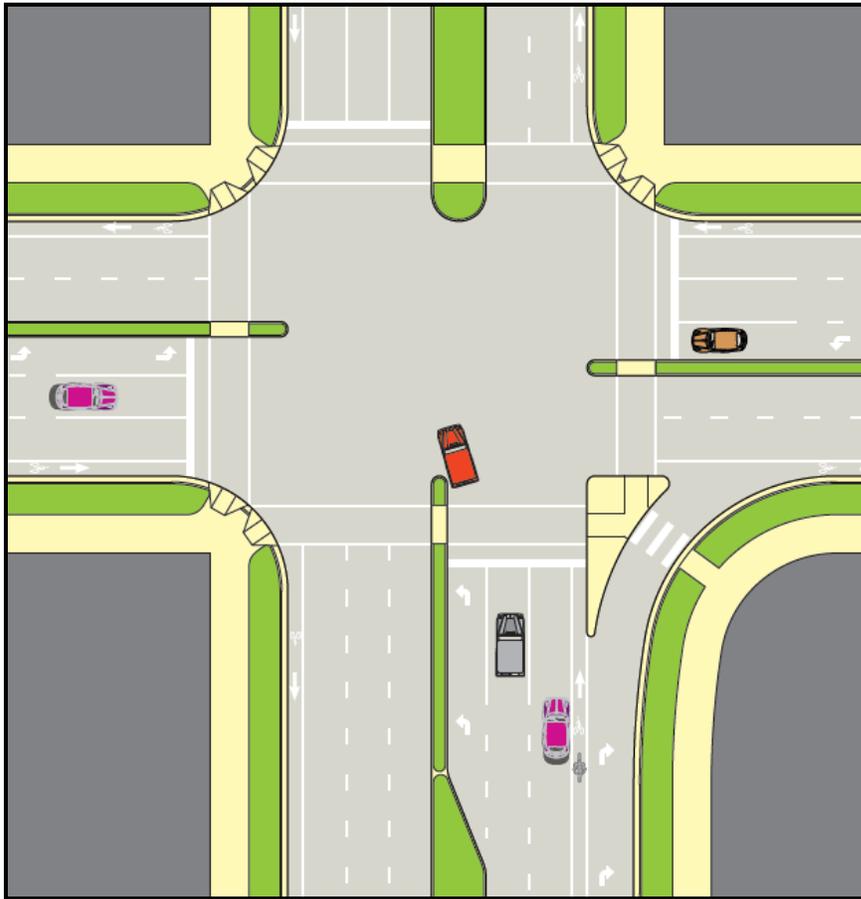
- Provide a yield sign for the slip lane;
- Provide at least a 60° angle between vehicle flows, which reduces turning speeds and improves the yielding driver's visibility of pedestrians and vehicles; and
- Place the crosswalk across the right-turn lane one car length back from the face of the curb on the island, allowing the yielding driver to respond to a potential pedestrian conflict independently of the vehicle conflict.

These goals are best accomplished by creating an island that is roughly twice as long as it is wide (See Figure 29). The corner radius will typically have a long radius (150 feet to 300 feet) followed by a short radius (20 feet to 40 feet). When creating this design, it is necessary to allow large trucks to turn into multiple receiving lanes. This design is not practical for turn lanes onto roads with only one through lane.

CSS projects should not include designs that provide free-flow movements where right-turning motorists turn into an exclusive receiving lane. Right turns should be signal controlled in this situation in order to provide for a signalized pedestrian walk phase. Right turn lanes with channelization created through islands can increase the number of rear end collisions as the yield condition for the right turners can result in a false go.



Figure 29 Channelized Right-turn Lane



Traffic channelization is an effective mitigation strategy when intersection radii reduction is not an option.

Signalized Intersections

Signalized intersections provide unique challenges and opportunities for livable communities. On one hand, signals provide control of motor vehicles with numerous benefits. Where signalized intersections are closely spaced, signals can be used to control vehicle speeds by providing appropriate signal progression on a corridor. Traffic signals allow pedestrians and bicyclists to cross major streets with only minimal conflict with moving motor vehicle traffic. On the other hand, traffic signals create challenges for non-motorized users. Signalized intersections often have significant turning volumes, which conflict with concurrent pedestrian movements.

To improve livability and pedestrian safety, the signalized intersections should accomplish the following objectives:

- Whenever feasible, provide signal progression at speeds that support the target speed of a corridor;

- Provide more frequent opportunities for users to cross major roadways by shortening signal cycle lengths, which improve the usability and livability of the surrounding area for all modes;
- Ensure that adequate signal intervals are provided for both pedestrians and bicyclists;
- Install countdown pedestrian signals at all intersections where sidewalks and crosswalks are located;
- Place pedestrian signal heads in locations where they are visible;
- Place pedestrian pushbuttons in convenient locations, using separate pedestals if necessary. Use the recommendations regarding pushbutton placement for accessible pedestrian signals found in the Manual on Uniform Traffic Control Devices (MUTCD);
- Ensure that signals detect bicycles. This can simply be a matter of adjusting the existing detection system, or it may require placing special loop detectors for bicycles, particularly where there are bicycle lanes; and
- Where appropriate, use signal timing and operations techniques that minimize conflicts with pedestrians and motor vehicles such as:
 - Protected only left turn phases;
 - Lead pedestrian intervals;
 - Restricted right-turns on red (if right-turns on red are likely to result in more conflicts than right-turns on green); and
 - Signs that remind drivers to yield to pedestrians when turning at signals.

Placement of Signal Structures within the Sidewalk Corridor

Signal Structures within the Sidewalk Corridor should be placed so as not to obstruct the Pedestrian Zone. They should be placed as close as possible to the back of the Pedestrian Zone with the foundation top flush to the top of the sidewalk. If the foundation must be placed within the Pedestrian Zone, the signal pole should be offset as much as possible on the foundation to maximize the sidewalk space available to pedestrians. At least four feet of clear width must be provided to meet accessibility guidelines.

Pedestrian Crosswalks

Crosswalk Placement

It is important to place crosswalks and ramps in an appropriate manner that provides convenience and safety for pedestrians. The following are recommended practices on projects:

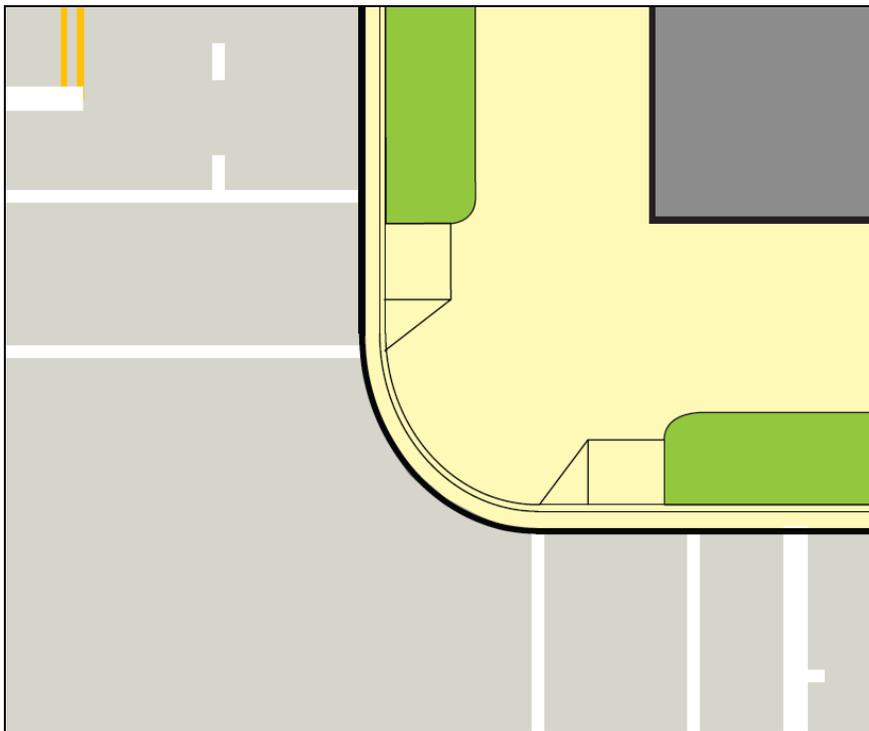
- Provide crosswalks on all four legs of all intersections, unless there are no destinations on one or more of the corners;
- At signalized intersections, provide marked crosswalks;
- When a raised median is present, extend the nose of the median past the crosswalk with a cut-through for pedestrians;
- Place crosswalks as close as possible to the desire line of pedestrians, which is generally aligned with the approaching sidewalks;
- Provide as short as possible crossing distance to reduce the time that pedestrians are exposed to motor vehicles;



- Provide crosswalks as close as possible to right angles across the roadway;
- Ensure that there are adequate sight lines between pedestrians and motorists. This typically means that the crosswalks should not be placed too far back from the intersection;
- Provide two curb ramps per corner; and
- Align the direction of the ramp with the crosswalk whenever possible, as ramps that are angled away from the crosswalk may lead some users into the intersection.

At intersections where roads are skewed or where larger radii are necessary for trucks, it can be difficult to determine the best location for crosswalks and sidewalk ramps. In these situations, it is important to balance the recommended practices above.

Figure 30 Crosswalks and Ramps



Two curb ramps per corner should be provided at crosswalks. Ramps should be aligned with sidewalks and crosswalks whenever possible.

Crosswalk Spacing

To better serve the crossing needs of pedestrians, enhanced crosswalks should be used between signalized intersections. Improved crosswalks should normally be spaced at no more than 600 feet apart. In high-pedestrian use areas, the goal should be spacing of about 300 feet. Improved crossing locations should be chosen based on crossing demand at a particular location, usually determined by the nearby land use including major pedestrian generators and transit stops. Midblock crosswalks should be located at least 100 ft. from the nearest side street or driveway so that drivers turning onto the major street have a chance to notice pedestrians and properly yield to pedestrians who are

crossing the street. Midblock crosswalks need to be designed with access management standards and vehicle operations in mind.

Marked Crosswalks

The subject of marked crosswalks has long been debated amongst traffic engineers and other practitioners. The FHWA report, *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations* includes the most recent data on this issue. The recommendations below are based on the conclusions of this report.

Marked crosswalks alone can be used when the following conditions apply:

- Two-lane roadways (at any speed and volume);
- Posted speed is less than 40 mph;
- The roadway has four or more lanes, no raised median or island, and average daily traffic of 12,000 or less; and
- The roadway has four or more lanes, a raised median or island that can act as a pedestrian refuge, and average daily traffic of 15,000 or less.

Even in conditions that do not meet the above criteria, the safety needs of pedestrians must not be ignored; transportation engineers have a responsibility to consider all types of road users and should provide safe facilities for pedestrian travel. While marked crosswalks by themselves cannot solve pedestrian crossing problems, additional substantial engineering and roadway treatments need to be considered. An engineering study should be conducted to identify the appropriate pedestrian crossing treatments that can be used to enhance the marked crosswalk.

The following sections of this document provide guidance on potential pedestrian crossing treatments. It is suggested that the following may be used to enhance marked crosswalks installed where the conditions above do apply and should be used to enhance marked crosswalks where the conditions above do not apply.

Wherever crosswalks are marked away from signalized intersections, high-visibility longitudinal crosswalk markings should be used. Roadway lighting should be supplemented at these intersections to improve driver visibility of pedestrians waiting to cross and those in the crosswalk.

Signalized Crosswalks

At most locations where signal warrants are met at a proposed location for an enhanced pedestrian crossing; a pedestrian-activated traffic signal should be installed. To encourage compliance by pedestrians, these signals should be designed to provide a relatively quick response when a pedestrian pushes the button.

On congested roads, stopping all traffic to let pedestrians cross the street can cause undue delay. The use of a two-step pedestrian signal minimizes delay to traffic while allowing pedestrians to cross. A raised median or island should be used to break the crossing into two steps. At a two-step crossing, separate crosswalks and pedestrian signal phases are provided for the two directions of motor vehicle traffic. Each crosswalk has two pushbuttons; one on the side of the road and one in the median. With this design, traffic in



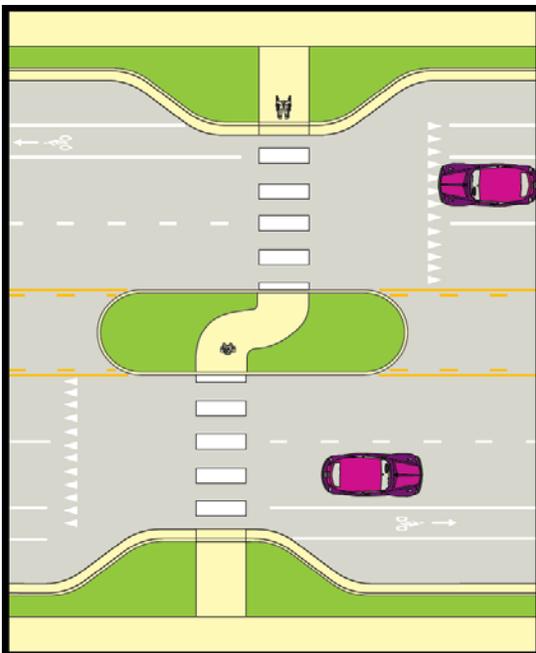
only one direction has to stop at a time, significantly reducing the vehicle delay per activation. To reduce the likelihood of confusion by pedestrians about which pedestrian signal serves each crosswalk, the two crosswalks should be offset by about thirty feet. To get from the first crosswalk to the second crosswalk; pedestrians will walk in the median for this short distance.

Raised Medians and Crossing Islands

Raised medians and crossing islands have been shown to reduce pedestrian crossing crashes by about 40 percent. A raised median or island allows a pedestrian to cross only one direction of traffic at a time, making it much easier to find acceptable gaps. The crossing task is simple: the pedestrian looks left, waits for an acceptable gap, crosses to the median island, then looks right, and seeks a second gap. Pedestrians are less likely to take risks and try to dash all the way across if they know they only need to cross halfway. Raised medians should always be used at unsignalized pedestrian crossings of roadways with four or more lanes. Raised medians are also beneficial at crossings of roadways with two or more lanes.

Raised medians and crossing islands need to be at least six feet wide to provide an adequate pedestrian refuge. The walkway through the median or island should be angled to the right, slightly offsetting the crosswalks, which encourages pedestrians to pause on the island and look to the right toward oncoming traffic. The walkway should be cut-through the island or median to provide accessibility to pedestrians with disabilities. Where a cut-through is not feasible, ramps should be installed.

Figure 31 Center Median Refuge Island

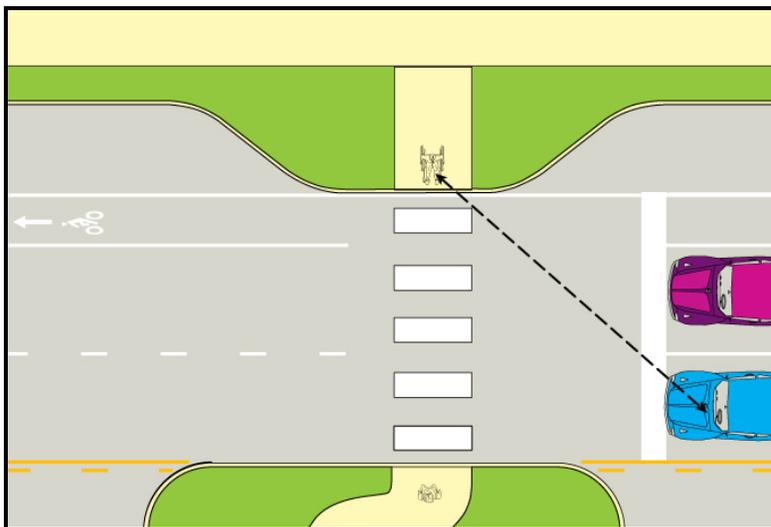


A median refuge provides additional protection for a pedestrian crossing a wide roadway. The angled crossing encourages pedestrians to look in the direction of oncoming traffic.

Advance Stop Line

On multi-lane roadways, many crashes involving pedestrians at marked crosswalks are the “multiple threat” crash type. These crashes occur when a driver in the first lane stops for the pedestrian but stops in close proximity to the crosswalk, reducing the sight lines between the pedestrian and drivers in the next lane. By placing a stop line and accompanying sign in advance of the crosswalk, the sight lines are opened up for pedestrians, and the chance of a crash is reduced (See Figure 32). Advance stop lines should always be used at any unsignalized midblock crosswalk with more than one lane in each direction. In addition, advance stop lines are recommended at marked crosswalks at unsignalized intersections if the lines can be placed at the intersection without creating potential for driver confusion.

Figure 32 Advance Stop Line



Mid-block Crossings

On most major roadways, signalized intersections are spaced relatively far apart; not frequent enough to conveniently serve the needs of pedestrians who want to cross the street. At unsignalized intersections, legal “crosswalks” often exist as defined by law, but without stop or signal control for the major street. These areas provide no additional features to help pedestrians cross the street. It is important to understand that pedestrians will choose to cross at random locations when they are not near a signalized intersection. In fact, some pedestrians may choose to avoid signalized intersections due to the large number of turning conflicts at the intersection. This random crossing behavior is safer when the following conditions exist:

- Raised medians allow pedestrians to take refuge during their crossing;
- Motor vehicle speeds are reduced;
- The number of travel lanes and lane widths are minimal; and
- There are a limited number of driveways and turning movements.

Other Crossing Enhancements

Other crossing enhancements include the following:



- Curb extensions should be used at any unsignalized crosswalks where there is on-street parking (See the Intersections subsection of this document for more information about curb extensions).
- All unsignalized crosswalks should be illuminated to improve visibility of pedestrians at night;
- In-street pedestrian crossing signs are recommended on two-lane streets and other locations where advance stop lines are not installed.
- Advance pedestrian crossing warning signs should be used in advance of most unsignalized crosswalks, except where they will significantly contribute to sign clutter. At locations where advance stop lines are not installed, pedestrian crossing warning signs may also be used at the crosswalk. Overhead pedestrian crossing signs may be used at the crosswalk location whether or not advance stop lines are installed.

Flashing beacons may be used to enhance pedestrian crossing warning signs, but only when the beacons are set to flash when activated (passively or actively) by pedestrians.

Roundabouts

Roundabouts (See Figure 33) are a unique intersection type that can provide the following livability benefits on projects:

- Reduced need for vehicle storage lanes and turn lanes resulting in a narrower roadway section, allowing more space for wider sidewalks, bicycle lanes, on street parking, street trees, and raised medians;
- An inherent traffic calming effect that reduces motor vehicle speeds to human scale;
- Improved safety for all users, including significant reductions in injury crashes and almost elimination of fatal crashes;
- Improved operating efficiency for all modes;
- Enhanced opportunity for landscape;
- Reduced fuel consumption and vehicle emissions; and
- Reduced vehicular speeds with many benefits for non-motorized users.

The livability benefits of roundabouts are diminished somewhat for multi-lane roundabouts, but roundabouts may still provide for more livability benefits than large signalized intersections. Multi-lane roundabout approaches have potential accessibility issues for pedestrians with visual impairments. Due to the significant benefits of roundabouts for livability, roundabouts should be considered to replace signalized intersections as well as stop-controlled intersections.

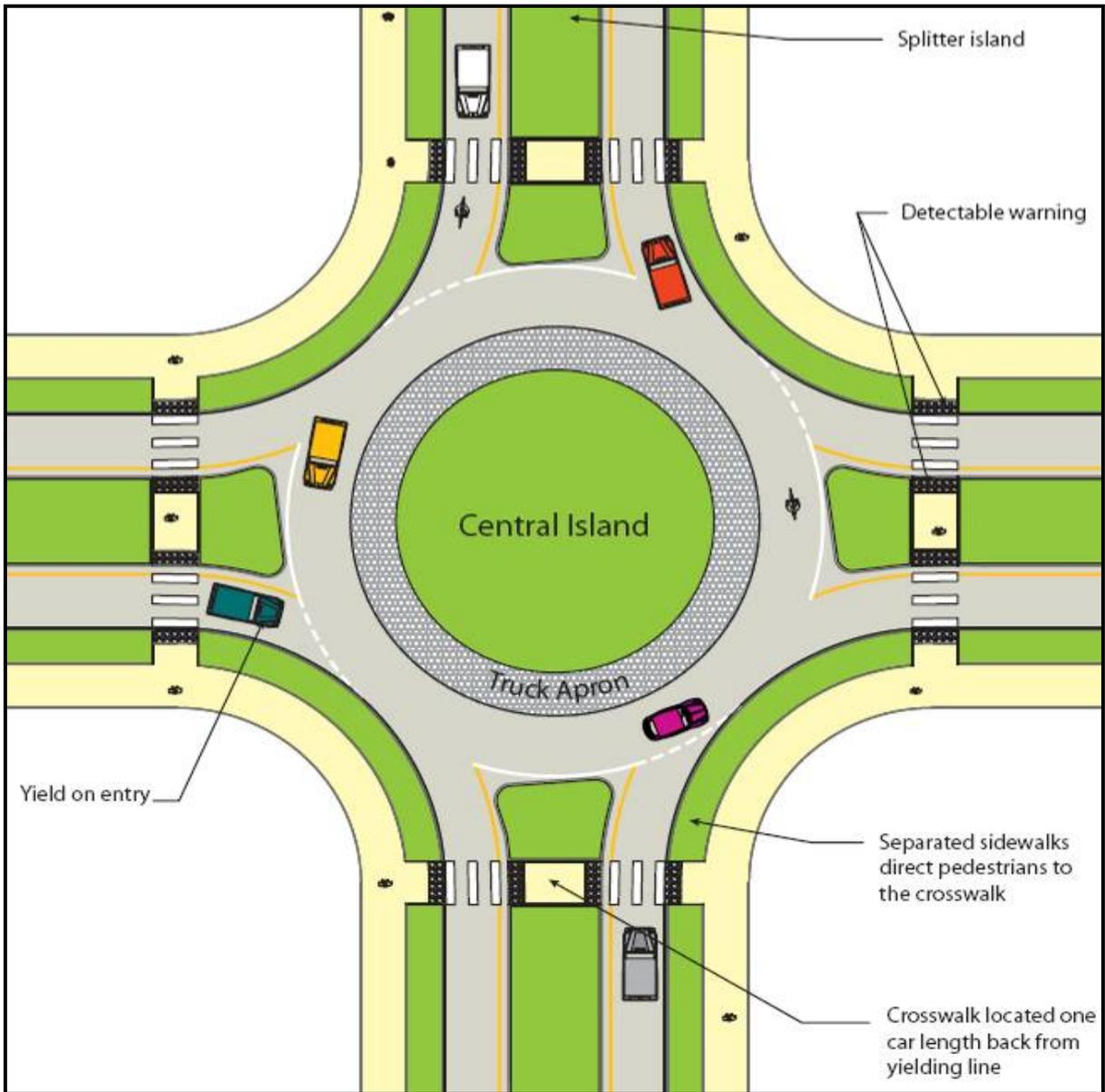
The following recommended practice for roundabouts should be used on CSS projects:

- Use tight turning radii and low design speeds (ideally no more than 23 mph), especially within urban areas where pedestrians and bicyclists are expected;
- Design single lane roundabouts whenever possible;
- Where thoroughfares intersect minor streets, consider using roundabouts with two entry and exit lanes for the thoroughfare and one entry and exit lane for the minor street; this design can often provide adequate vehicle capacity while maintaining nearly all of the livability benefits of single-lane roundabouts; and



- As with all roundabouts with pedestrian facilities, crosswalks on the approach and departure should be well-defined, placed at least one car length back from the circulatory roadway, and placed at approximately right angles to the travel lanes.

Figure 33 Roundabout Elements



Interchanges

Limited access expressways and freeways in urban areas can have significant negative impacts on livability primarily due to the fact that they divide neighborhoods and usually result in severed streets. The few remaining through streets are often arterial roads and thoroughfares with interchanges at the freeway or expressway. As a result, interchange ramp terminals need to accommodate pedestrians and bicyclists who want to cross the freeway corridor, but also have significant volumes of turning motor vehicle traffic. Whenever possible, non-interchange crossings of freeways and expressways should be provided, so non-motorized users can cross the freeway without conflicts with vehicles using interchange ramps.

Appropriate ramp terminal design is critical in designing interchanges that improve livability as well as safety and convenience for pedestrians and bicyclists. Designs that encourage high speed and/or free-flowing motor vehicle traffic movements should be avoided. Instead, ramp terminals on the arterial street should be designed in a similar manner to regular urban intersections. Ramps should be connected to the arterial street at right angles, with curb radii as small as possible for the trucks that use the interchange. Due to the fact that interchanges typically have significant truck volumes, the use of a well-designed raised island with a right-turn slip lane may be appropriate.

Continuity of sidewalks and bicycle lanes should be provided through the interchange to ensure linkage with nearby existing facilities. The signalized intersections at ramp terminals should have crosswalks on the side of the intersection away from the freeway right-of-way; the crosswalks on the freeway side should be closed.

For existing interchanges that have free flow movements for vehicles entering or exiting the freeway or expressway, it may not always be possible to fully retrofit it to an urban intersection design. In these situations, the crossings of the ramp terminals should be designed in a manner that provides:

- A crossing in an area where traffic speeds are relatively slow compared to other locations on the ramp;
- Adequate sight lines between motorists and pedestrians;
- A relatively short crossing distance across the ramp at close to a right angle; and
- Direct lines of travel for pedestrians.



Endnotes

- ⁱ More information is available from the US Federal Highway Administration CSS website: www.contextsensitivesolutions.org
- ⁱⁱ 2010, Institute of Transportation Engineers, *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, p. 3.
- ⁱⁱⁱ 2009, Texas Department of Transportation, *Project Development Process Manual*, p. 1-13.
- ^{iv} "Relationship of Lane Width to Safety on Urban and Suburban Arterials" published in 2007 in the Transportation Research Record: Journal of the Transportation Research Board, Issue Number 2023.
- ^v Cross sections may include optional design features that may require further study depending upon specific contexts.
- ^{vi} Institute of Transportation Engineers, Page 108, *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, 2010.
- ^{vii} TxDOT, Page 73, *TxDOT Roadway Design Guidelines*, 2010.
- ^{viii} Useful websites about CPTED include http://en.wikipedia.org/wiki/Crime_prevention_through_environmental_design and www.cptedtraining.net/

