City and County of

HONOLULU

Complete Streets Design Manual

CITY AND COUNTY OF HONOLULU
COMPLETE STREETS DESIGN MANUAL

FINAL

September 2016

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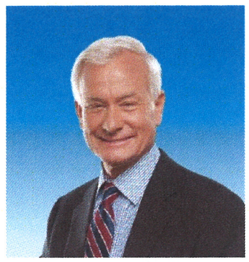
CITY AND COUNTY OF HONOLULU

MESSAGE FROM MAYOR KIRK CALDWELL



Aloha!

I'm pleased to present the City and County of Honolulu Complete Streets Design Manual to the community. Whether you are reading it as a design professional, or a traffic engineer, or a member of the general public, I think you will find it exciting that we are planning and designing our public streets in a whole new way.

The concept of Complete Streets is about ensuring that our public streets and surrounding spaces serve everyone's transportation needs, whether it be by car, bike, bus, rail or foot. Streets should be designed so that everyone in the City and County of Honolulu feels safe using them. In addition, public streets constitute a large percentage of government-owned property. We are committed to making the best use of the streets and streetscapes, and to create an integrated system that works for the island of Oahu.

This manual is a guide to implementing Complete Streets on Oahu, at every opportunity. Whether we are repaving, reconstructing, or building new streets and roads, the City and County of Honolulu's policy is to incorporate the principles of Complete Streets going forward. The result will provide Oahu residents with better transportation options, which lead to healthier and safer lifestyles.

Kirk Caldwell
Mayor

ACKNOWLEDGEMENTS

The *City and County of Honolulu Complete Streets Design Manual* (the Manual) was customized from the Los Angeles County *Model Design Manual for Living Streets* by the SSFM International consultant team, including participants from Ryan Snyder Associates, PlanPacific, Weslin Consulting Services, Blue Zones, Nelson\Nygaard Consulting Associates, and Gary Toth Associates. Individuals from the agencies listed below contributed to customizing the manual. A two-day workshop was conducted July 14 and 15, 2014 to engage stakeholders in modifying the manual for conditions in the City and County of Honolulu. The SSFM International consultant team incorporated comments received at the workshop then presented them to stakeholders at a second workshop. It is the intention of the City and County of Honolulu (the City) Department of Transportation Services that the *City and County of Honolulu Complete Streets Design Manual* serves to provide guidance in the future planning and design of streets and their amenities. This manual is a living document and will be updated periodically.

Complete Streets Workshop, Day 1. Credit: Samantha Thomas (Blue Zones)

PARTICIPATING STAKEHOLDERS:

City and County of Honolulu

- Department of Design and Construction
- Department of Environmental Services
- Department of Facility Maintenance
- Department of Parks and Recreation
- Department of Planning and Permitting
- Department of Transportation Services
- Honolulu Authority for Rapid Transportation
- Honolulu City Council
- Honolulu Emergency Services Department
- Honolulu Fire Department
- Honolulu Police Department
- Neighborhood Board
- Transportation Commission

State and Other Governmental Agencies

- Department of Health
- Department of Transportation
- Hawaii Community Development Authority
- Oahu Metropolitan Planning Organization

Non-governmental agencies

- American Association of Retired Persons
- Hawaii Bicycling League
- Oahu Transit Services
- vRIDE (vanpool)

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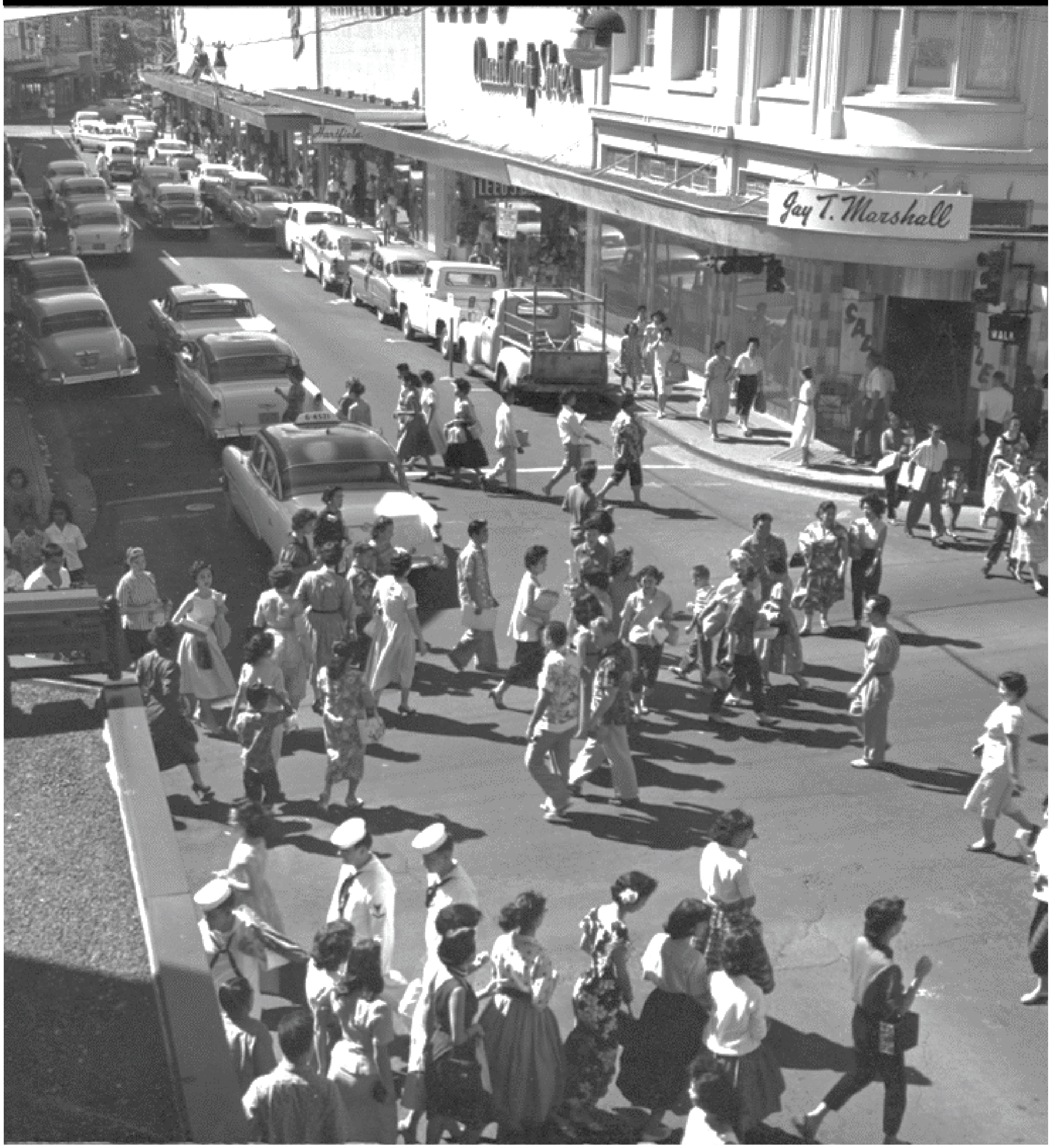
MASTER REFERENCES



Pedestrian Scramble, Fort Street at Hotel Street, circa 1960. Credit: Holst & Male, Inc. (Hawaii State Archives Digital Collection)

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ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guidelines
ADT	Average Daily Traffic
BFS	City and County of Honolulu Department of Budget and Fiscal Services
BMP	Best Management Practice
BRT	Bus Rapid Transit
BWS	Board of Water Supply
CAC	Citizen Advisory Committee
CCL	City and County of Honolulu City Council
CLK	City and County of Honolulu City Clerk
COR	City and County of Honolulu Department of Corporation Counsel
CSD	City and County of Honolulu Department of Customer Services
CSTF	Complete Streets Task Force
DCAB	Disability and Communication Access Board
DCS	City and County of Honolulu Department of Community Services
DDC	City and County of Honolulu Department of Design and Construction
DEM	City and County of Honolulu Department of Emergency Management
DFM	City and County of Honolulu Department of Facility Maintenance
DPP	City and County of Honolulu Department of Planning and Permitting
DPR	City and County of Honolulu Department of Parks and Recreation
DTS	City and County of Honolulu Department of Transportation Services
ENV	City and County of Honolulu Department of Environmental Services
FC	Foot-Candle
FHWA	Federal Highway Administration
HART	Honolulu Authority for Rapid Transportation
Haw Tel	Hawaiian Telcom
HDOH	State of Hawaii Department of Health
HDOT	State of Hawaii Department of Transportation
HESD	City and County of Honolulu Emergency Services Department
HFD	City and County of Honolulu Fire Department
HHCTCP	Honolulu High-Capacity Transit Corridor Project
HCDA	Hawaii Community Development Authority
HPD	City and County of Honolulu Police Department
HSWAC	Honolulu Sea Water Air Conditioning
IESNA	Illuminating Engineering Society of North America

(Continued)

ISTEA	Intermodal Surface Transportation Efficiency Act
ITE	Institute of Transportation Engineers
LBI	Leading Bicycle Interval
LED	Light-Emitting Diode
LOS	Level of Service
MPH	Miles Per Hour
MUTCD	Manual on Uniform Traffic Control Devices
NACTO	National Association of City Transportation Officials
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
NPDES	National Pollutant Discharge Elimination System
OahuMPO	Oahu Metropolitan Planning Organization
OC	Oceanic Time Warner Cable
OEQC	State of Hawaii Office of Environmental Quality Control
PAR	Pedestrian Access Route
PROWAG	Public Rights-of-Way Accessibility Guidelines
PUFFIN	Pedestrian User-Friendly Intelligent Crossing
ROH	Revised Ordinances of Honolulu
ROW	Right-Of-Way
RRFB	Rectangular Rapid Flashing Beacons
RTOR	Right Turn on Red
SLH	Session Laws of Hawaii
SRTS	Safe Routes To School
TRB	Transportation Research Board
TIAR	Traffic Impact Analysis Report
TIP	Transportation Improvement Program
TOD	Transit Oriented Development
USDOT	United States Department of Transportation
UVC	Uniform Vehicle Code
VPH	Vehicles Per Hour

MASTER DESIGN TREATMENT MATRIX

The following table summarizes the suitability of various design treatments for application on different types of streets and intersections in the City and County of Honolulu. Additional information about each street type and design treatment is provided in the following chapters of this design manual. For each street and intersection type, design treatments are classified into five categories:

1 - Incorporate: These design treatments must be incorporated into all street improvement projects on designated street types.

2 - Priority: These design treatments should be incorporated into all street improvement projects on designated street types.

3 - Accommodate: These design treatments should be considered for incorporation into all street improvement projects on designated street types, if adequate space is available after accommodating all category 1 and 2 treatments. Additional consideration should be given to how the design treatment complements the surrounding context and desired function of the street.

4 - Limited Circumstances: These design treatments may be incorporated into street improvement projects on designated street types in a limited number of circumstances such as, but not limited to, near schools, transit stops, trails and other non-auto oriented trip generators.

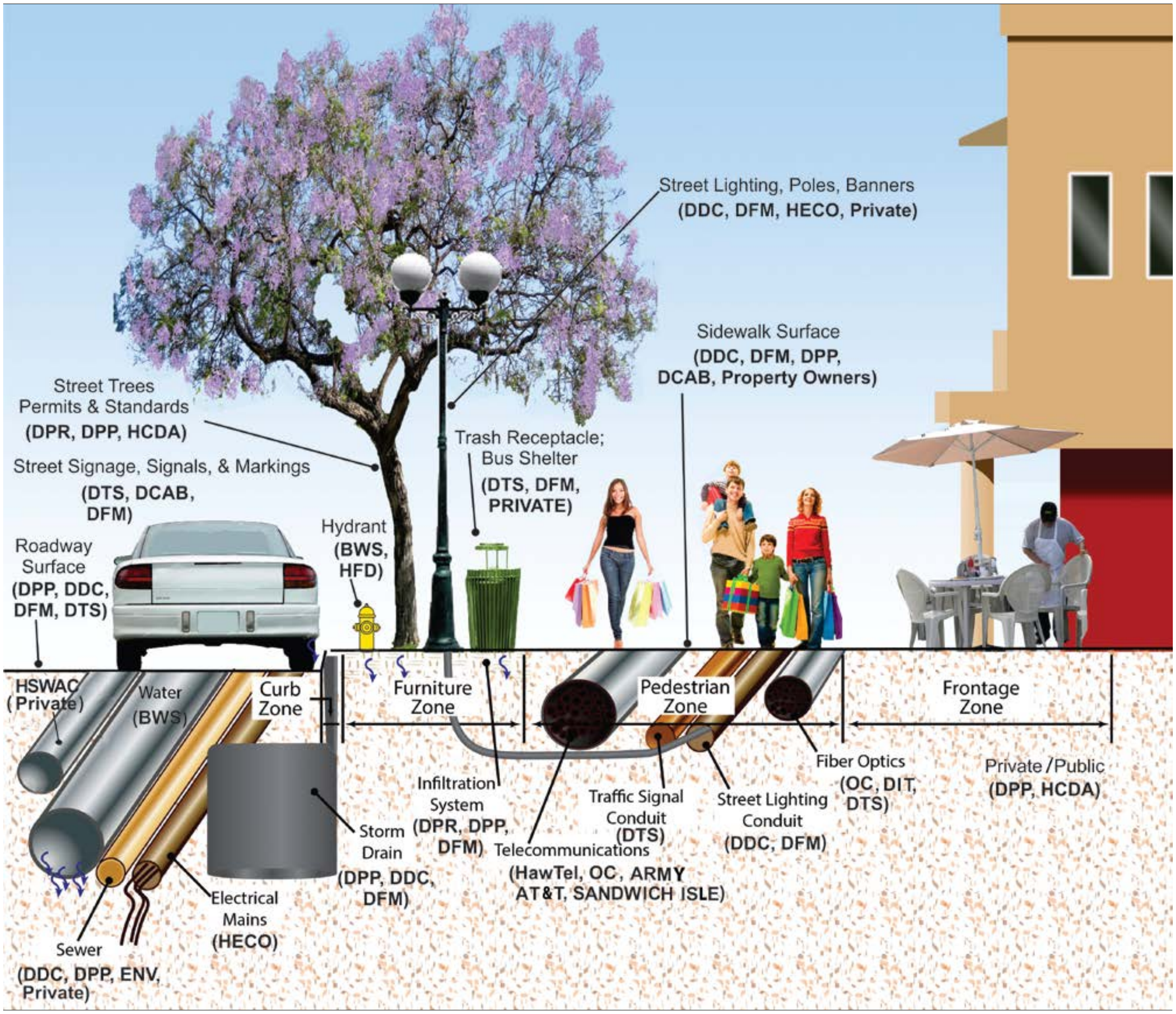
5 - Not Recommended – These design treatments are generally not recommended for use on designated street types.

Kailua Road. Credit: Mike Packard (SSFM International)

Master Design Treatment Matrix

Street Component	Section - Design Treatment	Street Type						
		2.6.1. Boulevard and Parkway	2.6.2. Avenue	2.6.3. Main Street	2.6.4. Street	2.6.5. Mall	2.6.6. Rural Road	2.6.7. Lane/ Alley
Travel Way	3.4 Design Vehicle	SU-30 default (see guidelines for exceptions)						
	3.6. Lane Width	10' wide default (see guidelines for exceptions)						
	3.7. Design/Target Speed	see guidelines						
	3.9. Medians	2	3	3	4	4	5	5
	3.11 Traffic Calming/Speed Reduction	4	4	2	2	4	3	5
	3.11.2.1. Center Line Removal	5	5	5	3	4	4	2
	4.9.1. Left-Turn Lanes	acceptable in urban areas where volumes necessitate (see guidelines for exceptions)						
	4.9.2. Right-Turn Lanes	should be generally avoided unless volumes necessitate (see guidelines for exceptions)						
Parking Lane	3.8. (3.21.) On-Street Parking	3	3	2	2	4	4	5
	3.8.4. Parklets	4	3	2	4	4	4	5
	3.8.5. (6.6.7.) Bike Corrals	4	3	2	4	2	4	5
Intersection	4.4. Corner Radii	28' effective curb radius default with 15' actual curb radius where possible (see guidelines)						
	4.5. (5.3.8.) Curb Extensions	2	2	2	3	3	5	5
Pedestrian Crossing	5.2 (5.3.5.1) Marked Crosswalks	all signalized intersections and other places where needed (see guidelines)						
	5.3.2 Pedestrian Signals	everywhere permitted crossings exist at traffic signal controlled approaches (see guidelines)						
	5.3.4. Pedestrian Scrambles	4	4	4	4	3	5	5
	5.3.9. Crosswalk Lighting	at all pedestrian crossing locations (see guidelines)						
	5.3.10. Signage	see guidelines						
	5.3.12. Angled Median Crossing	see guidelines						
	5.3.13. Raised Crosswalks	see guidelines						
	5.3.15. Rectangular Rapid Flash Beacon	see guidelines						
	5.3.16. Pedestrian Hybrid Beacon	see guidelines						
Bicycle Facility	6.4.2.1. Shared Roadway	5	5	4	3	3	5	1
	6.4.2.4. Shoulder Bikeways	4	4	4	4	4	1	5
	6.4.2.5. Bicycle Boulevards	5	5	5	4	5	4	5
	6.4.3. Bike Lanes	1	2	2	4	4	2	5
Sidewalk Zone (minimum width)	7.3.1. Frontage Zone	18"	18"	30"	18"	N/A	N/A	N/A
	7.3.2. Pedestrian Zone	6'	6'	6'	5'	N/A	N/A	N/A
	7.3.3. Furniture Zone	5'	5'	5'	4'	N/A	N/A	N/A
	8.6. Bus Stop Zone	8'	8'	8'	8'	8'	5	5
Street Furnishings	7.8.1. Seating	3	3	2	4	2	5	5
	7.8.2. News Racks	4	4	2	2	2	5	5
	7.8.3. Bollards	In limited circumstances such as at raised intersections or at raised crosswalks at channelized right-turn lane						
	7.8.4. Street Vendor Stands	4	4	4	4	3	5	5
	7.8.5. Informational Kiosks	4	4	2	4	2	5	5
	7.8.9. Public Art	3	3	2	4	2	5	4
	7.8.10. Sidewalk Dining	3	3	2	4	2	5	4
	3.22. (7.9.) Lighting	1	1	1	2	1	4	3
	9.3.1. Street Trees	1	1	1	2	3	4	4

AGENCY RESPONSIBILITY



Credit: Michele Weisbart (Michele Designs) with edits by John Whalen (PlanPacific) and Lulu Feng (SSFM International)

CHAPTER 1: INTRODUCTION & CONTEXT

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Chapter 1 Cover Image: Kalakaua Avenue. Credit: Ryan Nakamoto (SSFM International)

CHAPTER 1: INTRODUCTION & CONTEXT

1.1. What is the Complete Streets Design Manual

This Manual provides guidance to plan and design streets that adhere to the legal framework established by the provisions of Section 264-20.5, Hawaii Revised Statutes (Act 54 SLH 2009) and Ordinance 12-15, City and County of Honolulu. The State complete street legislation passed in 2009 required each county to establish a complete streets policy.

This Manual is for use by City and County of Honolulu staff, design professionals, private developers, community groups, and others involved in the planning and design of City and County of Honolulu streets. The Manual applies to all projects that impact the public right-of-way along City and County of Honolulu streets, including the construction of new streets and improvements to existing streets. The Manual should be used by professionals as a resource in design, ultimately applying their own engineering judgment to each situation and context.

This Manual contains nine relevant chapters to guide Honolulu in its street design.

- **Chapter 1** provides the background on the Manual and sets the legal framework and policies for achieving complete streets.
- **Chapter 2** organizes Honolulu's streets into different classifications.
- **Chapter 3** presents ideal street cross sections including details on components of the travel way.
- **Chapter 4** shows how to design intersections to better accommodate all street users.
- **Chapter 5** provides guidelines and design solutions for making pedestrian crossings safer.
- **Chapter 6** prescribes solutions for safely integrating people on bicycles into the road network.
- **Chapter 7** presents ways of making the pedestrian environment universally accessible.
- **Chapter 8** accommodates transit into the street network and gives it priority, where necessary.
- **Chapter 9** describes how to create a streetscape ecosystem by integrating natural design elements into the transportation system.

Figure 1-1: Aspects of a Complete Street

Kalakaua Avenue. Credit: Ryan Nakamoto (SSFM International)

1.2. Purpose/Standing of Manual

A growing number of communities are discovering the value of their streets as important public spaces for many aspects of daily life. People want streets that are safe to cross or walk along, offer places to meet people, link healthy neighborhoods, and have a vibrant mix of retail. People enjoy lingering at farmers' markets, street festivals, and gathering places. People want to be able to walk and ride bicycles in their neighborhoods.

Honolulu has joined the nationwide movement for complete streets. This Manual presents guidelines for making this happen. The Manual is not a legally enforceable ordinance. It will be used to update and bring other ordinances into conformance with complete street principles and best practices.

Figure 1-2: Street Festival

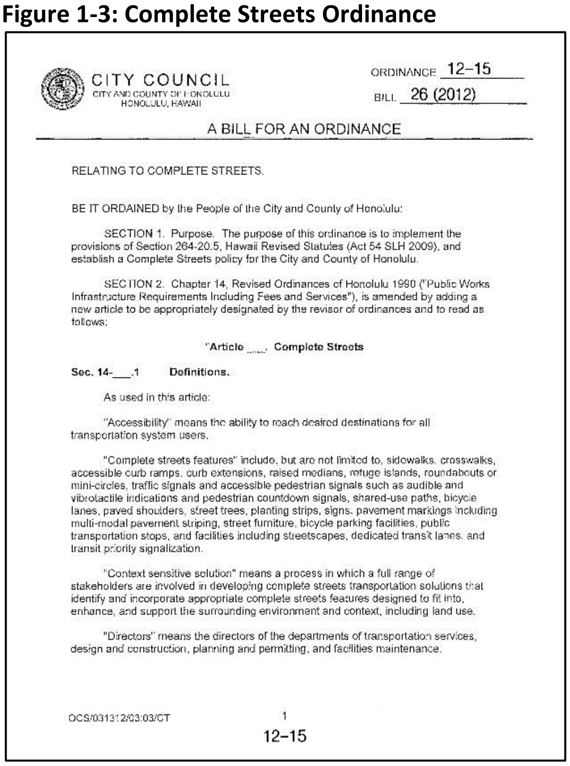
Hele on Kakaako Complete Streets Demonstration. Credit: Dwight Iwasa (Studio 2000)

1.3. Complete Streets Ordinance

The Honolulu Complete Streets Ordinance was passed by City Council and signed into law in 2012. It established the complete streets policy for the City and County of Honolulu. The ordinance reads:

"…the city hereby expresses its commitment to encourage the development of transportation facilities or projects that are planned, designed, operated, and maintained to provide safe mobility for all users. Every transportation facility or project, whether new construction, reconstruction, or maintenance, provides the opportunity to implement complete streets policy and principles. This policy provides that a context sensitive solution process and multi-modal approach be considered in all planning documents and for the development of all city transportation facilities and projects."

Figure 1-3: Complete Streets Ordinance



CITY COUNCIL
CITY AND COUNTY OF HONOLULU
HONOLULU, HAWAII

ORDINANCE 12–15
BILL 26 (2012)

A BILL FOR AN ORDINANCE

RELATING TO COMPLETE STREETS.

BE IT ORDAINED by the People of the City and County of Honolulu:

SECTION 1. Purpose. The purpose of this ordinance is to implement the provisions of Section 264-20.5, Hawaii Revised Statutes (Act 54 SLH 2009), and establish a Complete Streets policy for the City and County of Honolulu.

SECTION 2. Chapter 14, Revised Ordinances of Honolulu 1990 ("Public Works Infrastructure Requirements Including Fees and Services"), is amended by adding a new article to be appropriately designated by the revisor of ordinances and to read as follows:

"Article ___. Complete Streets

Sec. 14-___.1 Definitions.

As used in this article:

"Accessibility" means the ability to reach desired destinations for all transportation system users.

"Complete streets features" include, but are not limited to, sidewalks, crosswalks, accessible curb ramps, curb extensions, raised medians, refuge islands, roundabouts or mini-circles, traffic signals and accessible pedestrian signals such as audible and vibrotactile indications and pedestrian countdown signals, shared-use paths, bicycle lanes, paved shoulders, street trees, planting strips, signs, pavement markings including multi-modal pavement striping, street furniture, bicycle parking facilities, public transportation stops, and facilities including streetscapes, dedicated transit lanes, and transit priority signalization.

"Context sensitive solution" means a process in which a full range of stakeholders are involved in developing complete streets transportation solutions that identify and incorporate appropriate complete streets features designed to fit into, enhance, and support the surrounding environment and context, including land use.

"Directors" means the directors of the departments of transportation services, design and construction, planning and permitting, and facilities maintenance.

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The complete streets policy and principles consist of ten objectives:

"(1) Improve safety;

(2) Apply a context sensitive solution process that integrates community context and the surrounding environment, including land use;

(3) Protect and promote accessibility and mobility for all;

(4) Balance the needs and comfort of all modes and users;

(5) Encourage consistent use of national industry best practice guidelines to select complete streets design elements;

(6) Improve energy efficiency in travel and mitigate vehicle emissions by providing non-motorized transportation options;

(7) Encourage opportunities for physical activity and recognize the health benefits of an active lifestyle;

(8) Recognize complete streets as a long-term investment that can save money over time;

(9) Build partnerships with stakeholders and organizations statewide;

(10) Incorporate trees and landscaping as integral components of complete streets."

1.3.1. Implementation

The "Honolulu Complete Streets Ordinance" (Revised Ordinances of Honolulu (ROH) under Chapter 14, Article 33) has these implementation directives:

(a) *The directors shall, based on a context sensitive solution process, employ a multi-modal approach and incorporate complete streets features in the planning, design,* *construction, maintenance and operation of transportation facilities and projects, including, but not limited to, the reconstruction, rehabilitation or resurfacing of any transportation facility under the jurisdiction of the directors.*

(b) Within six months of the enactment of this ordinance, the directors shall jointly create, adopt, and publish a single complete streets checklist and associated procedures to be used by the directors and their staffs when initiating, planning, designing, revising, implementing and/or reviewing any transportation facility or project. The complete streets checklist shall be jointly updated from time to time by the directors as necessary to facilitate the implementation of complete streets.

(c) As used in this section, "complete streets checklist" means a tool to collect data and information about the status of the roadway and the surrounding area, as well as the details of the transportation facility or project, with a goal of identifying specific elements that can be incorporated to support and balance the needs of all users. Such specific elements shall be part of an implementation procedure to be prepared in conjunction with compilation of a checklist.

Data and information compiled in the checklist include, but are not limited to: traffic volume; street classification and type; an inventory of sidewalk condition; transit facilities; parking restrictions; and recommendations from any existing neighborhood, bicycle, pedestrian, transit or other plan.

(d) Complete streets features shall be incorporated into transportation plans, projects and programs following implementation procedures established by the complete streets checklist.

(e) Within one year of the enactment of this ordinance, the directors shall evaluate and initiate updates of existing ordinances, codes, subdivision standards, rules, policies, plans and design guidelines to ensure their consistency with the complete streets policy and principles. Design standards, guidelines and manuals shall incorporate national industry best practice guidelines, and shall be updated from time to time by the directors as necessary to reflect current best practices.

Major elements of the above directives have been started or achieved. Department directors have started using a context sensitive solution process that employs a multimodal approach and incorporates complete streets features into the planning, design, construction, maintenance and operation of transportation facilities and projects. The Honolulu "complete streets checklist" is an internal City document that has been created for use on all projects.

The purpose of this Manual is to enable the best compliance possible with directives (d) and (e) of the Honolulu Complete Streets Ordinance. The Manual identifies complete streets features and national industry best practice guidelines so that they may be incorporated into updates of existing codes, subdivision standards, rules, policies, plans and design guidelines to ensure their consistency with the complete streets policy and principles.

1.3.2. Exceptions

The Honolulu Complete Streets Ordinance lists certain exceptions where complete streets features are not required:

(a) *A multi-modal approach and complete streets features are not required if a director of an affected department determines, in writing with appropriate documentation, prior to or during the design process, that:*
  (1) *Use of a street or highway by non-motorized users is prohibited by law, or*
  (2) *The cost would be excessively disproportionate to the need or probable future use over the long term, or*
  (3) *There is an absence of current or future need, or*
  (4) *The safety of pedestrians, bicycle or motor vehicle traffic may be placed at unacceptable risk.*

(b) *Each written exception with accompanying documentation shall become a public record and shall be published electronically or online on the official website of the city, and shall be on file and available for public inspection at the Office of the City Clerk and at the office of the department making the determination.*

The Honolulu Complete Streets Design Manual addresses exceptions that need to be taken into account when making street revisions for each candidate of a complete streets treatment.

1.3.3. Compliance

The Honolulu Complete Streets Ordinance compliance requirements are:

(a) *On or before December 31st of each year following the enactment of this ordinance, the directors shall submit to the council a report detailing their compliance with the complete streets policy and principles during the prior fiscal year, and listing the transportation facilities and projects initiated during that year and the complete streets features incorporated therein. The report shall include a list of exceptions made for that year.*

(b) *Within two years of the enactment of this ordinance, the directors shall establish and publish performance standards with measurable benchmarks reflecting the capacity for all users to travel with appropriate safety and convenience along roadways under the jurisdiction of the city. Annual reports for the year in which measurable performance standards are established, and all years thereafter, shall include a report of each agency's performance under such measures, and where appropriate, shall identify problem areas and suggested solutions, and provide recommendations to improve the process.*

The annual reports required in this section may be part of an agency's annual report required by the City Charter.

1.4. Existing Standards, Guidelines and Checklists

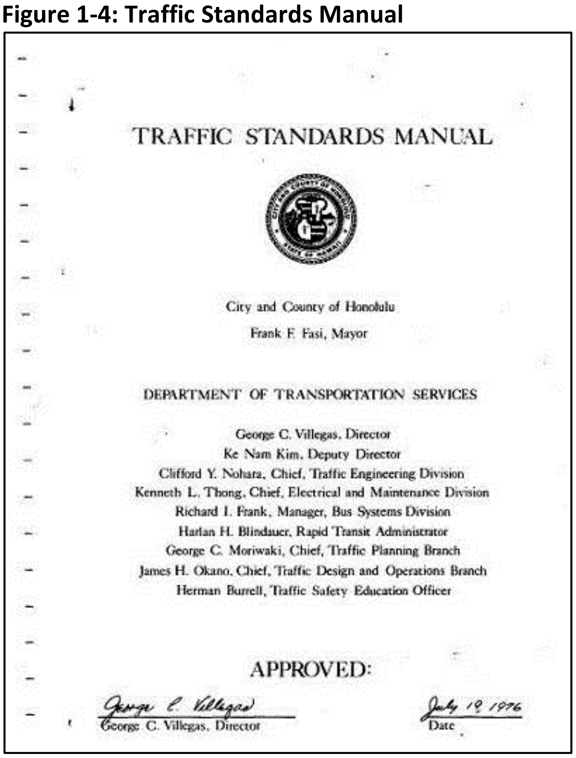
This Manual relates complete streets design to existing references, standards, and guidelines. These references are described below.

1.4.1. City and County of Honolulu

The following documents represent the latest standards, guidelines, and policies that govern the design of City and County of Honolulu travel ways.

- The City and County of Honolulu's ***Traffic Standards Manual*** was approved in 1976. While sections of the *Traffic Standards Manual* have been updated, there is no single location where updated standards are cross referenced with the 1976 Manual.

Figure 1-4: Traffic Standards Manual



TRAFFIC STANDARDS MANUAL

City and County of Honolulu
Frank F. Fasi, Mayor

DEPARTMENT OF TRANSPORTATION SERVICES

George C. Villegas, Director
Ke Nam Kim, Deputy Director
Clifford Y. Nohara, Chief, Traffic Engineering Division
Kenneth L. Thong, Chief, Electrical and Maintenance Division
Richard I. Frank, Manager, Bus Systems Division
Harlan H. Blindauer, Rapid Transit Administrator
George C. Moriwaki, Chief, Traffic Planning Branch
James H. Okano, Chief, Traffic Design and Operations Branch
Herman Burrell, Traffic Safety Education Officer

APPROVED:

George C. Villegas, Director — Date: July 19, 1976

- The ***Standard Details for Public Works Construction*** (1984) is used by all counties in the State of Hawaii.
- The ***City Complete Street Checklist*** (included in the Appendix of this document) was developed by the Department of Transportation Services (DTS) in 2014 in coordination with the Department of Planning and Permitting (DPP), Department of Design and Construction (DDC), and Department of Facility and Maintenance (DFM). The intent is that the checklist be completed by the department or agent responsible for the facility or project during the design process. The checklist is submitted to the DPP Complete Streets Coordinator for review and filing.
- The City and County of Honolulu, Department of Planning and Permitting, ***Subdivision Street Standards*** was adopted and made effective on June 1, 2001, replacing the 1973 ***Subdivision Rules and Regulations***. Its purpose is to regulate and control the subdivision and consolidation of land. Street details from the *Subdivision Street Standards* will continue to inform the design of new streets as a part of new developments.
- The *Oahu Metropolitan Planning Organization (**OahuMPO) Complete Streets Checklist*** (2013) was developed by the Citizen Advisory Committee (CAC). Its objective is to help confirm that projects submitted for inclusion in the Transportation Improvement Program (TIP) or the Oahu Regional Transportation Plan (ORTP) include complete streets features.
- The City's Department of Planning and Permitting began Honolulu's Neighborhood Transit Oriented Development (TOD) planning process in 2007. Eight plans have been completed or are in preparation.

- Honolulu Authority for Rapid Transportation (HART) developed the ***Compendium of Design Criteria*** for the Honolulu High-Capacity Transit Corridor Project (HHCTCP) in 2009. There are 26 chapters relating to all aspects of design for the rail project.
- The 2012 ***Oahu Bike Plan****'s* vision is "Oahu is a bicycle friendly community where bicycling is a safe, viable and popular travel choice for residents and visitors of all ages." The plan proposes an increase from 132 miles of bikeway facilities to 691 miles over a thirty-year period through the construction of bicycle paths, lanes and routes.

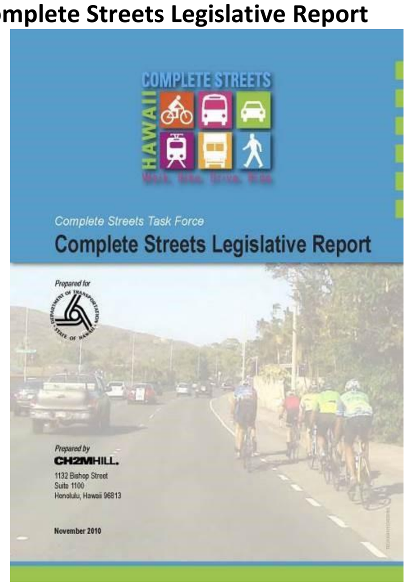
1.4.2. State Policies

- ***Hawaii Revised Statutes, Section 264-20 Flexibility in highway design; liability of State, counties, and public utilities*** indicates that the State or County department of transportation may select or apply flexible highway design guidelines consistent with practices used by the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO).

  HRS 264-20 Flexibility in highway design; liability of State, counties, and public utilities provides immunity from liability if flexible design is used and considers nine factors. This law exempts from liability the agency and the people who make decisions regarding safety, environmental, historical and all modes of transportation in highway design, if they follow certain practices.

  "Flexibility in highway design shall consider, among other factors:
  - ***Safety durability, and economy of maintenance;***
  - ***The constructed and natural environment of the area;***
  - ***Community development plans and relevant county ordinances;***
  - ***Sites listed on the State or National Registrar of Historic Places;***
  - ***The environmental, scenic, aesthetic, historic, community, and preservation impacts of the activity;***
  - ***Access for other modes of transportation, including but not limited to bicycle and pedestrian transportation;***
  - ***Access to and integration of sites deemed culturally and historically significant to the communities affected;***
  - ***Acceptable engineering practices and standards; and***
  - ***Safety studies and other pertinent research.***
- The work of the Complete Streets Task Force (CSTF) was a result of **Act 54, Session Laws of Hawaii (SLH) 2009**. Act 54 requires that the State of Hawaii Department of Transportation (HDOT) and county transportation departments ensure the

Figure 1-5: Complete Streets Task Force Complete Streets Legislative Report



accommodation of all users of the road, regardless of their age, ability, or preferred mode of transportation. It called for the creation of a statewide task force to review existing State and county highway design standards and guidelines. The CSTF Complete Streets Legislative Report (2010) documents the committee's activities and recommendations.

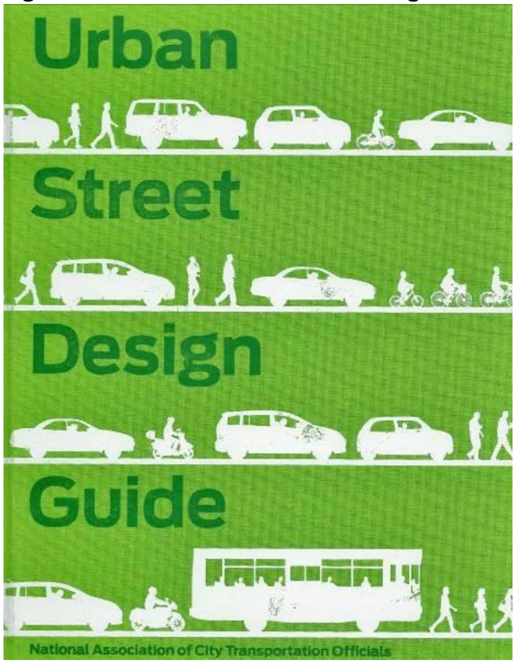
- The ***Hawaii Statewide Pedestrian Master Plan*** (2013) is intended to improve pedestrian safety and mobility on State highways, so it does not address City streets, but it has content directly related to the implementation of the Honolulu's Complete Streets Ordinance.
- ***Bike Plan Hawaii 2003*** updates the previous State bike plan completed in 1994. Chapter 7 of the Plan addresses bicycle facility planning and design. It refers to the *Guide for the Development of Bicycle Facilities* (or Bike Guide) by the American Association of State Highway and Transportation Officials (AASHTO, 1999) as the primary source for bikeway guidelines used by HDOT. AASHTO's more general design manual, *A Policy on Geometric Design of Highways and Streets* (2001) is also used to design bicycle facilities.

1.4.3. National Standards

The national standards and guides that govern design of the travel way are the following:

- The AASHTO *A Policy on Geometric Design of Highways and Streets* (the *Green Book*);
- The *Manual on Uniform Traffic Control Devices* (*MUTCD*);
- Institute of Transportation Engineers (ITE) Handbooks and Recommended Practices;
- AASHTO Guidebooks; and,
- The National Association of City Transportation Officials (NACTO) Guidebooks.

Figure 1-6: NACTO Urban Street Design Guide



Local governments that wish to use federal funds must develop a functional classification system identifying roads as arterials, collectors, and/or local streets. Federal funds are available for streets and roads that are on the federal-aid system. Arterials and certain collector streets, but not local streets, are in this system. The federal-aid system encourages communities to concentrate modifications along larger streets. Those projects on federal-aid travel ways using federal funds must comply with the standards set in the above documents.

Complete streets design also recommends using a system of street typologies to supplement the functional classification system. Local jurisdictions can use both systems to maintain access to these federal funds.

1.5. National Legal Framework

Local jurisdictions typically follow the AASHTO, the *Green Book*, *MUTCD*, and/or design guidance from organizations such as ITE. This is due in part to a desire to limit liability by following established engineering practices. Specific references are adopted to protect jurisdictions and agencies from lawsuits. Consideration of multimodal benefits can be inadvertently overlooked with a strict adherence to these standards which were developed for automobiles.

The Transportation Research Board (TRB) and National Cooperative Highway Research Program (NCHRP) have conducted extensive legal research into various aspects of tort liability. Research conducted by the TRB revealed that the perceived impediments to the creation of intermodal systems are not legal barriers as much as institutional barriers. Although public entity risk varies because of differing interpretations of laws from state to state, the general finding is that the risk is low. The defendant public entities prevailed in nearly all cases concerning bikeway litigation.

NCHRP investigated the tort liability defense practices for design flexibility in all states and found Hawaii’s law (see Section 1.4.2) to be among the best and an example for other states to emulate. NCHRP Legal Research Digest 57 concluded the following about Hawaii’s legislation: “This law practically guarantees that very little litigation relating to new design will occur.”

1.6. FHWA Flexibility in Design

Design flexibility was initially introduced in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and the National Highway System Designation (NHS) Act of 1995. Guidance on implementing these laws is contained in ***Flexibility in Highway Design*** (FHWA, 2014). The flexibility report poses a challenge of the highway design community to find design solutions, as well as operational options, that fully consider sometimes conflicting objectives.

FHWA regularly issues communications in various forms regarding its support or position on various transportation policies, programs and practices. Some of the most pertinent to complete streets are described below.

- ***Pedestrian Safety Guide for Transit Agencies*** (FHWA, 2008) addresses the multimodal safety aspects of pedestrian to transit connections. The guide includes descriptions of specific engineering procedures and prompts to determine the safety of bus stop locations. A chapter is dedicated to the legal issues of pedestrian safety with references to the Uniform Vehicle Code (UVC) and includes several case studies.
- On August 20, 2013 FHWA issued guidance on bicycle and pedestrian facility design flexibility. Essentially, the memorandum expresses FHWA’s support for taking a flexible approach to bicycle and pedestrian facility design.

1.7. Traffic Impact Analysis Reports

One of the break-out groups at the July 2014 Complete Streets workshop convened to review and revise this Manual, addressed the subject of using a Transportation Assessment as opposed to a Traffic Impact Analysis Report (TIAR). The unanimous conclusion of the group was that the City should move away from the TIAR, adopt some form of Transportation Assessment, and inform those involved in preparing such documents of this direction by including a section on this topic in the Manual at the end of this chapter.

There are two major differences between what has historically been included in a TIAR and what is proposed as part of a Transportation Assessment. A TIAR determines the ability of the street network to absorb levels of vehicle traffic that arise from a development proposal. In contrast to a TIAR, the Transportation Assessment can use a desired multimodal mode share target expressed in either qualitative or quantitative terms as established by the City through its Oahu General Plan, Development Plans, Sustainable Communities Plans, Neighborhood Transit-Oriented Development Plans, Special Area Plans or through administrative actions. These targets inform the project sponsor before the development is designed so that the scale, composition, transportation demand management and transportation linkages of the proposal are able to achieve the City's desired mode share goals.

Under the TIAR-style approach, amounts and types of land uses, street patterns and parking locations are provided and the traffic engineer analyzes those development features. The traffic engineer's task becomes one of working with the City to determine what needs to be done to mitigate the increased level of vehicle traffic so it is acceptable. The City can be placed in the difficult position of having to consider proposed street modifications that may improve vehicle Level of Service (LOS) but not achieve the intent of Honolulu's Complete Streets Ordinance.

A major difference between a TIAR and a Transportation Assessment is modal emphasis. The TIAR originated as a tool to evaluate mostly vehicle impacts of proposed land development. Recent TIAR's prepared for Honolulu's development projects have made adjustments to TIAR methodology to better account for higher transit utilization and other features associated with the project's location and composition.

Under the TIAR approach, adjustments are often made to the established vehicle trip generation rates to assure reasonableness and usefulness of the analysis. The vehicle trip generation rates used are generally intended for suburban single-purpose land uses serving auto-oriented communities. The locations where the trip generation data was collected may have had minimal or no sidewalks, safe bicycle paths, and access to quality public transportation. Such candidates do not represent urban conditions or what is intended by Honolulu's Complete Streets Ordinance. Peak hour traffic congestion is an inevitable fact of life in urban parts of Honolulu and therefore should not be used to gauge necessary mitigation measures. In a Transportation Assessment the primary modal consideration is a person's level of walking, bicycling, and access to public transportation, not the vehicle LOS orientation of the TIAR.

CHAPTER 2: STREET TYPE

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Chapter 2 Cover Image: Hotel Street. Credit: Alan Fujimori (SSFM International)

CHAPTER 2: STREET TYPE

2.1. Introduction

The goal of complete streets is that people be able to travel within their communities in a safe and efficient manner. Streets provide access to homes and businesses and serve as travel ways within and between neighborhoods and communities. A sustainable street network makes access possible and ensures a choice of transportation modes. A resilient street network ensures that multimodal transportation alternatives are available and a feasible option. This is important in an island state where fuel is imported through ports that are susceptible to natural disaster.

A sustainable and resilient street network fosters economic and social activity. It constrains traffic growth by limiting the number of lanes on each street while providing maximum travel options by collectively providing more lanes on more streets. Sustainable street networks increase the number of people walking and bicycling and reduce vehicle miles traveled. Travel way connectivity enables people to take shorter routes. It also enables them to travel on quieter streets. These shorter routes on quiet streets are more conducive to bicycling and walking.

Well-planned street networks help create sustainable cities that support the environmental, social, and economic needs of their residents. By providing opportunities for all modes of travel, an ideal street network enhances social equity and provides an ideal setting for high quality design at all scales: building, neighborhood, and region. The resulting communities can be some of the most beautiful places with the highest values in the world.

Figure 2-1: Cul-De-Sac Developments Break up Connectivity which results in Longer Trips and Larger Intersections

Ewa Neighborhood. Source: Google Earth

Figure 2-2: Interconnected Street Network with Small Blocks Are More Sustainable and Resilient

Diamond Head Neighborhood. Source: Google Earth

2.2. Principles of Sustainable Street Networks

Sustainable street networks come in many shapes and forms, but have the following overarching principles in common:

- The sustainable street network both shapes and responds to the natural and built environment.
- The sustainable street network privileges trips by foot, bicycle, and transit because these are the most sustainable types of trips.
- The sustainable street network is built to walking dimensions.
- The sustainable street network protects, respects, and enhances a city's natural features and ecological systems.
- The sustainable street network maximizes social and economic activity.

Figure 2-3: Aspects of a Sustainable Street

Hotel Street Transit Mall. Credit: Ryan Nakamoto (SSFM International)

2.3. Street Characteristics and Classifications

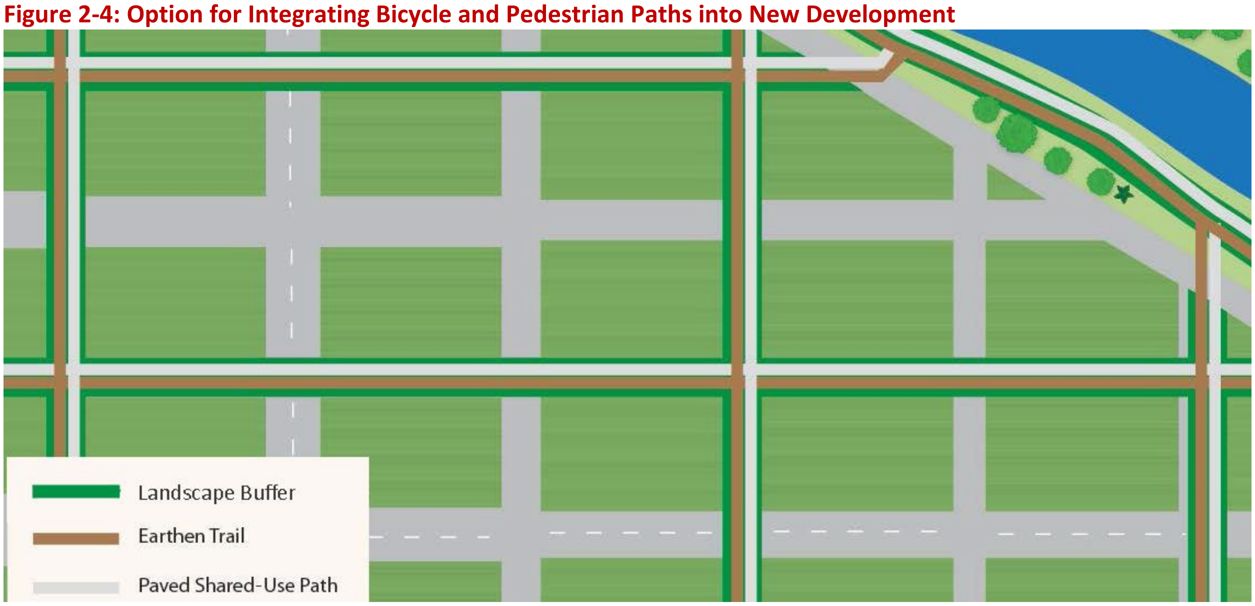
A sustainable street network provides a pattern of multimodal streets that serves all community land uses and facilitates easy access to local, city, and regional destinations. The pattern, which should give priority to non-motorized modes, results in the distribution of traffic that is consistent with the desired function of the street. One characteristic of this pattern is that it offers many route choices that connect origins and destinations.

The street network works best when it provides a variety of street types. The variety is enforced by the pattern of the street network itself but also by the design of individual street segments. Natural and built features, including topography and important community destinations, should be taken into account to create unique designs.

New subdivisions should consider integrating a network of shared-use paths and trails into the street network. Under this concept, every fourth or fifth "street" provides quiet, comfortable access for people on bicycles, people on foot, joggers, skaters, and others along a linear shared-use path without motor vehicles. Where non-vehicular ways cross vehicular streets, intersection treatments should provide safe passage for every mode. This type of network would allow people to circulate in their new communities to schools, parks, stores, and offices while staying primarily on dedicated paths and trails. These networks can also link to paths and trails along waterways, utility corridors, rail rights-of-way, and other active transportation corridors. Figure 2-4 illustrates this concept.

Urban areas should include sidewalks and designated streets such as bicycle boulevards in order to provide a multimodal network. The types of streets used in the network are described in the design standards later in this chapter. The types differ in terms of their network continuity, cross-section design, and adjoining land uses.

Figure 2-4: Option for Integrating Bicycle and Pedestrian Paths into New Development



Credit: Michele Weisbart (Michele Designs)

2.4. Context: The Transect

Context is the environment in which the street is built and includes the placement and frontage of buildings, adjacent land uses and open space, and historic, cultural, and other characteristics that form the built and natural environments of a given place. The Transect is a recognized tool for defining the context and it assists designers in creating an appropriate design for the context. Andres Duany of Duany, Plater, Zyberk & Company first introduced the Transect concept.

The Transect illustrates how the built environment varies depending on the degree of urbanization of a place. This section elaborates on the concept of the Transect and how context determines character. As integral elements of neighborhoods, streets change character depending on their context as well. The character of a single street should vary depending on the neighborhoods it passes through. In the rural context the street may be a two-lane rural road that gradually transitions into any other street type as it transverses through suburban and more urban contexts.

- T-6 (Urban Core) is the densest and most urban part of the human environment, often defined by a city's downtown.
- T-5 (Urban Center) has characteristics of a "main street."
- T-4 (General Urban) is primarily residential but still relatively urban in character. Some businesses may locate in this zone.
- T-3 (Sub-Urban) is mostly residential, located on the outskirts of town where the town grid begins to give way to nature.
- T-2 (Rural) is countryside where development may occur but may not be encouraged.
- T-1 (Natural) is the least populated and quietest zone.
- SD (Special District) is an urbanized area that specializes in a particular activity.

Figure 2-5: Transect Zones

Credit: Andres Duany (Duany, Plater, Zyberk & Company)

By definition, the urban T-Zones T-3 through T-6 do not exist as "stand alone" zones, but rather are organized in relationship to each other within a community. Each T-Zone is highly walkable and bikeable. They assume walking and biking is viable and often the preferred travel mode, especially for the five minute walk (¼ mile radius) and ½ mile bike trip.

The T-3 suburban zone defines the urban to rural edge. Of all the T-Zones, T-3 appears most like conventional sprawl. It has single-family dwellings, a limited mix of uses and housing types, and tends to be more automobile-oriented than T-4, T-5, or T-6. The five minute test of walkable distance limits the overall size of a T-3 Transect zone.

Contexts will not always flow evenly and incrementally from T-1 to T-6: there may be gaps. For example, a rural community may have only T-2 with a community center that is not urban enough to be T-5 (for example, a church, convenience store, and gas station at the one intersection in the whole town).

An important element of the design process is to ensure the travel way design fits the context of the intended design. Through use of a regulating plan, the appropriate street design will be established to fit the context, purpose, and type of street.

2.5. Street Network Design Standards

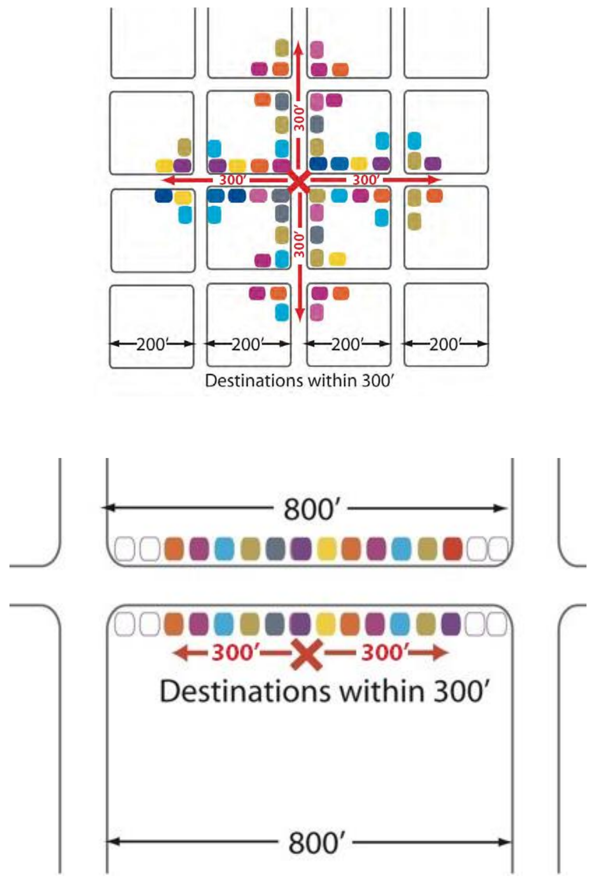
The most important time to ensure complete streets-oriented block size is with new development. Once streets are constructed, it is often infeasible to retrofit. Thus, it is critical to make sure that new development comes with small, interconnected blocks. Opportunities can arise through redevelopment to reconnect adjacent neighborhoods with smaller, better connected blocks. For example, when large shopping centers are redeveloped their large parcel may be broken up into small blocks that link to the surrounding street network. In other cases, new development may occur adjacent to existing development and can connect with small blocks. Some cul-de-sac streets can be connected, especially for people on bicycles and on foot.

The following lays out principles of street networks for complete streets:

- Establish a block size maximum of 1,600 linear feet (perimeter).
  - Ensure greater accessibility within the block through alleys, service courts, shared-use paths, and other access ways.
  - Where block size is exceeded, retrofit large blocks with new street, alley, pedestrian and/or bicycle connections.
  - For existing street networks, do not allow street closures that would result in larger distances for people traveling on foot or bicycle.
- Require multiple street connections between neighborhoods and districts across the whole region. This is achieved by having boulevards and avenues that extend beyond the local area. Adjacent neighborhoods must also be connected by multiple local streets.

- Connect streets across urban freeways so that people on foot and people on bicycles have links to neighborhoods without having to use streets with freeway on and off ramps.
- Maintain network quality by accepting growth and the associated expansion of the street network (including development, revitalization, intensification, or redevelopment) while avoiding increases in street width or in the number of lanes.
- Provide on-street curbside parking where appropriate and after all transportation modes have been accounted for in the network. Exceptions can be made where there is a more context-appropriate use of the space.
- Establish maximum speeds of 20 to 35 miles per hour (mph) within urban areas.
- Use design features that support lower-speed environments.
- On local streets, the speed should be 20 to 25 mph or less.
- Maintain network function by discouraging:
    - One-way streets;
    - Turn prohibitions;
    - Full or partial closures (except on bicycle boulevards, or areas taken over for other uses of public space);
    - Removal of on-street parking (except when replaced by wider sidewalks, an enhanced streetscape, bus lanes, bike lanes, etc. rather than additional vehicle lanes);
    - Gated streets;
    - Widening of individual streets; and,
    - Conversion of city streets to limited access facilities.
- Classify major streets using the common street and context types presented in Table 2-1. However, some streets are unique and deserve a special category that lies outside the common street network types.

Figure 2-6: Many More Designations Can Be Reached Walking 300’ (from X) within a Network of Short Blocks (top diagram) than in One with Long Blocks (bottom diagram)



Credit: Marty Bruinsma

2.6. Types and Roles of Streets

The Federal Highway Function and Classification system contains the conventional classification system that is commonly accepted to define the function and operational requirements for streets. These classifications are also used as the primary basis for geometric design criteria.

Traffic volume, trip characteristics, speed and level of service, and other factors in the functional classification system relate to the mobility of motor vehicles, rather than people on bicycles or people on foot. This approach, while appropriate for high speed rural and some suburban travel ways, does not provide designers with guidance on how to design for complete streets or in a context-sensitive manner.

The street types described here provide mobility for all modes of transportation with a particular focus on the pedestrian. The functional classification system can be generally applied to the street types in this document. Designers should recognize the need for greater flexibility in applying design criteria, based heavily on context and the need to create a safe environment for people on foot, rather than strictly following the conventional application of functional classification based on automobiles in determining geometric criteria.

The terms for street types for complete streets are described in the following sections. Honolulu's use of the term "avenue" or "street" in combination with the street name does not necessarily reflect the street typology definitions used in this Manual.

The definitions below fit the desired condition for each street typology. While existing streets can be categorized within these typologies, many may not currently have all the ideal features, such as bike lanes or sidewalks. Therefore, the definitions provide guidance for constructing new streets as well as guidance for retrofitting existing streets.

Table 2-1 crosses the new typology system for Honolulu to the FHWA classification system. This allows the City and County of Honolulu to maintain eligibility for federal funds that require that classification system to be used.

The following sections provide examples of these street typologies throughout Honolulu. However, some of the examples do not have all of the features of a complete street.

Table 2-1: New Street Typology for Honolulu Compared to Corresponding Functional Classification

	Street Typology						
Functional Classification	**Boulevard and Parkway**	**Avenue**	**Main Street**	**Street**	**Mall**	**Rural Road**	**Lane/Alley**
Principal Arterial	■						
Minor Arterial	■	■	■				
Collector		■	■	■	■	■	
Local				■	■	■	■

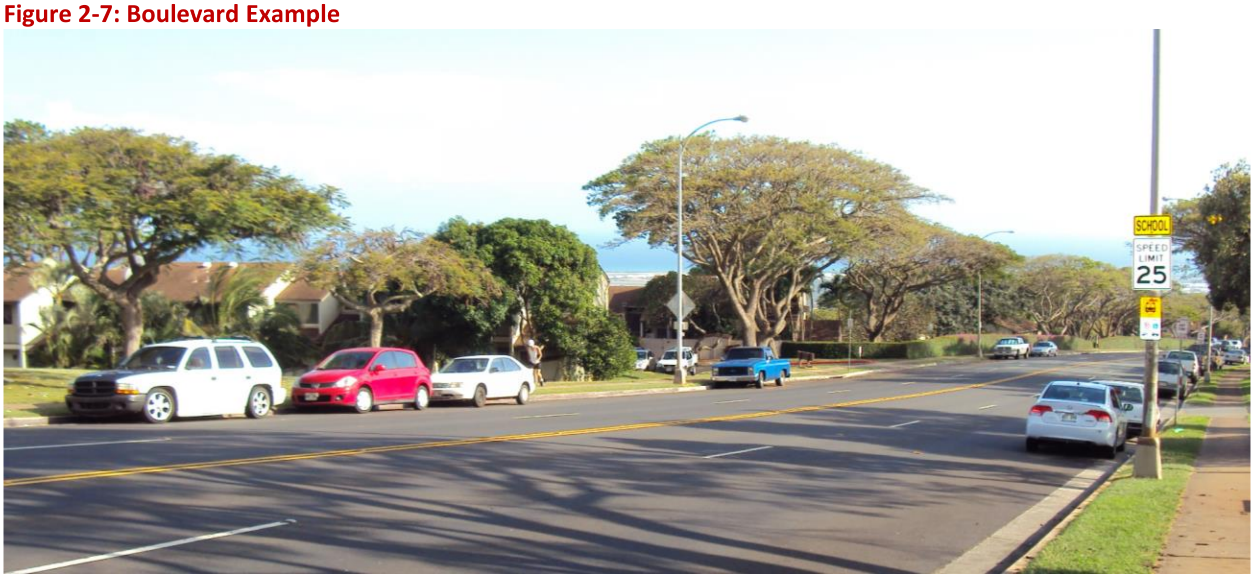
2.6.1. Boulevard and Parkway

A Boulevard is a street designed for high vehicular capacity and moderate speed, traversing an urbanized area. Boulevards have four or more travel lanes. Boulevards serve as primary transit routes. Boulevards should have bike lanes or protected bike lanes. They may be equipped with bus lanes or side access lanes buffering sidewalks and buildings. Parkways are Boulevards with landscaped medians.

Examples of Boulevards and Parkways include:

- Makakilo Drive (see below);
- University Avenue (see below);
- Kapiolani Boulevard;
- Kapolei Parkway; and
- Salt Lake Boulevard.

Figure 2-7: Boulevard Example



Makakilo Drive. Credit: Mike Packard (SSFM International)

Figure 2-8: Parkway Example

University Avenue. Credit: Mike Packard (SSFM International)

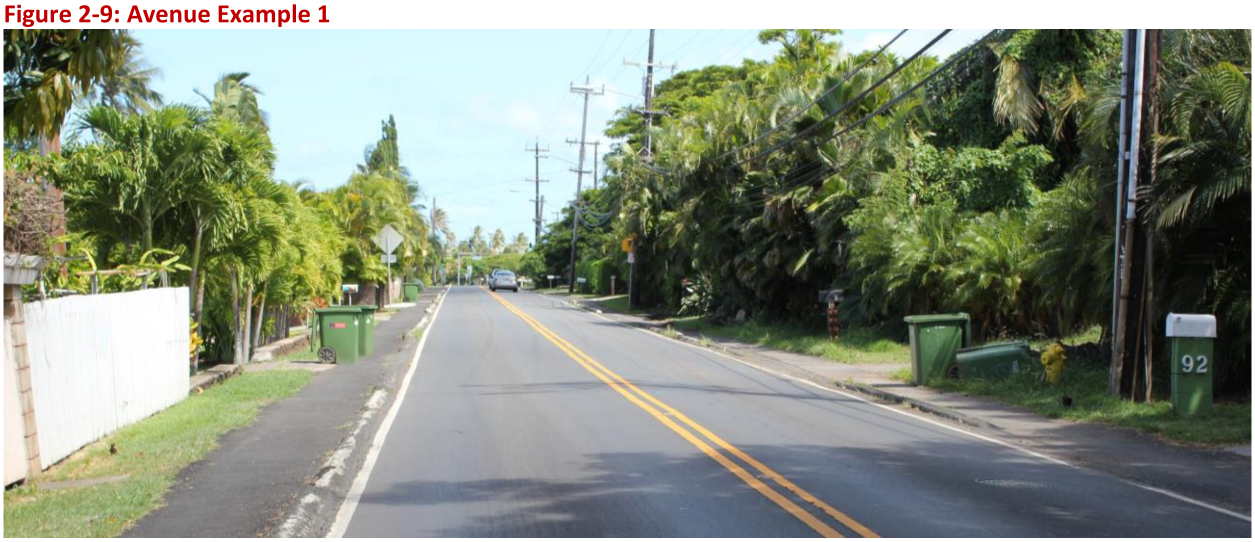
2.6.2. Avenue

An Avenue is a street of moderate to high vehicular capacity and low to moderate speed acting as a short distance connector between urban centers and boulevards. Avenues have two to four travel lanes. Avenues may have landscaped medians. Avenues should have bike lanes or protected bike lanes.

Examples of Avenues include:

- Kaneohe Bay Drive, between Kamehameha Highway and Mokapu Boulevard in Kaneohe (see below);
- Keolu Drive (see below);
- Waimano Home Road, between Kamehameha Highway and Komo Mai Drive; and.
- Lunalilo Home Road.

Figure 2-9: Avenue Example 1



Kaneohe Bay Drive. Credit: Mike Packard (SSFM International)

Figure 2-10: Avenue Example 2

Keolu Drive. Credit: Mike Packard (SSFM International)

2.6.3. Main Street

Main Streets are a subsect of Avenues, with the special distinction in that they represent a commercial section of a town center. Main Streets have improved designs for people on foot and are a high priority for including bike lanes.

Examples of Main Streets include:

- Kailua Road in Kailua (see below);
- Waialae Avenue in Kaimuki (see below); and,
- California Avenue in Wahiawa.

Figure 2-11: Main Street Example 1

Kailua Road. Credit: Mike Packard (SSFM International)

Figure 2-12: Main Street Example 2

Waialae Avenue. Credit: Ryan Nakamoto (SSFM International)

2.6.4. Street

A Street is local and suitable for all urbanized Transect zones and all frontages and uses. Streets have two travel lanes. A Street is urban or suburban in character. They may have raised curbs (except where curbless treatments are designed), sidewalks or other separated ways for people on foot, and landscaping. The character may vary in response to the commercial or residential uses lining the street. Streets should serve the needs of people on bicycles and people on foot.

A Street can serve as a "Bicycle Boulevard" where the bicycle travel is given priority over cars. A Street can also be a "Shared Street" (also called a "woonerf") where people on foot are given priority and all users share the travel way. Both of these street types can be implemented through the installation of various traffic calming measures.

Examples of Streets include:

- Kakahiaka Street in Kailua (see below);
- Papipi Road in Ewa (see below); and,
- Royal Hawaiian Avenue in Waikiki.

Figure 2-13: Street with On-Street Parking

Kakahiaka Street. Credit: Mike Packard (SSFM International)

Figure 2-14: Street without On-Street Parking

Papipi Road. Credit: Alan Fujimori (SSFM International)

2.6.5. Mall

Malls are Streets where private automobiles are prohibited or heavily restricted. Delivery vehicles may be permitted during off-peak hours. Transit Malls are dedicated primarily for buses or trains, but bicycles are permitted. Transit Malls serve multiple transit lines and have numerous transit stops. They are typically lined with retail and commercial uses that take advantage of the volume of people boarding and alighting from transit. Pedestrian Malls have no motor vehicles. They have stores, restaurants, and entertainment that cater to people on foot. Pedestrian Malls are destinations. They may be used for farmers markets, arts and crafts fairs, or other events. Pedestrian malls may accommodate slow speed bicycle travel.

Examples of Malls include:

- Fort Street (see below); and
- Hotel Street (see below).

Figure 2-15: Pedestrian Mall Example

Fort Street. Credit: Ryan Nakamoto (SSFM International)

Figure 2-16: Transit Mall Example

Hotel Street. Credit: Alan Fujimori (SSFM International)

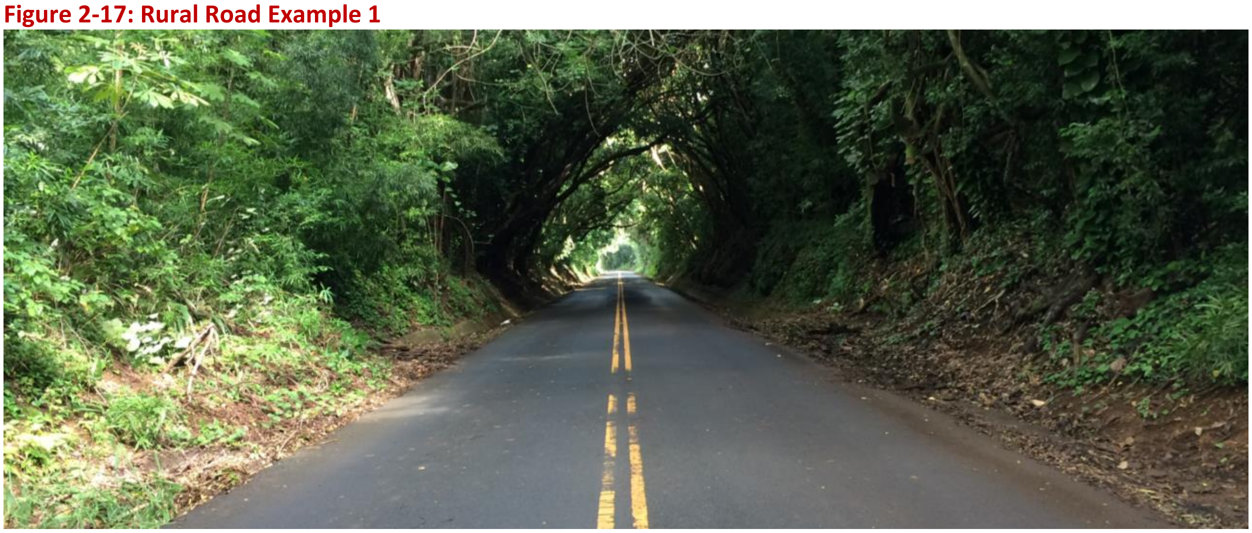
2.6.6. Rural Road

Rural Roads are roads that are sparsely developed and connect developed areas or connect to other Rural Roads. Rural Roads often serve as farm roads. They are distinguished from highways in that they are owned and maintained by the County and generally carry much less traffic. Vehicle volumes and speeds are typically low on Rural Roads which allow for people on foot and people on bicycles to share the road. Where subdivisions are developed with neighborhoods in rural areas, the streets within them are classified as those above.

Examples of Rural Roads include:

- Nuuanu Pali Drive (see below); and,
- Waihee Road in Kahaluu (see below).

Figure 2-17: Rural Road Example 1



Nuuanu Pali Drive. Credit: Mike Packard (SSFM International)

Figure 2-18: Rural Road Example 2

Waihee Road. Credit: Mike Packard (SSFM International)

2.6.7. Lane/Alley

A Lane or Alley is a narrow street, often without sidewalks. Lanes and alleys connect streets and can provide access to the backs of buildings and garages. Some are service alleys for deliveries and refuse collection.

Examples of Lanes and Alleys include:

- Marin Lane in Chinatown (see below); and
- Duke's Lane in Waikiki (see below).

Figure 2-19: Lane/Alley Example 1

Marin Lane. Credit: Ryan Nakamoto (SSFM International)

Figure 2-20: Lane/Alley Example 2

Duke's Lane. Credit: Wes Frysztacki (Weslin Consulting Services)

2.6.8. Scenic Byways and Other Designations

Certain roads have been designated scenic or have historical significance. Certain roads have been designated historic and listed on the United States Department of the Interior, National Park Service, National Register of Historic Places, and Hawaii Register of Historic Places. These roads typically have unique features or significance. Plaques may be installed along these roads to describe the significance of the road. This designation is in addition to a street's typology. This designation shall not preclude all improvements related to complete streets, just those that would change the character of the road that contribute to its historic nature.

Examples of significant roads include:

- Tantalus Drive (see below); and,
- Round Top Drive (see below).

Figure 2-21: Significant Road Example 1

Tantalus Drive. Credit: Friends of Tantalus

Figure 2-22: Significant Road Example 2

Round Top Drive. Credit: Friends of Tantalus

Figure 2-23: Significant Road Example 3

Tantalus Drive. Credit: Friends of Tantalus

CHAPTER 3: TRAVEL WAY

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Chapter 3 Cover Image: Kailua Road. Credit: Mike Packard (SSFM International)

CHAPTER 3: TRAVEL WAY

3.1. Introduction

Travel way design in this chapter is defined as the part of the street right-of-way between the two faces of curbs and can include parking lanes, bicycle lanes, transit lanes, general use travel lanes, and medians. For streets without curbs, the travel way would be defined by the area between the edges of pavement. The design of the travel way is critical to the design of the entire street right-of-way because it affects not just the users in the travel way, but those using the entire right-of-way, including the areas adjacent to the street. As a note on terminology, "travel way" in this document is more or less the equivalent of "roadway" in most conventional design manuals: the curb-to-curb portion of a curbed street.

This Manual presents desired dimensions for many components of streets ranging from parking lanes to bus lanes and sidewalks. When existing streets are improved there may not be room to meet all the desired dimensions, or the cost of doing so might be prohibitive. Existing curb-to-curb widths and/or existing buildings constrain what can be done. The City will need to prioritize components of the modified street. Along streets where transit service is critical, bus lanes may be a top priority. On other streets completing a network of protected bike lanes may take precedent. And in retail environments, wide sidewalks might be most important.

3.2. Complete Street Components

The following key principles should be kept in mind for a well-designed travel way:

- **Design to accommodate all users.** Street network design should accommodate *all* users of the street, including people on foot (pedestrians), people on bicycles (bicyclists), transit users, automobiles, and commercial vehicles. A well-designed travel way provides appropriate space for all street users to coexist.
- **Design using the appropriate speed for the surrounding context.** The right design speed should reflect the desired role and responsibility of the street, including the type and intensity of land use, urban form, the desired activities on the sidewalk, such as outdoor dining, and the overall safety and comfort of people on foot and people on bicycles. The speed of vehicles impacts all users of the street and the livability of the surrounding area.
- **Design for safety.** The safety of all street users, especially the most vulnerable users (children, the elderly, and disabled) and modes (people on foot and people on bicycles) should be paramount in any design of the travel way. The safety of streets can be dramatically improved through appropriate geometric design and operations.

3.3. Travel Way Users

3.3.1. Pedestrians

The goal of travel way and intersection design is to create an environment that is conducive to walking, where people can walk along and cross the road to get where they want to be. Two effective methods to achieve these goals are to minimize the footprint dedicated to motor vehicle traffic and to slow down the speed of moving traffic. The designer can add many features that enhance the walking environment such as trees, curb extensions, and street furniture. All streets should have pedestrian facilities except for rural roads, lanes/alleys, and shared-space streets. See Chapter 7, "Pedestrian Zone," for specifics of sidewalk design.

3.3.2. Bicyclists

Unless stated otherwise, all streets should be designed with the expectation that people on bicycles (bicyclists) will use them. This does not mean every street needs a dedicated bicycle facility, nor will every road accommodate all types of people on bicycles. Minimizing the footprint dedicated to motor vehicle traffic and slowing down the speed of moving traffic benefits people on bicycles. Chapter 6, "Bicycle Facility," describes in greater detail the various types of bikeways and their application.

3.3.3. Public Transportation

Designing for transit vehicles on travel ways takes into consideration many factors. Buses have special operational characteristics. They usually operate in mixed traffic, they stop and start often for passengers, and they must be accessible to people boarding the bus. The consequences for travel way design includes lane width (in most cases buses can operate safely in travel lanes designed for passenger cars), intersection design (turning radius or width of channelization lane), signal timing (often adjusted to give transit an advantage—queue jumping), pedestrian access (crossing the street at bus stops), sidewalk design (making room for bus shelters in the furniture zone), and bus stop placement and design (far side/near side at intersections, bus bays, or bulb outs). Chapter 8, "Transit Accommodation," describes in greater detail these and other design and operational considerations.

Figure 3-1: Street Design to Accommodate All Users

Kailua Road. Credit: Mike Packard (SSFM International)

3.4. 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 due to the potential negative impacts larger dimensions may have on pedestrian crossing distances and the speed of turning vehicles.

For intersection geometry design features such as corner radii, a design vehicle should be considered for 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 travel way for single right turn movements.

It may be inappropriate to design a facility by using a large design vehicle, which uses the street infrequently, or infrequently makes turns at a specific location. An example is a vehicle that makes no more than one delivery per day at a business. Depending on the frequency and location, the design vehicle can be allowed to encroach into opposing traffic lanes or make multiple-point turns.

Emergency vehicle access needs to be accounted for in the design of transportation networks. During emergency responses, other vehicles are required to give way to emergency responders thereby allowing for emergency vehicles to use the entirety of the travel way.

3.4.1. Design Guidelines

The design vehicle types below should be considered in order to maintain property access while emphasizing pedestrian safety and low speeds.

- **30-foot long single-unit truck (SU-30), representative of a refuse truck, for residential, downtown and commercial streets.**
- **50-foot long intermediate semitrailer (WB-50) for designated truck routes.**
- **City transit bus (CITY-BUS) along all designated and alternate bus routes.**

Figure 3-2: Refuse Truck Design Vehicle

Kalakaua Ave. Credit: Rvan Nakamoto (SSFM International)

3.4.2. National Guidelines

The *Green Book* (AASHTO, 2011) states that the designer should use the largest design vehicle that is likely to use that facility with considerable frequency. A passenger car may be used when the main traffic generator is a parking lot. A two-axle single-unit truck may be used for the design of residential streets and park roads. A three-axle single-unit truck may be used for the design of collector streets and other facilities where larger single-unit trucks are likely. A city transit bus may be used in the design of state highways intersection with city streets that are designated bus routes.

3.5. Movement Types

The following movement types are used to describe the expected driver experience on a given street and the target speed to enable pedestrian safety and mobility established for each of these movement types. They are also used to establish the components and criteria for design of complete streets.

3.5.1. Yield Movement

Yield movements have a target speed of less than 20 miles per hour (mph). Yield movements should accommodate people on bicycles through the use of shared lanes. During a yield movement, drivers should proceed slowly, with extreme care, and should yield right of way to all approaching traffic. This has traffic calming effects.

3.5.2. Slow Movement

Slow movements have a target speed of 20 to 25 mph. They should accommodate bicycling through the use of shared lanes. Drivers can proceed carefully with an occasional stop to allow a person on foot to cross or another car to park. Drivers should feel uncomfortable exceeding the target speed due to the presence of parked cars, a feeling of enclosure, tight turn radii, and other design elements.

3.5.3. Moderate Movement

Moderate movements have a target speed of 30 to 35 mph. Generally drivers can expect to travel at the target speed without delay; street design supports safe movements for people on foot at the higher target speed. They can accommodate people on bicycles with the use of bike lanes. This movement type is appropriate for streets designed to traverse longer distances or that connect to higher intensity locations. Target speeds higher than 35 mph should not normally be used within communities, or in Transects T-3 (Sub Urban) and above.

Figure 3-3: Yield Movement

Kakahiaka Street. Credit: Mike Packard (SSFM International)

Figure 3-4: Slow Movement

Wanaao Road. Credit: Mike Packard (SSFM International)

Figure 3-5: Moderate Movement

University Avenue. Credit: Mike Packard (SSFM International)

3.6. Lane Width

Travel lane widths should be provided based on the following factors:

- Street context and typology
- Target speed
- Design vehicle
- Available right-of-way
- Width of adjacent bicycle and parking lanes.

In order for drivers to understand how fast they should drive, lane widths have to create some level of driver discomfort when driving too fast. When designated bike lanes or multi-lane configurations are used, there is more room for operators of large vehicles, such as buses. These road configurations may result in passenger vehicle drivers driving faster than desired which should be mitigated through other measures.

3.6.1. Design Guidelines

Generally lane widths generally should be between 9 and 11 feet. Lane width can be measured from travel lane marking, face of curb, parking stall, or other physical barrier. The minimum width should be used, considering the applicable factors. Where travel lanes are not marked, along low-speed, low-volume roads, total road width may be designated for yield conditions.

- **Along local streets, travel lane widths may be 9 feet wide.**
- **The default value for all travel lanes other than local streets should be 10 feet wide.**
- **Along a transit route, or in an area where there is a high percentage of heavy vehicle traffic, a travel lane width may be 11 feet wide. Where there are multiple lanes in one direction, the outside curb lane should be 11 feet wide.**

3.6.2. National Guidelines

The *Green Book* (AASHTO, 2011) states that lane widths of 9 to 12 feet are generally used with a 12-foot lane predominant on most high-speed, high-volume highways. Specifically, a 12-foot lane is used to provide clearances between large commercial vehicles traveling in opposite directions on two-lane, two-way rural highways when high traffic volumes and particularly high percentages of commercial vehicles are expected.

Since this condition is not applicable on most City streets, use of 12-foot wide lanes should be rare and discouraged. The default width should be 10 feet on all roads, except local roads which may be 9 feet wide.

Figure 3-6: Travel Lane Width

Upper University Avenue 10-foot wide travel lanes. Credit: Mike Packard (SSFM International)

3.7. Design/Target Speed

The goal for complete streets is to establish a target speed that creates a safe environment for motorists, people on foot, and people on bicycles. Streets should be designed for the target speed, which aims for the desired speed at which we want motorists to operate.

For complete streets, target speeds of 20 to 35 mph are desirable. Alleys and narrow travel ways intended to function as shared spaces may have target speeds as low as 10 mph. A slower target speed allows the use of features that enhance the walking environment, such as small curb radii, narrower sections, trees, on-street parking, curb extensions, bulb-outs, street furniture, and bike facilities. The target speed should equal the design speed, as well as the posted speed.

3.7.1. Design Guidelines

Target speed should be based on the street context and typology.

Most City streets should be designed to a target speed that does not exceed 25 mph. Areas where this may differ are as follows:

- **15 mph – shared streets and school zones**
- **20 mph – neighborhood residential streets**
- **35 mph – Boulevards and Parkways**

Where these target speeds differ from existing posted speed limits, a study using accepted engineering practices and standards should be conducted to consider the appropriate posted speed limit and speed reduction measures. In mountainous areas, lower target speeds should be considered.

3.7.2. National Guidelines

The *Green Book* (AASHTO, 2011) states that design speed is a function of type of terrain and grade percentage. It states that design speed is not a major factor for local urban streets because in the typical street grid, the closely spaced intersections usually limit vehicular speeds. For consistency in design elements, design speeds ranging from 20 to 30 mph may be used, depending on available right-of-way, terrain, likely pedestrian presence, adjacent development, and other area controls.

Since the function of local streets is to provide access to adjacent property, all design elements should be consistent with the character of activity on and adjacent to the street, and should encourage speeds generally not exceeding 20 mph.

Figure 3-7: Target Speed Based on Street Context

Kailua Road toward Kailua Beach Park. Credit: Mike Packard (SSFM International)

3.8. On-Street Parking and Curbside Use

On-street parking can be important in the urban environment for the success of the retail businesses that line the street and to provide a buffer for people on foot and help calm traffic speeds. In addition to parking, other uses of the curbside, such as for bus transit, loading zones, bicycle facilities and parking, and parklets help support surrounding businesses.

3.8.1. On-Street Parking Tools

Marked parking stalls may be used in commercial areas or where travel lane delineation is desired. Pavement marking provides visual cues for parking vehicles as well as vehicles in the travel way.

Where angle parking is proposed for on-street parking, designers should consider the use of reverse-in angle (or front out) parking in lieu of front-in angled parking. Motorists pulling out of reverse-in angled parking can better see the active street they are entering. This is especially important to people on bicycles. Moreover, people exiting cars do so on the curb side and aren't likely to step into an active travel lane.

Another tool for on-street parking is the park assist lane. Often when on-street parking is provided on busy roads, drivers find it difficult to enter and leave their parked vehicle. Where space is available, consideration should be given to adding a park assist lane between the parking lane and travel way to provide 3 feet of space so car doors can be opened and vehicles can enter or depart with a higher degree of safety and less delay. Bike lanes can serve this function as well where travel way constraints exist. Parking assist lanes also narrow the feel of the travel lane.

Figure 3-9: Angled-In Parking

Ulune Street back-in angled parking. Credit: Wendy McLain (SSFM International)

Figure 3-8: Parallel Parking

Waialae Avenue. Credit: Ryan Nakamoto (SSFM International)

3.8.2. On-Street Parking Design Guidelines

Guidelines for standard on-street parking are as follows:

- **On Streets, parking lanes should be a minimum of 7-feet wide, measured from the face of curb.**
- **On Avenues, Parkways, and Boulevards parking lanes may range from 8-10 feet in width. If adjacent to a 5-foot minimum bike lane, parking lane widths may be reduced to 7-feet wide.**
- **Angled parking should be 16.5-feet long (as measured perpendicular from the curb) for 60-degree angles, and 15-feet long for 45-degree angles.**

3.8.3. Loading Zones

Curbside loading zones are needed along certain street types in urban areas to accommodate buses, taxis, and commercial vehicles. Various bus stop zone designs are discussed in Section 8.6. Design of commercial truck loading zones should reference the *Freight and Land Use Handbook* (FHWA, 2012).

3.8.4. Parklets

A parklet is a public space created by installing a platform over an on-street parking stall at the level of the sidewalk. Amenities that a parklet can feature include benches, tables, chairs, planters and landscaping, and bicycle parking. Parklets are temporary installations that can be in place for a period ranging from several months to several years.

Figure 3-10: Parklet Example

Coral Street. Credit: Mike Packard (SSFM International)

3.8.5. Bike Corrals

Bike corrals are on-street bicycle parking racks that provide greater capacity for short-term bicycle parking where there is a higher demand than can be accommodated on sidewalk racks. Bike corrals are particularly attractive when the demand for bicycle parking begins to crowd the sidewalk right-of-way.

Identifying the best location for a bike corral involves several factors. Locations should be identified in consultation with adjacent businesses, property owners, and business associations where feasible. Some elements to consider are convenience, street corners, main streets, existing parking spaces, and traffic operations.

Locating bike corrals near corners should take into account vehicular sight lines while providing greater visibility and access for people on bicycles. It also prevents large vehicles from parking near corners which is an added safety benefit for people on foot. Exiting people on bicycles are also easier to see when the bike corral is not concealed between a row of parked cars.

Additional guidance on bike corrals is included in section 6.6.7.

3.8.6. National Guidelines

The *Green Book* (AASHTO, 2011) states that within urban areas and in rural communities located on arterial highway routes, on-street parking should be considered in order to accommodate existing and developing land uses. The designer should consider all uses of the curbside so that the proposed street or highway improvement will be compatible with the land use.

Figure 3-11: Bike Corral Example

Hekili Street. Credit: Mike Packard (SSFM International)

3.9. Medians

During roadway reconfiguration, medians should be used if space is available after all modes have been accommodated. Medians used on urban streets provide access management by limiting vehicle left turn movements into and out of abutting development to select locations where a separate left turn lane or pocket can be provided. The reduced number of conflicts and conflict points decreases vehicle crashes, provides people on foot with a refuge as they cross the road, and provides space for landscaping, lighting, and utilities. These medians are usually raised and curbed, although they don't have to be, and may serve as infiltration where the lowest point in the street cross section is the center. Landscaped medians can be used to create tree canopies over travel lanes, contributing to a sense of enclosure. Landscaped medians also enhance the aesthetics of the street or help to create a gateway entrance into a community.

3.9.1. Design Guidelines

Recommended median widths during roadway reconfiguration depend on available right-of-way and function. Because medians require a wider right-of-way, the designer must weigh the benefits of a median with the issues of pedestrian crossing: distance, speed, context, accommodations of other modes, and available roadside width.

Table 3-1: Median Types and Widths

Median Type	Minimum Width	Recommended Width
Median for access control	4 feet	6 feet
Median for pedestrian refuge	6 feet	8 feet
Median for trees and lighting	6 feet [1]	10 feet [2]
Median for single left-turn lane	10 feet [3]	10 feet [2]
Median for single left-turn lane and pedestrian refuge	16 feet [4]	16 feet

[1] *Six feet measured curb face to curb face is considered the minimum width for proper growth of small caliper trees (less than 4 inches).*

[2] *Wider medians provide room for larger caliper trees and more extensive landscaping.*

[3] *A 10-foot lane provides for a turn lane without a concrete traffic separator.*

[4] *Includes a 10-foot turn lane and a 6-foot pedestrian refuge.*

Figure 3-12: Landscaped Median

Kailua Road. Credit: Mike Packard (SSFM International)

3.10. Road Diet

A "Road Diet" describes the narrowing and/or removal of motor vehicle lanes from the travel way cross-section. Both of these changes are traffic calming measures and aid in the improved safety of the corridor. Typically, the reclaimed space is used for other purposes such as wider sidewalks, landscaped spaces, bicycle lanes, linear parks, and/or on-street parking. Often, road diet projects employ other traffic calming measures as well. Roundabouts often enable implementation of road diets, especially on busier boulevards since they have greater capacity to handle traffic at intersections with fewer lanes than other intersection controls.

As noted in the 2014 FHWA Safety Program *Road Diet Informational Guide*, benefits of a road diet may include:

- *"An overall crash reduction of 19 to 47%.*
- *Reduction of rear-end and left-turn crashes.*
- *Fewer lanes for pedestrians to cross and an opportunity to install pedestrian refuge islands.*
- *The opportunity to install bicycle lanes when the cross-section width is reallocated.*
- *Reduced right-angle crashes.*
- *Traffic calming and reduced speed differential.*
- *The opportunity to allocate the "leftover" roadway width for other purposes, such as on-street parking, wider sidewalks or transit stops.*
- *Encouraging a more community-focused, "Complete Streets" environment.*
- *Simplifying road scanning and gap selection for motorists."*

3.10.1. Design Guidelines

In many contexts, streets with two lanes and a center turn lane have the capacity to carry an Average Daily Traffic (ADT) 20,000-25,000 vehicles. Streets with four lanes and a center turn lane have capacity for 35,000-40,000 ADT. Where streets have lower ADT than the road provides capacity for, a road diet should be considered. The FHWA advises that roadways with ADT of 20,000 vehicles or less may be good candidates and should be evaluated for feasibility. The peak hour volume in the peak direction may be the measure that determines whether the road diet can be feasibly implemented without affecting vehicle delay.

Figure 3-13: Example of a Four Lane Travel Way Following a Road Diet

Keolu Drive. Credit: Mike Packard (SSFM International)

3.11. Traffic Calming/Speed Reduction

Traffic calming is the combination of mainly physical measures that:

- Reduce the negative effects of motor vehicle use;
- Alter driver behavior; and
- Improve conditions for non-motorized street users.

The intent of traffic calming is to change the role and design of streets to accommodate motorists in ways that increase safety and reduce the negative social and environmental effects on individuals, neighborhoods, districts, retail areas, corridors, downtowns, and society in general. This includes reduced speeds, lower number of traffic crashes and collisions, reduced sense of vehicle intrusion/dominance, reduced energy consumption and pollution, reduced sprawl, and reduced automobile dependence.

Through design, traffic calming aims to slow the speeds of vehicles to the target speed in a context-sensitive manner by working with the stakeholders (i.e. residents, business owners, and agencies). Traffic calming success requires a supportive policy environment such that the measures are permitted and encouraged.

3.11.1. Application

Traffic calming has been practiced in Honolulu for over 15 years. The process includes the following:

- Understanding of the context;
- Involve the stakeholders in the definition of the problems to be solved and aspirations to be fulfilled;
- Educate the stakeholders such that they can have meaningful involvement;
- Align the project with a broader vision for the area;
- Achieve an informed consent.

Traffic calming is done as a retrofit, in conjunction with a development, revitalization, utility, or maintenance project; a downtown, corridor, or transit plan; a new street design; or other project. The traffic calming layer is simply incorporated into the larger project's processes.

Traffic calming typically connotes a street or group of streets that employ traffic calming measures with a "self-enforcing" quality that physically encourages motorists to drive at the desired speed. When a group of streets are involved, it is normally referred to as "area-wide calming."

Traffic calming measures can also be designed to treat and manage storm water.

3.11.2. Cross Section Measures

Traffic calming can be implemented by changing the travel way cross-section by narrowing the real or apparent width of the street. Real changes to the travel way includes extending curbs and sidewalks or marking for narrow travel lanes. Apparent changes to the travel way width includes changes to the edges such as:

- Reducing setbacks of buildings.
- Planting continuous street trees.
- Installing street furniture adjacent to the travel way.
- Using pavement marking to narrow the travel way.

3.11.2.1. Center Line Removal

On streets with one travel lane in each direction, removal of the center line is recommended where traffic volumes permit to facilitate passing of people on bicycles by motor vehicles. Motorists may be unwilling to cross over a center line to pass a person on a bicycle, which could result in instances where motorists attempt to pass a person on a bicycle too closely. People riding bicycles in these situations may feel pressured to ride to the extreme far right or in the gutter to allow motorists to pass. Removal of the center line opens the entire travel way for passing, and allows people on bicycles to position themselves at a safe and comfortable distance from the curb. Lack of center lines is also a traffic-calming technique, as drivers tend to drive slower without the visible separation from oncoming traffic.

The *MUTCD* (FHWA, 2009) allows for the absence of center line stripes on roads that comply with the guidelines of Table 3-2.

Table 3-2: Center Line Removal Guidelines

Street Functional Classification	Road Width	Average Daily Traffic [1]
Urban arterials and collectors	≥ 20 feet	< 4,000 vehicles
Local street	N/A	< 4,000 vehicles

[1] *If traffic volumes are not available, ADT may be estimated using engineering judgement.*

However, the *MUTCD* (FHWA, 2009) requires center line markings be placed on all paved two-way streets or highways that have three or more lanes for moving motor vehicle traffic, and on all paved urban roads that have a travel way width of 20 feet or more and an ADT of 6,000 vehicles or greater.

Additional consideration for center line placement should be given to paved urban arterials and collectors that have a travel way width of 20 feet or more and an ADT of 4,000 to 6,000 vehicles, and to rural arterials and collectors that have a travel way width of 18 feet or more and an ADT of 3,000 vehicles or greater.

Figure 3-14: Center Line Removal Allows for Shared-Use Travel Ways

Kailua Road. Credit: Mike Packard (SSFM International)

3.11.3. Use of Periodic Measures

To achieve a desired speed of 20 mph, periodic measures can be used. The spacing of these measures should be between 250 to 300 feet apart. Typically, measures are constructed at the locations such as pedestrian crossings, intersections, and curves. Subsequent measures are filled in to attain the correct spacing. In this way, a slow and steady speed profile is achieved. There is little opportunity or utility for motorists to speed up between the measures.

From an emergency perspective and a public acceptability perspective, it is important to limit the number of periodic measures in a row on major streets. The rule of thumb is, on the routes between two major streets there should be no more than 8 to 12 periodic measures. If more than 8 to 12 periodic measures are used in a row, motorists who use the streets will become highly irritated with the measures and will have them removed. This rule of thumb effectively limits the length of single-street traffic calming projects. It also limits the size of the area for area-wide calming (i.e., the maximum limit is 8 to 12 multiplied by the spacing between the measures).

Some local streets do not apply due to their long lengths and inability to be effectively calmed with no more than 8 to 12 periodic measures at the correct spacing.

Periodic measures are appropriate in some situations such as locations with heavy pedestrian generators (e.g., at elementary schools, community centers, entertainment venues, and key intersections along a main street or in a downtown).

3.11.4. Design Guidelines

Tables 3-3 and 3-4 provide examples of traffic calming measures and their appropriateness on various street categories.

The photos that follow include examples of some of these treatments both locally and nationally.

Figure 3-15: Use of Traffic Calming Measures

Aumoe Road. Credit: Mike Packard (SSFM International)

Table 3-3: Representative Examples of Traffic Calming Measures and Their Appropriateness on Various Street Categories

Street Typology			Boulevards, Parkways and Avenues	Boulevards, Parkways and Avenues	Avenues	Streets, Main Streets and Alleys
Posted / Design / Target / Operating Speed (mph)			35 mph or more	25 to 30 mph	25 to 30 mph	20 mph or less
Transition Zone from / to higher speed environment			Appropriate in Specific Circumstances	Appropriate	Not Appropriate	Not Appropriate
Entrance Features (architecture / landscaping / monument)			Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Reduction in number of lanes		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Reduction in width of lanes		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Long Median / Continuous Median		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Short Median / Refuge		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Short Medians on Curves		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Bulb-outs		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Curb and Gutter		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Curbless / Flush Streets		Not Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Flush Medians		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Pedestrian Scale Lighting		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Street Trees		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Building up to the right-of-way		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Lateral Shifts		Not Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Shared Spaces		Appropriate in Specific Circumstances	Appropriate	Appropriate	Appropriate
Cross-Section Measures	Bike Lanes / Protected Bike Lanes / Cycle Tracks		Appropriate	Appropriate	Appropriate in Specific Circumstances	Appropriate in Specific Circumstances
Cross-Section Measures	Textured and/or Colored Paving Materials (parking, lanes, bike lanes, crossings, intersections, general purpose lanes, turn lanes, medians)		Appropriate	Appropriate	Appropriate	Appropriate
Cross-Section Measures	On-street Parking	Parallel	Appropriate in Specific Circumstances	Appropriate	Appropriate	Appropriate
Cross-Section Measures	On-street Parking	Back-in-angled	Appropriate in Specific Circumstances	Appropriate	Appropriate	Appropriate
Cross-Section Measures	On-street Parking	Front-in-angled	Not Appropriate	Not Appropriate	Not Appropriate	Appropriate
Cross-Section Measures	On-street Parking	Right-angle	Not Appropriate	Not Appropriate	Not Appropriate	Appropriate
Cross-Section Measures	On-street Parking	Valley gutters used in conjunction with parking	Appropriate	Appropriate	Appropriate	Appropriate

Legend:

Appropriate	Appropriate in Specific Circumstances	Not Appropriate

Table 3-4: Representative Examples of Traffic Calming Measures and Their Appropriateness on Various Street Categories (cont.)

Street Typology			Boulevards, Parkways and Avenues	Boulevards, Parkways and Avenues	Avenues	Streets, Main Streets and Alleys
Posted / Design / Target / Operating Speed (mph)			35 mph or more	25 to 30 mph	25 to 30 mph	20 mph or less
Periodic Measures	Horizontal Measures	Roundabouts	[yellow]	[green]	[green]	[green]
		Mini Roundabouts	[red]	[green]	[green]	[red]
		Mini Traffic Circles	[red]	[red]	[green]	[green]
		Impellers (T-intersections)	[red]	[red]	[green]	[green]
		Two-lane chicanes	[red]	[red]	[green]	[green]
		One-lane chicanes (yield condition)	[red]	[red]	[green] < 3,000 ADT	[green] < 3,000 ADT
		Short medians	[red]	[red]	[green]	[green]
		Medians on curves	[red]	[red]	[green]	[green]
	Narrowings	Yield Streets	[red]	[red]	[green] < 1,500 ADT	[green] < 1,500 ADT
		Pinch Points	[red]	[red]	[green] < 3,000 ADT	[green] < 3,000 ADT
		Bulb-outs	[green]	[green]	[green]	[green]
	Vertical Measures	Raised Intersections	[yellow]	[yellow]	[green]	[green]
		Raised Crosswalks	[yellow]	[yellow]	[green]	[green]
		Flat-top Speed Humps (speed tables)	[red]	[red]	[green]	[green]
		Speed Cushions	[red]	[red]	[green]	[green]
		Speed Humps	[red]	[red]	[green]	[green]
Not Traffic Calming Measures	Vertical Changes	Rumble Strips (for warning purposes)	[green] In rural areas only	[red]	[red]	[red]
		Speed Bumps	[red]	[red]	[red]	[red]

Note: Many of these measures can be combined in a variety of ways that are too numerous to list in this table.

Legend: [green] Appropriate | [yellow] Appropriate in Specific Circumstances | [red] Not Appropriate

Figure 3-16: Reduction in Lane Widths (Addition of Bus Bulb-Out to the Left of Valley Gutter in Sidewalk)

Seattle, WA. Credit: Mike Packard (SSFM International)

Figure 3-17: Bulb-Out

Waialae Avenue. Credit: Ryan Nakamoto (SSFM International)

Figure 3-18: Short Median on Curve

Kihapai Street. Credit: Mike Packard (SSFM International)

Figure 3-19: Short Median with Refuge

Kaaholo Street. Credit: Mike Packard (SSFM International)

Figure 3-20: Curbless, Flush Street

Seattle, WA. Credit: Mike Packard (SSFM International)

Figure 3-21: Curbless Median

Kainui Drive. Credit: Mike Packard (SSFM International)

Figure 3-22: Tree Canopy

Paki Avenue. Credit: Ryan Nakamoto (SSFM International)

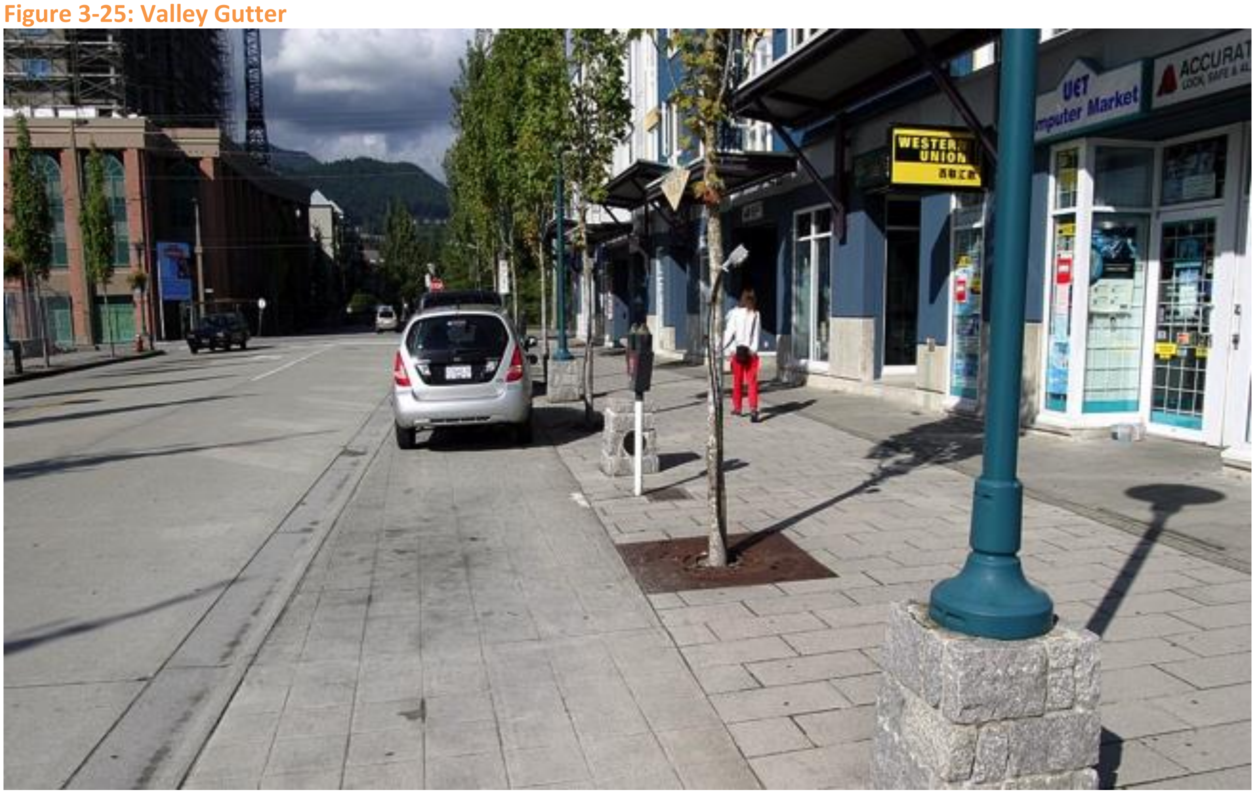
Figure 3-23: Long, Continuous Median

Makakilo Drive. Credit: Mike Packard (SSFM International)

Figure 3-24: Textured Pavement

Kailua Town parking lot. Credit: Mike Packard (SSFM International)

Figure 3-25: Valley Gutter



Coquitlam, British Columbia. Credit: Ian Lockwood (AECOM)

Figure 3-26: Roundabout

Keeaumoku Street at Heulu Street. Credit: Samantha Thomas (Blue Zones)

Figure 3-27: Domed or Mini-Roundabout

Manitou Springs, CO. Credit: Samantha Thomas (Blue Zones)

Figure 3-28: Impeller T-Intersection

West Palm Beach, FL. Credit: Ian Lockwood (AECOM)

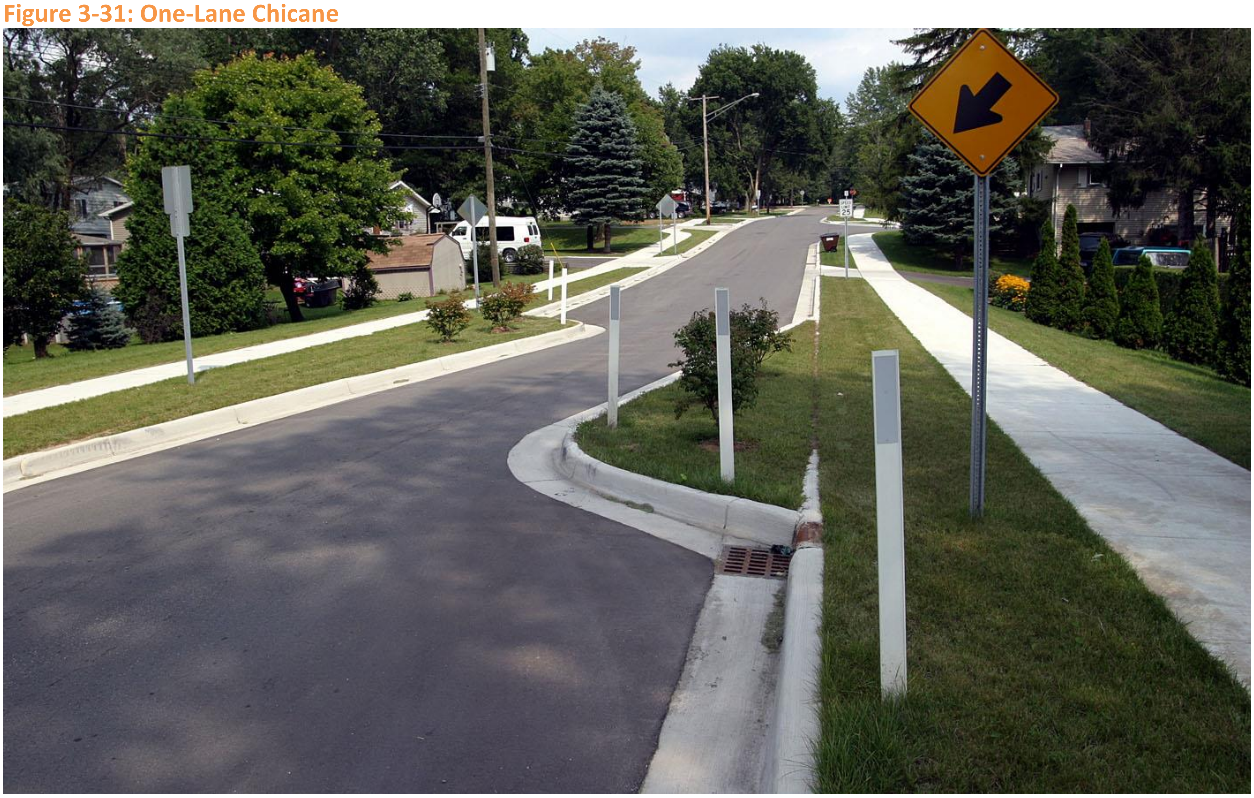
Figure 3-29: Two-Lane Chicane

Kihapai Street. Credit: Juanita Wolfgramm (SSFM International)

Figure 3-30: Traffic Circle with Landscaped Island

Uluhala Street at Ulupuni Street. Credit: Mike Packard (SSFM International)

Figure 3-31: One-Lane Chicane



Credit: Ian Lockwood (AECOM)

Figure 3-32: Short Median

Kuahaka Street. Credit: Mike Packard (SSFM International)

Figure 3-33: Raised Intersection

Orenco, OR. Credit: Mike Packard (SSFM International)

Figure 3-34: Raised Crosswalk

Queen Street. Credit: Mike Packard (SSFM International)

Figure 3-35: Speed Cushion

West Palm Beach, FL. Credit: Ian Lockwood (AECOM)

Figure 3-36: Oval Median

Kaaholo Street. Credit: Mike Packard (SSFM International)

Figure 3-37: Yield Street

Kahakea Street. Credit: Juanita Wolfgramm (SSFM International)

Figure 3-38: Zig-Zag Striping

Royal Poinciana Road in Kailua-Kona, HI. Credit: Mike Packard (SSFM International)

Figure 3-39: Mid-Block Curb Extension with Bioswale

Portland, OR. Credit: Brad Lancaster (HarvestingRainwater)

3.12. Reconfigured Cross Sections of Existing Streets

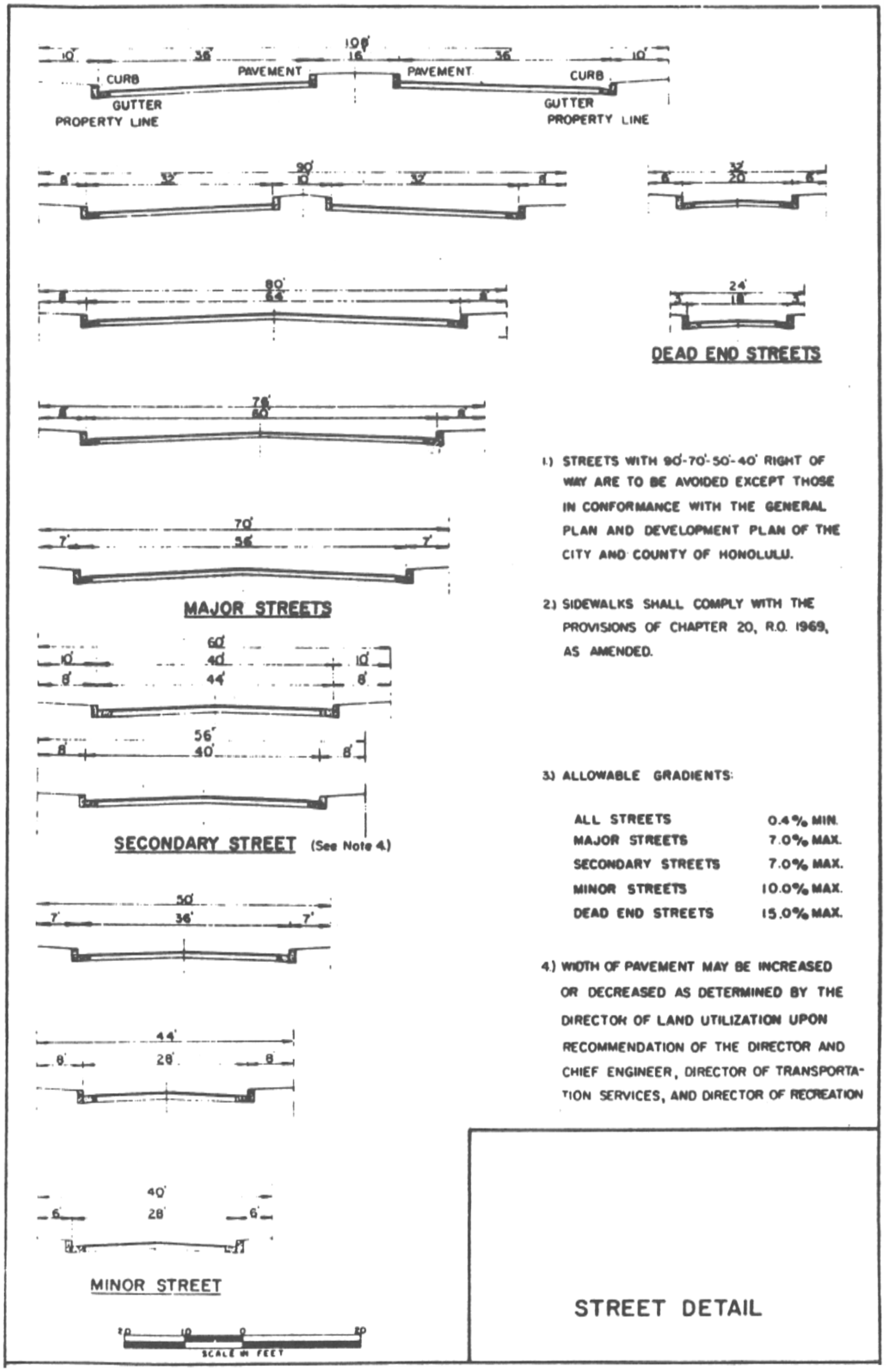
In built out places, curb-to-curb widths are set, buildings exist, and it is difficult or impractical to widen these streets. Existing streets can be reconfigured by reassigning space to make cross-sections more closely meet the principles of complete streets. In these cases, complete streets principles can be provided along with the minimum and recommended widths given in this manual.

The following diagrams show examples of how some of these apply using the existing road right-of-way (ROW) from the *Subdivision Rules and Regulations* (DPP, 1973) shown in Figure 3-41 and the *Subdivision Street Standards* (DPP, 2001) shown in Figure 3-42. Much of this can be accomplished within the existing travel way through use of pavement marking as demonstrated in Figure 3-40. Cross-sections have been separated by roadway/street type and ROW accounting for existing median and sidewalk widths.

Figure 3-40: Reconfigured Cross Section with Bike Lanes and On-Street Parking

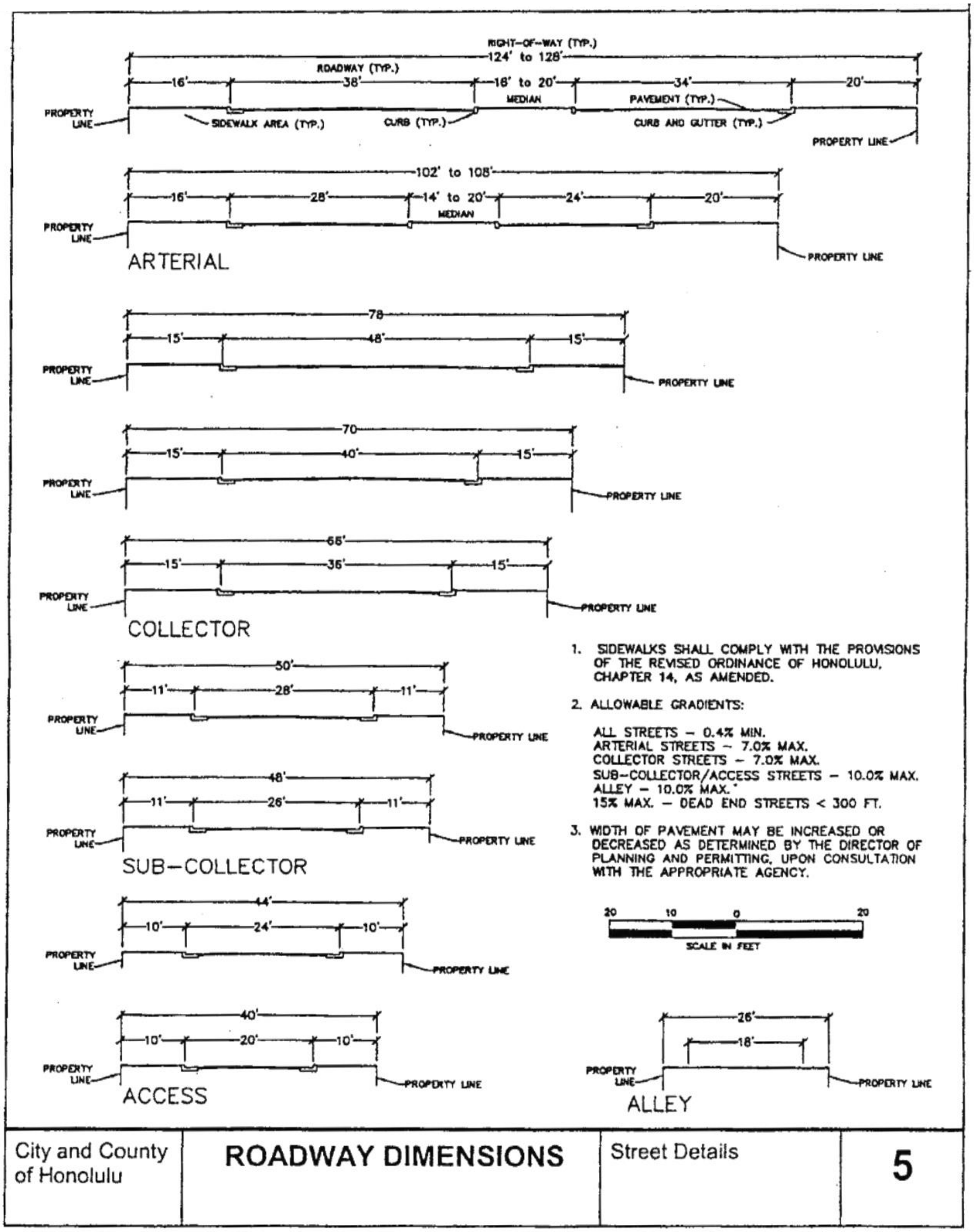
Keolu Drive. Credit: Mike Packard (SSFM International)

Figure 3-41: 1973 *Subdivision Rules and Regulations* Street Cross-Section



Source: Subdivision Rules and Regulations (DPP, 1973)

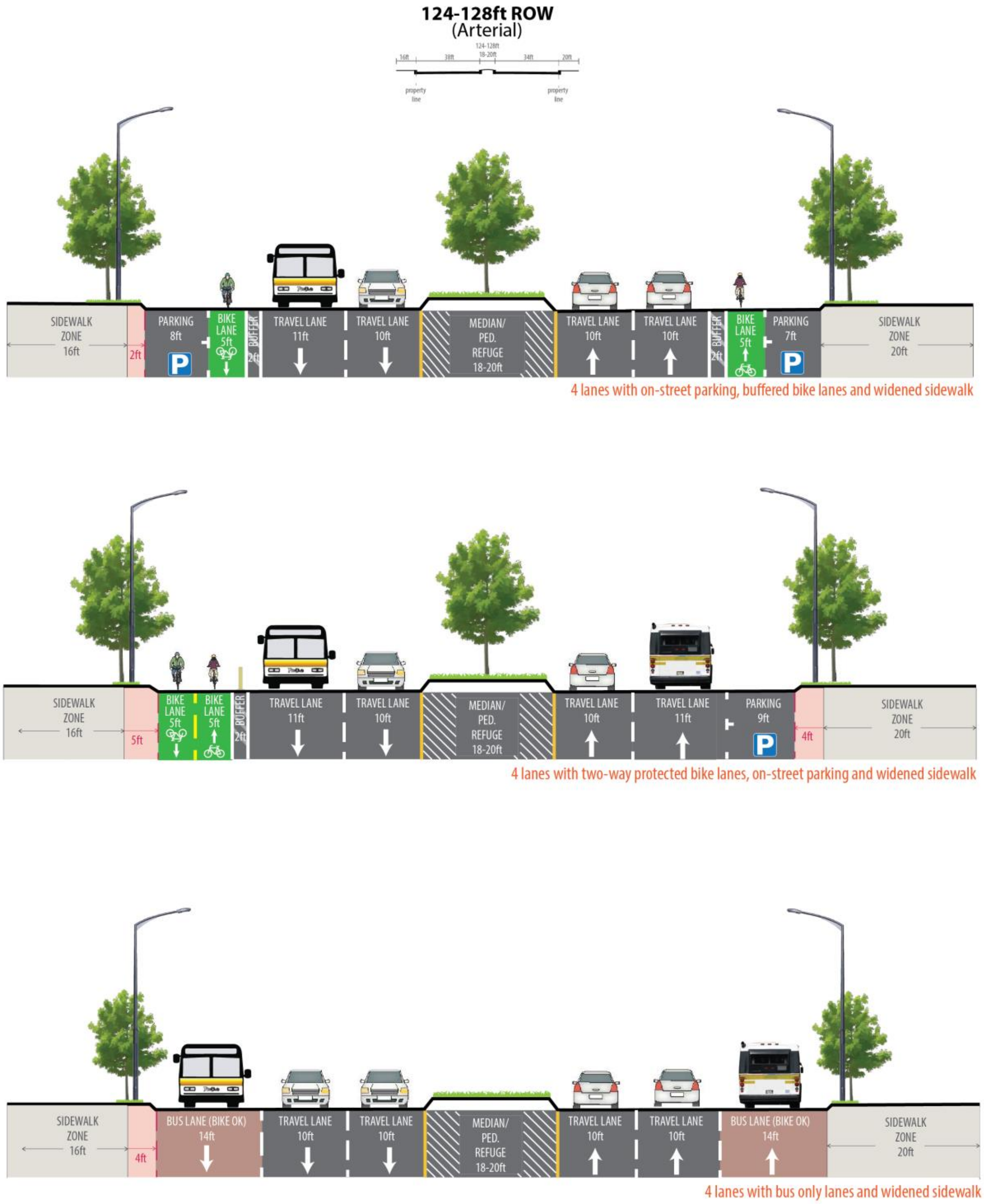
Figure 3-42: 2000 *Subdivision Street Standards* Cross-Sections



Source: Subdivision Street Standards (DPP, 2001)

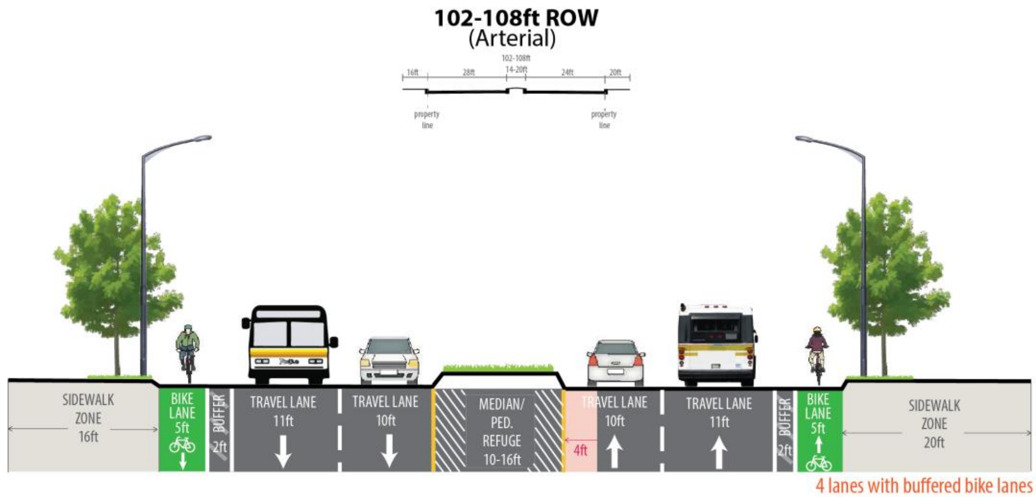
3.12.1.Arterial Roadway

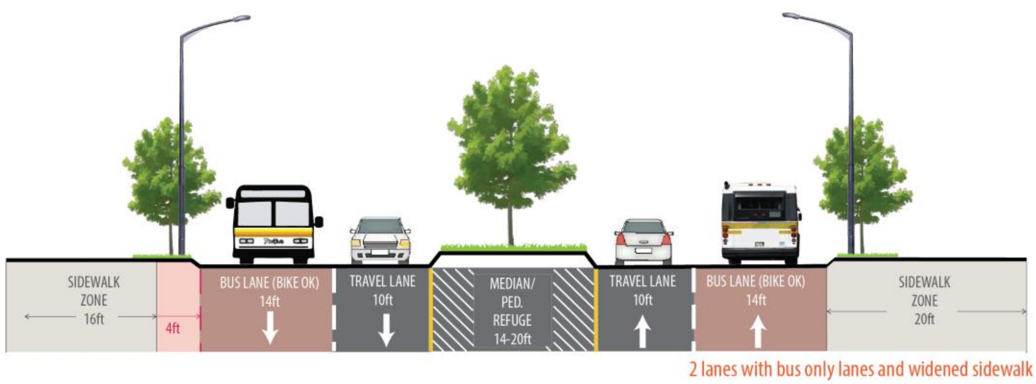
Figure 3-43: 124 to 128 Foot ROW with 18 to 20 Foot Median and 16 to 20 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

Figure 3-44: 102 to 108 Foot ROW with 14 to 20 Foot Median and 16 to 20 Foot Sidewalk

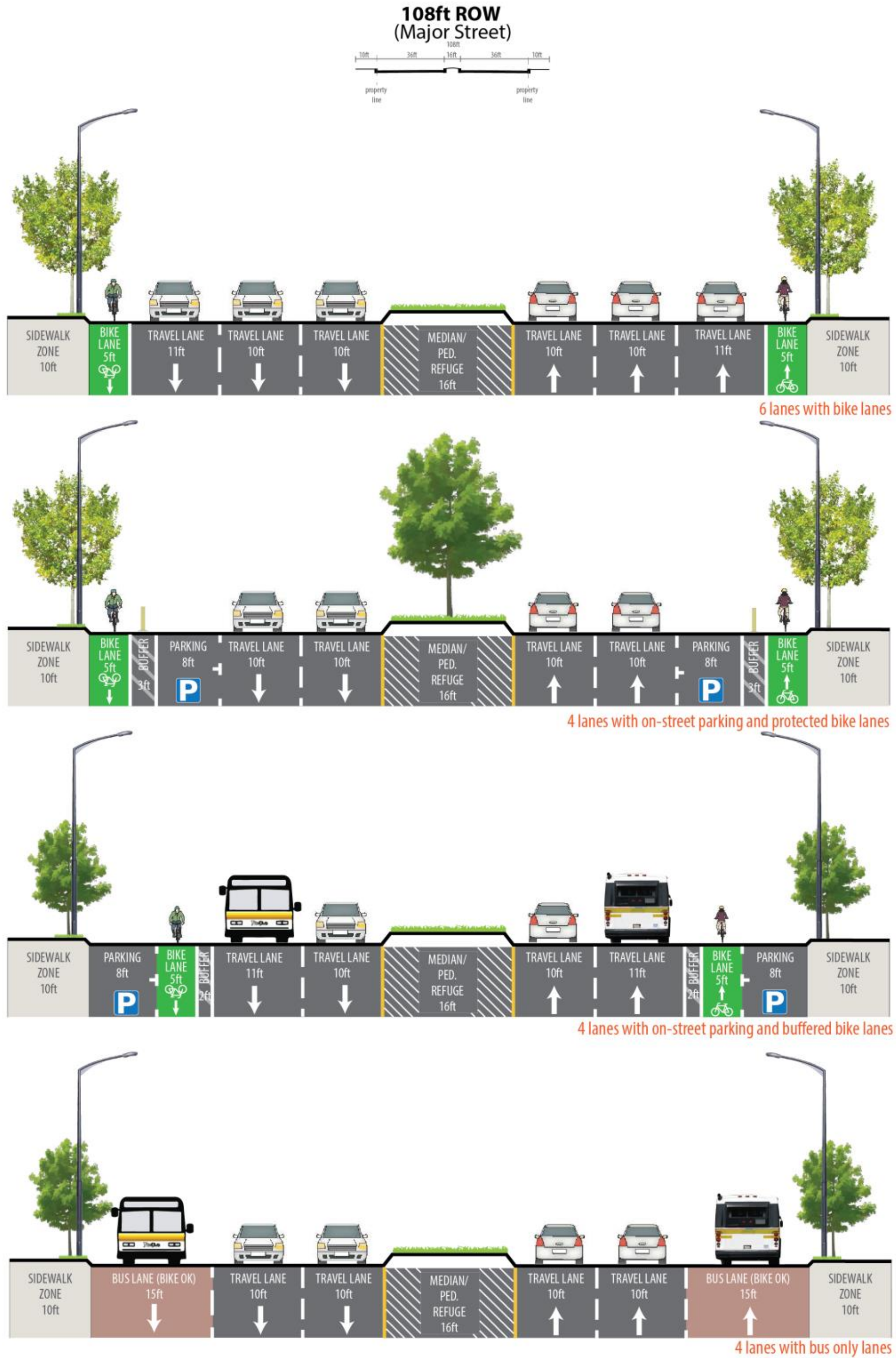




Credit: Lulu Feng (SSFM International)

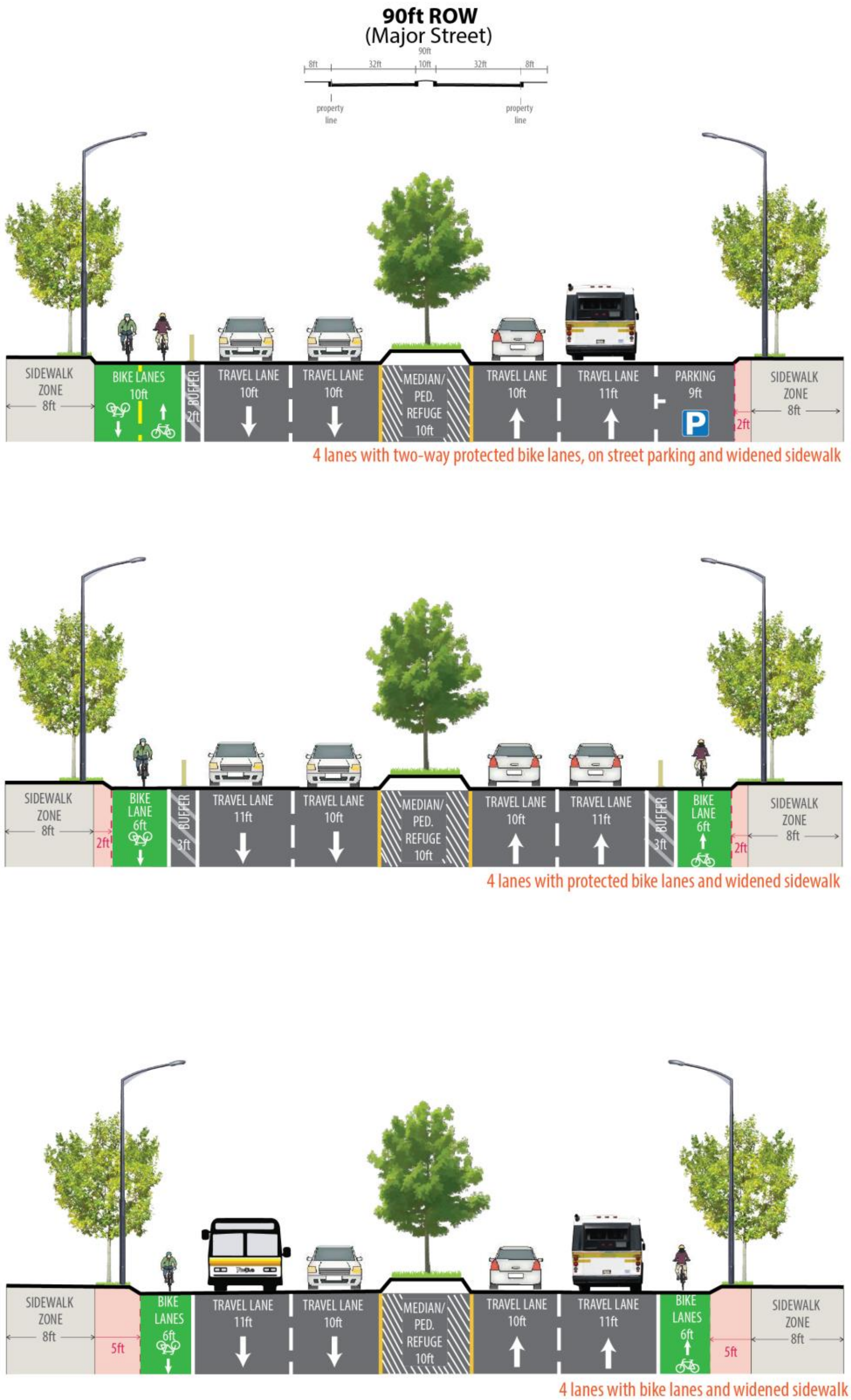
3.12.2. Major Street

Figure 3-45: 108 Foot ROW with 16 Foot Median and 10 Foot Sidewalk



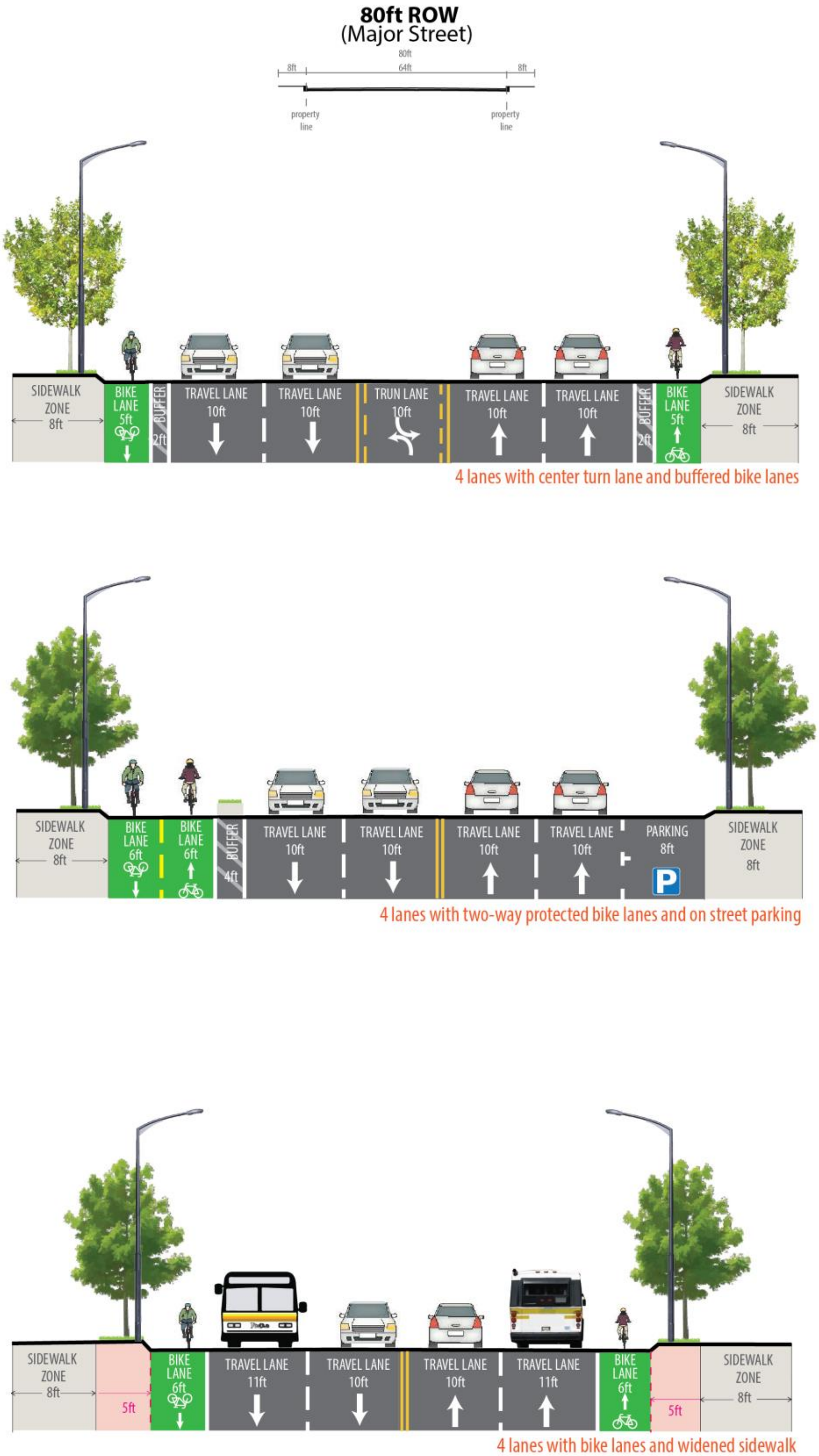
Credit: Lulu Feng (SSFM International)

Figure 3-46: 90 Foot ROW with 10 Foot Median and 8 Foot Sidewalk



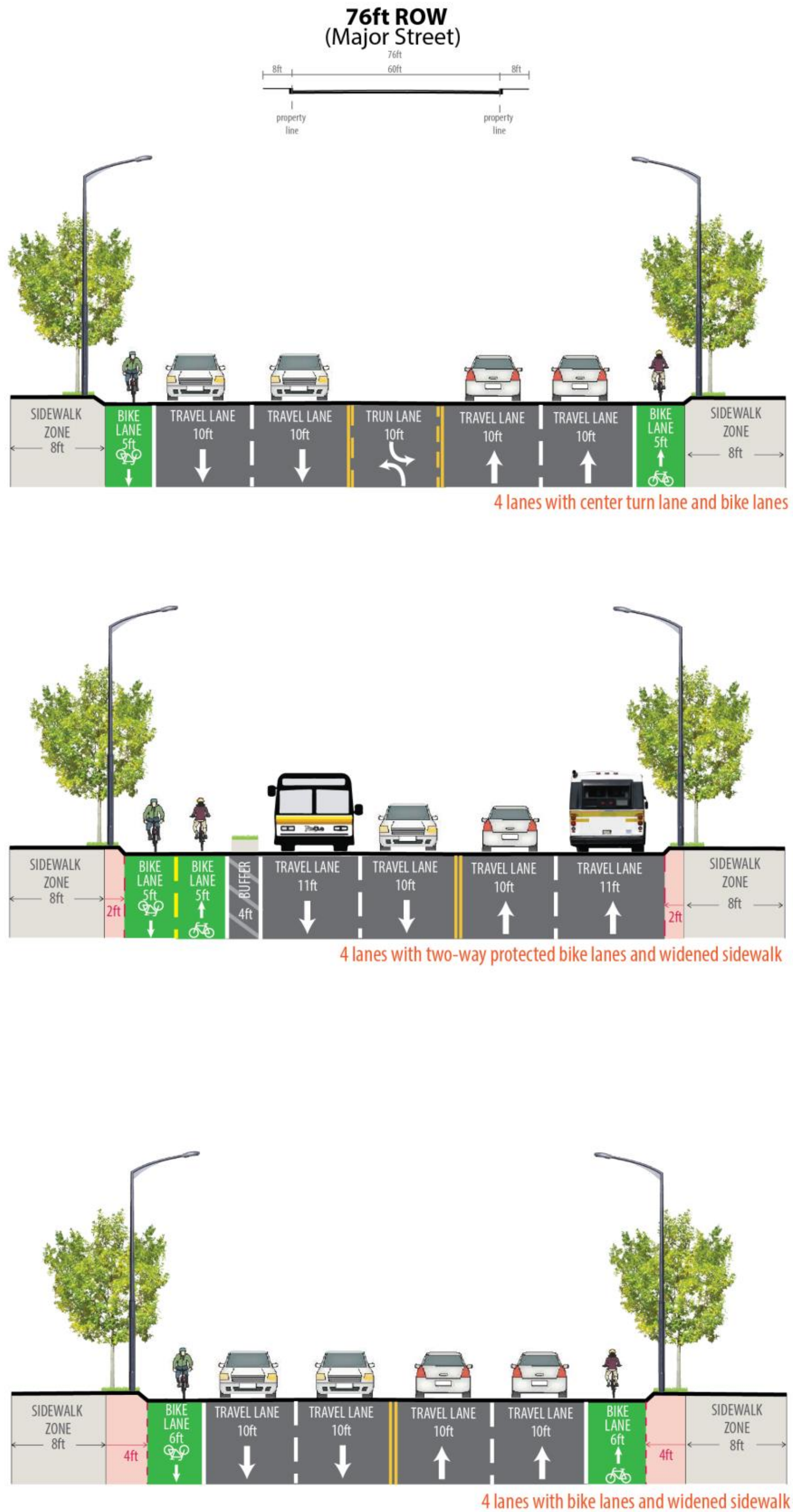
Credit: Lulu Feng (SSFM International)

Figure 3-47: 80 Foot ROW with 8 Foot Sidewalk



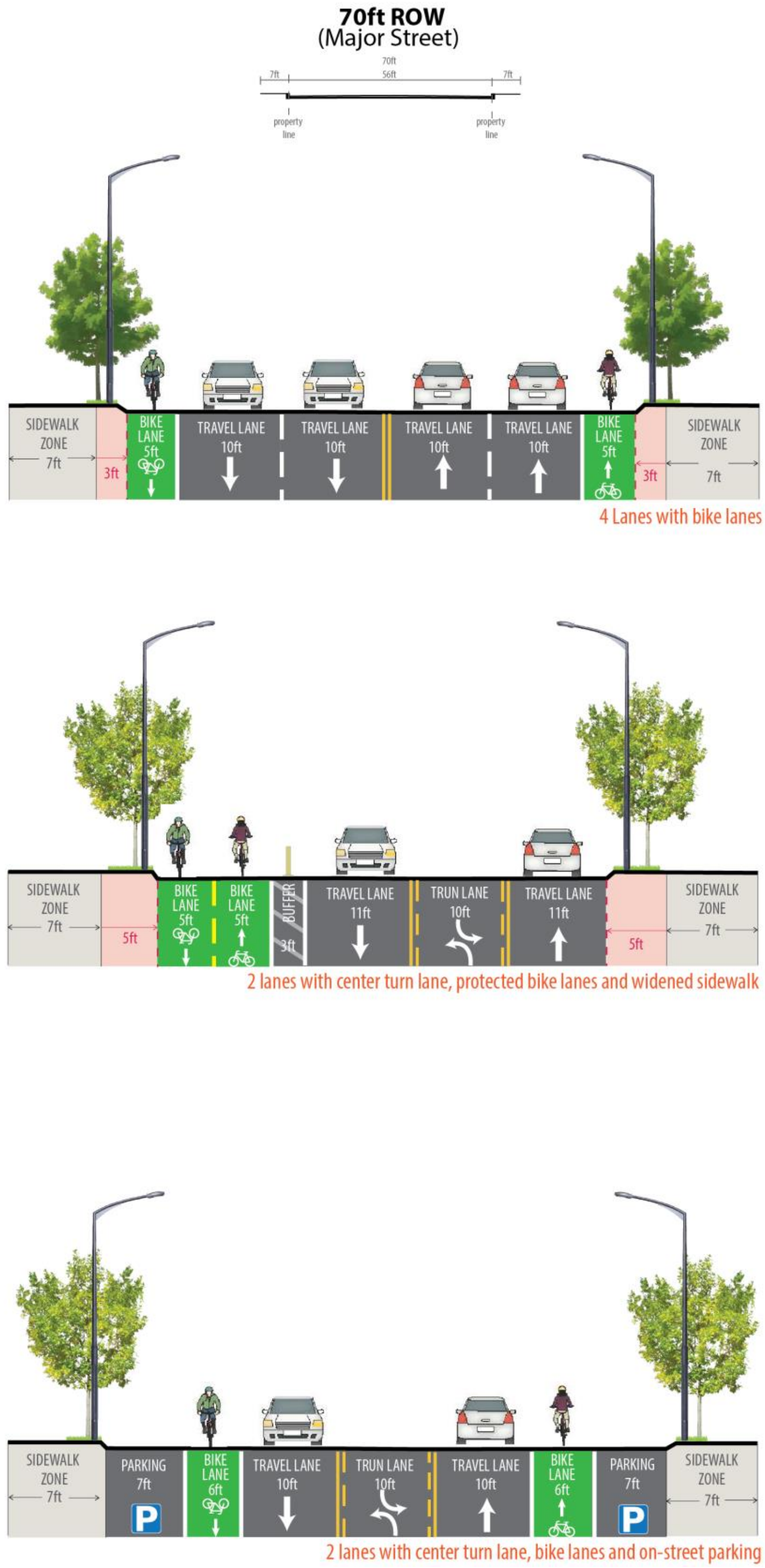
Credit: Lulu Feng (SSFM International)

Figure 3-48: 76 Foot ROW with 8 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

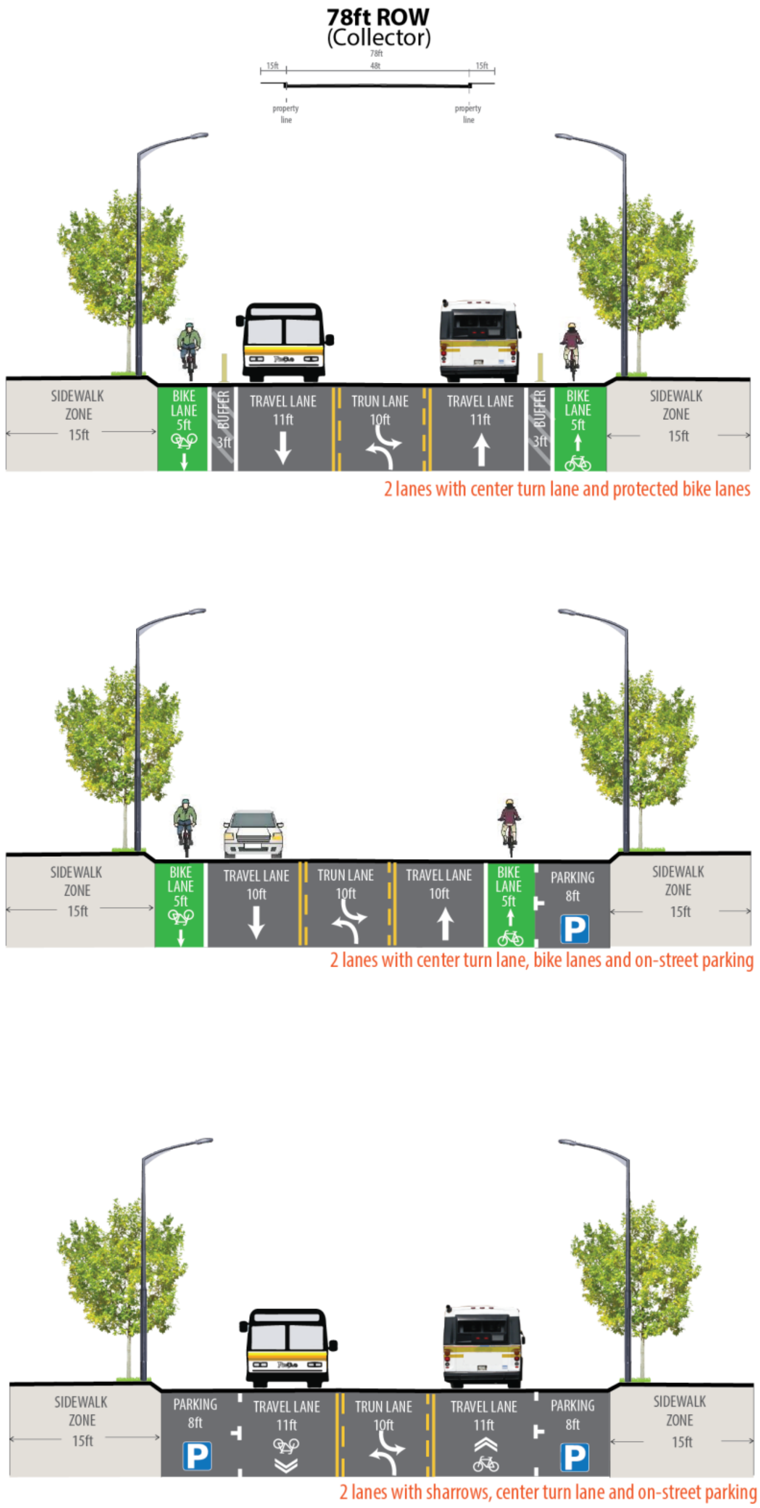
Figure 3-49: 70 Foot ROW with 7 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

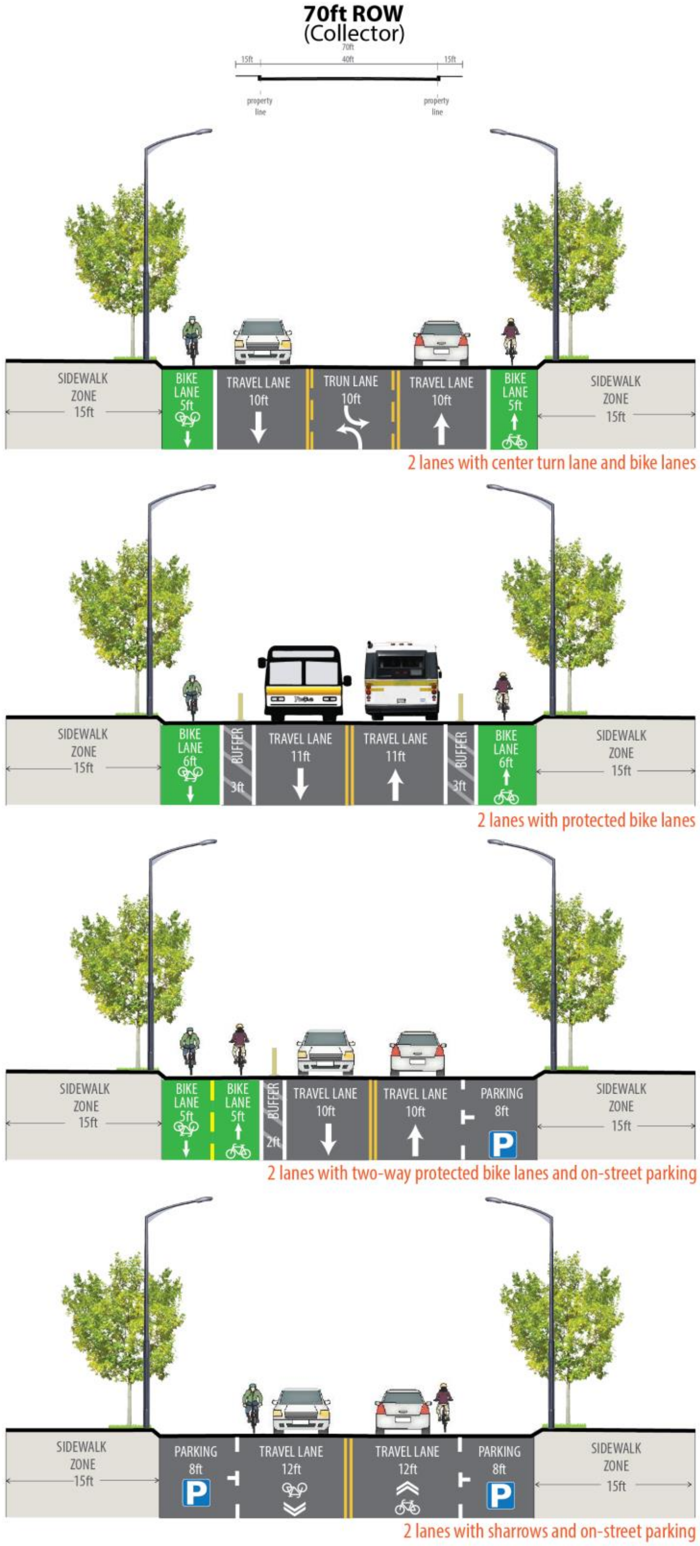
3.12.3. Collector Roadway

Figure 3-50: 78 Foot ROW with 15 Foot Sidewalk



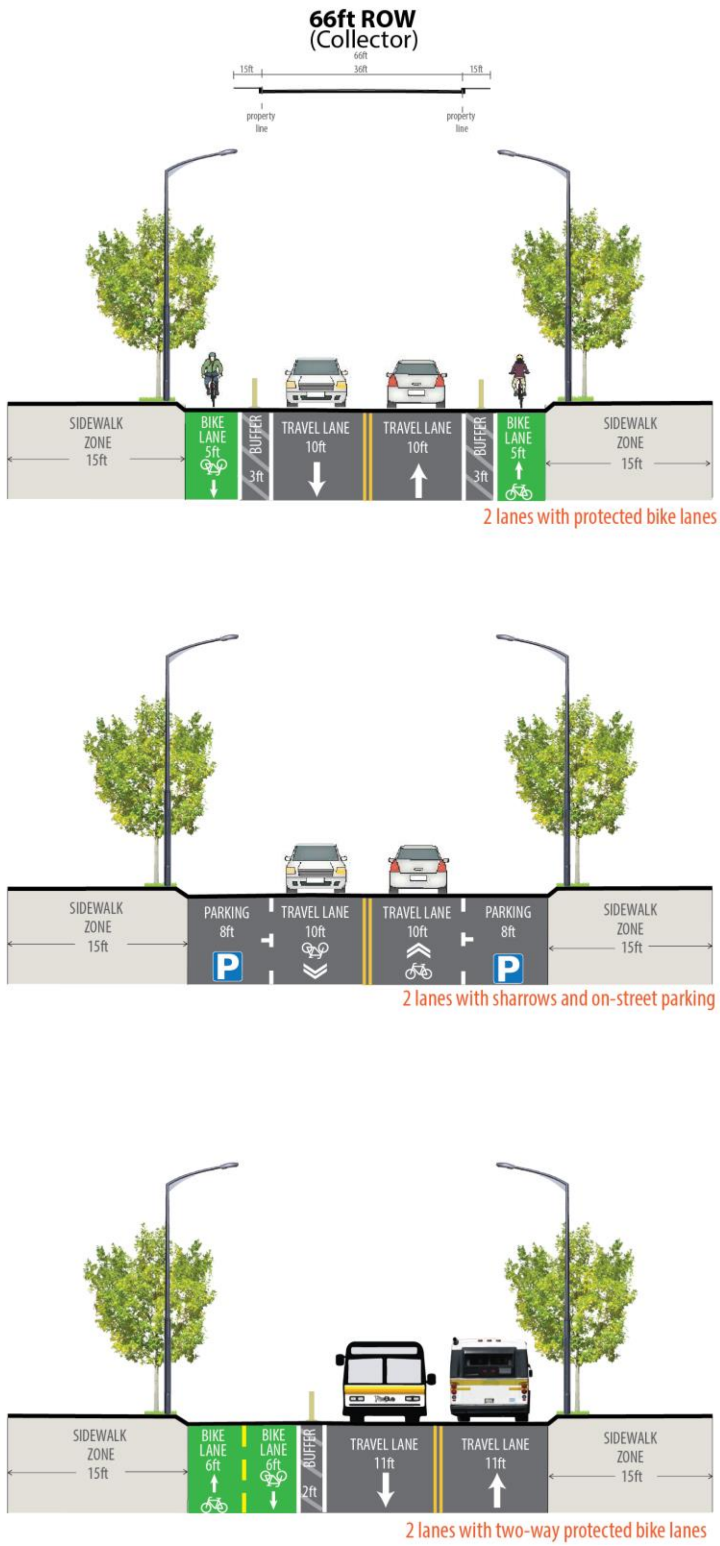
Credit: Lulu Feng (SSFM International)

Figure 3-51: 70 Foot ROW with 15 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

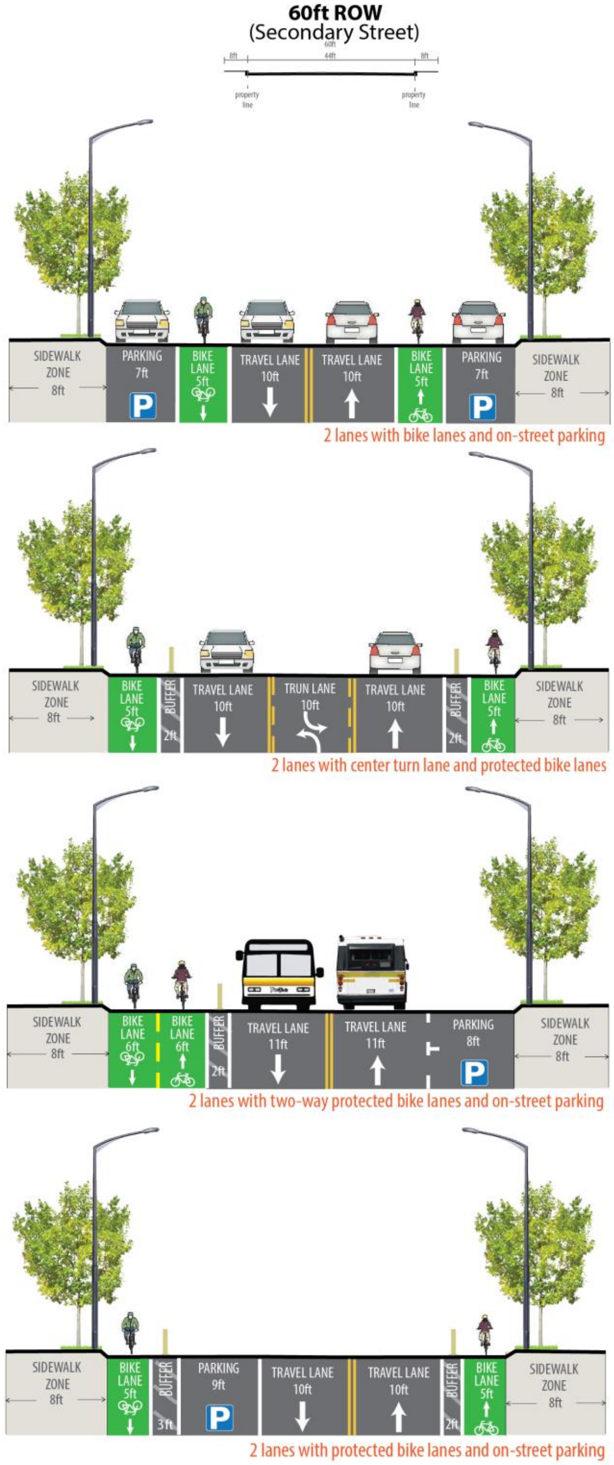
Figure 3-52: 66 Foot ROW with 15 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

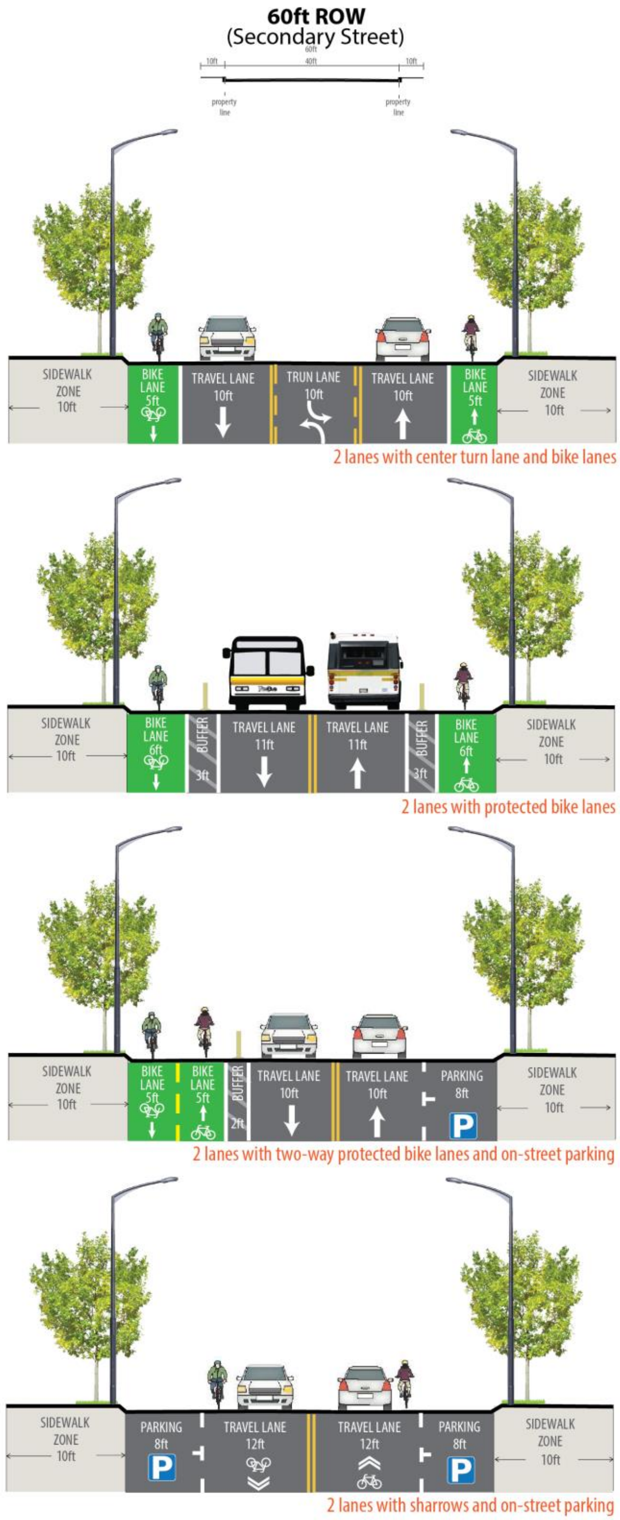
3.12.4. Secondary Streets

Figure 3-53: 60 Foot ROW with 8 Foot Sidewalk



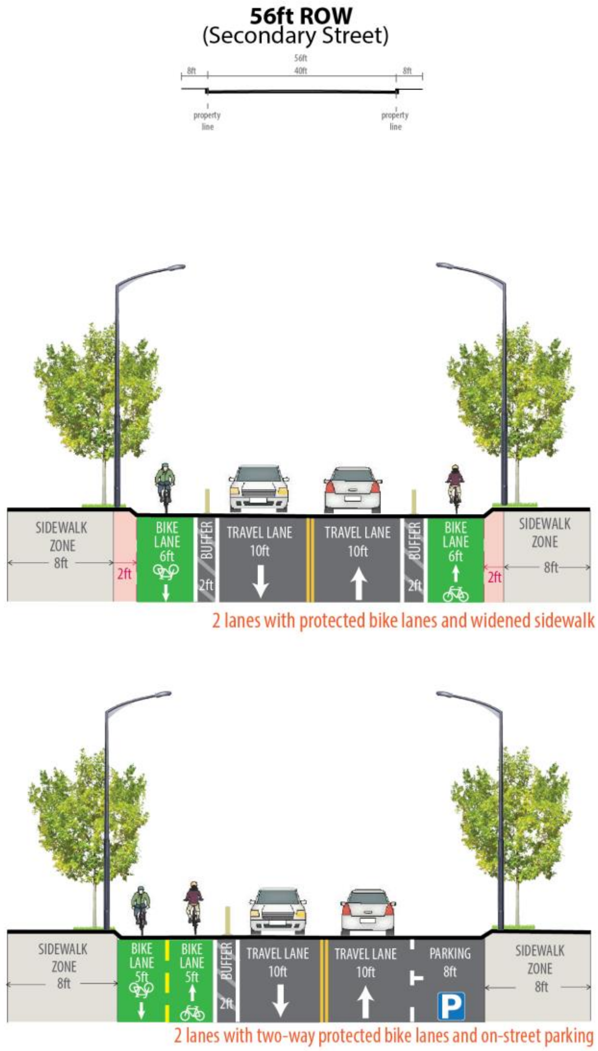
Credit: Lulu Feng (SSFM International)

Figure 3-54: 60 Foot ROW with 10 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

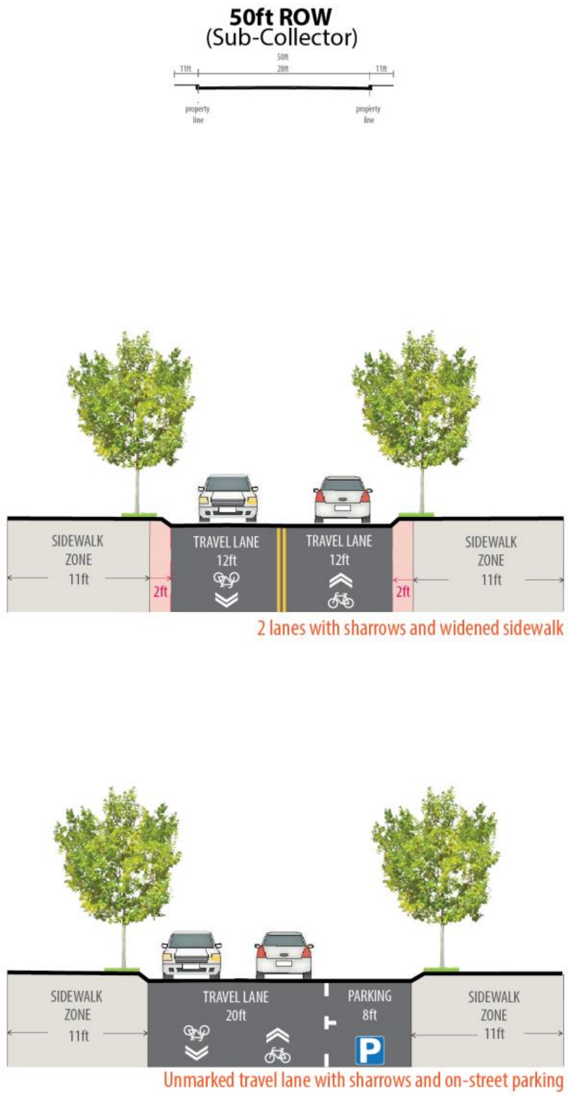
Figure 3-55: 56 Foot ROW with 8 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

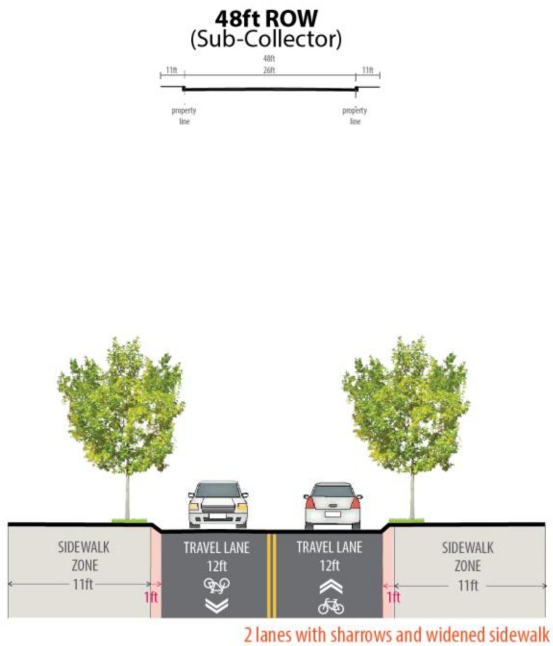
3.12.5. Sub-Collector Roadway

Figure 3-56: 50 Foot ROW with 11 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

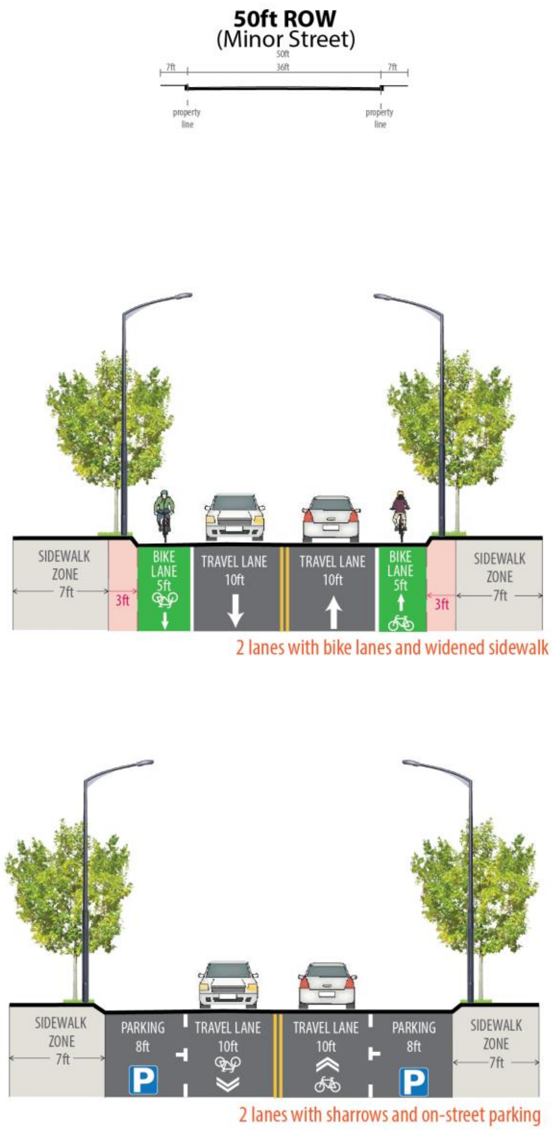
Figure 3-57: 48 Foot ROW with 11 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

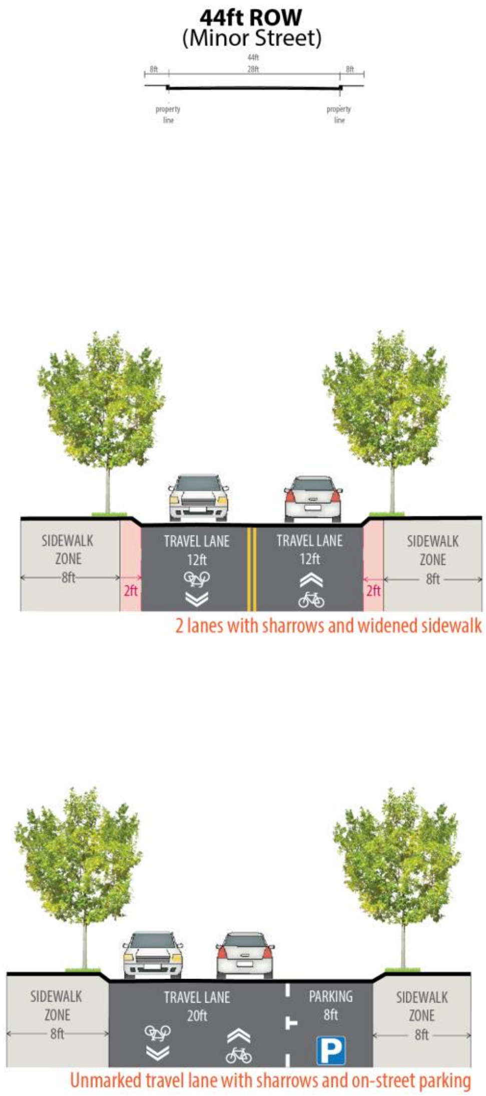
3.12.6. Minor Streets

Figure 3-58: 50 Foot ROW with 7 Foot Sidewalk



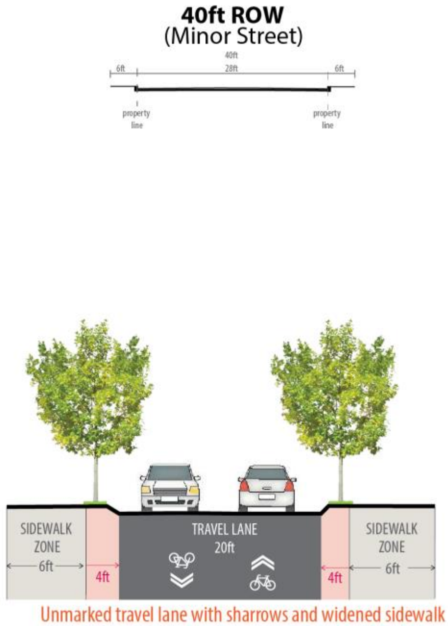
Credit: Lulu Feng (SSFM International)

Figure 3-59: 44 Foot ROW with 8 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

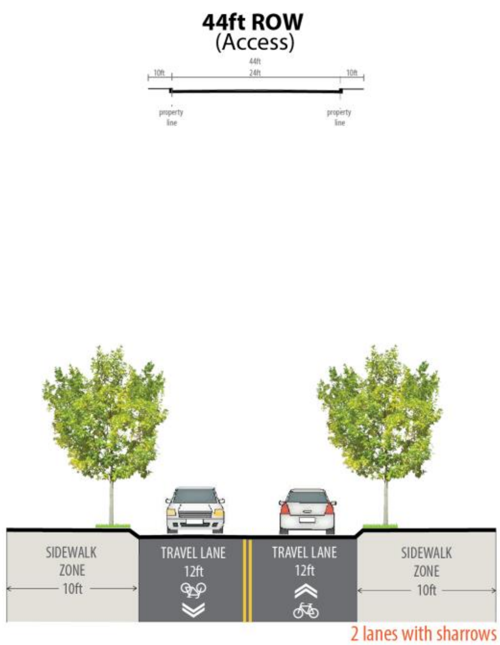
Figure 3-60: 40 Foot ROW with 6 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

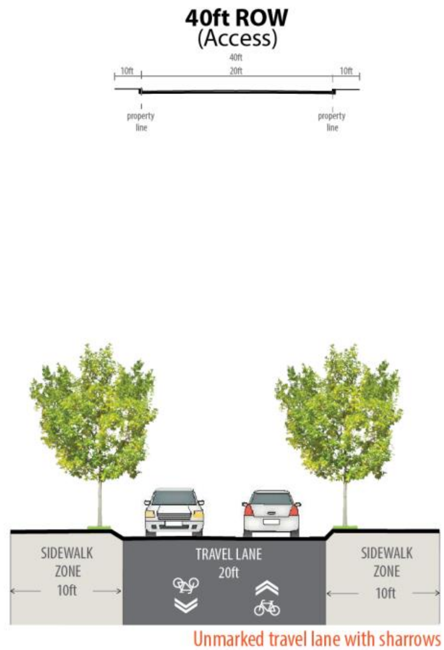
3.12.7. Access Roadway

Figure 3-61: 44 Foot ROW with 10 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

Figure 3-62: 40 Foot ROW with 10 Foot Sidewalk



Credit: Lulu Feng (SSFM International)

3.13. Alleys

An alley is a narrow street, often without sidewalks, that connect streets and can provide access to the backs of buildings and garages. Some are service alleys for deliveries and refuse collection.

3.14. Dead-End Streets

Dead-end streets are typically discouraged due to the fact that they restrict connectivity. Where needed due to existing constraints, design of the cul-de-sac or turnaround should follow the guidelines from the *Green Book* (AASHTO, 2011). If possible, pedestrian and bicycle access should be maintained through a path at the end of the cul-de-sac.

3.15. Driveways

The width, spacing, number, and location of driveways impact urban design and safety for all travel way users. Driveways act as intersections, which introduces conflicts with other uses. Therefore, the need for access to adjacent properties needs to be balanced with the impacts to people on foot, people on bicycles, and through-traveling vehicles. Driveways also reduce the availability of on-street parking. Therefore, depending on the travel way context, care should be taken to limit the number of driveway curb cuts to residential and commercial properties.

3.16. Stopping Sight Distance

The *Green Book* (AASHTO, 2011) provides appropriate values for designing stopping sight distance for complete streets. The *Guide for Achieving Flexibility in Highway Design* (AASHTO, 2004) is based on the latest research concerning the establishment of stopping sight distance. The document states that the established values for stopping sight distance are very conservative and provide adequate flexibility without creating increased crash risk. Consequently, appropriate design speed selection is critical to avoid overly negative impacts such as unnecessarily limiting on-street parking and vegetation.

3.17. Horizontal and Vertical Alignment

Design of travel way horizontal and vertical alignment should use the appropriate design speed and reference the *Green Book* (AASHTO, 2011) or the latest national guideline.

3.18. Minimum Centerline Radius

Based on the maximum allowable side friction factors (*f*), Table 3-5 from the *Green Book* (AASHTO, 2011), provides the minimum centerline radius based on a maximum superelevation (*e*) rate of 8.0%.

Table 3-5: Minimum Centerline Radius

Design Speed (mph)	Maxi-mum *e* (%)	Maxi-mum *f*	Total (*e*/100 + *f*)	Calcu-lated Radius (ft)	Rounded Radius (ft)
15	8.0	0.32	0.40	37.5	38
20	8.0	0.27	0.35	76.2	76
25	8.0	0.23	0.31	134.4	134
30	8.0	0.20	0.28	214.3	214
35	8.0	0.18	0.26	314.1	314
40	8.0	0.16	0.24	444.4	444
45	8.0	0.15	0.23	587.0	587

Source: Green Book (AASHTO, 2011)

3.19. Pavement Transition

Design of travel way pavement transition marking should use the appropriate posted speed and reference the *MUTCD* (FHWA, 2009) or the latest national guideline.

3.20. Travel Way Signage

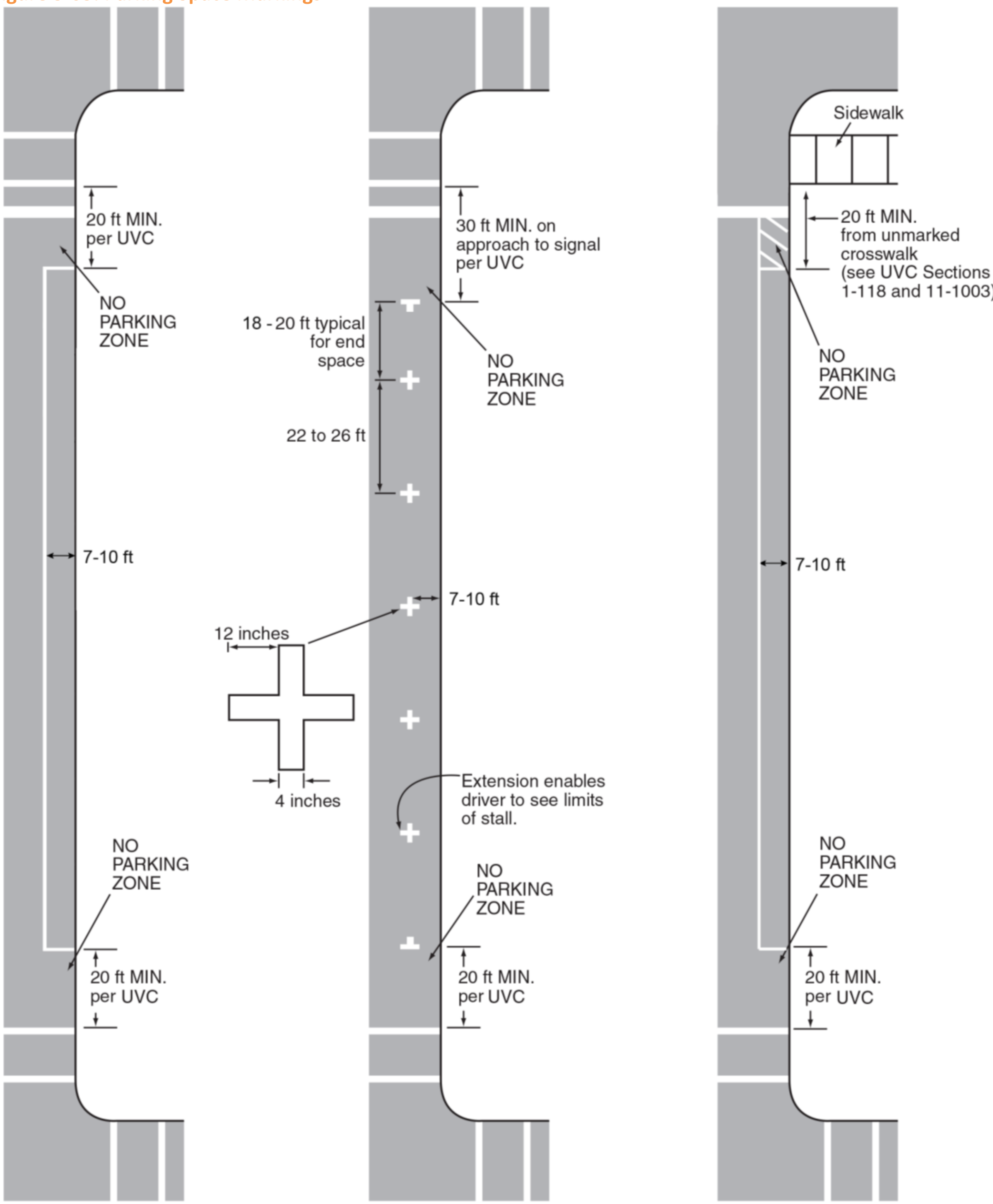
Design of travel way signage should use the appropriate target speed and reference the *MUTCD* (FHWA, 2009) or the latest national guideline.

3.21. Travel Way Markings

Design of travel way markings, including raised pavement markers, should use the appropriate target speed and reference the *MUTCD* (FHWA, 2009) or the latest national guideline.

Examples of possible parking space markings are provided in Figure 3-63.

Figure 3-63: Parking Space Markings



Credit: Lulu Feng (SSFM International)

3.22. Travel Way Lighting

Street lighting should facilitate the safe movement of people on foot, people on bicycles, and motor vehicles. People on foot are disproportionately hit by vehicles when visibility is poor: at dusk, night, and dawn. Lighting is also viewed as a crime deterrent and can encourage more citizens to travel on foot or on bicycle.

FHWA-HRT-08-053, *Informational Report on Lighting Design for Midblock Crosswalks* contains information about lighting design for people on foot at intersections. This is discussed in Chapter 5.3.9.

Illuminating Engineering Society of North America (IESNA), *Roadway Lighting, RP-8-14* contains design criteria for street lighting. Pedestrian scale (mounted at a lower height) lighting along sidewalks provides greater security, especially for people walking or bicycling alone at night. This is discussed in Chapter 7.9.

Transit stops require both travel way and pedestrian lighting: strong illumination of the travel way for safer street crossing, and pedestrian scale illumination at the stop or shelter for security.

If bus stops are present between travel way sections, it is necessary to illuminate the travel way and the bus stop. The lighting at the bus stop is essential to provide safety for transit users. Bus stops have high pedestrian activity; therefore, it is necessary to provide adequate lighting at these facilities.

Figure 3-64: Travel Way Lighting Example

Cooke Street Before Hele on Kakaako Event. Credit: Mike Packard (SSFM International)

3.23. Air Rights

Research and practice have shown that air rights development over street corridors is not only feasible but desirable. Development of the air space over urban street corridors can promote sustainable urban revitalization while also providing an opportunity for grade separated travel ways that reduce at-grade conflicts with other transportation modes. Examples of this type of infrastructure include the *Honolulu Rail Transit*.

As noted in *Creating Sustainable Air Rights Development Over Highway Corridors: Lessons From the Massachusetts Turnpike in Boston* (Campbell, 2004), air rights development is complex and requires special scrutiny and treatment from a planning and policy perspective, a distinct understanding of urban design and attention to neighborhood context, and specific development principles for construction and financial feasibility.

Figure 3-65: Development of the Air Space Provides Opportunity for Grade Separated Travel Ways

Portland, OR. Credit: Mike Packard (SSFM International)

Figure 3-66: Grade Separated Multimodal Travel Ways Reduce At Grade Conflicts

Seattle, WA Credit: Mike Packard (SSFM International)

CHAPTER 4: INTERSECTION DESIGN

Table of Contents

Chapter 4 Cover Image: Keeaumoku Street and Heulu Street. Credit: Samantha Thomas (Blue Zones)

CHAPTER 4: INTERSECTION DESIGN

4.1. Introduction

Most conflicts between travel way users occur at intersections, where travelers cross each other's path. Therefore, good intersection design should indicate to those approaching the intersection what they must do and who has to yield. Places where speeds are low (typically less than 20 mph), or where a shared space design causes users to approach intersections with caution, do not require traffic control devices. Vehicle conflicts with people on foot or on bike are of a heightened concern due to their greater vulnerability, lesser size, and variable visibility to other users.

The following principles apply to all users of intersections:

- Free-flowing movements should be avoided.
- Intersections should be designed as compact as possible while accommodating buses and emergency response vehicles.
- Unexpected conflicts should be avoided.
- Simple right-angle intersections are best for all users since many intersection problems are worsened at skewed and multi-legged intersections.
- Access management practices should be used to remove additional vehicular conflict points near the intersection.
- Signal timing should consider the safety and convenience of all users.
- Intersection designs should integrate geographic constraints.
- Special consideration should be given in areas where there are large populations of the elderly and children.
- Design should encourage proper travel behavior by all users.
- Intersections should be designed with high legibility and clarity.

Figure 4-1: High Conflict Intersection

Kapiolani Boulevard at Keeaumoku Street. Credit: Mike Packard (SSFM International)

4.2. Skewed Intersections

Skewed intersections are generally undesirable and introduce the following complications for all users:

- The travel distance across the intersection is greater, which increases exposure to conflicts and lengthens signal phases for people on foot and in vehicles;
- Skews require users to crane their necks to see other approaching users, making it less likely that all users will be seen; and,
- Obtuse angles encourage speeding around corners.

To alleviate the problems with skewed intersections, several options are available:

- Every reasonable effort should be made to design or redesign the intersection closer to a right angle. Some right-of-way may have to be purchased, but this can be offset by the larger area no longer needed for the intersection, which can be sold back to adjoining property owners or repurposed for a pocket park, rain garden, greenery, etc.
- Pedestrian refuges should be provided if the crossing distance exceeds approximately 40 feet.
- General use travel lanes and bike lanes may be marked with dashes to guide people on bicycles and motorists through a long undefined area.
- Channelize travel to maximize predictability and create space for pedestrian islands.

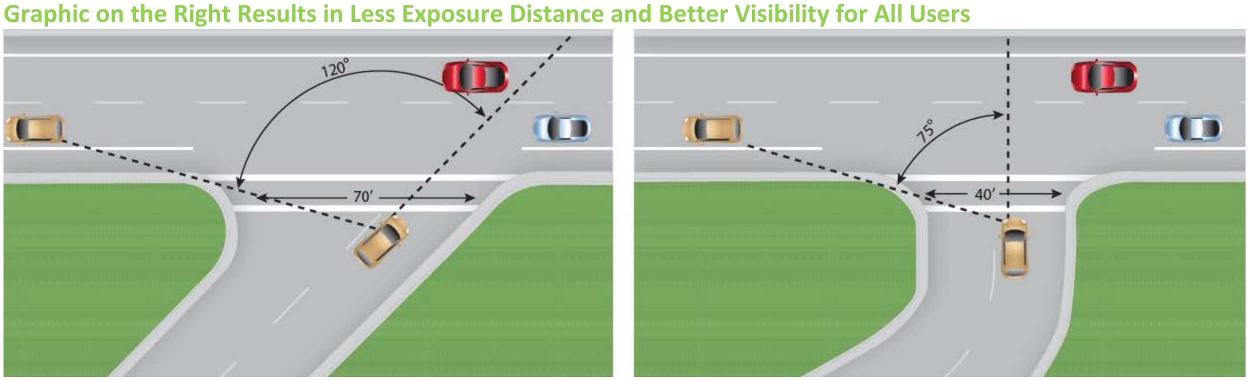
Figure 4-2: Skewed Intersection

Oahu Avenue at Alaula Way. Credit: Mike Packard (SSFM International)

Figure 4-4: Realigned Intersection

Glen Avenue and Royal Palm Road. Credit: Ryan Nakamoto (SSFM International)

Figure 4-3: Realigning the Skewed Intersection in the Graphic on the Left to the Right-Angle Connection in the Graphic on the Right Results in Less Exposure Distance and Better Visibility for All Users



Credit: Michele Weisbart (Michele Designs)

4.3. Multi-Leg Intersections

Multi-leg intersections (more than four legs) are generally undesirable and introduce the following complications for all users:

- Multiple conflict points are added as users arrive from several directions;
- Users may have difficulty assessing all approaches to identify all possible conflicts;
- At least one leg will be skewed; and,
- Users must cross more lanes of traffic and the total travel distance across the intersection is increased.

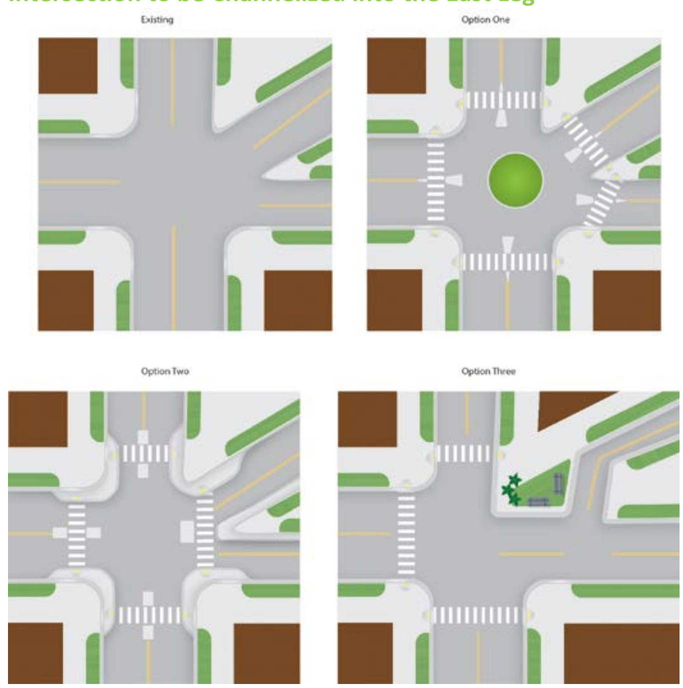
Figure 4-5: Five Leg Intersection

Oahu Avenue, Manoa Road and Lowrey Avenue. Credit Noah Baron (SSFM International)

To alleviate the problems with multi-leg intersections, several options are available:

- Roundabouts should be considered before other treatments, as they are a proven safety countermeasure. However, mini-circles may not be appropriate as they don't provide the same protection for crossing pedestrians.
- Redesign the intersection so there are no more than four legs. This is accomplished by removing one or more legs from the major intersection and creating a minor intersection further up or downstream.
- As an alternative, one or more of the approach roads can be closed to motor vehicle traffic, while still allowing access for people on foot or people on bicycles.
- Pedestrian refuges should be created if the crossing distance exceeds approximately 40 feet.
- General use travel lanes and bike lanes may be marked with dashes to guide people on bicycles and motorists through a long undefined area.

Figure 4-6: Options for Multi-Leg Intersections: Option One Shows a Roundabout with Splitter Islands Added, Option Two Shows Pedestrian Crossing Islands and Curb Extensions Added, and Option Three Shows Elimination of a Leg in the Intersection to be Channelized into the East Leg



Credit: Michele Weisbart (Michele Designs)

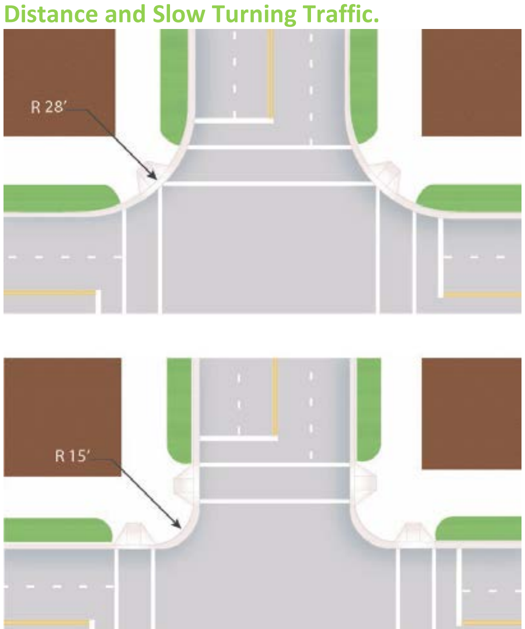
4.4. Corner Radii

An intersection's corner radius has a significant impact on the comfort and safety of non-motorized users. Small corner radii provide the following benefits:

- Smaller, more pedestrian-scale intersections resulting in shorter crossing distances;
- Slower vehicular turning speeds;
- Better geometry for installing perpendicular ramps for both crosswalks at each corner; and,
- Simpler, more appropriate crosswalk placement in line with the approaching sidewalks.

Therefore, the smallest feasible corner radii should be selected for intersection designs.

Figure 4-7: Tighter Corner Radii Reduce Crossing Distance and Slow Turning Traffic.

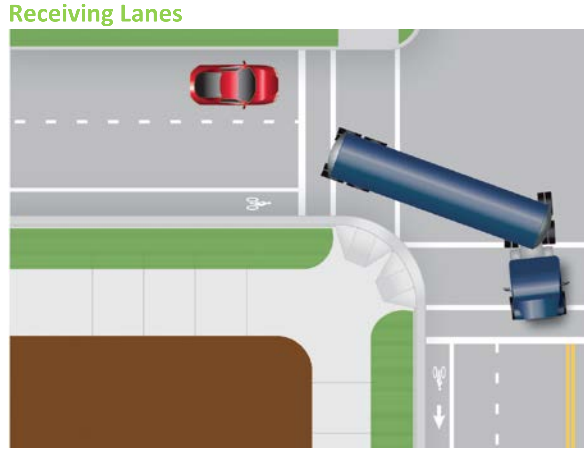


Credit: Michele Weisbart (Michele Designs)

When designing corner radii for complete streets, the default design vehicle should be the refuse truck which can be modeled through use of a single-unit truck. Larger design vehicles should be used only 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 bike lanes and on-street parking have on the effective radius, increasing the ease with which large vehicles can turn.

Encroachment by large vehicles is acceptable onto multiple receiving lanes. When using a design vehicle larger than the refuse truck, the vehicle should be allowed to turn into all available receiving lanes. As described in Chapter 3, larger, infrequent vehicles (the design vehicle) can be allowed to encroach on multiple departure lanes and part way into opposing traffic lanes.

Figure 4-8: Corner Radii can be Kept Smaller by Allowing Trucks and Buses to Turn into Multiple Receiving Lanes



Credit: Michele Weisbart (Michele Designs)

The required corner radius for a vehicle to make a turn is known as the effective curb radius. This differs from the actual curb radius, which is the radius of the constructed curb. Where on-street parking or bike lanes exist, and curb extensions are not present, the actual curb radius may be minimized.

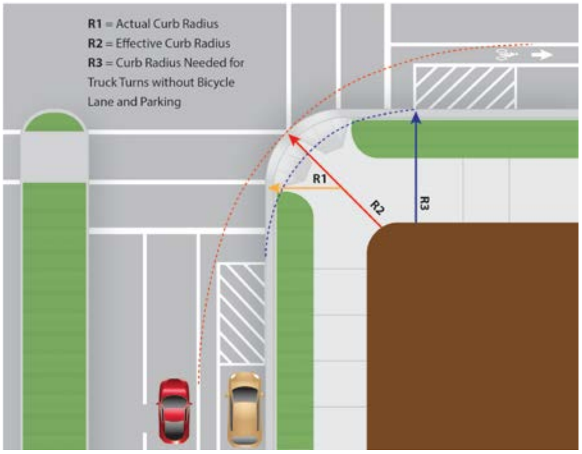
4.4.1. Design Guidelines

- The effective curb radius should be 28 feet to accommodate a single-unit truck (SU-30) design vehicle.
- Where parallel on-street parking or bike lanes exist, their width should be factored into the effective corner radius, and the actual curb radius should be 5 to 15 feet.
- Where bus routes turn right, the design vehicle should be the City Transit Bus (City Bus) and the effective curb radius set to accommodate the turn movement.
- In industrial areas, or locations with frequent truck movement, the design vehicle should be increased to an intermediate semi-trailer (WB-50) or appropriate, and the effective curb radius should be increased to accommodate the turn movement.

4.4.2. National Standards

The *Green Book* (AASHTO, 2011) recommends that the corner radius be designed for the intersecting street type and design vehicle. Guidelines for the right-turning radii into minor side streets are usually between 10 to 15 feet. Where a substantial number of people on foot are present, the lower end of the range may be appropriate. A corner radius as low as 15 feet may also be appropriate on arterial streets carrying heavy traffic volumes. Where buses or large trucks are prevalent, a larger curb radius should be considered.

Figure 4-10: The Effective Radius Controls Turning Speeds and the Ability of Large Vehicles to Turn



Credit: Michele Weisbart (Michele Designs)

Figure 4-9: Small Corner Radius

Hotel Street at Bethel Street. Credit: Alan Fujimori (SSFM International)

4.5. Curb Extensions

Where on-street parking is allowed, curb extensions should be considered to replace the parking lane at crosswalks. Curb extensions should be the same width as the parking lane. Bulb-outs and curb extensions should be designed with two return curves with a radius of over 10 feet to allow street sweepers to clean the corners. Due to reduced road width, the corner radius on a curb extension may need to be larger than if curb extensions were not installed. Curb extensions reduce pedestrian crossing distance, resulting in less exposure to vehicles and shorter pedestrian clearance intervals at signals.

Figure 4-11: Corner Curb Extensions

Waialae Avenue. Credit: Ryan Nakamoto (SSFM International)

Figure 4-12: Integrating Curb Extensions and On-Street Parking into the Sidewalk Corridor Enhances Pedestrian Safety and the Walking Experience

Credit: Michele Weisbart (Michele Designs)

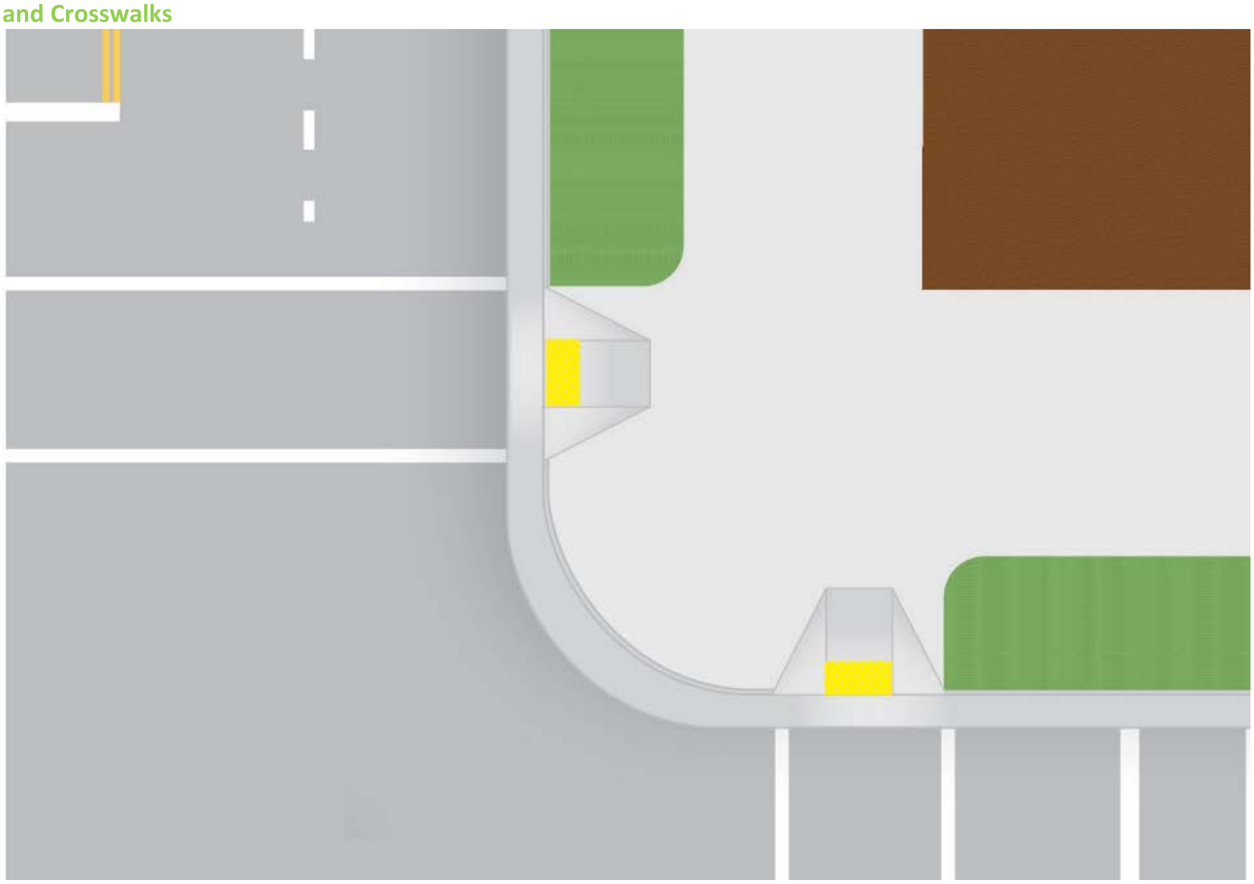
4.6. Crosswalk and Ramp Placement

Crosswalks and ramps at intersections should be placed so they provide convenience and safety for people on foot. The following recommended best practices will help achieve these goals.

- Allow crossings on all legs of an intersection to maximize pedestrian access, unless there are no pedestrian accessible destinations on one or more of the corners.
- Narrow the travel way, which has a potential traffic calming effect.
- Add room for street furniture, landscaping, and curb ramps.
- Slow turning vehicles.
- Add curb extensions to allow people to walk out toward the edge of the parking lane without entering the travel way.
- Manage stormwater runoff.
- Provide marked crosswalks on all legs of signalized intersections.
- Provide marked crosswalks at intersections along official school routes.
- Provide marked crosswalks on all legs of intersections in transit-oriented development districts.
- Provide marked crosswalks at other stop-controlled or uncontrolled locations where significant numbers of people cross.
- Place crosswalks as close as possible to the desired path of people on foot, which is generally in line with the approaching sidewalks.
- Minimize crossing distances when possible to reduce the time that people are exposed to motor vehicles.

- Ensure that there are adequate sight lines between people on foot and motorists. Crosswalks should not be placed too far away from the intersection.
- When a raised median is present, extend the nose of the median past the crosswalk with a cut-through for people on foot.
- Provide one ramp per crosswalk (two per corner for standard intersections with no closed crosswalks). Ramps must be entirely contained within a crosswalk (the crosswalk can be flared to capture a ramp that cannot be easily relocated). Align the ramp run with the crosswalk when possible, as ramps that are angled away from the crosswalk may lead some users into the intersection.
- Ensure consistency with the most recent adopted version of the federal ADA standards and the City & County of Honolulu *Accessibility Design Guidelines and General Policies and Procedures, Curb Ramps within Public Rights-of-Way* (C&C, 2014).

Figure 4-13: One Curb Ramp per Crosswalk Should be Provided at Corners. Ramps Should Align with Sidewalks and Crosswalks



Credit: Michele Weisbart (Michele Designs)

4.7. Intersection Grade

The *Green Book* (AASHTO, 2011) notes that the gradients of intersecting roads should be as flat as practical on those sections that are to be used for storage of stopped vehicles. The calculated stopping and acceleration distances for passenger cars on grades of 3 percent or less differ little from the corresponding distances on the level. Accordingly, grades in excess of 3 percent should be avoided however, where extenuating conditions exist, grades should not exceed about 6 percent.

4.8. Intersection Sight Distance

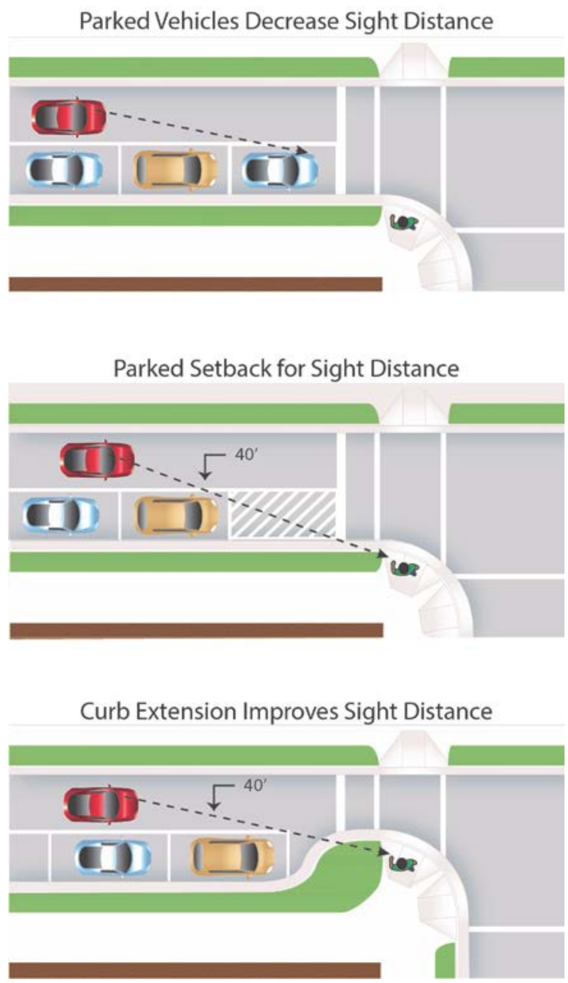
Intersection sight distance should be calculated in accordance with the *Green Book* (AASHTO, 2011) using the design speed appropriate for the streets being evaluated. When executing a crossing or turning maneuver onto a street after stopping at a stop sign, stop bar, or crosswalk, drivers will move slowly forward to obtain sight distance (without intruding into the crossing travel lane) stopping a second time as necessary. Therefore, when curb extensions are used or on-street parking is in place, the vehicle can be assumed to move forward on the second stop movement, stopping just shy of the travel lane, increasing the driver's potential to see further than when stopped at the stop bar. As a result, the increased sight distance provided by the two stop movement allows parking to be located closer to the intersection.

On-street parking should be positioned far enough away from intersections to allow for good visibility of people on foot preparing to cross the street. This should be at least 20 feet from crosswalks. One way to achieve this is with curb extensions.

Sightlines should be maintained to minimize conflicts between street users.

- A minimum of 75 feet of sightline should be maintained to signal posts at signalized intersections.
- A minimum of 40 feet of sightline should be maintained at controlled midblock crossings.
- A minimum of 40 feet of sightline should be maintained at uncontrolled crossings.
- Driveway users should have at least 10 to 20 feet of sightline to sidewalks, and at least 30 feet of sightline into the street.

Figure 4-14: Curb Extensions Improve Sight Distance between Pedestrians and Motorists



Credit: Michele Weisbart (Michele Designs)

4.9. Turn Lanes

The need for turn lanes for vehicle mobility should be balanced with the need to manage vehicle speeds and the potential impact on multimodal facilities such as bike lanes and sidewalks. Turn lanes allow turning vehicles to move over so that through vehicles maintain their speed.

4.9.1. Left Turn Lanes

Left turn lanes are considered to be acceptable in an urban environment since there are negative impacts to travel way capacity when left turning vehicles block the through movement of vehicles. Sometimes a left-turn pocket is sufficient, without providing for vehicular deceleration, just long enough for one or two cars to wait out of through traveling traffic.

4.9.1.1. Design Guidelines

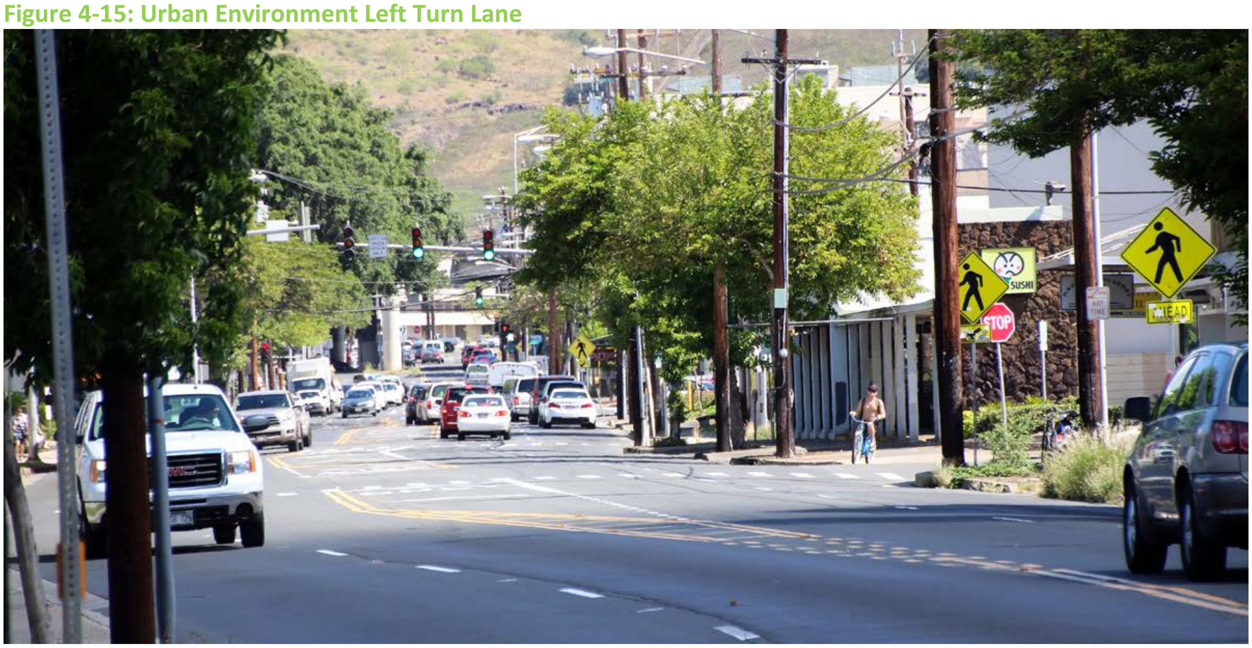
Left turn lanes should be considered where appropriate in an urban environment or when being used with a road diet. The number of turn lanes should be minimized and double turn lanes should be avoided where possible.

4.9.1.2. National Standards

NCHRP Report 745, *Left-Turn Accommodations at Unsignalized Intersections* and NCHRP Report 457, *Evaluating Intersection Improvements: An Engineering Study* include guidance on where to consider a left-turn lane at unsignalized intersections.

The *Green Book* (AASHTO, 2011) states that dedicated left turn lanes should be provided where exclusive left-turn signal phasing is provided. Dedicated left turn lanes should also be considered where the peak hour turn volumes are greater than 100 vehicles per hour (vph). Double left turn lanes should only be considered where the peak hour turn volumes are greater than 300 vph.

Figure 4-15: Urban Environment Left Turn Lane



Kapahulu Avenue. Credit: Samantha Thomas (Blue Zones)

4.9.2. Right Turn Lanes

While right turns from through lanes may delay through movements, they also create a reduction in speed due to the slowing of turning vehicles. The installation of right turn lanes increases the crossing distance for people on foot, increases the speed of vehicles, and increases the conflicts with people on bicycles; therefore, exclusive right turn lanes should be used only when necessary.

Where there are heavy volumes of right turns, or high volumes of conflicting pedestrian crossing movements, 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.

4.9.2.1. Right Turn Channelization Islands

At intersections of multi-lane travel ways where trucks make frequent right turns, a raised channelization island between the through lanes and the right turn lane is a good alternative to an overly large corner radius and enhances pedestrian safety and access.

The following design practices for right-turn lane channelization islands should be used to provide safety and convenience for people on foot, people on bicycles, and motorists:

- Provide a yield sign for the slip lane.
- Provide a 55 to 60 degree angle between vehicle flows, which reduces turning speeds and improves the yielding driver's visibility of people on foot and vehicles.
- Place the crosswalk across the right-turn lane about one car length back from where drivers yield to traffic on the other street,

Figure 4-16: Raised Crosswalk at Channelized Right-Turn Lane

Boulder, CO. Source: NCHRP Web-Only Document 208: Design Guidance for Channelized Right-Turn Lanes (TRB, 2011) allowing the yielding driver to respond to a potential pedestrian conflict first, independently of the vehicle conflict, and then move forward, with no more pedestrian conflict.

- Construct a raised pedestrian crossing to slow vehicle turning movements and improve safety for pedestrians.
- Install bollards, following the guidelines in Section 7.8.3., where a raised pedestrian crossing is constructed within a channelized right-turn lane. Bollards shall be placed on either side of the crosswalk within the raised island and sidewalk. ADA clearance must be maintained however the bollard separation should not be so great as to allow for a car to travel through.

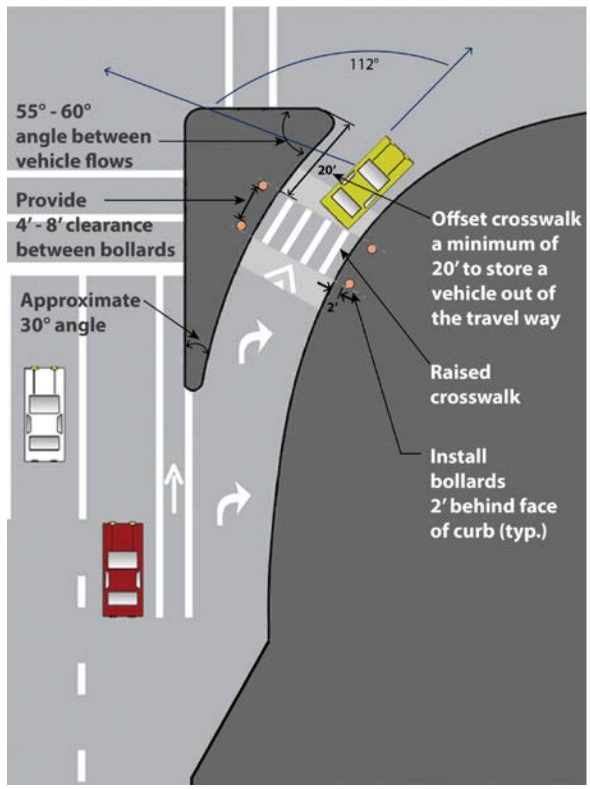
Channelized island should be designed roughly twice as long as it is wide. The corner radius will typically have a long radius (150 feet to 300 feet) followed by a short radius (20 feet to 50 feet). When creating this design, it is necessary to allow large trucks to turn into multiple receiving lanes. This design is often not practical for right-turn lanes onto roads with only one through lane. This right-turn channelization design is different from designs that provide free-flow movements (through a slip lane) where right-turning motorists turn into an exclusive receiving lane at high speed. Right turns could be signal-controlled in this situation to provide for a signalized pedestrian walk phase. A raised pedestrian crosswalk could also be used to slow vehicles down and make people on foot more visible.

4.9.2.2. National Standards

NCHRP Report 457, *Evaluating Intersection Improvements: An Engineering Study Guide* includes guidance on where to consider a right turn lane at unsignalized intersections.

Guidance from *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* (ITE, 2010) states that a right-turning volume of 200-300 vph is an acceptable range for the provision of right turn lanes at signalized intersections.

Figure 4-17: Design Guidance for Channelized Right Turn Lane



Credit: Lulu Feng (SSFM International)

4.9.3. Turn Lane Design

The *Green Book* (AASHTO, 2011) provides guidance on the design of components associated with an auxiliary, median or turn lane. A turn lane shall consider the necessary storage, deceleration, and taper lengths.

The deceleration length is a function of the brake-reaction distance and the distance required for the approaching vehicle to come to a stop (see Table 4-1 and 4-2). It is common practice to accept a moderate amount of deceleration within the through lanes and to consider the taper length as part of the deceleration within the through lanes. On urban or low-speed roadways, deceleration lengths are not always needed as the deceleration of the turning vehicles helps control the speed of through-traveling traffic.

Table 4-1: Stopping Sight Distance on Level Roadways

Design Speed (mph)	Brake Reaction Distance (ft)	Braking Distance on Level (ft)	Stopping Sight Distance	
			Calculat-ed (ft)	Design (ft)
15	55.1	21.6	76.7	80
20	73.5	38.4	111.9	115
25	91.9	60.0	151.9	155
30	110.3	86.4	196.7	200
35	128.6	117.6	246.2	250
40	147.0	153.6	300.6	305
45	165.4	194.4	359.8	360
50	183.8	240.0	423.8	425
55	202.1	290.3	492.4	495
60	220.5	345.5	566.0	570
65	238.9	405.5	644.4	645
70	257.3	470.3	727.6	730
75	275.6	539.9	815.5	820
80	294.0	614.3	908.3	910

Source: Green Book (AASHTO, 2011)

Table 4-2: Stopping Sight Distance on Grades

Design Speed (mph)	Stopping Sight Distance (ft)					
	Downgrades			Upgrades		
	3 %	6 %	9 %	3 %	6 %	9 %
15	80	82	85	75	74	73
20	116	120	126	109	107	104
25	158	165	173	147	143	140
30	205	215	227	200	184	179
35	257	271	287	237	229	222
40	315	333	354	289	278	269
45	378	400	427	344	331	320
50	446	474	507	405	388	375
55	520	553	593	469	450	433
60	598	638	686	538	515	495
65	682	728	785	612	584	561
70	771	825	891	690	658	631
75	866	927	1003	772	736	704
80	965	1035	1121	859	817	782

Source: Green Book (AASHTO, 2011)

The turn lane length should be sufficiently long to store the number of vehicles, or queue, likely to accumulate during a crucial period. On urban roads, where space is limited, a minimum 50-foot storage distance should be provided to accommodate two vehicles. Where a high percentage of buses or trucks are expected, this length should be increased.

The applicable taper design is a function of the design speed and roadway geometrics. For urban areas, short tapers are preferred because they provided more vehicle queue space and aren't as crucial for slow vehicle speeds during peak periods.

4.10. Intersection Control

4.10.1. Two-Way Stop Sign Control

Two-way stop controlled intersections are the most common form of intersection control. However, in low volume areas, they create unnecessary delay by forcing the minor approach to stop even in cases where no conflicting vehicle exists. This may also result in vehicles disregarding the stop sign, creating the potential for crashes or collisions when approaching vehicles are not seen. Where possible, mini-circles should be considered as an alternative intersection control measure in that they keep speeds low along both approaches and provide additional opportunity for landscaping.

4.10.2. All-Way Stop Control

All-way stop sign control is used in places where equal volumes of traffic exists along intersecting approaches. They are often an interim measure before the intersection is signalized. Where possible, mini-circles or roundabouts should be considered as an alternative intersection control to allow conflicting side street vehicle movements to occur concurrently with reduced delay.

Figure 4-18: Mini-Circle Intersection Control

High Point, WA. Credit: Mike Packard (SSFM International)

4.10.3. Signalized Intersections

Signalized intersections provide unique challenges and opportunities for livable communities and complete streets. On one hand, signals provide control of people on foot and motor vehicles with numerous benefits. Where signalized intersections are closely spaced, signals can control vehicle speeds by providing appropriate signal progression along a corridor. Traffic signals allow people on foot or on bicycles to cross major streets with only minimal conflicts with 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 movements with people on foot and people on bicycles. In many cases, roundabouts offer safer, more convenient intersection treatment than traffic signals.

To improve livability and pedestrian safety, signalized intersections should:

- Provide signal progression at speeds that support the target speed of a corridor whenever feasible.
- Provide short signal cycle lengths, which allow frequent opportunities to cross major travel ways, improving the usability and livability of the surrounding area for all modes.
- Ensure that signals detect bicycles.
- Place pedestrian signal heads in locations where they are visible.
- At locations with many people on foot - in business districts, in TOD districts, and near schools - time the pedestrian phase to be on automatic recall, so people do not have to seek and push a push-button. Automatic recall may also be used during those times of day when people on foot are most present.
- Signal timing may also be set to favor uninterrupted travel for people on bicycles or those using bus transit.
- Where few people on foot are expected and automatic recall of walk signals is not desirable, place pedestrian push-buttons in convenient locations per the *MUTCD* (FHWA, 2009).

Figure 4-19: Traffic Signal Progression May Be Set to Favor Uninterrupted Travel for People on Bicycles

Kalakaua Ave. Credit: Ryan Nakamoto (SSFM International)

4.10.4. Roundabouts

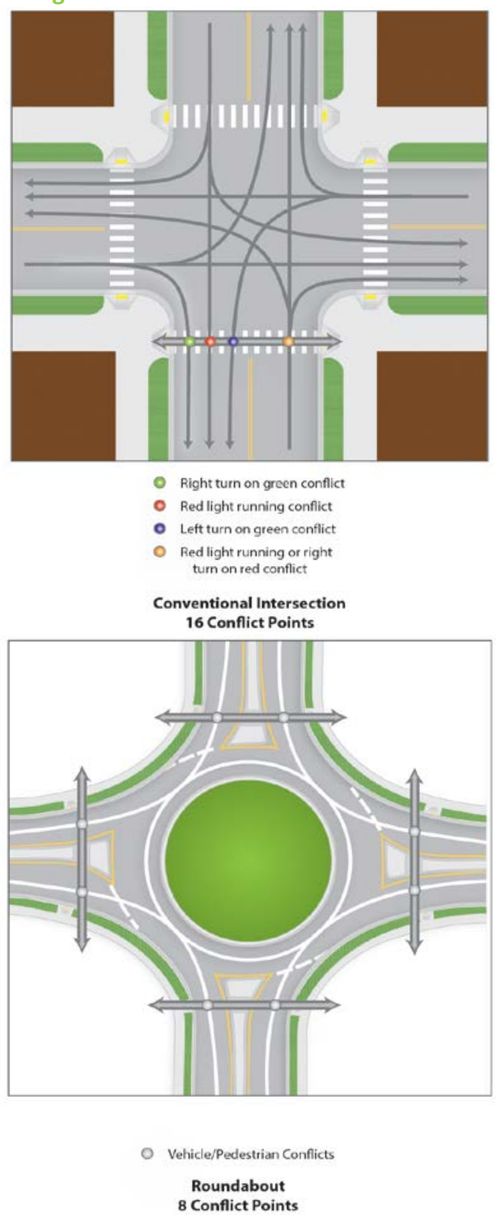
Roundabouts should be considered the first traffic control option at otherwise controlled intersections.

Roundabouts reduce vehicle-to-vehicle and vehicle-to-pedestrian conflicts and reduce all forms of crashes, and crash severity, due to a reduction in vehicle speed. In particular, roundabouts eliminate common crashes at signalized intersections: left-turn and right-angle crashes.

Other benefits of roundabouts include the following:

- Reduced delay, travel time, and vehicle queue lengths;
- Facilitated U-turns;
- Improved accessibility to intersections for people on bicycles through reduced conflicts and vehicle speeds;
- Options for people on bicycles of differing abilities to navigate the roundabout;
- A smaller carbon footprint (no electricity is required for operation and fuel consumption is reduced as motor vehicles spend less time idling and do not have to accelerate as often from a dead stop);
- The opportunity to reduce the number of vehicle lanes between intersections (e.g., to reduce a five-lane road to a two-lane road, due to increased vehicle capacity at intersections);
- Little to no delay for people on foot who have to cross only one direction of traffic at a time without waiting for a pedestrian crossing phase;
- Reduced maintenance and operational costs because the only costs are related to the landscape and litter control;
- Lowered noise levels;
- The central island can vary in shape from a circle to a “square-a-bout” in historic areas, ellipses at odd shaped intersections, dumbbell, or even peanut shapes; and,
- The ability to create a gateway and/or a transition between distinct areas.

Figure 4-20: Vehicle Pedestrian Conflict Points at Signalized Intersection vs. Roundabout



Credit: Michele Weisbart (Michele Designs)

4.10.4.1. Single-Lane Roundabouts

Single-lane roundabouts can vary in size with central island diameters from 12 to 90 feet to fit a wide range of intersections and accommodate through-movements and different turn movements by various design vehicles. As such, they can be used at a large number of intersections to achieve various objectives.

In some cases, roundabouts are constructed to accommodate through-movements by large articulated trucks, but do not permit the trucks to make turn movements. However, they do accommodate turn movements by single-unit trucks such as ladder trucks and garbage trucks.

In some cases, restricting or not accommodating turn movements by articulated trucks enables the construction of a smaller roundabout without acquisition of right-of-way and with all the benefits of roundabouts at the cost of forcing the occasional large truck to take an alternate route.

Pedestrian crossings are improved through the inclusion of splitter islands and slow speed approaches by vehicles. People on bicycles are able to navigate the roundabout by taking the lane or accessing the sidewalk through a ramp.

Figure 4-21: Single-Lane Roundabout

Lihue, Kauai. Credit: Mike Packard (SSFM International)

4.10.4.2. Multi-Lane Roundabouts

When single-lane roundabouts prove to be inadequate for the traffic volume, consideration should be given to using roundabouts that have two through lanes on the major street and a single lane on the minor street with or without additional turn lanes before automatically designing a full multi-lane roundabout. Because these roundabouts are larger than single-lane roundabouts, they often accommodate all turn movements by most large vehicles. However, it is still necessary to confirm the size and movements by the design vehicle(s) because these roundabouts often have to accommodate larger trucks or special vehicles.

An old style freeway interchange that is failing because of a lack of storage for turning vehicles, can be retrofitted to a roundabout on both sides of the freeway to reduce congestion and improve pedestrian mobility without widening the freeway bridge. Sometimes, the retrofit of a standard interchange with roundabouts can reduce the space allocated to the interchange, freeing the land for other community uses.

Additional treatments can be provided to improve pedestrian safety when crossing the multiple approach lanes such as pedestrian-activated rectangular rapid flashing beacons. Similar to single-lane roundabouts, people on bicycles are provided the option to take the lane or divert onto the sidewalk through a ramp.

Figure 4-22: Multi-Lane Roundabout Example with RRFBs and Bicycle Ramps

Oylmpia, WA. Credit: Mike Packard (SSFM International)

4.10.4.3. Mini-Roundabouts

Mini-roundabouts can be designed to include a traversable central island and traversable splitter islands to accommodate large vehicles. Mini-roundabouts are used in low-speed urban environments, where operating speeds are 30 mph or less, and right-of-way constraints preclude the use of a standard roundabout. The design is based on passenger vehicles passing through the roundabout without travelling over the central island, whereas large vehicles will turn over the central island and in some cases, the splitter islands.

4.10.4.4. Neighborhood Traffic Circles

Neighborhood traffic circles are very small circles that are retrofitted into local street intersections to control vehicle speeds within a neighborhood. Typically, a tree and/or landscaping are located within the central island to provide increased visibility of the traffic circle and enhance the intersection. Neighborhood traffic circles should generally have similar features as roundabouts, including yield-on-entry signage and painted or mountable splitter islands.

Neighborhood traffic circles should be used on low-volume, neighborhood streets. In these environments, larger vehicles can turn left in front of the central island. The design of neighborhood traffic circles is primarily confined to selecting a central island size to achieve the appropriate design speed of approximately 15 to 18 mph.

4.10.4.5. National Standards

Refer to NCHRP Report 672, *Roundabouts: An Informational Guide*, Second Edition for roundabout design guidance.

Figure 4-23: Neighborhood Traffic Circle

Uluhala Street at Ulupuni Street. Credit: Mike Packard (SSFM International)

CHAPTER 5: PEDESTRIAN CROSSINGS

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Chapter 5 Cover Image: North King Street at Bishop Street. Credit: Ryan Nakamoto (SSFM International)

CHAPTER 5: PEDESTRIAN CROSSINGS

5.1. Introduction

Crossing a street should be safe, convenient, and comfortable for people on foot. Pedestrian behavior, intersection or crossing design, and motorist behavior (how motorists stop for people on foot) are all factors in pedestrian safety.

A number of tools exist to improve pedestrian safety and to make crossing streets easier. Effective traffic management can address concerns about traffic speed and volume. A motorist driving more slowly has more time to see, react, and stop for a person on foot. The number of pedestrians also influences motorists; in general, motorists are more aware of pedestrians when there are more people walking. Most tools to address crossing challenges are engineering treatments, but tools from the enforcement, education, and planning toolboxes are equally important.

Figure 5-1: Crossings Are a Necessary Part of the Pedestrian Experience

Kalakaua Avenue at Liliuokalani Avenue. Credit: Ryan Nakamoto (SSFM International)

5.2. Marked Crosswalks

Crosswalks are present by law at all intersections, whether marked or unmarked, unless the pedestrian crossing is specifically prohibited often through signage. Crosswalk markings improve the safety of people on foot. The best locations to install marked crosswalks are at:

- All signalized intersections;
- Crossings near transit locations;
- Trail crossings;
- Intensive land use generators;
- School walking routes;
- When there is a preferred crossing location due to sight distance or other constraint; and,
- Along multi-lane streets between controlled crossings.

At mid-block locations, crosswalks only exist where marked. At these non-intersection locations, the crosswalk markings legally establish the crosswalk. Crosswalks should be considered at mid-block locations where there is strong evidence that people on foot want to cross there, due to origins and destinations across from each other or where there is an overly long distance to the nearest controlled crossing. Marked crosswalks alert drivers to expect crossing pedestrians and direct people on foot to desirable crossing locations.

The following principles should be incorporated into every pedestrian crossing improvement:

- People on foot should be able to cross roads safely.
- Real and perceived safety must be considered when designing crosswalks.
- Safety should not be compromised to accommodate traffic flow.
- Every crossing should be designed to fit its unique environment.
- Comply with ADA guidelines.

The Statewide Traffic Code of the Hawaii Revised Statutes (HRS) requires drivers to stop for pedestrians in any crosswalk, whether marked or unmarked when the pedestrian is either:

(1) Upon the half of the roadway upon which the vehicle is traveling; or

(2) Approaching the vehicle so closely from the opposite half of the roadway as to be in danger, and shall not proceed until the pedestrian has passed the vehicle and the driver can safely proceed.

Figure 5-2: School Walking Routes Should be Marked

Kihapai Street at Kawainui Street. Credit: Mike Packard (SSFM International)

5.2.1. Crosswalk Marking Options

Because of the low approach angle at which pavement markings are viewed by drivers, the use of longitudinal markings in addition to or in place of transverse markings can significantly increase the visibility of a crosswalk to oncoming traffic. The Federal Highway Administration notes that high-visibility pedestrian crosswalks (such as the longitudinal marking) have a positive effect on pedestrian and driver behavior. Colored and stamped crosswalks can be considered at controlled locations and raised intersections and crossings. Staggered longitudinal markings reduce maintenance since they avoid wheel paths.

5.2.2. Frequency of Crosswalks

Marked crosswalks should be spaced so people can cross at preferred locations. If people are routinely crossing streets at non-preferred locations, consideration should be given to installing a new crossing. Along urban streets, a well-designed crossing should be provided at least every 660 feet, although no closer than 300 feet from a signalized intersection crossing unless under extenuating circumstances.

5.2.3. Design Guidelines

The following issues should also be considered when planning and designing crossings:

- **Ideally, streets wider than 40 feet should be divided by installing a median or two crossing islands.**
- **There should be a safe, convenient crossing at every transit stop.**
- **Multiple left or right turns concurrent with pedestrian crossings at signalized intersections should not be allowed.**
- **Advanced stop lines should be installed at all signalized locations.**
- **Advanced stop lines should be considered where multiple lanes approach a crosswalk at an unsignalized or mid-block location. Advanced stop lines should be installed with appropriate signage per *MUTCD* (FHWA, 2009) guidelines.**

5.3. Pedestrian Crossing Toolbox

Various engineering measures may be used at a pedestrian crossing, depending on site conditions and potential users. Marked crosswalks are commonly used at intersections and sometimes at mid-block locations. Marking crosswalks is often the first measure in the toolbox followed by a series of other measures that are used to enhance and improve crossings. The decision to mark a crosswalk should not be considered in isolation, but rather in conjunction with other measures to increase awareness of people on foot. Due to the high cost, right-of-way impacts, and inconvenience to pedestrian travel, grade-separated pedestrian bridges are only appropriate in limited cases such as when providing direct access to an elevated high-volume pedestrian generator or when crossing an impassable obstacle such as a waterway or high-volume, high-speed travel way.

Figure 5-3: Pedestrian Crossing Treatment Flowchart and Table 5-1: Criteria for Crossing Treatments at Uncontrolled Locations shall be used to assess appropriate crossing treatments. Engineering judgment must still be used for each particular location.

Figure 5-3: Pedestrian Crossing Treatment Flowchart

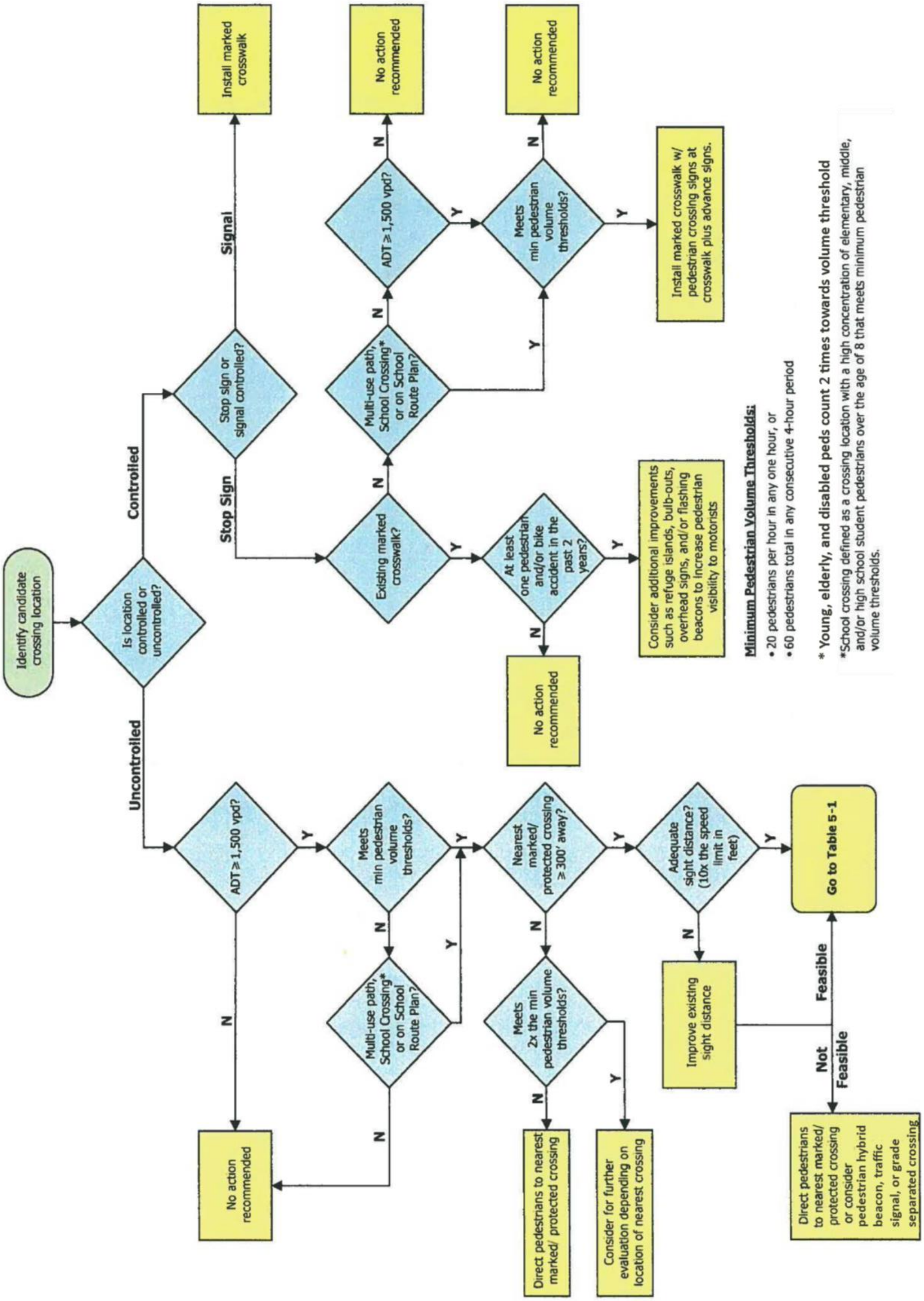


Table 5-1: Criteria for Crossing Treatments at Uncontrolled Locations

Roadway Configuration	Number of Lanes Crossed to Reach a Refuge	Roadway ADT and Posted Speed															
		1,500-9,000 vpd				9,000-12,000 vpd				12,000-15,000vpd				≥ 15,000 vpd			
		≤ 30 mph	35 mph	40 mph	> 40 mph	≤ 30 mph	35 mph	40 mph	> 40 mph	≤ 30 mph	35 mph	40 mph	> 40 mph	≤ 30 mph	35 mph	40 mph	> 40 mph
1 or 2 Lanes (One-Way Street)	2	A	A	B	C	A	A	B	C	A	A	B	C	A	B	B	C
2 Lanes (Two-Way Street)	2	A	A	B	C	A	A	B	C	A	A	B	C	A	B	B	C
3 Lanes With Raised Median	1 or 2	A	A	B	C	A	B	B	C	B	B	B	C	B	B	B	C
3 Lanes With Striped Median	3	A	A	B	C	A	B	B	C	B	B	B	C	B	B	B	C
4 Lanes (Two-Way Without Raised	4	A	B	B	C	B	B	C	C	C	C	C	C	C	C	C	C
4 Lanes With Raised Median	2	A	A	B	C	A	B	B	C	B	B	C	C	B	B	C	C
5 Lanes Without Raised Median	5	A	B	C	C	B	B	C	C	C	C	C	C	C	C	C	C
5 lanes With Raised Median	2 or 3	A	A	B	C	A	B	B	C	B	B	C	C	B	B	C	C
6 or More Lanes	3 or 6	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C

A. Install marked crosswalk with enhanced signs
Specific Guidance: Install marked crosswalk and consider installation of pedestrian crossing sign (W11-2) and down arrow (W16-7p) plus advance warning signs that include a pedestrian crossing sign with ahead plaque (W16-9P) and in-road State Law Stop for Pedestrians sign (R1-6a or similar) on bollard. Signage shall be installed at midblock crossings and at school crossing locations. Use S1-1 signs for School Crossing locations.

B. Install marked crosswalk with enhanced signs and geometric improvements to increase pedestrian visibility and reduce exposure
Specific Guidance: Install marked crosswalk with pedestrian crossing sign (W11-2) and down arrow (W16-7p) plus advance warning signs that include a pedestrian crossing sign with ahead plaque (W16-9P) . Use S1-1 signs for School Crossing locations. In addition, install overhead signs and/or RRFBs. Where possible, install geometric improvements such as raised crosswalks, refuge islands, and bulb-outs to increase pedestrian visibility to motorists or shorten the pedestrian crossing distance.

C. Do not install marked crosswalk
Specific Guidance: Consider traffic signal, pedestrian hybrid beacon, grade-separated crossing, or other substantial crossing improvement to improve crossing safety for pedestrians.

5.3.1. Controlled Intersections

Marked crosswalks should be provided on all intersection legs controlled by traffic signals, unless substantial safety concerns exist for all users. Marked crosswalks may be considered at stop sign-controlled intersection approaches. Factors to be considered include pedestrian volumes, vehicle volumes, official routes to school, volumes of elderly or disabled users, and other safety related criteria.

5.3.2. Pedestrian Signals

Standard pedestrian signal timing principles included in the *MUTCD* (FHWA, 2009) should be combined with innovative pedestrian signal timing techniques, where possible, to enhance pedestrian safety and convenience.

5.3.2.1. Walk Interval

The WALK interval should be a minimum of 5 to 7 seconds. However, to provide more time for pedestrian travel, and possibly more safety due to better pedestrian behavior, the WALK interval should be maximized using the following techniques:

- The WALK interval should be increased in areas with high numbers of people on foot, elderly, children, or disabled users. This can be done as a feature of selected intersection crossings, or with special user-activated technology.
- Maximize the WALK interval within the available green interval.
- Pedestrian (WALK) intervals should be set on “recall” except where pedestrian volumes are relatively low. This means that the WALK indication will automatically appear regardless of pedestrian presence or activation through pushing a button. Pedestrian push-buttons should be removed where the pedestrian phase is set to recall.
- Where a major street intersects a minor side street, the WALK interval for crossing the minor street can be set on recall, concurrent with the green interval for the parallel through vehicle movement, which is typically set to recall as well. This minimizes pedestrian delay along the major street with no impact to motor vehicle capacity.

Figure 5-4: Signalized Mid-Block Pedestrian Crossing

Dole Street. Credit: Stephanie Nagai (SSFM International)

5.3.2.2. Pedestrian Clearance Interval

The *MUTCD* (FHWA, 2009) requires that the pedestrian clearance interval is calculated to allow a person traveling at a walking speed of 3.5 feet per second to travel the length of the crosswalk. The crosswalk length should be measured from the center of one curb ramp to the center of the opposing curb ramp. This speed allows people on foot, especially seniors, children, and disabled people, to clear the intersection in the allotted time.

Figure 5-5: Pedestrian Clearance Interval

North King Street at Bishop Street. Credit: Ryan Nakamoto (SSFM International)

The *MUTCD* (FHWA, 2009) includes another test that requires the total of the WALK interval plus the pedestrian clearance interval to be sufficient to allow a person traveling at a walking speed of 3 feet per second to travel the length of the crosswalk, measured from the top of one ramp to the bottom of the opposing ramp. Any additional time that is required to satisfy this second requirement should be added to the WALK interval. In neighborhoods where high numbers of slow pedestrians are present, such as near senior centers, rehabilitation centers, and disabled centers, the interval should be set for even slower walking speeds.

5.3.3. Pedestrian Signal Toolbox

Where appropriate, use signal timing and operations techniques to minimize conflicts with people on foot and motor vehicles. These techniques include the following:

- Protected only left turn phases.
- Leading pedestrian intervals where the pedestrian WALK interval is displayed 2 to 5 seconds prior to the concurrent green interval. This enables people on foot to enter the crosswalk before drivers start to turn, increasing their chances of being seen by drivers.
- Prohibiting right-turns-on-red where there are restricted sight lines between motorists and pedestrians or where a leading pedestrian interval is used.
- Signs that remind drivers to yield to people on foot when turning at signals.
- Pedestrian-user-friendly-intelligent (PUFFIN) signals, which detect slower pedestrians in crosswalks and add clearance interval time to the pedestrian signal.
- Pedestrian scrambles, which stop traffic on all legs of the intersection and allow people to cross diagonally, may be used where turning vehicles conflict with very high pedestrian volumes.

5.3.4. Pedestrian Scrambles

Exclusive pedestrian phases (i.e., pedestrian 'scrambles' or 'Barnes Dance') may be used where turning vehicles conflict with very high pedestrian volumes and pedestrian crossing distances are short. Although people can cross in any direction during the pedestrian phase of a standard signalized intersection, they are required to wait for the respective signal phase before crossing in another direction (delaying people travelling diagonally).

5.3.5. Uncontrolled Intersections and Mid-block Crosswalks

Mid-block crosswalks and crosswalks at uncontrolled intersections may require special treatment. These are locations where motorists do not automatically expect to stop. Figure 5-3: Pedestrian Crossing Treatment Flowchart and Table 5-1: Criteria for Crossing Treatments at Uncontrolled Locations shall be used to assess appropriate crossing treatments.

5.3.5.1. Crosswalk Marking

The decision to mark a crosswalk at an uncontrolled location, for new and any operation that removes the existing markings (such as repaving), should be guided by an engineering study. Factors considered in the study should include vehicular volumes and speeds, travel way width and number of lanes, stopping sight distance and triangles, distance to the next controlled crossing, night time visibility, grade, origin-destination of trips, left turning conflicts, and pedestrian volumes. The engineering study should be based on Figure 5.3: Pedestrian Crossing Treatment Flowchart and Table 5-1: Criteria for Crossing Treatments at Uncontrolled Locations where applicable.

Figure 5-6: Pedestrian Scramble Example

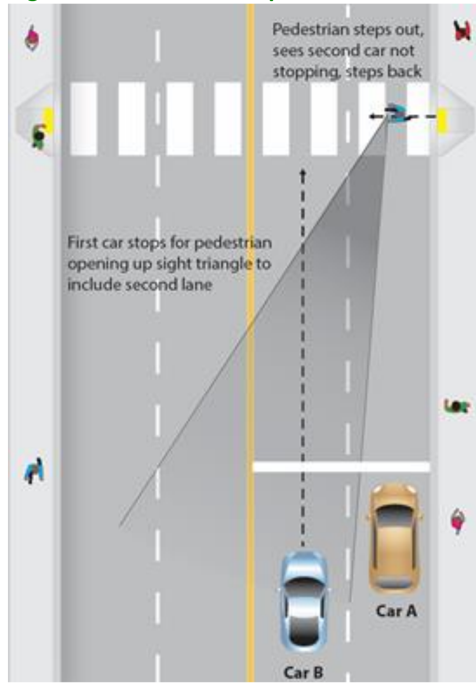
N. King Street at Kekaulike Rd. Credit: Ryan Nakamoto (SSFM International)

5.3.6. Advance Stop Line

Stop lines are solid white lines 12 to 24 inches wide, extending across all approach lanes to indicate where vehicles must stop in compliance with a traffic control feature. Advance stop lines reduce vehicle encroachment into the crosswalk and improve a driver's view of people on foot. At signalized intersections, a stop line is typically set back between 4 and 6 feet from the crosswalk. This may be increased up to 20 feet where right turn on red (RTOR) conflicts exist. At signalized mid-block crossings, stop lines should be placed 20 to 40 feet from the crosswalk. These uncontrolled crossings may be mid-block or at intersections of cross streets.

Section 3B.16 of the *MUTCD* (FHWA, 2009) specifies placing advance stop markings 20 to 50 feet in advance of crosswalks, depending upon location-specific variables such as vehicle speeds, traffic control, street width, on-street parking, potential for visual confusion, nearby land uses with vulnerable populations, and demand for queuing space. This setback allows a person on foot to see if a car in the second (or third) lane is stopping after a driver in the first lane has stopped. Where advanced stop lines are used at uncontrolled locations, sign R1-5b (STOP HERE FOR PEDESTRIANS) or similar shall be included, per the *MUTCD* (FHWA, 2009).

Figure 5-8: Advance Stop Line at Mid-Block Crossing



Credit: Michele Weisbart (Michele Designs)

Figure 5-7: Stop Here For Pedestrians Signage

Nimitz Highway. Credit: Juanita Wolfgramm (SSFM International)

5.3.7. Crosswalk Sight Distance

Sight lines should be maintained at the approach to crosswalks. This may require the restriction of landscaping and on-street parking. Parking may be prohibited through the use of signage or pavement markings.

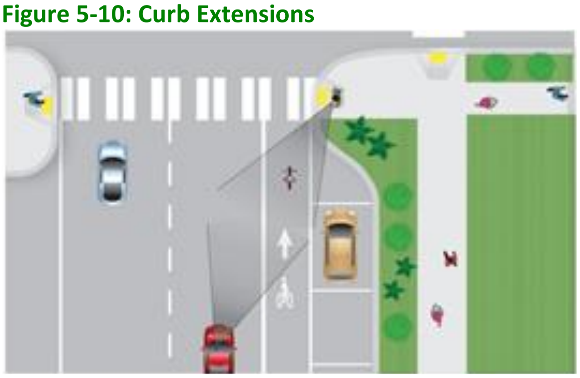
Figure 5-9: Pavement Marking to Restrict Parking

Wanaao Road. Credit: Mike Packard (SSFM International)

5.3.8. Curb Extensions

Curb extensions extend the sidewalk or curb line out into the parking lane, which reduces the effective street width. Curb extensions improve pedestrian crossings by reducing the pedestrian crossing distance, improving the ability of people on foot and motorists to see each other, and reducing the time that people are in the street. Reducing street width improves signal timing since people on foot need less time to cross.

Figure 5-10: Curb Extensions



Credit: Michele Weisbart (Michele Designs)

Motorists typically travel more slowly at intersections or mid-block locations with curb extensions, as the restricted street width sends a visual cue to slow down. Turning speeds are lower at intersections with curb extensions when curb radii are designed as tight as is practicable. Curb extensions also prevent motorists from parking too close to the intersection.

Curb extensions provide additional space for two curb ramps and for level sidewalks, increase the pedestrian waiting space, and provide additional space for pedestrian push-button poles, street furnishings, plantings, bike parking and other amenities. A benefit for drivers is that extensions allow for better placement of traffic control devices (e.g., stop signs and signals).

Curb extensions are generally only appropriate where there is an on-street parking lane. However, where street widths permit, a gently tapered curb extension can reduce crossing distance along streets without on-street parking. Curb extensions must not extend into travel lanes or bicycle lanes. Curb extensions may impact other aspects of travel way design and operation, such as:

- Street drainage, potentially requiring catch basin relocation or addition of drain inlets;
- Underground utilities;
- Curbside parking (careful planning often mitigates this potential loss, for example, by relocating curbside fire hydrants where no parking is allowed to a curb extension);
- Delivery access and garbage removal;
- Turning movements of larger vehicles such as school buses and large fire trucks; and,
- Pedestrian push-buttons.

5.3.9. Crosswalk Lighting

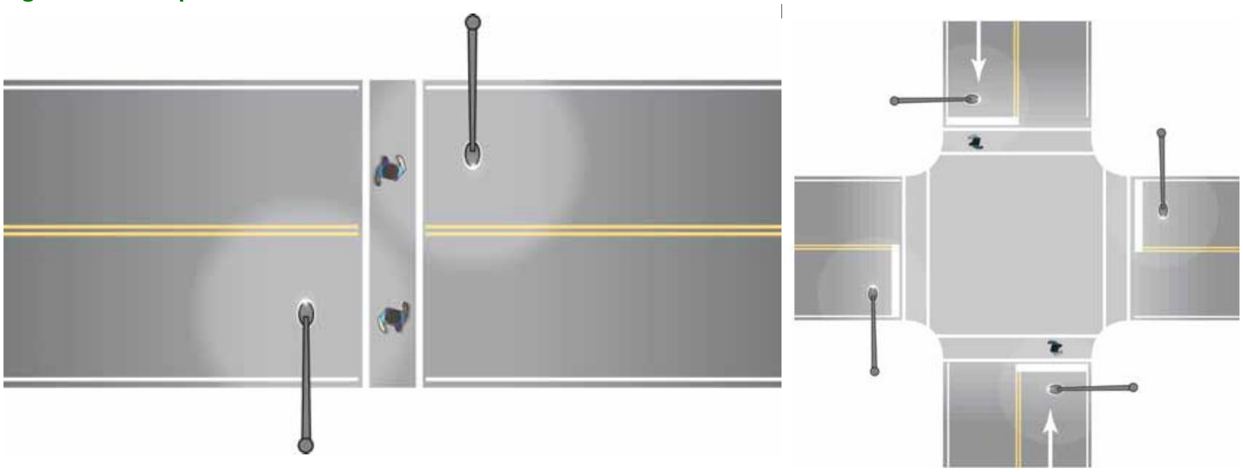
Lighting is important to include at all pedestrian crossing locations for the comfort and safety of the travel way users. Lighting should be present at all marked crossing locations with an unobstructed path for appropriate illumination of the crossing. This may require the trimming of tree branches or relocation of signage as needed.

5.3.9.1. National Guidelines

FHWA-HRT-08-053, *Informational Report on Lighting Design for Midblock Crosswalks* contains information about lighting design for people on foot at intersections.

The Illuminating Engineering Society of North America (IESNA), *Roadway Lighting, RP-8-14* should be referenced for crosswalk lighting guidance.

Figure 5-11: Proposed Crosswalk Illumination Placement



Source: FHWA-HRT-08-053, *Informational Report on Lighting Design for Midblock Crosswalks* (FHWA, 2008)

Table 5-2: Recommended Illumination by Intersection

Functional Classification	Average Maintained Illumination at Pavement by Pedestrian Area Classification [FC]		
	High	Medium	Low
Major / Major	3.4 fc	2.6 fc	1.8 fc
Major / Collector	2.9 fc	2.2 fc	1.5 fc
Major / Local	2.6 fc	2.0 fc	1.3 fc
Collector / Collector	2.4 fc	1.8 fc	1.2 fc
Collector / Local	2.1 fc	1.6 fc	1.0 fc
Local / Local	1.8 fc	1.4 fc	0.8 fc

FC stands for "foot candle" and is defined as the amount of illuminance on a 1 square foot surface of which there is uniformly distributed flux of one lumen.

5.3.10. Signage

Signage can provide important information to improve travel way safety by letting people know what to expect, so they can react and behave appropriately. Sign use and placement should be done judiciously, as overuse breeds noncompliance and disrespect. Too many signs also create visual clutter.

Regulatory signs, such as STOP or turn restrictions, require driver actions and can be enforced. Warning signs provide information, especially to motorists and people on foot unfamiliar with an area.

Advance pedestrian warning signs should be used where pedestrian crossings may not be expected by motorists, especially if there are many motorists who are unfamiliar with the area. The fluorescent yellow/green color is designated specifically for pedestrian, bicycle, and school warning signs and are required for all new and replacement installations. This bright color attracts the attention of drivers because it is unique.

A “State Law Stop for Pedestrian Within Crosswalk” sign (R1-6a) may be used on median islands, where they will be more visible to motorists than signs placed on the side of the street, especially where there is on-street parking. All signs should be periodically checked to make sure that they are in good condition, free from graffiti, reflective at night, and continue to serve a purpose. All sign installations need to comply with the provisions of the *MUTCD* (FHWA, 2009).

Figure 5-12: Pedestrian Crossing Signage

Hamakua Drive with R1-6a Sign in the Center Median and W11-2 Sign in the Planting Strip (Right). Credit: Mike Packard (SSFM International)

5.3.11. Raised Crossing Islands/ Medians

Raised islands and medians are the most important, safest, and adaptable engineering tool for improving street crossings. Note on terminology: medians are continuous raised areas separating opposite flows of traffic. Crossing islands are shorter in length and located only where a pedestrian crossing is needed. Raised medians and crossing islands are commonly used between intersections when blocks are long (500 feet or more in downtowns) and in the following situations:

- Speeds are higher than desired;
- Streets are wide;
- Traffic volumes are high; or
- Sight distances are poor.

Crossing islands have nearly universal applications and should be placed where there is a need for people to cross the street. They are also used to slow traffic.

Crossing islands perform best with tall trees and low ground cover. This greatly increases their visibility, reduces surprise, and lowers the need for a plethora of signs. When curves or hill crests complicate crossing locations, median islands are often extended over a crest or around a curve to where motorists have a clear (6 seconds or longer) sight line of the downstream change in conditions. Lighting of median islands is essential.

The suggested minimum width of a crossing island is 6 feet. The minimum desirable width of the crosswalk through crossing islands is five feet. Where adequate space exists, crosswalk curb cuts should be a minimum of 10 feet wide. On streets with traffic speeds higher than 30 mph, it may be unsafe to cross without a median island.

> At 30 mph, motorists travel 44 feet each second, placing them 880 feet out when a person on foot starts crossing an 80-foot wide multi-lane road. In this situation, this person may still be in the last travel lane when the car arrives; that car was not within view at the time the person started crossing.

Figure 5-13: Long Intersection Crossing without Refuge

University Avenue. Credit: Ryan Nakamoto (SSFM International)

With an island on multi-lane travel ways, people would cross two or three lanes at a time instead of four or six. Having to wait for a gap in only one direction of travel at a time significantly reduces the wait time to cross. Medians and crossing islands have been shown to reduce crashes by 40 percent (FHWA, 2005).

As a general rule, crossing islands are preferable to signal-controlled crossings due to their lower installation and maintenance costs, reduced waiting times, and their safety benefits. Crossing islands are also used with road diets, taking four-lane undivided, high-speed roads down to better performing three-lane travel ways (two travel lanes and a center turn lane); portions of the center turn lane can be dedicated to crossing islands. Crossing islands can also be used with signals.

5.3.11.1. National Guidelines

Additional considerations for the design of pedestrian crossings should follow the guidelines from the most recent versions of the *MUTCD* (FHWA, 2009), *Guide for the Planning, Design, and Operation of Pedestrian Facilities* (AASHTO, 2004), and the *Urban Street Design Guide* (NACTO, 2013).

5.3.12. Angled Median Crossing

When used on higher speed roads, and where there is space available, inserting a 45-degree bend to the right helps orient people on foot to the risk they encounter from motorists during the second half of their crossing. Angled pedestrian crossings through pedestrian refuges force people on foot to look for oncoming vehicles.

Figure 5-14: Angled Median Crossing

Kailua Road. Credit: Mike Packard (SSFM International)

5.3.13. Raised Crosswalks

Raised crosswalks slow traffic and put people on foot in a more visible position. They are trapezoidal in shape on both sides and have a flat top where the people cross.

The level crosswalk area must be paved with smooth materials; any texture or special pavements used for aesthetics should be placed on the beveled slopes, where they will be seen by approaching motorists. They are most appropriate in areas with significant pedestrian traffic and where motor vehicle traffic should move slowly, such as near schools, on college campuses, in Main Street retail environments, and in other similar places. They are especially effective near elementary schools where they raise small children by a few inches and make them more visible.

Figure 5-16: Raised Crosswalk

Queen Street. Credit: Mike Packard (SSFM International)

Figure 5-15: Raised Crosswalk With Median and Bulb Out

Kaaholo Street. Credit: Mike Packard (SSFM International)

5.3.14. Raised Intersections

Raised intersections create a safe, low-speed crossing and public space at minor intersections on streets with volumes under 10,000 vehicles per day. They are most appropriate in downtown commercial and redevelopment areas to encourage pedestrian activity.

Raised intersections reinforce slow speeds and encourage motorists to yield to people on foot. Textured pavement and curb extensions are often used to emphasize the pedestrian environment. Bollards along corners keep motorists from crossing into the pedestrian space. Bollards protect people on foot from errant vehicles.

Raised intersections are flush with the sidewalk with a slight lip or other tactile measure as a warning to visually impaired people. Crosswalks do not need to be marked. ADA-compliant paths are always required. The "Raised Pedestrian Crossing" sign (W11-2A) should be used.

5.3.14.1. National Guidelines

NACTO *Urban Street Design Guide (2013)* provides additional design guidance and direction.

Figure 5-18: Raised Intersection

Orenco, OR. Credit: Mike Packard (SSFM International)

Figure 5-17: Raised Intersection

Credit: Urban Street Design Guide (NACTO)

5.3.15. Rectangular Rapid Flashing Beacon

The Rectangular Rapid Flashing Beacon (RRFB) uses rectangular-shaped high-intensity LED-based indications, flashes rapidly in a wig-wag "flickering" flash pattern, and is typically mounted between the crossing sign and the sign's supplemental arrow plaque.

The RRFB offers significant potential safety and cost benefits because it achieves very high rates of compliance at a very low cost compared to other more restrictive devices such as full mid-block signalization. Additional cost savings exist when solar power is used. The components of the RRFB are not proprietary and can be assembled by any jurisdiction with off-the-shelf hardware.

The FHWA believes that the RRFB has a low risk of safety or operational concerns. Use of RRFBs should be limited to locations with the most critical safety concerns, such as pedestrian and school crosswalks at uncontrolled locations, and as tested in experimentation. It has been noted that proliferation of RRFBs in the travel way environment - to the point that they become ubiquitous - could decrease their effectiveness.

Figure 5-19: Rectangular Rapid-Flash Beacon

Lihue, Kauai. Credit: Mike Packard (SSFM International)

5.3.16. Pedestrian Hybrid Beacon

A pedestrian hybrid beacon is used to warn and control traffic at an unsignalized location so as to help people on foot cross a street or highway at a marked crosswalk.

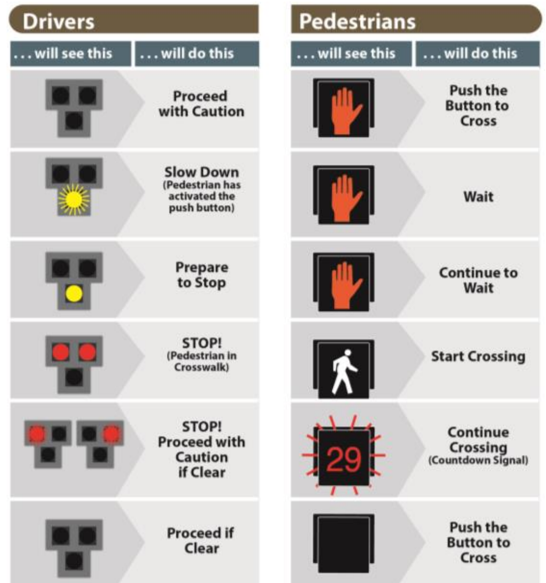
A pedestrian hybrid beacon can be used at a location that does not meet traffic signal warrants or at a location that meets traffic signal warrants but a decision has been made to not install a traffic control signal. A minimum number of 20 pedestrians per hour is needed to warrant installation, which is substantially less than the minimum of 93 pedestrians needed for a signal installation. In addition, minimum vehicular approach volumes and crossing lengths must be met.

If pedestrian hybrid beacons are used, they should be placed in conjunction with signs, crosswalks, and advance stop lines to warn and control traffic at locations where people on foot enter or cross a travel way. A pedestrian hybrid beacon should only be installed at a marked crosswalk.

Figure 5-20: Pedestrian Hybrid Beacon

Waimea, Hawaii Island. Credit: David Tarnas (Marine and Coastal Solutions International, Inc.)

Figure 5-21: Pedestrian Hybrid Beacon Phases



Credit: Michele Weisbart (Michele Designs)

5.3.17. Pedestrian Toolbox for Railroad Crossings

Pedestrian crossings of railroad tracks apply a special set of tools. The following are the primary tools to apply:

- Pedestrian gates
- Channelization of pedestrians through gates and across tracks
- Warning flashers
- Signs
- Audible signals

More details can be found in *Pedestrian Rail Crossings in California*, Richard Clark, California Public Utilities Commission, May 2008.

Grade-separated crossings should be considered as access to train stations where the station level is above the street.

CHAPTER 6: BICYCLE FACILITY

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Chapter 6 Cover Image: South King Street. Credit: Mike Packard (SSFM International)

CHAPTER 6: BICYCLE FACILITY

6.1. Introduction

People on bicycles operate a vehicle and are legitimate road users, but they are slower and less visible than motor vehicles. The following principles form the recommendations made in this chapter:

- People on bicycles of all ages and levels should have safe and convenient access to all destinations.
- Every street can be used by people on bicycles, regardless of bikeway designation, unless specifically prohibited through signage.
- People on bicycles should have a separated facility from people on foot and motor vehicles, whenever possible and practical.
- Bikeway treatments should be easily understood by all users.

Figure 6-1: Proficient Bicycle User

Waialae Ave. Credit: Alan Fujimori (SSFM International)

- Bikeway facilities should accommodate the needs of visitors to Honolulu and people not accustomed to bicycling.
- Bikeway facilities should take into account vehicle speeds and volumes, with:
  - Shared use on low volume, low-speed roads.
  - Separation on higher volume, higher-speeds roads.
- Since most bicycle trips are short, a complete network of designated bikeways shall have a grid of roughly ½ mile with long haul bikeways connecting networks. Bikeways within the ½-mile grid should be made up of facilities accessible to most people on bicycles.
- The inclusion of bikeways should be considered as an integral part of designing a multimodal street, and bikeway design needs to be a part of the initial planning and design phases of any travel way or development project.

Figure 6-2: Novice Bicycle User

Wanaao Road. Credit: Mike Packard (SSFM International)

6.2. Planning for a Range of Bikeway Users

People on bicycles need accommodation on busy, high-speed roads, and at complex intersections because they are more vulnerable in a crash than motorists. In congested urban areas, people on bicycles provided with well-designed facilities can often proceed faster than motorists.

People on bicycles use their own power, must constantly maintain their balance, and do not like to interrupt their momentum. Although roundabouts and traffic circles may increase travel distrances, they can benefit people on bicycles by decreasing conflict points and allowing people on bicycles to keep their momentum. Typical speeds of people on bicycles ranges from 10 to 15 mph, enabling them to make trips of up to 5 miles in urban areas in about 25 minutes, the equivalent of a typical suburban commuter trip time in a motor vehicle. People on bicycles may wish to ride side-by-side so they can interact socially with a riding companion.

Skill levels of people on bicycles contribute to a wide variety of speeds and expected behaviors. Several systems of bicycle user classification are used within the bicycle planning and engineering professions. These classifications can be helpful in understanding the characteristics and infrastructure preferences of different people riding bicycles. These classifications may change in type or proportion over time as infrastructure and culture evolve. Bicycle infrastructure should use planning and designing options, from shared roadways to separate facilities, to accommodate as many user types as possible and to provide a comfortable experience for the greatest number of people riding bicycles.

Figure 6-3: People on Bicycles Are Legitimate Road Users

Paki Ave. Credit: Alan Fujimori (SSFM International)

6.2.1. Bikeway Users

A classification system developed by the City of Portland, Oregon, provides the following bicycle user types:

- **Strong and Fearless**. People on bicycles who will ride anywhere regardless of travel way conditions. These people can ride faster than other user types, prefer direct routes, and will typically choose roadways, even if shared with vehicles, over separate bicycle facilities such as paths. This group represents a very low percentage of the population.
- **Enthused and Confident**. This group encompasses intermediate bicycle users who are mostly comfortable riding on all types of bicycle facilities but will usually prefer low traffic streets, bike lanes, or separate paths when available. They may deviate from a more direct route in favor of a preferred facility type. This group includes commuters, utilitarian cyclists, and recreational cyclists, and probably represents less than 10 percent of the population.
- **Interested but Concerned.** This user type makes up the bulk (likely between half and two-thirds) of the current and potential cycling population. They are people who typically ride only on low traffic streets or paths under favorable conditions and weather. They perceive traffic and safety as significant barriers towards increased use of cycling. These users may become "Enthused and Confident" with encouragement, education, and experience.
- **No Way, No How**. People in this category are not bicycle users; they perceive severe safety issues with riding in traffic and will never ride a bicycle under any circumstances. But some may eventually give cycling a second look and may progress to another user type. This group likely comprises something between a quarter and a third of the population.

In Honolulu some of the primary challenges facing people that bicycle are:

- Spatial constraints (i.e., insufficient right-of-way width);
- Topographic changes in hillside or valley neighborhoods;
- Lack of facilities and emphasis on shared roadways;
- Lack of confidence to ride in city streets;
- An entrenched driving culture;
- Discontinuous bikeway network with many gaps;
- Limited separation from motorized traffic; and,
- High occurence of bicycle theft.

Figure 6-4: Many People on Bicycles Prefer Separate Paths

Kapahulu Avenue Path, Credit: Ryan Nakamoto (SSFM International)

6.3. Oahu Bike Plan

The 2012 *Oahu Bike Plan* guides bikeway facility planning for the entire island of Oahu using best practices at the time. The *Oahu Bike Plan* provides recommendations for the development of a regional network of new bikeways, most within existing street rights-of-way. These are made up of an extensive network of:

- Bike Routes;
- Bike Lanes; and,
- Bike Paths.

Since 2012, alternatives to bike lane design have been developed to include wider pavement marking separation and/or vertical delineation beyond raised pavement markers for added safety. These are refered to as buffered bike lanes or protected bike lanes, respectively and should be implemented when space exists or additional protection is deemed neccesary. The term “Bike Lanes” can be assumed to include Protected Bike Lanes and Buffered Bike Lanes, except where noted.

6.4. Bicycle Network

The field of bikeway facility design is rapidly evolving and best practices are under refinement. Therefore, this chapter will need periodic refreshment to match the latest practices. The NACTO *Urban Bikeway Design Guide* is frequently updated and provides a detailed reference on various bicycle facility treatments.

A designated bikeway network provides a system of facilities that offers enhancement or priority to people on bicycles over other travel ways in the network. However, it is important to remember that all streets in a city should safely and comfortably accommodate people on bicycles, regardless of whether the street is designated as a bikeway. Several general types of bikeways are listed below with no implied order of preference. Local jurisdictions often *read* minimum bikeway widths in standards to mean *exact dimension*. Wherever possible, these minimums should be exceeded as wider and more protected bikeways provide for a more desireable bicycling environment.

Figure 6-5: Absence of Dedicated Bicycle Facilities

Hahani Street. Credit: Mike Packard (SSFM International)

6.4.1. Integrating with the Street System

Most bikeways are part of the street; therefore, well-connected street systems are very conducive to bicycling, especially those that provide direct access to destinations with a fine-meshed network of low-volume, low-speed streets suitable for shared travel ways. In less well-connected street systems, where wide streets carry the bulk of traffic, people on bicycles need supplementary facilities, such as short sections of protected bike facilities, paths and bridges to connect otherwise unconnected streets.

As a general rule, as traffic volumes and speeds increase, greater separation from motor vehicle traffic is desirable. Other factors to consider are users (more children or recreational cyclists may warrant greater separation), adjacent land uses (multiple driveways may cause conflicts with bike lanes and cycle tracks), available right-of-way (separated facilities require greater travel way width), and costs.

As a general rule, designated bicycle facilities (e.g., bike lanes) should be provided on all Parkways, Boulevards, and Avenues. These street generally are the most direct and offer the greatest connectivity in the network, and are typically where destinations are located. There are occasions when it is infeasible or impractical to provide bikeway facilities on a busy street, or the street does not serve the mobility and access needs of people on bicycles.

Off-street paths can also be used to provide transportation in corridors otherwise not served by the street system, such as along rivers and canals, through parks, or along utility corridors. While paths offer the safety and scenic advantages of separation from traffic, they must also offer frequent connections to the street system and to destinations such as residential areas, employment sites, shopping, schools, and other points of interest. Street crossings must be well designed with measures such as signals or median refuge islands.

Figure 6-6: Bike Network Gaps Cause Confusion

Young St. at Thomas Square. Credit: Alan Fujimori (SSFM International)

6.4.2. Bike Routes

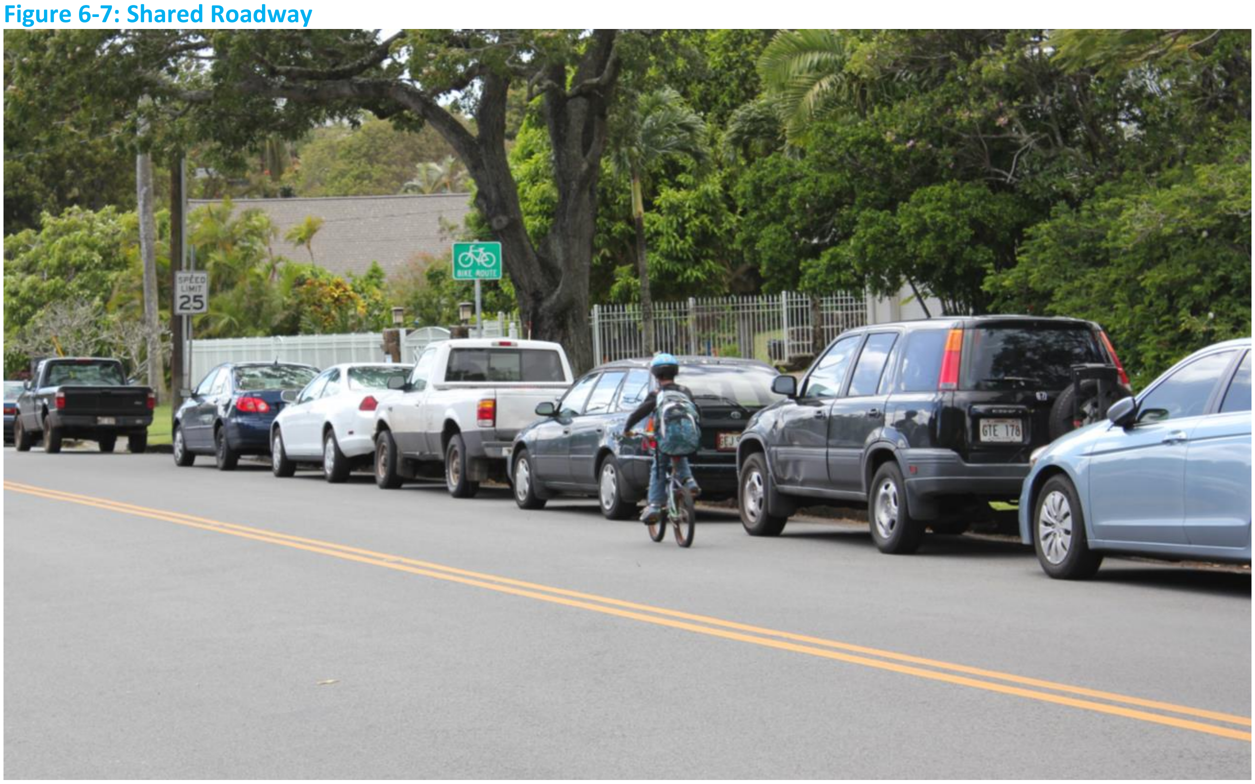
A Bike Route is a travel way section that has been designated as a recommended bicycle touring route and is often accompanied by signage. Bike Routes can utilize a variety of travel way cross-sections.

6.4.2.1. Shared Roadway

A shared roadway is a street in which people on bicycles ride in the same travel lanes as other traffic. There are no specific dimensions for shared roadways. On narrow travel lanes, motorists have to provide a minimum of three feet to pass a person on a bicycle which may require crossing over into the adjacent travel lane. Shared roadways work well and are common on low-volume, low-speed neighborhood residential streets, rural roads, and even many low-volume highways. The suitability of a shared roadway decreases as motor vehicle traffic speeds and volumes increase, especially on rural roads with poor sight distance.

Many local streets carry excessive traffic volumes at speeds higher than they were designed to carry. These can function better as shared roadway if traffic speeds and volumes are reduced. For a local street to function acceptably as a shared roadway, traffic volumes should not be more than 3,000 to 5,000 vehicles per day, and speeds should be 25 mph or less. If traffic speeds and volumes exceed those thresholds, dedicated facilities (e.g., Bike Lanes) should be considered or traffic calming should be applied to reduce the vehicle speeds/volumes. Many traffic-calming techniques can make these streets more amenable to bicycling.

Figure 6-7: Shared Roadway



Oahu Avenue. Credit: Mike Packard (SSFM International)

6.4.2.2. Sharrows

Shared-lane marking stencils (also commonly called “sharrows”) may be used as an additional treatment for shared roadways. The stencils can serve a number of purposes: they remind people on bicycles to ride further from parked cars to prevent “door zone” collisions; they increase visibility of people on bicycles and make motorists aware of bicycles potentially in the travel lane; and, they show people on bicycles the correct direction of travel and suggested route. Sharrows are only appropriate on low-volume and low-speed roads or in certain circumstances when making connections between other bicycle facilities.

Figure 6-9: Sharrow Marking on a Two-Lane Road

Isenberg St. Credit: Alan Fujimori (SSFM International)

Figure 6-8: Sharrow Marking on a Four-Lane Road

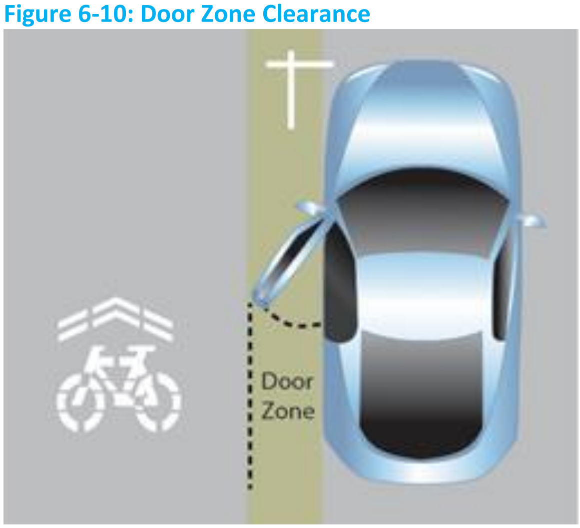
Waialae Ave. Credit: Alan Fujimori (SSFM International)

6.4.2.2.1 Sharrow Design Guidelines

Sharrows installed next to parallel parking should be a minimum distance of 11 feet from the curb. Installing them farther than 11 feet from the curb is desired in areas with wider parking lanes or in situations where the sharrow is best situated in the center of the shared travel lane to promote people riding bicycles taking the entire lane when that is the safest option.

Sharrows should not be placed in the door zone of parked cars. Placing the sharrow between vehicle tire tracks increases the life of the markings and decreases long-term maintenance costs.

Figure 6-10: Door Zone Clearance



Credits: Michele Weisbart (Michele Designs)

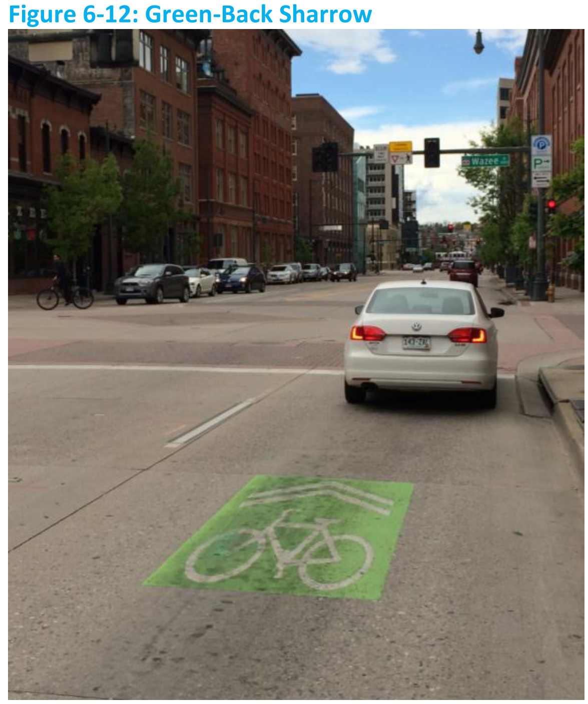
Sharrows can also help people on bicycles navigate along a bikeway route. Where shared lane markings are used for wayfinding and identifying where a Bike Route turns, the chevron marking may be tilted to direct people on bicycles to follow the route.

Figure 6-11: Shared Lane Marking as Wayfinding

Portland, OR. Credit: Mike Packard (SSFM International)

Sharrows can be made more prominent using a larger size or colored backing. The "green-back sharrow" is one example of this.

Figure 6-12: Green-Back Sharrow



Denver, CO. Credit: Mike Packard (SSFM International)

6.4.2.3. Wide Curb Lanes on Streets

Wide curb lanes may encourage higher motor vehicle speeds, which is contrary to the design principles of this Manual. Wide lanes should never be used on local residential streets. The minimum bike lane width is 5 feet. Where bike lanes would be more appropriate, but insufficient width exists, wide curb lanes may be provided. This may occur on retrofit projects where there are physical constraints and all other options, such as narrowing travel lanes, have been pursued. Wide curb lanes are not particularly attractive to most people riding bicycles; they simply allow a passenger vehicle to pass people riding bicycles within a travel lane if people riding bicycles are riding far enough to the right. A 14 to 15-foot wide lane is sufficient to allow a passenger car to pass a person on a bicycle in the same lane. Widths 16 feet or greater may encourage the undesirable operation of two motor vehicles in one lane. In this situation, a bike lane should be marked.

Figure 6-13: Wide Curb Lanes

Farmers Rd. Credit: Alan Fujimori (SSFM International)

6.4.2.4. Shoulder Bikeways

When providing shoulders for bicycle use, a minimum width of 6 feet is recommended. This allows a person on a bicycle to ride far enough from the edge of pavement to avoid debris and far enough from passing vehicles to avoid conflicts. On roads with prevailing speeds over 45 mph or where the shoulder is shared with people on foot, 8 feet is preferred. This may be divided between a 2-foot buffer and a 6-foot bike lane. If there are physical width limitations, a minimum 4-foot shoulder may be used.

Figure 6-14: Shoulder Bikeway

South Kalaheo Ave. Credit: Mike Packard (SSFM International)

6.4.2.5. Bicycle Boulevards

A Bicycle Boulevard is an enhanced shared roadway that is modified to function as a prioritized route for people on bicycles while maintaining local access for automobiles. This is done by adding traffic-calming devices to reduce motor vehicle speeds (20 mph or below) and through trips. This can also be done by installing traffic controls that limit conflicts between motorists and people on bicycles and give priority to through bicyclist movement.

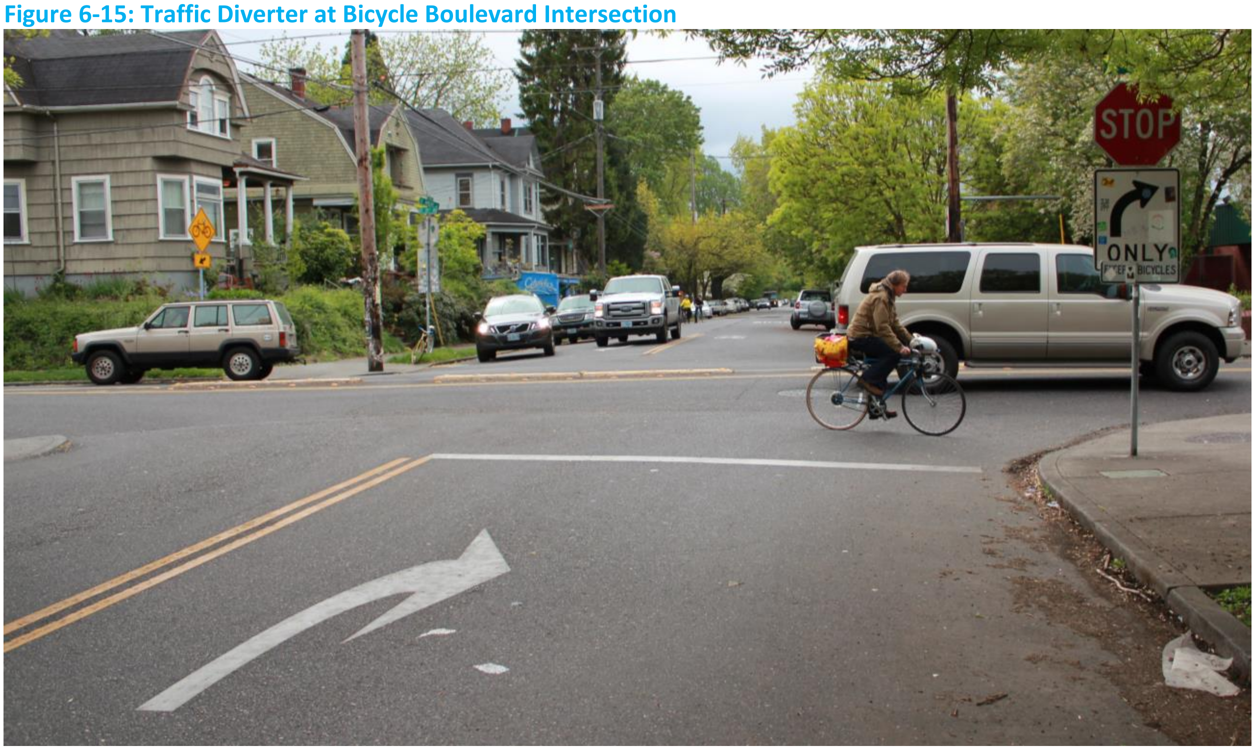
One key advantage of Bicycle Boulevards is that they attract people riding bicycles who do not feel comfortable on busy streets and prefer to ride on lower traffic streets.

Bicycle Boulevards are usually residential neighborhood streets or streets parallel to major streets. By reducing traffic and improving crossings, Bicycle Boulevards also improve conditions for people on foot. Residents who want slower traffic on neighborhood streets often like measures that support Bicycle Boulevards. Successful Bicycle Boulevard implementation requires careful planning with residents and businesses to ensure acceptance.

A successful Bicycle Boulevards includes the following design elements:

- Selecting a direct and continuous street, rather than a circuitous route that winds through neighborhoods. Bicycle Boulevards work best on a street grid. If any traffic diversion will likely result from the Bicycle Boulevard, selecting streets that have parallel higher-level streets can prevent unpopular diversions to other residential streets.
- Placing motor vehicle traffic diverters at key intersections to reduce through motor vehicle traffic (diverters are designed to allow through bicyclist movement).

Figure 6-15: Traffic Diverter at Bicycle Boulevard Intersection



Portland, OR. Credit: Mike Packard (SSFM International)

- Turning stop signs towards intersecting streets, so people on bicycles can ride with few interruptions.
- Replacing stop-controlled intersections with mini-circles and mini-roundabouts to reduce the number of stops people riding bicycles have to make.
- Installing traffic calming devices to lower motor vehicle traffic speeds.
- Placing wayfinding and other signs or markings (e.g., sharrows) to route people riding bicycles to key destinations, to guide people riding bicycles through difficult situations, and to alert motorists of the presence of people on bicycles.
- Where the Bicycle Boulevard crosses high-speed or high-volume streets, providing crossing improvements such as:
  - Signals, where a traffic study has shown that a signal is warranted and will be safe and effective. To ensure that people on bicycles can activate the signal, loop detection should be installed in the pavement where people on bicycles ride.
  - Roundabouts where appropriate.
  - Median refuges wide enough to provide a refuge (8 feet minimum) and with an opening wide enough to allow people on bicycles to pass through (6 feet). The design should allow people on bicycles to see the travel lanes they must cross.

Figure 6-16: Traffic Humps, Bump Outs and Sharrows Along Bike Boulevard

Portland, OR. Credit: Mike Packard (SSFM International)

6.4.3. Bike Lanes

Bike lanes are a portion of the travel way designated for preferential use by people on bicycles. They are required on Boulevards and Parkways; they are a high priority on Avenues and Main Streets. Bike lanes may also be provided on rural roads where there is high bicycle use. Bike lanes are generally not recommended on local streets with relatively low traffic volumes and speeds, where a shared roadway is the appropriate facility. As a general rule, bike lanes should be considered on roads with traffic volumes in excess of 3,000-5,000 ADT or posted speed limits of 30 mph or greater.

Bike lanes have the following advantages:

- They enable people riding bicycles to ride at a constant speed, especially when traffic in the adjacent travel lanes speeds up or slows down (stop-and-go);
- They enable people on bicycles to position themselves where they will be visible to motorists; and
- They encourage people riding bicycles to ride in the travel way rather than on the sidewalk.

Bike lanes are created with a solid marking and stencils. Motor vehicles are prohibited from using bike lanes for driving and parking, but may use them for emergency avoidance maneuvers or breakdowns. Bike lanes are one-way facilities that carry bicycle traffic in the same direction as adjacent motor-vehicle traffic unless otherwise marked, as in the case of a two-way bike facility or contra-flow bike lane. Bike lanes should be provided on both sides of a two-way street except where width is insufficient. Another exception is on hills where topographical constraints limit the width to a bike lane on one side only. In that instance, the bike lane should be provided in the uphill direction as people riding bicycles ride slower uphill. They can ride in a shared lane in the downhill direction.

The minimum bike lane width is 5 feet from the face of a curb, although 6 feet is preferred, or 4 feet on open shoulders. Bike lanes located between on-street parking and the travel lane should be 6 feet wide, so people riding bicycles can ride outside the door zone. However, where travel way widths are constrained, a 5 foot bike lane may be installed next to a 7 foot parking lane. Streets with high volumes of traffic and/or higher speeds need wider bike lanes, buffers, or physical protection. On curbed sections, a 4-foot (minimum 3-feet) wide smooth surface should be provided between the gutter pan and lane marking.

This minimum width enables people riding bicycles to ride far enough from the curb to avoid debris and drainage grates and far enough from other vehicles to avoid conflicts. By riding further away from the curb, people riding bicycles are more visible to motorists than when hugging the curb. Where on-street parking is permitted, delineating the bike lane and parking with separate pavement markings is required.

Figure 6-17: Bike Lane Adjacent to Curb

Kailua Road. Credit: Mike Packard (SSFM International)

6.4.3.1. Bike Lanes on Two-Way Streets

The majority of bike lanes are on two-way streets. They should follow the design guidelines for bike lane width with and without on-street parking and curbs. Treatments at intersections are dependent on the intersection control.

6.4.3.2. Bike Lanes on One-Way Streets

Bike lanes on one-way streets should generally be on the right side of the travel way and should always be provided on both legs of a one-way couplet. The bike lane may be placed on the left of a one-way street if it decreases the number of conflicts (e.g., those caused by heavy bus traffic or parking) and if people riding bicycles can safely and conveniently transition in and out of the bike lane. If sufficient width exists, the bike lanes can be marked on both sides.

Figure 6-18: Marked Bike Lanes at Roundabout with Ramp to Sidewalk

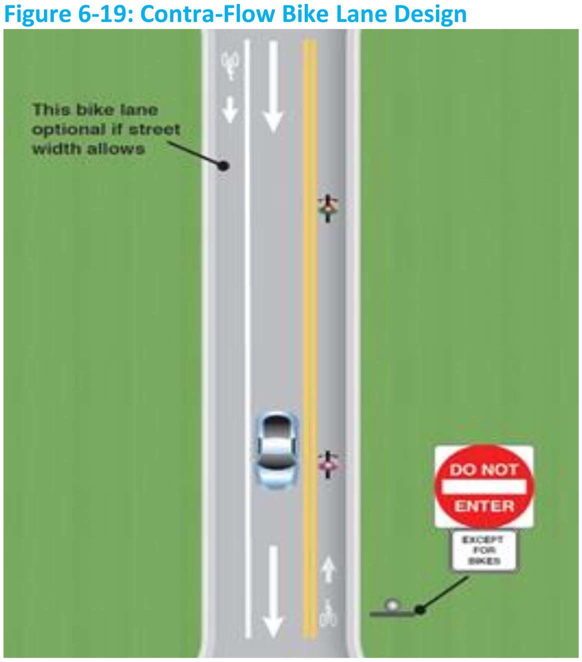
University Place, WA. Credit: Mike Packard (SSFM International)

6.4.3.3. Contra-Flow Bike Lanes

Contra-flow bike lanes are provided to allow people on bicycles to ride in the opposite direction of motor vehicle traffic. They convert a one-way traffic street into a two-way street: one direction for motor vehicles and bikes and the other for bikes only. Right side contra-flow lanes are separated with yellow center lane markings. Combining both directions of bicycle travel on one side of the street to accommodate contra-flow movement and adding a physical barrier results in a two-way protected bike lane.

Contra-flow bike lanes are useful where they provide a substantial savings in out-of-direction travel with direct access to high-use destinations. Safety is improved because of reduced conflicts compared to the longer route. The contra-flow design introduces new design challenges and may create additional conflict points as motorists may not expect on-coming people on bicycles.

Figure 6-19: Contra-Flow Bike Lane Design



Credit: Michele Weisbart (Michele Designs)

6.4.3.4. Climbing Bike Lanes

Climbing bike lanes should be considered on two-way streets with steep slopes and inadequate widths to permit 5-foot bike lanes in both directions. Climbing lanes are a hybrid combination of a 5-foot (minimum) bike lane on the uphill side of the travel way and shared lane markings in the downhill direction. People on bikes traveling in an uphill direction tend to move significantly slower than adjacent vehicular traffic, and therefore benefit from the presence of a bike lane.

When travelling downhill, people on bikes gain momentum and the speed differential between bicycles and vehicles is lower; therefore, shared lane markings are used in the downhill direction. Debris also tends to collect at the edge of downhill lanes, creating hazards for people on bikes confined to a bike lane. If on-street parking is present in the downhill direction, it is important to ensure that people on bikes are directed to ride in a location outside of the door zone. The uphill bike lane width should be a minimum of 5 feet wide, while 6 feet is prefered for extra maneuvering room on steep grades.

Figure 6-20: Left-Side Bike Lane and Contra-flow Bike Lane

Lihue, Kauai. Credit: Mike Packard (SSFM International)

6.4.3.5. Shared Bus Lanes

Where adequate space exists, separate bus lanes and bike lanes should be designed to reduce conflicts between buses and people on bicycles. Where insufficient space exists for separate bus and bike lanes, bicycles and buses can share the street space.

Where a separate bus lane and a protected bike lane exist, bus stop islands can be used at the intersection to maintain the separation.

Figure 6-22: Bus Stop Islands Can Maintain Separation From Bike Lanes

Portland, OR. Credit: Mike Packard (SSFM International)

Figure 6-21: Shared Bus and Bike Lane

Kalakaua Avenue at Pau Street. Credit: Alan Fujimori (SSFM International)

6.4.3.6. Buffered Bike Lanes

Buffered bike lanes provide a painted divider between the bike lane and the travel lanes. This additional space can improve the comfort of people riding bicycles as they do not have to ride as close to motor vehicles. Buffered bike lanes can also be used to slow traffic as they narrow the travel lanes. An additional buffer may be used between parked cars and bike lanes to direct people riding bicycles to ride outside of the door zone of the parked cars.

Ideally, a buffer will be provided both between the travel lane and the parking lane. Where insufficient space exists for both buffers, traffic volumes, speeds, and parking turnover should be considered as criteria for putting the buffer on the travel side or the parking side. Streets with high parking turnover, lower traffic volumes, and lower vehicle speeds favor the buffer on the parking side. Buffered bike lanes are most appropriate on busy streets, high-speed streets, or streets with significant parking turnover where protected bike lanes are undesirable for cost, operational, or maintenance reasons. The painted buffers should be a minimum of 18 inches wide on both the travel lane side and the parking lane side, although two to three feet is preferred.

Figure 6-23: Painted Buffered Bike Lanes

Seattle, WA. Credit: Mike Packard (SSFM International)

6.4.3.7. Protected Bike Lanes

Protected bike lanes, also known as cycle tracks or separated bike lanes, are bikeways located on or adjacent to streets where bicycle traffic is separated from motor vehicle traffic by physical barriers, such as on-street parking, posts/bollards, curbing, or landscaped islands. Less experienced riders often require this level of protection in order to feel comfortable riding along high-speed high-volume roads. Ideally, streets selected for protected bike lanes should have minimal pedestrian crossings and driveways. They should also have minimal loading/unloading activity and other curb side activity. The protected bike lanes should be designed to minimize conflicts with these activities as well as with people on foot and driveways.

The area to be used by bicycles should be designed with adequate width for street sweeping to ensure that debris will not accumulate. Protected bike lanes work most effectively where there are few uncontrolled crossing points with unexpected traffic conflicts.

Protected bike lane concerns include treatment at intersections, uncontrolled mid-block driveways and crossings, wrong-way bicycle traffic, and difficulty accessing or exiting the facility at mid-block locations.

Measures such as separate signal phases for turning motor vehicles and people riding through on bicycles, and turning people on bicycles and through motor vehicles, can be deployed to regulate crossing traffic.

Protected bike lanes can be either one-way or two-way facilities. Two-way protected bike lanes require less street width than one-way protected bike lanes since there is only one protected buffer needed. They also require more complex treatments at intersections.

Similar to buffered bike lanes, protcted bike lane buffers should be a minimum of 18 inches wide adjacent to a travelway and 3 feet when adjacent to a parking lane.

Figure 6-24: One-Way Protected Bike Lane

Seattle, WA. Credit: Mike Packard (SSFM International)

6.4.3.8. Raised Bike Lanes

Bike lanes are typically an integral portion of the travel way and are delineated from motor vehicle lanes with painted markings. Though the majority of people on bicycles ride on these facilities comfortably, less confident riders prefer more separation from vehicles. Raised bike lanes incorporate the convenience of riding on the street with some physical separation. This is done by elevating the bicycle lane surface 1 to 6 inches above street level; thus, separating the bikeway from the motor vehicle travel way. This treatment offers the following advantages:

- Mountable curbs can be used at driveways to provide vehicular access.
- The mountable curb allows people riding bicycles to enter or leave the bike lane (e.g., for turning left or overtaking another person on a bicycle).
- The raised bike lane drains towards the center line, leaving it clear of debris and puddles.
- People new to bicycling are more likely to ride in the bike lane, leaving the sidewalk for people on foot.

Raised bike lanes can be constructed at little additional expense for new roads. Retrofitting streets with raised bike lanes is more costly; it is best to integrate raised bike lanes into a larger project to remodel the street due to drainage replacement. Special maintenance procedures may be needed to keep raised bike lanes swept. Raised bicycle lanes are considered a type of protected bike lane.

Figure 6-25: Raised Two-Way Protected Bike Lanes

Seattle, WA. Credit: Mike Packard (SSFM International)

6.4.4. Bike Path

Bike Paths are also known as shared use paths or multi-use paths since they may be used by people on foot, people on bicycles, skaters, and other permitted users. Bike Paths are beneficial to a bikeway network in that all levels of people on bikes feel comfortable riding on them due to the lack of conflicts with motor vehicles.

Bike Paths should be a minimum of 8 feet wide with 2 feet of graded shoulder on each side. This width is suitable in rural or small-town settings. Generally, 12 feet of paved path is preferred. Wider pavement may be needed in high-use areas. Where there are a significant number of users, either wider pavement or separate modal paths help to eliminate conflicts. Most important in designing Bike Paths is good design of intersections where they cross streets. These crossings should be designed as intersections with appropriate treatment.

6.4.5. National Guidelines

Additional considerations for the design of bike facilities and amenities should follow the guidelines from the most recent versions of the *MUTCD* (FHWA, 2009), *Guide for the Development of Bicycle Facilities* (AASHTO, 2013), and *Urban Bikeway Design Guide* (NACTO, 2012).

6.5. Bikeway Design Guidelines

Table 6-1 outlines general considerations for different bikeway types per *AASHTO Guide to Bicycle Facilities, 4th Edition*.

Figure 6-26: Curb Side Shared Use Path

Date Street Bike Path. Credit: Alan Fujimori (SSFM International)

Table 6-1: General Considerations for Different Bikeway Types

Type of Bikeway	Best Use	Motor Vehicle Design Speed	Traffic Volume	Classification or Intended Use	Other Considerations
Shared Lanes (No special Provisions)	Minor roads with low volumes, where bicyclists can share the road with no special provisions	Speeds vary based on location (rural or urban)	Generally less than 1,000 vehicles per day	Rural roads, or neighborhood or local streets	Can provide an alternative to busier highways or streets. May be circuitous, inconvenient, or discontinuous.
Shared Lanes (Wide outside lanes)	Major roads where bike lanes are not selected due to space constraints or other limitations	Variable. Use as the speed differential between bicyclist and motorists increases. Generally any road where the design speed is more than 25mph.	Generally less than 3,000 vehicles per day	Arterials and collectors intended for major motor vehicles traffic movements	Explore opportunities to provide marked shared lanes, paved shoulder, or bike lanes for less confident bicyclists
Marked Shared Lanes	Space-constrained roads with narrow travel lanes, or road segments upon which bike lanes are not selected due to space constraints or other limitations	Variable. Use where the speed limit is 35 mph or less	Variable. Useful where there is high turnover in on-street parking to prevent crashes with open car doors	Collectors or minor arterials	May be used in conjunction with wide outside lanes. Explore opportunities to provide parallel facilities for less confident bicyclists. Where motor vehicles allowed to park along shared lanes, place markings to reduce potential conflicts with opening car doors
Paved Shoulders	Rural highways that connect town centers and other major attractors	Variable. Typical posed rural highway speeds (generally 40-55 mph)	Variable	Rural roadways; inter-city highways	Provides more shoulder width for roadway stability. Shoulder width should be dependent on characteristics of the adjacent motor vehicle traffic, i.e. wider shoulders on higher speed and/or higher-volume roads
Bike Lanes	Major roads that provide direct, convenient, quick access to major land uses. Also can be used on collector roads and busy urban streets with slower speeds.	Generally, any road where the design speed is more than 25 mph	Variable. Speed differential is generally a more important factor in the decision to provide bike lanes than traffic volumes	Arterials and collectors intended for major motor vehicles traffic movements	Where motor vehicles are allowed to park adjacent to bike lane, provide a bike lane of sufficient width to reduce probability of conflicts due to opening vehicle doors and objects in the road. Analyze intersections to reduce bicyclist/motor vehicle conflicts

Source: Guide for the Development of Bicycle Facilities (AASHTO, 2012)

Table 6-2: General Considerations for Different Bikeway Types (cont.)

Type of Bikeway	Best Use	Motor Vehicle Design Speed	Traffic Volume	Classification or Intended Use	Other Considerations
Bicycle Boulevards	Local roads with low volumes and speeds, offering an alternative to, but running parallel to, major roads. Still should offer convenient access to land use destinations	Use where the speed differential between motorists and bicyclists is typically 15 mph or less. Generally posted limits of 25 mph or less.	Generally less than 3,000 vehicles per day	Residential roadways	Typically only an option for gridded street networks. Avoid making bicyclists stop frequently. Use signs, diverters, and other treatments so that motor vehicle traffic is not attracted from arterials to bicycle boulevards
Shared use path: Independent right-of-way	Linear corridors in greenways, or along waterways, freeways, active or abandoned rail lines, utility rights-of-way, unused rights-of-way. May be a short connection, such as a connector between two cul-de-sacs, or a longer connection between cities	N/A	N/A	Provides a separated path for non-motorized users. Intended to supplement a network of on-road bike lanes, shared lanes, bicycle boulevards, and paved shoulders	Analyze intersections to anticipate and mitigate conflicts between path and roadway users. Design path with all users in mind, wide enough to accommodate expected usage on road alternatives may be desired for advanced riders who desire a more direct facility that accommodates higher speeds and minimizes conflicts with intersection and driveway traffic, pedestrians, and young bicyclists
Shared use path: adjacent to roadways (i.e. sidepath)	Adjacent to roadways with no or very few intersections or driveways. The path is used for a short distance to provide continuity between sections of path on independent rights-of-way	The adjacent roadway has high-speed motor vehicle traffic such that bicyclists might be discouraged from riding on the roadway	The adjacent roadway has very high motor vehicle traffic volumes such that bicyclists might be discouraged from riding on the roadway	Provides a separated path for non-motorized users. Intended to supplement a network of on-road bike lanes, shared lanes, bicycle boulevards, and paved shoulders. Not intended to substitute or replace on-road accommodations for bicyclists, unless bicycle use is prohibited.	Several serious operational issues are associated with this facility type.

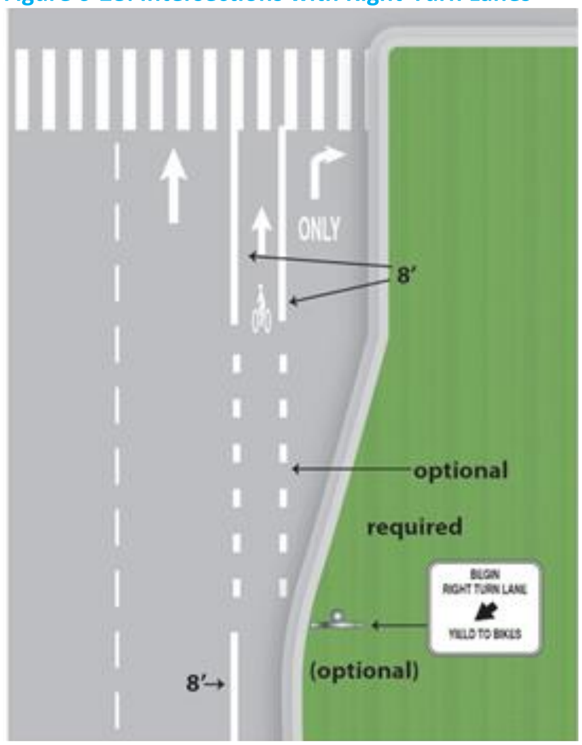
Source: Guide for the Development of Bicycle Facilities (AASHTO, 2012)

6.6. Intersection Bike Treatment

Intersections are junctions at which different modes of transportation meet and facilities overlap. A well-designed intersection facilitates the interchange between people on bicycles, people on foot, motorists, and bus transit so that people can travel in a safe and efficient manner. Designs for intersections with bicycle facilities should reduce conflicts between people on bicycles and vehicles by increasing separation, heightening visibility, denoting a clear right of way, and ensuring that the various users are aware of each other. Intersection treatments can resolve both queuing and merging maneuvers for people on bicycles, and are often coordinated with timed or specialized signals.

Chapter 4, "Intersection Design," provides general principles of geometric design; all these recommendations will benefit people riding bicycles. The configuration of a safe intersection for people on bicycles may include additional elements such as color, signs, medians, signal detection, and pavement markings. Intersection design should take into consideration existing and anticipated movements by people on foot, people on bicycles, and motorists.

Figure 6-28: Intersections with Right-Turn Lanes



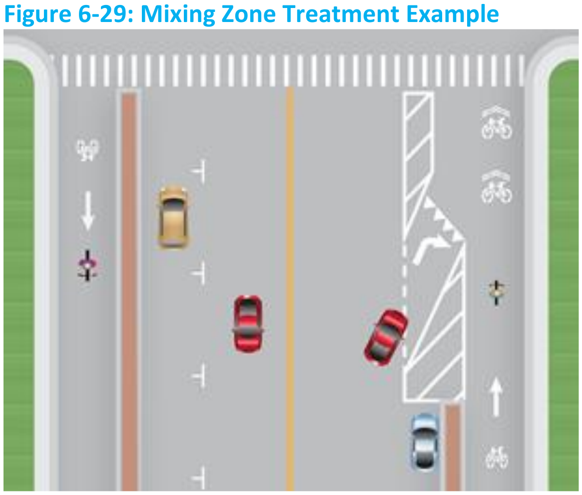
Credit: Michele Weisbart (Michele Designs)

Figure 6-27: Intersection with Right-Turn Lane Example

Keolu Drive at Hamakua Drive. Credit: Mike Packard (SSFM International)

In all cases, the degree of mixing or separation between people on bicycles and other modes is intended to reduce the risk of crashes and increase the comfort of people on bicycles. The level of treatment required for people on bicycles at an intersection will depend on the bicycle facility type used, whether bicycle facilities are intersecting, the adjacent street function, and the adjacent land use.

Figure 6-29: Mixing Zone Treatment Example

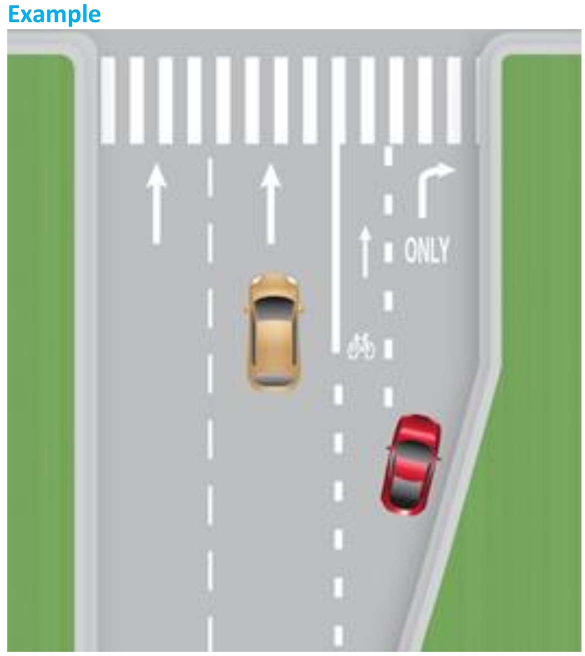


Credit: Michele Weisbart (Michele Designs)

Continuing marked bicycle facilities at intersections (up to the crosswalk) ensures that separation, guidance on proper positioning, and awareness by motorists are maintained through these potential conflict areas. The appropriate treatment for right-turn only lanes is to place a bike lane pocket between the right-turn lane and the rightmost through lane. If a full bike lane pocket cannot be accommodated, a shared bicycle/right turn lane can be installed that places a standard-width bike lane on the left side of a dedicated right-turn lane. A dashed marking delineates the space for people on bicycles and motorists within the shared lane. This treatment includes signs advising motorists and people on bicycles of proper positioning within the lane. Sharrows are another option for marking a bikeway through an intersection where a bike lane pocket cannot be accommodated.

Where insufficient space exists for both a bike lane and a right-turn lane, a combined bike and right-turn lane may be used. This delineates the bike lane on the left side of the right-turn lane, as shown below. Where a one-way protected bike lane approaches an intersection with a right-turn lane, a mixing zone may be created for a shared bike lane and right-turn lane.

Figure 6-30: Combined Bike Lane/Turn Lane Example



Credit: Michele Weisbart (Michele Designs)

At roundabouts, bicycles are given the option to share the lane with the vehicle or to access a ramp at the approach and depart the intersection onto a wide sidewalk shared with people on foot.

6.6.1. Bike Boxes

A bike box is a designated area at the head of a traffic lane at a signalized intersection that provides people on bicycles with a safe and visible way to get ahead of queuing traffic during the red signal phase. Right-turn-on-red should be prohibited where bike boxes exist. Bike boxes should be painted green to achieve maximum adherance by motorists.

Appropriate locations include:

- At signalized intersections with high volumes of bicycles and/or motor vehicles, especially those with frequent left-turns by people on bicycles and/or motorist right-turns.
- Where there may be right or left-turning conflicts between people on bicycles and motorists.
- Where there is a desire to better accommodate left-turning bicycle traffic.
- Where a left turn is required to follow a designated bike route or boulevard or access a shared-use path, or when the bicycle lane moves to the left side of the street.
- When the dominant motor vehicle traffic flows right and bicycle traffic continues through (such as at a Y intersection or access ramp).

Figure 6-32: Bike Box Example 2

Portland, OR. Credit: Samantha Thomas (Blue Zones)

Figure 6-31: Bike Box Example 1

Dole St at Lower Campus Rd. Credit: Alan Fujimori (SSFM International)

6.6.2. Two-Stage Turn Queue Boxes

On right side protected bike lanes, people on bicycles are often unable to merge into traffic to turn left due to physical separation. This makes the provision of two-stage left turns critical in ensuring these facilities are functional. The same principles for two-stage turns apply to both bike lanes and protected bike lanes. While two-stage turns may increase the comfort of people on bicycles in many locations, this configuration will typically result in higher than average signal delay for people on bicycles due to the need to receive two separate green signal indications (one for the through street, followed by one for the cross street) before proceeding.

Figure 6-34: Two-Stage Turn Box Example 1

Seattle, WA. Credit: Mike Packard (SSFM International)

Figure 6-33: Two-Stage Turn Box Example 2

Portland, OR. Credit: Mike Packard (SSFM International)

6.6.3. Bicycle Wayfinding

The ability to navigate through a region is provided by landmarks, natural features, signs, and other visual cues. Wayfinding is a cost-effective and highly visible way to improve the bicycling environment by familiarizing users with the bicycle network, helping users identify the best routes to destinations, addressing misperceptions about time and distance, and helping overcome a barrier to entry for infrequent people riding bicycles (e.g., "interested but concerned" people on bicycles).

A bikeway wayfinding system is typically composed of signs indicating direction of travel, location of destinations, and travel time/distance to those destinations; pavement markings indicating to people on bicycles that they are on a designated route or bike boulevard and reminding motorists to drive courteously; and maps providing users with information regarding destinations, bicycle facilities, and route options. The *MUTCD* (FHWA, 2009) provides guidance on the design of bicycle wayfinding signs.

Figure 6-36: Bicycle Wayfinding Sign Example 2

Seattle, WA. Credit: Mike Packard (SSFM International)

Figure 6-35: Bicycle Wayfinding Sign Example 1

Isenberg Street. Credit: Mike Packard (SSFM International)

6.6.4. Bicycle Signals

Bicycle signal heads may be installed at signalized intersections to improve identified safety or operational problems for people on bicycles. They provide guidance for people on bicycles at intersections where they may have different needs from other road users (e.g., bicycle-only movements and leading bicycle intervals) or to indicate separate bicycle signal phases and other bicycle-specific timing strategies. A bicycle signal should only be used in combination with an existing conventional or hybrid beacon. In the United States, bicycle signal heads typically use standard three-lens signal heads in green, yellow, and red with a stencil of a bicycle.

Figure 6-37: Bicycle Signal Head

Seattle, WA. Credit: Mike Packard (SSFM International)

6.6.4.1. Bicycle Countdowns

Near-side bicycle signals may incorporate a "countdown to green" display to provide information about how long until the green bicycle indication is shown, enabling people on bicycles to push off as soon as the light turns green.

6.6.4.2. Leading Bicycle Intervals

Based on the Leading Pedestrian Interval, a Leading Bicycle Interval (LBI) can be implemented in conjunction with a bicycle signal head. Under an LBI, people on bicycles are given a green signal while the vehicular traffic is held at all red for several seconds, providing a head start for them to advance through the intersection. This treatment is particularly effective in locations where people on bicycles are required to make a challenging merge or lane change (e.g., to access a left turn pocket) shortly after the intersection, as the LBI would give them sufficient time to make the merge before being overtaken by vehicular traffic. This treatment can be used to enhance a bike box.

6.6.4.3. Bicycle Signal Detection

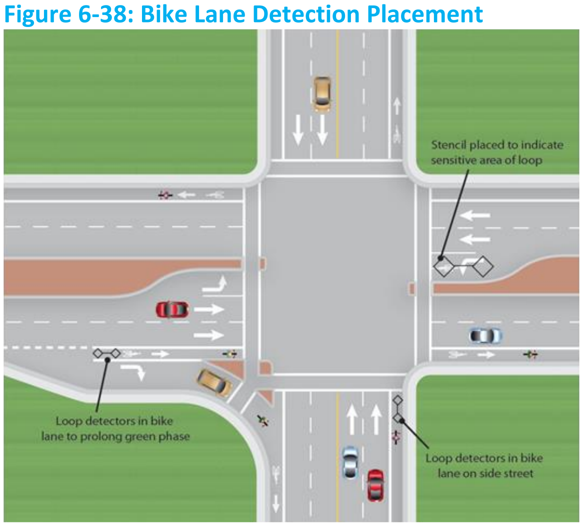
Bicycle detection is used at actuated traffic signals to alert the signal controller of bicycle crossing demand on a particular approach. Bicycle detection occurs either through the use of push buttons or by automated means (e.g., in-pavement loops, video, or microwave). Inductive loop vehicle detection at many signalized intersections is calibrated to the size or metallic mass of a vehicle, meaning that bicycles may often go undetected. The result is that people on bicycles must either wait for a vehicle to arrive, dismount, and push the pedestrian button (if available), or cross illegally. Loop sensitivity can be increased to detect bicycles.

Proper bicycle detection must accurately detect people on bicycles (be sensitive to the mass and volume of a bicycle and its rider). It must provide clear guidance to people on bicycles on how to actuate detection (e.g., what button to push or where to stand). For dedicated bicycle facilities, loop detectors can be placed in the bike lane to trigger the signal activation or to extend the green phase in the same direction. Per *MUTCD* (FHWA, 2009), where travel lanes are shared, a bicycle symbol may be placed on the pavement indicating the optimum position for a people on a bicycle to actuate the signal. Additionally, a R10-22 sign may be installed to supplement this pavement marking.

Figure 6-39: Bicycle Signal Detection Marking

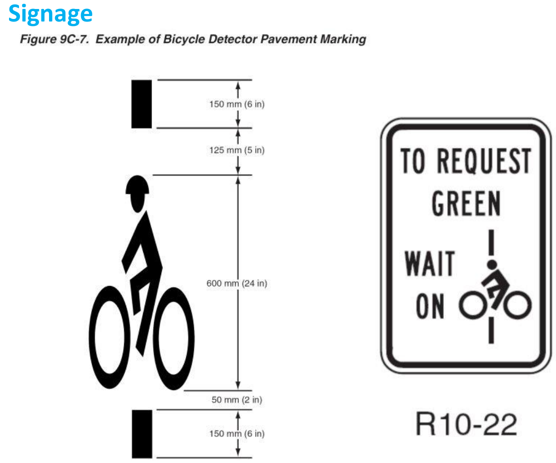
Portland, OR. Credit: Mike Packard

Figure 6-38: Bike Lane Detection Placement



Credit: Michele Weisbart (Michele Designs)

Figure 6-40: Bicycle Signal Detection Marking and Signage



Credit: MUTCD (FHWA, 2009)

6.6.5. Colored Pavement Treatments

Pavement coloring is useful for a variety of applications in conjunction with bicycle facilities. The primary goal of colored pavements is to differentiate specific portions of the travel way. Colored pavements can also visibly reduce the perceived width of the street.

Colored pavements are used to highlight potential conflict areas between bicycle lanes and turn lanes, especially where bicycle lanes merge across motor vehicle turn lanes. Colored pavements can be used in conjunction with sharrows (shared lane markings) in heavily used commercial corridors where no other provisions for bicycle facilities are evident.

Spring green is the preferred color for bicycle facilities of this type as set by the FHWA. Maintenance of color and surface condition are considerations. Traditional traffic paints and coatings can become slippery and therefore long life surfaces with good wet skid resistance should be considered.

Figure 6-41: Green Colored Bicycle Lane to Designate Potential Conflict Areas Such as Turning Vehicles

South King Street Protected Bike Lane. Credit: Alan Fujimori (SSFM International)

6.6.6. Bicycle Parking

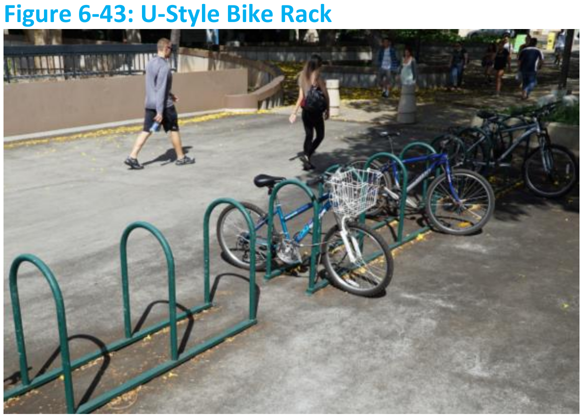
Secure bicycle parking at likely destinations is an integral part of a bikeway network. Fear of bicycle theft and the lack of secure parking are often cited as reasons why people hesitate to ride a bicycle. The same consideration should be given to people on bicycles as to motorists, who expect convenient and secure parking at all destinations. Bicycle parking should be located in well-lit, secure locations close to the main entrance of a building, no further from the entrance than the closest automobile parking space. Bike parking should not interfere with pedestrian movement or ADA accessibility.

Bike racks along sidewalks should support the bicycle well, and make it easy to lock a U-shaped lock to the frame of the bike and the rack. Refer to the Association of Pedestrian and Bicycle Professionals' *Bicycle Parking Guidelines* for additional information.

Figure 6-42: City and County Installed Bike Rack

Richard St. Credit: Alan Fujimori (SSFM International)

Figure 6-43: U-Style Bike Rack



University of Hawaii at Manoa. Credit: Mike Packard (SSFM International)

6.6.7. Bike Corrals

Bicycle corrals, or bike corrals, are in-street bicycle parking racks that provide greater capacity for short-term bicycle parking where there is a higher demand than can be accommodated on sidewalk racks. Bike corrals are particularly attractive when the demand for bicycle parking begins to crowd the sidewalk right-of-way. Depending on the sidewalk width, this usually occurs when parking for 10 or more bikes is desired.

Figure 6-44: Lack of Dedicated Bike Parking Can Result in Obstructions to the Pedestrian Way

Hahani St. Credit: Mike Packard (SSFM International)

Figure 6-45: Insufficient Bike Parking Can Result in Obstructions to the Pedestrian Way

Kailua Road. Credit: Mike Packard (SSFM International)

6.6.7.1. Bike Corrals Location

Identifying the best location for a bike corral involves several factors. Locations should be identified in consultation with adjacent businesses, property owners, and business associations where feasible. Some elements to consider in locating bike corrals are convenience, street corners, main streets, existing parking spaces, and traffic operations.

The bike corral should be located as close as possible to the entrance to high demand businesses and other destinations. In most cases, people on bicycles are unwilling to park their bicycle more than 100 feet from their destination.

Locating bike corrals near corners provides greater visibility and access for people on bicycles. It also prevents large vehicles from parking near corners which is an added safety benefit for people on foot. People exiting on bicycles are also easier to see when the bike corral is not concealed between a row of parked cars.

It is tempting to locate bike corrals on side streets away from higher traffic volumes. However, locating bike corrals on main streets makes them easier for people on bicycles to find and usually reduces the distance to the entrance of the destination.

Bus stops, fire hydrants, turning bus and truck movements, location of catch basins, parking meters, and adjacent sidewalk areas all need to be considered when choosing a location for bike corrals.

Figure 6-46: Bike Corral Example 1

Hekili Street. Credit: Mike Packard (SSFM International)

6.6.7.2. Bike Corral Design

A bike corral is composed of the bicycle rack, a method of demarcating the parking area, and signage. The type of rack used is critical for a successful facility. Inverted-U racks in a series are generally recommended as they are space-efficient and intuitive for the user. Several manufacturers make bike corral systems that use inverted-U racks on rails that are either welded or modular. This makes installation easier and more secure.

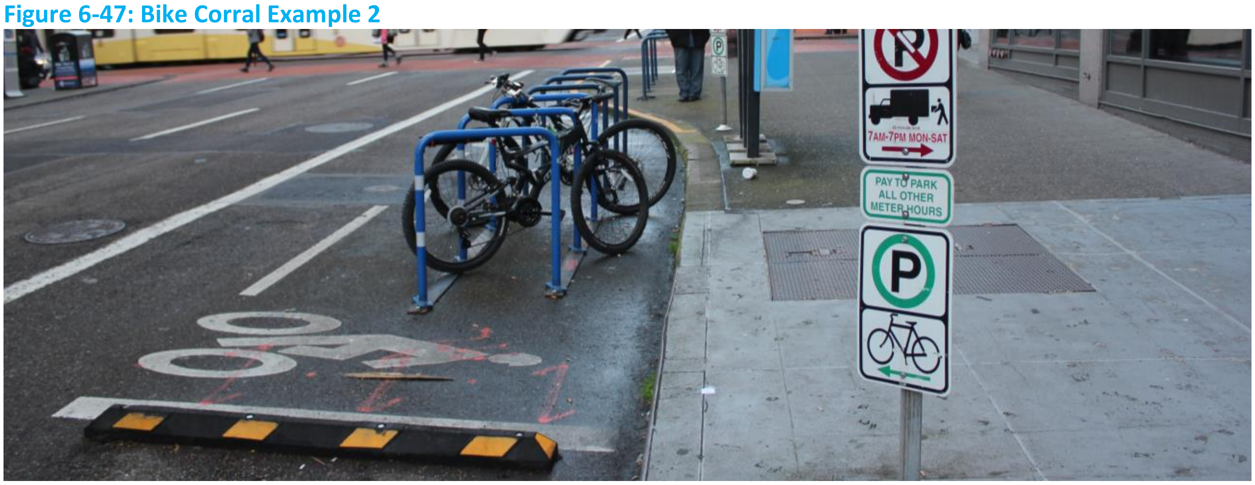
A popular design feature is to angle the racks at 60 degrees which reduces the depth of a bicycle from 6 feet to 5 feet. Most on-street parking spaces are 8 feet wide. The angled racks provide a greater buffer between moving traffic and the bicycles wheel and also minimizes handlebar conflicts. However, angling the racks reduces the number of bicycles that can be accommodated in the available space. The spacing between racks should be 36 inches on center. This width allows for greater convenience and maneuverability for people on bicycles.

Another option for the rack choice is to use a prefabricated bike corral, such as *Deros Cycle Stall Elite*. These are stand-alone racks that include a railing that acts as a physical barrier from traffic. The open side of the rack should face the curb and ensures that people on bicycles enter and exit from the curb side. This type of rack is especially recommended when the corral location is on a very busy street and no bike lane is present. A bike lane provides a buffer area for people on bicycles, especially when exiting the rack.

Demarcating the bicycle parking area is important for visibility for both people on bicycles and motorists. It also provides clear space on both ends of the rack, so cars do not encroach into the bicycle parking space. This can be accomplished with bicycle markings on the pavement and a 4-foot rubber or cement parking block.

Some type of vertical delineator is also recommended to make the facility more visible. This may not be necessary with a prefabricated bike corral but some kind of reflective tape should be applied to the vertical part of the rack to make it more visible at night. Bicycle parking signs may be included to make the rack easier to locate for people on bicycles.

Figure 6-47: Bike Corral Example 2



Portland, OR. Mike Packard (SSFM International)

6.6.8. Bicycle Share Stations

Bikeshare is a public transportation service that provides on-demand access to a network of publically-rentable bicycles. Public bicycles are distributed across a service area at fixed, destination-based bicycle share station locations.

6.6.9. Bicycle Facility Maintenance

Maintenance is a critical part of safe and comfortable bicycle access. Two areas that are of particular importance to people on bicycles are pavement quality and drainage grates. Rough surfaces, potholes, and imperfections, such as joints, can cause a person on a bicycle to lose control and fall. Care must be taken to ensure that drainage grates are bicycle-safe; otherwise a bicycle wheel may fall into the slots of the grate, causing people on bicycles to fall. The grate and inlet box must be flush with the adjacent surface. Inlets should be raised after a pavement overlay to the new surface. If this is not possible or practical, the new pavement should taper into drainage inlets so the inlet edge is not abrupt.

Figure 6-48: Bicycle Share Station Example

Kailua Road. Mike Packard (SSFM International)

6.7. Implementation of Bikeway Network

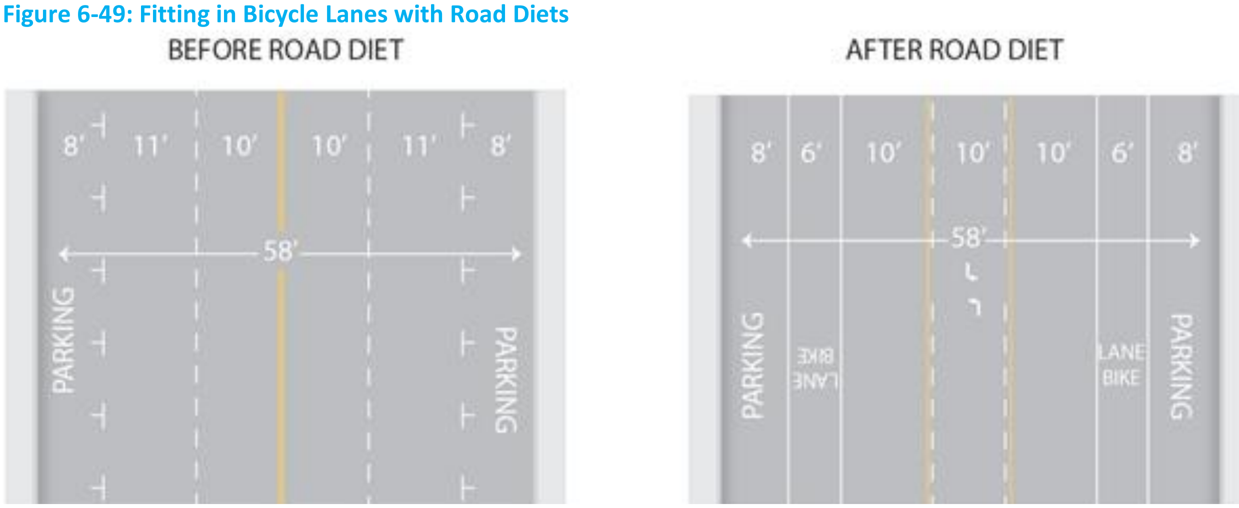
Implementation of a bikeway network often requires an implementation plan. Some bikeways, such as paths, bicycle boulevards, and other innovative techniques described in this Manual, may require a capital improvement project process, including identifying funding, a public and environmental review process, and plan preparation. Other bikeway improvements piggy-back onto planned construction, such as resurfacing, reconstruction, or utility work since all planned construction projects are required to consider complete streets treatments.

The majority of bikeway facilities are provided on streets in the form of shared roadways or bike lanes. Shared roadways usually require virtually no change to existing travel ways, except for some directional signs, occasional markings, and minor changes in traffic control devices. Removing unnecessary center line markings is a strategy that can be implemented after resurfacing projects by not putting the center line back. Marked bike lanes are implemented on existing roads through use of the following strategies.

There are three basic techniques for finding room for bike lanes:

- **Road diets**. Reducing the number of travel lanes provides space for bike lanes. The traditional road diet changes a four-lane undivided street to two travel lanes, a continuous left-turn lane (or median), and bike lanes. In other cases, a four-lane street can be reduced to a two-lane street without a center-turn lane, if there are few left turns movements.
- **Lane narrowing**. Where all existing or planned travel lanes must be retained, travel lanes can be narrowed to provide space for bike lanes. Recent studies have indicated that the use of 10-foot travel lanes does not result in decreased safety in comparison with wider lanes for vehicle speeds up to 35 mph. Eleven-foot lanes can be used satisfactorily at higher speeds especially where trucks and buses frequently run on these streets. However, where a choice between a 6-foot bike lane

Figure 6-49: Fitting in Bicycle Lanes with Road Diets



Credit: Michele Weisbart (Michele Designs)

and an 11-foot travel lane must be made, it is usually preferable to have the 6-foot bike lane. Parking lanes can also be narrowed to 7 feet to create space for bike lanes.

- **Parking Removal**. On-street parking is vital on certain streets (such as residential or traditional central business districts with little or no off-street parking), but other streets have allowable parking without a significant visible demand. In these cases, parking prohibitions can be used to provide bike lanes with minimal public inconvenience.

6.7.1. Resurfacing

The cost of marking bike lanes is negligible when incorporated with resurfacing, as this avoids the high cost of paint removal; the fresh pavement provides a blank slate. Departments will need to anticipate opportunities and synchronize painting plans with repaving and reconstruction plans. If new pavement is not anticipated in the near future, grinding out the old lane lines can still provide bike lanes.

6.7.2. Utility Work

Utility work often requires reconstructing the street surface to complete restoration work. This provides opportunities to implement bike lanes and more complex bikeways such as bike boulevards, protected bike lanes, or paths. It is necessary to provide plans for proper implementation and design of bikeway facilities prior to the utility work. It is equally necessary to ensure that existing bikeways are replaced where they exist prior to utility construction.

6.7.3. Redevelopment

When streets are slated for reconstruction in conjunction with redevelopment, opportunities exist to integrate bicycle lanes or other facilities into the redevelopment plans.

6.7.4. Paved Shoulders

Adding paved shoulders to existing roads can be quite expensive if done as stand-alone capital improvement projects, especially if ditches have to be moved, or if open drains are changed to enclosed drains. Paved shoulders can be added at little extra cost if they are incorporated into projects that already disturb the area beyond the pavement, such as laying utility lines or drainage work.

6.7.5. Additional Resources

National Association of City Transportation Officials. *Urban Bikeway Design Guide,* 2010.

Caltrans. *Complete Intersections: A Guide to Restructuring Intersections and Interchanges for Bicyclists and Pedestrians*, 2010.

AASHTO. *Guide for the Development of Bicycle Facilities,* 2000.

CHAPTER 7: SIDEWALK ZONE

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Chapter 7 Cover Image: Hekili Street. Credit: Mike Packard (SSFM International)

CHAPTER 7: SIDEWALK ZONE

7.1. Introduction

Nowhere is the concept of universal access more important than in the design of the pedestrian environment within the sidewalk zone. This is the realm of streets with the greatest variation in user capabilities, and thus the realm where attention to design detail is essential to effectively balance user needs. This is also the realm where signs and street furniture are located, and where transitions are made between modes (e.g., driver or passenger to pedestrian via parking, bus stop/train station, or bike rack). The sidewalk zone includes pedestrian pathways, curb ramps, bus stops, signs, and street furniture.

Without design guidelines, sidewalks may be too narrow, utility poles may obstruct pedestrian travel, steep driveway ramps are impassable to wheelchair users, and bus stops become blocked by the disorderly placement of shelters, poles, trash receptacles, and bike racks.

With well-defined guidelines, sidewalks are built to accommodate pedestrians of all ages and physical abilities, and become inviting environments for people on foot.

Figure 7-1: Design for Pedestrian Environment

South King Street. Credit: Ryan Nakamoto (SSFM International)

7.2. Legal Framework

Under Title II of the Americans with Disabilities Act (ADA) of 1990, state and local governments and public transit authorities must ensure that all of their programs, services, and activities are accessible to, and usable by, individuals with disabilities. They must ensure that new construction and altered facilities are designed and constructed to be accessible to persons with disabilities. State and local governments must also keep the accessible features of facilities in operable working condition through maintenance measures including sidewalk repair, landscape trimming, work zone accessibility, and snow removal.

Under the ADA, the U.S. Access Board is responsible for developing the minimum accessibility guidelines needed to measure compliance with ADA obligations when new construction and alterations projects are planned and engineered. These guidelines for public rights-of-way are found in draft form in the Public Rights-of-Way Accessibility Guidelines (draft PROWAG). The U.S. Department of Transportation has recognized this document as current best practices in pedestrian design and has indicated its intent to adopt the final PROWAG.

In addition to the PROWAG guidelines, Title II of the ADA also requires states and localities to develop ADA Transition Plans that remove barriers to disabled travel.

These plans must:

- Inventory physical obstacles and their location;
- Provide adequate opportunity for residents with disabilities to provide input into the Transition Plan;
- Describe in detail the methods the entity will use to make the facilities accessible;
- Provide a yearly schedule for making modifications;
- Name an official/position responsible for implementing the Transition Plan; and,
- Set aside a budget to implement the Transition Plan.

ADA Transition Plans are intended to ensure that existing inaccessible facilities are not neglected indefinitely and that the community has a detailed plan in place to provide a continuous pedestrian environment for all residents.

Figure 7-2: Pedestrian Zones Must Accommodate All Users

Kailua Road at Kalaheo Avenue. Credit: Mike Packard (SSFM International)

7.3. Sidewalk Zones

Sidewalks should provide a comfortable space for people on foot between the roadway and adjacent land uses. Sidewalks along city streets are the most important component of pedestrian mobility. They provide access to destinations and critical connections between modes of travel, including automobiles, transit, and bicycles. General provisions for sidewalks include pathway width, slope, space for street furniture, utilities, trees and landscaping, and building ingress/egress.

Sidewalks include four distinct zones: the frontage zone, the pedestrian (aka walking) zone, the furniture zone, and the curb zone. The minimum widths of each of these zones vary based on street classifications as well as land uses. Later sections in this chapter describe these recommendations in more detail as applied to individual cities. The table at the end of this chapter recommends minimum widths for each zone for different street types and land uses. The recommended minimum width for the pedestrian zone of any sidewalk is 5 feet. Where existing sidewalks are narrower, 5 feet by 5 feet of clear space must be provided every 200 feet.

7.3.1. Frontage Zone

The frontage zone is the portion of the sidewalk located immediately adjacent to buildings, and provides shy distance from buildings, walls, fences, or property lines. In most cases, the frontage zone is in private property. In those cases where the frontage zone is in public property, the adjacent property owner will need to secure approval for new uses in the frontage zone. The frontage zone includes space for building-related features such as entryways and accessible ramps. It can include landscaping as well as awnings, signs, news racks, seating, merchandise displays, and outdoor café seating. In single-family residential neighborhoods, landscaping and driveways typically occupy the frontage zone.

Figure 7-3: Well Defined Sidewalk Zone

Credit: Mike Packard (SSFM International)

7.3.2. Pedestrian Zone

The pedestrian zone, situated between the frontage zone and the furniture zone, is the area dedicated to walking and should be kept clear of all fixtures and obstructions. It is the path that provides continuous connections from the public right-of-way to building and property entry points, parking areas, and public transportation. This pathway is required to comply with ADA guidelines and is intended to be a seamless pathway for wheelchair and white cane users. As such, this route should be firm, stable, and slip-resistant, and should comply with maximum cross slope requirements (2 percent grade). The walkway grade shall not exceed the general grade of the adjacent street. Aesthetic textured pavement materials (e.g., brick and pavers) are best used in the frontage and furniture zones, rather than in the pedestrian zone. The pedestrian zone should be a minimum of 4 feet, but preferably at least 5 feet in width to provide adequate space for two people to comfortably pass or walk side by side. All transitions (e.g., from street to ramp or ramp to landing) must be flush and free of changes in level. The engineer should determine the pedestrian zone width to accommodate the projected volume of users.

7.3.3. Furniture Zone

The furniture zone is located between the curb line and the pedestrian zone. The furniture zone should contain all fixtures, such as street trees, bus stops and shelters, parking meters, utility poles and boxes, lamp posts, signs, bike racks, news racks, seating, waste receptacles, and other street furniture to keep the pedestrian zone free of obstructions. In residential neighborhoods, the furniture zone is often landscaped. Resting areas with seating and space for wheelchairs should be provided in high volume pedestrian districts and along blocks with a steep grade to provide a place to rest for older adults, wheelchair users, and others who need to catch their breath. The furniture zone should be appropriately sized to accommodate all proposed items.

7.3.4. Curb Zone

The curb zone serves primarily to prevent water and cars from encroaching on the sidewalk. It defines where the area for pedestrians begins and the area for cars ends. It is the area people using assistive devices must traverse to get from the street to the sidewalk, so its design is critical to accessibility.

7.3.5. Other Sidewalk Guidelines

- Landscaped buffers or fences should separate sidewalks from off-street parking lots or off-street passenger loading areas.
- Pedestrian and driver sight distances should be maintained near driveways. Fencing and foliage near the intersection of sidewalks and driveways should ensure adequate sight distance as vehicles enter or exit.
- Where no frontage zone exists, driveway ramps usually violate cross slope requirements. In these situations, sidewalks should be built back from the curb at the driveway.

7.4. Design Specifications by Roadway Type and Land Use

Desired minimum widths for the frontage, pedestrian, furniture, and curb zones, as well as minimum total widths for applicable street typologies are provided in Tables 7-1 and 7-2. Rural Roads and Lanes/Alleys are not applicable. Main Street guidelines are included in a special row of the table. Transit Malls should follow guidelines from Main Streets. Pedestrian Malls are not included because the entire street is a pedestrian pathway. These guidelines are for roadway and sidewalk retrofit as the *Subdivision Street Standards* (DPP, 2001) govern roadway cross-sections for the construction of roads associated with new subdivisions.

7.4.1. General Guidelines

The land uses included in the following tables cover most areas. For those few areas not covered, the following list provides general guidelines for sidewalks:

- The recommended minimum frontage zone width is 18 inches.
- The recommended minimum pedestrian zone width is 5 feet.
- The recommended minimum curb zone width is 6 inches, or 18 inches where pedestrian or freight loading is expected and may conflict with obstacles in the furniture zone.
- The recommended minimum furniture zone width is 4 feet, and 6 feet to 8 feet where bus stops exist.
- Low curbs (3 to 4 inches high) reduce the division between the travel way and the sidewalk. They are favored in areas with significant pedestrian traffic. Low curbs also improve the geometry and feasibility of providing two perpendicular curb ramps per corner.
- A vertical clearance of signs, trees, planters, awnings, and other protrusions above the pedestrian zone should be a minimum of 80 inches.

Some judgment may be needed on a case-by-case basis to establish the actual widths of each of the four zones. Where existing widths are insufficient, or regulations differ, then ADA requirements will dictate design and all other elements should be scaled proportionately.

Figure 7-4: Sidewalk Zone Amenities Should Accommodate the Surrounding Uses

Kailua Road. Credit: Mike Packard (SSFM International)

Table 7-1: Sidewalk Zone Desired Minimum Widths for Each Land Use Context

	Boulevard	Avenue	Street
Low / Medium-Low Density Residential	Not applicable	Frontage: 18” Pedestrian: 5’ Furniture: 4’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 11’	Frontage: 18” Pedestrian: 5’ Furniture: 4’ Curb: 6” Min. Total Width: 11’
Med / High Density Residential	Frontage: 18” Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 13’	Frontage: 18” Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 13’	Frontage: 18” Pedestrian: 6’ Furniture: 4’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 12’
Neighborhood Commercial	Not applicable	Frontage: 18” Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 13’	Frontage: 18” Pedestrian: 6’ Furniture: 4’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 12’
General Commercial	Frontage: 18” Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 13’	Frontage: 18” Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 13’	Not Applicable
Mixed / Multi-use	Frontage: 30”, 8’ with café seating Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 14’	Frontage: 30”, 8’ with café seating Pedestrian: 6’ Furniture: 4’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 13’	Frontage: 18” Pedestrian: 6’ Furniture: 4’ Curb: 6” Min. Total Width: 12’

Table 7-2: Sidewalk Zone Desired Minimum Widths for Each Land Use Context (cont.)

	Boulevard	Avenue	Street
Industrial	Frontage: 18” Pedestrian: 5’ Furniture: 5’ Curb: 18” Min. Total Width: 13’	Frontage: 18” Pedestrian: 5’ Furniture: 4’ Curb: 18” Min. Total Width: 12’	Frontage: 18” Pedestrian: 5’ Furniture: 4’ Curb: 18” Min. Total Width: 12’
Downtown Core / Main Street	Frontage: 30”, 8’ with café seating Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 14’	Frontage: 30”, 8’ with café seating Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 14’	Frontage: 30”, 8’ with café seating Pedestrian: 6’ Furniture: 5’ Curb: 6” Min. Total Width: 14’
Transit Oriented Districts	Frontage: 30” Pedestrian: 8’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 16’	Frontage: 30” Pedestrian: 8’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 16’	Frontage: 18” Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 13’
Office Park	Frontage: 18” Pedestrian: 5’ Furniture: 5’ Curb: 6” Min. Total Width: 12’	Frontage: 18” Pedestrian: 5’ Furniture: 5’ Curb: 6” Min. Total Width: 12’	Not Applicable
Public Facilities	Frontage: 30” Pedestrian: 8’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 16’	Frontage: 30” Pedestrian: 8’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 16’	Frontage: 18” Pedestrian: 6’ Furniture: 5’, 6’-8’ at bus stops, and where large trees are desired Curb: 6” Min. Total Width: 13’

7.5. Land Use Context

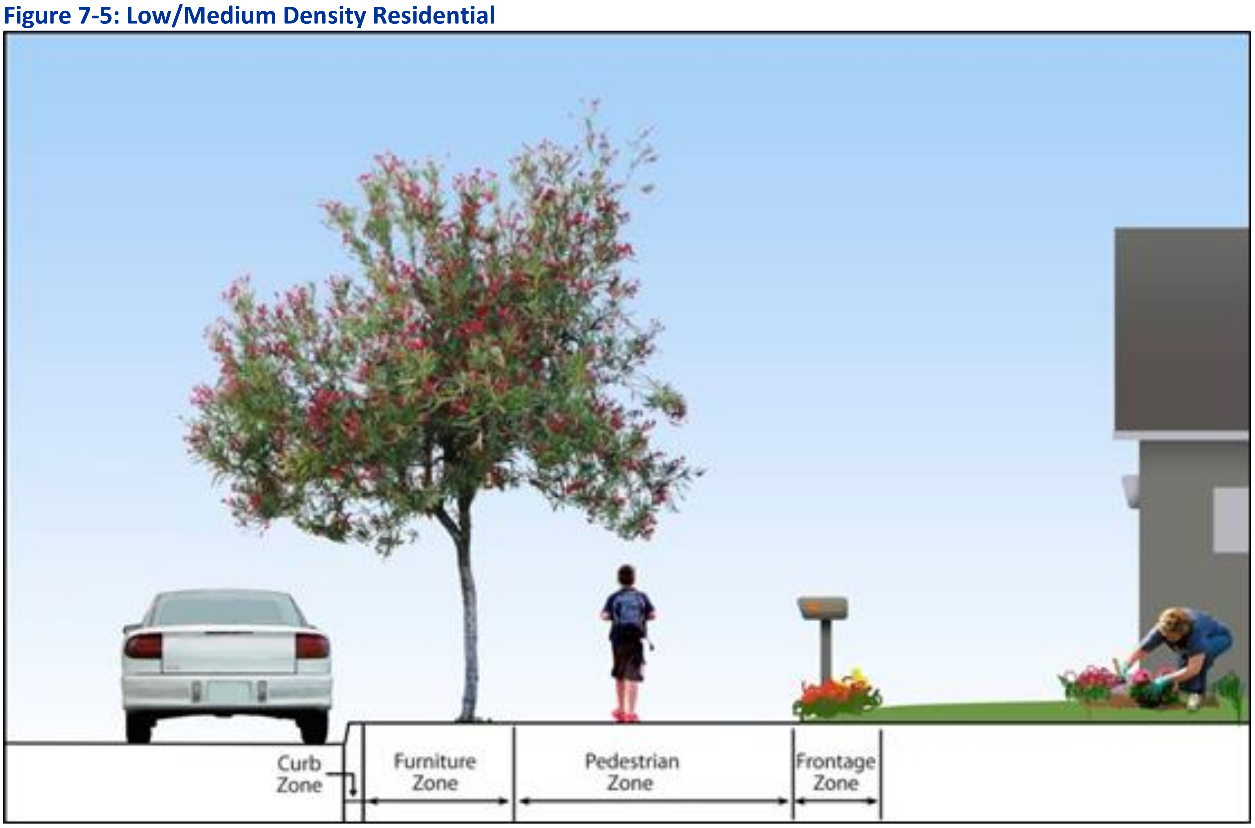
The sidewalk design guidelines in this chapter integrate design and land use to provide safe and convenient passage for people on foot. Sidewalks should have adequate walking areas and provide comfortable buffers between pedestrians and traffic. These guidelines will ensure that sidewalks in all new development and redevelopment provide access for people of all ages and physical abilities.

Sidewalks will vary according to the type of street. A local street with residences will require different sidewalk dimensions than a Boulevard with commercial establishments.

7.5.1. Low/Medium Density Residential

These streets are typically quieter than others and generally do not carry transit vehicles or high volumes of traffic. People on foot require a pleasant walking environment within these neighborhoods, as well as access to land uses and transit on nearby streets. The furniture zone should be appropriately sized to accommodate street trees.

Figure 7-5: Low/Medium Density Residential



Credit: Marty Bruinsma (Self-Employed)

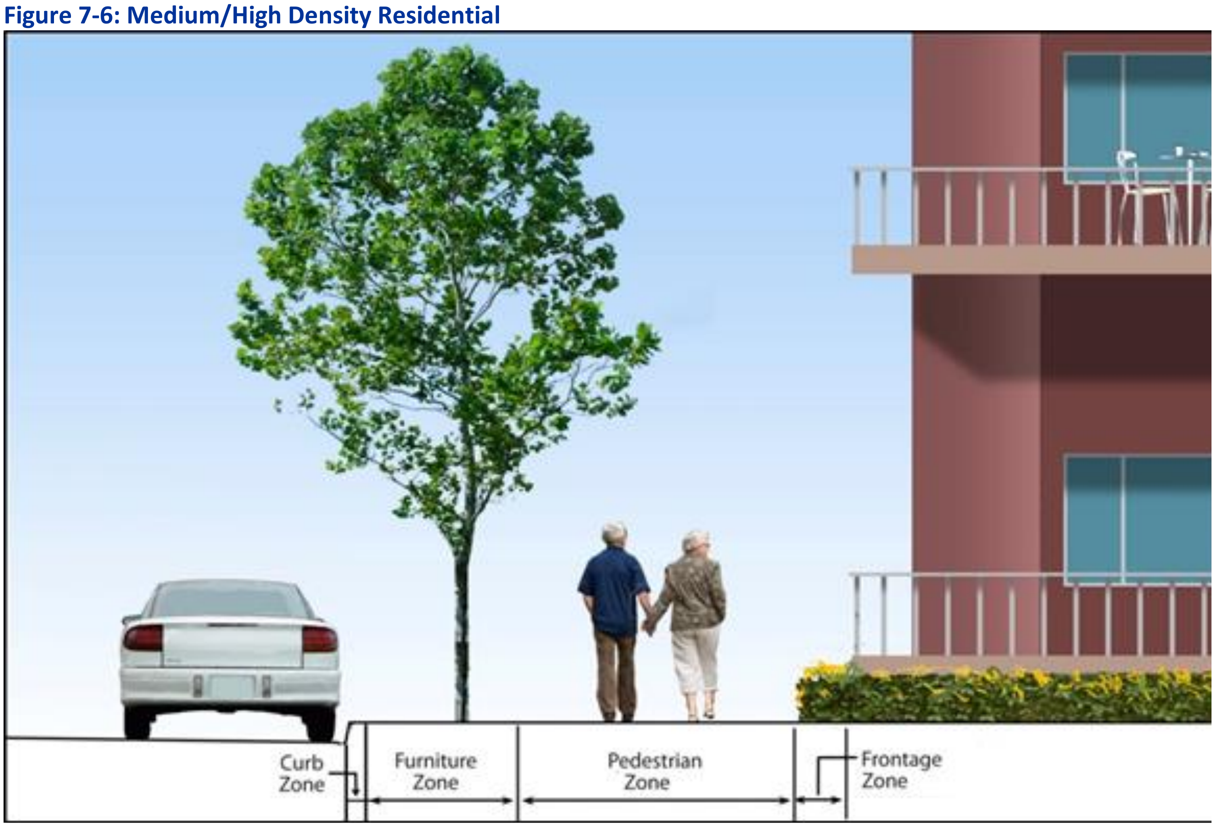
7.5.2. Medium/High Density Residential

These streets support greater volumes of people on foot. Streets with transit service require good pedestrian links to bus stops. The pedestrian zone should be wider than in low/medium density residential areas.

7.5.3. Neighborhood Commercial

These streets often have grocers, laundromats, drug stores, and other neighborhood-serving retail establishments. Sidewalks in neighborhood commercial areas should accommodate people walking from residences to stores. Of the four sidewalk zones, the pedestrian zone should be the widest, with a generous frontage zone to provide room for features next to buildings such as newspaper boxes. These sidewalks should also be designed with the understanding that cars will cross sidewalks as they enter and exit commercial driveways.

Figure 7-6: Medium/High Density Residential



Credit: Marty Bruinsma (Self-Employed)

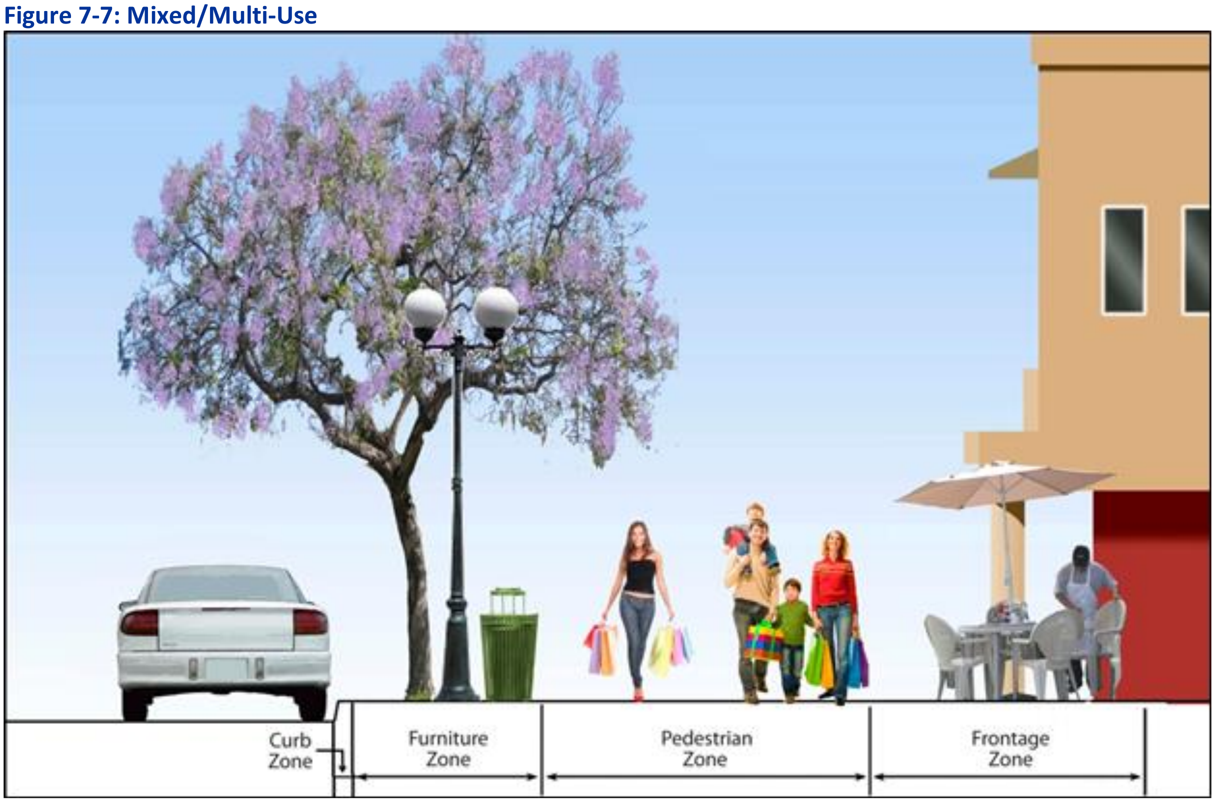
7.5.4. General/Regional Commercial

These streets have retail, office, civic, and recreational uses concentrated along Boulevards and Avenues. Transit service runs along these streets and people on foot need buffers from traffic. Of the four sidewalk zones, the pedestrian and furniture zones need the greatest design attention. These sidewalks also should be designed with the understanding that a significant number of cars will cross sidewalks as they enter and exit commercial driveways.

7.5.5. Mixed/Multi-Use

The sidewalks along these streets should support significant pedestrian volumes due to their mixed-use nature and higher densities. Of the four sidewalk zones, the pedestrian and frontage zones need the greatest design attention. Transit service runs along these streets and sidewalks will require buffers from traffic.

Figure 7-7: Mixed/Multi-Use



Credit: Marty Bruinsma (Self-Employed)

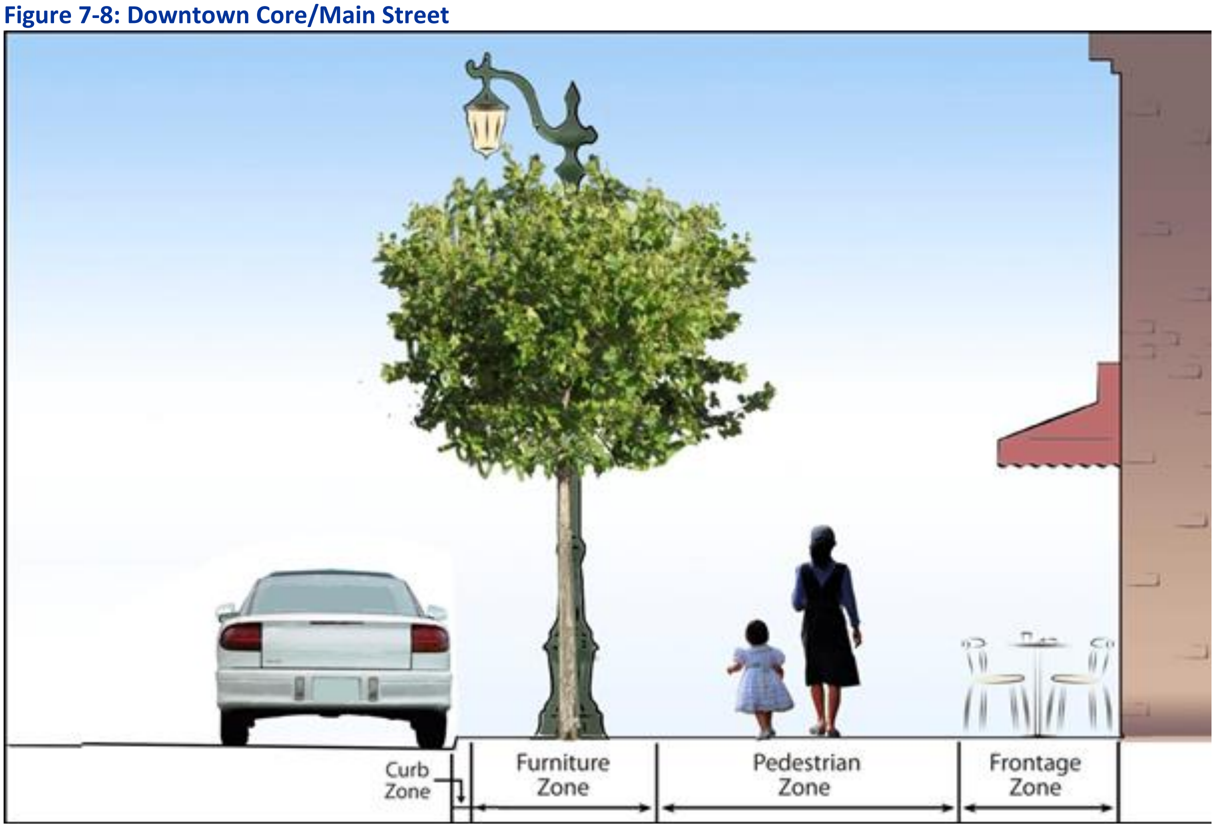
7.5.6. Industrial

These streets have adjacent industrial uses that are zoned for manufacturing, office warehousing, and distribution. Pedestrian volumes are likely to be lower here given that these land uses typically employ fewer people per square foot than general commercial areas. Employees will need good sidewalks to get to work.

7.5.7. Downtown Core/Main Street

A downtown core or Main Street is a pedestrian-oriented area. This is where the greatest numbers of people on foot are encouraged and expected. The downtown core serves as the retail, restaurant, and entertainment center of a community. This area will need the widest sidewalks, the widest crosswalks, the brightest street lighting, the most furnishings, and other features that will enhance the pedestrian environment. Of the four sidewalk zones, the pedestrian and frontage zones need the greatest design attention, with a furniture zone wide enough for street trees.

Figure 7-8: Downtown Core/Main Street



Credit: Marty Bruinsma (Self-Employed)

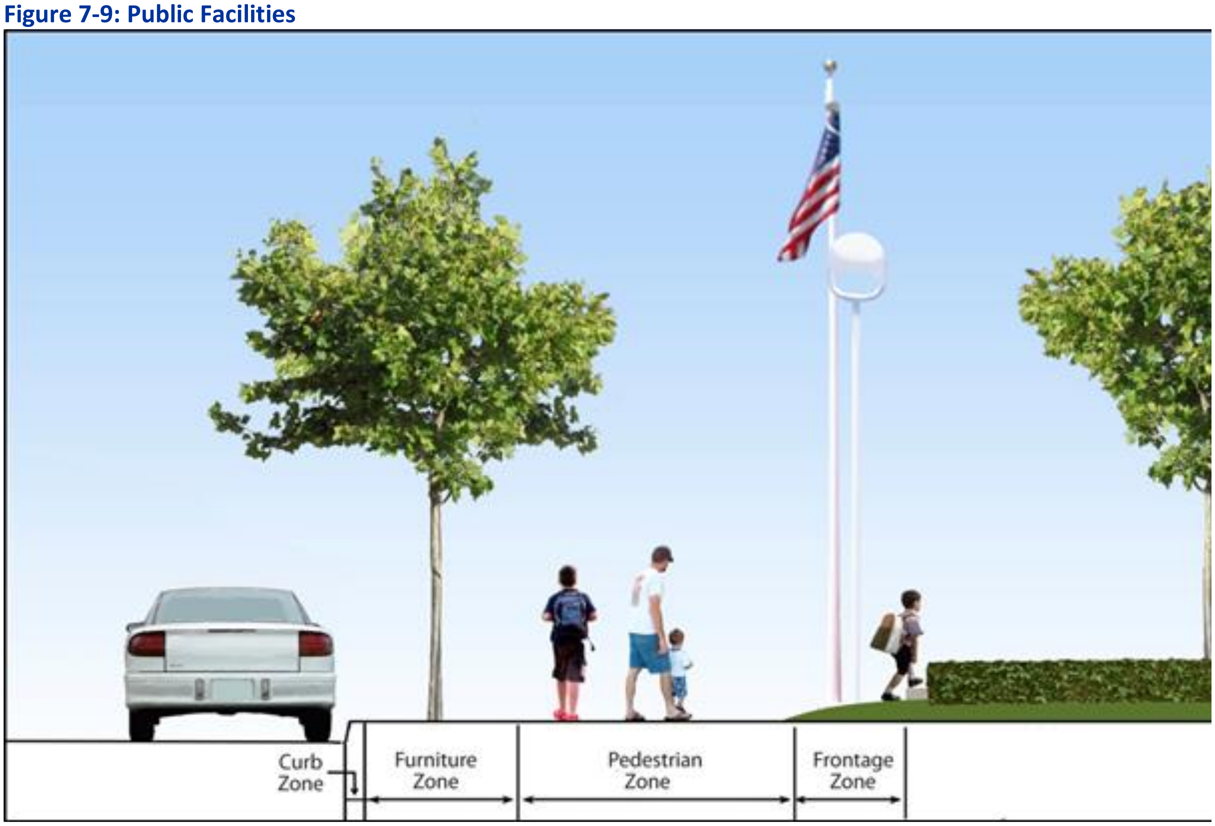
7.5.8. Office Park

These streets are home to national and regional offices of financial institutions, government, large companies, and other uses. Cities can expect people during the morning and evening commutes walking to and from their cars. Visitors will use the sidewalks throughout the day and employees will need them during the lunch hour. The furniture zone should provide adequate buffer from parked vehicles.

7.5.9. Public Facilities

Public facilities streets, particularly streets near schools, libraries, and civic centers, require special attention and treatment. High pedestrian volumes are expected during peak times, such as school pick-up and drop-off, and during the morning and evening commute hours. Sidewalk design should accommodate these peak travel times and include adequate furniture zones to buffer people on foot from the street. Public facilities are located on various types of streets ranging from local streets to Boulevards with transit service.

Figure 7-9: Public Facilities



Credit: Marty Bruinsma (Self-Employed)

7.5.10. Rural Roads

Rural roads do not need to comply with the four-zone sidewalk system, but they still need a reasonably safe place for people on foot. This may be in the form of a wide paved shoulder (6 to 10 feet), a wide graded shoulder (minimum 5 feet wide), or a combination of both a paved and graded shoulder. These roads are in areas of relatively sparse development.

Sidewalks are typically not built in rural areas. In truly rural areas, buildings are spaced far apart and sidewalks are not practical. In these cases, a wide paved or graded unpaved shoulder will suffice.

Subdivisions within rural areas should be considered low-density residential, and sidewalks should adhere to guidelines for that land use.

Some subdivisions have been built without sidewalks where children need to get to school, people need to walk to the store, and sidewalks are needed for other purposes. For new developments, sidewalks should be required in these areas. Where these neighborhoods are already built, retrofitting presents the following challenges:

- Adequate easement may not exist.
- Residents resist the idea of adding sidewalks because they believe it changes the rural character of their neighborhood.
- Residents may perceive that the sidewalk takes part of their front yard or parking.
- Adequate right-of-way sometimes does not exist within the street.
- Concerns over who will fund and build.

In these cases, the following options should be considered:

- Constructing sidewalks without a curb or gutter, but with a landscaped furniture zone (see Option 1).
- Using curb stops, A/C berm curbs, landscaping, and other devices to delineate a protected pedestrian area within the existing travel way (see Option 2).

Where these options are not possible, aggressive traffic calming should be used to turn the streets into shared spaces where people on foot can safely use the street.

Figure 7-10: Sidewalk Retrofit Option 1

Kailua Road. Credit: Mike Packard (SSFM International)

Figure 7-11: Sidewalk Retrofit Option 2

Old Kalanianaole Road. Credit: Mike Packard (SSFM International)

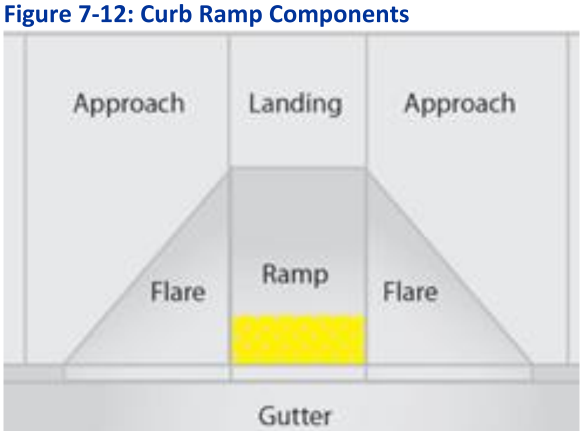
7.6. Curb Ramps

Proper curb ramp design is essential to enable people using assistive mobility devices (e.g., wheelchairs, scooters, walkers, and crutches) to transition between the street and the sidewalk. These design guidelines provide a basic overview of curb ramp design. The ADA requires installation of curb ramps in new sidewalks and whenever an alteration is made to an existing sidewalk or street. Roadway resurfacing is considered an alteration and therefore an opportunity for curb ramp installations or retrofits to current standards. Curb ramps are typically installed at intersections, marked mid-block crossings (including trail connections), accessible on-street parking, and passenger loading zones and bus stops.

The following define the curb ramp components along with minimum dimensions:

- **Landing** – the level area at the top of a curb ramp facing the ramp path. Landings allow wheelchairs to enter and exit a curb ramp, as well as travel along the sidewalk without tipping or tilting. This landing must be the width of the ramp and measure at least 4 feet by 4 feet. There should also be a level (not exceeding a 2 percent grade) 4 foot by 4 foot bottom landing of clear space outside of vehicle travel lanes.
- **Approach** – the portion of the sidewalk on either side of the landing. Approaches provide space for wheelchairs to prepare to enter landings.
- **Flare** – the transition between the curb and sidewalk. Flares provide a sloped transition (10 percent maximum slope) between the sidewalk and curb ramp to help prevent people from tripping over an abrupt change in level. Flares can be replaced with a curb where the furniture zone is landscaped.
- **Ramp** – the sloped transition between the sidewalk and street where the grade is constant and cross slope at a minimum. Curb ramps are the main pathway between the sidewalk and street.
- **Gutter** – the trough that runs between the curb or curb ramp and the street. The slope parallel to the curb should not exceed 2 percent at the curb ramp.
- **Detectable Warning** – surface with distinct raised areas to alert people with visual impairments of the sidewalk-to-street transition. There are several different types of curb ramps. Selection should be based on local conditions. The most common types are diagonal, perpendicular, parallel, and blended transition. PROWAG provides additional design guidance and curb ramp examples appropriate for a variety of contextual constraints.

Figure 7-12: Curb Ramp Components



Credit: Michele Weisbart (Michele Designs)

7.6.1. Diagonal Curb Ramps

Diagonal curb ramps are single curb ramps at the apex of the corner. These have been commonly installed by many jurisdictions to address the requirements of the ADA, but have since been identified as a non-preferred design type as they introduce dangers to wheelchair users. Diagonal curb ramps send wheelchair users and people with strollers or carts toward the middle of the intersection and make the trip across longer.

Figure 7-13: Diagonal Curb Ramp

University Avenue at Maile Way. Credit: Mike Packard (SSFM International)

7.6.2. Perpendicular Curb Ramps

Perpendicular curb ramps are placed at a 90-degree angle to the curb. They must include a level landing at the top to allow wheelchair users to turn 90 degrees to access the ramp, or to bypass the ramp if they are proceeding straight. Perpendicular ramps work best where there is a wide sidewalk, curb extension, or planter strip. Perpendicular curb ramps provide a direct, shorter trip across the intersection.

Figure 7-14: Perpendicular Curb Ramp

Hookelewaa Street at Meheula Parkway. Credit: Alan Fujimori (SSFM International)

7.6.3. Parallel Curb Ramps

Parallel curb ramps are oriented parallel to the street; the sidewalk itself ramps down. They are used on narrow sidewalks where there isn't enough room to install perpendicular ramps. Parallel curb ramps require people who are continuing along the sidewalk to ramp down and up. Where space exists in a planting strip, parallel curb ramps can be designed in combination with perpendicular ramps to reduce the ramping for through pedestrians. Careful attention must be paid to the construction of the bottom landing to limit accumulation of water and/or debris.

Figure 7-15: Parallel Curb Ramp

Credit: Michele Weisbart (Michele Designs)

7.6.4. Curb Ramp Placement

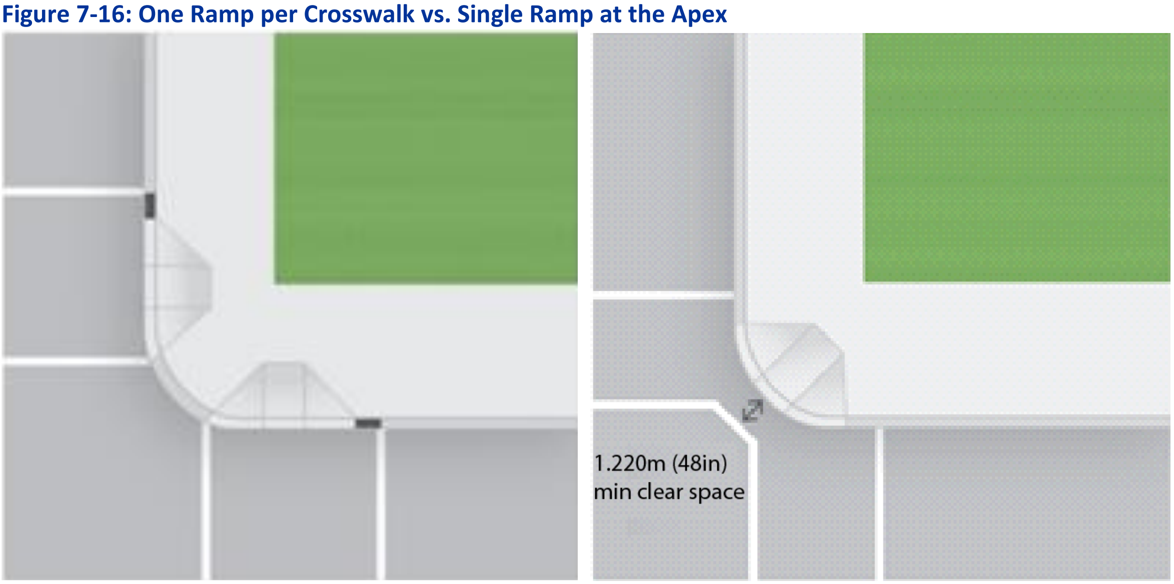
One ramp should be provided for each crosswalk, which usually translates to 2 per corner. This maximizes access by placing ramps in line with the sidewalk and crosswalk, and by reducing the distance required to cross the street, compared with a single ramp on the apex.

A single ramp at the apex requires users to take a longer, more circuitous travel path to the other side and causes users to travel towards the center of the intersection where they may be in danger of getting hit by turning cars; being in the intersection longer exposes the user to greater risk of being hit by vehicles. A single ramp at the apex should be avoided in new construction and may be used only for alterations where a design exception is granted because of existing utilities and other significant barriers. In all cases, reducing the curb radius makes ramp placement easier.

7.6.5. Blended Transitions

Blended transitions are situations where either the entire sidewalk has been brought down to the street or crosswalk level, or the street has been brought up to the sidewalk level. They work well on large radius corners where it is difficult to line up the crosswalks with the curb ramps, but have drawbacks. Children, persons with cognitive impairments, and guide dogs may not distinguish the street edge. Turning vehicles may also encroach onto the sidewalk. For these reasons, bollards, planting boxes, or other intermittent barriers should be installed to prevent cars from traveling on the sidewalk. Detectable warnings should also be placed at the edge of the sidewalk to alert people with visual impairments of the transition to the street.

Figure 7-16: One Ramp per Crosswalk vs. Single Ramp at the Apex



Credit: Michele Weisbart (Michele Designs)

7.6.6. Detectable Warnings

Because a curb ramp removes the curb that visually impaired persons use to identify the location of a street, a detectable warning surface should be placed at the back of the curb. This detectable warning surface should be as wide as the ramp and a minimum of 24 inches deep. One corner should be located at the back of the curb and the other corner may be up to 5 feet from the back of the curb. These warning surfaces are most effective when adjacent to smooth pavement so the difference is easily detected. Color contrast is needed so partially sighted people can see them.

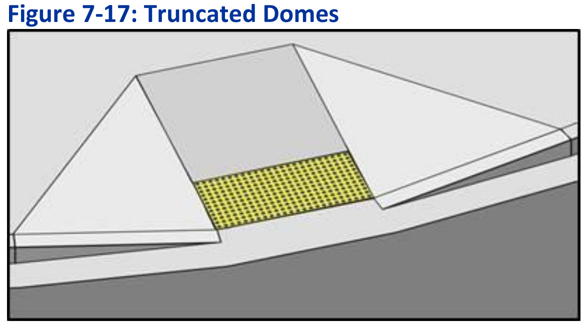
The Americans with Disabilities Act Accessible Guidelines for detectable warnings are as follows:

- General: Detectable warnings shall consist of a surface of truncated domes and shall meet standards for size, spacing, contrast and edges.
- Base diameter: 0.9 inches minimum; 1.4 inches maximum.
- Top diameter: 50 percent of base diameter minimum to 65 percent maximum.
- Height: 0.2 inches.
- Center-to-center spacing: 1.6 inches minimum to 2.4 inches maximum.
- Base-to-base spacing: 0.65 inches minimum.
- Visual contrast: light on dark, or dark on light with adjacent walking surface.
- Platform edges: 24 inches wide and shall extend the full public use area of the platform.

PROWAG best practices include the following:

- Width: as wide as the ramp and 24 inches deep.
- Location: one corner at back of the curb, the other corner up to 5 feet from back of curb.
- Used at:
    - The edge of depressed corners.
    - The border of raised crosswalks and intersections.
    - The base of curb ramps.
    - The border of medians.
    - The edge of transit platforms and where railroad tracks cross the sidewalk.

Figure 7-17: Truncated Domes



Source: United States Access Board

7.6.7. National Guidelines

Curb ramp design on City streets should follow the most recent adopted version of the federal ADA and PROWAG standards and the City & County of Honolulu *Accessibility Design Guidelines and General Policies and Procedures, Curb Ramps within Public Rights-of-Way* (C&C, 2014).

7.7. Utilities

The location of underground and aboveground utilities must be considered when planning new landscaped areas in the right-of-way. Each jurisdiction should establish guidelines to organize and standardize utility location and to minimize conflicts between landscaping and utilities based on input from all involved departments and agencies.

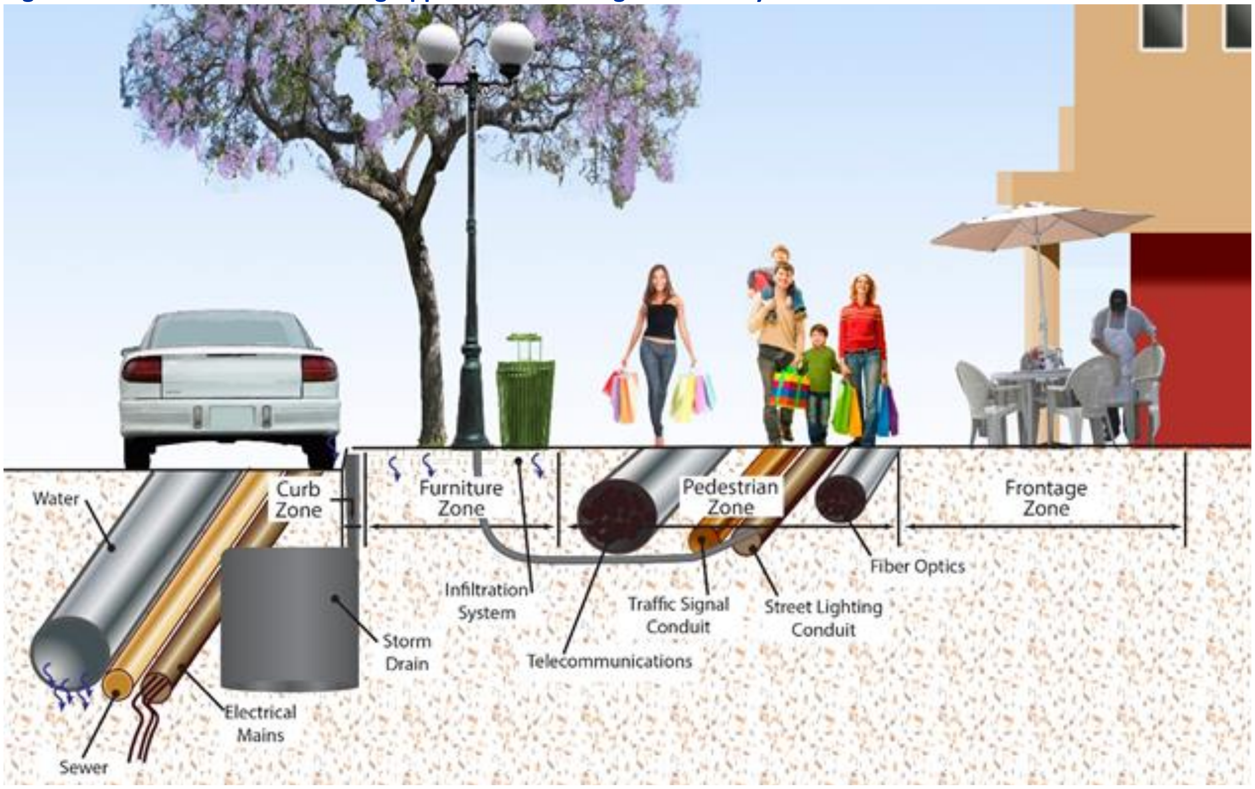
The majority of underground utilities, including sanitary sewers and storm drains, and water, gas, and electrical mains, are typically located under the roadway. Sanitary sewers are often in the center of the street directly under the potential location of a landscaped median. They are usually relatively deep. In general, if they have at least 4 or 5 feet of cover, they should not be affected by the introduction of a landscaped median. The other utilities within the roadway are typically located closer to the curbs.

Telecommunications, street lighting conduit, traffic signal conduit, and fiber optic conduit are often located under the sidewalk. Lateral lines extend from the utility mains in the public rights-of-way to serve adjacent properties.

Benefits of well-organized utility design/placement include:

- Reduced clutter in the streetscape;
- Increased opportunity for planting areas and adequate soil volume to support tree growth and storm water infiltration;
- Reduced maintenance conflicts; and,
- Improved pedestrian safety and visual quality.

Figure 7-18: Cross Section Showing Approximate Underground Utility Placement



Credit: Michele Weisbart (Michele Designs)

7.7.1. Location

Utilities should be located to minimize disruption to pedestrian travel and to avoid ideal locations for directing storm water, planting trees and other vegetation, and siting street furniture, while maintaining necessary access to the utilities for maintenance and emergencies.

Utilities within 10 feet of where a landscaped median may be located should have at least 5 feet of cover. Otherwise, utilities in the road right-of-way should have a minimum 3 feet of cover.

Utility main lines that run laterally under the sidewalk should be located in a predetermined zone to minimize conflicts with tree roots and planting areas. The ideal location to minimize conflicts with trees would be under the pedestrian or frontage zones, although the more practical location is often under the furniture zone. Stacking dry utilities (telephone, cable television (CATV), electric, etc.) in the pedestrian or frontage zones will further reduce conflicts with the landscaped area.

Trees and tree-wells should be designed concurrently with the placement of water lines, drain lines, sewage lines, and other underground utilities so as to prevent conflicts between the utilities and tree roots.

7.7.2. Roadway/Parking Lane

Large utility vaults and conduits running the length of a city block may be located in the roadway or parking lane where access requirements allow. Vaults in the parking lane may be located in short-term parking zones or in front of driveways to facilitate access. They can also be placed in mid-block curb extensions.

7.7.3. Furniture Zone

Small utility vaults, such as residential water vaults, residential water meters, gas valves, gas vaults, or street lighting access, should be located in the sidewalk furniture zone at the back of the curb wherever possible to minimize conflicts with existing or potential tree locations and landscaped areas. Vaults should be aligned or clustered wherever possible.

Generally, utility boxes are sited in the direction of the pipe. Utility boxes that are parallel with the curb should be located in the sidewalk furniture zone when possible. Vaults perpendicular to the curb should be located between existing or potential street trees or sidewalk landscape locations (e.g., in walkways through the sidewalk furniture zone to parked cars).

Utility laterals should not run directly under landscaped areas in the furniture zone, but instead under driveways and walkways wherever possible.

7.7.4. Sidewalk Pedestrian Zone

Flush utility vaults and conduits running the length of the city block may be located in the pedestrian zone. Vaults in the pedestrian zone should have slip-resistant covers.

Large flush utility vaults should be placed at least 3 feet from the building and 4 feet from the curb where sidewalk widths allow.

Surface-mounted utilities should not be located in the pedestrian zone.

7.7.5. Sidewalk Frontage Zone

In most cases, the utilities are in the City right-of-way. In those cases where utilities are in private property, easements are required.

Utility vaults and valves may be placed in the frontage zone. Placement of utility structures in this zone is preferred only when incorporating utility vaults into the furniture zone is not feasible.

Utility vaults in the frontage zone should not be located directly in front of building entrances.

7.7.6. Curb Extensions

Utility vaults and valves should be minimized in curb extensions where plantings or street furnishings are planned.

Surface-mounted utilities may be located in curb extensions outside of crossings and curb ramp areas to create greater pedestrian through width.

Utility mains located in the parking lane and laterals accessing properties may pass under curb extensions. With curb extensions or sidewalk widening, utilities such as water mains, meters, and sewer vents may remain in place as they can be cost prohibitive to move.

7.7.7. Driveways

Utility boxes may be located in driveways if the sponsor provides a vehicle-rated box; however, this is not a preferred solution due to access difficulties.

7.7.8. Pedestrian Crossings and Curb Ramps

New utility structures should not be placed within street crossing and curb ramp areas.

Existing vaults located in the center accessible portion of a ramp should be moved or modified to meet accessibility requirements, as feasible, as part of utility upgrades.

Catch basins and surface flow lines associated with storm drainage systems should be located away from the crosswalk or between curb ramps. Catch basins should be located upstream of curb ramps to prevent ponding at the bottom of the ramp.

7.7.9. Consolidation

Utilities should be consolidated for efficiencies and to minimize disruption to the streetscape:

- Dry utility lines and conduits (telephone, CATV, electric, gas, etc.) should be initially aligned, rearranged, or vertically stacked to minimize utility zones.
- Wherever possible, utility conduits, valves, and vaults (e.g., electrical, street lighting, and traffic signals) should be consolidated if multiple lines exist within a single street or sidewalk section.
- Dry utilities (gas, telephone, CATV, primary and secondary electric, streetlights) may use shared vaults, wherever possible.
- Street lighting, and traffic signals should share poles wherever possible. When retrofitting existing streets or creating new streets, pursue opportunities to combine these poles.

7.7.10. Other Design Guidelines

- Street design and new development should consider the overall pattern of plantings, lighting, and furnishings when placing new utilities in the street, and locate utility lines so as to minimize disruption to the prevailing streetscape rhythms.
- Utilities should be located underground, wherever possible, as opposed to overhead or surface-mounted. Overhead utilities should be located in alleys, where possible.
- New utilities should use durable pipe materials that are resistant to damage by tree roots and have minimal joints.
- Trenchless technologies, such as moling and tunneling, should be used, wherever possible, to avoid excavation and disruption of streetscape elements.
- New infrastructure projects should use resource-efficient utility materials. Re-used or recyclable materials should be incorporated, wherever possible.
- Utility boxes may be painted as part of a public art program.
- Tree removal should be avoided and minimized during the routing of large-scale utility undergrounding projects.
- Any utility-related roadway or sidewalk work should replace paving material in kind (e.g., brick for brick) where removed during maintenance, or replace with new upgraded paving materials.
- Where utilities exist and planting new trees would introduce conflicts between tree roots and utilities, the City can consider shade and beautification options such as awnings, arcades, and raised planters.

7.7.11. New Development and Major Redevelopment

Alleys for vehicle, utility, and service access should be incorporated to enable a more consistent streetscape and minimize above-ground utilities.

New utilities should be located to minimize disruption to streetscape elements per guidelines in this section.

7.7.12. Abandonment

Currently abandoned dry conduits should be reused or consolidated if duplicate lines are discovered during street improvement projects. Utilities should be contacted for rerouting or consolidation. Where it is not possible to reuse abandoned mains, conduits, manholes, laterals, valves, etc., they should be removed per agency recommendations, when possible, to minimize future conflicts.

Abandoned water and sewer lines may be retrofitted as dry utility conduits, where available or if possible, to minimize the need for future conduit installations.

7.7.13. Process

Utility installation and repair should be coordinated with planned street reconstruction or major streetscape improvements.

New development should submit utility plans with initial development proposals so that utilities may be sited to minimize interference with potential locations for streetscape elements.

Utility work also offers opportunities to make other changes to the street after the work is completed and should be coordinated with planned improvements to avoid duplication of efforts or making new cuts in new pavement. Examples of improvements to streets that can be done at low cost after utility work include painting for bike lanes, if utility work requires total street repaving, as well as building sidewalks in conjunction with utility work occurring outside of the travel way.

7.8. Street Furnishings

Street furnishings add vitality to the pedestrian experience and recognize the importance of people on foot to the fabric of a vibrant urban environment. Street furnishings encourage use of the street by people on foot and provide a more comfortable environment for non-motorized travel. They provide a functional service to the user and provide uniformity to the urban design.

Street furnishings include seating, bollards, kiosks, news racks, public art, signs, refuse receptacles, parking meters, bike racks, and other elements.

Street furnishings achieve improved vitality in many ways, including:

- They make walking, bicycling, and public transit more inviting;
- They improve the street economy and common city prosperity; and,
- They enhance public space and create a place for social interaction.

Placement of street furnishings should be provided:

- At concentrations of pedestrian activity (nodes, gathering areas).
- On streets with pedestrian-oriented destinations. People may gather or linger and enjoy the public space.
- Site furnishing placement should follow these criteria:
    - Street furnishings are secondary to the layout of street trees and light standards, as street trees and light standards develop a street rhythm and pattern. Site furnishing should be placed in relation to these elements sensitive to the vehicular flow and pedestrian use of these elements. Careful consideration of their placement provides ease of recognition and use.
    - In addition to the guidelines provided for each element, placement should adhere to the minimum spacing. Site furnishing installed within the appropriate zone will be spaced not less than as shown in Table 7.4.
- All site furnishing must be accessible per PROWAG and other City regulations.
- The City should strive to include sustainable materials for street furnishings.

Table 7-3: Site Furnishing Minimum Setbacks

Location	Setback
Face of Curb	18”
Driveway	4’
Wheelchair Ramp	3’
Ramp Landing	4’
Fire Hydrant	5’
Stand Pipe	2’
Transit Passenger Shelter	4’

7.8.1. Seating

Public seating contributes to a comfortable, utilitarian, and active environment where people can rest, socialize, or read in a public space. The proper placement of a seat is a simple gesture that creates a sense of place for the immediate area.

Location

Seating arrangements should be located and configured according to the following guidelines:

- Seating should be located in a shaded area such as under trees.
- Seating should be oriented toward points of interest; this can be the adjacent building, an open space, or the street itself if the street is lively. Where sidewalk width permits, seating can also be oriented perpendicular to the curb.
- Informal seating opportunities incorporated into the adjacent building architecture may be used as an alternative to free-standing seating. Low planter walls can be used as informal seating areas.

Design

Seating should be made of durable high-quality materials. The seating design should complement and visually reinforce the design of the streetscape.

Seating opportunities should be integrated with other streetscape elements.

7.8.2. News Racks

Location

News rack placement is subject to municipal guidelines. The following additional guidelines should be considered:

- News racks located within the furniture or frontage zones should not reduce the minimum width of the sidewalk pedestrian zone when news rack doors open.
- News racks should be placed no closer than 2 feet from adjacent street signs and 4 feet from bike racks.

Design

News racks should visually blend with their surroundings and complement the architectural character. Multiple news racks should be consolidated into a standard decorative stand.

Figure 7-19: Seating and News Rack

Hekili Street. Credit: Mike Packard (SSFM International)

7.8.3. Bollards

Bollards are primarily safety elements to separate people on foot and non-motorized traffic from vehicles. Bollards can add interest, visually strengthen street character, and define pedestrian spaces.

Location

Bollards are used to prevent vehicle access on sidewalks, or on other areas closed to motor vehicles. Removable bollards should be placed at entrances to permanent or temporary street closures.

Design

Bollards may range in size from 4 to 10 inches in diameter. The top of the bollard should be 3 to 4 feet above the vehicle travel way for greatest visibility.

Where access for people on foot or people on bicycles needs to be maintained, a minimum 4 foot accessible path should be provided between bollards. A path width of 5 to 8 feet is preferred along shared use paths or where high volumes of people on foot are expected.

Bollards may have articulated sides and tops to provide distinct design details. The details should be coordinated with other street elements of similar architectural character.

Removable bollards should be designed with a sturdy pipe projecting from the bottom of the exposed bollard. Removable bollards should appear permanent. Manual bollards may include a locking system in order to prevent vandalism. Electrically controlled bollards can retract into a void below the surrounding finish surface allowing emergency vehicle access to closed streets.

7.8.4. Street Vendor Stands

Street vendor stands, such as flower, magazine, and food vendor stands, rely on regular pedestrian traffic to sustain their businesses. To maximize efficiency, the stands operate during daytime work hours and cater to those commuting to/from employment areas. In areas with a vibrant evening environment, stands may have evening hours to benefit from the extended period of exposure to pedestrian traffic.

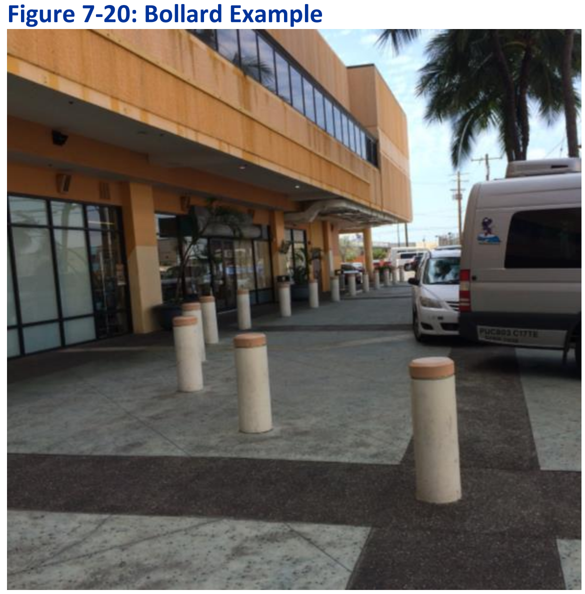
Location

Generally, street vendor stands should either be located outside the street right-of-way or in the furniture or frontage zones.

Design

The design of street vendor stands should have details and features coordinated with other street elements. These details should be of a similar architectural character. The stands should allow a minimum of 6 feet of clear pedestrian passage between the edge of the display area and other elements.

Figure 7-20: Bollard Example



Dole Cannery. Credit: Mike Packard (SSFM International)

7.8.5. Informational Kiosks

Kiosks in public areas provide valuable information, such as maps, bulletin boards, and community announcements. Kiosks can often be combined with gateway signs and are an attractive and useful street feature.

Location

Kiosks should not block scenic views.

Kiosks may be located in any of the following areas:

- The furniture or frontage zones;
- Curb extensions;
- Where parking is not allowed; and,
- Close to, but not within, transit stops.

Design

Kiosks should be designed to the following guidelines:

- Kiosks should include digital displays, bulletin boards or an enclosed case for display of information.
- As a gateway element, the kiosk should include the neighborhood, commercial district, street, or park name; a map; or other information.
- Kiosks should have details and features coordinated with other street elements and should have a similar architectural character.

7.8.6. Parking Meters

Parking meters can be either be “traditional” single-space meters or digital multi-space units (parking stations).

Location

Parking meters should be placed in the sidewalk furniture zone. Single-space meters should be placed at the front end of the individual stalls.

Multi-space units are preferred over single-space meters. Multi-space units should be placed every 8 to 10 parking spaces and spaced approximately 150 to 200 feet apart. Signs should clearly direct patrons to the meter. The signs should be spaced at approximately 100 feet on-center.

Design

Municipalities should encourage the conversion of single-space meters to multi-space units to reduce visual clutter from the urban landscape. The multi-space units should be selected to minimize their impact on the pedestrian zone.

Figure 7-21: Parking Station

7.8.7. Streetscape Signs

Streetscape signs provide information specific to direction, destination, or location. The sign plans should be developed individually for each neighborhood or district. Streetscape signs are most appropriate for downtown, commercial, or tourist-oriented locations or around large institutions. Streetscape signs include parking, directional, and wayfinding signs.

Location

Streetscape signs should be kept to a minimum and placed strategically. They should align with the existing street furnishings and be placed in the sidewalk furniture zone.

Design

The sign design should be attractively clean and simple and complement the architectural character of other street furnishings.

Figure 7-22: Streetscape Sign

Kailua Town. Credit: Mike Packard (SSFM International)

7.8.8. Refuse Receptacles

Refuse receptacles should accept both trash and recyclables. Where there is a demand, different receptacles should be provided for different recyclable materials. Use of solar trash and recycling compacting unit stations have a larger upfront cost however provide a reduction in disposal labor costs and resulting landfill waste.

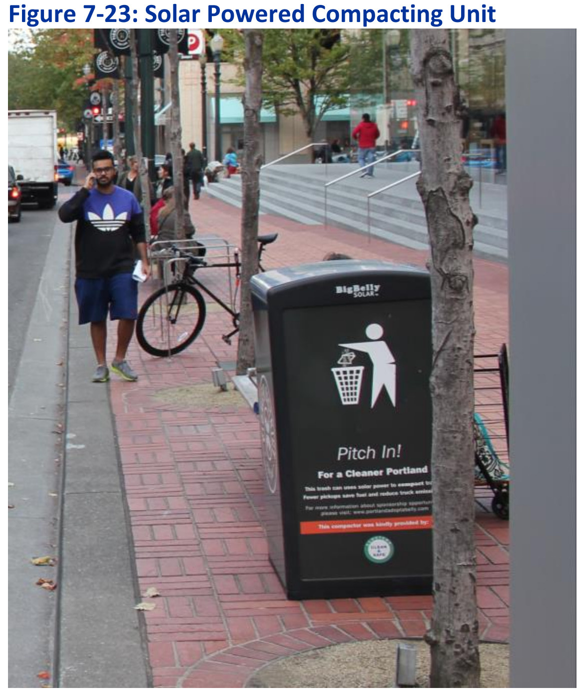
Location

Refuse receptacles should be located:

- Near high activity generators such as major civic and commercial destinations;
- At transit stops; and,
- Near street corners, but outside of the sidewalk pedestrian zone.

There should be a minimum of one refuse receptacle every 200 feet along commercial streets and a maximum of four refuse receptacles at an intersection (one per corner).

Figure 7-23: Solar Powered Compacting Unit



Portland, OR. Credit: Mike Packard (SSFM International)

7.8.9. Public Art

On a large scale, public art can unify a district with a theme or identify a neighborhood gateway. At a pedestrian scale, public art adds visual interest to the street experience.

Location

Public art can be situated in a variety of areas and locations, including streets, public spaces with high concentrations of people on foot, or areas of little pedestrian traffic, to create a unique space for discovery.

Design

Public art should be considered during the planning and design phase of development to more closely integrate art with other streetscape elements, taking into account the following:

- Public art is a pedestrian amenity and should be presented in an area suited for pedestrian viewing. The piece should be placed as a focal element in a park or plaza, or situated along a pedestrian path and discovered by the traveler.
- Public art can be incorporated into standard street elements (light standards, seating, trash receptacles, utility boxes).
- Public art can provide information (maps, signs) or educational information (history, culture). All installations do not need to have an educational mission; art can be playful.
- Public art should be accessible to persons with disabilities and placement must not compromise the sidewalk pedestrian zone.

Figure 7-24: Public Art Example 1

Hawaii State Library. Credit: Ryan Nakamoto (SSFM International)

Figure 7-25: Public Art Example 2

Kailua Town. Credit: Mike Packard (SSFM International)

7.8.10. Sidewalk Dining

Outdoor café and restaurant seating adjacent to the sidewalk activates the street environment and can encourage economic development.

Location

Tables and chairs are to be placed on the sidewalk directly at the front of the restaurant and allowed in the frontage zone or furniture zone of the sidewalk where permitted and sufficient width is available while not encroaching into the pedestrian zone.

Design

Placement of tables and chairs must include diverters (barriers) at the end of the dining area to guide people away from the accepted area of sidewalk. Since the public purpose of allowing restaurants to have dining on the sidewalk is to stimulate activity on the street, the City should discourage restaurants from fully enclosing the dining area.

Figure 7-26: Sidewalk Dining

Waikiki. Credit: Ryan Nakamoto (SSFM International)

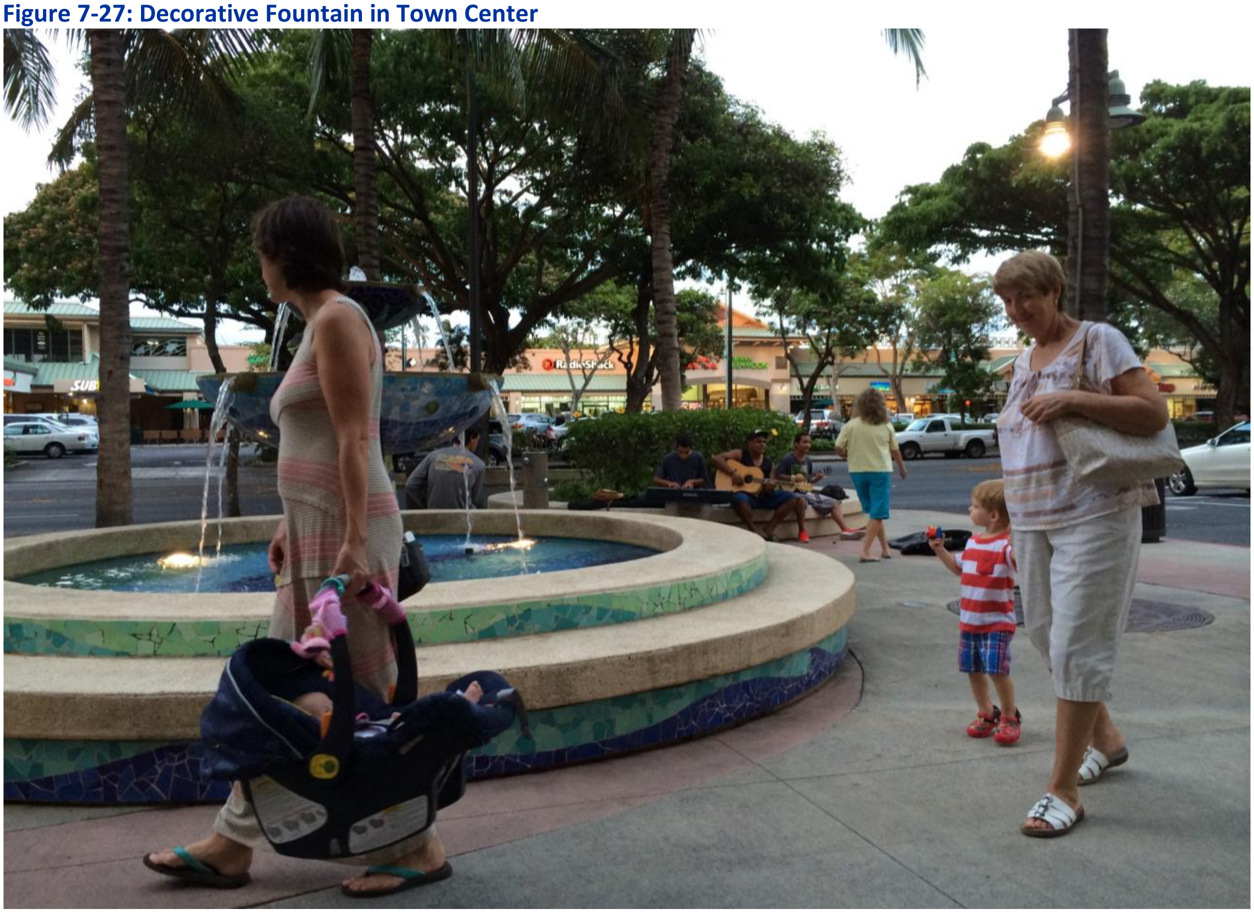
7.8.11. Other Streetscape Features

Other features that enhance the pedestrian experience include clocks, towers, and fountains, which strengthen the sense of place and invite people to come and enjoy.

Figure 7-28: Clock Tower at Transit Center

Wahiawa Bus Transit Center. Credit: Ryan Nakamoto (SSFM International)

Figure 7-27: Decorative Fountain in Town Center



Kailua Town. Credit: Mike Packard (SSFM International)

7.9. Street Lighting

Lighting provides essential nighttime illumination to support the pedestrian activity and safety as well as vehicle safety. Well-designed street lighting enhances the public realm while providing safety and security on guides, bike paths, and lanes as well as pedestrian paths including sidewalks, paths, alleys, and stairways.

Historically significant street light poles and fixtures should be maintained and upgraded where appropriate.

Pedestrian scale lighting should be coordinated with building and property owners to provide lighting attached to buildings for sidewalks, alleys, pedestrian paths, and stairways where separate pedestrian lighting poles are not feasible or appropriate.

Figure 7-30: Pedestrian Scale Lighting

Nuuanu Avenue at Hotel Street. Credit: Alan Fujimori (SSFM International)

Figure 7-29: Specialty Street Lighting

Waialae Avenue. Credit: Ryan Nakamoto (SSFM International)

7.9.1. Guidelines

Location and Spacing

Street and pedestrian lighting poles should be installed in the sidewalk furniture zone. Light fixtures should not be located next to tree canopies that may block the light. Where pedestrian lighting or pedestrian scale lighting is not provided on the street light pole, special pedestrian lamps should be located between street light poles where appropriate.

Light Color

The City and County of Honolulu will use street lights with a correlated color temperature of 3000K and 4000K.

Light Poles and Fixtures

Design should relate to, and be coordinated with, the design of other streetscape elements and recognize the history and distinction of the neighborhoods where the light poles are located.

Dark-Sky Compliant Lighting

As appropriate, dark sky-compliant lighting should be selected to minimize light pollution cast into the sky while maximizing light cast onto the ground.

Figure 7-31: Dark Sky Compliant Lighting

Credit: Brad Lancaster (Harvesting Rainwater)

Energy Efficiency

LED and solar light fixtures should be utilized where possible for new installations or for retrofit projects. Where solar light fixtures are not appropriate or possible, a more energy-efficient technology should be used.

Pedestrian Lighting

Retrofits of existing street lights and new installations should provide lighting on pedestrian paths. Pedestrian lighting should be added to existing street light poles, where feasible, unless spacing between street light poles does not support adequate pedestrian lighting, in which case pedestrian lighting may need to be provided between existing street light poles.

Light Levels and Uniformity

All optic systems should be cut off with no light trespass into the windows of residential units. Recommended pedestrian lighting levels are included in Table 7-4: Pedestrian Light Levels.

Table 7-4: Pedestrian Light Levels

Streetscape Type	Light Level
Commercial	1 fc
Mixed-Use	0.5 fc
Residential	0.4 fc
Industrial	0.3 fc
Alleys and Paseos	0.3 fc
Special	Varies

Note: Light levels are measured in foot candles (fc). Suggested light levels are consistent with ANSI/IES RP-8-14 American National Standard Practice for Roadway Lighting

CHAPTER 8: TRANSIT ACCOMMODATION

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Chapter 8 Cover Image: Credit: Wes Frysztacki (Weslin Consulting Services)

CHAPTER 8: TRANSIT ACCOMMODATION

8.1. Introduction

Public transit on Oahu serves a vital transportation function for many people; it is their access to jobs, school, shopping, recreation, visitation, worship, and other daily functions. For transit to provide optimal service, streets must accommodate transit vehicles and provide access to stops. Transit connects passengers to destinations and is an integral component of shaping future growth into a more sustainable form. Transit design should also support placemaking.

This chapter provides design guidance for both transit stops and transit operating in the streets, including bus stop layout and placement and the use of bus bulbs and transit lanes. The chapter fully incorporates and updates the City and County of Honolulu Department of Transportation Services' *Bus Stop Improvement and Design Guidelines* dated December 2005.

These design standards address the following:

- Principles of Designing Streets for Transit;
- Access to Transit;
- Bus Stop Placement;
- Bus Stop Zone Design;
- Signal Treatment;
- Urban Design;
- Bicycle Connections;
- Bus Lanes; and,
- Accommodating Light Rail, Street Cars and Bus Rapid Transit.

Figure 8-1: Bus Stops Should Be Designed for All Passengers

Credit: Wes Frysztacki (Weslin Consulting Services)

8.2. Principles of Designing Streets for Transit

Public transit should be planned and designed as part of the street system. It should interface seamlessly with other modes, recognizing that successful transit depends on customers getting to the service via walking, bicycling, car, taxi, or paratransit. Transit should be planned following these principles:

- Transit has a high priority on city streets. On some streets, transit vehicles should have higher priority than private vehicles.
- The busiest transit lines should have designated bus lanes.
- Where ridership justifies, some streets, such as the Hotel Street transit mall, may permit only buses or trains in the travel way. These streets often allow bicycles as is the case with Hotel Street.
- Technology should be applied to increase average speeds of transit vehicles where appropriate.
- Transit stops should be easily accessible with safe and convenient crossing opportunities.
- Transit stops should be active and attractive public spaces that appeal to people on a regular basis, at various times of day, and all days of the week.
- Transit stops function as community destinations. The largest stops and stations should be designed to facilitate programming for a range of community activities and events.
- Transit stops should include amenities for passengers waiting to board.
- Transit stops should provide space for a variety of amenities in commercial areas, to serve residents, shoppers, and commuters alike.

Figure 8-2: Bus Stops Are Centers of Activity

Credit: Wes Frysztacki (Weslin Consulting Services)

- Transit stops should be attractive and visible from a distance.
- Transit stop placement and design influences accessibility to transit and network operations, and influences travel behavior/mode choice.
- Zoning codes, local land use ordinances, and design guidelines around transit stations should encourage walking and a mix of land uses.
- Streets that connect neighborhoods to transit facilities should be especially attractive, comfortable, and safe and inviting for people on foot and people on bicycles.

Figure 8-3: Hotel Street Transit Mall

Hotel Street. Credit: Ryan Nakamoto (SSFM International)

8.3. Access to Transit

Transit depends primarily on walking to function well; most transit users walk to and from transit stops. Sidewalks on streets served by transit and on the streets that lead to transit corridors provide basic access. Bicycle-friendly streets do the same for those who access transit by bicycle.

Every transit trip also requires a safe and convenient street crossing at the transit stop. A disproportionally high number of pedestrian crossing crashes occur at transit stops. Every transit stop should be evaluated for its crossing opportunities. If the crossing is deemed inappropriate, mitigation can occur in two ways: pedestrian crossing treatments should be provided at the existing stop, or the stop should be moved to a location with a safer crossing. Simply stated, there should not be transit stops without means to safely and conveniently cross the street.

Simply moving a stop is not always a service to transit users who may have to walk further to access their stop. Convenient access by passengers must remain at the forefront of all transit stop planning. Eliminating stops because they are perceived as unsafe will not be satisfactory to riders who cannot walk very far.

Eliminating or consolidating stops can be beneficial to transit operations and users by reducing the number of times a bus, streetcar, or light rail train has to stop. The tradeoffs may be added walking time for some users but reduced transit operator delay, resulting in a shorter journey overall. For example, this might mean a 2 to 3 minute longer walk for some passengers and an 8 to 10 minute shorter bus ride for all.

Figure 8-4: Some Bus Stops Require Abundant Pedestrian Space

Credit: Wes Frysztacki (Weslin Consulting Services)

8.4. Transit Wayfinding

Wayfinding is an important element to successful access to transit by pedestrians and people on bicycles. Directional signs should include the distance to the transit stop or station.

Figure 8-5: Transit Wayfinding Sign With Station Direction and Distance

Madrid, Spain. Credit: Wes Frysztacki (Weslin Consulting Services)

Whenever wayfinding signs are used to point the way for popular destinations they should include where transit connections are located. Color coding is a way to distinguish the type of destination.

Figure 8-6: Transit Wayfinding Sign With Station Direction and Distance

Seattle, WA. Credit: Mike Packard (SSFM International)

8.5. Bus Stop Placement

The following factors shall be considered in the placement of bus stops:

- Distance between stops:
  - Urban areas: Five to ten stops per mile with an average spacing of 750 feet between stops.
  - Suburban areas: Four to six stops per mile with an average spacing of about 1,000 feet per stop.
  - Rural areas: As needed, but no more than suburban areas.
- Location of the expected passenger traffic generator, including:
  - Multi-family housing areas;
  - Major shopping areas;
  - Employment centers;
  - School and university campuses; and,
  - Transit centers.
- Pedestrian safety and access:
  - In general, bus stops should be placed as close as possible to intersections whether signalized or unsignalized, where sufficient rights-of-way exist for pedestrian safety, installation of a shelter, and other amenities.
- Characteristics of a near-side stop include:
  - Bus operators have a direct view of three directions;
  - Easier for a bus to leave the curb;
  - Parking restrictions at these zones increases street capacity.
- Far-side bus stops may allow buses to re-enter into traffic more easily, especially if the stop is in a pull off lane or a right-turn only lane. Other characteristics of a far-side stop include:
  - No pedestrian crossing in front of a bus;
  - Eliminates blocking of a signal by a bus;

  - Eliminates the rear-end of buses protruding into adjacent lanes;
  - May reduce delay and congestion by buses blocking a right turn on a green signal.
- Mid-block bus stops are discouraged. Where a mid-block crosswalk exists, the bus stop should be located on the far side of the crosswalk to maximize visibility to approaching traffic of crossing pedestrians. Other characteristics of a mid-block stop include:
  - Minimum interference of sight distance;
  - Less crowded sections of sidewalks;
  - May be closer to the center of a bus patron generator.
- In some areas, it may be desirable to design the route to eliminate the need for passengers to cross streets, such as the use of off-street stops. Off-street stops are also appropriate for destinations set far back from the travel way, such as hospitals and shopping malls.
- Traffic and Safety Considerations:
  - Availability of adequate right-of-way to ensure the stop meets ADA Accessibility Guidelines (ADAAG);
  - Curb clearance (i.e., clear access of the bus to the curb or adjacent property, not blocked by on-street parking);
  - Operational effectiveness issues including relation to the nearest intersection, bus turning requirements, and re-entering the travel lane;
  - Junction of two routes proceeding in the same direction (should have the same stop) as well as hubs and transfer points.

Figure 8-8: Good Crosswalks and Sidewalks Are Essential for Access to Transit

Kuhio Avenue. Credit: Wes Frysztacki (Weslin Consulting Services)

At intersections, a bus stop's optimal placement depends on the operational characteristics of both the travel way and the transit system.

In general, bus stops should be located at the far side of a signalized intersection in order to enhance the effectiveness of traffic signal synchronization or bus signal priority projects. Near-side bus stops are appropriate for stop sign-controlled intersections. In all cases, priority should be given to the location that best serves the passengers.

Each bus stop location has its advantages and disadvantages, as shown in Table 8-1, and should be tried on a case-by-case basis.

Figure 8-7: Operational Considerations Include Bus Staging

Ala Moana Transit Center, Kona Street. Credit: Wes Frysztacki (Weslin Consulting Services)

Table 8-1: Intersection Bus Stop Placement Considerations

Location	Advantage	Disadvantage
Near Side	• Minimizes interference when traffic is heavy on the far side of an intersection. • Provides an area for a bus to pull away from the curb and merge with traffic. • Minimizes the number of stops for buses. • Allows passengers to board and alight while the bus is stopped at a red light. • Allows passengers to board and alight without crossing the street if their destination is on the same side of the street. This is most important where one side of the street has an important destination, such as a school, shopping center, or employment center that generates more passenger demand than the far side.	• Increases conflicts with right-turning vehicles. • Stopped buses may obscure curb-side traffic control devices and crossing pedestrians. • Obscures sight distances for vehicles crossing the intersection that are stopped to the right of the buses. • Decreases roadway capacity during peak periods due to buses queuing in through lanes near bus stops. • Decreases sight distance of on-coming traffic for pedestrians crossing intersections. • Can delay buses that arrive during the green signal phase and finish boarding during the red phase. • Less safe for passengers crossing in front of the bus.
Far Side	• Minimizes conflicts between right-turning vehicles and buses. • Optimal location for traffic signal synchronized corridors. • Provides additional right-turn capacity by allowing traffic to use the right lane. • Improves sight distance for buses approaching intersections. • Requires shorter deceleration distances for buses. • Signalized intersections create traffic gaps for buses to reenter traffic lanes. • Improves pedestrian safety as passengers cross in back of the bus.	• Queuing buses may block the intersection during peak periods. • Sight distance may be obstructed for vehicles approaching intersections. • May increase the number of rear-end accidents if drivers do not expect a bus to stop after crossing an intersection. • Stopping both at a signalized intersection and a far-side stop may interfere with bus operations.
Mid-Block	• Minimizes sight distance problems for pedestrians and vehicles. • Boarding areas experience less congestion and conflicts with pedestrian travel paths. • Can be located adjacent to or directly across from a major transit mid-block use generator.	• Decreases on-street parking supply (unless mitigated with a curb extension). • Requires a mid-block pedestrian crossing. • Increases walking distance to intersections. • Stopping buses and mid-block pedestrian crossings may disrupt mid-block traffic flow.

Source: Federal Transit Administration, BRT Stops, Spacing, Location, and Design, www.fta.dot.gov/research_4361.html.

Table 8-2: Bus Stop Zone Standards

Location	Pull-In	Bus Station	Pull-Out	Total
Near Side Non-Signalized Intersection	50 feet	40-60 feet	20 feet	110-130 feet
Near Side Signalized Intersection	50 feet	40-60 feet	10 feet	100-120 feet
Far Side Across Intersection	10 feet	40-60 feet	40 feet	90-110 feet
Far Side After Right Turn	60 feet	40-60 feet	40 feet	140-160 feet
Far Side After Left Turn	65 feet	40-60 feet	40 feet	145-165 feet
Mid-Block	60 feet	40-60 feet	40 feet	150-170 feet

Source: City and County of Honolulu, Department of Transportation Services, Public Transit Division; Bus Stop Improvement and Design Guidelines; December 2005.

8.6. Bus Stop Zone

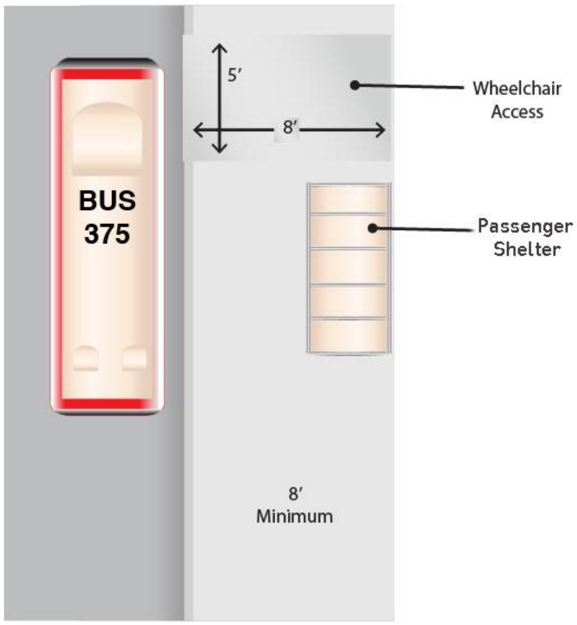
A well-placed and configured transit stop offers the following characteristics:

- Clearly defines the stop as a special place;
- Provides a tactile or visual cue on where to wait for a transit vehicle;
- Does not block the path of travel on the adjacent sidewalk; and
- Allows for ease of access between the sidewalk, the transit stop, and the transit vehicle.

Bus Stop Zone Standards include the following:

- The front of the zone will be located as near as practical to a point five feet from the nearest crosswalk or traffic control device where the zone is for a near-side intersection stop.
- The rear of the zone will be located five feet from the crosswalk or traffic control device where the zone is a far-side stop.
- A far-side zone after a right turn shall start not less than 50 feet from the intersection.
- Driveways with a reasonable slope are acceptable at rear door exits if there is no unusual hazard to alighting passengers.
- Zones shall be established so that access to doors is not impeded by structures such as poles, guy wires, fire hydrants, trees, etc.
- The bus zone shall not be extended to include driveways, alleyways, or other parking-restricted areas when those land uses generate large amounts of conflicting vehicle traffic over 100 vehicles per hour.

Figure 8-9: ADA Compliant Bus Stop



Credit: Michele Weisbart (Michele Designs)

- The bus zone shall only be extended to include driveways, alleyways, or other parking-restricted areas when necessary and only if low volumes of conflicting vehicle traffic exists, preferably less than 100 vehicle per hour.
- An additional 50 to 70 feet of length should be provided for each additional bus expected to stop simultaneously at any given bus stop area. This allows for the length of the extra bus (40 feet or 60 feet) plus 10 feet between buses.
- Additional space should be provided in the bus zone when off-board fare payment systems are included.
- The bus stop zone should consist of a curb length of no less than the length needed so that:
  - The bus may be able to stop parallel to the curb with the front door adjacent to the landing area.
  - The rear door is no more than six inches from the curb.
  - The rear door is clear of any obstructions that may be in the passenger's path while using the door.
- Streetscape elements shall be consolidated to create a clear waiting space and minimize obstructions between the sidewalk, waiting area, and boarding area.
- Special paving treatments or curb extensions (where there is on-street parking) shall be used to distinguish transit stops from the adjacent sidewalks, whenever possible.
- Transit stops shall be integrated with adjacent activity centers, whenever possible, to create active and safe places.

ADAAG requires a clear loading area (minimum 5 feet by 8 feet) perpendicular to the curb with a maximum 2 percent cross-slope to allow a transit vehicle to extend its lift to allow people with disabilities to board. The loading area should be located where the transit vehicle has its lift and be accessible directly from a passenger shelter. The stop must also provide 30 by 40 inches of clear space within a shelter to accommodate wheelchairs. The shelters must be connected by an accessible route to the boarding area.

Figure 8-10: Bus Stops Require a Clear Loading Area for Lift Deployment

Credit: Wes Frysztacki (Weslin Consulting Services)

8.7. Transit-Specific Streetscape Elements

The essential streetscape elements for transit include signs, shelters, seating, trash receptacles, static transit information (such as a route map and schedule), and real-time information available through electronic message sign boards. All streetscape elements shall comply with ADAAG and consider the impact on the pedestrian zone. Table 8-3: Transit Facility Amenities includes a list of amenities to include per bus facility.

Transit stops require both travel way and pedestrian lighting: strong illumination of the travel way for safer street crossing, and pedestrian scale illumination at the stop or shelter for security.

Flag signs indicate where people are to wait and board a transit vehicle. The signs should clearly identify the transit operator, route number, and schedule. Maps showing the transit lines servicing that stop, local destinations, and additional transfer transit lines should be provided whenever the boarding volume exceeds 1,000 passengers per day. Flag signs should be located towards the front of the stop.

According to ADAAG, new or replaced bus route identification signs should meet the following specifications:

- Letters and numbers on signs shall have a width-to-height ratio between 3:5 and 1:1, and a stroke width-to-height ratio between 1:5 and 1:1.
- The signs should be a minimum of 84 inches above the ground. Where this is not possible, a barrier shall be placed to warn visually-impaired people.
- Character height shall be at least 3 inches.

The bus route numbers should be displayed at bus stops whenever the passenger loading volume exceeds 100 boardings per day. All bus stop sign posts should include the bus stop number so people can use the HEA application. All signs at stops exceeding 500 passengers per day boardings should be double-sided.

Transit sign poles may be used for ancillary purposes such as route schedules, route maps, or private operator signs.

Figure 8-11: Transit Sign Poles May be Used for Ancilliary Purposes

Credit: Wes Frysztacki (Weslin Consulting Services)

Figure 8-12: Route Numbers and HEA Numbers Should be Displayed on Signage

Credit: Wes Frysztacki (Weslin Consulting Services)

Table 8-3: Transit Facility Amenities

	AMENITY	TYPE OF BUS FACILITY: Basic Local Transit Stop	Primary Local Stop	Super Stop	Transit Center	Park and Ride Lot
Developer and County Agreement	Bus Stop Sign on Post	Essential	Essential	Essential	Essential	Essential
	Route Designation on Sign	Essential	Essential	Essential	Essential	Essential
	Route Schedule on Post	Essential	Essential	Essential	Essential	Essential
	Passenger Shelter		Essential	Essential	Essential	Essential
	Benches, Stools or Leaning Rails		Essential	Essential	Essential	Essential
	Security Cameras		Beneficial in Some Situations	Beneficial in Most Situations	Beneficial in Most Situations	Beneficial in Most Situations
	Fare Media Vending Machine		Beneficial in Some Situations	Beneficial in Most Situations	Essential	Beneficial in Most Situations
	System Map/Fare Info		Beneficial in Some Situations	Essential	Essential	Essential
	Route Map/Schedule		Beneficial in Some Situations	Essential	Essential	Essential
	Refuse Receptacles		Beneficial in Some Situations	Essential	Essential	Essential
	Courtesy Telephone		Beneficial in Some Situations	Beneficial in Most Situations	Essential	Essential
	Landscaping and Artwork		Beneficial in Some Situations	Essential	Essential	Essential
	Reinforced Concrete Pad		Beneficial in Some Situations	Beneficial in Most Situations	Essential	Essential
	Specialty Decorative Paving		Beneficial in Some Situations	Beneficial in Most Situations	Beneficial in Most Situations	Beneficial in Most Situations
	Basic Ambient Lighting		Beneficial in Some Situations	Essential	Essential	Essential
	Multi-Source Lighting		Beneficial in Some Situations	Beneficial in Most Situations	Essential	Essential
	Bicycle Racks & Lockers		Beneficial in Some Situations	Beneficial in Most Situations	Essential	Essential
	Information Kiosk		Beneficial in Some Situations	Beneficial in Most Situations	Essential	Essential
	Real Time Info Display		Beneficial in Some Situations	Beneficial in Most Situations	Essential	Essential
	Bus Bays or Pullouts			Beneficial in Some Situations	Beneficial in Most Situations	Beneficial in Most Situations
	Drinking Fountain			Beneficial in Some Situations	Essential	Essential
	Passenger Loading Zones			Beneficial in Some Situations	Essential	Essential
	Turnaround for Buses			Beneficial in Some Situations	Essential	Essential
	Private Vehicle Parking				Beneficial in Some Situations	Essential
	Bathrooms				Beneficial in Some Situations	Beneficial in Some Situations
Vendor	Bicycle Sharing		Beneficial in Some Situations	Beneficial in Most Situations	Essential	Essential
	Electronic Bulletin Board		Beneficial in Some Situations	Beneficial in Most Situations	Essential	Essential
	On-Site Management			Beneficial in Most Situations	Essential	Essential
	Car Sharing			Beneficial in Some Situations	Essential	Essential
	Self Serve Library			Beneficial in Some Situations	Beneficial in Some Situations	Beneficial in Some Situations
	Cash Machine			Beneficial in Some Situations	Essential	Essential
	Public Telephone				Beneficial in Most Situations	Beneficial in Most Situations
	Post Office Vending				Beneficial in Some Situations	Beneficial in Some Situations
	Retail Kiosk				Beneficial in Some Situations	Beneficial in Some Situations
	Day Care Center				Beneficial in Some Situations	Beneficial in Some Situations
	Taxi Stand				Beneficial in Some Situations	Beneficial in Some Situations
	Joint Development				Beneficial in Some Situations	Beneficial in Some Situations

Legend:
- Essential
- Beneficial in Most Situations
- Beneficial in Some Situations

source: Weslin Consulting Services, Inc.

Additional information displays should be provided where there are more than five routes and/or more than 500 passenger boardings. These high volume bus stops should never be closed due to construction activity. This would apply to all public and private transit operations such as in Waikiki where most stops experience very heavy pedestrian activity.

Figure 8-13: Stops that have Multiple Routes or a High Volume of Boardings Should Never be Closed

Credit: Wes Frysztacki (Weslin Consulting Services)

Shelters keep waiting passengers out of the rain and sun and provide increased comfort and security. Shelters vary in size and design. The City has the following types of shelters:

- **Type A Shelters**: for sidewalks with a width of six feet, the roof measures five feet by 14 feet; two roof support posts are 10 feet apart; manufactured seating is located between the posts. Sidewalks should be widened to eight feet where there is a passenger shelter.
- **Type B Shelters**: for sidewalks with a width of eight feet, the roof measures 6.5 feet by 14 feet; two pairs of roof support posts connected by a series of recycled plastic lumber slats located 10 feet apart with manufactured seating located between the posts.
- **Type C Shelters**: for sidewalks requiring a narrow footprint, the roof measures eight feet by 16 feet; two roof support posts are 12 feet apart and stools are located between the posts.
- **Custom Shelters**: located at transit centers, rail stations, and major trip generators that are larger and offer more architectural features. Future custom shelters should include provisions for capturing stormwater

Figure 8-14: Custom Shelters at the Mililani Mauka Park & Ride Lot and the Former Kapolei Transit Center

Credit: Wes Frysztacki (Weslin Consulting Services)

from the roof and the surrounding area with flow into a natural vegetation filtration and/or use of the roof area for solar panels.
- Historic Shelters: those that have existed for many years and provide suitable functionality.

Shelters should:
- Be context sensitive;
- Be provided at transfer points, locations served by more than two routes or transit stops with longer total wait time;
- Have electrical connections to power lighting and/or real-time transit information, or accommodate solar power; and,
- Have light levels equal to or greater than the standard for the adjoining travel way applied to the immediate surrounding sidewalk and under the shelter roof.

Seating – Should be provided at transfer points, locations served by two or more routes, or stops where the wait time is longer than five minutes.

Trash Receptacles – Should be provided at transfer points, locations served by two or more bus routes, stops on bus routes with wait times greater than 15 minutes, and/or where the stop is in the general vicinity of waste receptacle use generator(s).

Figure 8-15: Bus Stop Waiting Areas Shall Not Conflict with the Pedestrian Zone

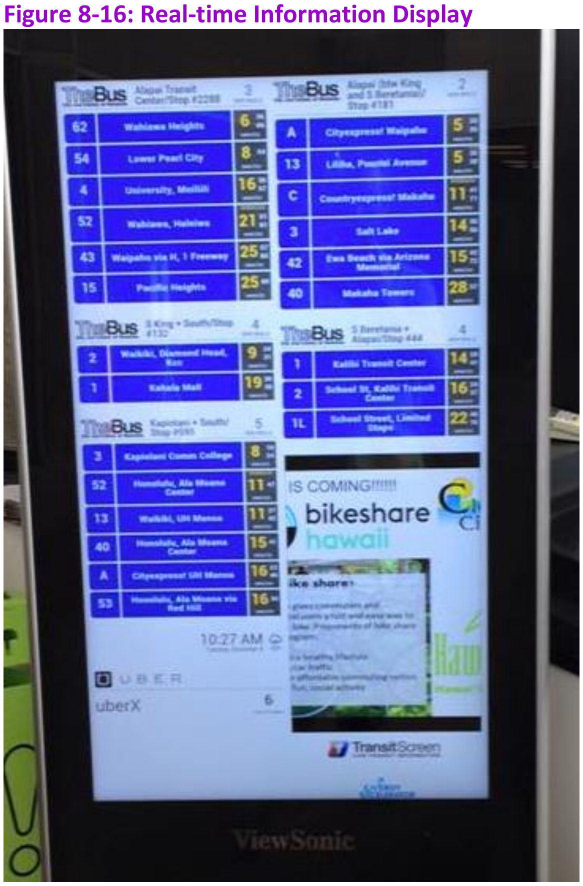
Hotel Street. Credit: Alan Fujimori (SSFM International)

Static Transit Information Displays (Information panels or equal) - Should be provided at transfer points, locations served by two or more bus routes and stops on bus routes with wait times greater than 15 minutes and at lone express route bus stops.

Real-time Information Displays – Should be provided at transit centers and stops that serve more than four bus routes or more than 200 passengers per day.

Very busy bus stops with more than 200 passenger boardings per day, transit centers, and rail stations should include space for vendors to sell newspapers, magazines, flowers, and other goods to keep the stops lively. No amenities (newspaper vending machines or tourist information stands) should be chained to any pole where a bus stop sign is installed, a transit information display, bollards, trees, other streetscape fixture, or within 10 feet of these items associated with the transit zone or facility.

Figure 8-16: Real-time Information Display



Credit: Mike Packard (SSFM International)

Rapid bus lines can include facilities that allow passengers to pay their fare before boarding the bus. This allows passengers to board from the rear door. It also allows buses to reduce their travel time by reducing dwell time at stops.

Fixed bicycle stands shall be provided wherever space is available, preferably at every bus stop. However, bicycle stands shall not be installed where passengers enter or exit a bus within a bus stop zone.

Figure 8-17: Bus Stops Should Provide Bike Stands, Racks, and Locker to Provide Accommodation for Bikes Often Seen Chained to Sign Poles

Kalakaua Avenue at McCully Street. Credit: Wes Frysztacki (Weslin Consulting Services)

8.8. Bus Stop Facilities

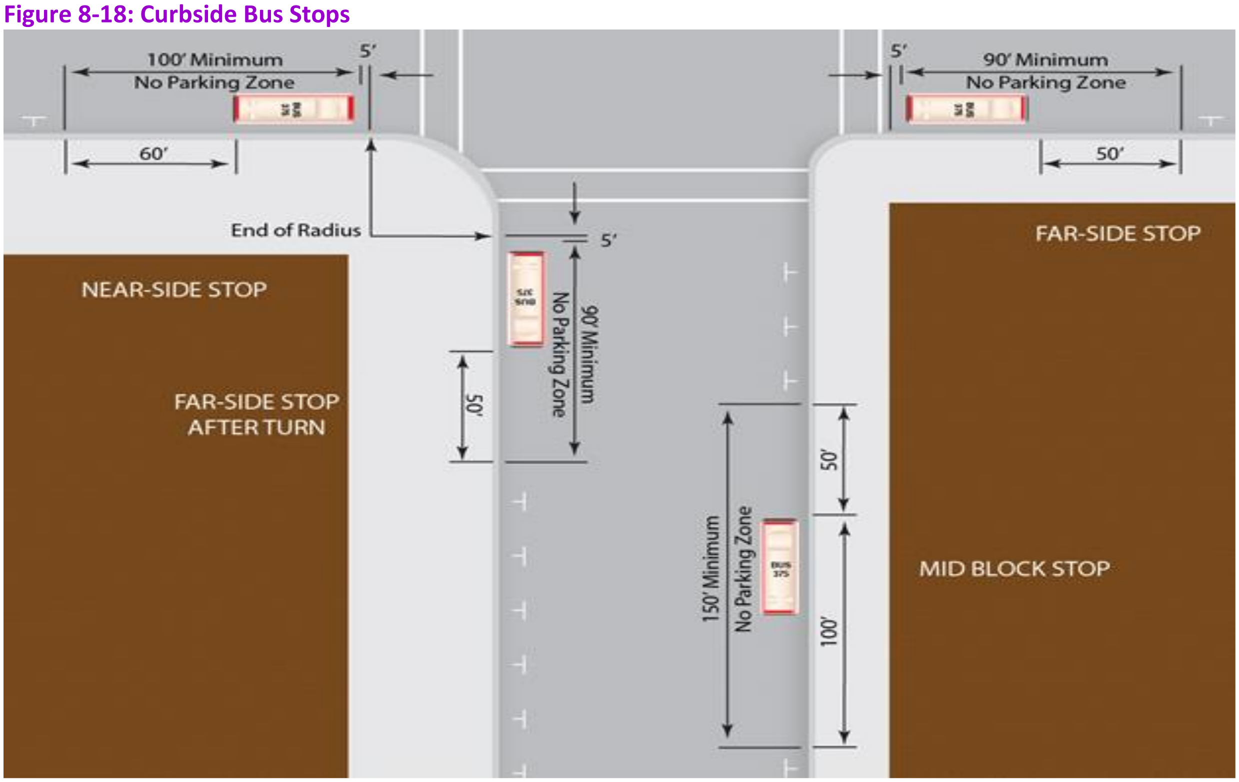
This section provides guidance for designing bus stop facilities. The guidelines provided allow for customization depending on the location. A significant number of these guidelines come from the Transit Cooperative Research Program Report 19, *Guidelines for the Location and Design of Bus Stop*s, prepared by the Transportation Research Board of the National Research Council and sponsored by the Federal Transit Administration. The length and configuration of a bus stop facility varies depending on the type of bus stop. Bus stop zones should be marked.

The following provides guidance for designing the bus stop facilities for four typical kinds of bus stops: curbside bus stops, bus bulbs, queue jumper bus bays, and partial open bus bays.

8.8.1. Curbside Bus Stops

Curbside bus stops have no curb extensions or cut outs. They provide easy access for bus drivers, are simple and inexpensive, and are easy to relocate. However, where they block the travel lane they can cause traffic to queue behind, and where they do not block the travel lane bus drivers may have difficulty re-entering traffic. Where articulated buses operate, an additional 20 feet should be added to the length of the bus stop zone. Where multiple buses may queue, the bus stop zone should be extended by 50 feet for each standard 40-foot bus, and by 70 feet for each additional 60-foot articulated bus.

Figure 8-18: Curbside Bus Stops



Credit: Michele Weisbart (Michele Designs)

8.8.2. Bus Bulbs

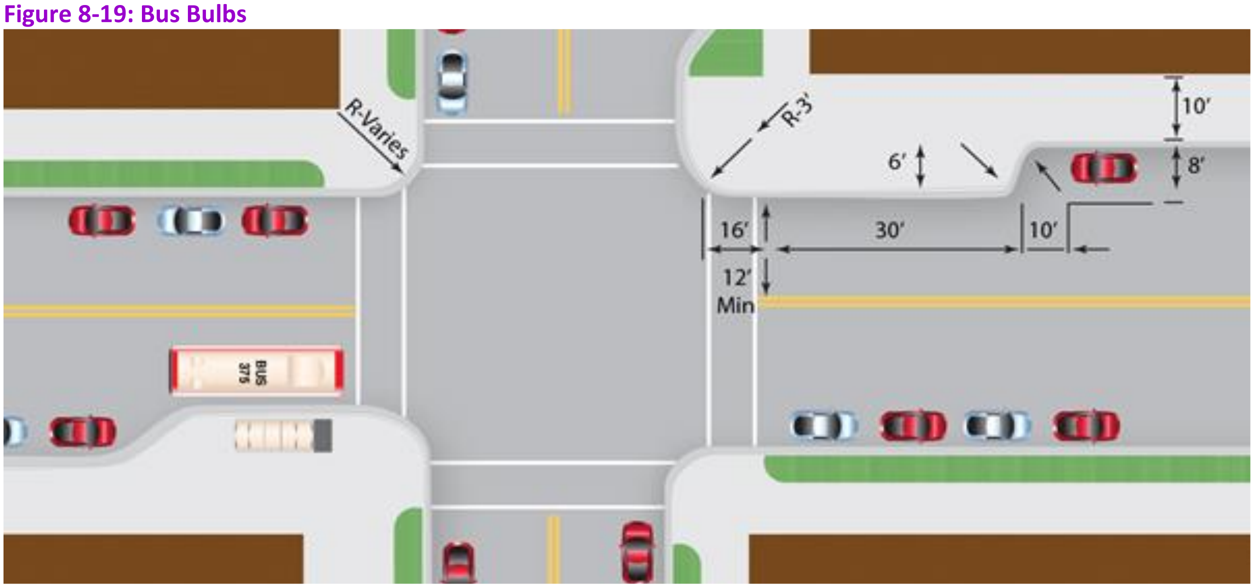
Bus bulbs are curb extensions that extend the length of the transit stop on streets with on-street parking. They improve transit performance by eliminating the need for buses to merge into mixed traffic after every stop. They also facilitate passenger boarding by allowing the bus to align directly with the curb. Waiting passengers can enter the bus immediately after it has stopped. They improve conditions for people on foot by providing additional space for people to wait for transit and by allowing the placement of passenger shelters where they do not conflict with a sidewalk's pedestrian zone. Bus bulbs also reduce the crossing distance of a street for people on foot if they are located at a crossing. In most situations, buses picking up passengers at bus bulbs block the curbside travel lane; but this is mitigated by the reduced dwell time, as it takes less time for the bus driver to position the bus correctly, and less time for passengers to board.

One major advantage of bus bulbs over pulling over to the curb is that they require less parking removal. Typically two on-street parking spots are eliminated for a bus bulb instead of four for pulling over.

The following conditions should be given priority for the placement of transit bus bulbs:

- Where transit performance is significantly slowed by the transit vehicle's merging into a mixed-flow travel lane;
- Travel ways served by express, limited stop service, or Bus Rapid Transit (BRT) lines;
- Stops that serve as major transfer points; and,
- Areas with heavy transit and pedestrian activity, and where narrow sidewalks do not allow for the placement of a passenger shelter without conflicting with the pedestrian zone.

Figure 8-19: Bus Bulbs



Credit: Michele Weisbart (Michele Designs)

Figure 8-20: Bus Bulb

Waialae Ave. at Koko Head Ave. Credit: Ryan Nakamoto (SSFM International)

Bus bulbs should not be considered for stops with any of the following:

- A queue-jumping lane provided for buses;
- On-street parking prohibited during peak travel periods; and,
- Near-side stops located at intersections with heavy right-turn movements, except along streets with a "transit-first" policy.

At a minimum, bus bulbs should be long enough to accommodate all doors of a transit vehicle to allow for the boarding and alighting of all passengers, or be long enough to accommodate two or more buses (with a 5-foot clearance between buses and a 10-foot clearance behind a bus) where there is frequent service such as with BRT or other express lines.

Bus bulbs located on the far side of a signalized intersection should be long enough to accommodate the complete length of a bus so that the rear of the bus does not intrude into the intersection.

Table 8-4: Standard Transit Vehicle and Transit Bus Bulb Dimensions

Vehicle	Length (feet)	Number of Buses at Stop	Minimum Platform Length (feet)	
			Near Side	Far Side
Standard bus	40	1	35	45
		2	55	65
Articulated bus	60	1	80	90
		2	120	130

Source: Federal Transit Administration, August 2004. Characteristics of Bus Rapid Transit for Decision Making Project NO: FTA-VA-26-7222-2004.1.

8.8.3. Queue Jumper Bus Bay

Queue jumper bus bays allow buses to bypass queued traffic and take advantage of queue jumper signals, which give them a head start across the intersection. A queue jumper bus bay is a dedicated bus lane that extends for a short distance at both sides of the intersection. Queue jumper bus bays are not needed with queue jumper signals where bus lanes exist. Queue jumper bus bays are most useful in the following situations:

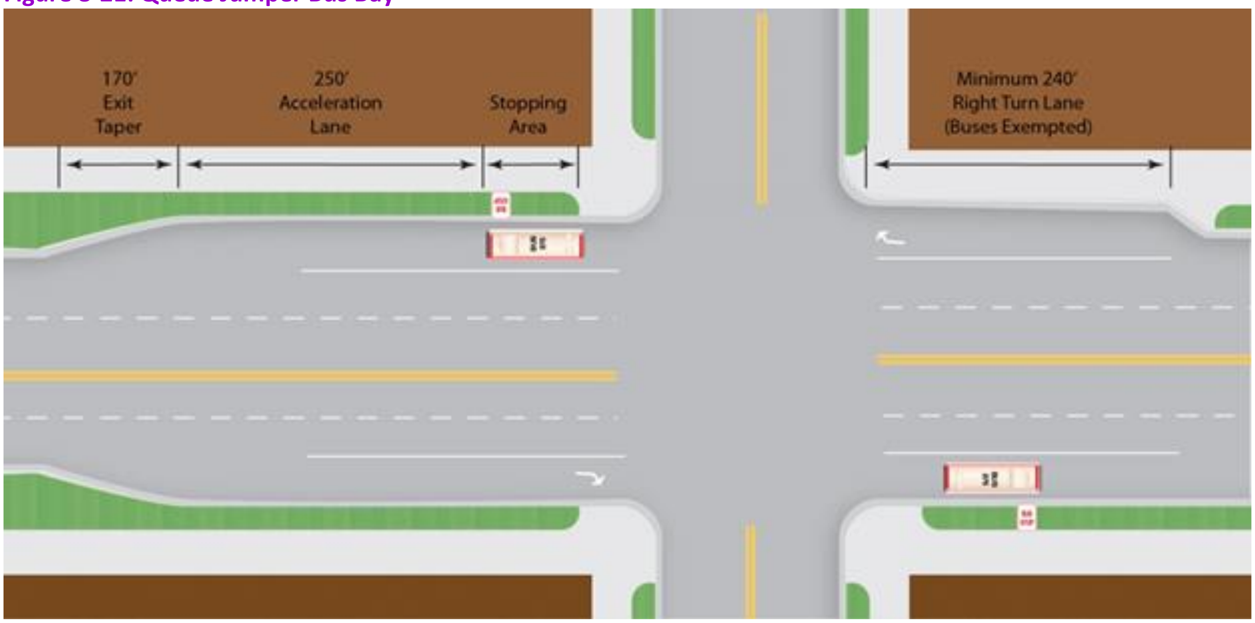
- Along bus routes with short wait times;
- Where traffic volumes exceed 250 vehicles per hour in the curb lane during the peak hour;
- At congested intersections; and,
- Where the physical space for the lane exists and creating the bay is not too costly.

The stopping area length should be 50 feet for each standard 40-foot bus, and 70 feet for each 60-foot articulated bus expected to be simultaneously stopped. The dimensions shown for the length of the exit taper, acceleration lane, and entrance taper are based on a through speed of 35 mph. These can be decreased with lower speeds and should be increased with higher speeds. The entrance taper should be at least 5:1 and the exit taper not sharper than 3:1.

Figure 8-22: Queue Jumper Bus Bay Example

South King St. at Alakea St. Credit: Mike Packard (SSFM International)

Figure 8-21: Queue Jumper Bus Bay



Credit: Michele Weisbart (Michele Designs)

8.8.4. Partial Open Bus Bays

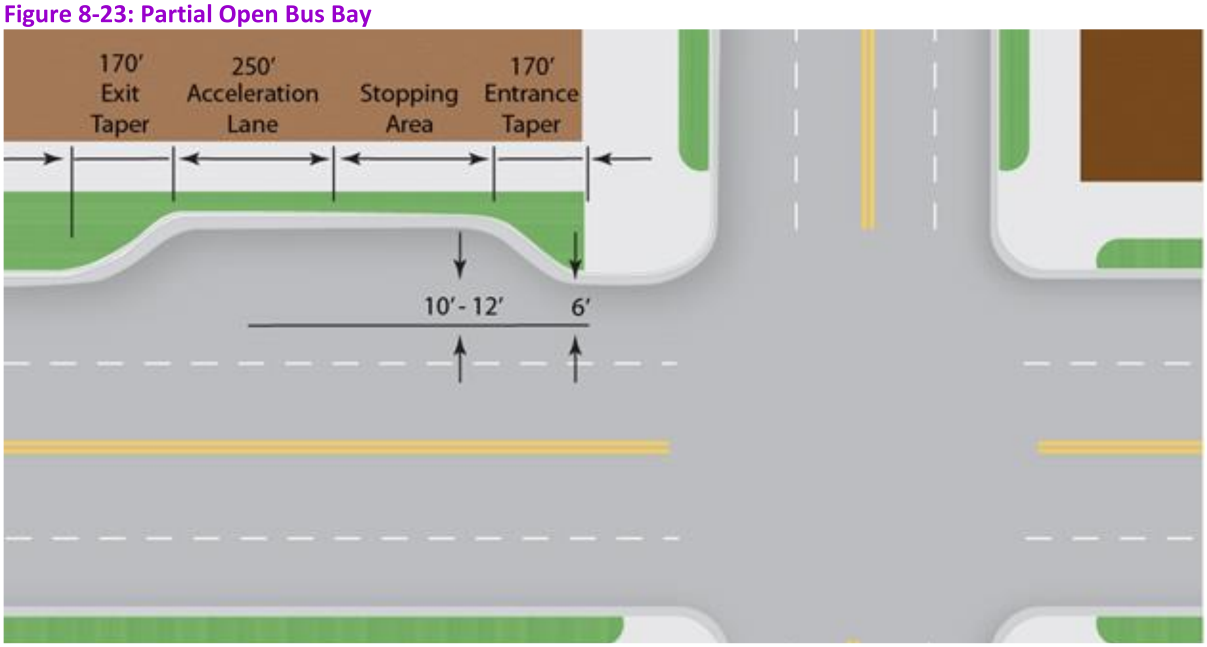
Partial open bus bays provide a curb extension to assist people on foot, many of whom may be bus passengers from across the street. They also prevent right-turning vehicles from using the bus bay for acceleration. The bays have the disadvantage of requiring buses to merge into traffic when they re-enter the travel lane.

The stopping area length should be 50 feet for each standard 40-foot bus and 70 feet for each 60-foot articulated bus expected to be simultaneously stopped. The dimensions shown for the length of the exit lane, and entrance taper are based on a through speed of 35 mph. These can be decreased with lower speed facilities and should be increased with higher speed facilities. The entrance taper should be at least 5:1 and the exit taper not sharper than 3:1.

8.8.5. Bus Turnouts

Bus turnouts have historically been used in Honolulu where traffic volumes are high. However, these present a situation where it can be difficult for buses to merge back into traffic. This adds to transit passenger delay and degrades transit service. Bus turnouts differ from bus bays in that the space consumed by the bus turnout interrupts the continuity of pedestrian zone and urban design treatments. Bus bays do not interfere with pedestrian zone continuity. Bus turnouts are not compatible with complete streets.

Figure 8-23: Partial Open Bus Bay



Credit: Michele Weisbart (Michele Designs)

8.9. Transit Signal Prioritization

Signal prioritization is a component of technology-based “intelligent transportation systems” (ITS). These systems are often used by road authorities in conjunction with transit agencies to help improve overall operations as follows:

- Reduce traffic signal delays for transit vehicles;
- Improve an intersection’s person throughput;
- Reduce the need for transit vehicles to stop for traffic at intersections;
- Help reduce transit vehicles’ travel time; and,
- Help improve transit system reliability and reduce waiting time for people at transit stops.

Signal prioritization projects include signal timing or phasing projects and transit signal priority projects.

Signal timing projects optimize the traffic signals along a corridor to make better use of available green time capacity by favoring a peak directional traffic flow. These passive systems give priority to travel ways with significant transit use within a district-wide traffic signal timing scheme. Transit signal prioritization can also be achieved by timing a corridor’s traffic signals based on a bus’s average operating speed instead of an automobile’s average speed.

Transit signal-priority projects alter a traffic signal’s phasing as a transit vehicle approaches an intersection. This active system requires the installation of specialized equipment at an intersection’s traffic signal controller and on the transit vehicle. It can either give an early green signal or hold a green signal that is already being displayed in order to allow buses that are operating behind schedule to get back on schedule. Signal-priority projects also help improve a transit system’s schedule adherence, operating time, and reliability.

Figure 8-24: Signal-Priority Technology Can Help to Reduce Delay for Buses

Credit: Michele Weisbart (Michele Designs)

Although they may use similar equipment, signal-priority and pre-emption are two different processes. Signal-priority modifies the normal signal operation process to better accommodate transit vehicles, while signal pre-emption interrupts the normal signal to favor transit or emergency vehicles.

The placement of a bus stop at the far side of a signalized intersection increases the effectiveness of transit signal-priority projects. Signal treatments should be used along streets with significant bus service.

8.9.1. Queue Jumpers

Queue jumpers give preference to buses at signalized intersections with a special phase in the traffic signal that gives buses a head start in crossing the intersection. They are used on dedicated bus lanes and where a special queue jumper lane provides an opportunity for buses to circumvent congestion at the intersection. (See Queue Jumper Bus Bay section.)

8.9.2. Minimum Turn Radius

Where bus routes make right turns, it is important to ensure adequate turn radii of the curb to enable the buses to turn without difficulty. The following diagrams illustrate the needed turning radii for a 40-foot bus, a 45-foot bus, and a 60-foot articulated bus. They are taken from the Los Angeles County Metropolitan Transportation Authority Standard Data Sheets.

Figure 8-26: 90 Degree Turn 45 Foot Bus

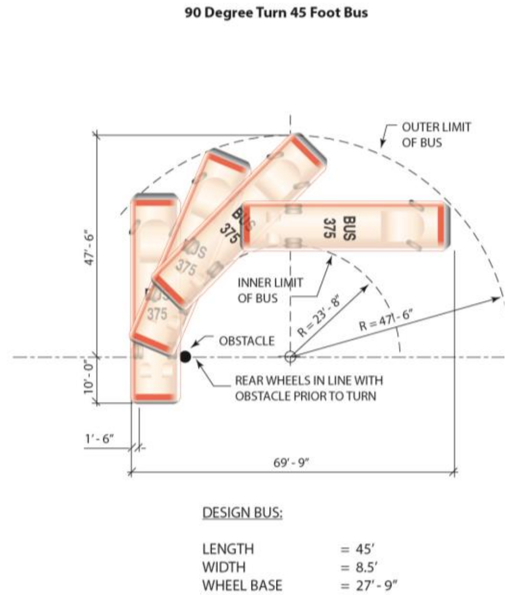


Figure 8-27: 90 Degree Turn 60 Foot Bus

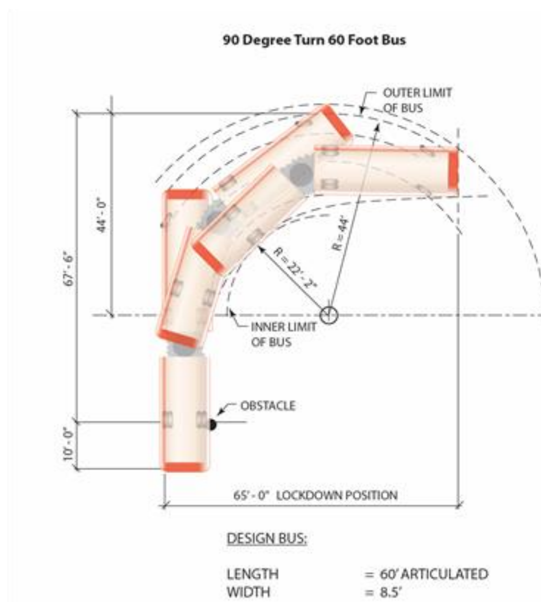
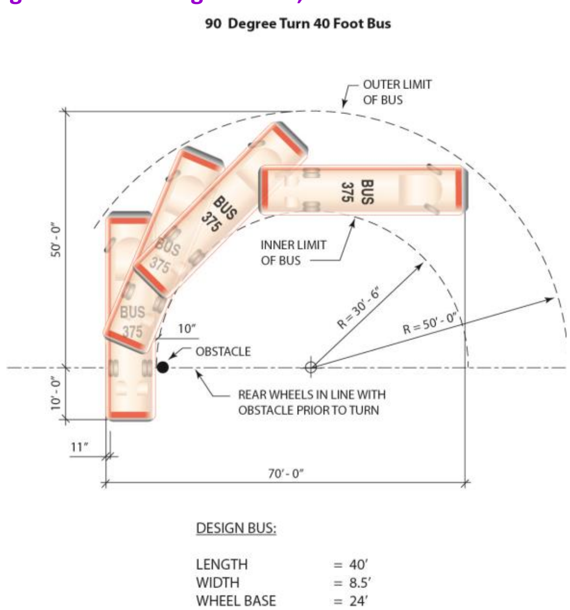


Figure 8-25: 90 Degree Turn, 40 Foot Bus



8.10. Bicycle Connections

Connecting bicycle facilities to transit stations helps extend the trip length for people on bicycles and reduces automobile travel. Secure bicycle parking must be provided at or within close proximity to a bus stop, preferably sheltered. At a minimum, the accommodations can include bike racks or lockers. Bike stations and automated bicycle parking can be located at areas with high levels of transit and bicycle use.

Bike sharing stations should be placed within close proximity to transit stops, centers, and stations to optimize multimodal connectivity.

Determining modal priorities is necessary to develop the most suitable design solutions. At some bus stops, the boarding area may be separated from the passenger shelter where bicycling has priority over transit.

Figure 8-29: Bus Stops Should Be Integrated With Bike Lanes

Portland, OR. Credit: Mike Packard (SSFM International)

Figure 8-28: Bus Stops Should Be Integrated with Bicycle Sharing

Kailua Road. Credit: Mike Packard (SSFM International)

8.11. Bus Lanes

Bus lanes provide exclusive or semi-exclusive use for transit vehicles to improve the transit system's travel time and operating efficiency by separating transit from congested travel lanes. They can be located in an exclusive right-of-way or share a travel way right-of-way. They can be physically separated from other travel lanes or differentiated by lane markings and signs.

Bus lanes can be located within a travel way median or along a curb-side lane and are identified by lane markings and signs. They should generally be at least 11 feet wide, but where bicycles share the lane with buses, 13 to 15 feet wide is preferred. When creating bus lanes, the following shall be considered:

- Exclusive transit use may be limited to peak travel periods or shared with high-occupancy vehicles.
- On-street parking may be allowed depending on travel way design, especially with bus lanes located in the center of the street.
- A mixed-flow lane or on-street parking may be displaced; this is preferable to adding a lane to an already wide travel way, which increases the crossing distance for people on foot and creates other problems discussed in other chapters.
- Within a mixed-flow lane, the travel way can be delineated with markings and signs.
- High-occupancy vehicles and/or bicycles may be permitted to use bus lanes.
- BUS-ONLY pavement markings and red colored paint may be applied to emphasize bus only travel. Red paint has been shown to deter unauthorized driving and parking in the bus lane.

Figure 8-30: Bus and Bike Only lane

Kalakaua Ave. Credit: Wes Frysztacki (Weslin Consulting Services)

8.12. Accommodating Rail, Light Rail, Street Cars, and BRT

The various options for accommodating light rail, street cars, and Bus Rapid Transit (BRT) within streets are as follows:

- Center-running;
- Two-way split-side, with one direction of transit flow in each direction;
- Two-way single-side, with both directions of transit flow on one side of the street right-of-way; and,
- One-way single-side, with transit running in one direction (either with or against the flow of vehicular traffic) and usually operating in a one-way couplet on parallel streets.

For each configuration, transit can operate in a reserved guideway or in mixed street traffic. When installing light rail or street cars within streets, the safety of people on foot and people on bicycles needs to be fully provided for. If poorly designed, these transit lines introduce hazards and serve to divide neighborhoods where crossings are highly limited and/or difficult or inconvenient (see Chapter 5, "Pedestrian Crossing" for more guidance). In general, in areas of high pedestrian activity, the speed of the transit service should be compatible with the speed of people on foot, if operating in mixed traffic.

The potential for each configuration is influenced by the street type. Some transit configurations will not work effectively in combination with certain street types.

Table 8-5 outlines the compatibility of each configuration with the street types that may have BRT, streetcars, or light rail.

Table 8-5: Street Types and Transit Configurations

	Center Running		Two-Way Split Side		Two-Way Single Side		One-Way Single Side	
Street Type	**Reserved Guideway**	**In Street**	**Reserved Guideway**	**In Street**	**Reserved Guideway**	**In Street**	**Reserved Guideway**	**In Street**
Boulevard	Y	N	N	Y	Y	N	Y*	Y
Avenue	Y	Y	Y*	Y	Y*	N	Y	Y
Street	N	Y	Y	Y	N*	N	Y	Y

Notes:
Y = Recommended street type/transit configuration combination
N = Not recommended/possible street type/transit configuration combination
*Denotes configurations that may be possible under certain circumstances, but are not usually optimal
Source: *Integration of Transit into Urban Thoroughfare Design*, DRAFT White Paper prepared by the Center for Transit-Oriented Development, updated: November 9, 2007.

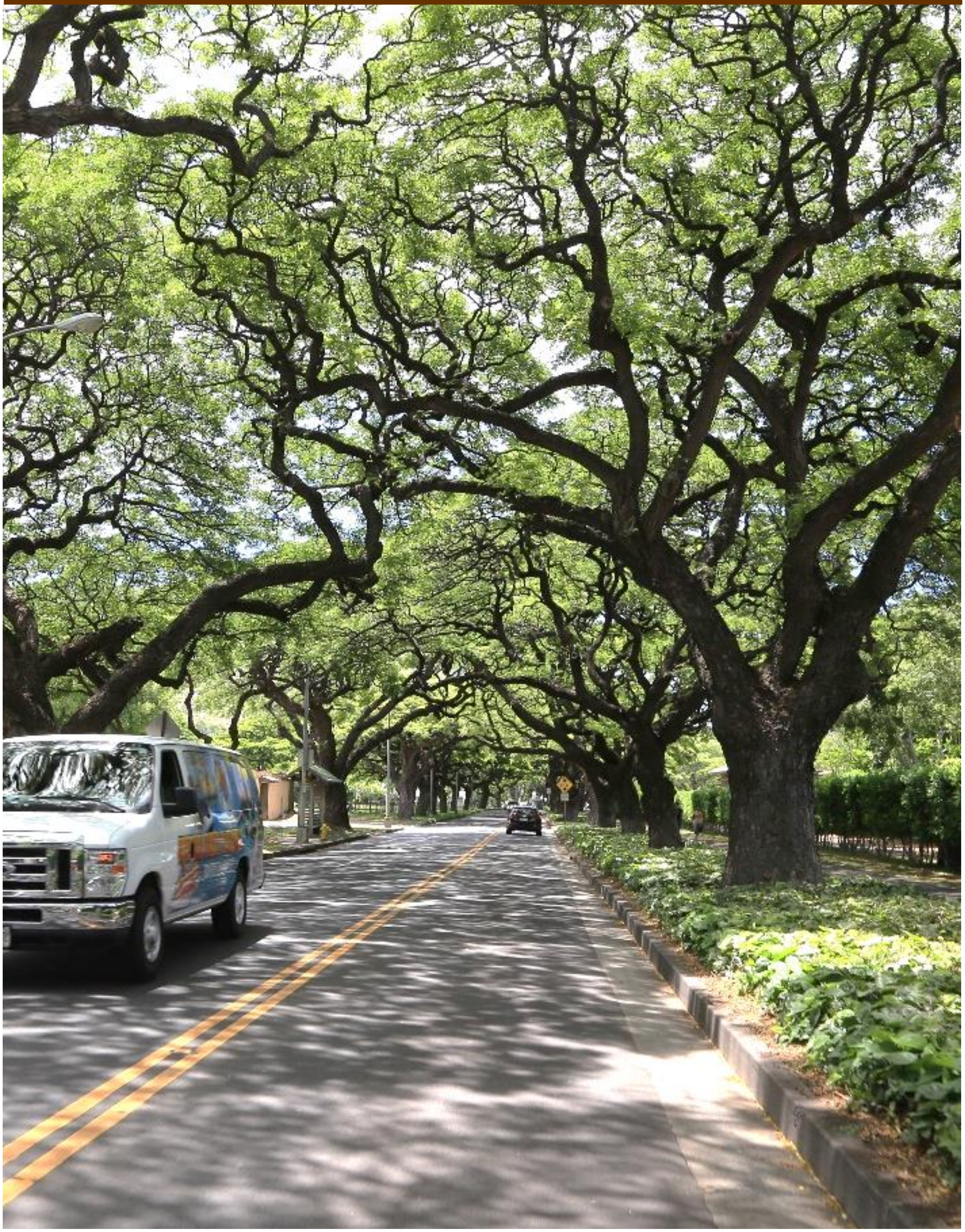
Figure 8-31: Street Car Within Multimodal Street

Portland, OR. Credit: Mike Packard (SSFM International)

Figure 8-32: Center-Running Light Rail

Source: Urban Street Design Guide (NACTO)

CHAPTER 9: STREETSCAPE ECOSYSTEM



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Chapter 9 Cover Image: Paki Avenue. Credit: Ryan Nakamoto (SSFM International)

CHAPTER 9: STREETSCAPE ECOSYSTEM

9.1. Introduction

The street is a system: a transportation system, an ecosystem, and a system of social and economic interactions. The idea of a streetscape ecosystem is to mimic nature, building reciprocal relationships within an interconnected system to sustainably enhance the local environment, its resources, the community, and the local economy. To do this, the tools addressed in this chapter should be integrated with those of the other chapters in this Manual.

This chapter is organized into sections based on a natural hierarchy. The first section focuses on stormwater management. Water is the fundamental ingredient for other components of a streetscape ecosystem. The stormwater management section provides guidance on how to work with and maximize the beneficial aspects of rain, its byproduct, stormwater, and other sources of water. The second section addresses street trees and landscaping, and provides guidance on how to design streets to include site-appropriate vegetation that maximizes environmental and social benefits. Canopy trees provide shade in the summer that cools the streets and the hardscapes from which the stormwater is harvested. These sheltered micro-climates create ideal locations for people to gather, walk, and bike.

Figure 9-1: Landscaped Neighborhood Traffic Circle

Uluhala Street at Ulupuni Street. Credit: Mike Packard (SSFM International)

No individual street project should be pursued in a vacuum, but rather planned as part of a comprehensive strategy. Use street medians, roundabouts, chicanes, curb extensions, and other road configurations as spaces for people and nature. They provide opportunities for spaces with vegetation and stormwater management tools.

Using the menu provided in this chapter, select streetscape elements that reflect the context and unique character of the location as well as support connections to adjacent land uses. The street can then function as a shared living room for the community and a welcoming front door for the buildings along the street. Native plantings can be used to root the context in the surrounding natural landscape while acknowledging the local ecosystem and climate.

The City and County of Honolulu Department of Planning and Permitting administers the *Standards and Procedures for the Planting of Street Trees* (DPP, 1999) which provides guidance on how to properly locate, select, plant, and maintain street trees. The *Standard Specifications for Public Works Construction* (DPW, 1986) and *Standard Details for Public Works Construction* (DPW, 1984) also contain information on street planing details. Technical guideance on the planting standards comes from the Department of Parks and Recreation, Division of Urban Forestry.

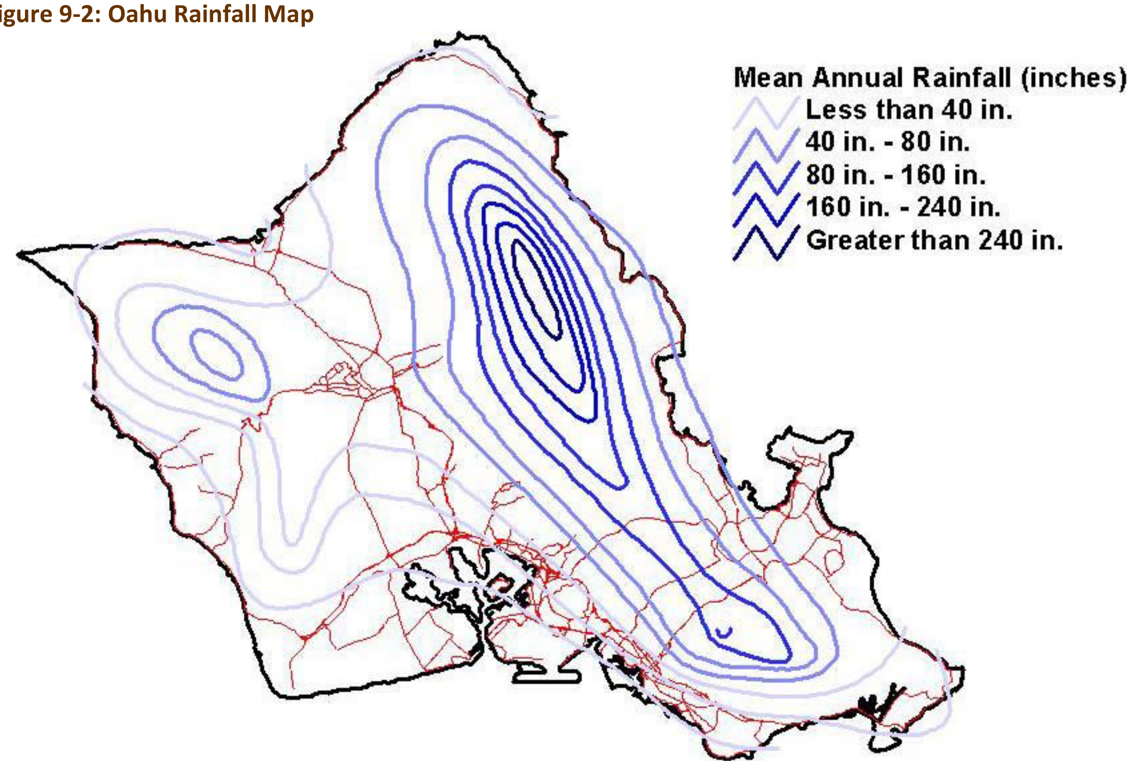
9.2. Stormwater Management

The street is a constructed waterway, often differing from the natural path of water and disconnected from the hydrologic cycle. Traditional design has focused on speedy removal of water from the street and disposal of it as waste in storm drains and sewers. This section provides tools to reclaim stormwater as a resource and nourish trees and soils on its path to ground or surface waters. These tools help cities design streets to sustainably work with both dry and wet weather sources of water. Climate is a key indicator of what types of stormwater management would be most appropriate. Oahu's diverse terrain, combined with near constant trade winds from the northeast, creates a mosaic of localized microclimates. There is a marked difference in the rainfall rate from the windward side, which is typically wet, to the leeward side which is typically arid. There are also seasonal variations, with winters tending to be wetter than summer months.

In both drier and wetter conditions stormwater can contain bacteria and other pollutants and is, therefore, regulated at the state and local levels. Streets represent a large percentage of the impervious area within urban Honolulu and generate substantial amounts of runoff from storm events. Many of the sources of pollutants to waterways come from streets, which contain oils, rubber, metals, and galvanized materials from automobiles.

While conventional stormwater controls aim to move water off-site and into storm drains as quickly as possible, stormwater management seeks to use and store water on-site for absorption and infiltration in order to clean it naturally and use it as a resource. The storm

Figure 9-2: Oahu Rainfall Map



Credit: State of Hawaii, Office of Planning, March 2001 drain system, therefore, becomes an overflow support system rather than a primary conveyance system. Stormwater management deals with water as an amenity rather than a liability.

Many of the stormwater management options discussed in this section can and should integrate easily with traffic calming measures installed along streets, such as medians,traffic circle islands, street ends, chicanes, and curb extensions. These measures can easily incorporate stormwater treatment into the landscape. Stormwater tools can be made more cost-effective if integrated early in the design process.

Stormwater management also provides opportunities to leverage other streetscape elements and components of complete streets. A strategic plan linking streetscape elements and street design can maximize benefits.

The City and County of Honolulu, Department of Planning and Permitting published the *Storm Water BMP Guide* (DPP, 2012) which provides general guidelines to support the implementation of low impact development site strategies, source control best management practices, and post-construction treatment control best mangement practices (BMPs) to meet water quality criteria. More detailed information is included in the *City and County of Honolulu Storm Water BMP Manual, New Development and Redevelopment*.

This section provides additional guidance to comply with the *National Pollutant Discharge Elimination System* (NPDES) requirements of the Clean Water Act, as promulgated by the U.S. Environmental Protection Agency.

9.2.1. Goals and Benefits of Stormwater Management

The primary goals of stormwater management are as follows:

- Reduce—limit the amount of impervious surfaces that generate additional runoff;
- Slow—friction slows flow;
- Spread—allow water to be slowed enough to infiltrate;
- Sink—keep water on site;
- Store—contain water for direct non-potable/potable indoor/outdoor purposes;
- Use—to irrigate and replace imported potable water.

These goals can be expressed succinctly: slow it, spread it, store it, and sink it, but use it.

The tools provided in this chapter enable cities to attain regulatory compliance and provide the following ecological, economic, and aesthetic benefits:

- Reduced use of potable water for irrigation;
- Reduced surface water pollution;
- Support for the urban ecosystem and wildlife habitat;
- Enhanced flood control;
- Biological filtration and bioremediation;
- Groundwater recharge;
- Reduced heat island effect;
- Education through best management practices (BMP) visibility;
- Aeration of root zone;
- Potential reductions in stormwater infrastructure and treatment costs;
- Improved aesthetics and public space within neighborhoods.

9.2.2. Principles of Stormwater Management

Use the conventional storm drain system as the overflow approach, not the primary system to manage stormwater. Wherever possible, natural drainages should be the primary overflow.

Harvest, use, and/or store stormwater as close to its source as possible. Wet weather rainfall and its byproduct, stormwater, can offset or eliminate imported potable irrigation water needs when harvested and used on-site. Harvesting and storing stormwater transforms a flooding liability into an on-site irrigation resource. This ensures natural waterways and their plant communities have local sources of water, thereby reducing the need for imported water. Harvesting and storing rainwater also reduces the need for costly drainage conveyance infrastructure for stormwater management.

Use on-site non-potable water sources for irrigation before any imported water source. In dry weather, irrigation overspray can be reduced by enforcing existing laws/ordinances banning these practices. This leads to more efficient water use and reduces costly imported potable water consumption.

Select tools that mimic natural processes. Minimize the cost of the installation and maintenance by using gravity flow rather than pumped flow, living filtration over synthetic/mechanical filtration, and living surface infiltration instead of piped drainage. Priority should also be given to pervious versus impervious surfaces. The primary purpose is to harvest and utilize rain as part of a healthy vegetated watershed. For example, vegetation can reduce runoff water volume and pollutant load, provide shade and cooling in the summer, and enhance wildlife habitat and sense of place with native vegetation rooted to the local ecosystem.

Maximize stormwater management by integrating it into the myriad design elements in the public right-of-way. The water system is part of a larger, interconnected system. Maximize the benefits of stormwater strategies. For example, traffic calming and road diets can double as stormwater harvesting strategies. In addition, use vegetation to make streets better places and use stormwater management as an integral element of the urban forest.

Show the water flow. The benefits of stormwater management are ecological, economic, and social. Make the functions described in this chapter visible for street users to see, understand, appreciate, and replicate. Public right-of-way stormwater installations can inspire private property installations and serve as model installations for neighborhoods. Visible water flow systems are also easier to maintain. Blockages are easier to notice and easier to access for regular maintenance.

Figure 9-3: Flourishing Rain Garden

Portland, OR. Credit: Mike Packard (SSFM International)

9.2.3. Stormwater Management Definitions

The terms below describe the elements and techniques of sustainable stormwater management:

- ***Best Management Practice (BMP)*** - Operating methods and/or structural devices used to reduce stormwater volume, peak flows, and/or pollutant concentrations of stormwater runoff through one or more of the following processes: evapotranspiration, infiltration, detention, filtration, and biological and chemical treatment.
- ***Bioretention*** - A soil and plant-based retention practice that captures and biologically degrades pollutants as water infiltrates through sub-surface layers containing microbes that treat pollutants. Treated runoff is then slowly infiltrated and recharges the groundwater. These biological processes operate in all infiltration-based strategies, including various retention systems.
- ***Conveyance -*** The process of water moving from one place to another.
- ***Daylight -*** To bring stormwater or stormwater flow to the surface, exposed to open air and visible to the public.
- ***Design Storm*** - A storm whose magnitude, rate, and intensity do not exceed the design load for a storm drainage system or flood protection project.
- ***Detention -*** Stormwater runoff that is collected at one rate and then released at a controlled rate. The difference is held in temporary storage.
- ***Dry weather runoff -*** Human activity-related sources of water, such as irrigation overspray, car wash runoff, leaking plumbing, fire hydrant and well flushing, and runoff from mechanical processes such as air conditioning.
- ***Filtration -*** A treatment process that allows for removal of solid (particulate) matter from water by means of porous media such as sand, soil, vegetation, or a man-made filter. Filtration is used to remove contaminants.
- ***Hardscape*** - Impermeable surfaces, such as concrete or stone, used in the landscape environment along sidewalks or in other areas used as public space.
- ***Infiltration -*** The process by which water penetrates into soil from the ground surface.
- ***Permeability/Impermeability*** - The quality of a soil or material that enables water or air to move through it, and thereby determines its suitability for infiltration-based stormwater strategies.
- ***Retention*** - The reduction in total runoff that results when stormwater is diverted and allowed to infiltrate into the ground through existing or engineered soil systems.
- ***Runnel*** - Narrow, shallow drainage channel designed to carry small amounts of runoff.
- ***Runoff*** - Water from rainfall that flows over the land surface that is not absorbed into the ground.
- ***Sedimentation*** - The deposition and/or settling of particles suspended in water as a result of the slowing of the water.
- ***Softscape*** - Natural, permeable, landscape surfaces such as vegetation, mulch, and loose rock.
- ***Stormwater*** - Rainwater that flows and collects in the street.
- ***Stormwater*** - All waters flowing in the street or other hardscapes in the right-of-way, whether from dry weather runoff or rainwater sources.

9.2.4. Tools for Stormwater Management

There are many tools and BMPs for managing stormwater sustainably. Most popular are devices and practices that encourage water percolation on-site to the maximum degree practicable (given soil conditions, pollutant levels, etc.). The most important devices and practices are bioretention BMPs consisting of swales, planters, and vegetated buffer strips, as well as detention BMPs consisting of rain gardens, infiltration trenches, and dry wells. While permeable paving also slows and retains stormwater, it is listed separately because its primary function is to serve as a surfacing material that reduces runoff. Additional tools include delivery and conveyance tools and inlet protections.

The stormwater management tools mentioned in this Manual are highly customizable and can be integrated into a variety of different types of spaces in any of the street types. They can be implemented alone or in concert with one another to achieve cumulative benefits. Opportunity sites include medians, corner and mid-block curb extensions, travel way and park edges, front building edges, and surrounding street trees. Selecting the appropriate BMP is dependent on the street type and site conditions. High-traffic commercial streets have different parameters than smaller residential streets.

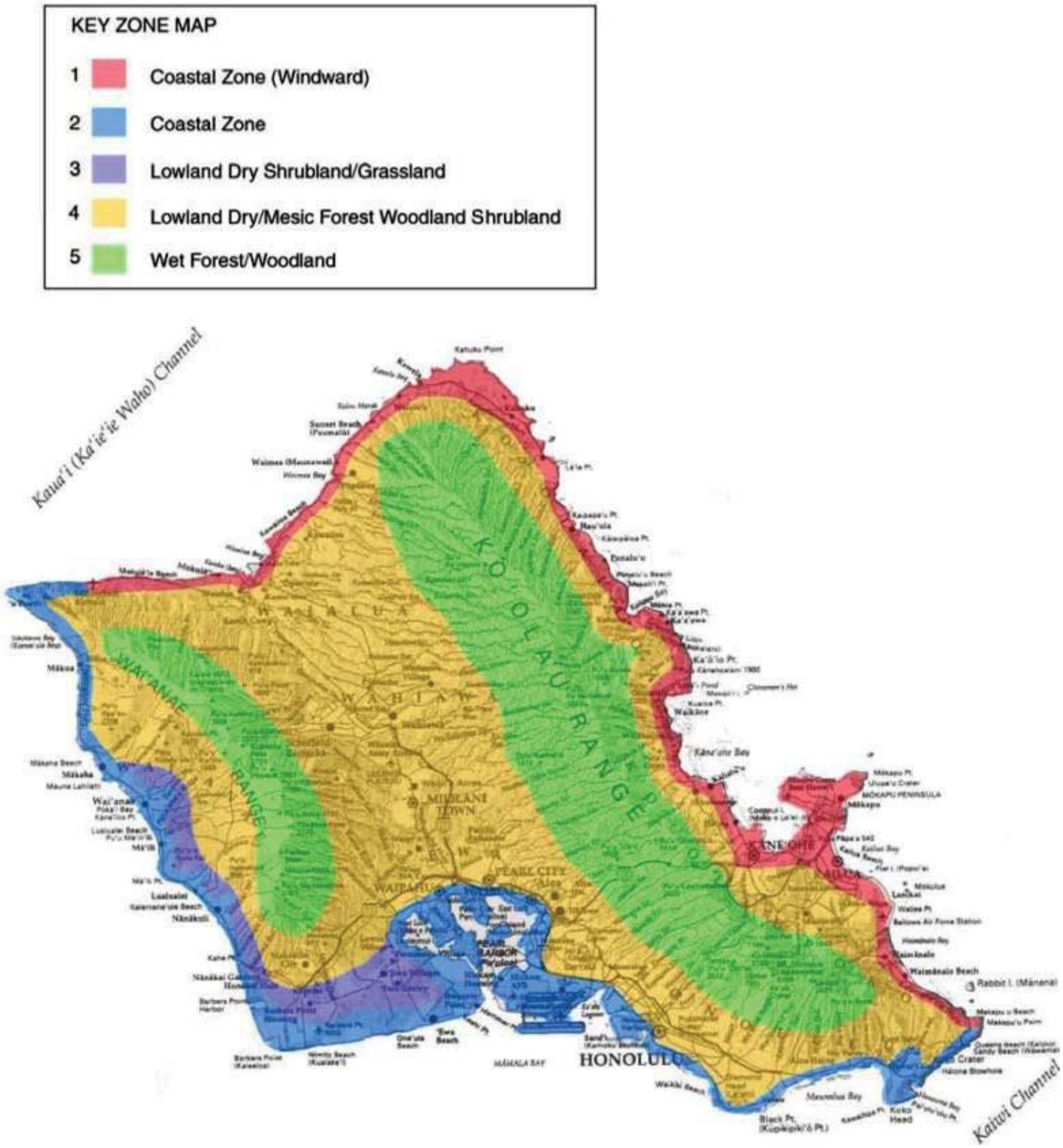
Selection of stormwater management techniques involves an analysis of the biome and soil, as well as adjacent land use and sidewalk components and width. Honolulu has a variety of soils, some of which lend themselves to infiltration more than others. For example, in higher elevations with higher rainfall rates, soils generally have moderate draining capacity. Soils near the coastline are typically alluvial plain soils with less drainage capacity. These biomes and soil types are identified in the City's 2006 *Urban Reforestation Master Plan*. Sidewalks with wide, planted furniture zones lend themselves to more management tools than narrow sidewalks. Areas of high pedestrian activity should keep the paved area of the sidewalk as wide as needed and furniture zones should not be a continuous planted strip. These will be in such places as along Main Streets, in the downtown core, TODs, and in Waikiki. These areas may use porous concrete as a more appropriate tool.

The following sections describe techniques to site and construct systems to integrate stormwater management tools into both new and existing streets. Table 9-1: Best Fit for Stormwater Tols by Street Context describes typical applicability of specific stormwater tools to individual street types.

Figure 9-4: Rain Garden in Bulbout

Portland, OR. Credit: Mike Packard (SSFM International)

Figure 9-5: Biome Map



Credit: Urban Reforestation Master Plan (City and County of Honolulu, December 2006)

Table 9-1: Best Fit for Stormwater Tools by Street Context

		BIORETENTION			DETENTION		PAVING	DELIVERY AND CONVEYANCE	INLET PROTECTIONS		
	STREET CONTEXT	Swales	Planters	Vegetated Buffer Strips	Rain Gardens	Infiltration Trenches and Dry Wells	Permeable Paving	Channels and Runnels	Screens	Inlet Inserts	Pipe Filters
Commercial	Downtown Commercial		o			o	o	o	o	o	o
	Commercial Through Way		o	o		o	o	o	o	o	o
	Neighborhood Commercial		o	o	o	o	o	o	o	o	o
Residential	Downtown Residential	o	o		o	o	o	o	o	o	o
	Residential Through Way	o	o		o	o	o	o	o	o	o
	Neighborhood Residential	o	o		o	o	o	o	o	o	o
Industrial And Mixed-Use	Industrial	o	o		o	o	o	o	o	o	o
	Mixed-Use		o	o		o	o	o	o	o	o
Special	Sidewalk Furniture Zone	o	o		o	o	o	o	o	o	o
	Park Edge	o	o		o	o	o	o	o	o	o
	Boulevard	o	o		o	o	o	o	o	o	o
	Ceremonial (Civic)						o	o	o	o	o
Small	Alley		o			o	o	o	o	o	o
	Shared Public Way		o			o	o	o	o	o	o
	Walk Street		o	o		o	o	o	o	o	o

9.2.4.1. General Guidelines

Site Considerations: Streetscape geometry, topography, and climate determine the types of controls that can be implemented. The initial step in selecting a stormwater tool is determining the available open space and constraints. Although the maximum size of a selected stormwater facility may be determined by available area, the standard design storm should be used to determine the appropriate size, slope, and materials of each facility.

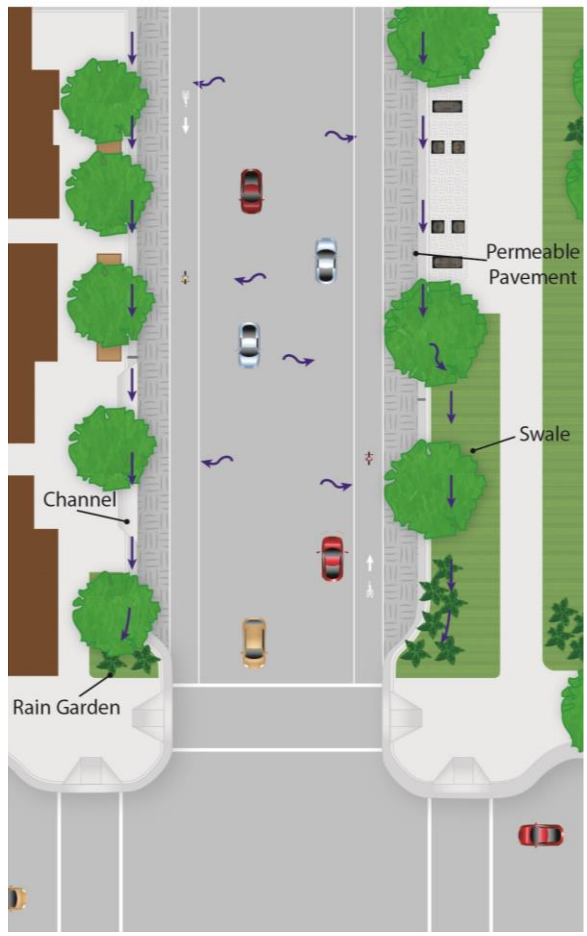
After identifying the appropriate stormwater facilities for a site, an integrated approach using several tools is encouraged. To improve water quality and functional hydrologic benefits, several stormwater management tools can be used in succession. This is called a "treatment train" approach. The control measures should be designed using available topography to take advantage of gravity for conveyance to and through each facility.

Figure 9-6: Rain Garden in Traffic Circle Island

Credit: Michele Weisbart (Michele Designs)

Traffic calming measures, such as medians, circles, chicanes, and curb extensions, should integrate stormwater management options discussed in this chapter. Figure 9-6 illustrates a center-draining street utilizing a rain garden integrated into a circle. These areas offer ideal opportunities for treating runoff as they typically intercept the flow path of water along a street and provide additional surface and subsurface space for treating and infiltrating stormwater. By integrating stormwater management tools at an early design stage, new facilities can be added with only marginal cost when paired with other streetscape construction projects.

Figure 9-7: Crowned Complete Street



Credit: Michele Weisbart (Michele Designs)

Infiltration Considerations: Appropriate soils, infiltration media, and infiltration rates should be used for infiltration BMPs. Ideally, a complete geotechnical or soils report should be undertaken to determine infiltration rates, soil toxicity and stability, and other factors that will affect the ability and the desirability of infiltration. At a minimum, the infiltration capacity of the underlying soils should be deemed suitable for infiltration and appropriate media should be used in the BMP itself.

Using certain techniques, stormwater tools can still be incorporated into areas of low permeability or where infiltration of stormwater is not desirable. Underdrains should be used in areas of low soil permeability. The location of the underdrain is an important consideration: if placed higher in a facility, the stored water below the perforated pipe will be infiltrated. If placed at the bottom of a sealed system, the perforated pipe will release the stored water slowly over time. These infiltration BMPs may overflow to appropriate locations such as catch basins and outfalls.

Details are important to the ultimate success or failure of an infiltration system. Poor soil conditions may cause stormwater to infiltrate either too fast or too slow. Over-compaction of subsurface soil during construction can lead to reduced infiltration capacity, flooding, and ponding. The bottom surface of infiltration areas should be level to allow even distribution. Soils and gravels in an infiltration installation should be meticulously specified and verified in the field during construction. Proper maintenance is crucial to the success of an infiltration BMP. To ensure proper caretaking, a maintenance plan or contract with a local agency is necessary.

9.2.4.2. Bioretention

Bioretention is a stormwater management process that cleans stormwater through a natural soil filtration processes as water flows through a bioretention BMP. It incorporates mulch, soil pores, microbes, and vegetation to reduce and remove sediment and pollutants from stormwater. Bioretention is designed to slow, spread, and, to some extent, infiltrate water. Each component of the bioretention BMP is designed to assist in retaining water, evapotranspiration, and adsorption of pollutants into the soil matrix. As runoff passes through the vegetation and soil, the combined effects of filtration, absorption, and biological uptake of plants remove pollutants.

For areas with low permeability or other soil constraints, bioretention can be designed as a flow-through system with a barrier protecting stormwater from native soils. Bioretention areas can be designed with an underdrain system that directs the treated runoff to infiltration areas, cisterns, or the storm drain system, or may treat the water exclusively through surface flow.

Honolulu will need to closely monitor and regulate retention for droughts, floods, and fluctuating rainfall levels due to climate change.

9.2.4.2.1. Location and Placement

Bioretention facilities can be included in the design of all street components: adjacent to the travel way and in the frontage or furniture zones. They can be designed into curb extensions, medians, traffic circles, roundabouts, and other landscaped area. Depending on the feature, maintenance and access should always be considered in locating the device. Bioretention systems are also appropriate in constrained locations where other stormwater facilities requiring more extensive subsurface materials are not feasible.

If bioretention devices are designed for infiltration, native soil should have a minimum permeability rate of 0.5 inches per hour and at least 10 feet to the ground water table. Sites that have more than a 5 percent slope may require other stormwater management approaches or special engineering.

Figure 9-8: Bioretention

Windward Mall, Kaneohe. Credit: Roth Ecological Design

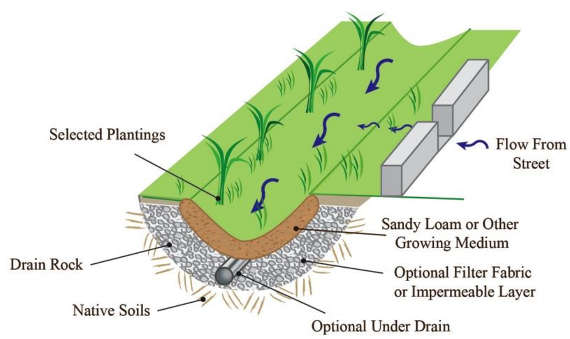
9.2.4.2.2. Guidelines

A sponge-like surface application of organic mulch can quicken the rate of absorption into the soil, slow soil moisture loss to evaporation, and reduce the solid waste stream if the mulch is generated from local organic matter. This strategy can also intercept and reduce sediment and nutrient concentrations in runoff via bioremediation.

Plants should be microclimate-appropriate and must be able to tolerate occasional saturation as well as dry periods.

The use of multiple small devices is often more feasible in tight urban environments than the use of one large device. Small systems can be linked together to achieve the desired cumulative capacity.

Figure 9-9: Established Swale in the Landscape



Credit: Julia Campbell and Michele Weisbart (Michele Designs)

9.2.4.2.3. Swales

Swales are linear, vegetated depressions that capture rainfall and runoff from adjacent surfaces. The swale bottom should have a gradual slope to convey water along its length. Swales can reduce off-site stormwater discharge and remove pollutants along the way. In a swale, water is slowed by traveling through vegetation on a relatively flat grade. This gives particulates time to settle out of the water while contaminants are removed by the vegetation. Because the vegetation receives much of its needed moisture through stormwater, the need for irrigation is greatly reduced.

Location and Placement: Swales can easily be located adjacent to travel ways, sidewalks, or parking areas. Travel way runoff can be directed into swales via flush curbs or small evenly-spaced curb cuts into a raised curb. Swale systems can be integrated into traffic calming devices such as chicanes and curb extensions.

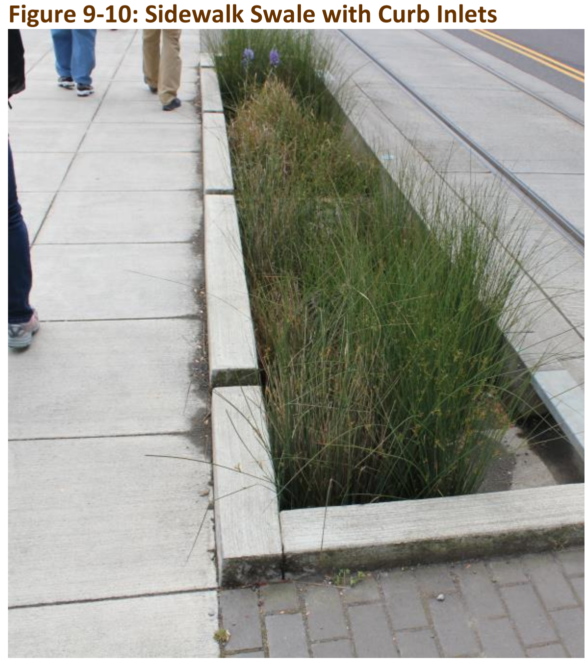
Swales can be placed in medians where the street drains to the median. Placed alongside streets and pathways, vegetated swales can be landscaped with native plants which filter sediment and pollutants and provide habitat for wildlife. Swales should be designed to work in conjunction with the street slope to maximize filtration and the slowing of stormwater.

Guidelines*:* Soils that promote absorption and support vegetation, such as sandy loams, should be specified on a case-by-case basis. Base layers of rock and stabilizing filter fabric may also be specified. Swale length, width, depth, and slope should be determined by capacity needed for treatment of the design storm**.**

Swales are designed to allow water to slowly flow through. Depending on the landscape and design storm, an overflow or bypass for larger storm events may be needed. Curb openings should be designed to direct flow into the swale. Following the inlet, a sump may be built to capture sediment and debris. Mulch can be used in systems where it will not escape the swale system, such as in flatter, deeper swales. Check dams should be used to slow the velocity of water and catch sediment when the slope along the length of the swale exceeds 4 percent.

Swales should be landscaped with deep-rooted grasses and vegetation that tolerate short periods of inundation, deposits of sediment, and periods of drought. Vegetation will filter sediment and slow erosion, protecting the swale from failure. The sides of swales should be minimally sloped to protect the swale from erosion and slope failure.

Figure 9-10: Sidewalk Swale with Curb Inlets



Portland, OR. Credit: Mike Packard (SSFM International)

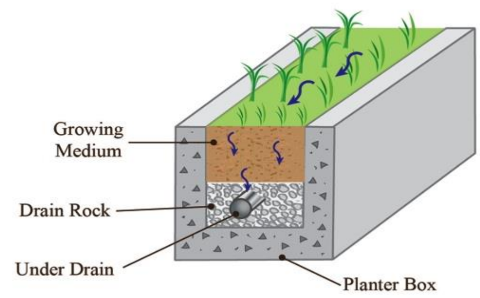
9.2.4.2.4. Planters

Planters are typically above-grade or at-grade with solid walls and a flow-through bottom. They are contained within an impermeable liner and use an underdrain to direct treated runoff back to the collection system. Where space permits, buildings can direct roof drains first to building-adjacent planters. Both underdrains and surface overflow drains are typically installed with building-adjacent planters.

At-grade street-adjacent planter boxes are systems designed to take street runoff and/or runoff from sidewalks and incorporate bioretention processes to treat stormwater. These systems may or may not include underdrains.

Location and placement: Above-grade planters should be structurally separate from adjacent sidewalks to allow for future maintenance and structural stability per the City's standards. At-grade planter systems can be installed adjacent to curbs within the frontage and/or furniture zones.

Figure 9-12: Planter Detail



Credit: Julia Campbell and Michele Weisbart (Michele Designs)

Guidelines: All planters should be designed to pond water for less than 48 hours after each storm. Flow-through planters designed to detain roof runoff can be integrated into a building's foundation walls, and may be either raised or at grade.

For at-grade planters, small localized depressions may be included in the curb opening to encourage flow into the planter. Following the inlet, a sump (depression) to capture sediment and debris may be integrated into the design to reduce sediment loadings.

Figure 9-11: Planter Along a Curbless Street

Portland, OR. Credit: Mike Packard (SSFM International)

9.2.4.2.5. Vegetated Buffer Strips

Vegetated buffer strips are sloping planted areas designed to treat and absorb sheet flow from adjacent impervious surfaces. These strips are not intended to detain or retain water, only to treat it as a flow-through feature. They should not receive concentrated flow from swales or other surface features, or concentrated flow from pipes.

Location and placement: Vegetated buffer strips are well-suited to treating runoff from roads and highways, small parking lots, and pervious surfaces. They may be commonly used on boulevards, park perimeter streets, or sidewalk furniture zones with sufficient space. Vegetated buffers can be situated so they serve as pre-treatment for another stormwater management feature, such as an infiltration BMP.

***Guidelines**:* Buffer strips cannot treat large amounts of runoff; therefore, the maximum drainage width (with the direction of flow being towards the buffer) of the contributing drainage area should be 60 feet. In general, a buffer strip should be at least 15 feet wide in the direction of flow to provide the highest water quality treatment.

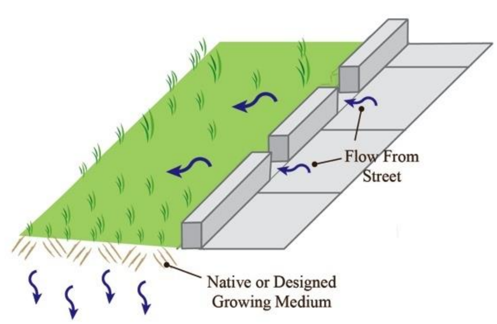
The top of the strip should be set 2 to 5 inches below the adjacent pavement or contributing drainage area, so that vegetation and sediment accumulation at the edge of the strip does not prevent runoff from entering.

Buffer strips should be sited on gentle slopes. Steep slopes in excess of 15 percent may trigger erosion during heavy rain events, thus eliminating water quality benefits.

9.2.4.3. Detention

Detention devices differ from retention in that they are designed and sized to hold a specific volume of water and then slowly release it over time. In contrast, the bioretention BMPs described in the previous section are designed and sized based on flow—the rate of water passing through them. The objective of bioretention is to improve the quality of stormwater by promoting filtration and adsorption as water flows through vegetation and soil. Detention devices do not function as flow-through features, but rather the objective is to collect and contain water until it is removed by controlled release or infiltrated into the soil. Overflow outlets may be included to manage large storm events. Pollutants may be removed by vegetation and the topsoil layer as in bioretention BMPs so that stormwater is treated before it is infiltrated. Detention devices can greatly reduce the volume of runoff from streetscapes. For small storm events, they may completely eliminate runoff.

Figure 9-13: Vegetated Buffer Strip



Credit: Julia Campbell and Michele Weisbart (Michele Designs)

9.2.4.3.1. Rain Gardens

Rain gardens are vegetated depressions in the landscape. They have flat bottoms and gently sloping sides. Rain gardens can be similar in appearance to swales, but their footprints may be any shape. Rain gardens hold water on the surface, like a pond, and have overflow outlets. The detained water is infiltrated through the topsoil and subsurface drain rock unless the volume of water is so large that some must overflow. Rain gardens can reduce or eliminate off-site stormwater discharge while increasing on-site recharge.

Location and placement: Rain gardens may be placed where there is sufficient area in the landscape and where soils are suitable for infiltration. Rain gardens can be integrated with traffic calming measures installed along streets, such as medians, islands, circles, street ends, chicanes, and curb extensions. Rain gardens are often used at the terminus of swales in the landscape.

Guidelines*:* Native soils should have a minimum permeability rate of 0.5 inches per hour and at least 10 feet to the ground water table. Sites that have more than a 5 percent slope may require other stormwater management approaches or special engineering. The topsoil layer should be designed on a case-by-case basis and may often be a type of sandy loam. Subsurface drain rock will promote infiltration and should also be designed for each installation. City and County of Honolulu *Storm Water BMP Guide* contains additional guidelines for rain garden design.

The size and shape of rain gardens will vary in each case and the available area in the landscape may determine the maximum footprint. Because rain gardens are volume-based BMPs, their surface area and depth will be designed to achieve the desired detention volume. Overflow outlets should be below the lip of the rain garden and at a height consistent with the desired detention volume. Sides should be gently sloping to prevent erosion.

Rain gardens should be landscaped with deep-rooted grasses and other vegetation that can tolerate short periods of inundation, deposits of sediment, and periods of drought.

Figure 9-14: Rain Garden in Curb Extension

Portland, Oregon. Credit: Brad Lancaster (Harvesting Rainwater)

9.2.4.3.2. Infiltration Trenches and Dry Wells

Infiltration trenches are linear, rock-filled features that promote infiltration by providing a high ratio of sub-surface void space in permeable soils. They provide on-site stormwater retention and may contribute to groundwater recharge. Infiltration trenches may accept stormwater from sheet flow, concentrated flow from a swale or other surface feature, or piped flow from a catch basin. Because they are not flow-through BMPs, infiltration trenches do not have outlets but may have overflow outlets for large storm events.

Dry wells are typically distinguished from infiltration trenches by being deeper than they are wide. They are usually circular, resembling a well, and are backfilled with the same materials as infiltration trenches. Dry wells typically accept concentrated flow from surface features or from pipes and do not have outlets.

Infiltration trenches and dry wells are typically designed to infiltrate all flow they receive. In large storm events, partial infiltration of runoff can be achieved by providing an overflow outlet. In these systems, significant or even complete volume reduction is possible in smaller storm events. During large storm events, these systems may function as detention facilities and provide a limited amount of retention and infiltration.

Location and placement guidelines*:* Infiltration trenches and dry wells typically have small surface footprints, so they are some of the most flexible elements of landscape design. However, because they involve sub-surface excavation, these features may interfere with surrounding structures. Care needs to be taken to ensure that surrounding building foundations, pavement bases, and utilities are not damaged by infiltration features. Once structural soundness is ensured, infiltration features may be located under sidewalks and in sidewalk planting strips, curb extensions, roundabouts, and medians. When located in medians, they are most effective when the street is graded to drain to the median. Dry wells require less surface area than trenches and may be more feasible in densely developed areas.

Infiltration features should be sited on uncompacted soils with acceptable infiltration capacity. They are best used where soil and topography allow for moderate to good

Figure 9-15: Infiltration Trench With Perforated Pipe During Installation

Credit: Neal Shapio (City of Santa Monica) infiltration rates (0.5 inches per hour) and the depth to groundwater is at least 10 feet. Prior to design of any retention or infiltration system, proper soil investigation and percolation testing should be conducted to determine appropriate infiltration design rates. Any site with potential for previous underground contamination should be investigated. Infiltration trenches and dry wells can be designed as stand-alone systems when water quality is not a concern or may be combined in series with other stormwater tools.

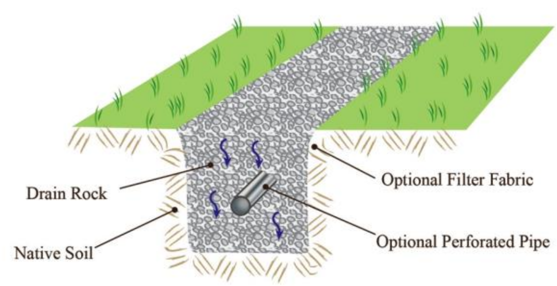
Pre-treatment, design, and installation guidelines: Infiltration features do not treat stormwater and may become damaged by stormwater carrying high levels of sediment. In general, infiltration features should be designed in series with bioretention tools unless the infiltration features receive water from well-vegetated areas where sediment is not expected. Pre-treatment features should be designed to treat street runoff prior to discharging to infiltration features. Bioretention devices, sumps, and sedimentation basins are several pre-treatment tools effective at removing sediment.

Trenches and dry wells are typically backfilled with coarse drain rock (coarse gravel) and may or may not be lined with filter fabric. Additional void space can be achieved by including materials such as perforated pipes, half pipes, or open blocks within the drain rock. The trench surface can be planted, covered with grating, covered with boardwalks, or simply remain as exposed drain rock. The Department of Planning and Permitting should be contacted for any local guidance on infiltration feature design.

The slope of the infiltration trench bottom should be designed to be level or with a maximum slope of 1 percent. Infiltration BMPs should be installed parallel to contours with maximum ground slopes of 20 percent and be located no closer than 5 feet to any building structure. Sub-soils should not be compacted. Drain rock and, if needed, filter fabric with an overflow drain should be designed for each installation.

Perforated pipes and piped inlets and outlets may be included in the design of infiltration trenches. Cleanouts should be installed at both ends of any piping, and at regular intervals in long sections of piping, to allow access to the system. Monitoring wells are recommended for both trenches and wells and can be combined with clean-outs. If included, the overflow inlet from the infiltration trench should be properly designed for anticipated flows.

Figure 9-16: Infiltration Trench



Credit: Julia Campbell and Michele Weisbart (Michele Designs)

9.2.4.4. Permeable Paving

Permeable paving is a system with the primary purpose of slowing or eliminating direct runoff by absorbing rainfall and allowing it to infiltrate into the soil. This BMP is impaired by sediment-laden run-on which diminishes its porosity. Care should be taken to avoid flows from landscaped areas reaching permeable paving. In those cases, bioretention is a better choice for BMPs. Permeable paving is, in certain situations, an alternative to standard paving. Conventional paving is designed to move stormwater off-site quickly. Permeable paving, alternatively, accepts the water where it falls, minimizing the need for management facilities downstream.

Permeable paving:

- Filters and cleans pollutants such as petroleum deposits on streets;
- Reduces water volumes for existing overtaxed pipe systems; and,
- Decreases the cost of offsite or onsite downstream infrastructure.

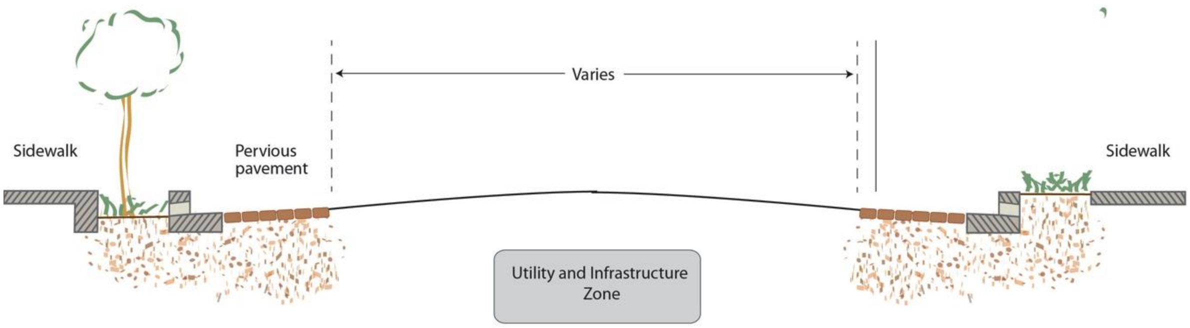
Figure 9-18: Permeable Concrete After a Rain Event

Credit: Neal Shapio (City of Santa Monica)

Location and placement guidelines*:* Conditions where permeable paving should be encouraged include:

- Sites where there is limited space in the right-of-way for other BMPs;
- Parking or emergency access lanes (shoulders);
- Bike Lanes and Bike Paths; and,
- Furniture zones of sidewalks especially adjacent to tree wells.

Figure 9-17: Street Section Elevation Illustrating Placement of Pervious Pavement



Credit: Marty Bruinsma (Self-Employed)

Conditions where permeable paving should be avoided include:

- Where runoff is already being harvested from an impervious surface for direct use, such as irrigation of bioretention landscape areas;
- Where there is a high sediment load or area with poor soil conditions;
- Steep streets;
- Large traffic volume or heavy load lanes;
- Gas stations, car washes, auto repair, and other sites/sources of possible chemical contamination;
- Areas with shallow groundwater;
- Within 20 feet of sub-sidewalk basements; and,
- Within 50 feet of domestic water wells.

Material guidelines: When used as a road paving, pervious pavement that carries light traffic loads typically has a thick drain rock base material. Pavers should be concrete as opposed to brick or other light-duty materials. Other possible permeable paving materials include porous concrete and porous asphalt. These surfaces also have specific base materials that detain infiltrated water and provide structure for the road surface. Base material depths should be specified based on design load and a soils report.

Plazas, emergency roads, and other areas of limited vehicular access can also be paved with permeable pavement. Paving materials for these areas may include open cell paver blocks filled with stones or grass and plastic cell systems. Base material specifications may vary depending on the product used, design load, and underlying soils.

When used for pedestrian paths, sidewalks, and shared-use paths, appropriate materials include those previously listed as well as rubber pavers and decomposed granite or something similar (washed or pore-clogging fine material). Pedestrian paths may also use broken concrete pavers as long as ADA Accessibility Guidelines are met. Paths should drain into adjoining landscapes and should be higher than adjoining landscapes to prevent run-on. Soil paths are not successful on slopes in excess of 4 percent. Any pervious materials used for sidewalks or paths should be very smooth for wheelchairs and people on bicycles.

Figure 9-19: Permeable Paving and a Trench Drain in a Parking Area

Credit: Stephanie Landregan (City of Glendale)

***Design guidelines**:* Design considerations for permeable paving include:

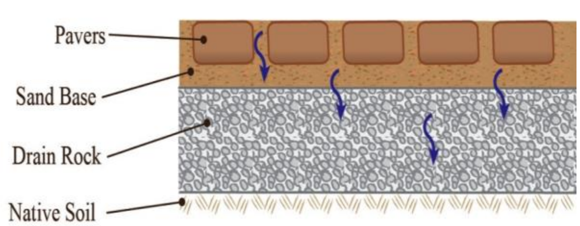
- The location, the slope and load-bearing capacity of the street, and the infiltration rate of the soil;
- The amount of storage capacity of the base course;
- The traffic volume and load from heavy vehicles;
- The design storm volume calculations and the quality of water;

- Drain rock, filter fabrics, and other subsurface materials;
- Installation procedures including excavation.

A soil or geotechnical study should be conducted to provide information about the permeability and load-bearing capacity of the soil. Infiltration rate and load capacity are key factors in the functionality of this BMP. Permeable paving generally does not have the same load-bearing capacity as conventional paving, so this BMP may have limited applications depending on the underlying soil strength and paving use. Permeable paving should not be used in general traffic lanes due to the possible variety of vehicles weights and heavy volumes of traffic.

The soil report should also provide the depth of the water table to determine if permeable pavers are an appropriate application for the site. Pervious pavement typically requires a 4-foot or more separation from the water table or bedrock to properly infiltrate stormwater. Pervious pavement is not recommended over new or compacted fill.

Figure 9-20: Pervious Pavement Detail



Credit: Julia Campbell and Michele Weisbart (Michele Designs)

Because permeable pavement is damaged by sediment deposits, it should be carefully placed in the landscape so as to avoid run-on, especially from sediment-laden sources such as landscaped areas.

Pavement used for sidewalks and pedestrian paths should be ADA compliant, especially smooth, and not exceed a 2 percent slope or have gaps wider than 0.25 inches. In general, tripping hazards should be avoided.

***Maintenance and installation guidelines**:*
Proper construction and installation of permeable pavement is vital to its success. To ensure that the paving system functions properly, sub-base preparation and stormwater pollution prevention measures should be performed appropriately during installation.

Construction considerations include:

- Scarifying soils so that they remain porous;
- Avoiding compaction of soils; and
- Preventing run-on and sedimentation during construction.

Maintenance of permeable pavement systems is essential to their continued functionality. Regular vacuuming and street sweeping should be performed to remove sediment from the pavement surface. The bedding and base material should be tested to ensure sufficient infiltration rates on a regular basis. Additionally, base material may need to be removed and replaced every several years based upon the material manufacturer's specifications.

9.2.4.5. Delivery and Conveyance

Water conveyance measures in the hardscape may support the treatment BMPs previously outlined. By daylighting stormwater flow, these measures draw attention to water movement and can, in turn, highlight bioretention and detention BMPs. Delivery and conveyance measures do not treat stormwater for quality and do not reduce water volume. They are, therefore, only recommended as supporting infrastructure (i.e., a preferable alternative to traditional piped flow).

Some municipalities place the requirement for BMP maintenance with the property frontage owner through the use of a maintenance agreement. Those features that fall within the public right of way, such as landscaped medians and rain gardens in curb extensions, would be maintained by the government.

9.2.4.5.1. Channels, Runnels, Trench Drains and Constructed Swales

Channels, runnels, trench drains, and constructed swales are conventional methods of conveying moderate amounts of stormwater from buildings and impervious surfaces to other drainage collection systems, streets, or planters. They are hardscape features constructed from impermeable materials.

Typically, these structures work well when there is a need for water redirection and space is limited. These hardscape methods may serve to move stormwater from the street to landscaped areas. Channels and constructed swales are not used for stormwater treatment but serve as daylighted, visible conveyance features in lieu of closed pipe systems. They provide opportunities to acknowledge natural drainage processes with artistic design features along the drainage path.

A variety of materials can be used for channels, runnels, and constructed swales: stone, brick, pebbles, pavers, and concrete. Rock swales can be created by arranging stones loosely and mortaring them in place. When a closed top is required, grates can be constructed. Proprietary products in standard sizes are readily available. Decorative grates are aesthetic and help illustrate water flow processes.

Because these structures are gravity fed, they require slopes to function properly. On slopes greater than 6 percent, check dams or other velocity reduction devices should be provided.

These conveyance features may direct sheet flow to bioretention or infiltration features or simply serve as an alternative to piped flow in conventional drainage systems. Dimensions should be determined based on the design storm.

Channels have vertical sides and provide a drainage path to a downstream stormwater management feature. Channels vary in depth depending on the amount of flow they are designed to carry, have a sloped bottom, and can be covered or open. In some cases, channels can be constructed with pervious bottoms. Channels can be placed in plazas, driveways, and other hardscapes where conveyance is needed. Channels may be used in some situations where swales or pipes would be too costly or impossible due to site constraints. In broad landscape contexts, channels can be large and constructed to carry large volumes of water.

Runnels are shallower than channels, typically only a couple of inches deep, and are designed to carry small flows of stormwater. Runnels may have an open top but must be covered if they cross pedestrian walkways. Runnels are, most often, used to convey runoff from hardscapes to adjacent stormwater treatment landscapes. Runnels may be very useful in pedestrian hardscape areas where artistic construction is highly visible. The location and design of runnels should be carefully selected so that they do not pose tripping hazards.

Trench drains are a type of conveyance system similar to runnels. Trench drains differ from runnels in that they are usually smaller and have a grated top. They also have solid sides and bottoms. Trench drains are available in standard sizes and dimensions from a variety of manufacturers.

Constructed swales are similar to the swales discussed earlier but are constructed from impervious materials. They typically are long narrow depressions used to convey water. The size of a swale should be determined by the design storm and landscape features.

Access, design, and maintenance guidelines*:* All conveyance structures, both open and covered, need to meet accessibility guidelines when in the path of travel. Boardwalks can cover large swales, or decorative grates can be used over smaller widths.

Channels, runnels, and constructed swales should be designed to meet Department of Planning and Permitting design storm requirements. Overflow features may be required in some areas and should drain to the nearest gutter or other drainage feature, always draining away from adjacent properties. These features should be designed to allow debris to move through them and account for stoppages that could limit the drainage capacity.

Maintaining a clear conduit is essential for the proper functioning of conveyance structures. These features should be cleaned before the rainy season and checked before and after storm events. Trash, cigarette butts, soil sediment, and leaf litter all can contribute to failure and decrease the function of these features.

Figure 9-21: Constructed Swale With Drain

Credit: Stephanie Landregan (City of Glendale)

9.2.4.6. Storm Drain Inlet Protections Retrofitting Existing Storm Drains

Existing storm drain systems may be retrofitted to improve stormwater quality without costly capital improvements. The BMPs described below can be used with existing conventional piped storm drain systems to address water quality but not water volume concerns. The measures described below are designed to prevent particulates, debris, metals, and petroleum-based materials conveyed by stormwater from entering the storm drain system. All storm drain protection units should have an overflow system that allows the storm drain to remain functional if the filtration system becomes clogged during rainstorms.

Typical maintenance of catch basins includes scheduled trash removal, if a screen or other debris capturing device is used. Street sweeping should be performed by vacuum sweepers, with occasional weed and large debris removal. Maintenance should include keeping a log of the amount of sediment collected and the data of removal. Some cities have incorporated the use of GIS systems to track sediment collection and to optimize future catch basin cleaning efforts. Bulb-outs and curb extensions should be designed with two return curves with a radius of over 10 feet to allow street sweepers to clean the corners.

All inlet tools located in the pedestrian zone should conform to ADA requirements.

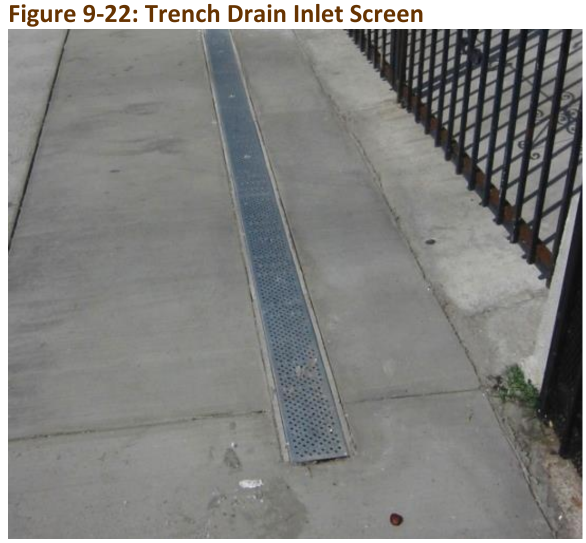
9.2.4.6.1. Storm Drain Inlet Screens: Placement and Guidelines

Inlet screens are designed to prevent large litter and trash from entering the storm drain system while allowing smaller particles to pass through. The screens function as the first preventive measure in removing pollutants from the stormwater system. Storm drain inlet screens can be designed and fabricated on an as-needed basis. Proprietary screens are readily available for standard size inlets.

Inlet screens are external units mounted on existing curb side storm drain catch basins. The unit captures larger particles and allows the stormwater and small particles to pass through. The screen can be mounted on hinges to create a bypass if the screen is clogged during a storm.

A wide range of storm drain inlet screens is available. The Department of Facility Maintenance should be consulted to ensure compliance with local specifications and to schedule regular maintenance. Annual inspections of screens are recommended to ensure functionality.

Figure 9-22: Trench Drain Inlet Screen



Credit: Stephanie Landregan (City of Glendale)

9.2.4.6.2. Storm Drain Inlet Protection: Placement and Guidelines

The inlet protection should be designed to protect curbside catch basins or inlets within the travel way. Inlet inserts contain filter cartridges that can be easily replaced.

The inlet protection can be installed on the existing wall of the catch basin. It can be placed on the curb side wall of catch basins so that during storm events water can overflow around the unit.

Inlet inserts should be sized to capture all debris and should, therefore, be selected to match the specific size and shape of each catch basin and inlet. Maintenance should be taken into account. Systems with lower maintenance requirements are preferred.

9.2.4.6.3. Storm Drain Pipe Filter: Placement and Guidelines

The storm drain outlet pipe protection or filter is designed to be installed on an existing outlet pipe or at the bottom of an existing catch basin with an overflow. This filter removes debris, particulates, and other pollutants from stormwater as it leaves the storm drain system. This BMP is less desirable than a protection system that prevents debris from entering the storm drain system because the system may become clogged with debris.

Outlet pipe filters can be placed on existing curbside catch basins and flush grate openings. Regular maintenance is required and inspection should be performed rigorously. Because this filter is located at the outlet of a storm drain system, clogging with debris is not as apparent as with filters at street level. This BMP may be used as a supplemental filter with an inlet screen or inlet insert unit.

Figure 9-23: Curb Inlet Grade Catching Debris

Credit: Andre Haghverdian (City of El Segundo)

9.3. Urban Forestry

The urban forest includes all trees, shrubs, and other understory plantings on both public and private lands. Street trees and landscaping are essential parts of the urban forest, as they contribute positively to the urban environment —to climate control, stormwater collection, and the comfort and safety of people who live or travel along the street. A street lined with trees and other plantings looks and feels narrower and more enclosed, which encourages drivers to slow down and to pay more attention to their surroundings. Trees provide a physical and a psychological barrier between people on foot and motorized traffic, increasing safety as well as making walking more enjoyable.

A healthy urban forest is also a powerful stormwater management tool. Leaves and branches catch and slow rain as it falls, helping it to soak into the ground. The plants themselves take up and store large quantities of water that would otherwise contribute to surface runoff. Part of this moisture is then returned to the air through evaporation to further cool the city.

9.3.1. Street Trees

The goal of adding street trees is to increase the canopy cover of the street, the percentage of its surface either covered by or shaded by vegetation, not simply to increase the overall number of trees. The selection, placement, and management of all elements in the street should enhance the longevity of a city's street trees. Healthy, mature plantings should be retained and protected whenever possible. However, street tree roots can have a negative impact on sidewalk accessibility and subsurface utilities.

9.3.1.1. Principles for Street Trees

The following principles influence the selection of street trees and landscaping design:

- **Reclaim space for trees.** Traffic circles, medians, channelization islands, and curb extensions can provide space for trees and landscaping.
- **Create optimum conditions for growth.** Typically a 6 to 8-foot wide, continuous sidewalk furniture zone must be provided, with uncompacted soil to a minimum of a 3-foot depth. If space for trees is constrained, provisions should be made to connect these smaller areas below the surface to form larger effective areas for the movement of air, root systems, and water through the soil.
- **Select the right tree for the space.** In choosing a street tree, consider what canopy, form, and height will maximize benefits over the course of its life. Provide necessary clearances below overhead high-intensity electrical transmission lines and prevent limbs from overhanging potentially sensitive structures such as flat roofs. In commercial areas where the visibility of façade-mounted signs is a concern, choose species whose mature canopy allows for visibility, with the lowest branches at a height of 12 to 14 feet or more above the ground. Select trees with non-aggressive root systems to avoid damaging paving and sidewalks.
- **Selection of shady trees is desirable on and adjacent to sidewalks.**

9.3.2. Guidelines

The City's 2006 *Honolulu Urban Reforestation Master Plan* provides detailed guidelines for tree and plant selection and placement.

9.3.2.1. Climate and Soil

Selecting trees that are adapted to a site's climate and local rain cycles can create a more sustainable urban forest. The urban environment is harsh for many plants. Often plants native to an area are best adapted to that area's climate. Select plants that can tolerate the environmental elements, such as radiant heat from the sidewalk or street surface or 50 to 60 mph winds from passing traffic.

Urban soils have become highly compacted through construction activities and the passage of vehicle and even foot traffic. Compaction reduces the soil's capacity to hold and absorb water. Plants need healthy soil, air, and water to thrive.

Using planters in the urban forest can increase the biomass and canopy cover, but these plants and trees are still compromised and confined. At its bottom and sides a barrier will exist as the prepared area meets the surrounding compacted soils. Covering the soil surface with some form of mulch can help as the shade, cooling, and retained moisture that mulch provides help support the biological activities close to the soil's surface. These activities open the pore structure of the soil over time, help keep it open, and cushion the impact of foot traffic. This process works better if the mulch material is organic, as opposed to stones. If planters have limited resources for soil preparation they should have an extensive covering of mulch.

The generalized soil types map for a city can be used as a starting point when planning projects, but then the basic soil classifications should be identified on-site, especially when confronted by planting sites at the extreme ends of the spectrum: very fast-draining, nutrient-poor sands and dense, often nutrient-rich but oxygen-starved poorly drained clays.

Structural soils that provide for healthy tree growth and can withstand the uplifting of sidewalks and damage to the road structure should be considered where possible .

9.3.2.2. Planting Sites

Traditionally, trees have been squeezed into whatever limited space is easily found, but this does not work well for either the tree or the street. The following guidelines provide recommended planting areas:

- Establish and maintain 6 to 8-foot wide furniture zones where possible. Many large trees need up to 12 feet in width, and are not suitable for placement in narrower furniture zones. In residential areas, furniture zones within the root zone should be unpaved and planted/surfaced with low groundcover, mulch, or stabilized decomposed granite where these can be maintained. Where maintenance of such extensive furniture zones is not feasible, provide 12-foot long tree wells with true permeable pavers (standard interlocking pavers are not permeable).
- If the above conditions are not feasible, provide for the tree's root system an adequate volume of uncompacted soil or structural or gap-graded soil (angular rock with soil-filled gaps) to a depth of 3 feet

under the entire sidewalk (in the furniture, frontage, and pedestrian zones).

- Spacing between trees will vary with species and site conditions. The spacing should be 10 percent less than the mature canopy spread. Closer spacing of large canopy trees is encouraged to create a lacing of canopy, as trees in groups or groves can create a more favorable microclimate for tree growth than is experienced by isolated trees exposed to heat and desiccation from all sides. On residential streets where lots are 40 or 50 feet wide, plant a minumum of one tree per lot between driveways. Where constraints prevent an even spacing of trees, it is preferable to place a tree slightly off the desired rhythm than to leave a gap in the pattern.
- Planting sites should be graded, but not overly compact, so that the soil surface slopes downward toward the center, forming a shallow swale to collect water. The crown of the tree should remain 2 inches above finished grade and not be in the center of a swale, but off to the side. The finished soil elevation after planting is held below that of the surrounding paving so 2 to 3 inches of mulch can be added. The mulch layer must be replenished, as needed, to maintain a nearly continuous level surface adjacent to paving.
- Generally tree grates and guards are best used along streets with heavy foot traffic. Along streets without heavy foot traffic and in less urban environments, use mulch in lieu of tree grates.

Figure 9-24: Street Trees

Kilauea Avenue. Credit: Alan Fujimori (SSFM International)

9.3.2.3. Species Selection

Honolulu has a list of recommended tree species for use in the public street rights-of-way in its *Standards and Procedures for the Planting of Street Trees* and its *Urban Reforestation Master Plan*. Suggested requirements are as follows:

- On commercial streets with ground-floor retail, trees with a strong central leader are desirable as they grow rapidly above the ground floor business signs.
- Select trees with non-aggressive root systems to avoid damaging paving and sidewalks.
- In general, street trees should be species that will achieve a height and spread of 50 feet on residential streets and 40 feet on commercial streets within 10 years of planting to provide reasonable benefits.
- Typically, trees on commercial streets will not achieve the same scale as they will on residential streets where greater effective root zone volumes may be achieved. On commercial streets with existing multi-story buildings and narrow sidewalks, select trees with a narrower canopy than can be accommodated in the limited sidewalk width.
- Where there are overhead power lines that are less than 50 feet above grade, braided insulated electrical wire should be used so that trees do not have to be pruned to avoid the electrical lines. If braided insulated electrical wire cannot be provided, appropriate trees that will not grow tall enough to reach the power lines should be specified and planted.
- Trees that are part of stormwater management practices must be species that respond well to the extremes of periodic inundation and dry conditions found in water catchment areas. The design of all planting areas should include provisions for improved stormwater detention and infiltration.
- Consistent use of a single species helps reinforce the character of a street or district, but a diversity of species may help the urban canopy resist disease or insect infestations. New plantings added to streets with existing trees should be selected with the aim of meeting the same watering requirements and creating visual harmony with existing trees and plantings. Native species should be considered for inclusion whenever possible, but consideration should be first given to a species' adaptability to urban conditions.

9.3.2.4. Tree Spacing and Other Considerations

- Take intersection sight distance into account when designing intersections to provide visibility at corners. This distance can often be reduced with no compromise in safety in slow speed environments.
- Consider spacing requirements between trees and street lights (typically about 30 feet high). The smaller setback provides greater flexibility in tree spacing and allows for a more complete tree canopy.
- Pedestrian street lights, which are about 12 feet tall, generally do not conflict with the tree canopy, so spacing is less rigid. However additional clearance allows for convenience in maintaining the lights.
- Ensure that the lighting of intersections and crosswalks are not obstructed by trees.

- An 8-foot minimum clearance must be maintained between accessible parking spaces and trees.
- Trees may be planted as close as 6 feet from passenger shelters, where they provide welcoming shade at transit stops.
- Adequate clear space should be provided between trees and awnings, canopies, balconies, and signs so they will not come into conflict through normal growth or require excessive pruning to remediate such conflicts.
- Trees must have an adequate clear height between the surface of the median and the lowest branches so that people on foot can be seen.

9.3.2.5. Tree Wells

Trees should be located in the furniture zone so as to not obstruct the pedestrian zone. In high pedestrian activity areas where the furniture zone is paved, tree wells can be used to even the bottom of the tree and prevent tripping. Tree wells should be flush with the sidewalk and should be permeable.

Figure 9-25: Tree Well in Heavy Volume Pedestrian Area

Waikiki. Credit: Ryan Nakamoto (SSFM International)

9.3.3. Understory Landscaping

Understory landscaping refers to landscape elements beneath the tree canopy in areas within the public right-of-way not required for vehicular or pedestrian movement, including:

- Medians;
- Curb extensions; and,
- Furniture and frontage zones.

9.3.3.1. Benefits

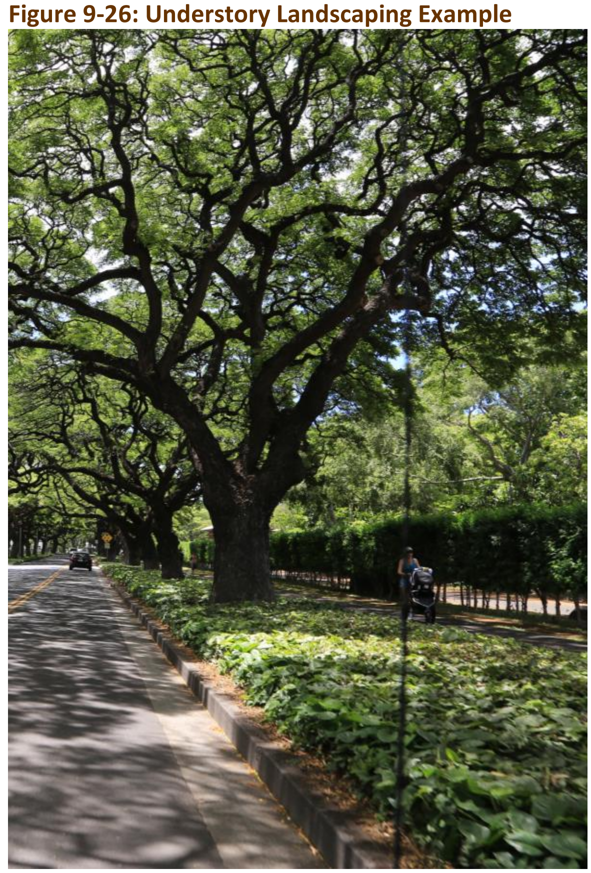
Understory landscaping has the following benefits:

- Complements and supports street trees, in particular by providing uncompacted, permeable areas that accommodate roots and provide air, water, and nutrients;
- Reduces impervious area and surface runoff;
- Treats stormwater, improving water quality;
- Provides infiltration and groundwater recharge;
- Provides habitat;
- Reduces the perceived width of the street by breaking up wide expanses of paving, particularly when the understory is in medians and furniture zones;
- Contributes to traffic calming;
- Provides a buffer between the walkway zone and the street, contributing to comfort for people on foot;
- Improves the curb appeal of properties along the street, potentially increasing their value;
- Enhances the visual quality of the community.

9.3.3.2. Principles

- Within the understory, trees take precedence and the landscape should support them, not compete with them.
- Only pave where necessary: keep as much of the right-of-way unpaved and planted as possible to maximize benefits and minimize erosion.
- Design understory areas to infiltrate water.
- The entire understory area does not have to be covered with plants—composted mulch is a good groundcover. The top of the mulch should be below adjoining hardscape so that runoff will flow into planting areas.
- Make the understory sustainable: use drought-tolerant plants.
- Replenish the soil with compost.

Figure 9-26: Understory Landscaping Example



Paki Avenue. Credit: Ryan Nakamoto (SSFM International)

9.3.3.3. Guidelines

9.3.3.3.1. Soil

Provide good quality, uncompacted, permeable soil. Soil analyses should address the concentration of elements that may affect plant growth, such as pH, salinity, infiltration rate, etc. Remove and replace or amend soil as needed. Preparation saves money in the long run because it reduces the need to replace plants, lowers water consumption, and reduces fertilizer applications.

9.3.3.3.2. Design

Generally, where there are trees, the understory landscaped areas should be as wide as possible. When feasible, the understory area should be at least 6 to 9 feet wide for parkways and 8 to 12 feet wide for medians. However, many existing parkways and medians are less wide. Narrower parkways can support understory plants and some tree species. A path or multiple paths should be added as needed across a parkway as a means of access from the curb to the sidewalk. For example, where there are marked curbside parking spaces, a path across the parkway should be provided at every one or two parking spaces.

Plant understory areas with species that:

- Do not require mowing more frequently than once every few months.
- Are drought tolerant and can survive with minimal irrigation upon establishment.
- Do not exceed a height of 2 feet within 5 feet of a driveway/curb cut and within 20 feet of a crosswalk, and, excluding trees, 3 feet elsewhere.
- Do not have thorns or sharp edges adjacent to any walkway or curb.

  Are located at least 4 feet from any tree trunk.

Figure 9-27: Walking Path Across Parkway Provides Access from Parked Cars to Sidewalk

Credit: Patricia Smith (Patricia Smith Landscape Architecture)

APPENDIX
COMPLETE STREETS CHECKLIST AND INSTRUCTIONS

Multimodal Street, King Street, circa 1910. Credit: Holst & Male, Inc., (Hawaii State Archives Digital Collection)

Complete Streets Checklist Instructions

During the design process for every transportation facility or project, this checklist shall be completed by the City Department[1] or agent responsible for the facility or project and submitted to the DPP Complete Streets Coordinator.

The DPP Complete Streets Coordinator shall file each checklist and submit a copy to the Office of the City Clerk. Every facility or project where it is determined that complete streets features are not required shall be noted as an exception on the complete streets checklist, and substantiating documentation shall be required.

Furthermore:

- Every exception and substantiating documentation shall be electronically posted on DPP's website under "Reports and Notices."
- Every exception and substantiating documentation shall be on file and available for public inspection at the Office of the City Clerk.
- Every exception and substantiating documentation shall be on file and available for public inspection at the Office of the Department making the exception determination.

Section A: Definitions

"Transportation facility or project" means the planning, design, construction, reconstruction, maintenance or improvement of public highways, roadways, streets, sidewalks, traffic control devices and signage, and all facilities or improvements related to public transit.

Street Type:

Name of Street Type	Adjacent Land Use
Residential	Residential
Commercial	Commercial
Industrial	Industrial
Mixed Use	Residential, Commercial, Industrial

[1] Either Department of Transportation Services, Department of Design and Construction, Department of Planning and Permitting, or Department of Facilities Maintenance.

STREET CLASSIFICATION:

STREET CLASSIFICATION	LOCAL ROADS	COLLECTOR ROADS Minor/ Major	MINOR ARTERIAL ROADS	MAJOR ARTERIAL ROADS
TRAFFIC MOVEMENT	Traffic movement is the secondary consideration.	Traffic movement and land access are of equal importance **Minor**: Generally 1 lane in each direction. **Major**: Generally 2 lanes in each direction.	Traffic movement is the primary consideration.	Traffic movement is the primary consideration.
LAND ACCESS FUNCTION	Land access is the primary consideration.	Land access and traffic movement are of equal importance	Land access is a secondary consideration.	Limited, restricted or prohibited access.
ROAD WIDTH	Generally 18' – 24'	Generally 26' – 48'	Generally 48' – 56'	Generally 68' – 76'
NUMBER OF MOVING LANES	Usually one shared by vehicles on an alternating directional basis.	Usually two with additional lanes at some main intersections as necessary.	Usually two with additional lanes at some main intersections as necessary.	Usually three or more with additional lanes for turning movements at intersections.
PARKING	Usually both sides but may be only on one side if local problems exist.	One or both sides as is necessary or feasible.	Limited and quite often restricted and/or prohibited.	Limited and quite often restricted and/or prohibited.

<u>Section B:</u>

Oahu Bike Plan website: http://www1.honolulu.gov/dts/oahu+bike+plan.htm

Neighborhood plans are available on the DPP website at www.honoluludpp.org/planning.

Existing transportation plans for the project are may include: the Statewide Pedestrian Safety Master Plan, Honolulu Transit Master Plan (Short Range Transit Operations Plans), Waikiki Regional Circulator Study, Waikiki Traffic Study, Oahu Bike Plan and Bike Plan Hawaii, Pedestrian Master Plan, Intelligent Transportation Systems (ITS) Strategic Plan, and the Street Tree and Landscaping Plan.

Section C: Complete Street Features Instructions

To document which complete streets features will be provided or impacted by a transportation facility or project please, fill out the Complete Streets Features table.

<u>INSTRUCTIONS</u>:

Column #1:
If complete streets feature is already in place, check here.

Column #2:
Indicate (Y/N) which complete streets feature(s) indicated in Column #1 will be included or repaired in this transportation facility or project.

*If **yes**, the remainder of columns #3, #4 & #5 may be left blank.

*If **no**, proceed to Column #3.

Column #3:
Check which complete streets feature(s) indicated in Column #3 will be included in a Future ID or part of a future Separate Project.

*If the element will be included, indicate the date.

*If **no**, leave date blank and proceed to Column #4.

Column #4:
If not an existing feature for each **no** answer in Columns #2 and #3, indicate whether one or more of the exceptions from Section D apply.

If claiming an exception, the appropriate documentation must be attached.

Column #5: Remarks
List pertinent remarks (eg., “sharrows not needed because there is a bike lane”).

Section D: Exceptions

A multi-modal approach and complete streets features are not required if a director of an affected department determines, in writing with appropriate documentation, prior to or during the design process, that:

1. Use of a street or highway by non-motorized users is prohibited by law; or

2. The cost would be excessively disproportionate to the need or probable future use over the long term; or

3. There is a absence of current or future need; or

4. The safety of pedestrian, bicycle or vehicular traffic may be placed at unacceptable risk.

X. Minor maintenance such as street sweeping, pothole fill/repair, curb repair, traffic signal maintenance.
Emergency repairs such as water/sewer utility main break, storm damage, sinkhole.

P. Privately-owned streets.

Any exceptions claimed by the project engineer will be publicly available information.

City & County of Honolulu: Complete Streets Checklist

Certification

Project Title: ____________________

Project Engineer: ____________________
Print Name
____
Signature Date

Division Chief:
(City Projects Only) ____________________
Print Name
____
Signature Date

Dept. Director/
Principal: ____________________
Print Name
____
Department/Firm Name
____
Signature Date

DPP Complete Streets Coordinator: ____________________
Print Name
____
Signature Date

Refer to "Complete Streets Checklist Instructions" for explanation and clarification. Do not certify until checklist is fully completed.

Section A: Street Classification, Street Type and Other Data

1) Is this a transportation facility or project? This includes, but is not limited to, reconstruction, rehabilitation and resurfacing.

_________ Yes (please describe the project below and complete entire form.)

_________ No (stop, complete certification and submit to DPP Complete Street Coordinator)

Project Description:

□ Is this a bridge seismic retrofit/scour project? If yes, stop, complete certification and submit to DPP.
□ Is this a curb ramp only project? If yes, skip to C.

2) What is the Street Classification?

□ Local □ Minor Collector □Minor Arterial □Major Arterial
□Major Collector

3) What is the Street Type? Check all that apply.

□ Residential □ Commercial □ Industrial □ Mixed Use □ Other - Explain

4) What is the daily traffic volume (ADT)? (complete for a major collector road or higher classification).

5) If there are sidewalks in the area, describe their condition:

6) Are there any nearby (within a 1/4 mile) transit facilities? If so, please describe.

7) Please describe the parking restrictions in the area surrounding the facility or project:

Section B: Approved Plans

1) Does the Oahu Bike Plan make any recommendations with respect to the area surrounding the facility or project? If so, please describe:

2) Does any other neighborhood plan, bicycle plan, pedestrian plan, transit plan or other transportation-relevant plan apply to the area surrounding the facility or project? If so, please identify the plan and describe the recommendations.

Please complete other side.

City & County of Honolulu: Complete Streets Checklist

Project Title:

Section C: Complete Streets Features

	#1	#2	#3		#4	#5
	Existing	Included or Repairs To Be Included	Future ID or Separate Project		Exceptions	REMARKS
Enter	(√)	(Y/N)	(FID/SP)	(Date)	(1,2,3…)	
PEDESTRIAN/BICYCLE						
Sidewalks						
Crosswalks/Curb Ramps						
Refuge Island						
Curb Extensions						
Paved Shoulders						
Signage						
Shared Use Path						
BICYCLE						
Sharrows						
Lanes						
Bike Parking						
TRANSIT FACILITIES						
Public Transit Stops						
Transit Priority Signal						
STREETSCAPE						
Street Trees						
Planting Strips						
Street Furniture						
For NEW DEVELOPMENT ONLY						
Traffic Signal (audible, vibrotactile, countdown)						
Raised Medians						
Roundabouts/Mini Circles						
Transit Lanes						
Transit Priority Signal						

Submit completed form to DPP Complete Street Coordinator