U.S. Department of Transportation
Federal Highway Administration

# Complete Streets Workshop

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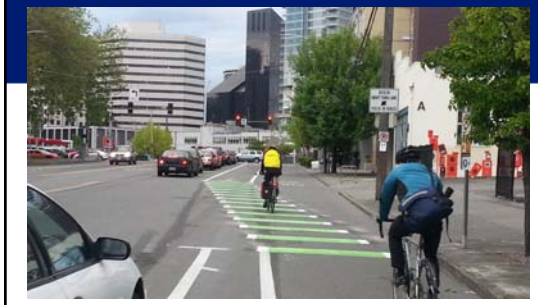
## Workshop Agenda

- Introduction
- Treasure Valley Perspective
- Planning Concepts
- Along the Road Design
- Intersections
- Group Exercise



## What is a Complete Street?

A Complete Street is safe, comfortable & convenient for travel via automobile, commercial vehicle, foot, bicycle, & transit.


Complete Streets policies provide for all users


What is a Complete Streets policy?
Ensures that the **entire right-of-way** is designed for all users


What is a Complete Streets policy?
Make the needs of all users the default:
• No need to prove ped, bike, transit, & freight facilities are needed
• Rather, it's assumed they're needed unless proven otherwise


Why have a Complete Streets policy?
• To shift transportation investments
• Create better streets opportunistically
• Planning
• Construction
• Operations, and
• Maintenance activities
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## An Ideal Complete Streets Policy

1) Sets a vision
2) Includes all users and modes
3) All projects and phases
4) Clear, accountable exceptions
5) Connected network
6) Other jurisdictions, involved in the process
7) Inclusive design guidelines - flexible
8) Is context-sensitive
9) Sets performance measures
10) Includes implementation steps

## What does a Complete Street look like?

One size doesn't fit all:

Complete Streets doesn't mean every street has sidewalks, bike lanes, and transit

**There is no magic formula**

## The Many Types of Complete Streets

Shoulders on Rural Roads

## The Many Types of Complete Streets

A Slow-Speed Shared Street

## The Many Types of Complete Streets


Commercial Neighborhood with Mid-Block Crossing

## The Many Types of Complete Streets

High Density Neighborhood with Mid-Block Crossing

## The Many Types of Complete Streets

Historic Main Street

## The Many Types of Complete Streets

Transit Route on an Urban Arterial

## The Many Types of Complete Streets

High Density Neighborhood with One-way Protected Bike Lane, Parking, and Sidewalk

## The Many Types of Complete Streets

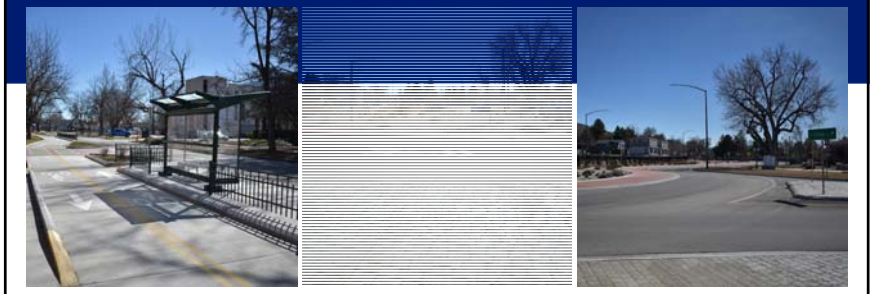
A Two-Way Protected Bike Lane Through Downtown

## The Many Types of Complete Streets

A Roundabout with Space for Over-size Trucks

## The Many Types of Complete Streets

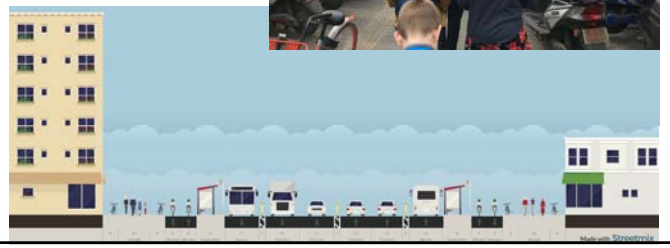
A Natural Drainage System as Part of a Complete Street

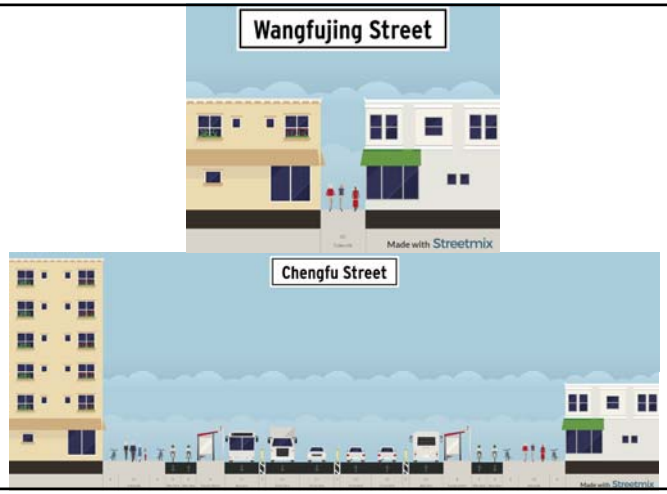


Treasure Valley Perspective

## Wangfujing Street


## Chengfu Street



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## Planning Concepts

- Land use
- Complete network
- Network connectivity
- Site design

## Why do we have cities?

**To minimize travel and maximize exchange**

## How have we built our cities?

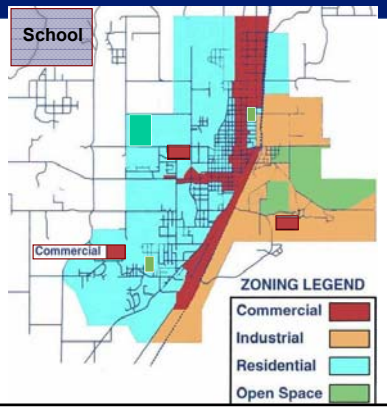
To facilitate longer travel distances

## Reducing Travel Demand Through Land Use

- ☐ The problem:
- ☐ Commercial activities concentrated in auto-dominated corridors.
- ☐ Segregated land uses
- ☐ Result: long travel distances, not conducive to walking

Potential solutions?

1. Allow small-scale retail in neighborhoods
2. Create neighborhood parks
3. Site school closer to residences & parks

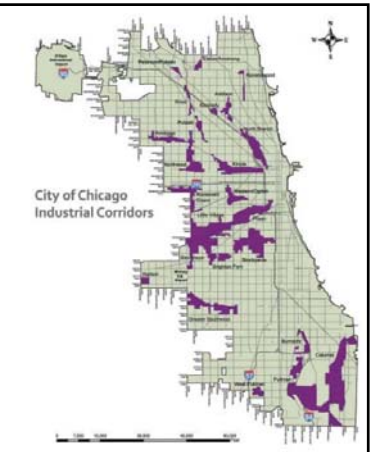



## Neo-traditional Development

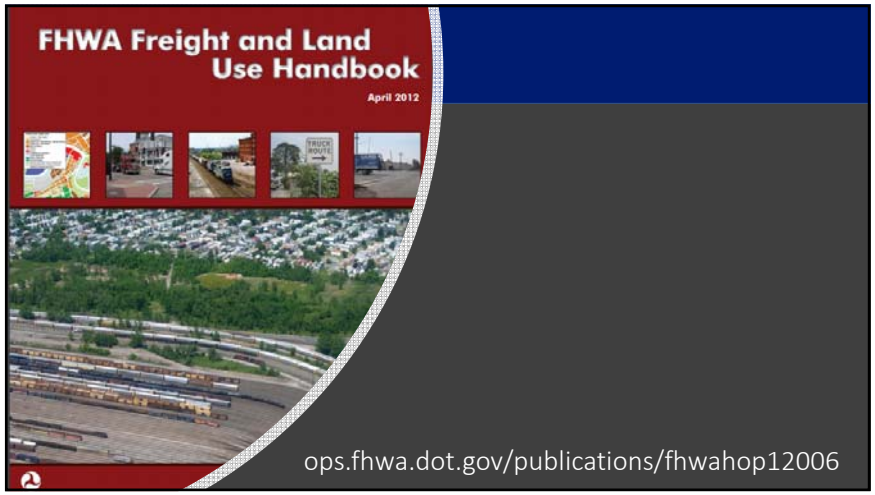

Destinations are close to residential area

## Manufacturing District

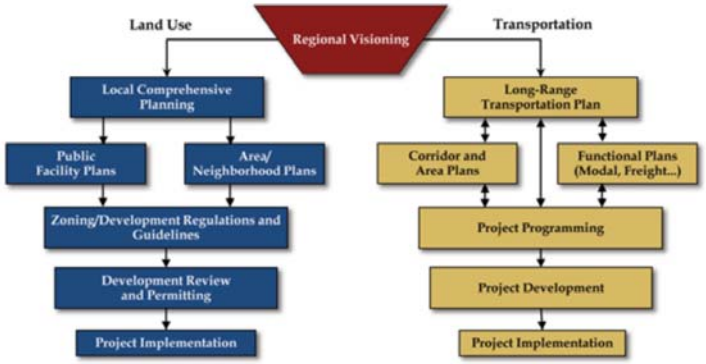
- Prevent encroachment of incompatible land uses
- Buffer sub-zones
- Performance criteria for each zone



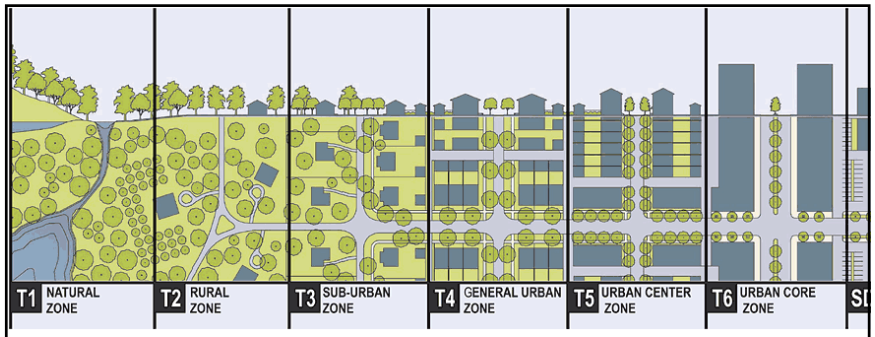

Source: City of Chicago.




## Land Use and Transportation Planning




Source: Cambridge Systematics, Inc., 2010




Context zones categorize a corridor by typical land uses and development intensities rather than just “urban” or “rural”

- Rural in Transition
- Suburban
- General Urban
- Undeveloped
- Developing
- Developed

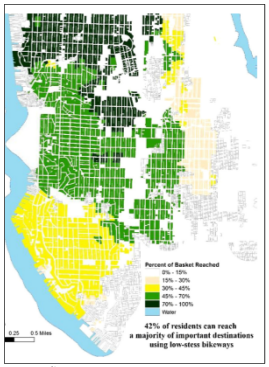
## Complete Network

- Network for each mode
- Not all users are prioritized on all corridors
- Always provide access:
  - Across low-comfort corridors
  - Along key links


Source: METRANS Transportation Center

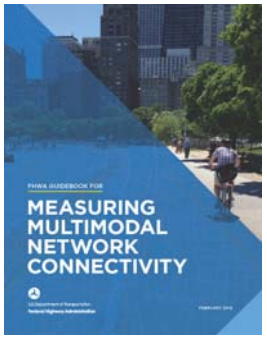
## What is Multimodal Connectivity?

- Networks are accessible, interconnected transportation facilities that allow all users to safely and conveniently get where they want to go.
- Connectivity is the extent to which users can make comfortable trips from beginning to end when traveling to destinations throughout a community.




Map credit: Lowry 2016

## Measure Multimodal Connectivity





www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_connectivity

## City of Baltimore

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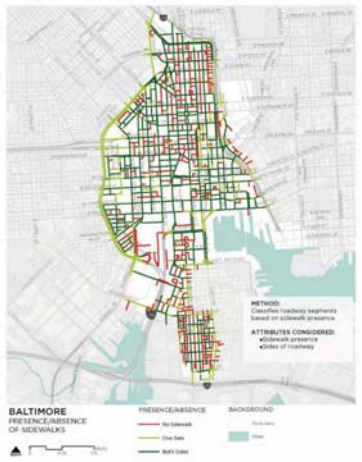
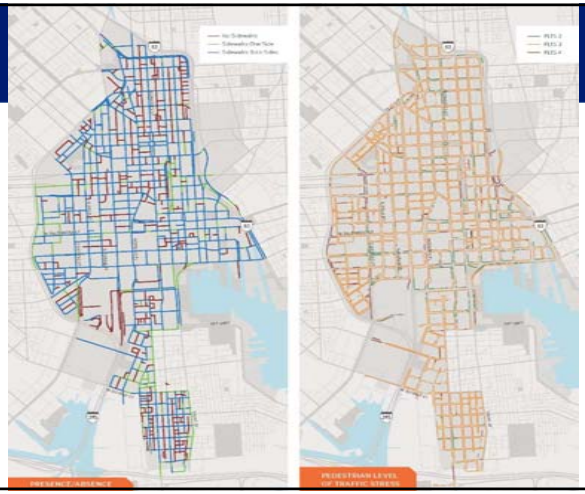
## City of Baltimore

- What does connectivity assessment look like in a robust network?
- Focus on accessibility



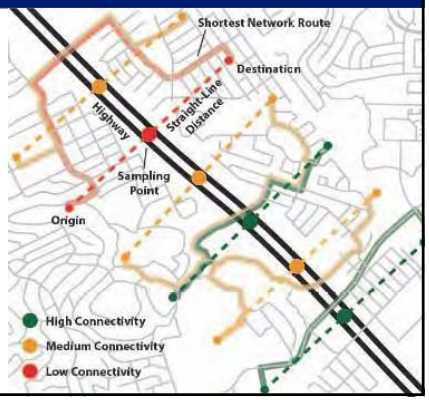


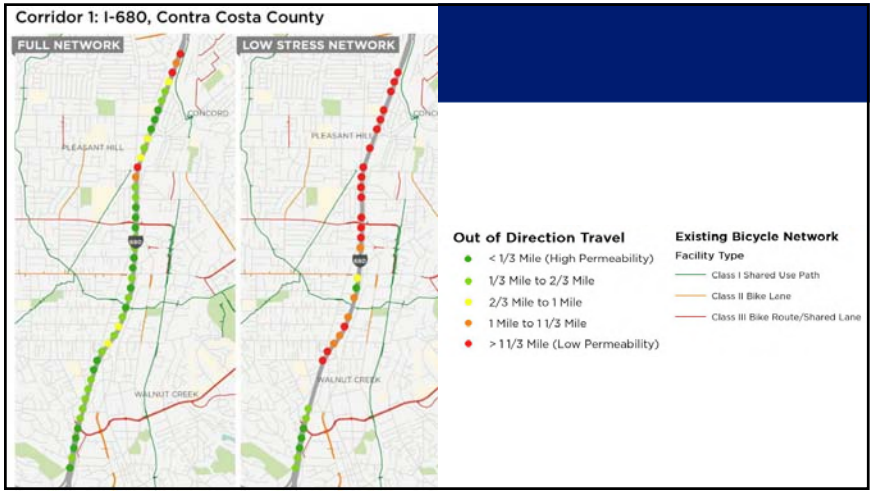
## Caltrans District 4

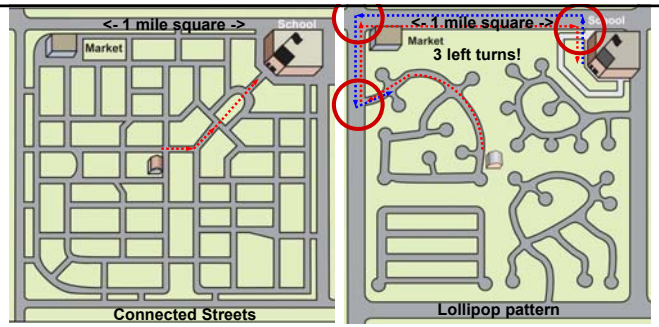
- Plan assesses network need for crossing improvements by overlaying:
  - Potential bicycle demand
  - Supply and quality of bicycle access
  - Safety
  - User comments


## Caltrans District 4

Route Directness Index (RDI) used to assess the crossing quality and opportunity at regular points along the corridor



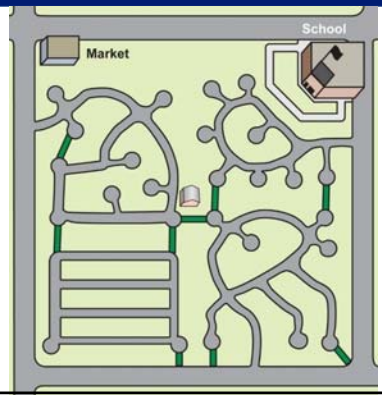



- ☐ Connectivity creates a walkable street system by:
- ☐ Reducing travel distances;
- ☐ Offering more route choices on quiet local streets;
- ☐ Dispersing traffic – reducing reliance on arterials for all trips

## Restoring Connectivity

Can you increase connectivity with paths, greenways?

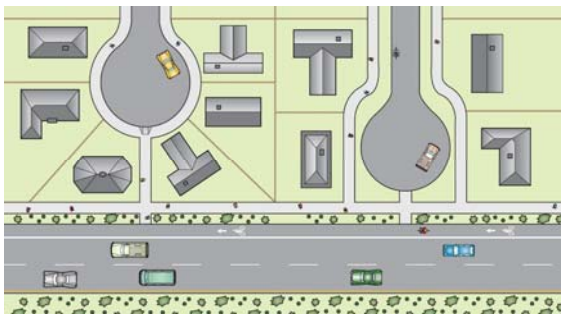
- Reduces walking distances: **YES**
- Offers more route choices: **YES**
- Disperses traffic: **NO**




## Maintaining Pedestrian and Bicyclist Connectivity

- Dedicate ROW to link culs-de-sac with linear parks
- Schools located next to parks


## Connecting Pedestrian & Bicyclist Routes



## Connecting Pedestrian & Bicyclist Routes

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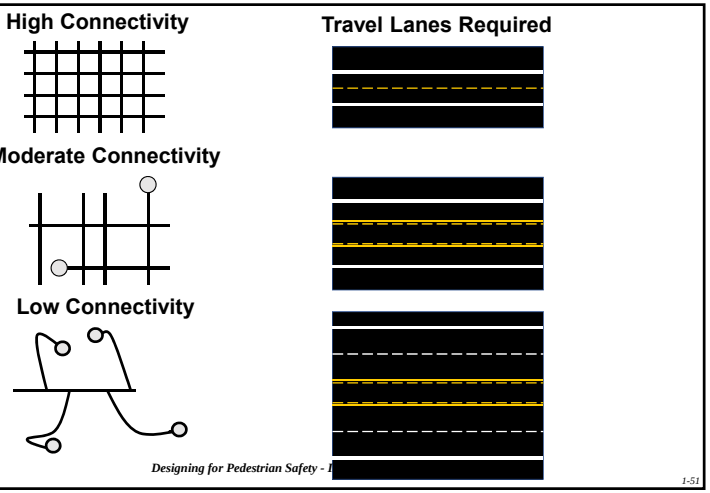
Source: Bike SLO County




## Lack of Connectivity

Overly wide streets

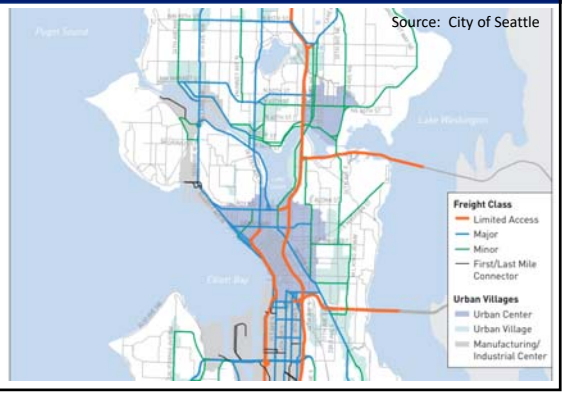
## Lack of Connectivity

**Fewer, but larger, intersections**

## Freight Network: City of Seattle

Major Truck Street

- Arterial street that has significant truck traffic
- Also includes some State and US Routes
- Criterion for
  - Design
  - Traffic management
  - Pavement
  - Repairs





| Street Type | Centerline Miles | % of MTS |
|---|---|---|
| Major Truck Streets (MTS) | 142 | |
| City Arterials | 490 | 29% |
| All City Streets | 1,176 | 12% |

- Commercial Vehicle Load Zones – Estimated Spaces - 460
- Truck Load Zones - Estimated Spaces – 430 to 440

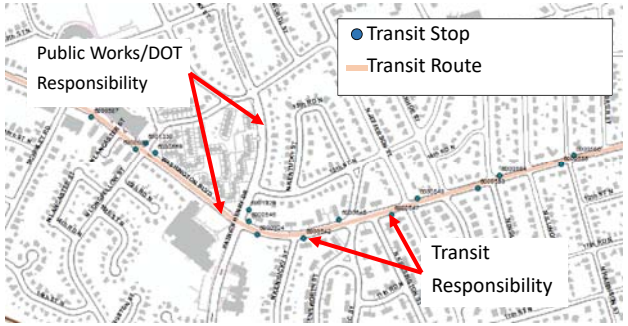
Source: City of Seattle

## City of Seattle

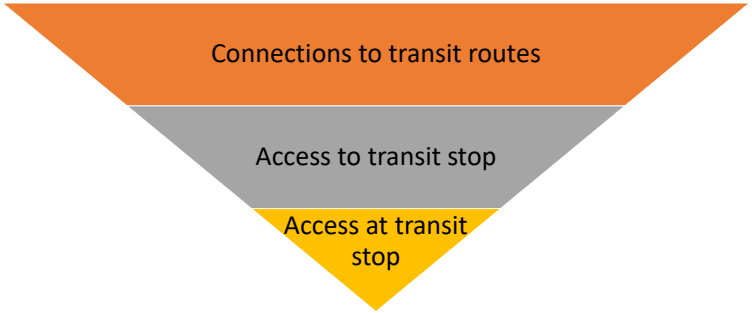
Policies to manage freight operations:

- Reserve some on-street parking for commercial vehicles
- Require permits for over-size trucks
- Require new developments to provide off-street truck loading areas
- Retain alleys for truck delivers and garbage/recycling collection
- Provide signage for truck drivers to identify appropriate routes and note prohibitions
- Provide businesses with information regarding route closures and detours early enough for them to adjust routes or delivery schedules if requires
- Provide real-time information about incidents that will disrupt traffic operations

## Transit Networks




## Access to Transit

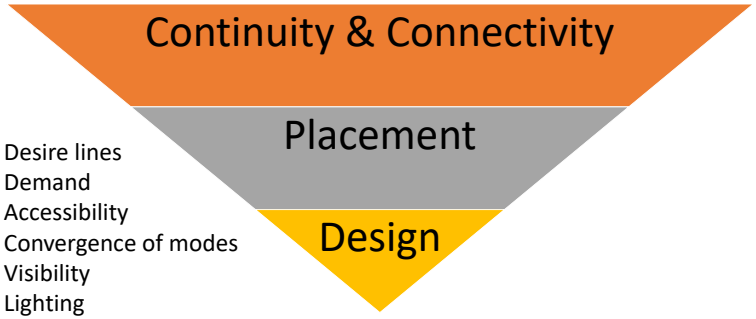



## Catchment Area

- The catchment area is defined as the area served by transit
- Transit access considers elements within catchment area
- In general, people are willing to:
  - Walk ¼ mile to access local bus
  - Walk ½ mile to BRT or rail transit
  - Bike 1-3 miles
  - Drive 15 miles

## Catchment Area

## Planning & Design




- Desire lines
- Demand
- Accessibility
- Convergence of modes
- Visibility
- Lighting
- Available information/guidance

## Agency Considerations

High-use Locations (Ridership)
- Busy corridors
- Busy stops near key generators or high transfer activity

Infrastructure Gaps/Needs
- Sidewalks
- Crossings
- ADA compliance
- Placement relative to intersections

Safety
- High incident locations


## Passenger Demand

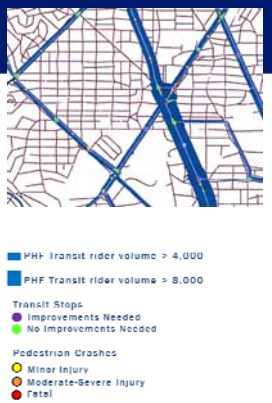
- Waiting space should meet passenger demand
- This may change as routes change and land use changes

## Key Generators

- Understand activities and locations that generate demand
- Understand pedestrian paths


## Transfer Activity

- Understand passenger travel patterns and the effect on pedestrian paths




## Evaluate All Aspects

- Transit ridership
- Transit stop inventory (ADA compliance and other design elements)
- Crashes

**Site-specific**

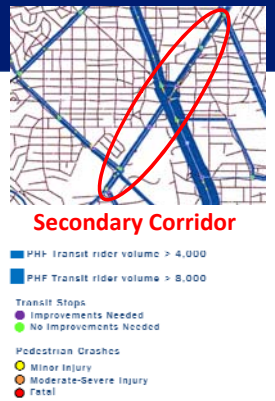

## Evaluate All Aspects

- Transit ridership
- Transit stop inventory (ADA compliance and other design elements)
- Crashes

**Priority Corridor**


## Evaluate All Aspects

- Transit ridership
- Transit stop inventory (ADA compliance and other design elements)
- Crashes

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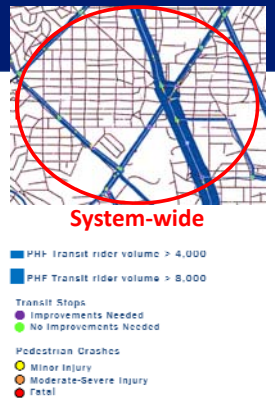



## Evaluate All Aspects

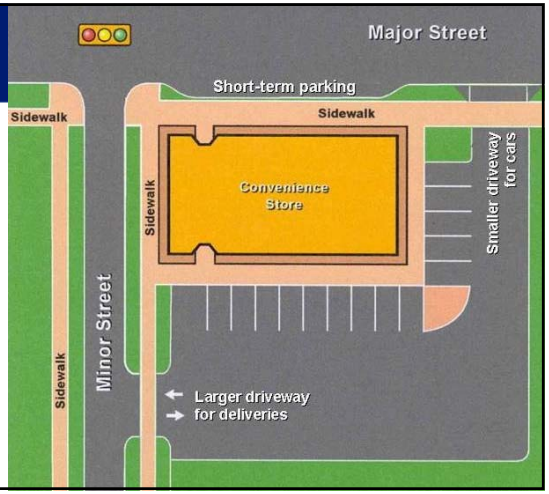
- Transit ridership
- Transit stop inventory (ADA compliance and other design elements)
- Crashes

## Site Design

- Set-backs
- Walkable access to store front
- Driveways
- Parking (cars, bikes, & sharing economy)
- Commuter services
  - Repair stations
  - Showers
- Off-street transit stops
- Off-street loading


## Bringing Buildings Closer to the Street

Creates a street where drivers know to expect pedestrians



## Bringing Buildings Closer to the Street

Building at the back of the sidewalk is a pedestrian-oriented design

Doylestown, PA

## Connecting All Modes to Street

- Parking between sidewalk and building is not pedestrian-friendly

Sweet Home, OR

## Connecting All Modes to the Street

- Fast food typically favors drive-thru over walk-ins
- Pedestrians must cross drive-thru lane

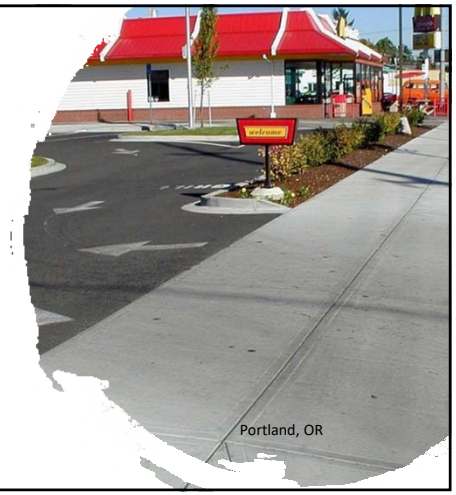
## Connecting All Modes to the Street

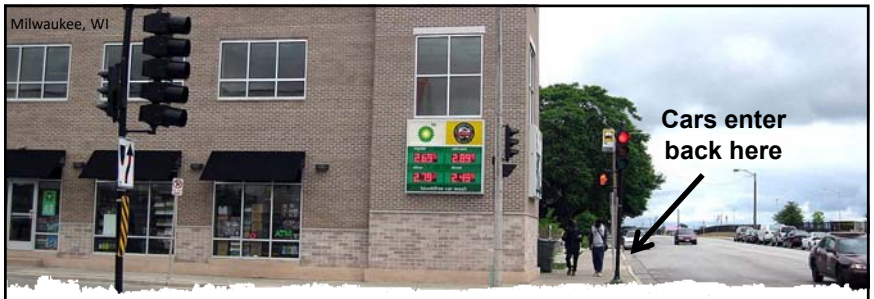
- Provide direct pedestrian access with no vehicular conflicts


Portland, OR

## Connecting All Modes to the Street

- Still providing parking and drive-thru




## Connecting All Modes to the Street

- Even a gas station/ convenience store can be built with pedestrian friendly design, at back of sidewalk


## Connecting All Modes to the Street

- Pedway retrofitted from sidewalk to building, through parking lot


## Connecting All Modes to the Street

- Same principles apply to large-scale developments
- Provide direct, safe, and convenient access

## Site Design

- These goals are achieved by local ordinances, which must be enforced.
- They are beyond the scope of road designers, yet contribute greatly to the safety, comfort, and aesthetics


## Planning Concepts

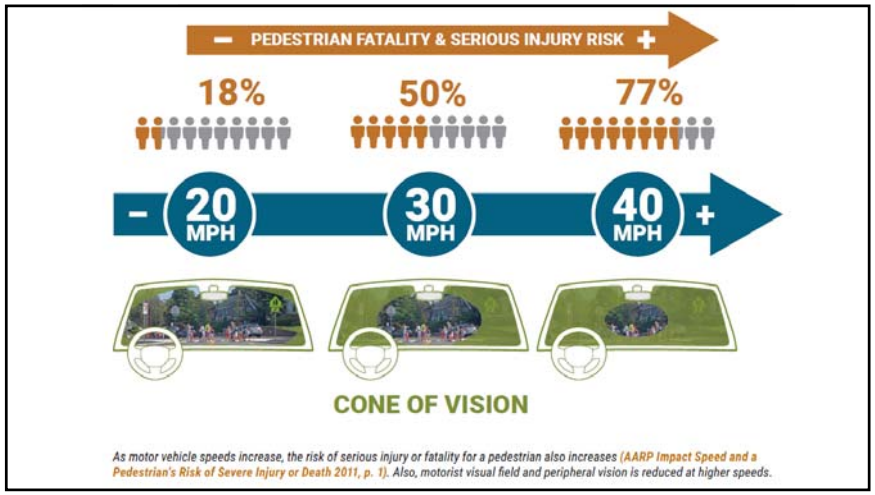
- Land use
- Complete network
- Network connectivity
- Site design

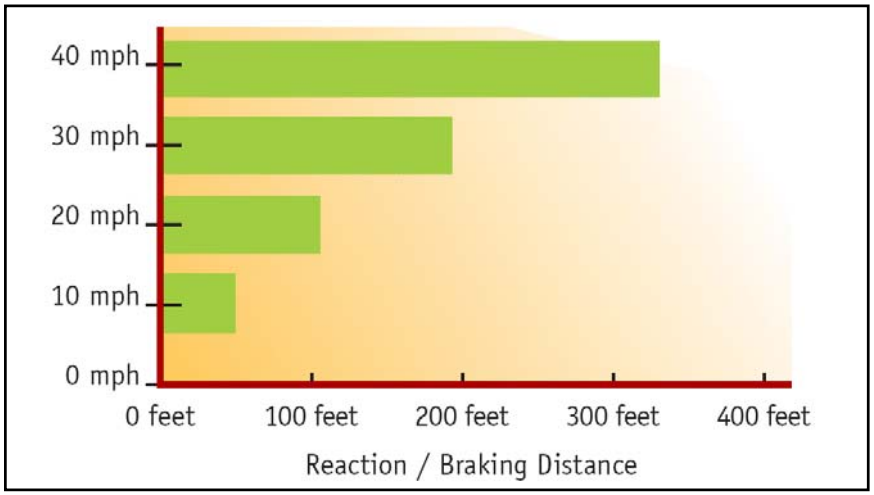
## Along the Road

- Speed
- Context
- Pedestrian zone system
- Bicycle facilities
- Street crossings

## Along the Road

- **Speed**
- Context
- Pedestrian zone system
- Bicycle facilities
- Street crossings



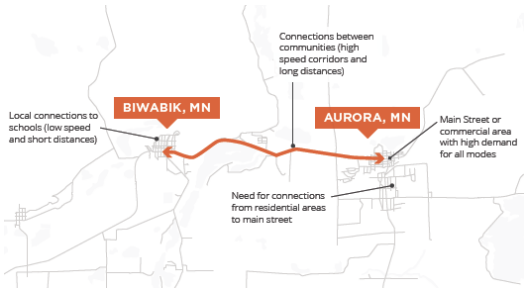

## Along the Road

- Speed
- **Context**
- Pedestrian zone system
- Bicycle facilities
- Street crossings

## Selecting Facility for Context

Average US walking trip: 1.2 mi
- (50% are < 0.5 mi)

Average US bicycling trip: 4.0 mi
- (50% are < 2.0 mi)



## Selecting Facility for Context

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## Selecting Facility for Context

## Shoulders Benefit All Users

- Pedestrians—a place to walk
- Bicyclists—a place to ride
- Motorists and Trucks—room to avoid crashes
- Transit—boarding and alighting

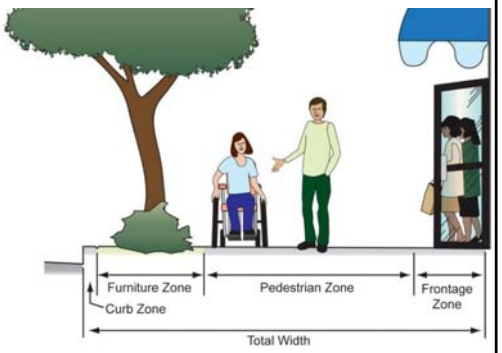

## Along the Road

- Speed
- Context
- **Pedestrian zone system**
- Bicycle facilities
- Street crossings

## Sidewalk Zones

The sidewalk corridor extends from the edge of roadway to the right-of-way and is divided into four zones:

- Curb zone
- Furniture zone
- Pedestrian zone
- Frontage zone




## Curb Zone

- Typically 6 inches
- Vertical Curb less likely to be mounted
- Mountable curbs are inappropriate on local streets

## Furniture Zone

- Local or collector streets 2 to 4 ft
- Arterial or major streets 4 to 6 ft
- Place for all the "stuff"
- Buffer from vehicles

## Pedestrian Zone

- Local or collector streets—2 to 4 ft
- Arterial or major streets—4 to 6 ft
- Place for all the "stuff"
- Buffer from vehicles

## Frontage Zone

- Doors, planters, signs, etc.—3 feet
- Café seating—8 feet
- An interesting façade makes narrow sidewalks feel wider

## Along the Road

- Speed
- Context
- Pedestrian zone system
- **Bicycle facilities**
- Street crossings

## Level of Traffic Stress

Comfortable for children

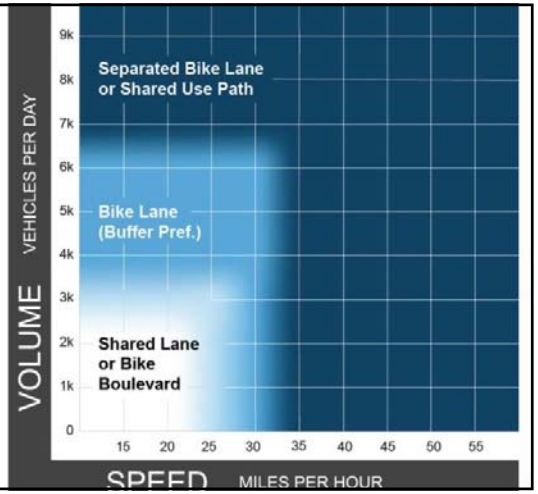
Comfortable for most adults

Typical of most U.S. facilities

"Strong and fearless" or those who absolutely have to

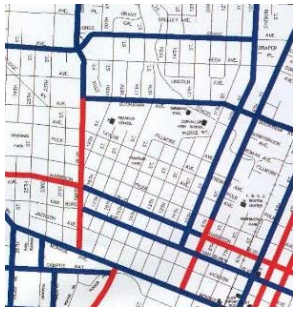
## Level of Traffic Stress

- Increased bicyclist comfort leads to increased ridership




## Shared Roadway

- Unless prohibited, all roads have shared lanes
- No special features for:
  - Minor roads
  - Low volumes (< 1000 vpd)
  - Speeds vary (urban v. rural)
- 85% or more of a well-connected grid



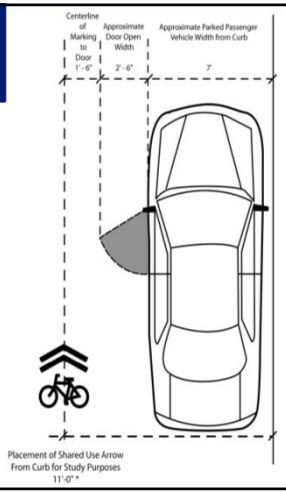
## Shared Lane Marking


- More than 1 lane
- Downhill or level
- Short segment to fill gap in bikeway
- Speed < 30 mph
- High bicycle use

- Single lane
- Uphill
- Parallel route option
- Long segment
- Speed > 40 mph
- Low bicycle use

## Shared Lane Marking

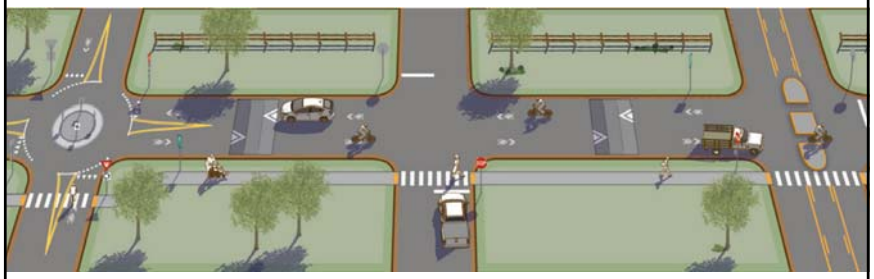
- Center in lane
  - Prevent "dooring"
  - Prevent passing too closely
  - Keep bicyclist visible




## Shared Road Signs

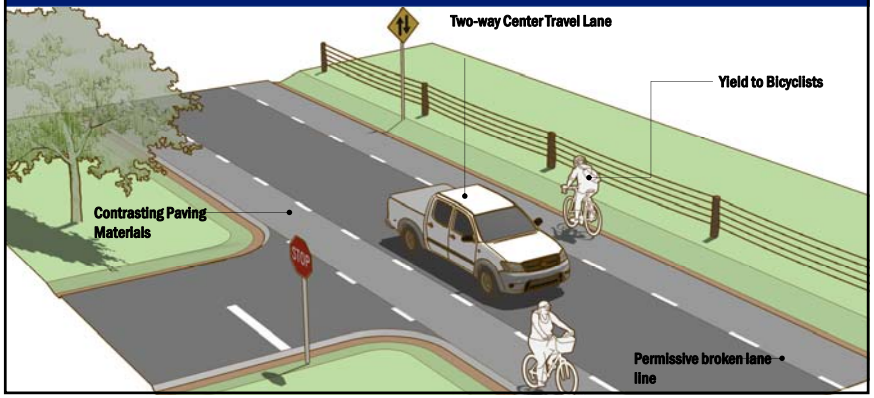
- Reminder for motorists


## Bike Boulevard



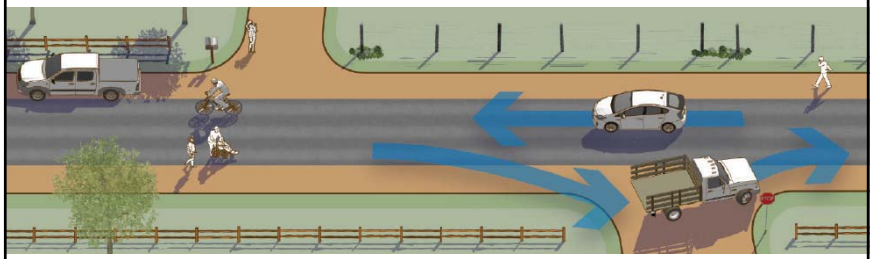
## Yield Roadway

## Yield Roadway





## Yield Roadway



## Shoulder Bikeway

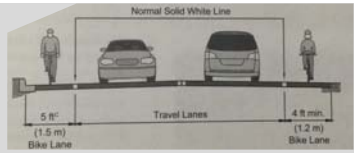

| Functional classification | Volume (AADT) | Speed (Mi/h) | Recommended Minimum Paved Shoulder Width |
|---|---|---|---|
| Minor Collector | up to 1,100 | 35 (55 km/h) | 5 ft (1.5 m) |
| Major Collector | up to 2,600 | 45 (70 km/h) | 6.5 ft (2.0 m) |
| Minor Arterial | up to 6,000 | 55 (90 km/h) | 7 ft (2.1 m) |
| Principal Arterial | up to 8,500 | 65 (100 km/h) | 8 ft (2.4 m) |

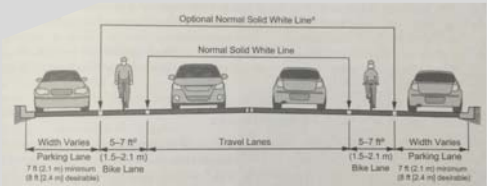
## Bike Lanes

- Low stress on wide/low-speed streets
- Access to major destinations
- Mobility on arterials
- Guide bicyclist behavior
- Improve visibility

## Bike Lane Width

The minimum dimensions should NOT be your default!




## Buffered Bike Lane

- Shy distance
- Bike passing
- Door zone
- Wider w/out confusing motorists
- More comfortable

## Level of Traffic Stress for Different Bike Lanes

LTS 1
- Wide or buffered bike lanes

LTS 2
- 5 ft bike lane/30 mph

LTS 3
- 5 ft bike lane/35 mph

LTS 4
- 5 ft bike lane/40 mph

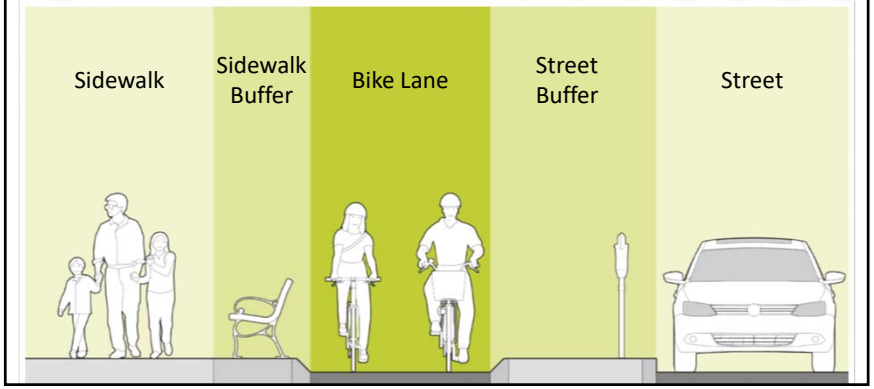
## Pavement Markings

- Shared-lane markings
- Bike lane extension lines
- Bike lane arrow and symbol
- Green pavement

## Separated Bike Lanes

- Exclusive bike facility
- Adjacent to or on roadway
- One-way or contra-flow
- Separated from traffic by vertical element

## Separated Bike Lane Zones





## SBL Elevation

- Considerations
  - Ped/bike encroachment
  - Usable bike lane width
  - Accessibility
  - Frequency of transition ramps
  - Drainage
  - Maintenance

## SBL Width

Widths vary by peak hour volume

- 6.5-10 ft recommended
- 5-8 ft minimum
- 4’ allowable at bus stops or accessible parking

| Same Direction Bicyclists/ Peak Hour | Bike Lane Width (ft.) | |
|---|---|---|
| | Rec. | Min.* |
| <150 | 6.5 | 5.0 |
| 150-750 | 8.0 | 6.5 |
| >750 | 10.0 | 8.0 |

## SBL Width

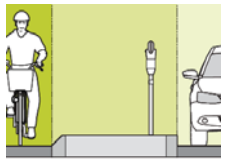
Widths vary by peak hour volume

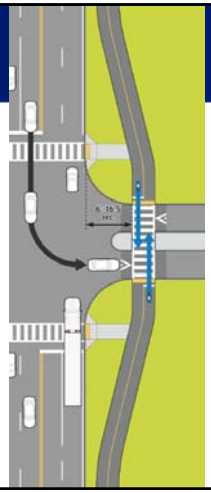
- 10-14 ft recommended
- 8-11 ft minimum

| Bidirectional Bicyclists/ Peak Hour | Bike Lane Width (ft.) | |
|---|---|---|
| | Rec. | Min.* |
| <150 | 10.0 | 8.0 |
| 150 400 | 11.0 | 10.0 |
| >400 | 14.0 | 11.0 |

## Street Buffer Width

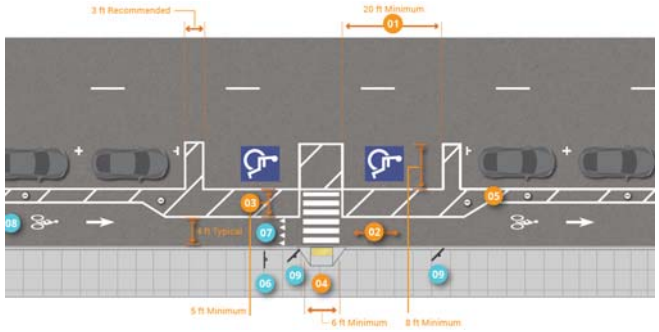
- 6’ preferred
- 2’ when constrained
- 1’ along raised SBL
- 6-16.5’ optimum for intersections



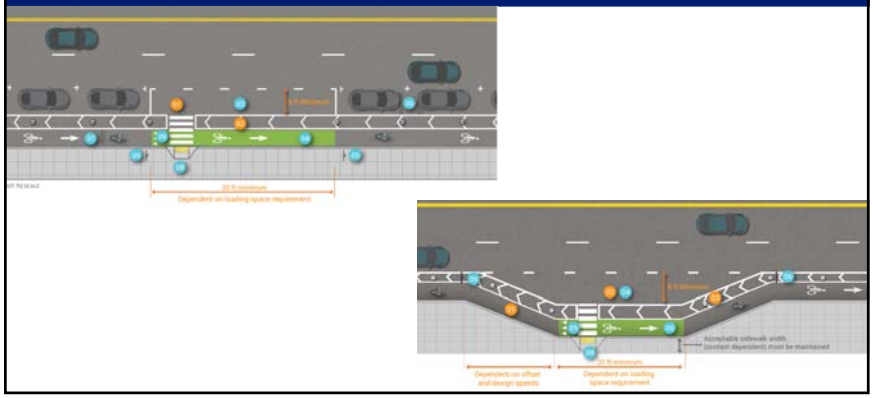


## Parking

## Accessible Parking



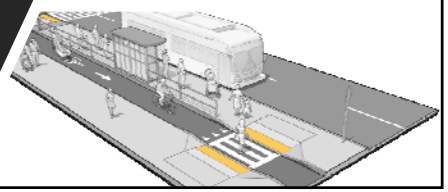
## Loading Zones



## Transit Stops

Considerations

- Opposite side of street
- Guide passengers
- Two crossings
- Communicate to bicyclists
- Floating bus stop
- In-lane bus operation



## Flexibility in Motor Vehicle Lane Width

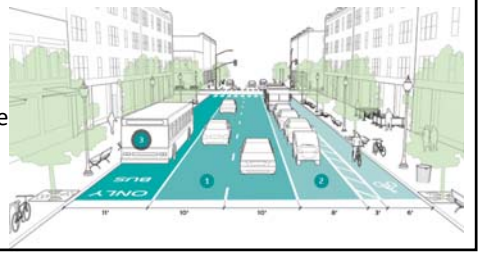
Lane Widths AASHTO Green Book 7th Edition

- 4.3 Lane Width
  - 9 to 12 ft generally used
  - 12 ft predominant on most high-speed, high-volume highways.
- 7.2.11.2 Lane Widths
  - In rural town contexts with low-speed conditions and low percentage of trucks, 10-ft lanes may be satisfactory
- 7.3.3.2
  - Lane widths of 10ft may be used in more constrained areas where truck and bus volumes are relatively low and speeds are less than 35mph.
  - 11ft are used quite extensively for urban arterial street designs.

## Flexibility in Motor Vehicle Lane Width

Lane Widths NACTO

- 10 feet appropriate urban areas
- Designated truck or transit routes one travel lane of 11 feet may be used in each direction.
- Select cases narrower travel lanes (9-9.5 ft) can be effective as through lane in conjunction with a turn lane



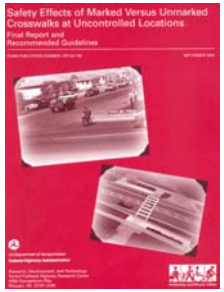

## Along the Road

- Speed
- Context
- Pedestrian zone system
- Bicycle facilities
- **Street crossings**

## Marked vs. Unmarked Crosswalks at Uncontrolled Locations

Marked vs. Unmarked Analysis
Speeds < or = to 40 mph

- Two-lane roads: No significant difference in crash rate
- Multilane roads (3 or more lanes)
  - o Under 12,000 ADT: no significant difference in crash rate
  - o Over 12,000 ADT w/ no median: crashes marked > crashes unmarked
  - o Over 15,000 ADT & w/ median: crashes marked > crashes unmarked

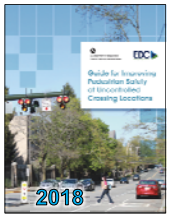



https://www.fhwa.dot.gov/publications/research/safety/04100/



## One explanation of higher crash rate at marked crosswalks: multiple-threat crash

1st vehicle stops and "masks" visibility for driver in 2nd lane
Solution: advance stop bar (we'll discuss later…)


https://safety.fhwa.dot.gov/ped_bike/step/docs/STEP_Guide_for_Improving_Ped_Safety_at_Unsig_Loc_3-2018_07_17-508compliant.pdf

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## Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations

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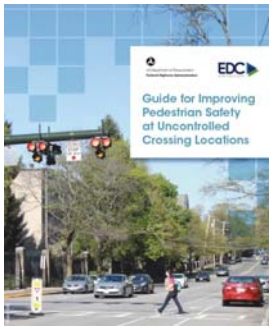
## FHWA Guide

- Provides guidance and suggested process for selecting countermeasures
- Assists agencies in developing a policy to support the installation of countermeasures at uncontrolled pedestrian crossing locations




www.fhwa.dot.gov/innovation/everydaycounts/edc_4/guide_to_improve_uncontrolled_crossings.pdf

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## Countermeasure Selection Process

Following the process suggested in the guide offers countermeasure options based on road conditions, crash causes, and pedestrian safety issues.


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## 4 Select countermeasures

**Review Table 1 (roadway features)**
- AADT
- Number of lanes
- Median presence
- Speed limit

**Review Table 2 (safety issues)**
- Conflicts at crossings
- Excessive speed
- Visibility issues
- Other



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## 4 Select countermeasures

Table 1. Application of pedestrian crash countermeasures by roadway feature.

| Roadway Configuration | Posted Speed Limit and AADT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Vehicle AADT <9,000 | | | Vehicle AADT 9,000–15,000 | | | Vehicle AADT >15,000 | | |
| | ≤30 mph | 35 mph | ≥40 mph | ≤30 mph | 35 mph | ≥40 mph | ≤30 mph | 35 mph | ≥40 mph |
| 2 lanes (1 lane in each direction) | ● 2 4 5 ○ | ● 5 6 7 ○ | ① 5 6 9 ○ | ● 4 5 6 7 ○ | ① 5 4 9 ○ | ① 5 6 9 ○ | ● 4 5 6 7 ○ | ① 5 6 9 ○ | ① 5 6 9 ○ |
| 3 lanes with raised median (1 lane in each direction) | ● 2 3 ● 4 5 ○ | ● ① 5 7 ○ | ① ① 5 9 ○ | ● ① 3 4 5 7 ○ | ① ① 5 9 ○ | ① ① 5 9 ○ | ● ① 4 5 7 ○ | ① ① 5 9 ○ | ① ① 5 9 ○ |
| 3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane) | ● 2 3 ● ① 4 5 6 7 ○ | ● ① 5 6 7 ○ | ① ① 5 6 9 ○ | ● ① 3 4 5 6 7 ○ | ① ① 5 6 9 ○ | ① ① 5 6 9 ○ | ● ① 4 5 6 7 ○ | ① ① 5 6 9 ○ | ① ① 5 6 9 ○ |
| 4+ lanes with raised median (2 or more lanes in each direction) | ● ● ① ● ① 5 7 8 9 ○ | ● ① 5 7 8 9 ○ | ① ① 5 8 9 ○ | ● ① ① 3 5 7 8 9 ○ | ① ① 5 8 9 ○ | ① ① 5 8 9 ○ | ● ① ① 5 7 8 9 ○ | ① ① 5 8 9 ○ | ① ① 5 8 9 ○ |
| 4+ lanes w/o raised median (2 or more lanes in each direction) | ● ● ① ● ① 5 6 7 8 9 ○ | ● ① 5 6 7 8 9 ○ | ① ① 5 8 9 ○ | ● ① ① 3 5 6 7 8 9 ○ | ① ① 5 8 9 ○ | ① ① 5 8 9 ○ | ● ① ① 5 6 7 8 9 ○ | ① ① 5 8 9 ○ | ① ① 5 8 9 ○ |

Given the set of conditions in a cell.
- ★ Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.
- ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning sign
2 Raised crosswalk
3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4 In-Street Pedestrian Crossing sign
5 Curb extension
6 Pedestrian refuge island
7 Rectangular Rapid-Flashing Beacon (RRFB)**
8 Road Diet
9 Pedestrian Hybrid Beacon (PHB)**

*Table 6 (Chapter 4, Using Table 1 and Table 2 to Select Countermeasures, for more information about using multiple countermeasures.
**The PHB and RRFB are not both installed at the same crossing location.

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## STEP's Spectacular Six

- Crosswalk Visibility Enhancements
- Raised Crosswalks
- Pedestrian Refuge Islands
- Rectangular Rapid Flashing Beacon
- Pedestrian Hybrid Beacon (PHB)
- Road Diets

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## Crosswalk Visibility Enhancements


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## Crosswalk Visibility Enhancements

Tampa FL











## Raised Crosswalks

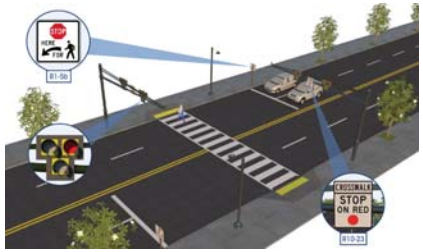
Photo Source: SRTS Guide



## Pedestrian Refuge Islands


## Rectangular Rapid Flashing Beacon


## Pedestrian Hybrid Beacons (PHB)





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## Road Diet:

Before

After

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## Mid-Block or Intersection?

~300 ft from Signalized Intersection to Mid-block Crossing

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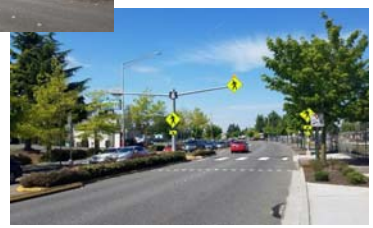
## Street View



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## Crosswalk Visibility Enhancements
## High Visibility Crosswalk

What Pedestrians See

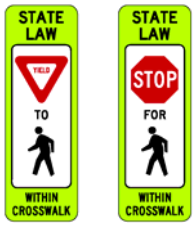

Photo Source all 4: Michael Ronkin

What Drivers See



## In-street pedestrian crossing signs

Tampa FL




R1-6 R1-6a

MUTCD signs

Yield or Stop depends on state law

2009 MUTCD Section 2B.12 and Figure 2B-2



## In-Street Pedestrian Sign
## MUTCD Some Standards

- Shall be placed in the roadway at the crosswalk location on the center line, on a lane line, or on a median island
- Shall not be post-mounted on the left-hand or right-hand side of the roadway
- Unless placed on a physical island, the sign support shall be designed to bend over and then bounce back to its normal vertical position when struck by a vehicle
- Shall be a maximum of 4 feet above the pavement surface. Top of sign placed in an island shall be a maximum of 4 feet above the island surface

https://mutcd.fhwa.dot.gov/htm/2009r1r2/part2/part2b.htm#section2B12

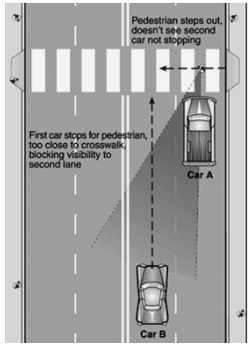


## Crosswalk Visibility Enhancements
## Pedestrian Crossing signs


2009 MUTCD Sec. 2C.50 & Fig. 2C-11

## Multiple Threat Crash Problem

- 1st car stops to let pedestrian cross, blocking sight lines
- 2nd car doesn't stop, hits pedestrian at high speed

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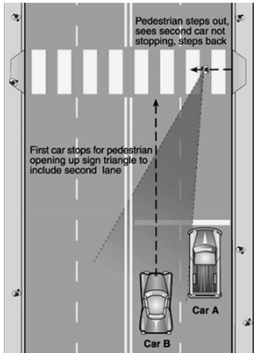
## Multiple Threat Crash Solution

Advance stop or yield line

- 1st car stops further back, opening up sight lines
- 2nd car can be seen by pedestrian

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## Signing to go along with markings


R1-5 R1-5a R1-5b R1-5c

(Use where local law says yield to pedestrians)

(Use where local law says stop for pedestrians)

MUTCD Sec. 2B.11 and Figure 2B-2

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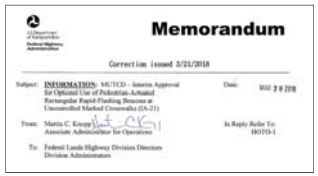
## Rectangular Rapid Flashing Beacon New IA-21


Memorandum

Correction issued 3/21/2018

https://mutcd.fhwa.dot.gov/res-interim_approvals.htm#valid09

- Must request and receive permission to use this new Interim Approval (1A-21) even if prior approval had been given for Interim Approval 1A-11
- A State may request Interim Approval for all jurisdictions in that State.

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## Interim Approval – Allowable Uses

- Function as pedestrian-actuated conspicuity enhancement
- Shall only be used to supplement post-mounted Pedestrian, School, Trail Crossing warning sign with diagonal downward arrow, plaque, or overhead-mounted warning sign located at or immediately adjacent to an uncontrolled marked crosswalk
- If deemed necessary by the engineer, in event of sight distance, additional RRFB may be installed in advance of crosswalk. Shall supplement not replace.

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158 St. Petersburg FL

IA-21 3.a For any approach two RRFB required, One on right-hand and one on left-hand of roadway. If divided highway left-hand should be installed on median if practical rather than far left-hand.

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## Crosswalk Visibility Enhancements

- Curb Extensions
- Corner Radii
- Brief mention here but further discussed in Intersection Geometry

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## Lighting Over Crosswalks

Fig 11. Traditional midblock crosswalk lighting layout

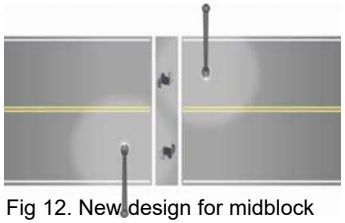

Fig 12. New design for midblock crosswalk lighting layout

Recommended lighting level: 20 lux at 5' above pavement

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## Raised Crosswalks

- Typically installed on 2-lane or 3-lane roads
- Speed limits of 30 mph or less
- AADT below about 9,000
- CRF: 45%

Photo Source: SRTS Guide

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## Raised Crosswalk

Traffic Calming ePrimer

- https://safety.fhwa.dot.gov/speedmgt/traffic_calm.cfm

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## Pedestrian Refuge Islands

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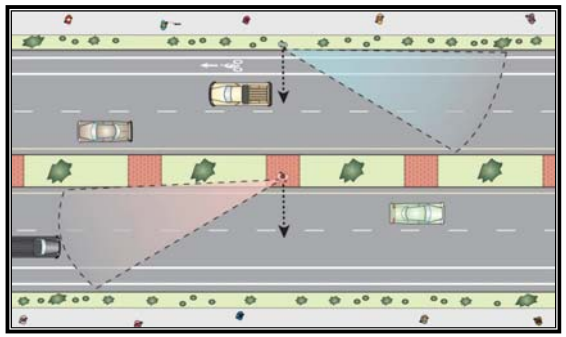
## Raised median- Breaks complex crossing into two simpler crossings



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## Pedestrian Hybrid Beacons (PHB)


CRF: Vehicle/Pedestrian 69%

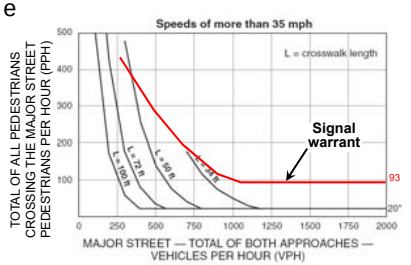



## Excerpts from 2009 MUTCD Chapter 4F For Pedestrian Hybrid Beacons

The CROSSWALK STOP ON RED sign shall be used

There are Guidelines (similar to signal warrants) for Pedestrian Hybrid Beacons – variables include:

- Pedestrian volume
- Traffic speeds
- Traffic volumes
- Crosswalk length






## Road Diet




## Road Diet / Roadway Reconfiguration

- Reduce crossing distance
- Eliminate /reduce "multiple threat" crash types
- Install crossing island to cross in 2 simple steps

## Road Diet / Roadway Reconfiguration


- Reduce top end travel speeds
- Buffer sidewalk from travel lanes (parking or bike lane)
- Reclaim street space for "higher and better use" than moving peak hour traffic

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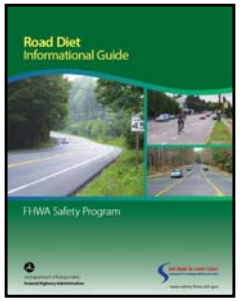
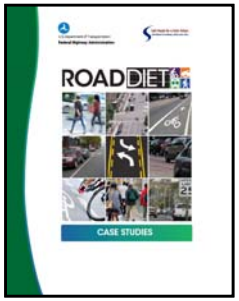
## Road Diet Informational Guide & Road Diet Case Studies




https://safety.fhwa.dot.gov/road_diets/guidance/info_guide/




https://safety.fhwa.dot.gov/road_diets/case_studies/

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## Intersections

- Signal timing or phasing changes at intersections to optimize operations and safety benefits
- Single Lane Roundabouts
  - ~ 20,000 ADT


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## STEP's Spectacular Six

- Crosswalk Visibility Enhancements
- Raised Crosswalks
- Pedestrian Refuge Islands
- Rectangular Rapid Flashing Beacon
- Pedestrian Hybrid Beacon (PHB)
- Road Diets

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## Along the Road

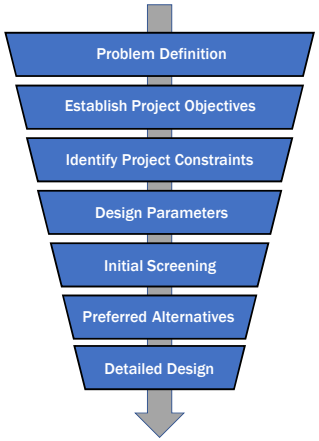
- Speed
- Pedestrian zone System
- Bicycle facilities
- Street crossings

## Intersections

- Intersection Control Evaluation
- Roundabouts
- Intersection Geometry
- Signals
- Bicycle Conflicts
- Protected Intersections

## Intersections

- **Intersection Control Evaluation**
- Roundabouts
- Intersection Geometry
- Signals
- Bicycle Conflicts
- Protected Intersections



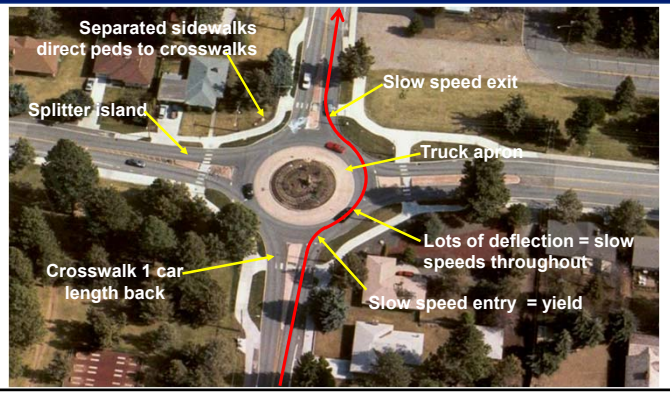

## Intersection Control Evaluation (ICE)

**Tiered process for developing and evaluating intersection improvement alternatives**

## Intersections

- Intersection Control Evaluation
- **Roundabouts**
- Intersection Geometry
- Signals
- Protected Intersections

## Essential Roundabout Characteristics




## Roundabouts Are Safer for All Users

Pedestrian crashes:
- CMF = 0.73 (CRF = 27%)

Conversion from Two-way stop control:
- All crashes: CMF = 0.56 (CRF = 44%)
- Injury crashes: CMF = 0.18 (CRF = 82%)

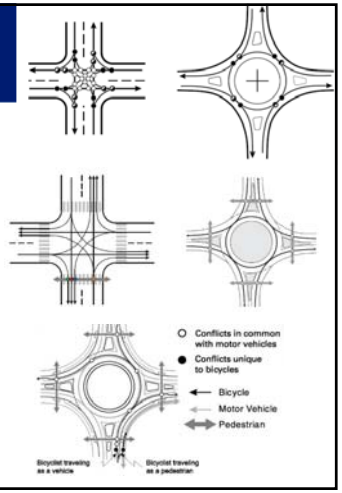
Conversion from signal control:
- All crashes: CMF = 0.52 (CRF = 48%)
- Injury crashes: CMF = 0.22 (CRF = 78%)

## Fewer Conflict Points

Vehicles: 32 to 8

Pedestrians: 16 to 8

Bicyclists: depends on whether sharing lane or using crosswalks



## Advantages for Pedestrians

- Reduced vehicle speeds
- Reduced number of conflict points
- Shorter crossing distances
- Splitter island provides a refuge – ped crosses one direction of traffic at a time
- Crosswalk is placed one car length back

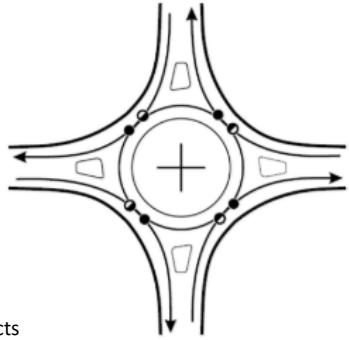

Bird Rock, San Diego, CA

## Making Roundabouts Work for Bicyclists

- Slow speeds
  - Deflection
  - Truck apron
  - NO BIKE LANES
- Simple
  - Single lane
  - NO BIKE LANES
- Splitter islands
- Bike ramps

## Safety Benefits for Vehicles

- Low travel speeds
  - Typically 15 to 20 miles per hour
  - Low severity collisions
- No signal
  - Continuous flow of traffic
  - Drivers only yield—no stopping if no traffic
  - No incentive to speed up to "beat the light"
- One-way travel
  - Deflection and curvature calms traffic
  - Eliminates severe head-on and T-bone conflicts



## Works for Large Trucks and Oversize Loads


Roundabout Myth - Large Trucks

## Intersections

- Intersection Control Evaluation
- Roundabouts
- **Intersection Geometry**
- Signals
- Protected Intersections

## Intersection Geometry Affects:

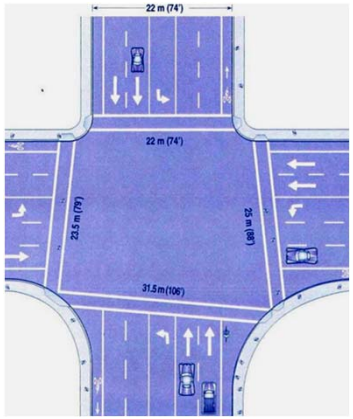
- Crossing distance
- Signal timing
- Turning speeds
- Number of conflict points
- Curb ramp design
- Marked crosswalks placement


## Intersection Design Principles:

- Reduce speed
- Minimize exposure to conflicts
- Communicate right-of-way priority
- Provide adequate sight distance
- Accommodate motor vehicle turning
- Accomodate pedestrian needs
  - Minimize crossing distance
  - Ramps for wheelchairs
  - Detectible warnings
- Accommodate bicyclist needs

## Large Curb Radius

- Increases crossing distance & time
- Makes crosswalk & ramp placement more difficult
- Indirect crossing
- Increased crossing setback
- Increased vehicle speed

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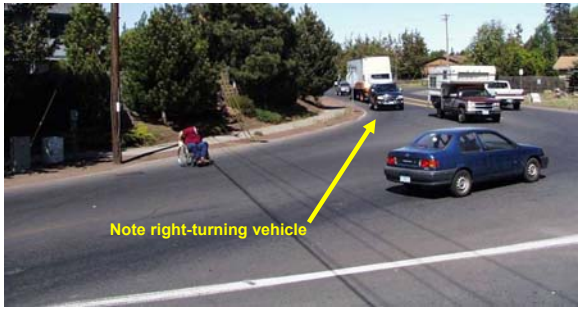
## Large Curb Radius




… and makes it hard to figure out where to cross

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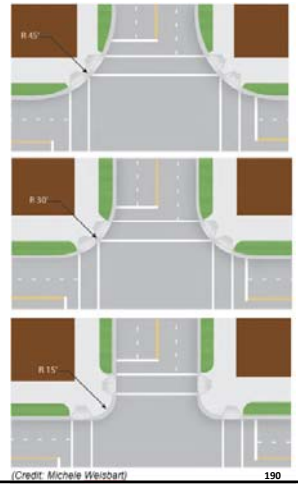
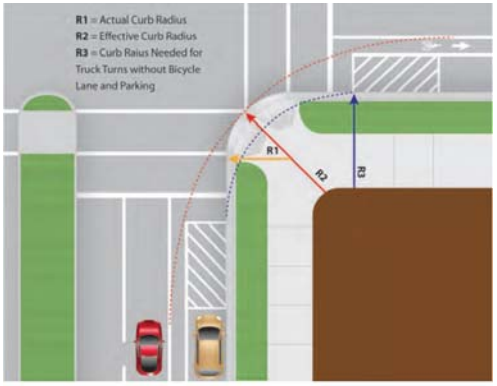
## Small Corner Radii Benefits:

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



(Credit: Michele Weisbart)

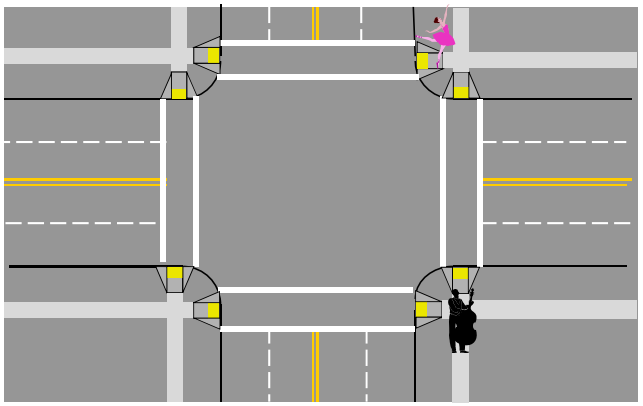
190



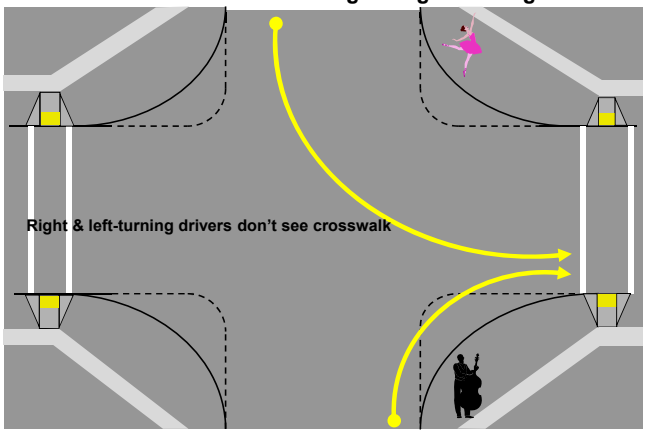

*The effective corner radius controls turning speeds and the ability of large vehicles to turn (Credit: Michele Weisbart)*

## Effective Curb Radius

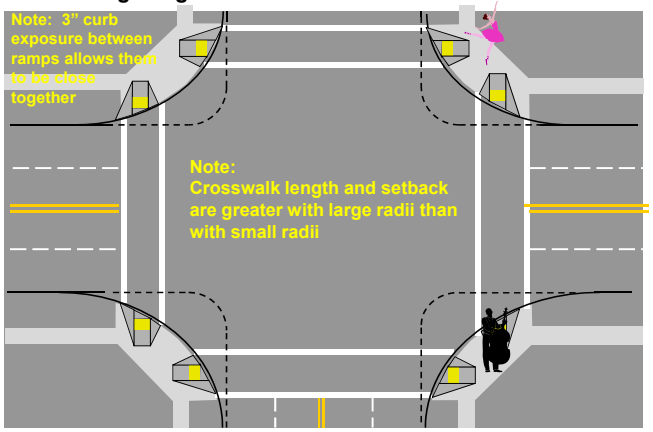
Small corner radii allow two ramps, shortest crosswalks, direct travel paths



Crosswalks at shortest crossing = longer walking distance

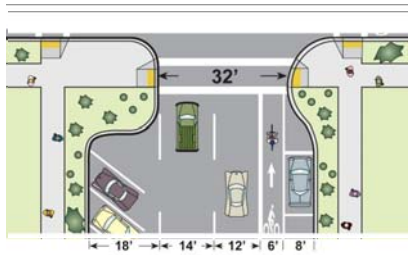



Balancing the goals works best




**Curb extensions**

**Most focus is on reduced crossing distance**




**Other advantages:**

- Better visibility between peds and motorists
- Traffic calming
- Room for street furniture

**Curb extensions should be the width of the parking lane and not encroach on bike lanes or travel lanes**

Before: road looks and feels wide

After: curb extension integral to sidewalk
Street looks narrow even with no parked cars

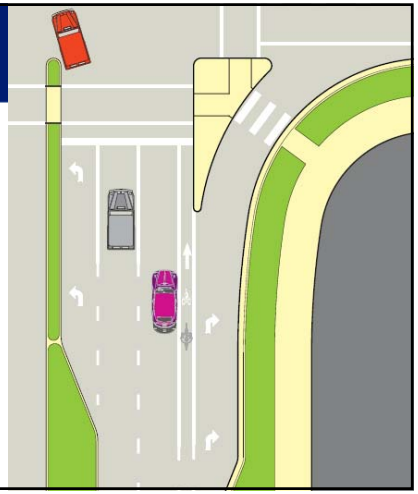
• Curb extension retrofit

• Curb extension integrated into sidewalk

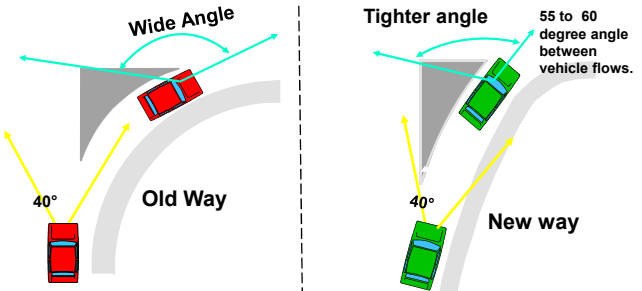
## Pedestrian Islands

Benefits:

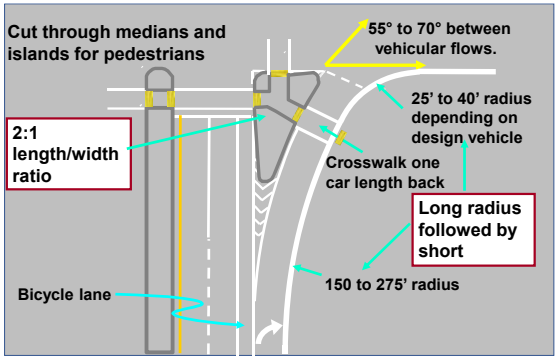
- Separate conflicts & decision points
- Reduce crossing distance
- Improve signal timing
- Reduce crashes



## Right-turn Slip Lane: Design for Pedestrians




## Right-turn Slip Lane - Details




## Island Design Details

- ❑ Cut-through preferred over ramps
- ❑ Truncated domes at cut-throughs


## Minimize Curb Radius w/Truck Apron

## Left-turn Conflicts and Countermeasures

## Two-stage Left Turn Box IA-20

## Two-Stage Left Turn Queue Box

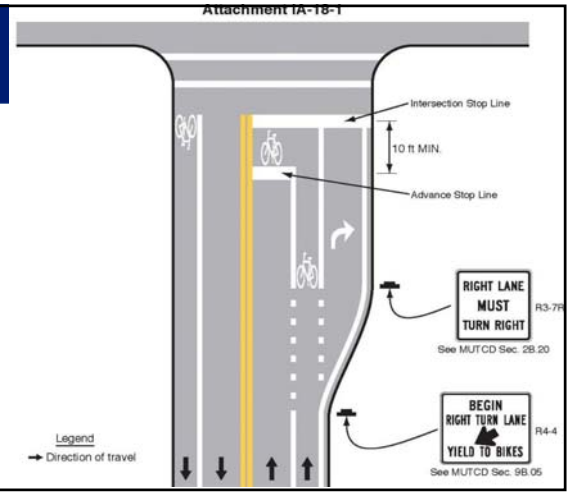
- Required design elements include:
  - Bicycle symbol
  - Turn arrow
  - Solid white line on all sides
  - Turn on red prohibition
  - Passive detection of bicycles
  - Queued bicyclists outside path of moving traffic
  - Avoid crosswalk conflicts
- Size to prevent conflicts

SALT LAKE CITY, UT (PHOTO: SALT LAKE CITY PUBLIC WORKS)

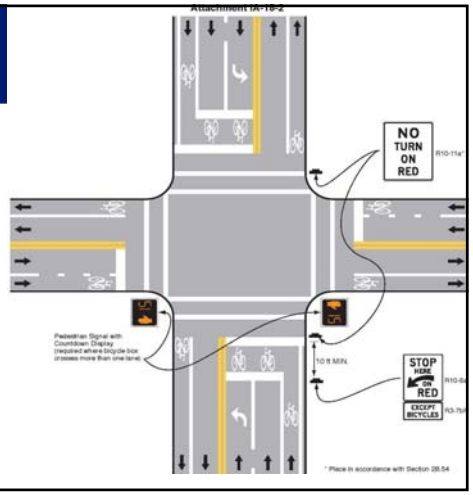
## Bike Box IA-18

- Reduced conflicts between bicyclists and turning vehicles
- Reduced avoidance maneuvers
- Reduced encroachment into crosswalks
- Use clearly understood by motorists and bicyclists

## Bike Box IA-18

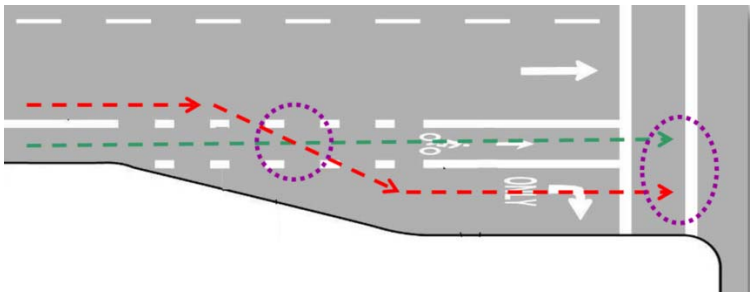



## Bike Box IA-18




## Right-turn Conflict

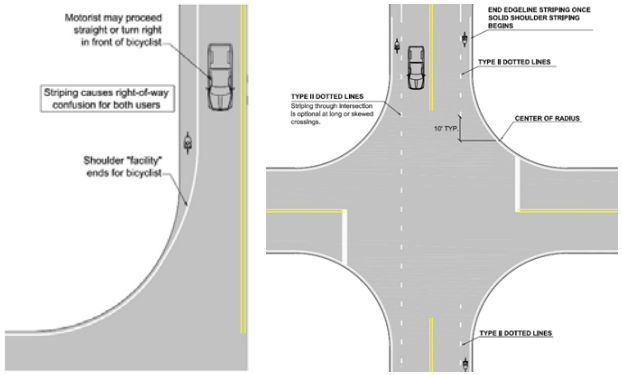
## Right-turn/Thru Conflict



## Shoulder Riding at Intersection

- Shoulder not a travel lane
- Modify shoulder striping
- Opportunity to switch to shared lanes **OR**
- Add bike lane thru intersection

## Shoulder Striping



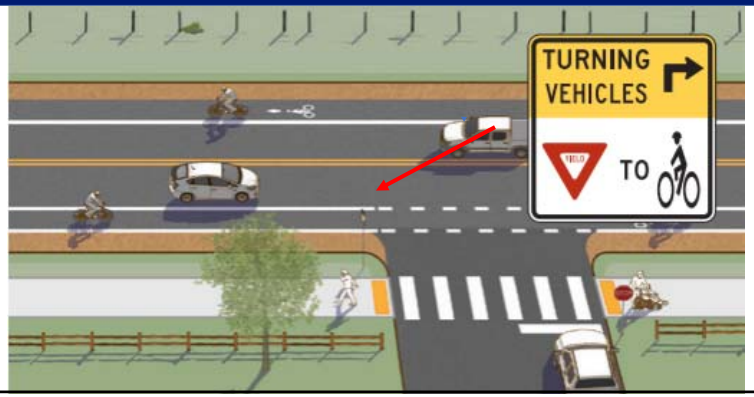

## Intersection with Shared Lanes

- Additional/all lanes are shared at intersection

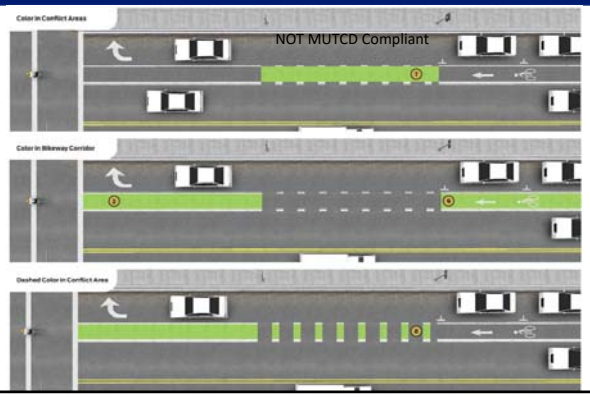
## Bike Lane Thru Intersection

MC10

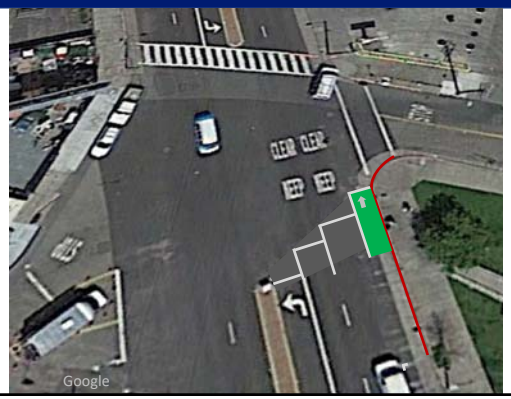
## Extension Thru Intersection



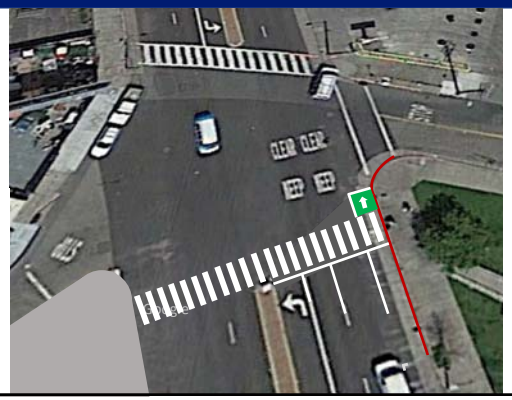

## Highlight Conflict Zone




## Stop Bars Placed for Forward Queueing




## Stop Bars Placed for Forward Queueing



## Bike Lane at Drop Lane

## Bike Lane at Drop Lane

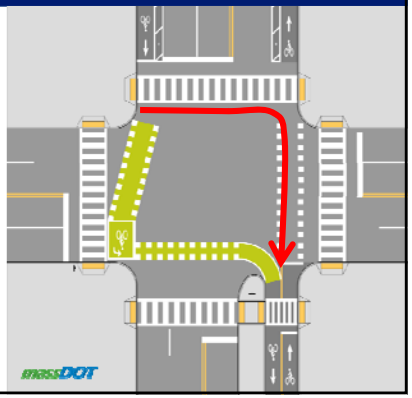
## Bike Lane at Drop Lane

## Transition Considerations

- What happens at termini?
- What happens when bicycle facility type changes?
- Have you stranded or created a barrier to the less confident user?
- How many stops will bicyclist have to make to traverse transition?
- Will bicyclists cross from the right side of the street to the left to continue on their path?

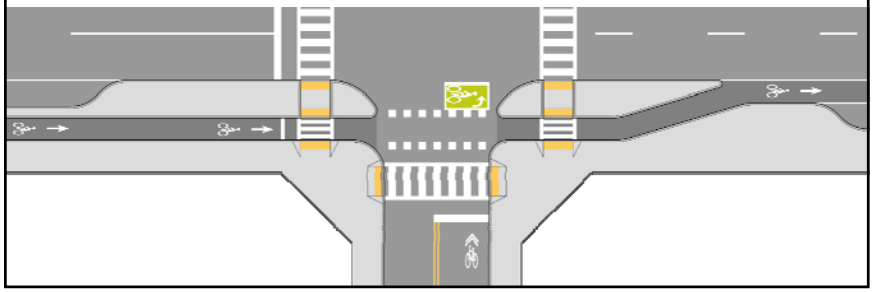
## Example Transitions

Into a two-way separated bike lane




## Example Transitions

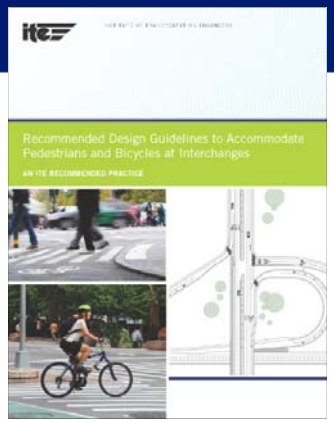
- Into a conventional bike lane
- Into shared roadway cross-street



## Freeway Interchanges

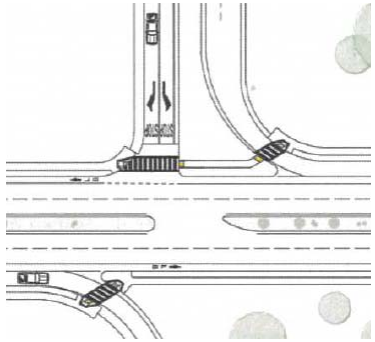
Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges

ITE 2016



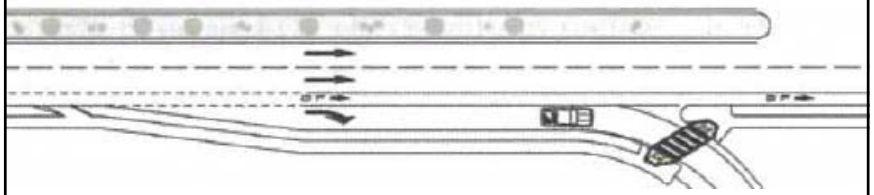

## Guiding Principles for Pedestrians

- Ramp geometry
- Locate crosswalk
  - Best visibility
  - Before acceleration
  - Short and direct
- Crosswalk short w/out excessive deviation
- Widen sidewalks shared with bicyclists



## Guiding Principles for Bicyclists

- Buffer where bicyclists are between moving vehicles more than 200 ft
- Provide bike “exit” option ahead of on-ramps
- Define a weaving area



## Intersections

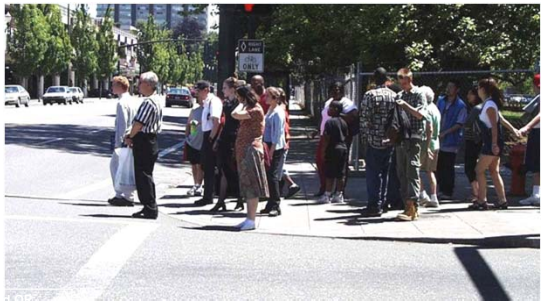
- Intersection Control Evaluation
- Roundabouts
- Intersection Geometry
- **Signals**
- Protected Intersections

## Signalized Intersections

- Signal timing & walking speeds
- Countdown signals
- Turning vehicle conflicts
  - Protected left turns
  - Flashing yellow arrow
  - Restricting right turn on red
  - LPI/LBI
- Bicyclist signals

## Use Short Signal Cycle Length

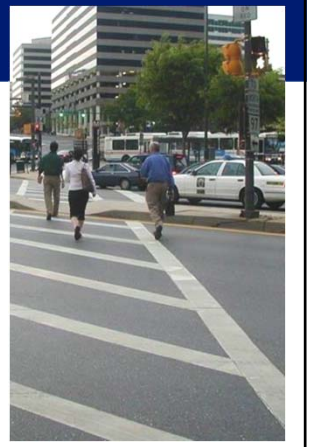
- Long wait causes stacking: pedestrians wait in street, or don’t wait and cross against the signal



## Pedestrian Walking Speeds

2009 MUTCD:

- 7 sec walk, 4 sec option (no change)
- Ped clearance time (flashing hand) calculated at 3.5'/sec curb-to-curb.
- Example: 60' crosswalk requires 17 sec
  - 7 + 17 = 24 sec total
- Additional test for walk plus clearance time: Calculate travel time from push button (or 6' feet from curb if no button) to curb on other side at 3'/sec
  - Example: 6' + 60' crosswalk = 66
    - 66' requires 22 sec
    - 24 sec > 22 sec; passes test.



MUTCD Sec. 4E.06

## Pedestrian Conflicts with Turning Vehicles

- Countermeasures
  - Protected vs. permissive turns
  - No turn on red
  - Exclusive pedestrian phase
  - Leading pedestrian interval

## Signs: Remind Turning Drivers to Yield to Peds


R10-15 in 2009 MUTCD

Older local variations, using MUTCD-approved lettering and symbols:

Leesburg, FL


Juneau, AK
Orlando, FL

MUTCD Sec. 2B.53, Paragraph 09

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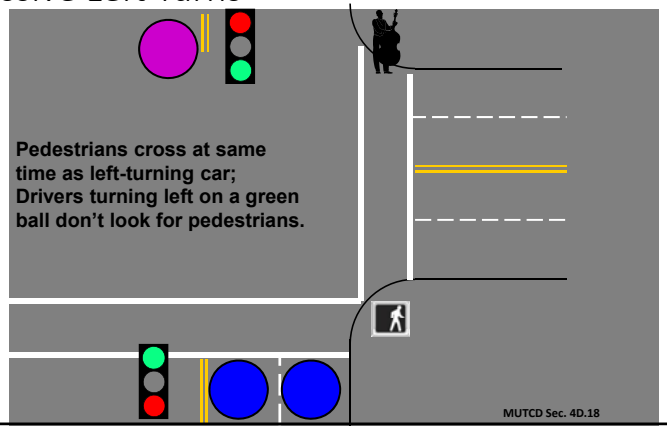
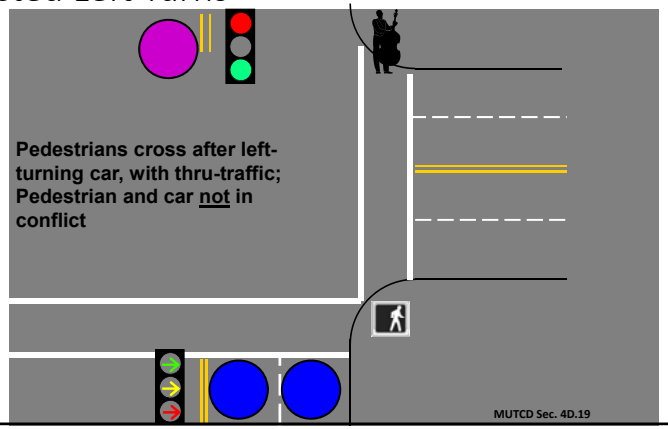
## Protected Vs. Permissive Left Turns

- CMF = 0.3 (CRF 70%) (all crashes) converting permissive left turns to protected only left turns

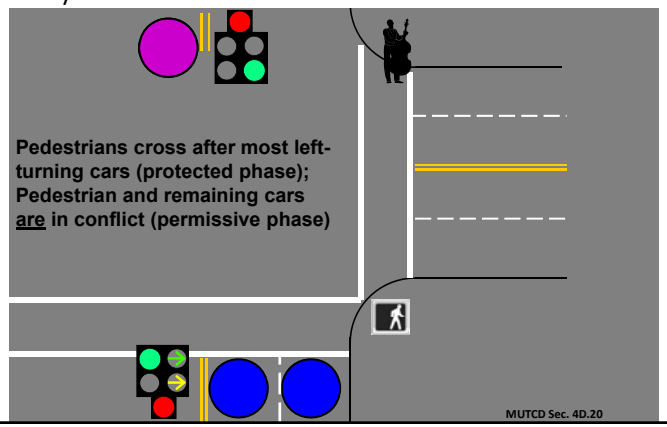
## Permissive Left Turns




## Protected Left Turns

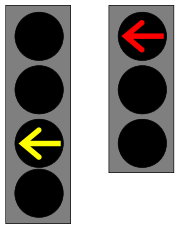



## Protected/Permissive Left Turns



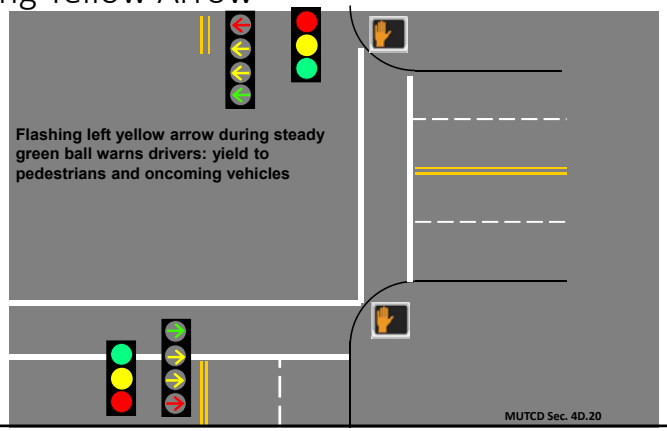

## Protected/Permissive Left Turns: Solutions

1. Provide protected-permissive phasing by default, but revert to protected-only when pedestrian button is pushed or based on time of day
2. Flashing Yellow Arrow (details on the next slide)



MUTCD Sec. 4D.20

## Flashing Yellow Arrow




## Restricting Turns on Red

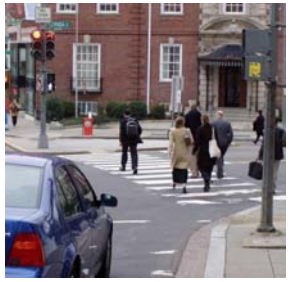
**Consider No Turn on Red signs where there is:**

- Poor sight distance between vehicles and peds
- An unusual number of ped conflicts with turns on red (compared to turns on green)
- An exclusive pedestrian phase
- A leading pedestrian or bicyclist interval
- Two-stage turn box
- Bike box
- Two-way separated bike lane

MUTCD Section 2B.54

## Restricting Turns on Red

1. At all times



2. When pedestrians are present


Difficult to enforce

## Restricting Turns on Red

3. By time of day


Limits most turns on red

4. Changeable message sign—activated by push button or by controller


Note: A dynamic NTOR sign can be used to improve the effectiveness of a Lead Pedestrian Interval

## EDC5 STEP's Spectacular Seven

- Crosswalk Visibility Enhancements
- Raised Crosswalks
- Pedestrian Refuge Islands
- Rectangular Rapid Flashing Beacon
- Pedestrian Hybrid Beacon (PHB)
- Road Diets
- Leading Pedestrian Interval


## LPI = Lead Pedestrian Interval

**MUTCD Sec. 4E.06, paragraphs 19-23**

WALK comes on at least 3 seconds prior to the green signal; pedestrians enter crosswalk before turning vehicles arrive there.


These peds waited 3 cycles before turning drivers let them cross as legally required. LPI would give them a head start.

CMF = 0.95 (CRF: 5%)

## Safer Signals for Bicyclists

- Bikes start-up and travel slower than cars
  - Differentiating bike detection to optimize signals
  - Set initial and gap times to accommodate bikes
- Leading Bike Interval
- Segregate conflicting movements

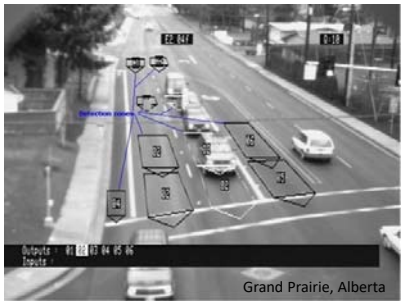
## Bicycle Signal Face

Application for:

- Bicyclist non-compliance
- Provide a leading or lagging bicycle interval
- Continue the bicycle lane on the right-hand side of an exclusive turn lane
- Augment the design of a segregated counter-flow
- Unusual or unexpected arrangements of the bicycle movement through complex intersections, conflict areas, or signal control.

## Bicycle Detection

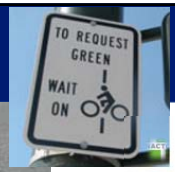
- Buttons
- Loops
- Video
- Microwave
- Radar
- Infrared

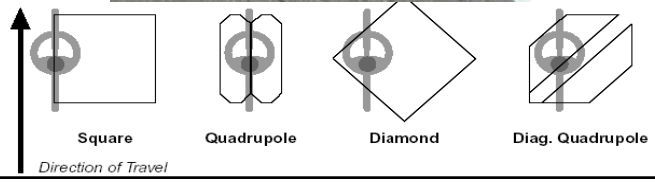


Grand Prairie, Alberta

## Loop Detection

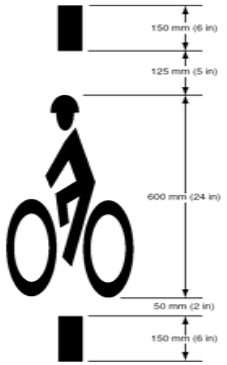
Portland, OR



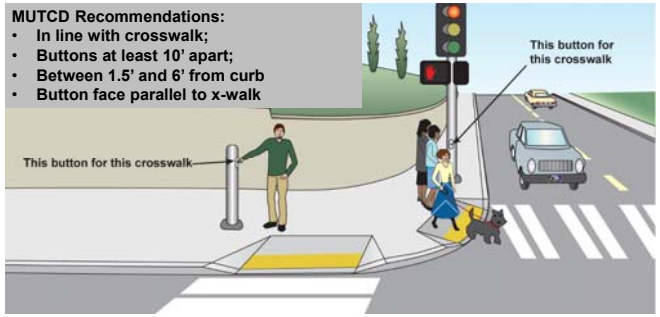



## Loop Detection

MUTCD standard for signal loop marking for bicyclists (Section 9C.05)



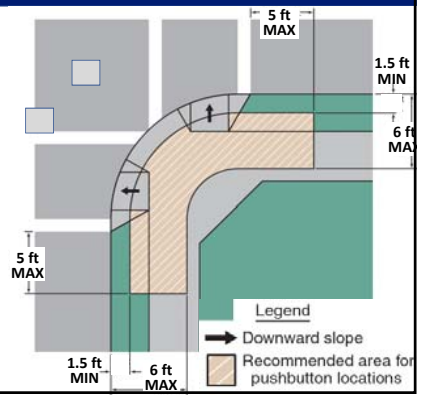

## Proper Pushbutton Placement




MUTCD Sec. 4E.08

## Proper Pushbutton Placement

The MUTCD recommends these dimensions




MUTCD Figure 4E-3

## Poor Pushbutton Placement

Behind guardrail

Behind vegetation

## Proper Pushbutton Placement

On side of pole

At top of ramp

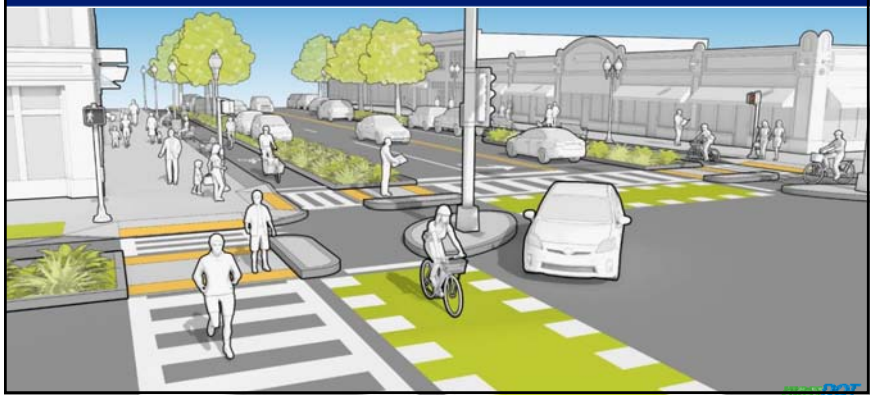
## Accessible Pedestrian Signals (APS)

- Provide ped signal information in audible and vibrotactile format
- Benefit all pedestrians by providing redundancy
- The 2009 MUTCD describes the features of APS, but does not require them
- Future accessibility standards and future MUTCD editions will likely require APS for all ped signals


## Intersections

- Intersection Control Evaluation
- Roundabouts
- Intersection Geometry
- Signals
- **Protected Intersections**

## Protected Intersection



## Protected Intersections Video


## Visibility at Conflict Points

motorist's view at conventional bike lane

motorist's view at **separated bike lane**

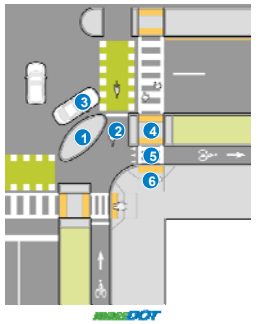
## Visibility at Conflict Points





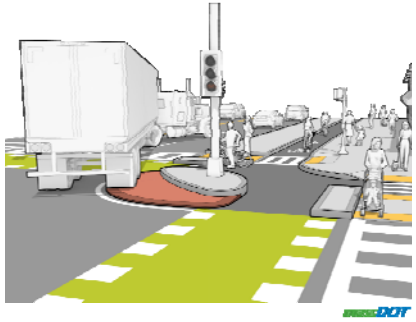
## Protected Intersections

1. Corner refuge island
2. Forward bicycle queuing area
3. Motorist yield zone
4. Pedestrian crossing island
5. Pedestrian crossing of separated bike lane
6. Pedestrian curb ramp



## Slow Right Turning Speeds

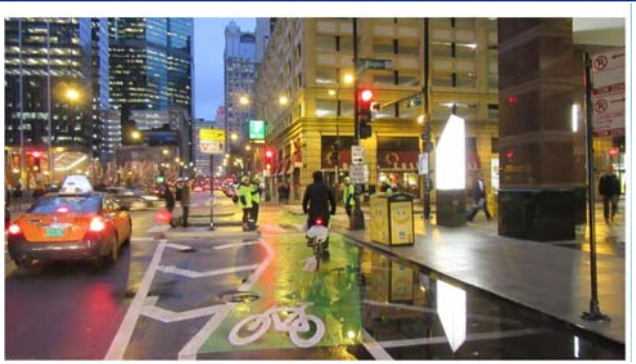
- Design for ≤**10 mph** vehicle turns
- Mountable truck apron
  - 3" max.
  - Visually distinct
- Large radii reduces bicycle, pedestrian queuing areas



## Indianapolis, IN

## Chicago, IL

## Chicago, IL



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## Chicago, IL

## Intersections

- Intersection Control Evaluation
- Roundabouts
- Intersection Geometry
- Signals
- Bicycle Conflicts
- Protected Intersections

## Complete Streets

- Networks are accessible, interconnected transportation facilities that allow all users to safely and conveniently get where they want to go.
- Connectivity is the extent to which users can make comfortable trips from beginning to end when traveling to destinations throughout a community.

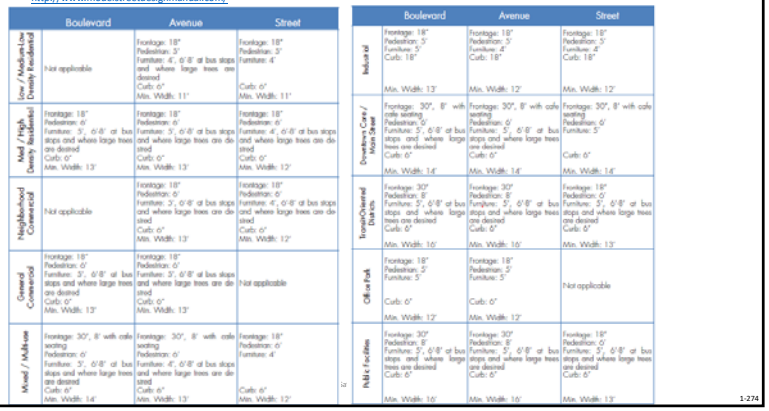
## References

## Levels of Traffic Stress (LTS)

| Levels of Traffic Stress | | | |
|---|---|---|---|
| LTS 1 | LTS 2 | LTS 3 | LTS 4 |
| • Physically separated from traffic or low-volume, mixed-flow traffic at 25 mph or less<br>• Bike lanes 6 ft wide or more<br>• Intersections easy to approach and cross<br>• Comfortable for children | • Bike lanes 5.5 ft wide or less, next to 30 mph auto traffic<br>• Unsignalized crossings of up to 5 lanes at 30 mph<br>• Comfortable for most adults<br>• Typical of bicycle facilities in Netherlands | • Bicycle lanes next to 35 mph auto traffic, or mixed-flow traffic at 30 mph or less<br>• Comfortable for most current U.S. riders<br>• Typical of bicycle facilities in U.S. | • No dedicated bicycle facilities<br>• Traffic speeds 40 mph or more<br>• Comfortable for "strong and fearless" riders (vehicular cyclists) |

## Recommendations from Model Design Manual for Living Streets

http://www.modelstreetdesignmanual.com/




## Shared Lane Marking

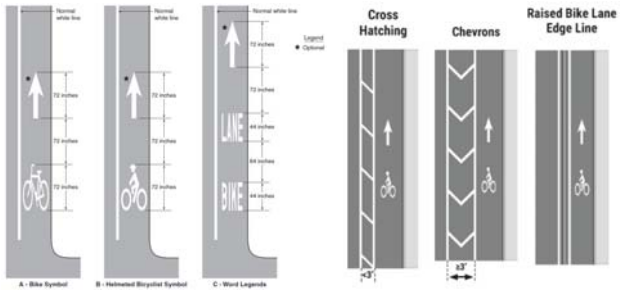

- More than 1 lane
  Downhill or level
- Short segment to fill gap in bikeway
- Speed < 30 mph
- High bicycle use

- Single lane
- Uphill
- Parallel route option
- Long segment
- Speed > 40 mph
- Low bicycle use

## Shoulder Bikeway


| Functional classification | Volume (AADT) | Speed (Mi/h) | Recommended Minimum Paved Shoulder Width |
|---|---|---|---|
| Minor Collector | up to 1,100 | 35 (55 km/h) | 5 ft (1.5 m) |
| Major Collector | up to 2,600 | 45 (70 km/h) | 6.5 ft (2.0 m) |
| Minor Arterial | up to 6,000 | 55 (90 km/h) | 7 ft (2.1 m) |
| Principal Arterial | up to 8,500 | 65 (100 km/h) | 8 ft (2.4 m) |

## Pavement Markings



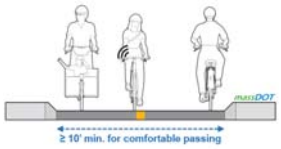

## Bike lane Width for One-Way

**Widths vary by peak hour volume**
- 6.5-10 ft recommended
- 5-8 ft minimum
- 4' allowable at bus stops or accessible parking


| Same Direction Bicyclists/ Peak Hour | Bike Lane Width (ft.) | |
|---|---|---|
| | Rec. | Min.[a] |
| <150 | 6.5 | 5.0 |
| 150 750 | 8.0 | 6.5 |
| >/50 | 10.0 | 8.0 |

## Bike lane Width for Two-Way

**Widths vary by peak hour volume**
- 10-14 ft recommended
- 8-11 ft minimum



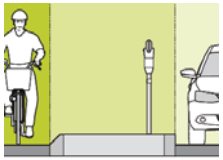

| Bidirectional Bicyclists/ Peak Hour | Bike Lane Width (ft.) | |
|---|---|---|
| | Rec. | Min.* |
| <150 | 10.0 | 8.0 |
| 150-400 | 11.0 | 10.0 |
| >400 | 14.0 | 11.0 |

## Shy Distance

- Lateral offset
  - Height < 36" no offset
  - Height > 36" 6" offset
- Vertical clearance
  - 100"

## Street Buffer Width

- 6’ preferred
- 2’ when constrained
- 1’ along raised SBL
- 6-16.5’ optimum for intersections



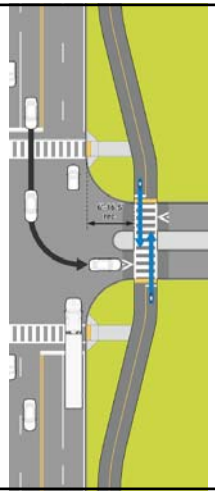


Table 1. Application of pedestrian crash countermeasures by roadway feature.

| Roadway Configuration | Posted Speed Limit and AADT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Vehicle AADT <9,000 | | | Vehicle AADT 9,000–15,000 | | | Vehicle AADT >15,000 | | |
| | ≤30 mph | 35 mph | ≥40 mph | ≤30 mph | 35 mph | ≥40 mph | ≤30 mph | 35 mph | ≥40 mph |
| 2 lanes (1 lane in each direction) | ❶ 2 4 5 6 | ❶ 5 6 7 9 | ① 5 6 ❼ ❽ | ❶ 4 5 6 | ❶ 5 6 7 9 | ① 5 6 ❼ ❽ | ❶ 4 5 6 7 9 | ① 5 6 7 9 | ① 5 6 ❼ ❽ |
| 3 lanes with raised median (1 lane in each direction) | ❶ 2 3 4 5 | ❶ ❸ 5 7 9 ❼ ❽ | ① ❸ 5 ❼ ❽ | ① 3 4 5 7 9 | ① ❸ 5 ❼ ❾ ❽ | ① ❸ 5 ❼ ❽ | ① ❸ 4 5 7 9 ❼ ❽ | ① ❸ 5 ❼ ❾ ❽ | ① ❸ 5 ❼ ❽ |
| 3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane) | ❶ 2 3 4 5 6 7 9 | ❶ ❸ 5 6 7 9 | ① ❸ 5 6 ❼ ❽ | ① 3 4 5 6 7 9 | ① ❸ 5 6 ❼ ❽ | ① ❸ 5 6 ❼ ❽ | ① ❸ 4 5 6 7 9 | ① ❸ 5 6 ❼ ❽ | ① ❸ 5 6 ❼ ❽ |
| 4+ lanes with raised median (2 or more lanes in each direction) | ❶ ❸ 5 7 8 9 | ❶ ❸ 5 7 8 9 | ① ❸ 5 8 ❽ | ① ❸ 5 7 8 9 | ① ❸ 5 8 ❽ | ① ❸ 5 8 ❽ | ① ❸ 5 7 8 9 | ① ❸ 5 8 ❽ | ① ❸ 5 8 ❽ |
| 4+ lanes w/o raised median (2 or more lanes in each direction) | ❶ ❸ ❺ 5 6 7 8 9 | ① ❸ ❺ 5 ❿ 7 8 9 | ① ❸ ❺ 5 ❿ 8 ❽ | ① ❸ ❺ 5 ❿ 7 8 9 | ① ❸ ❺ 5 ❿ 8 ❽ | ① ❸ ❺ 5 ❿ 8 ❽ | ① ❸ ❺ 5 ❿ 7 8 9 | ① ❸ ❺ 5 ❿ 8 ❽ | ① ❸ ❺ 5 ❿ 8 ❽ |

Given the set of conditions in a cell,

\# Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.

● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.

○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
2 Raised crosswalk
3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4 In-Street Pedestrian Crossing sign
5 Curb extension
6 Pedestrian refuge island
7 Rectangular Rapid-Flashing Beacon (RRFB)**
8 Road Diet
9 Pedestrian Hybrid Beacon (PHB)**

*Refer to Chapter 4, 'Using Table 1 and Table 2 to Select Countermeasures,' for more information about using multiple countermeasures.

**It should be noted that the PHB and RRFB are not both installed at the same crossing location.

Table 2. Safety issues addressed per countermeasure.

| Pedestrian Crash Countermeasure for Uncontrolled Crossings | Safety Issue Addressed | | | | |
|---|---|---|---|---|---|
| | Conflicts at crossing locations | Excessive vehicle speed | Inadequate conspicuity/ visibility | Drivers not yielding to pedestrians in crosswalks | Insufficient separation from traffic |
| Crosswalk visibility enhancement | ✓ | ✓ | ✓ | ✓ | ✓ |
| High-visibility crosswalk markings* | ✓ | | ✓ | ✓ | |
| Parking restriction on crosswalk approach* | ✓ | | ✓ | ✓ | |
| Improved nighttime lighting* | ✓ | | ✓ | | |
| Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line* | ✓ | | ✓ | ✓ | ✓ |
| In-Street Pedestrian Crossing sign* | ✓ | ✓ | ✓ | ✓ | |
| Curb extension* | ✓ | ✓ | ✓ | | ✓ |
| Raised crosswalk | ✓ | ✓ | ✓ | ✓ | |
| Pedestrian refuge island | ✓ | ✓ | ✓ | | ✓ |
| Pedestrian Hybrid Beacon | ✓ | ✓ | ✓ | ✓ | |
| Road Diet | ✓ | ✓ | ✓ | | ✓ |
| Rectangular Rapid-Flashing Beacon | ✓ | | ✓ | ✓ | ✓ |

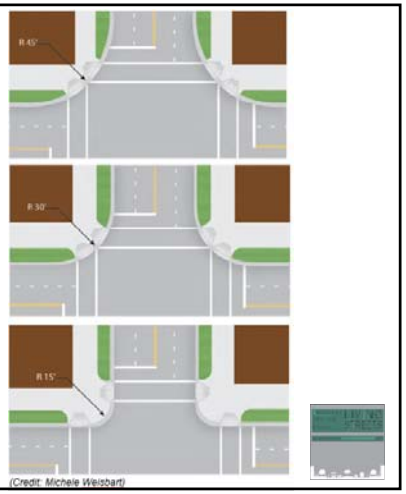
*These countermeasures make up the STEP countermeasure "crosswalk visibility enhancements." Multiple countermeasures may be implemented at a location as part of crosswalk visibility enhancements.

## Countermeasure Selection

| Objective Type | Shared Roadway | On-Road Bike Facilities | Intersection Treatments | Maint-enance | Traffic Calming | Trails/ Shared Paths | Markings, Signs & Signals | Other Measures |
|---|---|---|---|---|---|---|---|---|
| Provide safe on-street facilities/space for bicyclists | X | X | | X | X | | X | X |
| Provide off-road paths or trails for bicyclists | | | | X | | X | X | X |
| Provide and maintain quality surfaces for bicyclists | X | | | X | | | X | |
| Provide safe intersections for bicyclists | X | | X | | X | X | X | |
| Improve motorist behavior/ compliance with traffic laws | X | | X | X | X | | X | X |

## Small Corner Radii Benefits:

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



(Credit: Michele Weisbart)

## Road Diets

- Considerations
  - Safety
  - Operations
    - Peak Hour
  - Design
    - Signalized Intersection Adjustments
  - Resurfacing
  - Context Sensitive Solutions/Complete Streets

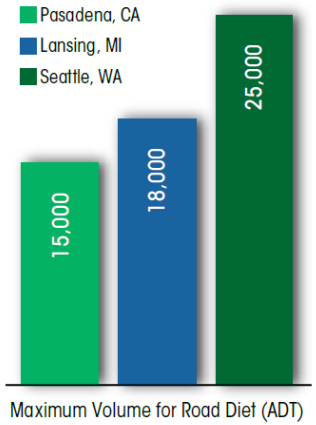


**Figure 12.** Road Diet Implementation Maximum Volume Thresholds by Agency