

Billgeville's new pedestrian monkey bars not only reduced accidents but also whipped people into great shape.

STREET CROSSINGS

Module 4

Part 2: Countermeasures

Learning Outcomes

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- At the end of this module, you will be able to:
- Identify which crossing technique is appropriate
- Ensure oft-requested solutions (crosswalks, signals, pedestrian bridges) are effective:
 - Concerned citizens and elected officials often respond to a tragic pedestrian crash asking for an immediate solution, which may or may not be appropriate.
 - This module explains why some countermeasures work, and why others don't.

Basic Street Crossing Techniques

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- Crosswalks
- Illumination
- Signs
- Striping
- Medians/pedestrian islands
- Signals
- Over/undercrossings

Crosswalks

4

- Crosswalk FAQ's:
 - Why are they marked?
 - Where should they be marked?
 - Do marked crosswalks increase safety, or provide a “false sense of security?”

1. Why are crosswalk markings provided?

5

University Place WA

- To indicate to pedestrians where to cross
- To indicate to drivers where to expect pedestrians
- At mid-block locations, crosswalk markings legally establish the crosswalk.



2. How to determine where to mark a crosswalk?

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Cambridge MA

- Crosswalk markings are commonly used to guide pedestrians and alert other road users of pedestrians at signalized locations and approaches controlled by STOP or YIELD signs
- An engineering study should be performed before crosswalk markings are installed at locations away from traffic signals or STOP signs. (MUTCD Section 3B.18)



2. How to determine where to mark a crosswalk?

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Corvallis OR

Consider origins and destinations



In this case, apartments across from bus stop & stores

8

Not Suitable Location for a Marked Crosswalk



9

Corvallis OR

- ❑ Not a good location for a marked crosswalk:
- ❑ No consistent place where pedestrians cross



10

Clatskanie OR

- ❑ Not a good location for a marked crosswalk:
- ❑ Poor sight distance

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Suitable Locations for a Marked Crosswalk



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Madison WI

- Suitable location for a marked crosswalk:
- Two-lane, high use, driver expectancy



13 Washington DC

- Suitable location for a marked crosswalk:
- Slow speed, high use, driver expectancy

3. Looking or Not Looking?

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Madison WI

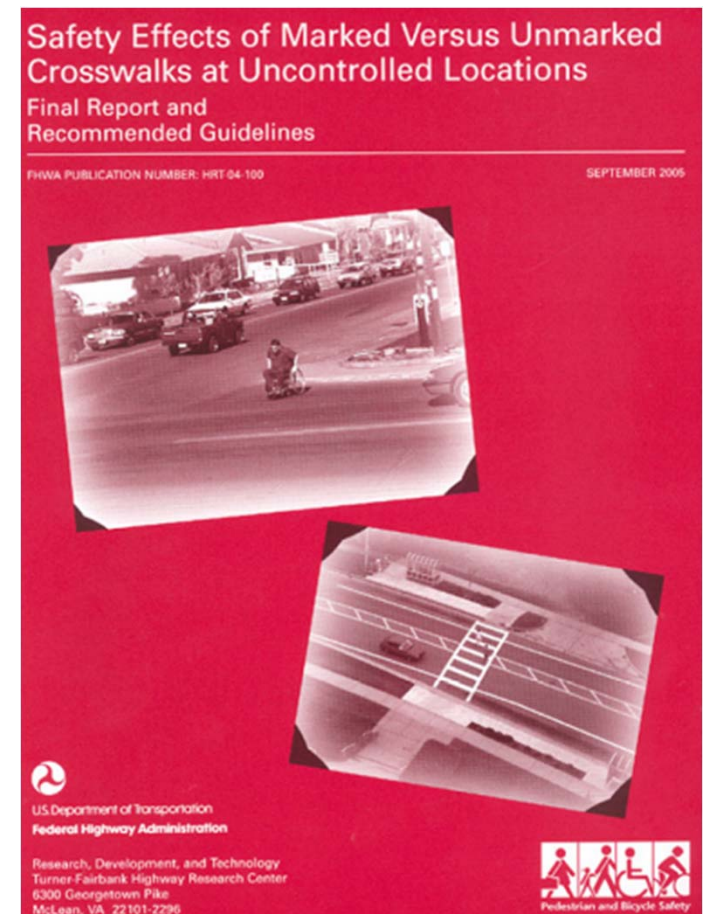
Do marked crosswalks increase safety, or encourage people to cross without looking?



Results of Most Recent Study (Zegeer et al 2005)

15

- Marked vs. Unmarked Analysis
- Speeds $<$ or $=$ to 40 mph
 - Two-lane roads: No significant difference in crash rate
 - Multilane roads (3 or more lanes)
 - Under 12,000 ADT: no significant difference in crash rate
 - Over 12,000 ADT w/ no median: crashes marked $>$ crashes unmarked
 - Over 15,000 ADT & w/ median: crashes marked $>$ crashes unmarked

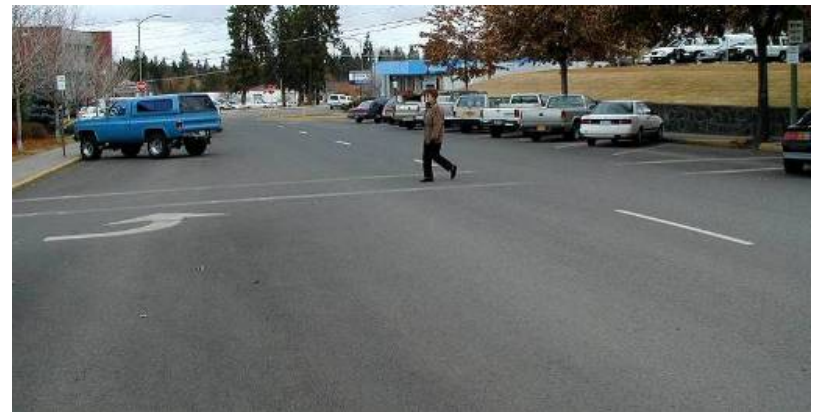


Study Results



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- Median reduces crashes by 40%
- Pedestrians over 65 are over-represented in crosswalk crashes
- Pedestrians are not less vigilant in marked crosswalks:
 - Looking behavior increased after crosswalks installed

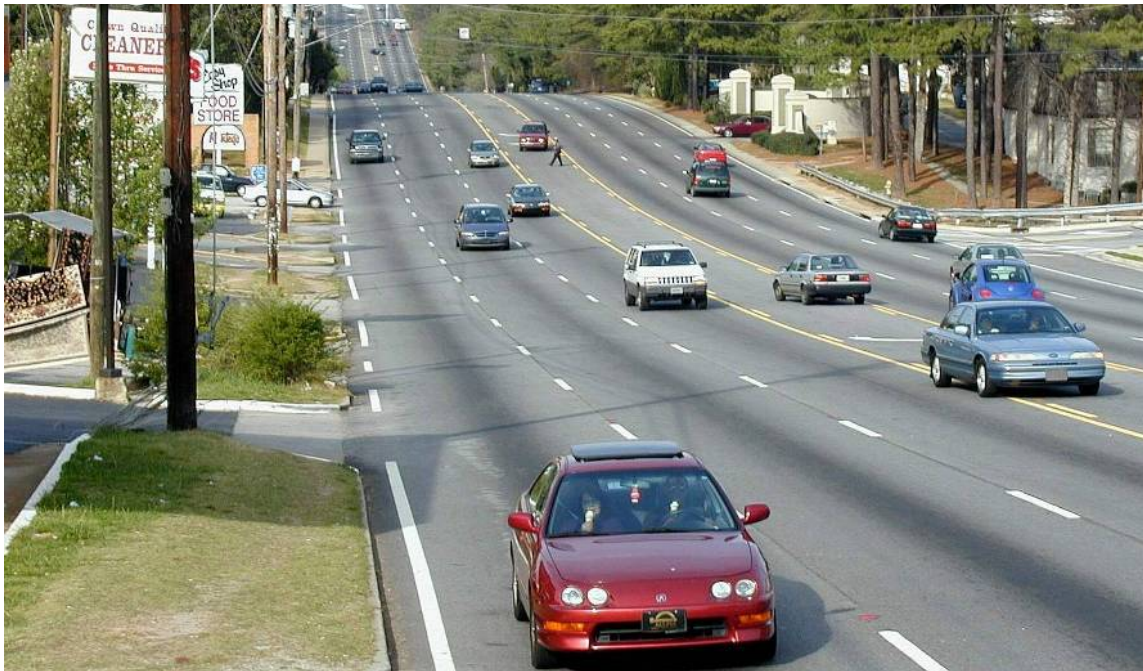


Study Results

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Atlanta GA

- Crashes correlate with ADT & number of travel lanes.
- ▣ Other studies have shown similar results



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

18



1st car stops too close, masks visibility for driver in 2nd lane
Solution: advance stop bar (comes later...)

Text in the 2009 MUTCD

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- New marked crosswalks alone, **without other measures designed to reduce traffic speeds**, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence, should not be installed across uncontrolled roadways where the speed limit exceeds 40 mph or either:
 - Has 4 or more lanes without a raised median or island and ADT of 12,000 or more, or
 - 4 or more lanes with raised median island and ADT of 15,000 or more
 - (2009 MUTCD Section 3B.18)



Increase Effectiveness Of Crosswalks

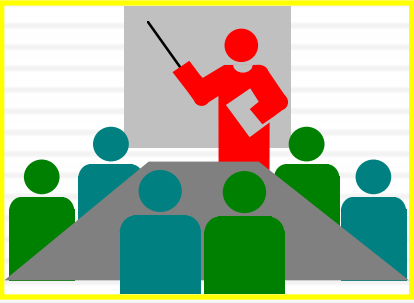
With:

20

- Proper location
- High Visibility Markings
- Illumination
- Signing
- Advance Stop Bars
- Median Islands
- Curb Extensions
- Signals

Key Quotes from the Study Conclusion

- “When considering marked crosswalks at uncontrolled locations, the question should not be simply, “Should I provide a marked crosswalk or not?”...
- “Regardless of whether marked crosswalks are used, there remains the fundamental obligation to get pedestrians safely across the street. In most cases, marked crosswalks are best used in combination with other treatments (e.g., curb extensions, raised crossing islands, traffic signals, roadway narrowing, enhanced overhead lighting, traffic calming measures)....
- “In all cases, the final design must accomplish the goal of getting pedestrians across the road safely....”
- “The design question is, “How can this task [getting pedestrians across the road safely] best be accomplished?”



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Discussion:

What are your policies & practices regarding marked crosswalks?

Marked crosswalk must be visible to the DRIVER

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Atlanta GA



What the pedestrian sees

Marked crosswalk must be visible to the DRIVER

24

Atlanta GA



What the driver sees

(same crosswalk)

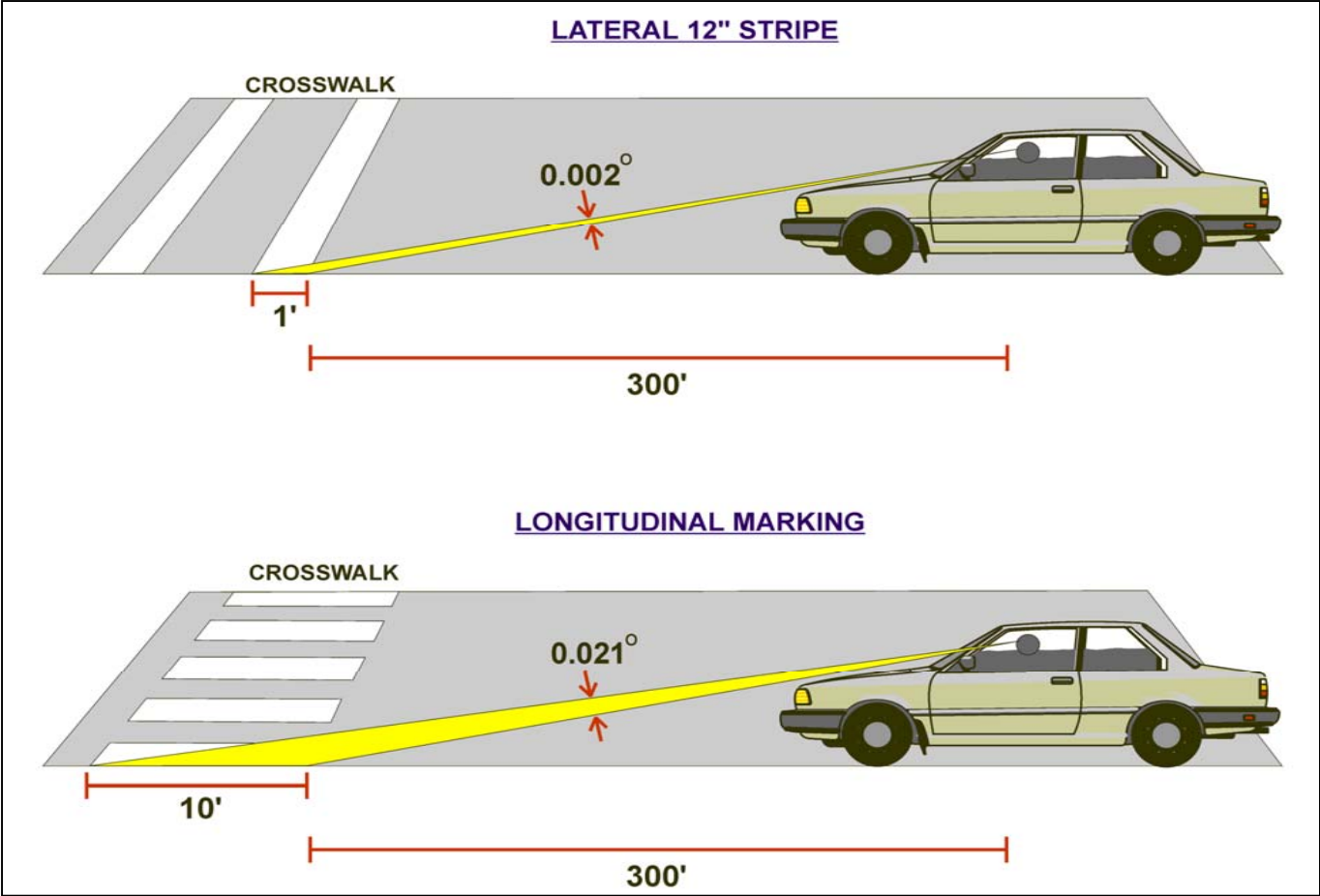
Crosswalk Visibility

25



Crosswalk Marking Types

Crosswalk Visibility



Longitudinal markings are more visible to driver from afar



Longitudinal markings with transverse markings – very visible



Place longitudinal markings to avoid wheel tracks, reducing wear & tear & maintenance



Staggered markings improve visibility from afar

Textured crosswalks: How effective are they?



In theory, more visible. Reality?



31

Corvallis OR

What the pedestrian sees



32

Corvallis OR

What the driver sees



33

- ❑ Brick crosswalks: prone to failure
- ❑ Difficult for wheelchair users

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Mitigation Measures For Colored Crosswalks



35

Emmaus, PA

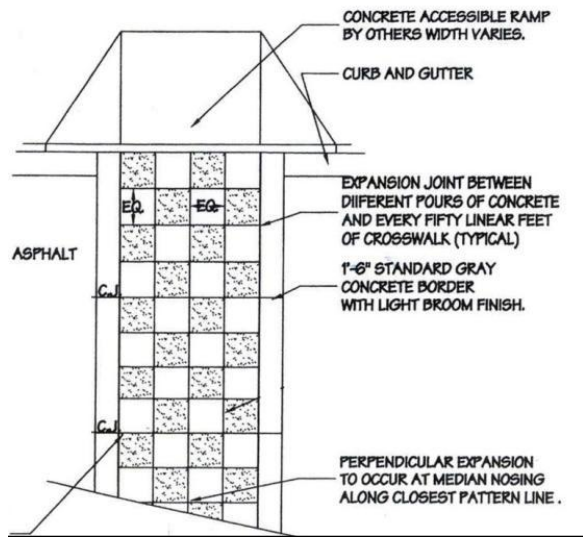
- Supplement textured crosswalks with white lines to increase visibility



36

Orlando, FL

Brick street with (asphalt-coated) concrete crosswalk



- Checkerboard pattern created by alternating brushed concrete with exposed aggregate (use fine rock)



38

St Paul MN

Idea: imbed white crosswalk within contrasting color



39

St Paul MN

Driver perspective: crosswalks show up well

Raised Crosswalks

1-40



Figure 6. Raised crosswalk and overhead flasher, Towerview Drive, Durham, North Carolina.

- FHWA Study “The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior” -2001
- Increase pedestrian visibility & likelihood the driver yields to pedestrians especially when combined with an overhead flashing light
- Most appropriate on low speed local or neighborhood streets
- Should not be used on emergency routes, bus routes, or high speed streets
- Drainage of storm water runoff and snow plowing considerations may also be a concern with raised crosswalks

Raised Crosswalk

Table 8. Comparison of Vehicle Speeds at the Treatment and Control Sites.

CITY AND TREATMENT	50TH PERCENTILE SPEED TREATMENT SITE	50TH PERCENTILE SPEED CONTROL SITE	DIFFERENCE IN SPEEDS
Durham, NC – Research Drive Raised crosswalk	33.3 km/h (20.7 mi/h)	39.8 km/h (24.7 mi/h)	6.5 km/h (4.0 mi/h) <i>lower at treatment site</i> SIGNIFICANT ¹
Durham, NC – Towerview Drive Raised crosswalk & overhead flasher	18.5 km/h (11.5 mi/h)	38.4 km/h (23.9 mi/h)	19.3 km/h (12.4 mi/h) <i>lower at treatment site</i> SIGNIFICANT
Montgomery County, MD ² Raised Crosswalk	34.6 km/h (21.5 mi/h)	38.6 km/h (24.0 mi/h)	4.0 km/h (2.5 mi/h) <i>lower at treatment site</i> NOT SIGNIFICANT

¹ Significant at the 0.05 level or better, using a two-tailed test.

² Vehicle speeds in Montgomery County were measured only when the staged pedestrian was present

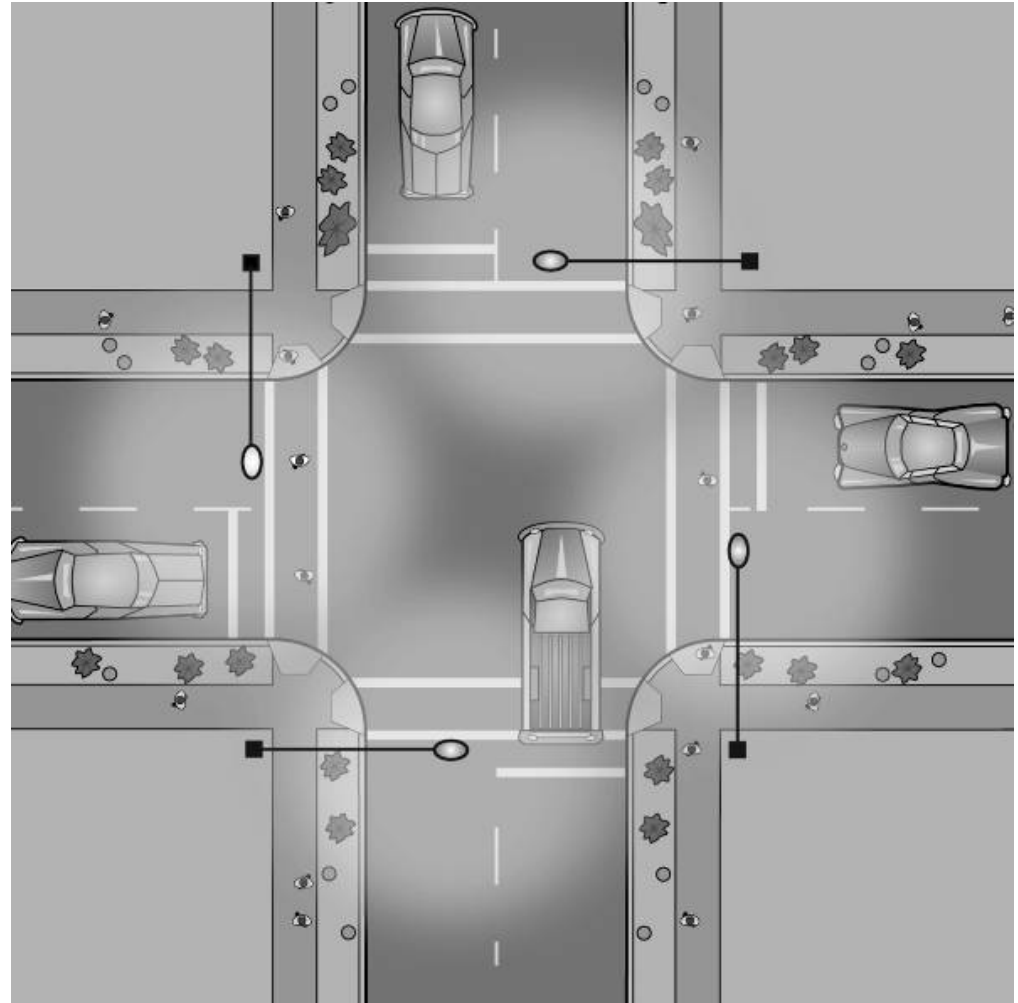
Table 9. Pedestrians for Whom Motorists Stopped to Let Them Cross.

SITE AND TREATMENT	TREATMENT SITE	CONTROL SITE	SIGNIFICANCE
Durham, NC — Towerview Dr Raised crosswalk and overhead flasher	79.2% (159)*	31.4% (35)	• (0.000)
Montgomery County, MD Raised crosswalk	1.2% (169)	1.0% (198)	N

Illumination – Essential For Any Crossing

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- Marked crosswalk?
- ▣ Light it
- Up to 50% of pedestrian crashes occur at night





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Corvallis OR

- Lighting reduces the odds of pedestrian fatalities:
 - ▣ by 42% at midblock locations
 - ▣ by 54% at intersections

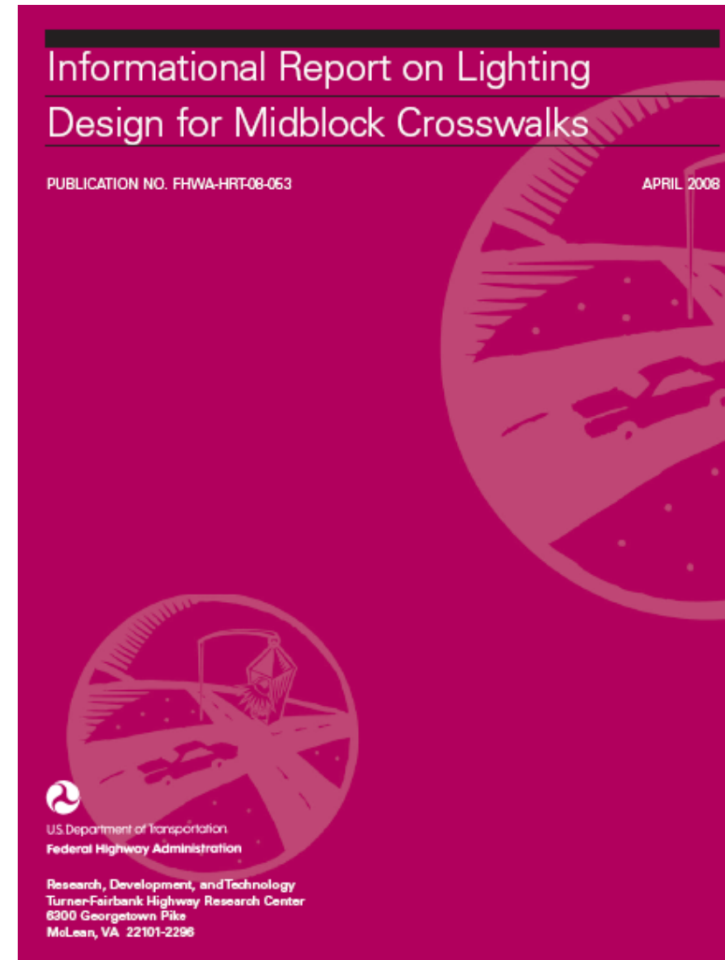


Ped shows up well in well-lit crosswalk

Informational Report on Lighting Design for Midblock Crosswalks

45

- FHWA-HRT-08-053
 - April 2008
 - Available at <http://www.tfhrc.gov/safety/pubs/08053/08053.pdf>



Sample Illustrations from FHWA Report

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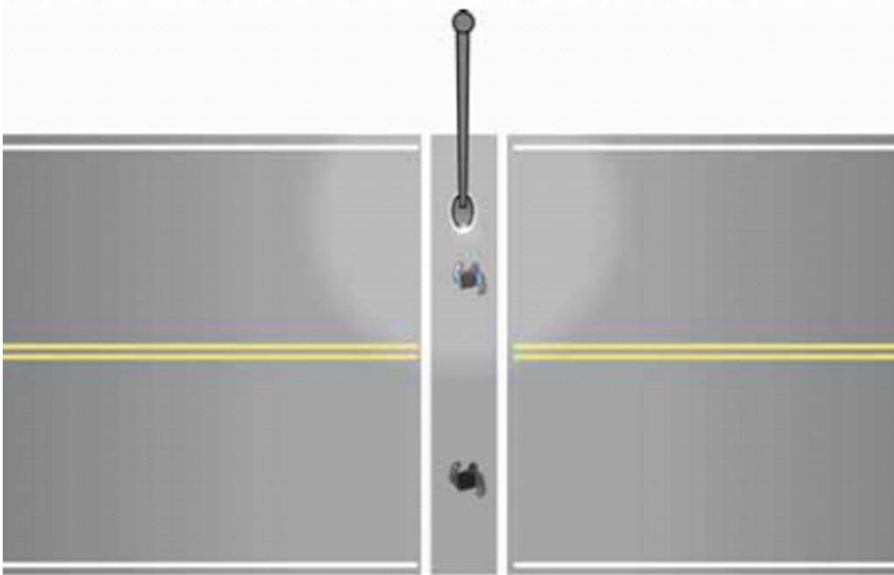


Fig 11. Traditional midblock crosswalk lighting layout

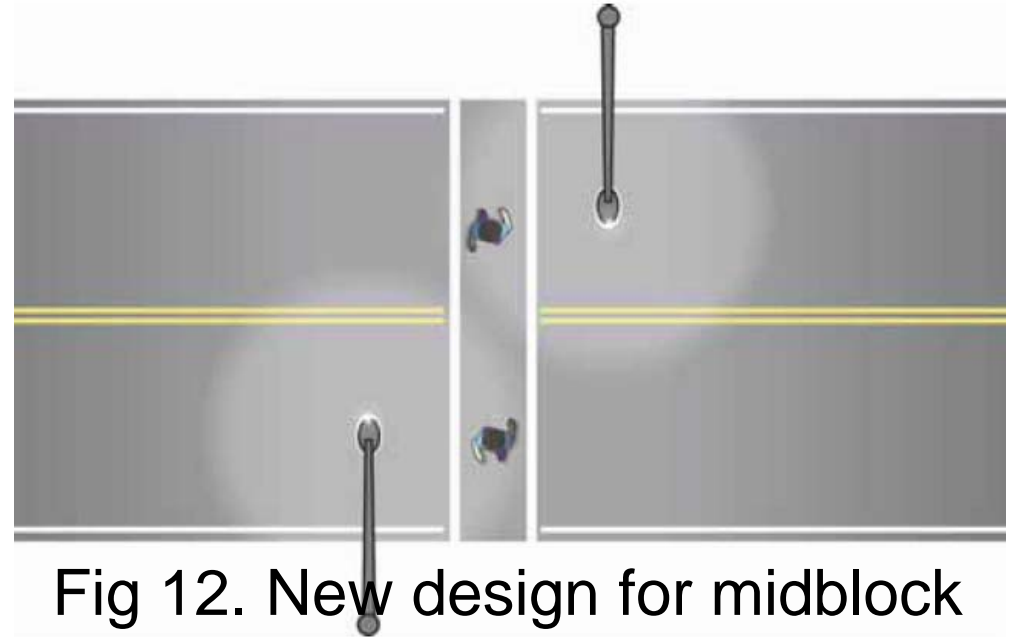


Fig 12. New design for midblock crosswalk lighting layout



Recommended lighting level: 20 lux at 5' above pavement

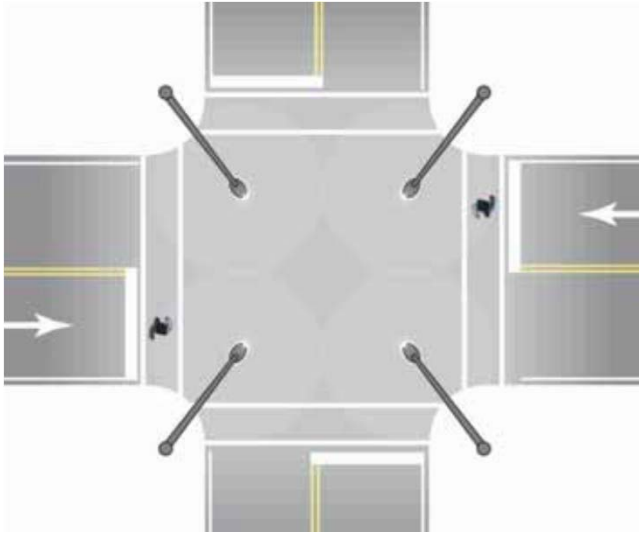


Fig 13. Traditional intersection lighting layout

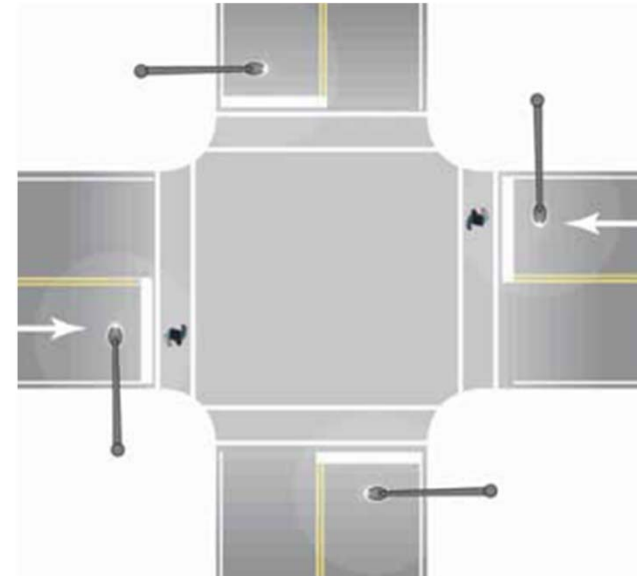


Fig 14. New design for intersection lighting layout for crosswalks.

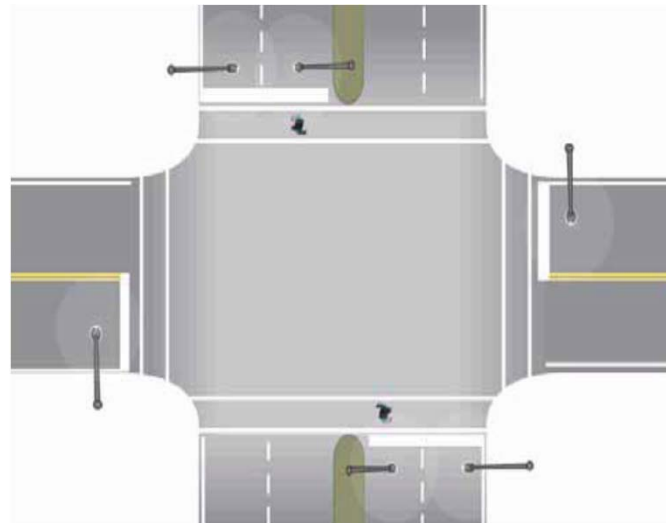


Fig 15. New design for wide roadway intersection lighting layout for crosswalks

Ped crossing signs: old vs. new MUTCD standards



Old



New



Placement



R1-6 R1-6a
MUTCD signs
Yield or Stop
depends on state law

In-street pedestrian crossing signs



In-street signs increase yield rates, especially on slow-speed streets

Pedestrian crossing sign with flashing beacon

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College Station TX



Improves visibility of sign and crosswalk; CMF/CRF unknown

Rectangular Rapid Flash LED Beacon

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Coconut Grove FL

- MUTCD Interim approval July 2008
 - ▣ Must submit a written request to the FHWA
 - ▣ http://mutcd.fhwa.dot.gov/resources/interim_approval/ia11/fhwamemo.htm
- Studies indicate motorist yield rates increased from about 20% to 80%
- Beacon is yellow, rectangular, and has a rapid “wig-wag” flash
- Beacon located between the warning sign and the arrow plaque
- Must be pedestrian activated (pushbutton or passive)



RRFB Video

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Beacons required on the both right side and on the left side or in a median if practical

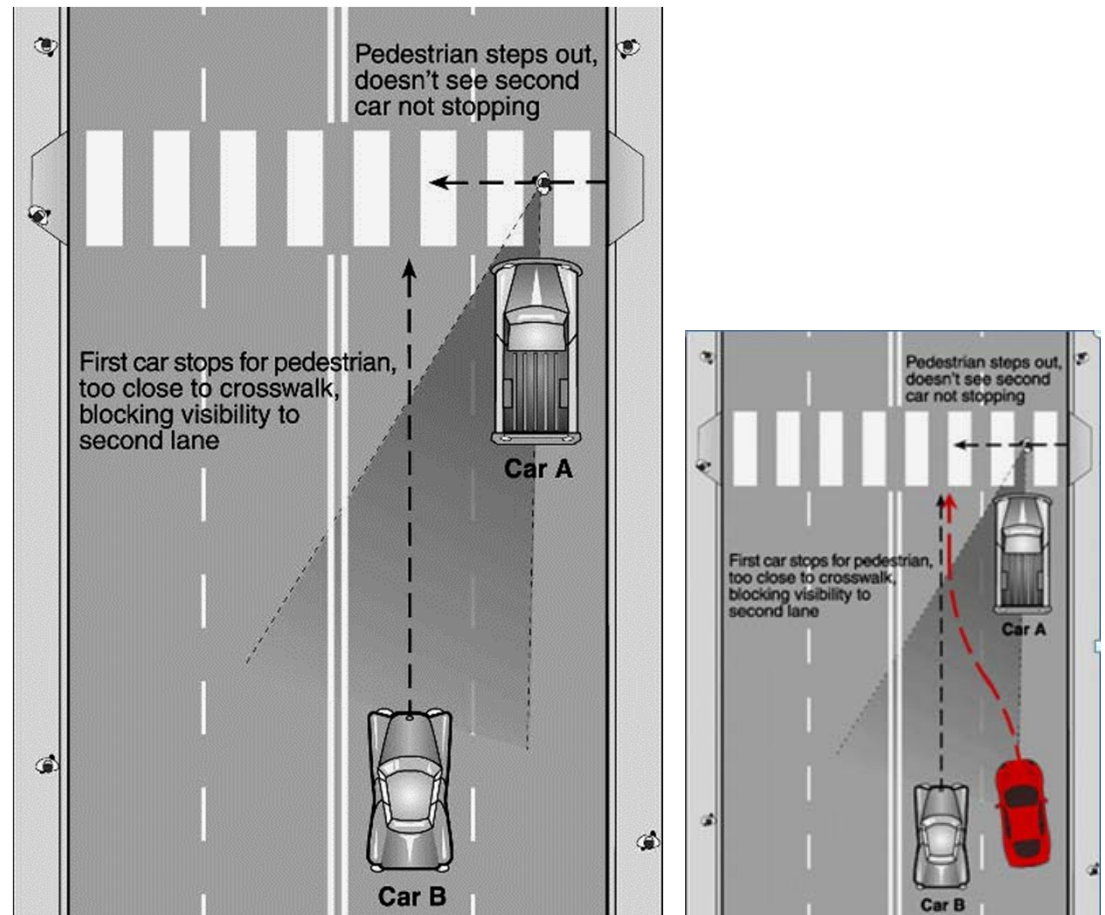
55

Advance Stop or Yield Line: Reduces Multiple-threat Crashes

Multiple Threat Crash Problem

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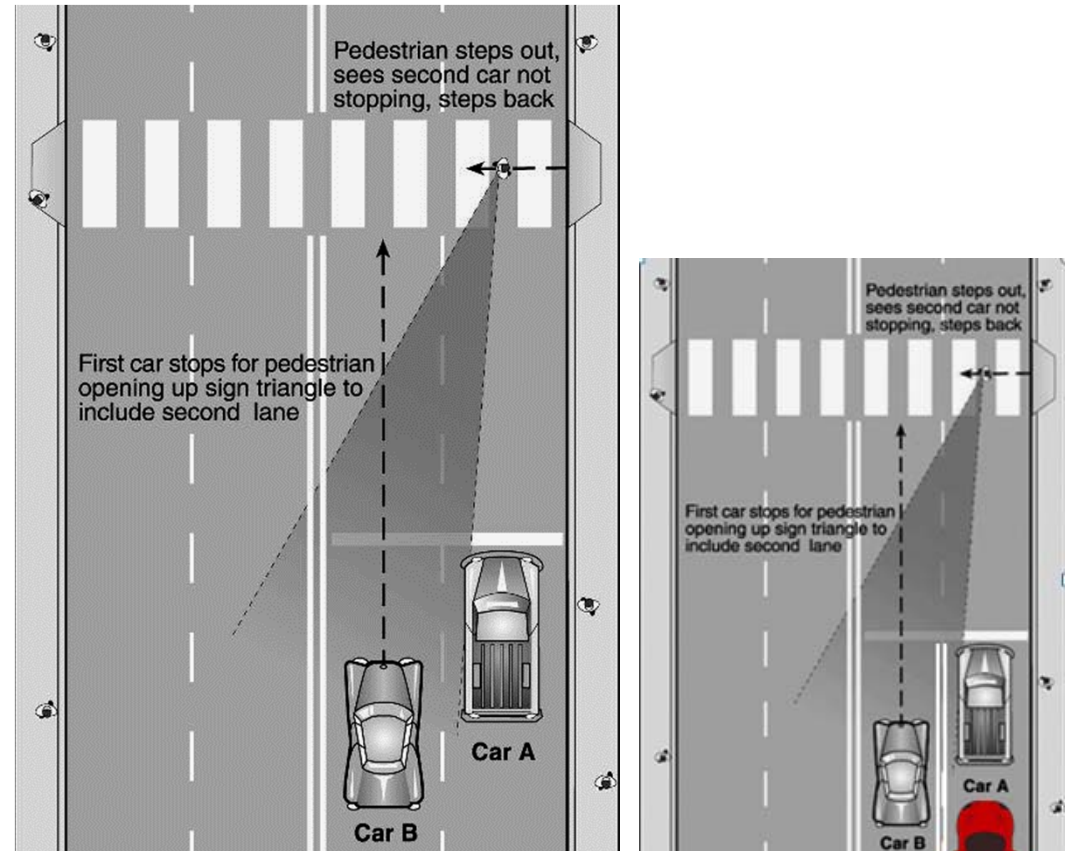
- 1st car stops to let pedestrian cross, blocking sight lines
- 2nd car doesn't stop, hits pedestrian at high speed



Multiple Threat Crash Solution

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- Advance stop or yield line
- 1st car stops further back, opening up sight lines
- 2nd car can be seen by pedestrian



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)



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Milwaukee WI

- Advance yield line (shark's teeth) & sign
- Consider double white lines for no passing

2009 MUTCD Section 3B.16 and Figure 3B-17



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Portland OR

Advance stop line and sign

2009 MUTCD Section 3B.16

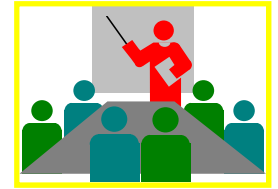


61

Las Vegas NV

- 20' to 50' setback (30' preferred for effectiveness)
- Prohibit parking between line and crosswalk

Marking a Crosswalk Summary



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When is it OK to mark a crosswalk without other treatments on roads with speed limits $<$ or $=$ to 40 mph?

- 2-lane roads
- Multi-lane roads w/ ADT $<$ 12,000 (no median)
- Multi-lane roads w/ADT $<$ 15,000 (median)

How can you increase the effectiveness of marked crosswalks?

- Marked crosswalk: Add median, advance stop line
- Textured crosswalks: Smooth and white is best
- Signs: In road; supplement with striping
- In all cases (nighttime): Illumination!

Raised Medians And Islands

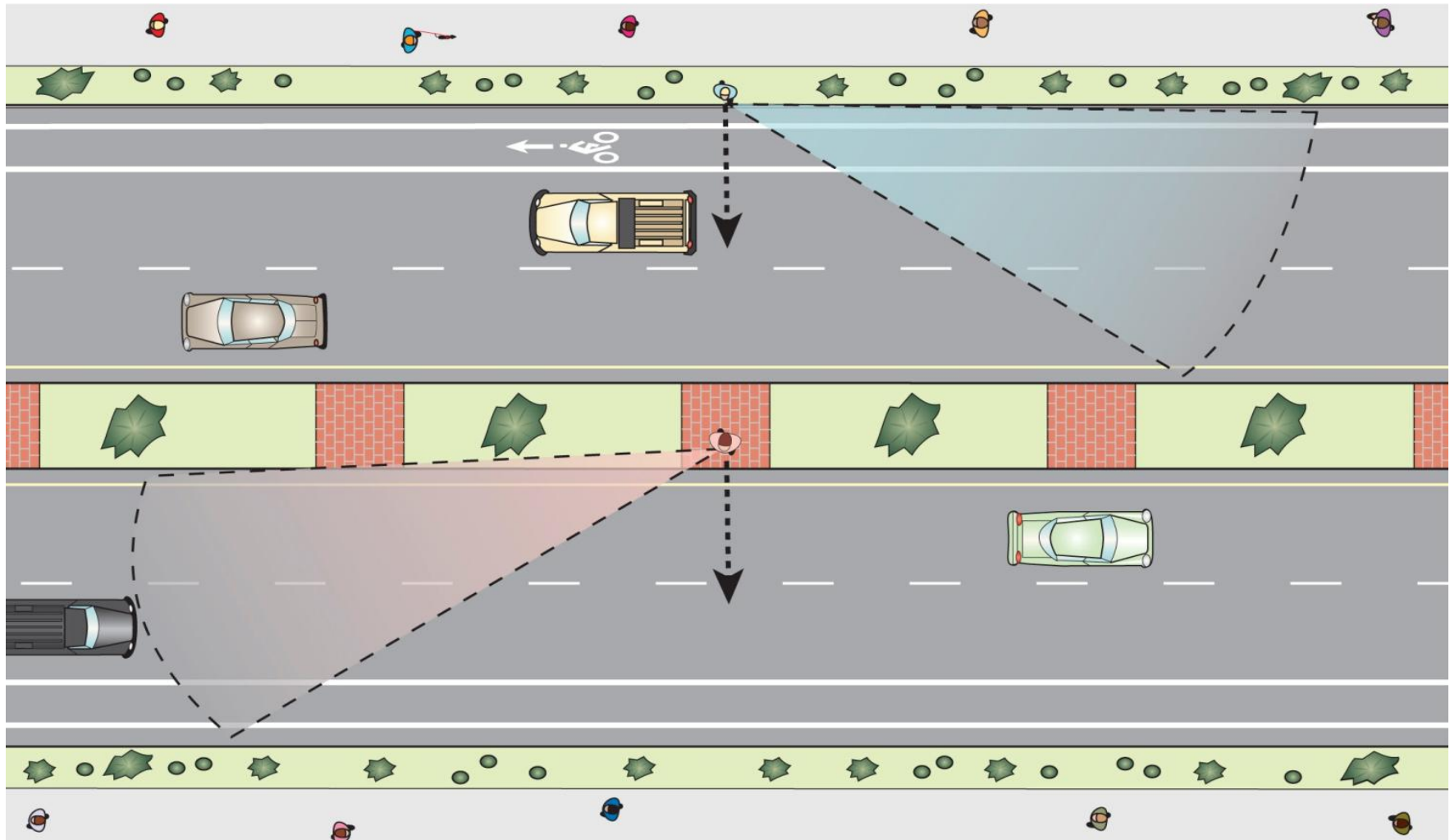
63

Significant crash reductions:

- Marked crosswalks
 - ▣ $CMF = 0.54$ ($CRF = 46\%$)

Unmarked crosswalks

- ▣ $CMF = 0.61$ ($CRF = 39\%$)



- Continuous raised median – basic principle:
- Breaks long complex crossing into two simpler crossings



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Eugene OR

Step 1: look at traffic on left



66

Eugene OR

Step 2: cross first half



67

Eugene OR

Step 3: look at traffic on right



68

Eugene OR

Step 4: cross second half



People figure out on their own how to use a median to cross in two steps



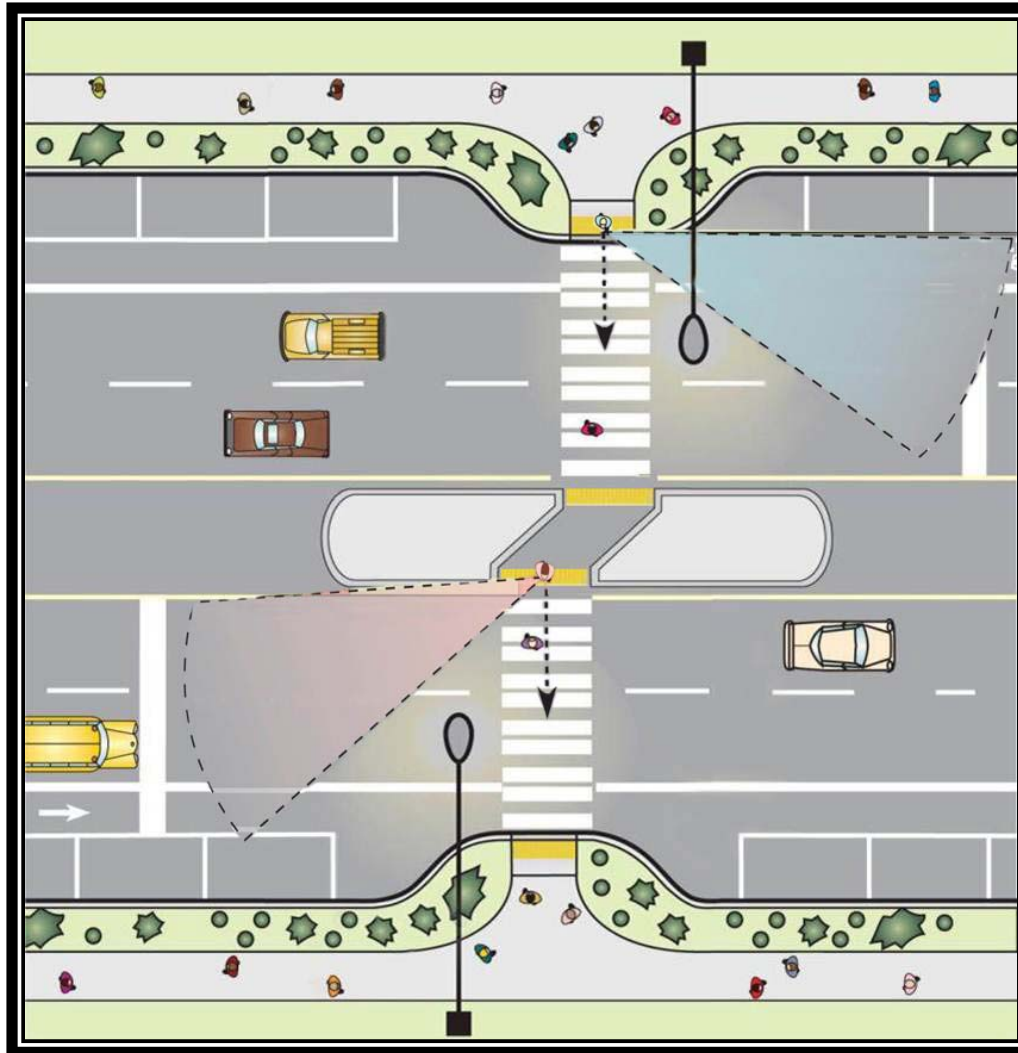
A flush median is not a refuge



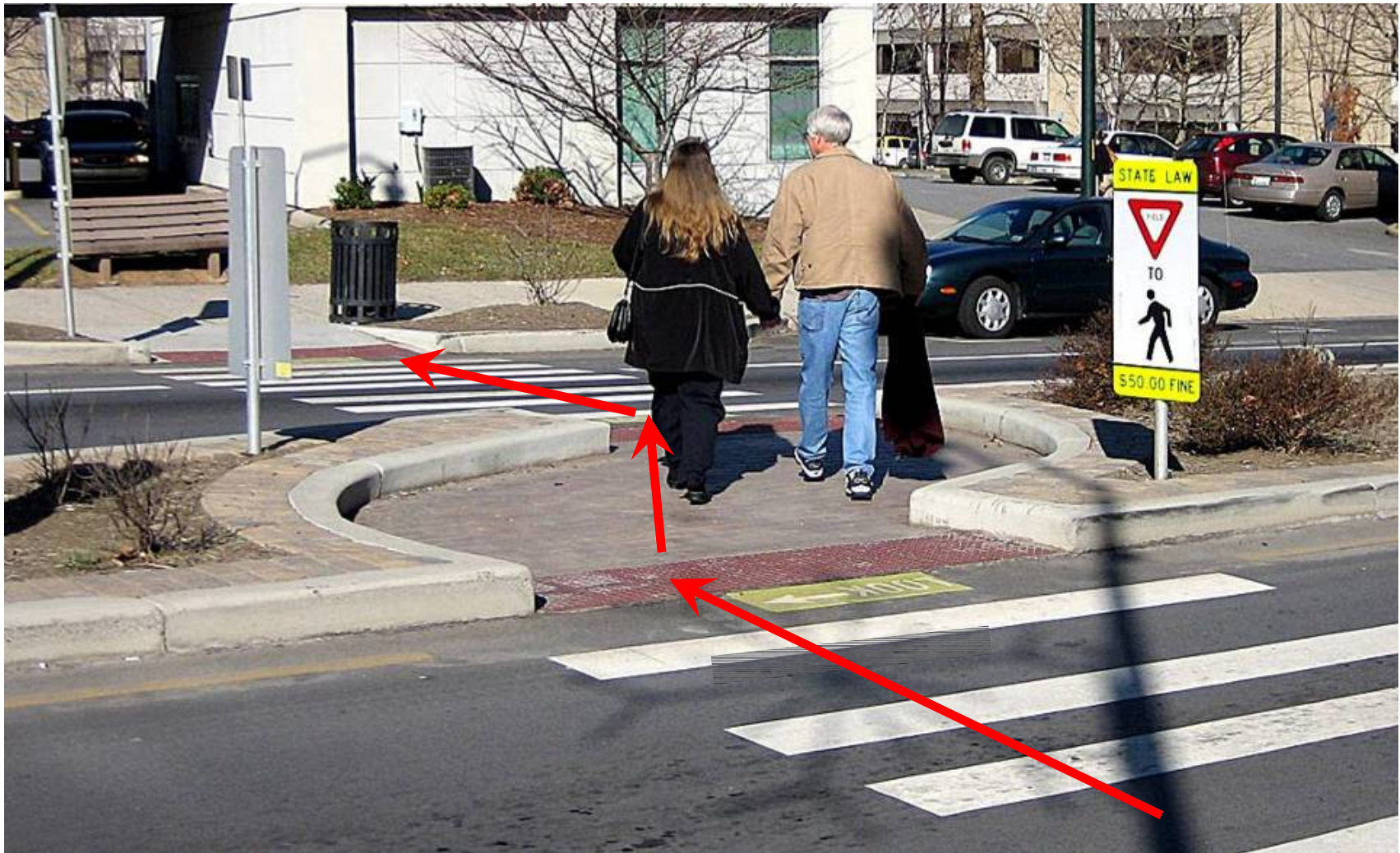
71

Atlanta GA

Add a raised island

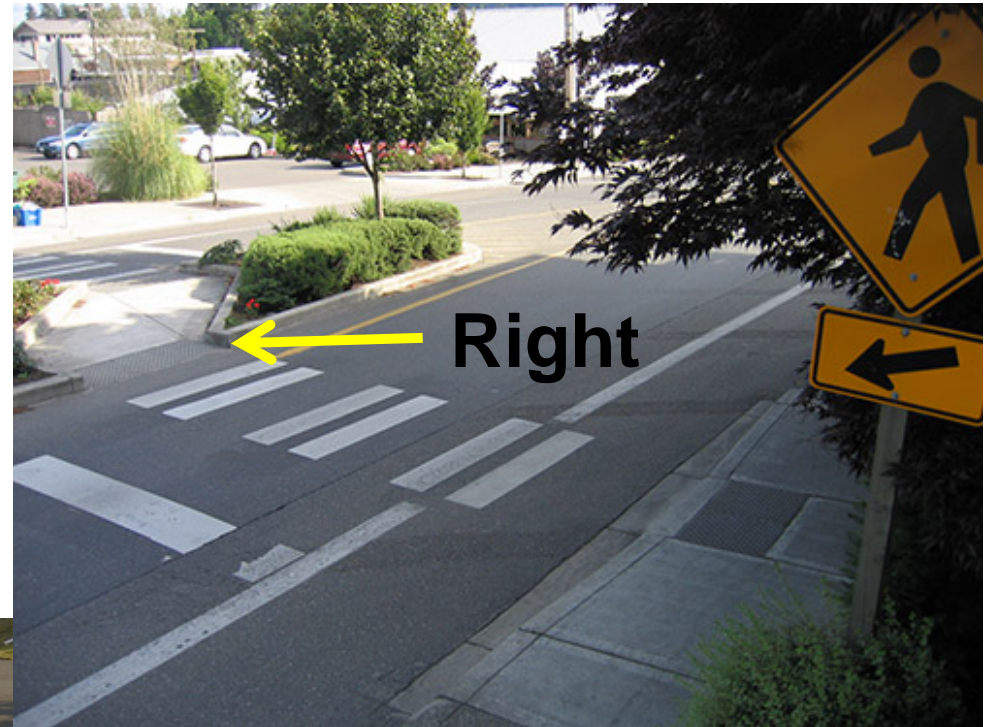


- Crossing island at marked crosswalk - same principle:
- Breaks long complex crossing into two simpler crossings

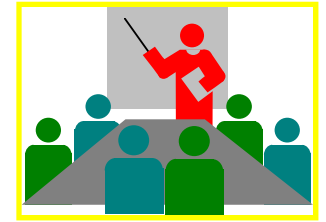


- Option: stagger or angle cut-through so pedestrians face oncoming traffic before 2nd crossing

Angled cut through: Line up ends with crosswalk direction for the blind



Medians:



75

- Why do medians reduce pedestrian crashes?
 - ▣ They reduce crossing distance and break up an otherwise complex task into 2 simpler crossings
- What is the crash reduction factor?
 - ▣ At marked crosswalks $CMF = 0.54$ ($CRF = 46\%$)
 - ▣ At unmarked crosswalks $CMF = 0.61$ ($CRF = 39\%$)

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Pedestrian Signal

MUTCD signal warrants

77

1. Eight-hour vehicle volume
2. Four-hour vehicle volume
3. Peak hour
4. Pedestrian volume*
5. School crossing*
6. Coordinated signal system
7. Crash experience*
8. Roadway network
9. Intersection near a grade (rail) crossing

* = potential ped warrant



Very difficult to meet pedestrian volume warrant

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Honolulu HI

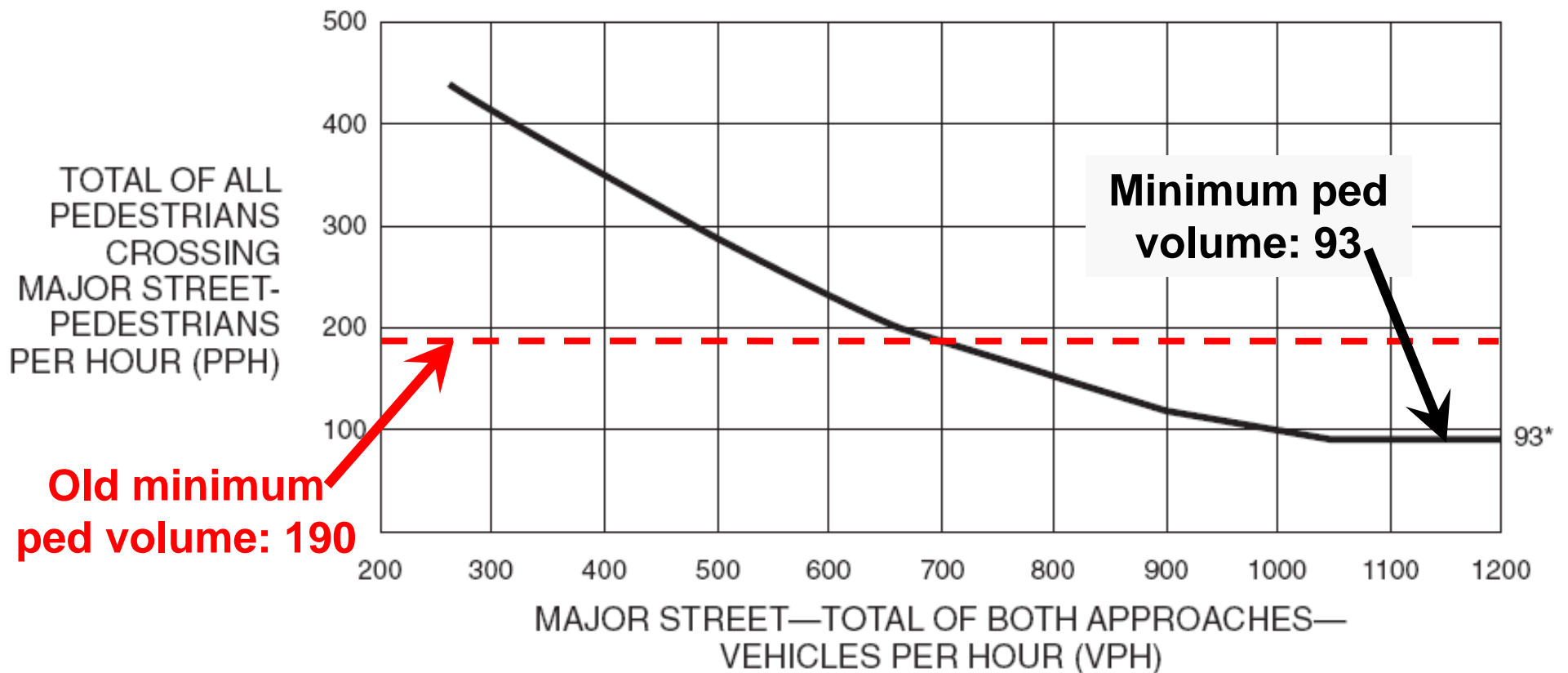


You need many pedestrians

2009 MUTCD Pedestrian Volume Warrant for Speeds > than 35 mph

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Figure 4C-8. Warrant 4, Pedestrian Peak Hour (70% Factor)

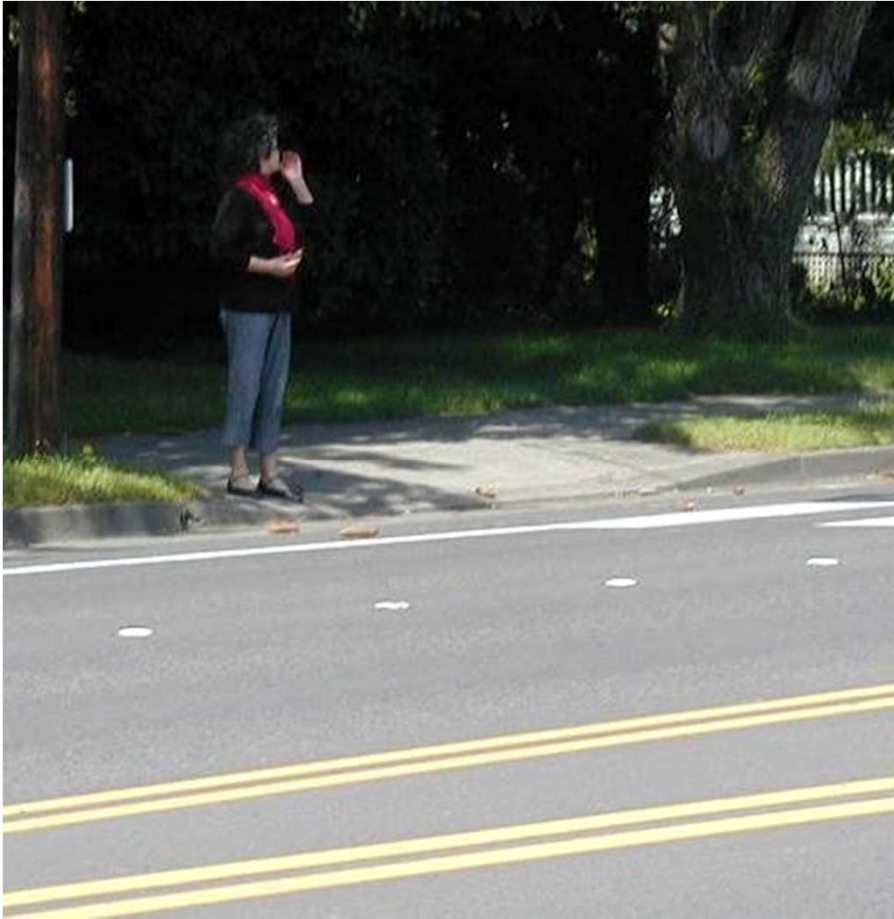




80

Washington DC

- Provide a HOT response
- Otherwise pedestrians won't wait for the light



If wait is too long, pedestrians will seek gaps

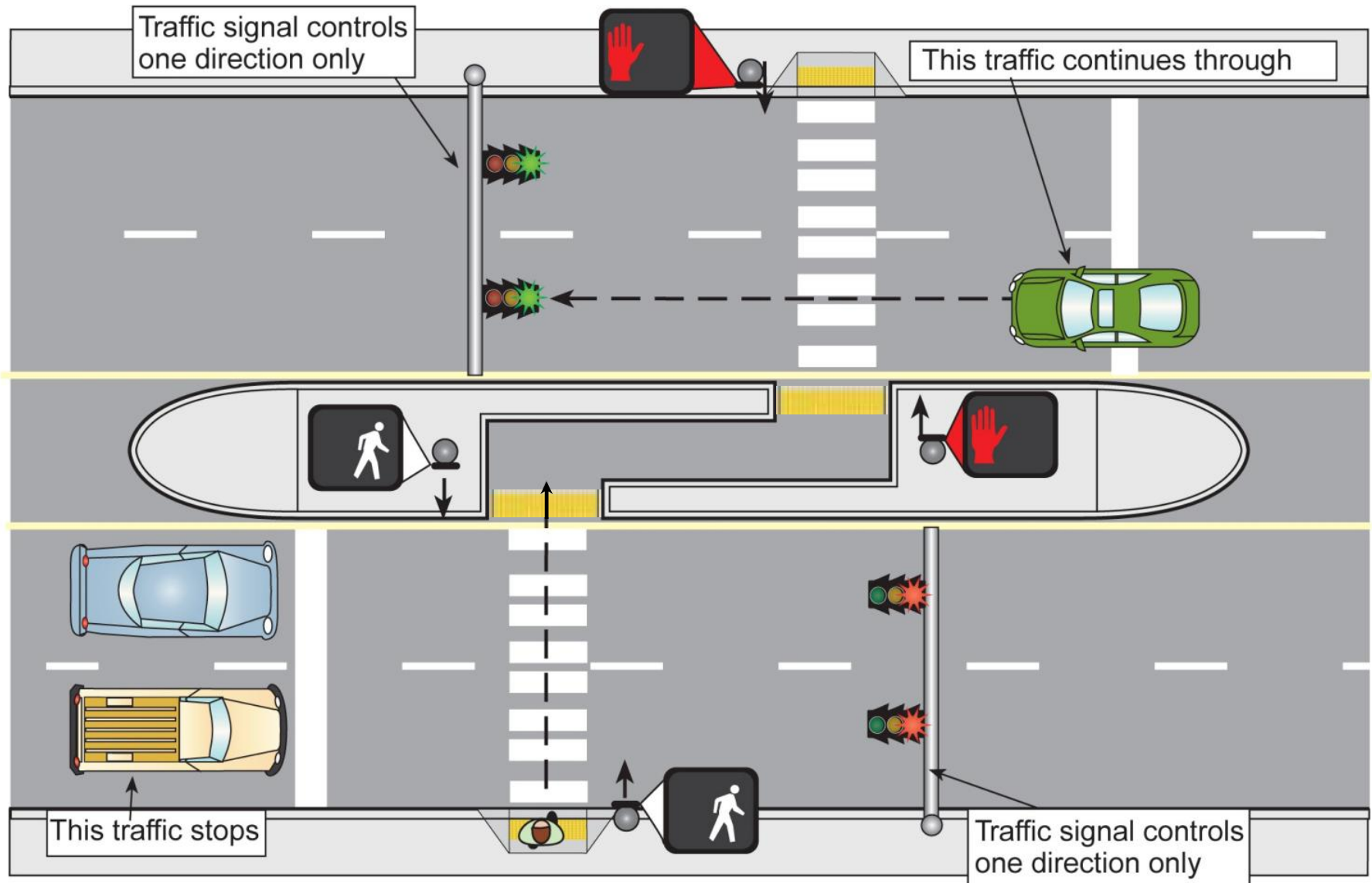


And then traffic waits for no reason

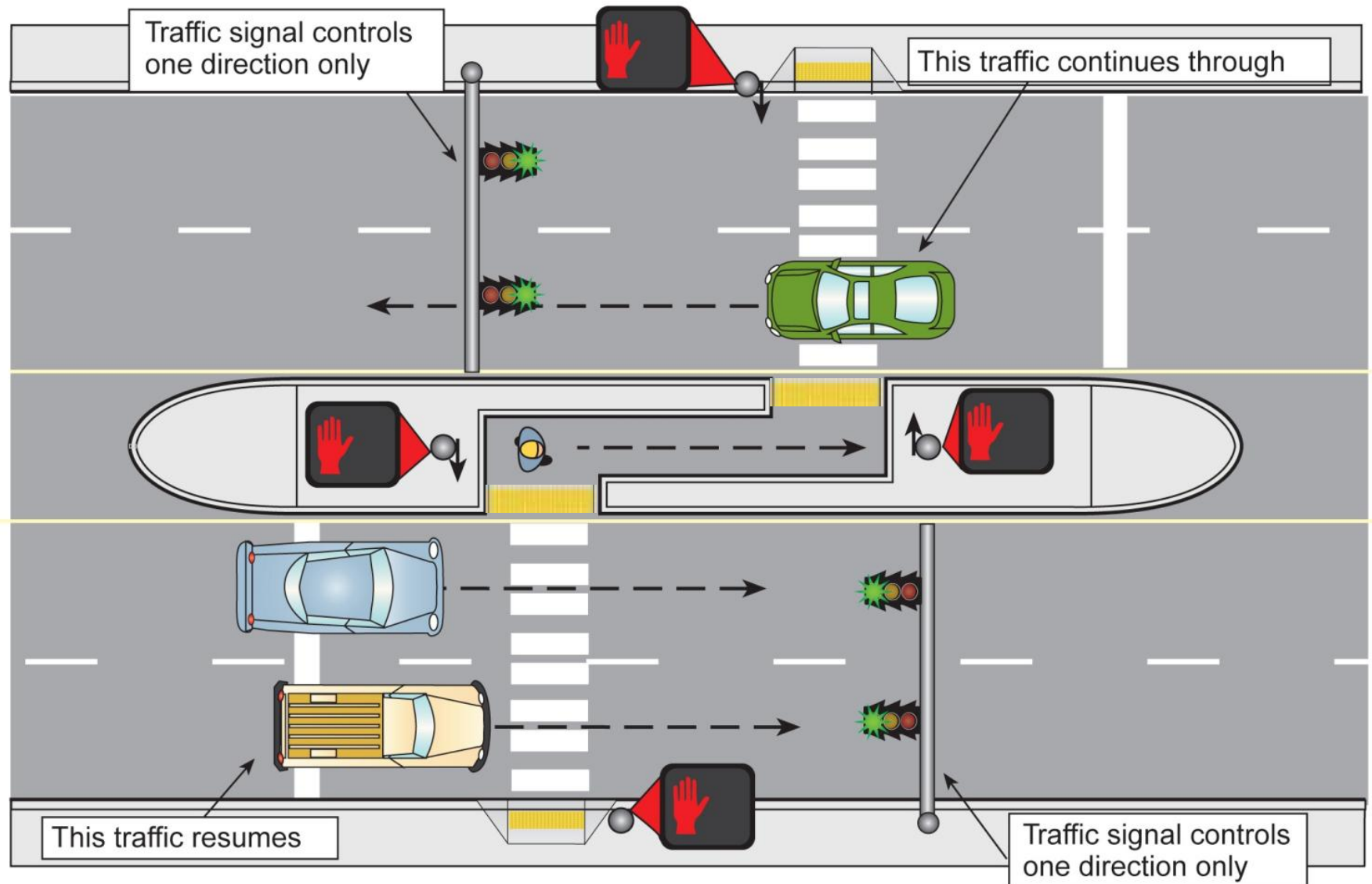
83

Pedestrian Signal

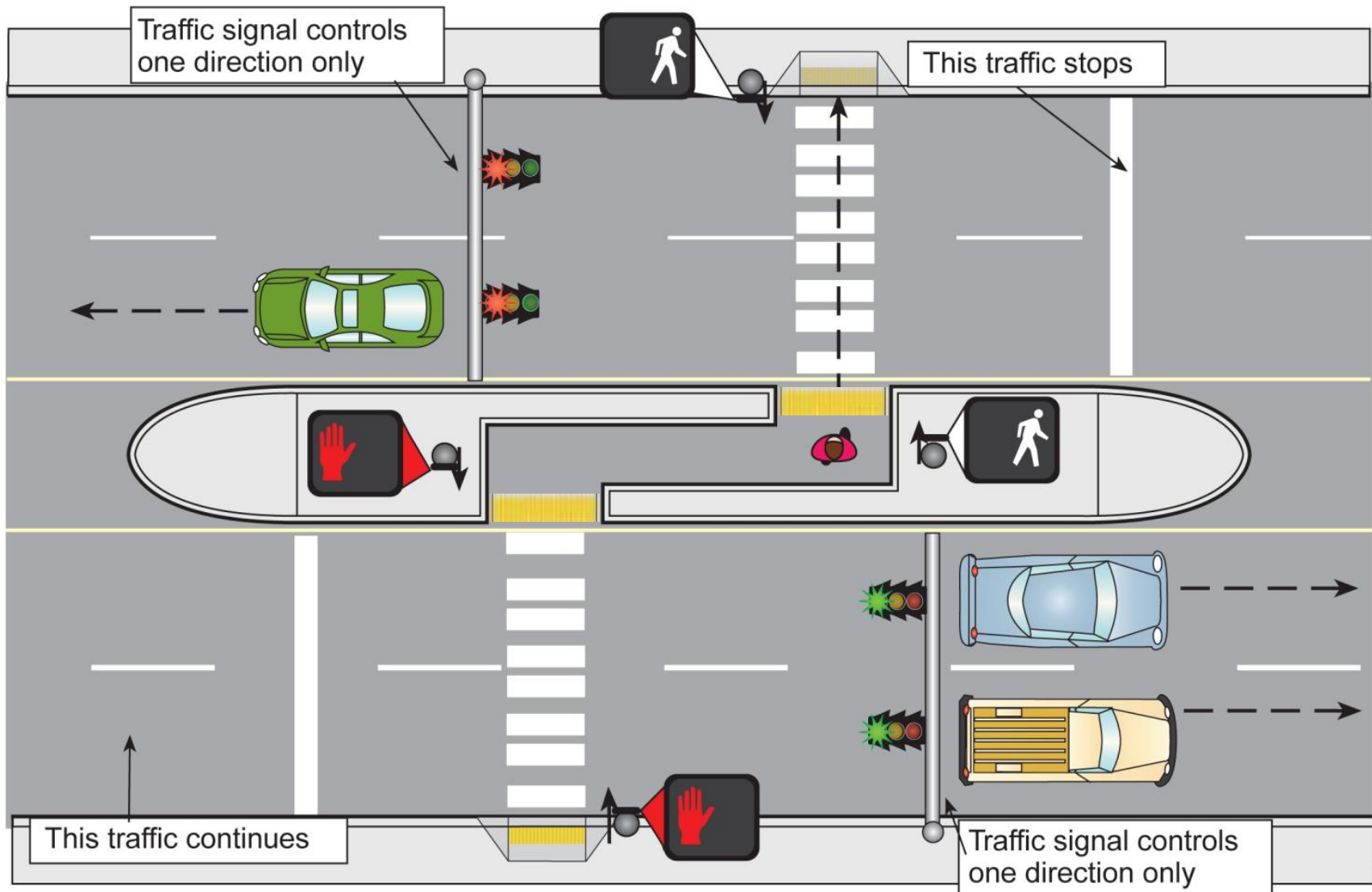
2-stage crossing increases effectiveness
and disrupts traffic less



1. Ped pushes button, waits, crosses to island



2. Ped crosses to island, proceeds to 2nd button



3. Ped on island – pushes button to finish crossing



87

Bellevue WA

Stage 1: Ped stops traffic in one direction



88

Bellevue WA

Stage 1: Ped crosses to median island



89

Bellevue WA

Stage 1 over: Traffic in one direction resumes



90

Bellevue WA

Stage 2: Ped stops traffic in other direction



91

Bellevue WA

Stage 2 over: Traffic resumes



92

Bellevue WA

Detail 1: Requires ped push button on island



93

Bellevue WA

Detail 2: Fences force peds to walk against on-coming traffic

Pedestrian Hybrid Beacon aka “HAWK” (High Intensity Activated Crosswalk)

94

WIDOT



Hybrid Beacon Sequence

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1
**Blank for
drivers**



4
**Steady
red**



2
**Flashing
yellow**



5
Wig-Wag



3
**Steady
yellow**



**Return
to 1**



Pedestrian Hybrid Beacon Effectiveness

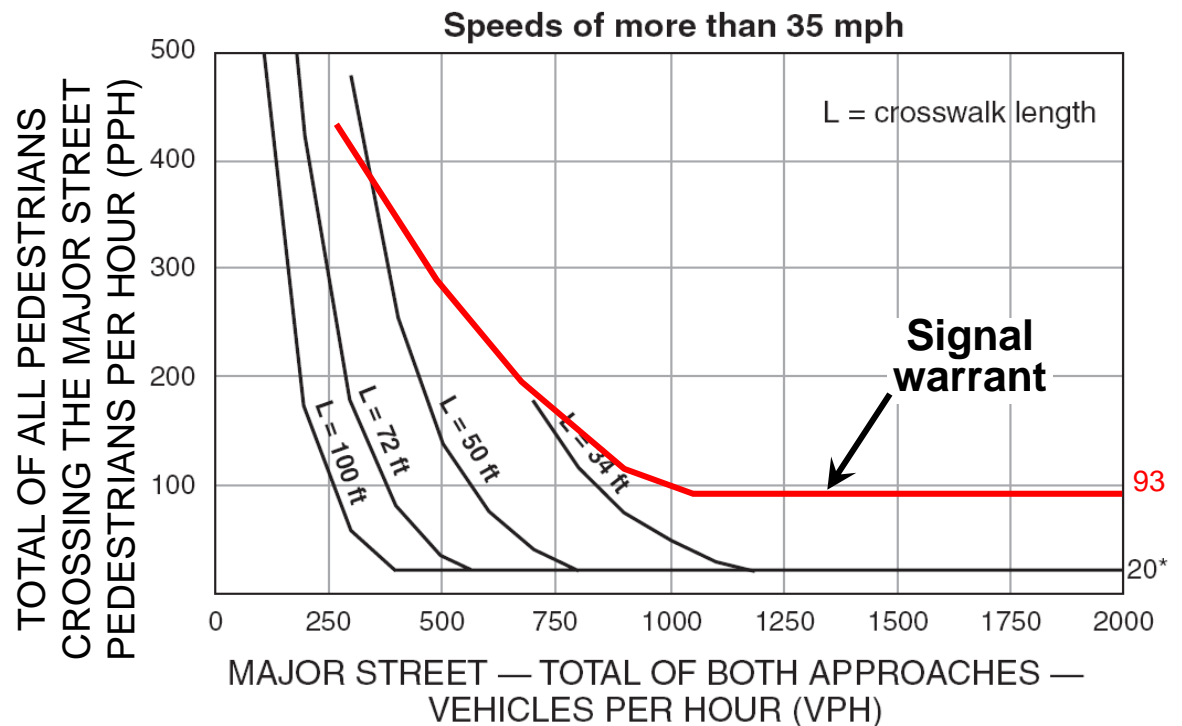
Table 21. Summary of motorist yielding compliance from three sources for red signal or beacon and active when present.

Crossing Treatment	TCRP D-08/NCHRP 3-71 Study						Other Studies		
	Compliance – Staged Pedestrian Crossing			Compliance – General Population Pedestrian Crossing			Compliance – Literature Review (from Table L-1)		
	# of Sites	Range (%)	Average (%)	# of Sites	Range (%)	Average (%)	# of Sites	Range (%)	Average (%)
Red Signal or Beacon									
Midblock Signal	2	97 to 100	99%	4	91 to 98	95%	NA	NA	NA
Half Signal	6	94 to 100	97%	6	96 to 100	98%	1	99	99%
HAWK Signal Beacon	5	94 to 100	97%	5	98 to 100	99%	1	93	93%
Active When Present									
In-Roadway Warning Lights	NA	NA	NA	NA	NA	NA	11	8 to 100	66%
Overhead Flashing Beacon (Pushbutton Activation)	3	29 to 73	47%	4	38 to 62	49%	10	13 to 91	52%
Overhead Flashing Beacon (Passive Activation)	3	25 to 43	31%	3	61 to 73	67%	NA	NA	74%

Excerpts from 2009 MUTCD Chapter 4F For Pedestrian Hybrid Beacons

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- 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



MUTCD Sections 4F.1 and 4F.2

PHB & Intersections

- 2009 MUTCD Section 4F.02, paragraph 04 provides the following Guidance:
 - “When an engineering study finds that installation of a pedestrian hybrid beacon is justified, then the PHB should be installed at least 100 feet from side streets or driveways controlled by STOP or YIELD signs.”
- This MUTCD statement is “Guidance” not a “Standard” and has been recommended by the NCUTCD to be removed.

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Over & Under crossings



100

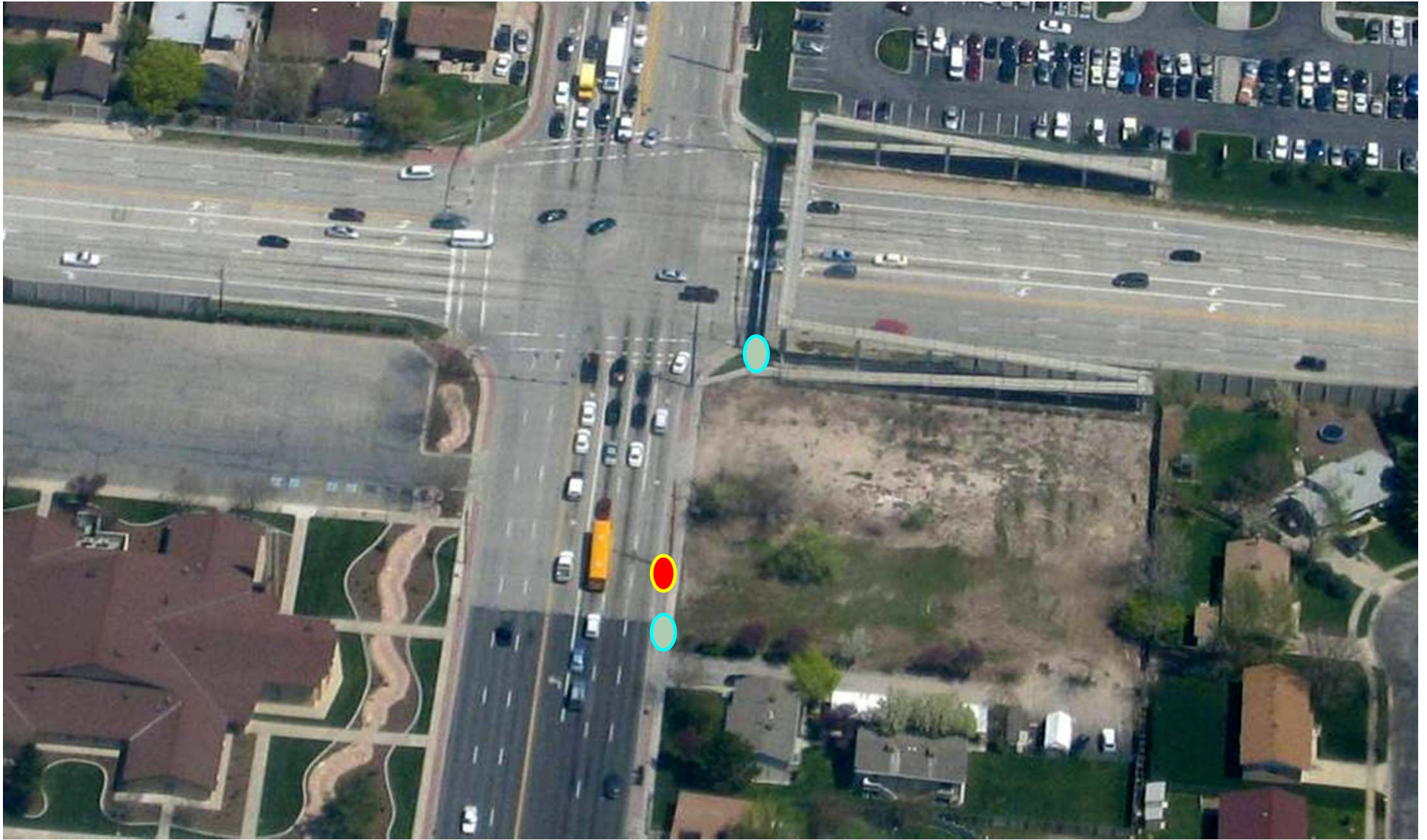
Reno NV

In theory, grade separation = no conflicts



101 Salem OR

- In reality, pedestrians often ignore structures placing themselves in greater danger



Why don't they get used? Longer travel distance



103

Reno NV

Sometimes fences are needed to direct users

Grade separation is more useful for purposes beyond simply crossing from sidewalk to sidewalk



To connect buildings



To connect land uses



To cross freeways



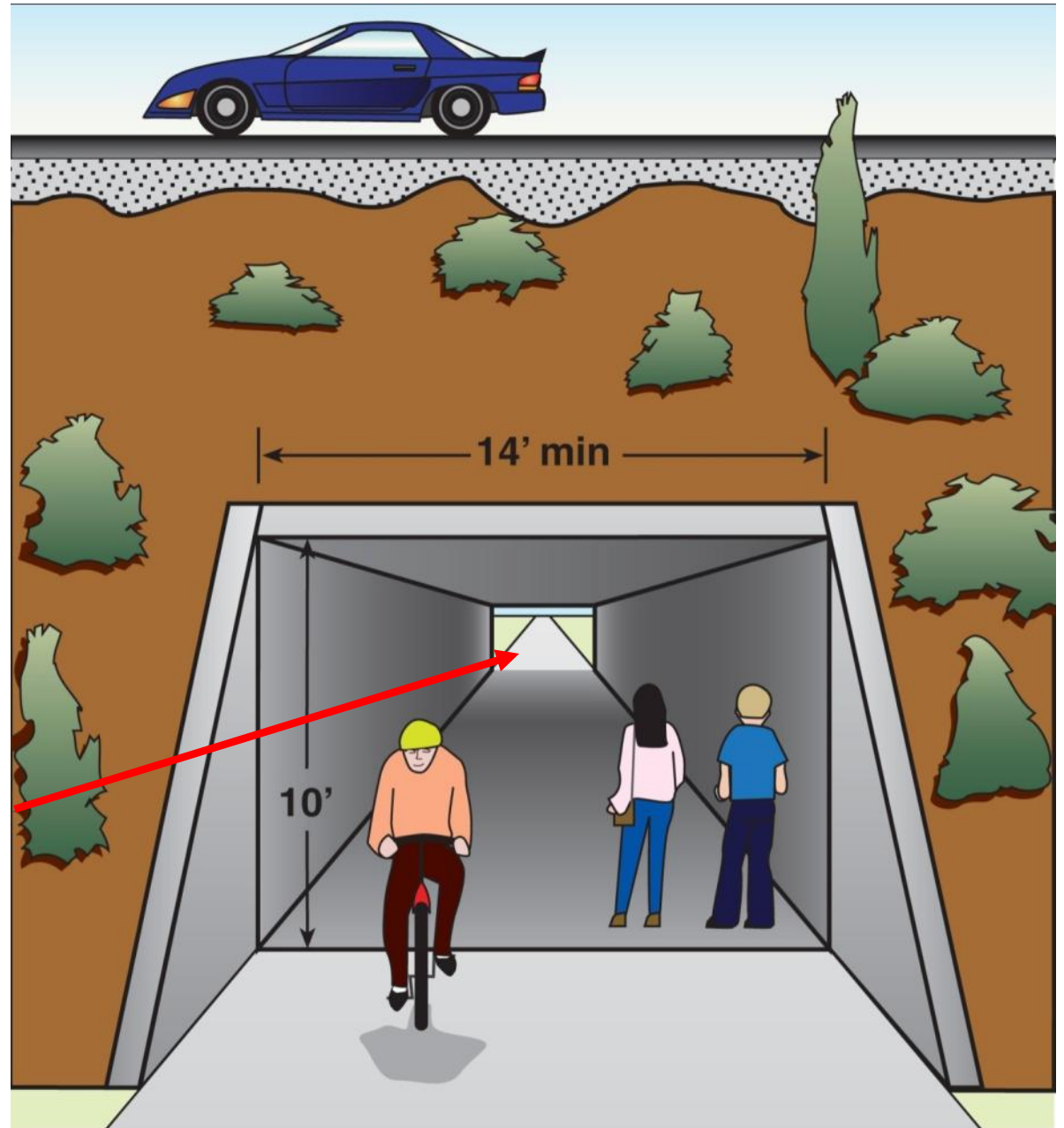
Light rail stations

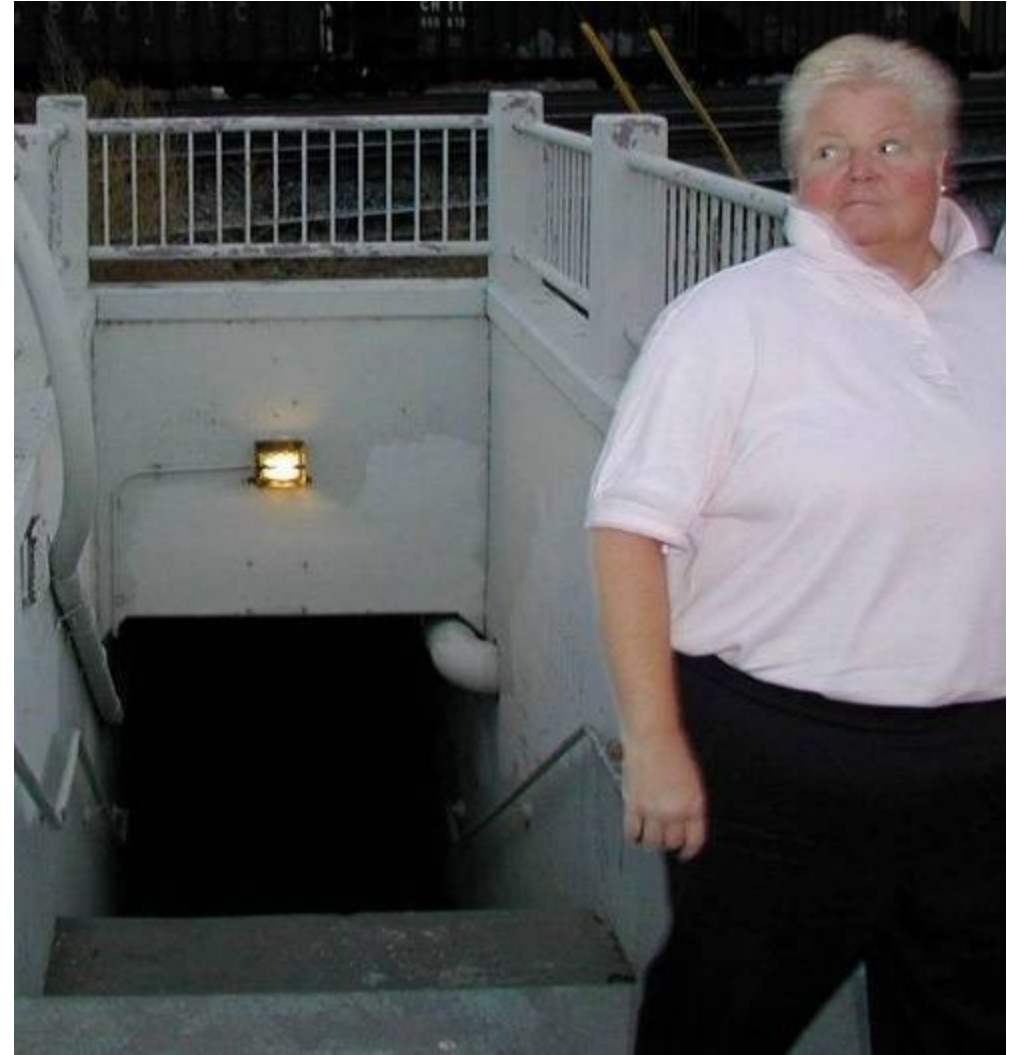


- Overcrossings are expensive because of their height, which requires long ramps

**Undercrossings
require generous
dimensions to be
attractive: security
is the main issue**

**Good design practice:
Users must see light
at the end of the tunnel**





Undercrossing must not intimidate potential user



Undercrossings work best if roadway is elevated, even if it is just a small amount



109

Boulder CO

Elevated roadway allows open, airy undercrossing



110

Boulder, CO

Undercrossings work best if well lit & attractive

Over/undercrossings



111

- Why are they not effective for street crossings?
 - They add out-of-direction travel
- When are they useful?
 - To connect land uses separated by a roadway
- How can you increase their effectiveness?
 - By providing a direct route
 - By providing security

Crossing treatments cost comparison:

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		Effectiveness
Signing	\$500 – 1,000	*
High visibility markings	\$2,000 – 15,000	**
Advance stop or yield line	\$1,000 – 2,000	****
Illumination	\$5,000 – 15,000	****
Median Islands	\$15,000 – 90,000	****
Signals (including HAWK)	\$75,000 – 400,000	***
Over/undercrossings	\$1,000,000 – 4,000,000	*
Proper location	“Priceless”	*****

Case Studies

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- These case studies show before and after pictures of locations where agencies developed projects specifically to enhance pedestrian safety.
- Some of these examples were done based on this workshop.



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- St. Petersburg, FL – 4th Street North (US Hwy. 92)
- 3/4-mile signal spacing; No existing marked crosswalks between signals



115

St. Petersburg, FL

Before: View from near Sunken Gardens entrance



116

St. Petersburg, FL

After: Raised median, Signs with rapid flash beacons, Advance yield lines, High-visibility marked crosswalk



117

Phoenix, AZ – W. Van Buren Street. Before: 1/2-mile signal spacing; high-volume, high-speed; marked crosswalks at unsignalized intersections



118

Phoenix, AZ

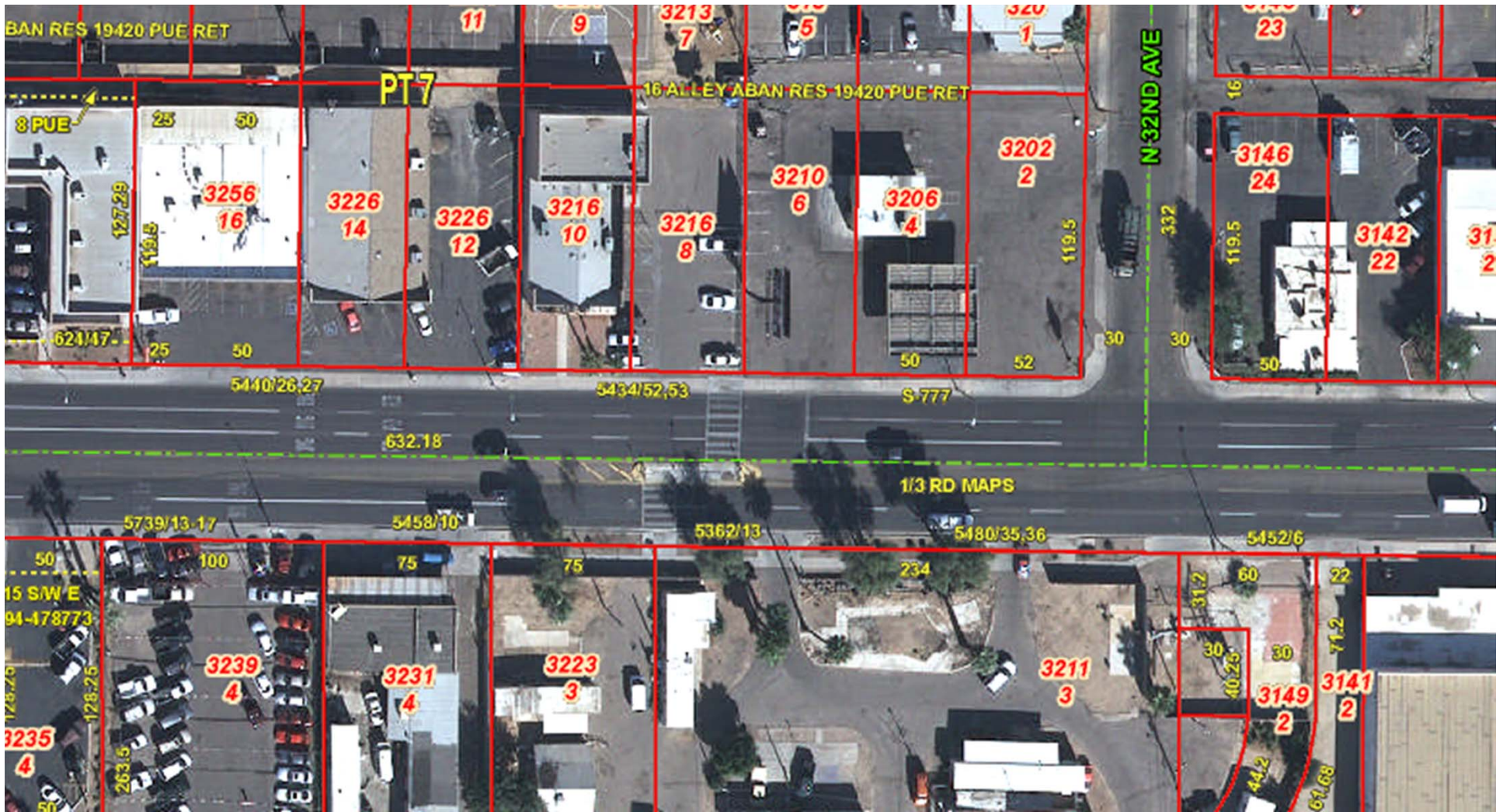
Before: No frills marked crosswalk at intersection



119

Phoenix, AZ

Before: Challenging 6-lane crossing at Community Center



After: Marked crosswalk moved to midblock location near Community Center; Raised median with stagger; advance stop lines



121

Phoenix, AZ

After: Raised median with stagger, Advance stop lines (not visible), Location near destination

Learning outcomes: Street Crossings

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- You should now be able to:
- Identify which crossing techniques are appropriate
- To ensure oft-requested solutions (crosswalks, signals, ped bridges) are effective

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Questions?