Pedestrian & Bicycle Safety Innovations & Applications

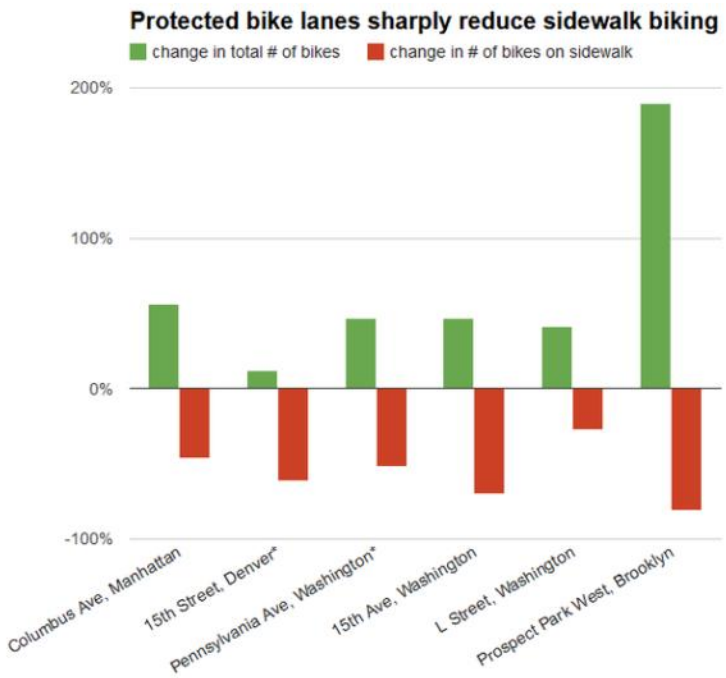
County Engineers Association of Maryland
Spring, 2017 Conference

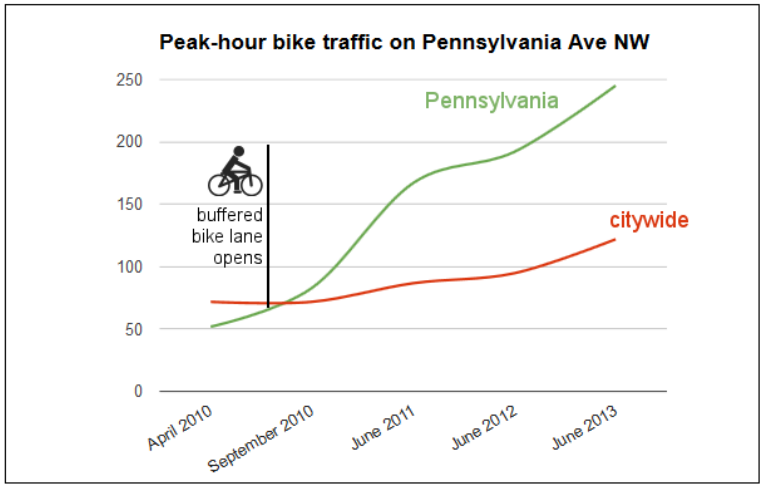
May 25, 2017

George Branyan
Pedestrian Program Coordinator
District Department of Transportation

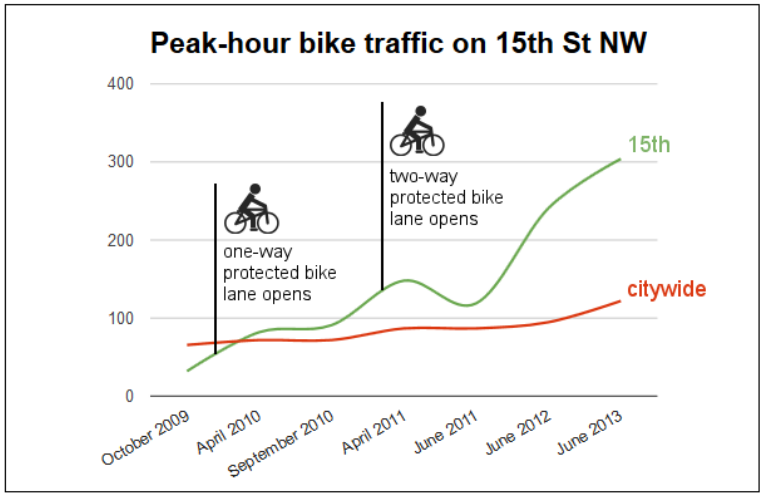
Why *protected* bike lanes?

- Safety
- Perception and popularity
- Benefits to pedestrians and neighbors
- Benefits to drivers





Peak-hour bike count on Pennsylvania between 6th and 7th streets. Source: DDOT.



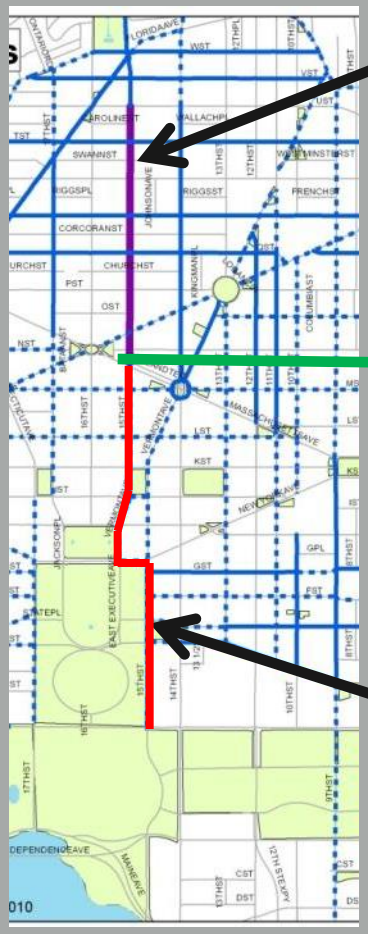
Peak-hour bike count on 15th between T and Swann streets.

Credit: People for Bikes, using DDOT data

15th Street NW

- The first physically separated bike lanes in the City
- Two-way cycle track
- Protected by Parking Lane

15th Street, NW Cycle Track



Two-way for Bikes

Residential

One Way North for Cars

Two Way for Cars

Downtown CBD

Two-way for Bikes

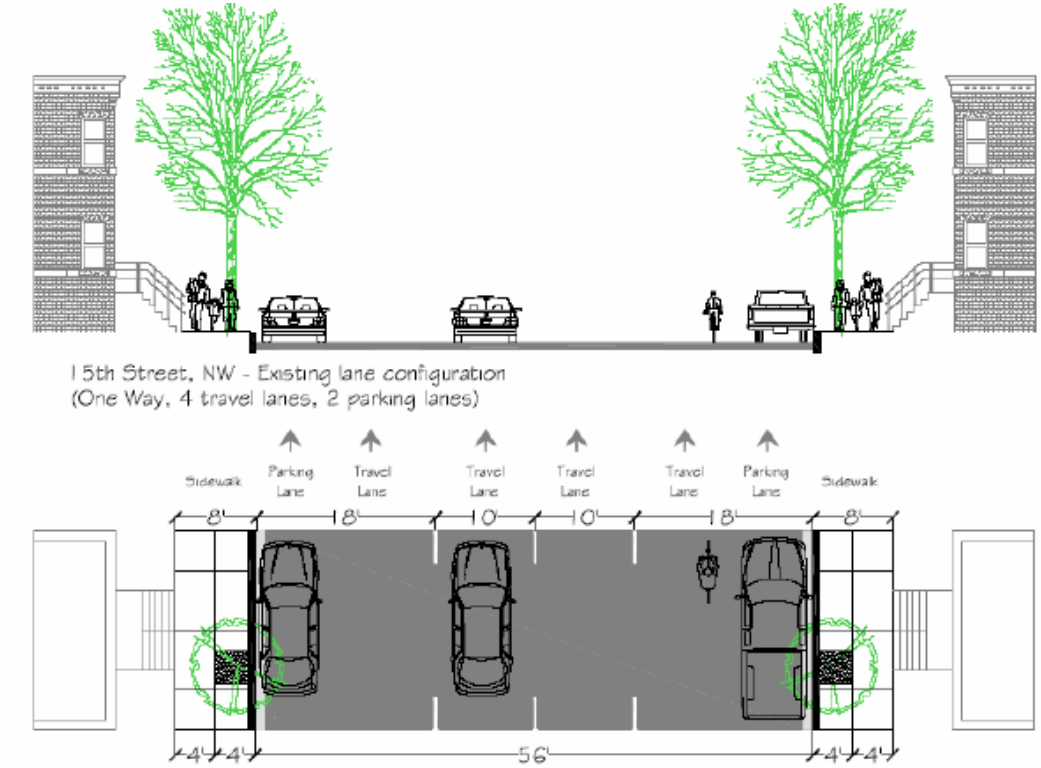
15th Street Before

North Half

- 4 lanes 1-way North
- Residential Neighborhood
- Concerns of safety, traffic speeds
  - Posted speed 25
  - 85th Percentile between 36-45 mph
- Excess capacity
  - 6 to 12,000 ADT

South Half

- 6 to 7 lanes, 2-way
- Downtown



15th St. After

North Half

- Removed 1 NB auto lane
- Protected left-turns
- LOS drop of one letter grade at most intersections

South Half

- Removed 1 auto lane

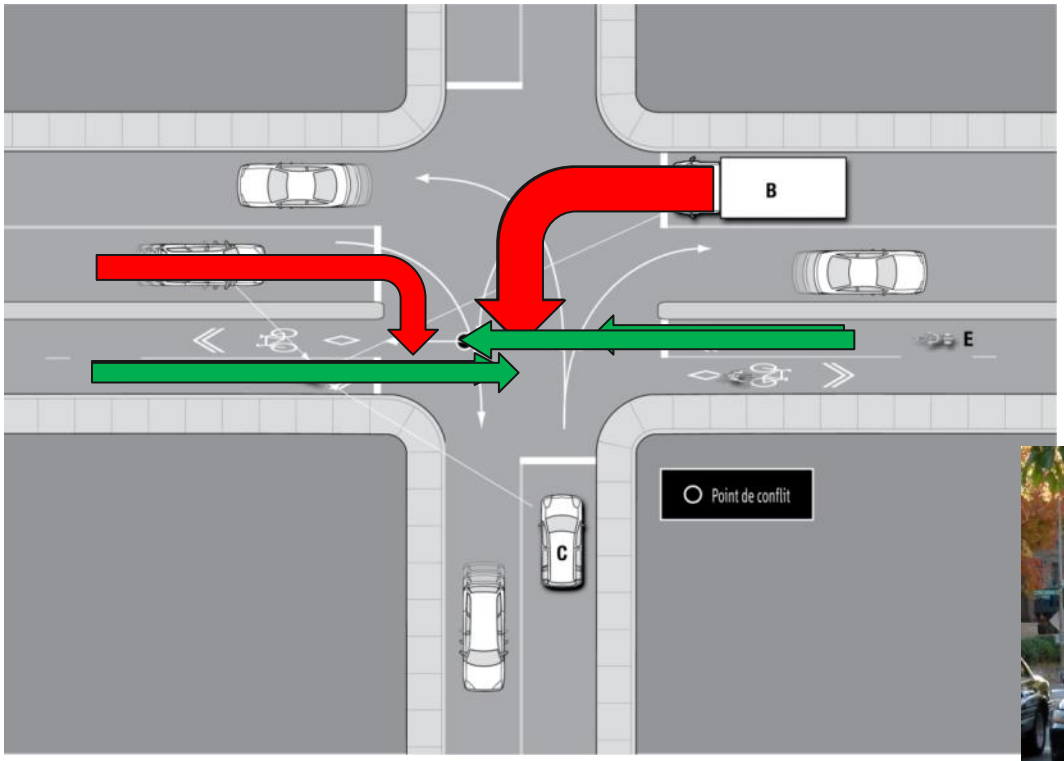
One Way North

Residential

CBD

Two Way

Signalization Challenges of Bidirectional Cycletracks



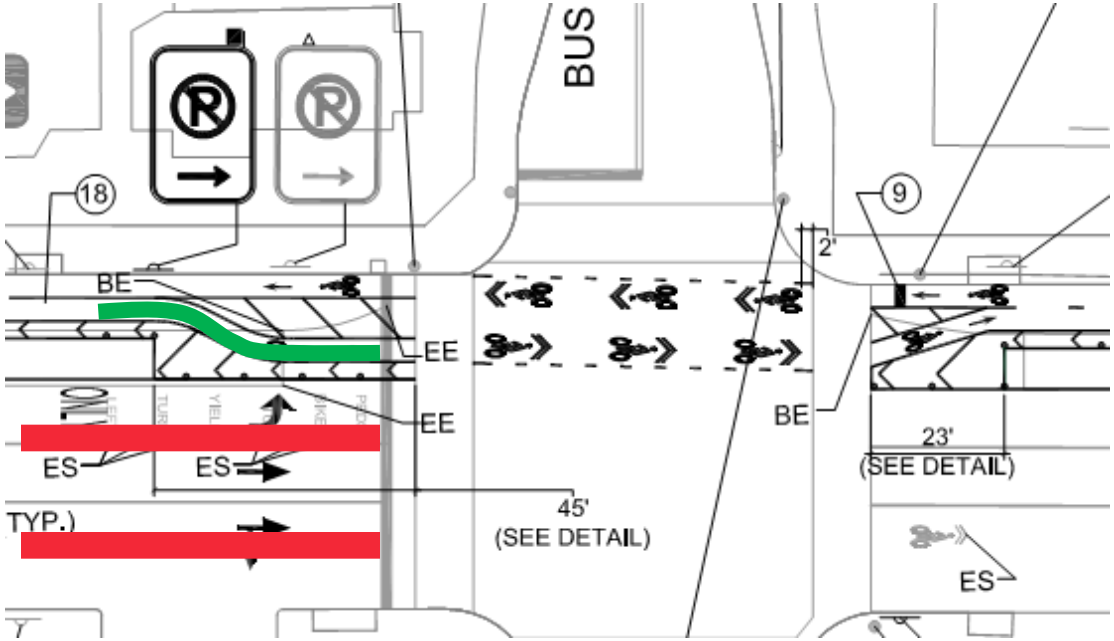
15th St has 46 Intersections

- 21 signal control
- 6 uncontrolled minor streets
- 4 parking garage drives
- 1 hotel driveway
- 11 alleys
- 3 residential driveways

Same direction bicyclist crashes with left turning vehicles is the primary danger where utilizing two way roadway and cycle track designs…

Controlled Intersection. Left Turn Conflict Mitigation, one-way section

- Separate phasing
  - Left arrow/lane
  - Leading bike/ped phase
- Parking restriction
  - Bike SSD 50 feet
- Chicane bike approach designed for 10 mph
  - Shifts cyclist to line of sight of approaching motorists
  - Flex post keep cars in lane
- No color in bike xwalk



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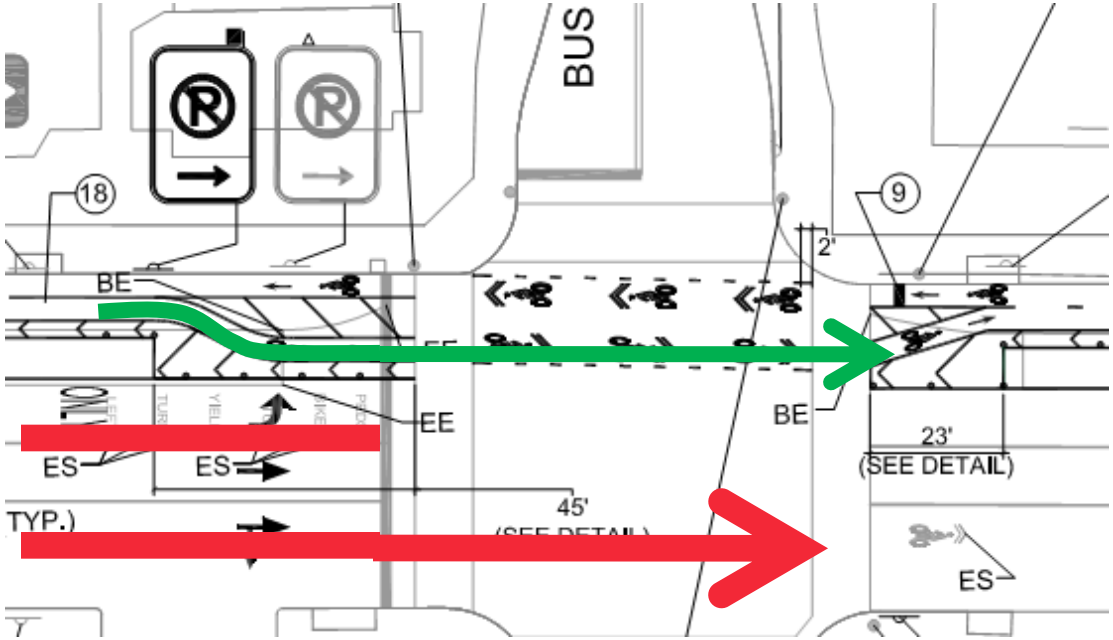

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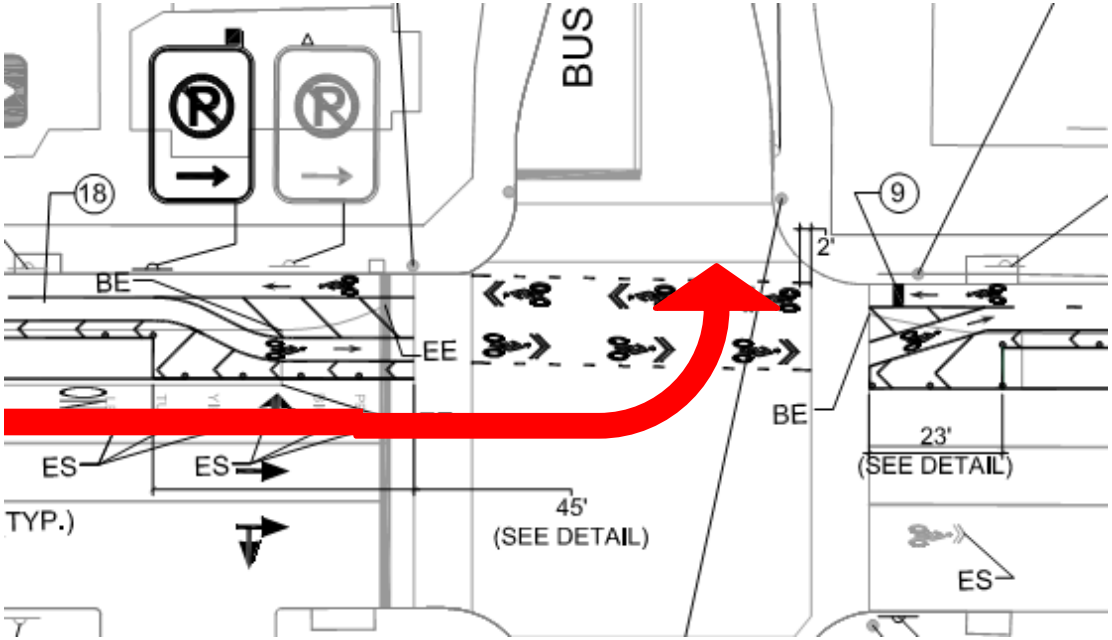
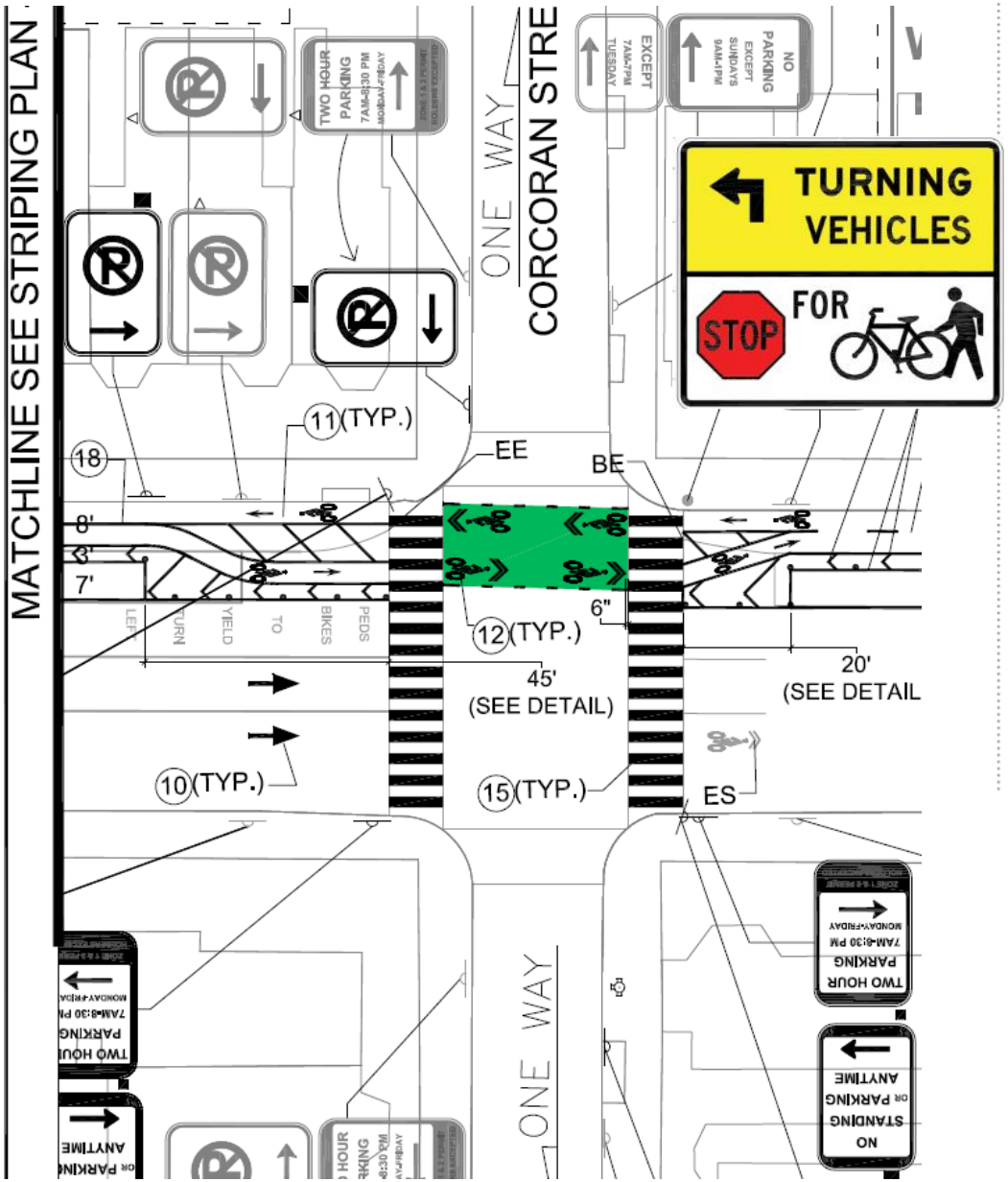


Uncontrolled Intersection Mitigations

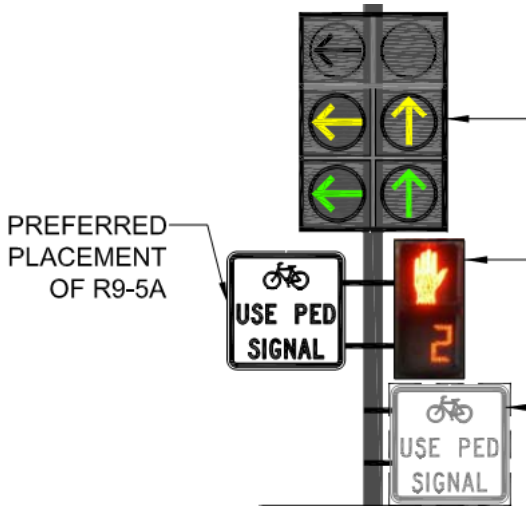
- Parking restriction on approach
- Chicane cycle track approaching conflict
- Flex posts up to crosswalk
- Bike symbols within conflict zone
- Signs

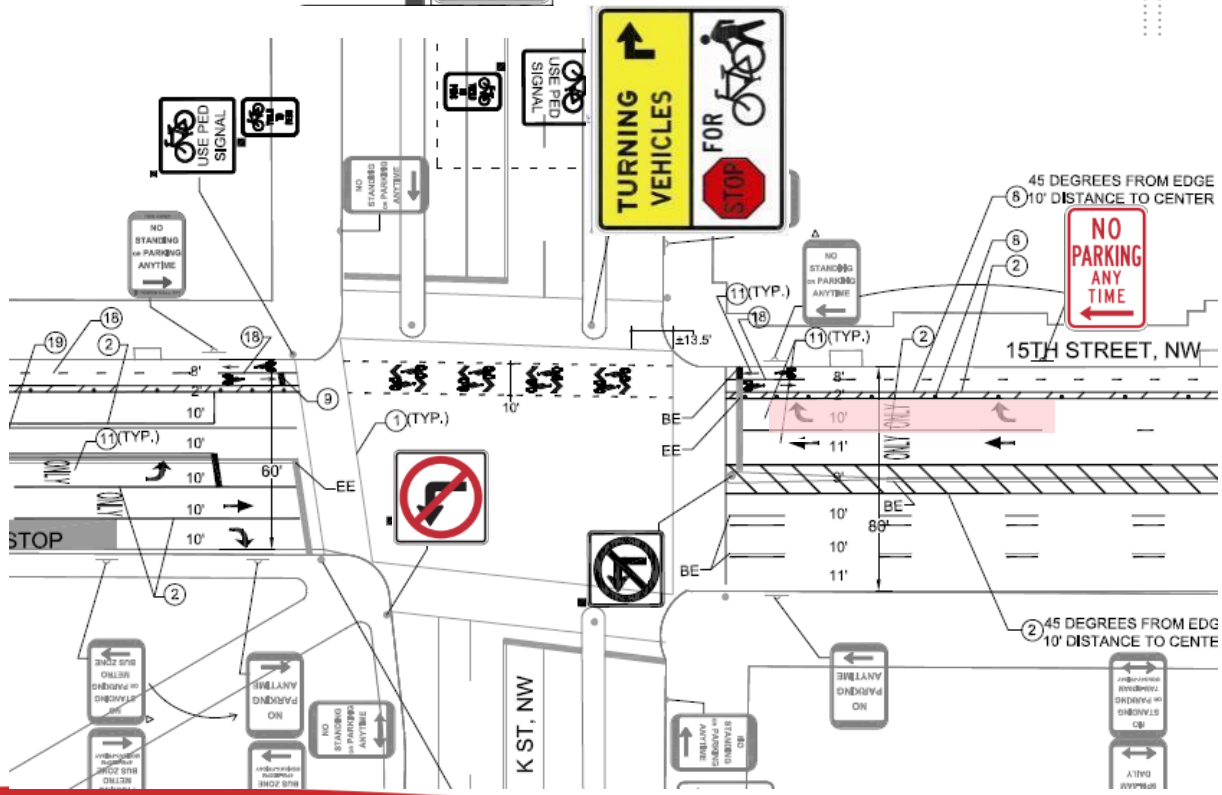
Replace parking to minimize complaints



Two-way traffic CBD mitigations

- Fully protect left turns
- Left turn prohibitions at 3 locations (to reduce traffic delay)
- Parking restrictions to create right turn lanes for 100 feet
- RTOR prohibited
- Separate bike crosswalk
- Leading Bike/Ped Interval of 3 seconds





Pennsylvania Avenue, NW

- Center median bike lanes with buffers
- Turn lane and signals for cars turning left across the bike path

Pennsylvania Ave. Before

- Dozen **WMATA bus** routes
- **Tour bus** loading zones
- **Flush median** – portions with parking
- **Limited curb side parking** with some VIP and valet
- High **pedestrian** volumes (up to 2,000/hr/intersection)

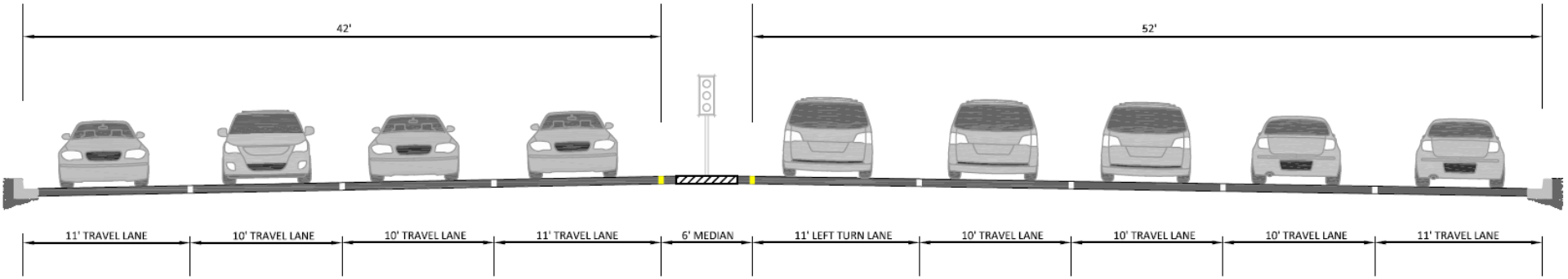
Pennsylvania Ave. Before

- **Mix of left turn treatments** (protected /restricted /permitted)
- Excellent Vehicular LOS

Intersection	Level of Service	Volume-to-Capacity Ratio	Average Delay
Pennsylvania Avenue at 6th Street	B (C)	0.38 (0.58)	15.2 (27.5)
Pennsylvania Avenue at 7th Street	C (C)	0.66 (0.51)	20.6 (20.7)
Pennsylvania Avenue at 9th Street	B (C)	0.47 (0.69)	10.0 (21.1)

- ADT - 35,000 vehicles per day
- **Not a through route** – all vehicles turn off to congested north/south routes
- **Inauguration Parade** & other local & national events

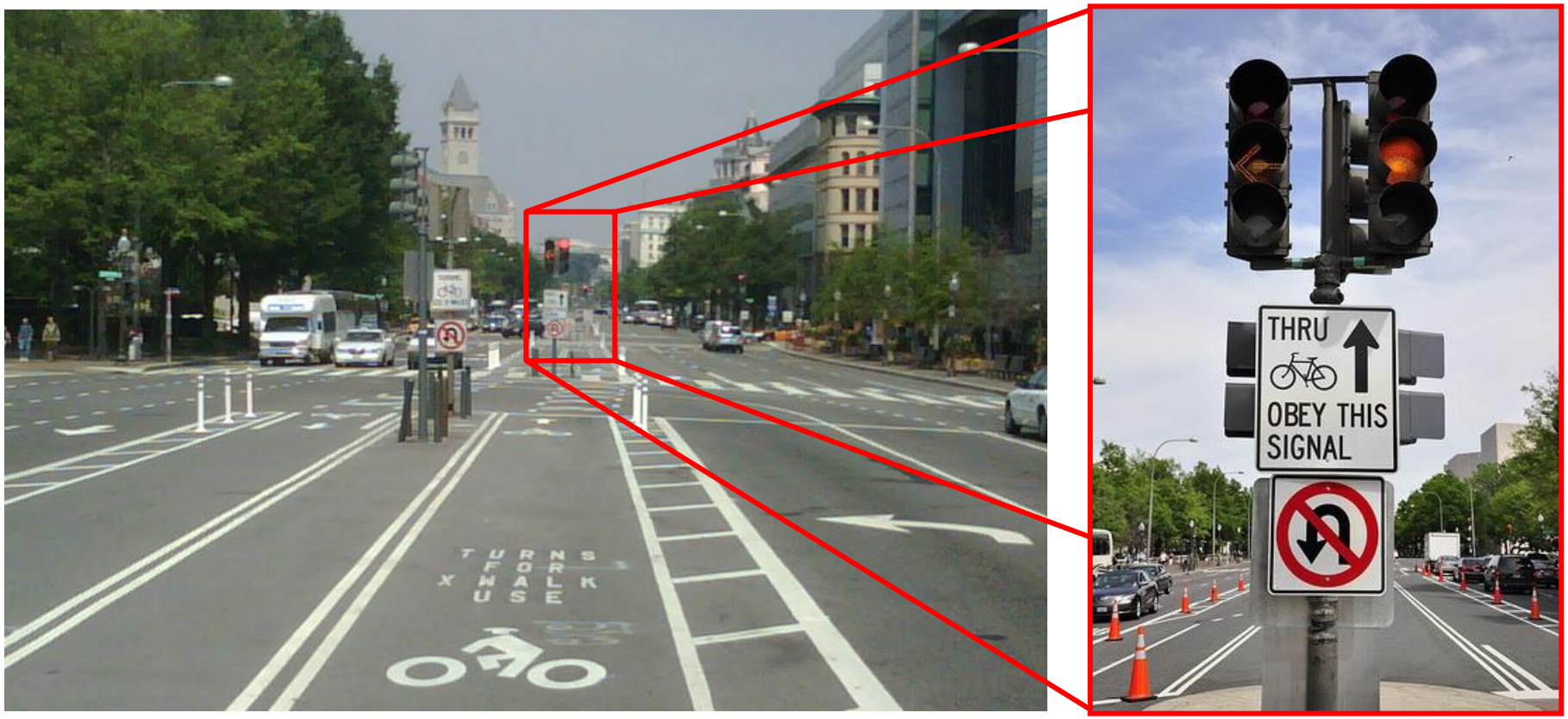
Pennsylvania Ave. – Before



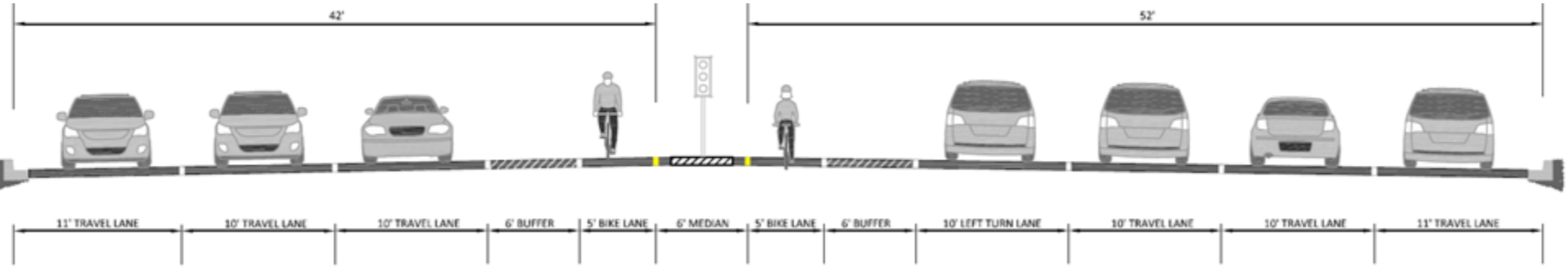
Pennsylvania Ave. After

- **Median cycle track**
  - Avoids bus & other curb conflicts
  - No Left Turn easier to enforce than No Right Turn
- Auto **left turns prohibited** or changed to **protected only phasing**
- **Bike turns via crosswalks**, following ped signals

Pennsylvania Ave – After



Pennsylvania Ave. – After



Pennsylvania Ave – After

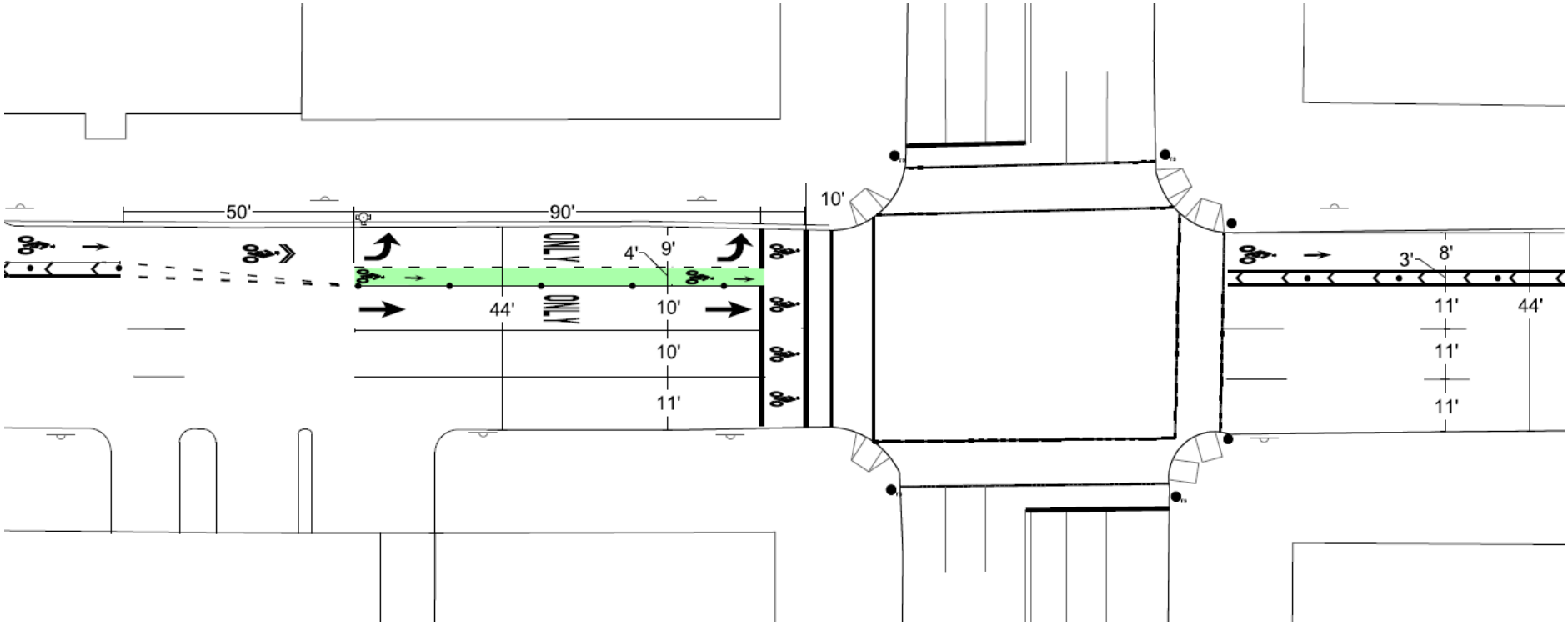
Pennsylvania Ave – Illegal u-turns

Pennsylvania Ave – After After

L Street Parking and Loading Impacts

- North Side Parking Removed
- South Side Parking during non rush-hours
- Loading zones on south side and side streets
- Reduction in redundant signs/clutter

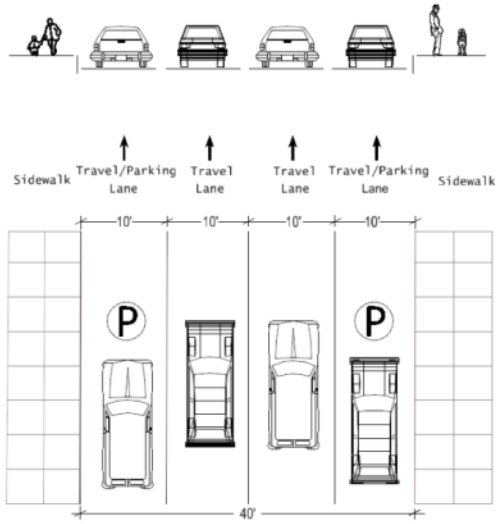
L Street NW – Left Turn Typical



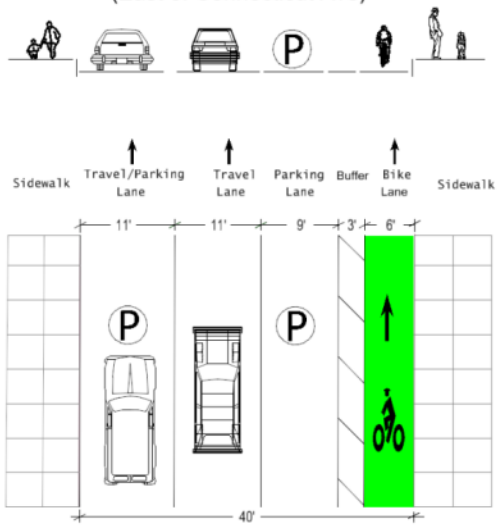
- **Car/bike merge area – cars must yield to through bikes**
- **Left-turn lane**
- **Green through bike lane**
- **“Mix zone” – adherence vs. perception**

14th St to Connecticut Ave

EXISTING 40' CROSS SECTION
(East of Connecticut Ave)

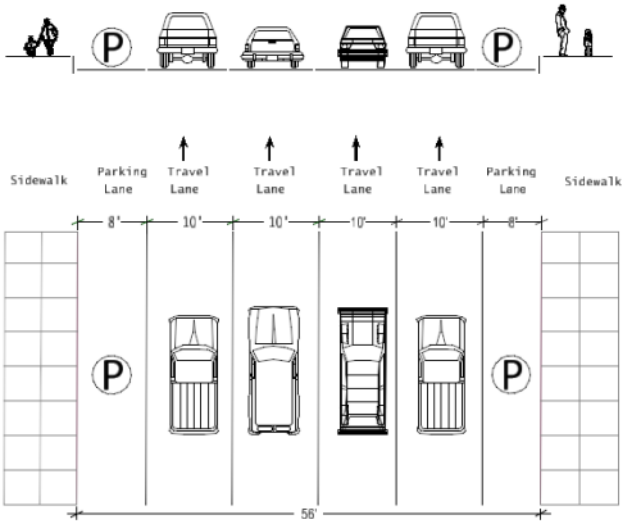


PROPOSED 40' CROSS SECTION
(East of Connecticut Ave)

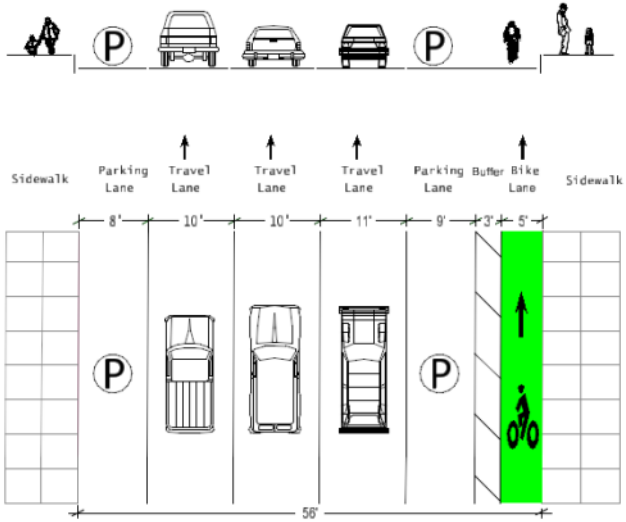


Connecticut Ave to 28th St

EXISTING 56' CROSS SECTION
(West of Connecticut Ave)

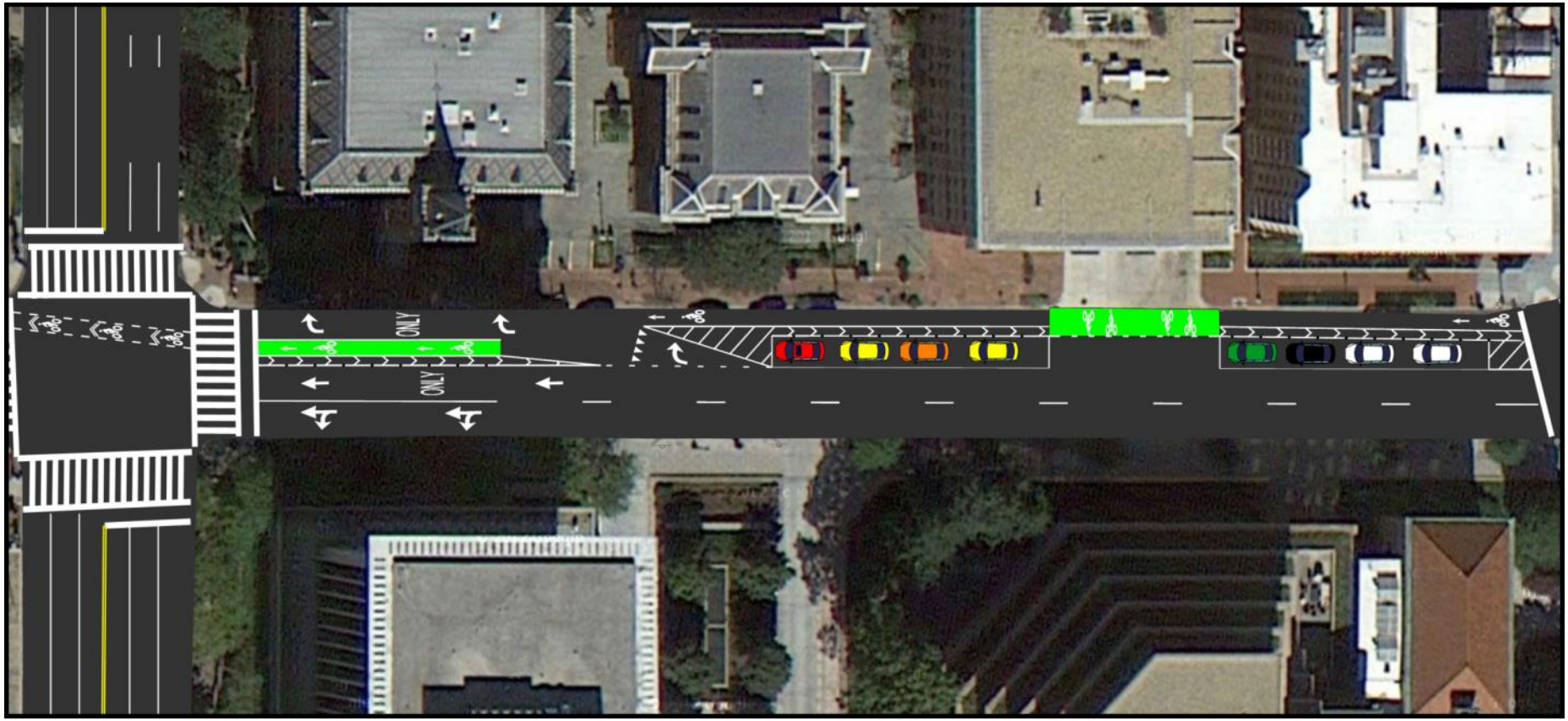


PROPOSED 56' CROSS SECTION
(West of Connecticut Ave)

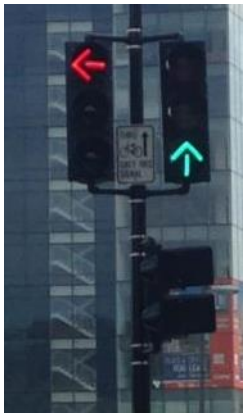


M STREET, NW

M Street NW – Right Turn Typical Section



1st St NE – First hard-barrier cycletrack



Measures of Success:
Goals of 15th St Cycle Track Pilot

- Increase bicycle trips
- Improve safety for all modes
- Calm traffic
- Minimize motorist delay
- Provide more options for cyclists
- Provide DDOT with a better understanding for future cycle tracks

District Department of Transportation

Research Overview

- One Year
- Three projects:
  - 16th, U, New Hampshire
  - Pennsylvania Avenue
  - 15th Street
- Safety
  - Compliance with traffic laws
  - Modal interactions
  - Crash analysis
- Traffic volumes
- Operations
  - Multi-modal LOS
- Convenience
  - Multi-modal travel time
- Comfort
  - Intercept & neighborhood surveys

15th St, NW

16th St, U St, New Hampshire Ave NW

15th St, NW

16th St, U St, New Hampshire Ave NW

Highlights of Research Results – 15th St

- Increase bicycle trips
  - Over 500% increase in bicyclist volumes
- Improve safety for all modes
  - Bicycle crashes increased but remained similar when adjusted for exposure
  - No increase for other modes
- Calm traffic
  - > 45 mph -98%
  - > 25 mph -60%
- Minimize motorist delay
  - Motor vehicle volumes remained the same
  - Minor changes in LOS
- Provide DDOT with a better understanding for future cycle tracks
  - Bicycle signals are important, but be cautious which intersection you choose to signalize
  - Consider coloring conflict zones
  - Improve signal progression for southbound (contra-flow) movement

Highlights of Research Results – 15th St

Cyclists

- Cyclists believe that the cycle track makes riding a bicycle safer (96%), easier (98%), more convenient (98%), and would go out of their way to ride in it (93%).
- Up to 39% of riders do not understand what traffic signal they should follow.
- Cyclists violate traffic signals 41% of the time.

Residents

- 81% agree that DC should be investing in projects that encourage more people to ride bicycles for transportation.
- 83% think that the cycle track is a valuable neighborhood asset
- Only 45% think bicycling in DC is safe.

Safest Places to Bike RANKING

STATES	CITIES
1. South Dakota	1. Honolulu
2. Vermont	2. Milwaukee
3. Oregon	3. Omaha
4. Nebraska	4. Washington, DC
5. North Dakota	5. Portland, OR
6. Colorado	6. San Francisco
7. Montana	7. Sacramento
8. Wyoming	8. Boston
9. Idaho	9. Minneapolis
10. Washington	10. Austin

2012 Benchmarking Report

Highlights of Research Results – Pennsylvania Ave, NW

- Arterial LOS was similar for motor vehicles before and after the bicycle facilities were installed.
- Motor vehicle volumes decreased between 15% and 21% since the installation of the bike facilities.

Cyclists

- Cycling volume increased over 300%.
- Cyclists believe that the center bike lanes make riding a bicycle safer (90%), easier (94%), more convenient (92%), and would go out of their way to ride in it (86%).
- Cyclists understand what traffic signal to follow, but frequently don't obey: 42% violate the red signal indication.
- 26% indicated that they would stop in the crosswalk, a potential safety hazard due to the path of left-turning vehicles.
- Bicycle crashes have increased: 16 in 14 months versus 9 during previous 4 years.

Pedestrians

- 75% notice fewer cyclists on the sidewalks since the installation of the center bike lanes.
- 33% feel that crossing the street is more difficult with the center bike lanes.

Motorists

- 69% think that there are fewer cyclists in the car lanes due to the bike facility.
- 84% like that bicycles are separated from the motor vehicle traffic.

Residents

- 74% agree that DC should be investing in projects that encourage more people to ride bicycles for transportation.
- 71% think that the cycle track is a valuable neighborhood asset.
- Only 33% think bicycling in DC is safe.

Pedestrian Safety and Access Countermeasures

Vision Zero & MoveDC Multi-Modal Plan policy foundations:

District Department of Transportation

VISION ZERO
SAFE STREETS FOR WASHINGTON, DC

move dc
The District of Columbia's
Multimodal Long-Range Transportation Plan

Pedestrian Element

1. **Crosswalk Marking Policy - Recommends enhancements for crosswalks multi-lane arterials with high traffic volumes:**
   a. **Pedestrian Hybrid Beacon ("HAWK")**
   b. **Rectangular Rapid Flash Beacon (RRFB)**
   c. **Pedestrian Refuge Crossing Island**
   d. **Uncontrolled Crosswalk Side-of-Street Sign**

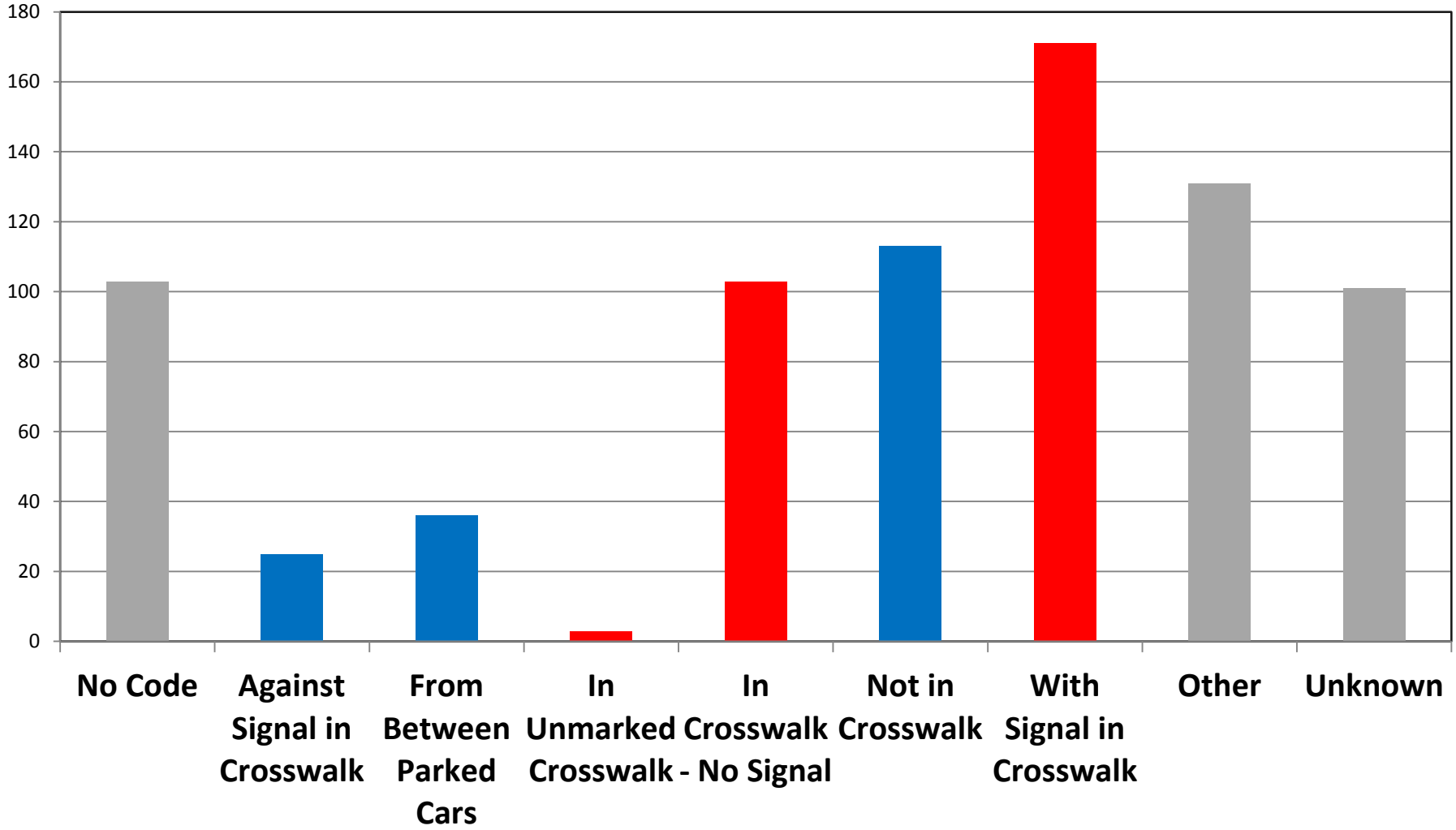
2. Bus stop alignment with safer crossings
3. Curb Extensions
4. Leading Pedestrian Interval Signal Timing
5. **Complete Streets Policy**
6. **Vision Zero – Reduce speeding and reduce crash severity**

October 2014

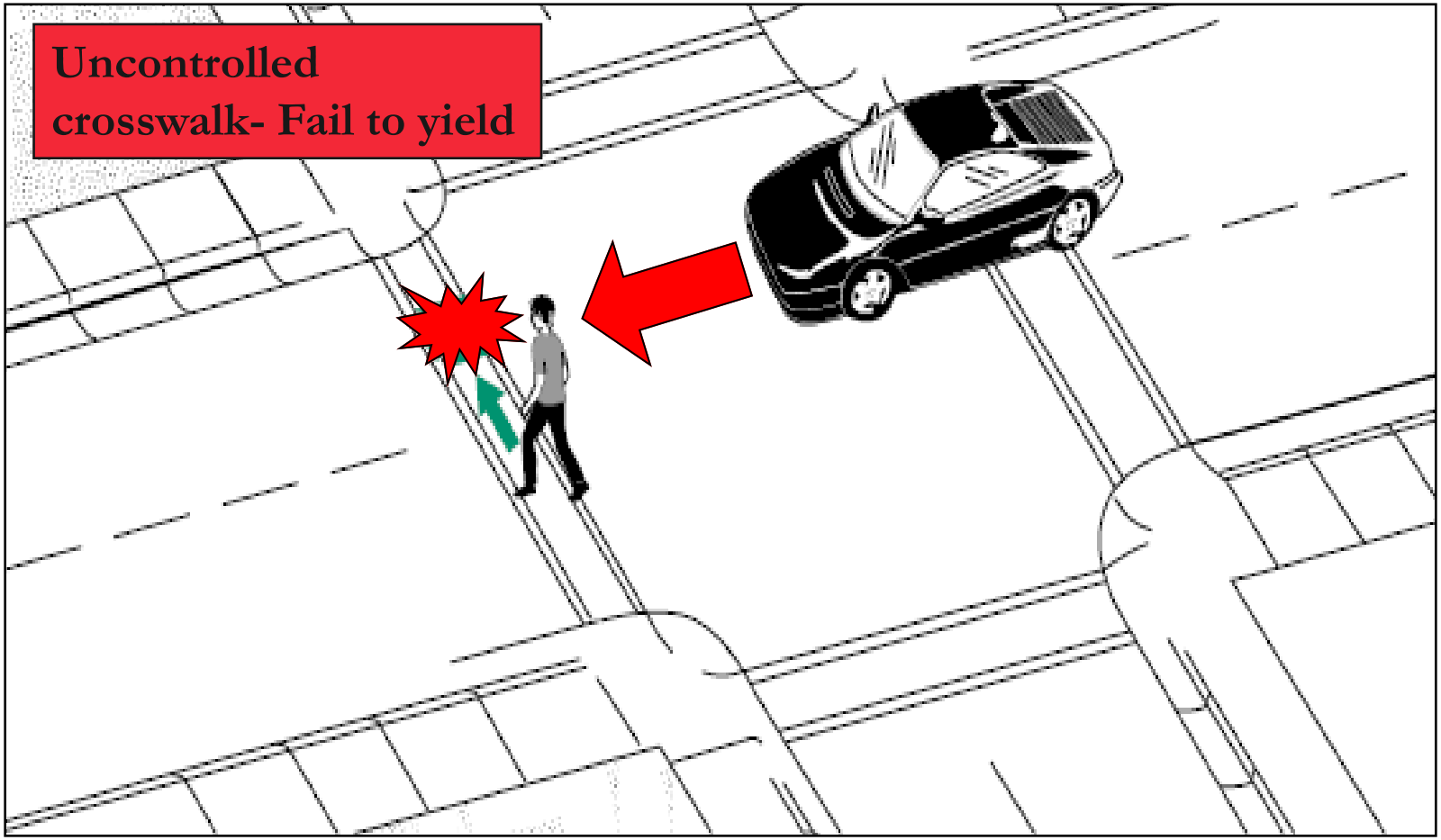
Crash Typing
&
Countermeasure ID

DC Pedestrian Crash Types

Pedestrian Action, 2015

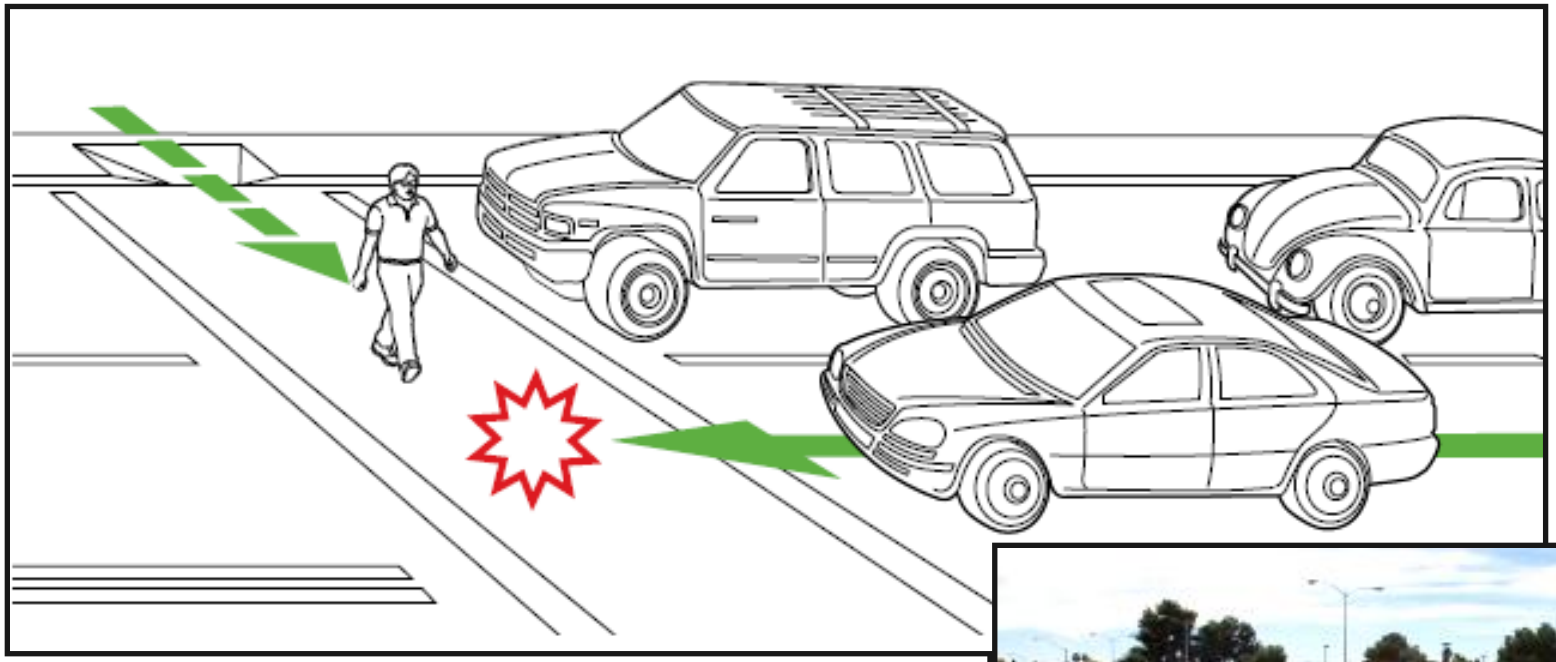


Most Frequent DC Ped Crash Types



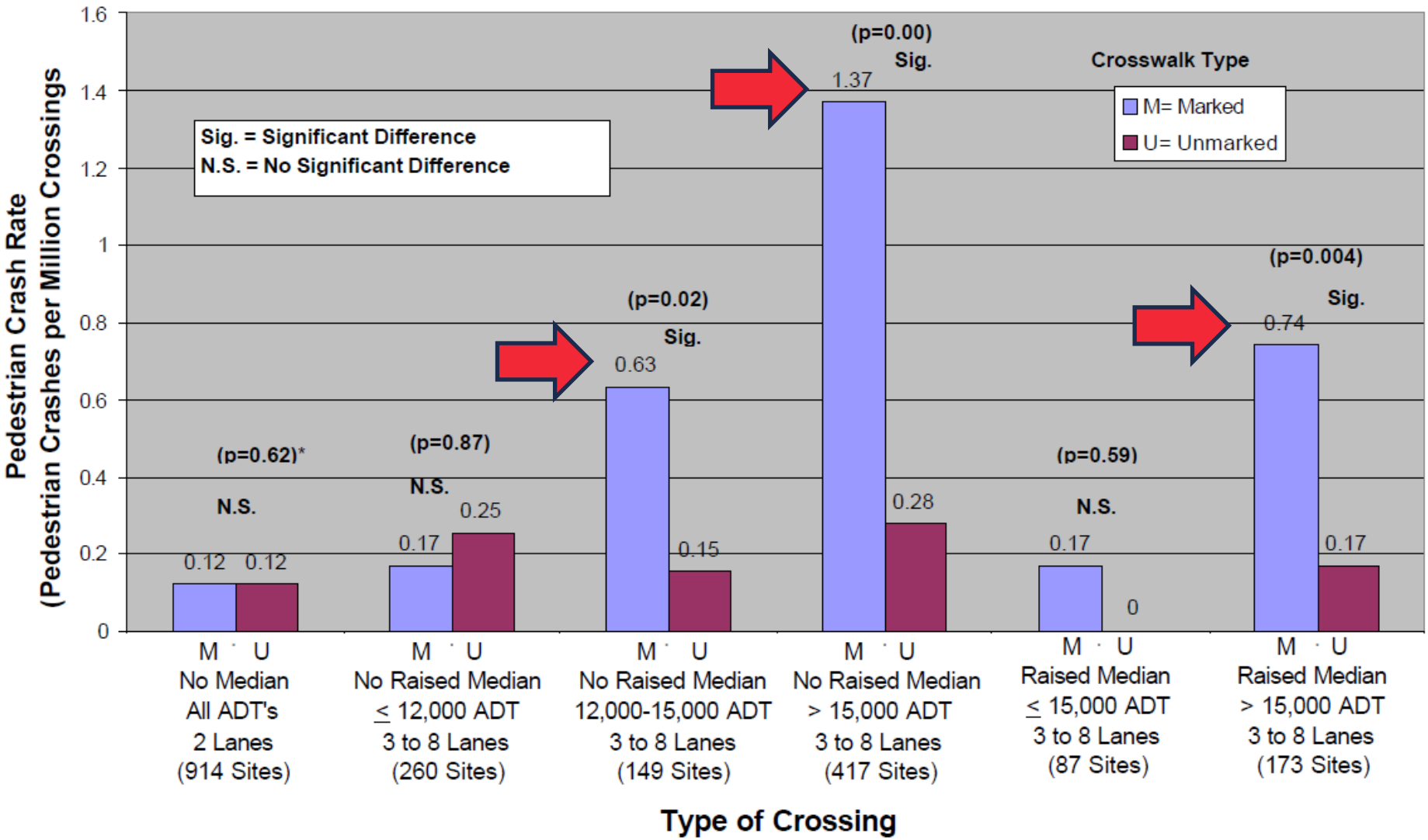
High Risk Motorist At-Fault Crashes, Unsignalized

- "Multiple Threat" crash



In crosswalk, no signal, multiple threat

Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations (Zegeer, 2002):



FHWA Crosswalk Compliance Matrix

Table 1. Recommendations for installing marked crosswalks and other needed pedestrian improvements at uncontrolled locations.*

Roadway Type (Number of Travel Lanes and Median Type)	Vehicle ADT ≤ 9,000			Vehicle ADT >9000 to 12,000			Vehicle ADT >12,000 - 15,000			Vehicle ADT > 15,000		
	Speed Limit**											
	≤ 30 mi/h	35 mi/h	40 mi/h	≤ 30 mi/h	35 mi/h	40 mi/h	≤ 30 mi/h	35 mi/h	40 mi/h	≤ 30 mi/h	35 mi/h	40 mi/h
2 Lanes	C	C	P	C	C	P	C	C	N	C	P	N
3 Lanes	C	C	P	C	P	P	P	P	N	P	N	N
Multi-Lane (4 or More Lanes) With Raised Median***	C	C	P	C	P	N	P	P	N	N	N	N
Multi-Lane (4 or More Lanes) Without Raised Median	C	P	N	P	P	N	N	N	N	N	N	N

- Zegeer Study, FHWA, 2002

FHWA Guidance on Uncontrolled Crosswalks

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 and either:

A. The roadway has four or more lanes of travel without a raised median or pedestrian refuge island and an ADT of 12,000 vehicles per day or greater; or

B. The roadway has four or more lanes of travel with a raised median or pedestrian refuge island and an ADT of 15,000 vehicles per day or greater.

- 2009 MUTCD, Section 3B-18 (page 384)

DDOT Uncontrolled Crosswalk Policy Matrix

District Department of Transportation

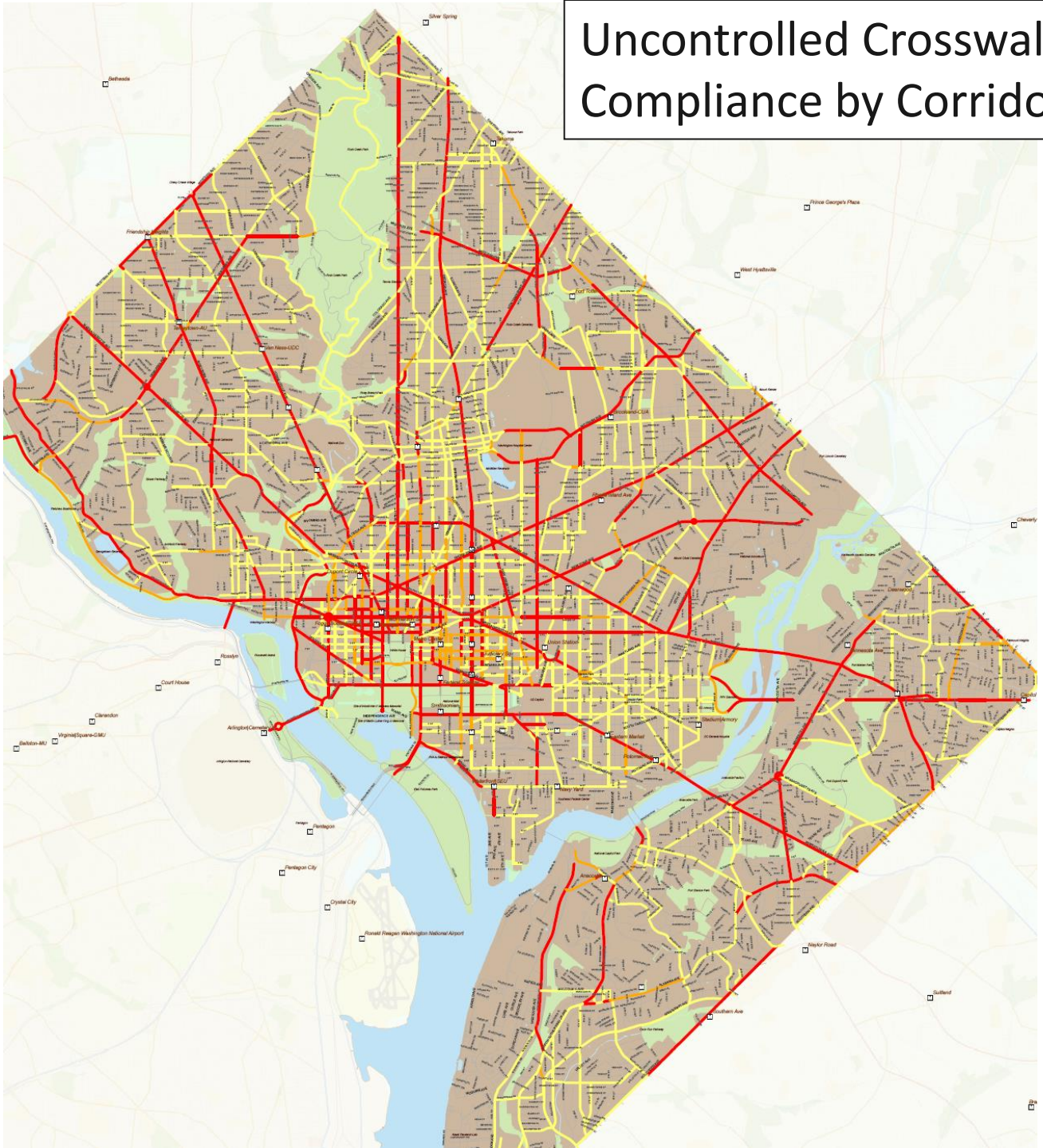
Table 1 - Proposed DC Uncontrolled Crosswalk Engineering Treatments

For roadways posted 30mph or less

Roadway Configuration	1,500 - 9,000 vpd	9,000 - 12,000 vpd	12,000 - 15,000 vpd	> 15,000 vpd
2 Lanes[1]	A	A	A or B	B or C
2 Lanes with CTL[1]	A	A	B	B or C
2 Lanes One Way	B	B	C	C
4 Lanes w/Raised Median[2]	B	B	C	C
3 Lanes No Median[3]	B	B	C	C
5 Lanes w/Raised Median[3]	B	B	C	C
6 Lanes w/Raised Median[4]	B	B	C	D
4 Lanes No Median[4]	B	B or C	C	D
5 Lanes No Median[3]	B	B or C	D	D
6 Lanes No Median[4]	B	B or C	D	D

Volumes Below 1500 vpd	Parallel Crosswalk and/or W11-2 assembly
Treatment A	High Visibility Crosswalk and Side of Street Ped Law Sign
Treatment B	In-Street Stop For Peds Sign and/or Traffic Calming
Treatment C	Activated Pedestrian Device (RRFB, In-road LEDs, etc.)
Treatment D	Something with a red signal (Ped Hybrid, Full Signal)

Uncontrolled Crosswalk Compliance by Corridor



Legend

- Metro Station
- Road Outside Study Area
- Park

Pedestrian Crossing

- Compliant
- Possibly Compliant
- Not Compliant

DC HAWK Preliminary Evaluation Form

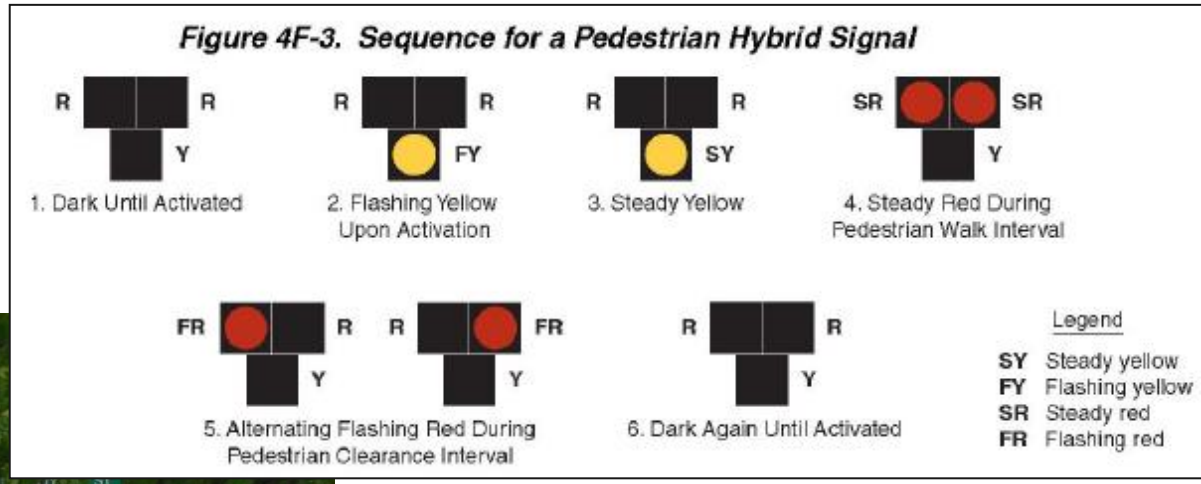
- Planning department conducts preliminary evaluation
- If score is sufficiently high, Signals Team conducts formal Warrant Study

DDOT HAWK (PHB) Preliminary Evaluation Matrix			
Location:			
Date: 2015			
Analyst: Branyan			
	Max Points Possible	Points Awarded	Points and Considerations
Pedestrian and Bicycle Crashes at intersection	20		Crashes over a recent 3 year period: 5 points per crash
Vehicular crashes at intersection	10		Crashes over a recent 3 year period: 2 point per crash
Street Traffic Volume (ADT)	30		< 12,000=0 pts 12,000-15,000 w/median=10 pts >15,000-w/median=20 pts >15,000-w/o median=30 pts
Number of lanes at peak hour	30		2 lanes in each direction=20 pts Each additional lane=5 pts If one-way, 1 lane=10, each additional lane=10 pts
Elderly/disabled population density (65+, based on 2010 census tracts)	10		< 5%=0 pts, 5-11%=5 pts, > 11%=10 pts
Proximity to school (pre-K-HS)	15		5 pts per school w/in 1/4 mile 2 pts per school w/in 1/2 mile
Connection to parks, rec ctr, libraries, commercial zone, or other large ped generator	15		5 pts per facility or zone w/in 1/4 mile 2 pts per faclity or zone w/in 1/2 mile
Metro Station/Bus Stop presence and use (each stop)	20		<50 daily boardings=5 pts 50-150 daily boardings=10 pts >150 daily boardings or Metro Station w/in 2 blocks=20 pts
Posted speed limit	15		25-30 mph= 10 pts,>30 mph= 15 pts
Distance to nearest signalized intersction	30		<300 ft.=0 pts 300-500 ft.=20 pts >500 ft.=30 pts
Crossing part of designated bike route	5		Yes=5 pts
TOTAL LOCATION SCORE:	200	0	
Notes and Comments:			

Uncontrolled Crosswalks:

HAWK Pedestrian Hybrid Beacon/Signal

For Use at selected uncontrolled crosswalks on <u>major arterial streets</u>



HAWK Pedestrian Hybrid Beacons in DC

District Department of Transportation

- Major roadway sees a beacon/signal
- Minor roadway sees a stop sign
- Dark when not in use

FHWA Study:

- Up to a 69% reduction in pedestrian crashes
- Up to a 29% reduction in total crashes.

- DDOT study showed 97% compliance
- No problem observed with stop-controlled side street
- Minor roadway gets less cut-through traffic

Operational Issues with the PHB/HAWK in DC

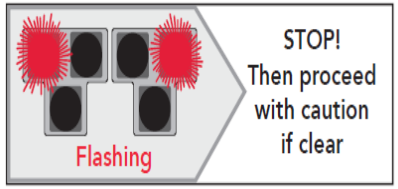
District Department of Transportation

1. Some drivers do not understand that they may proceed on Flashing Red:

- Not observed as a safety problem
- Reduces somewhat the operational advantage of the PHB
- DDOT posted a sign to help explain the Flashing Red phase

2. Some reports of drivers moving on the Flashing Red in a manner that seemed hazardous to pedestrians:

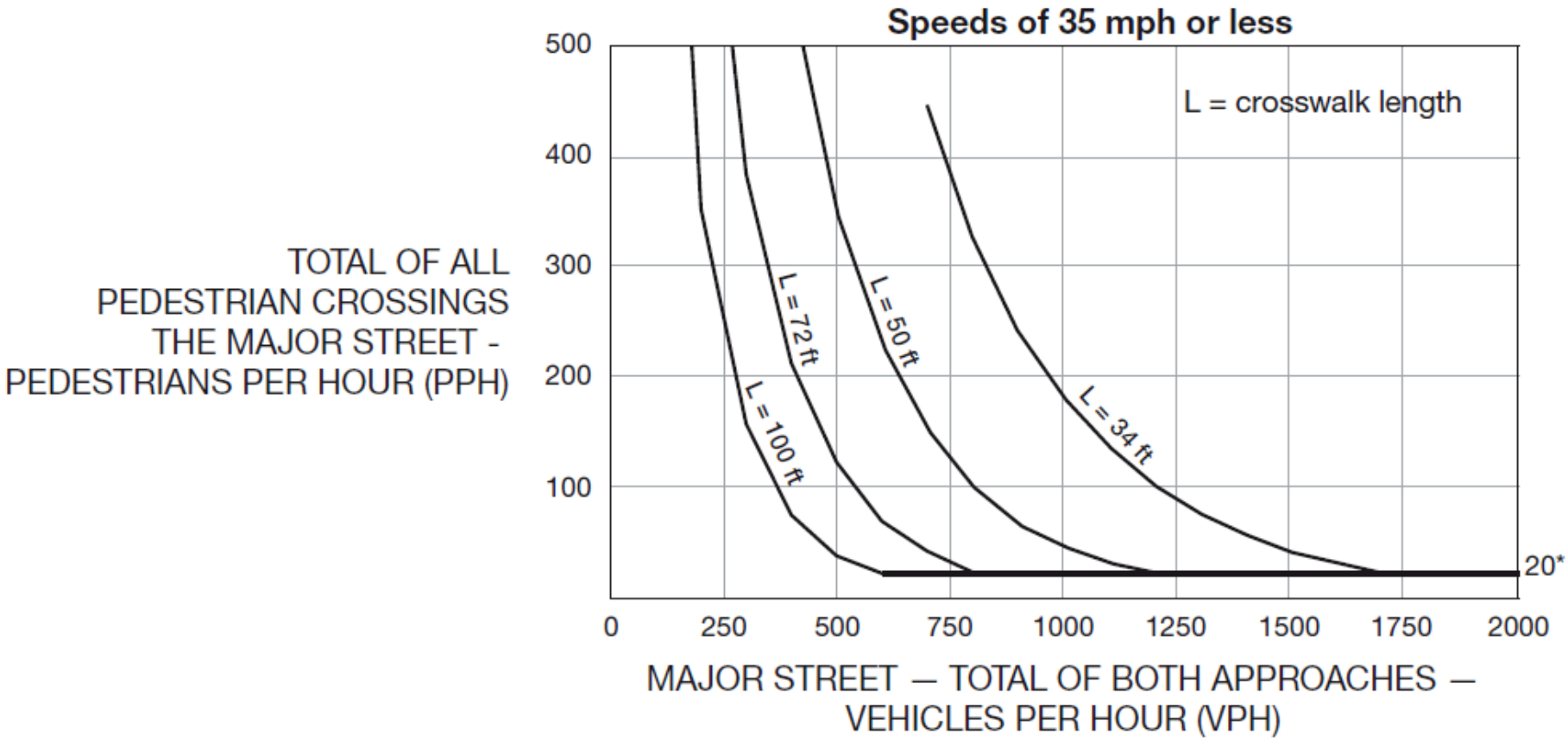
- Lengthen the solid red phase
- Enforcement



PHBs in the suburban context

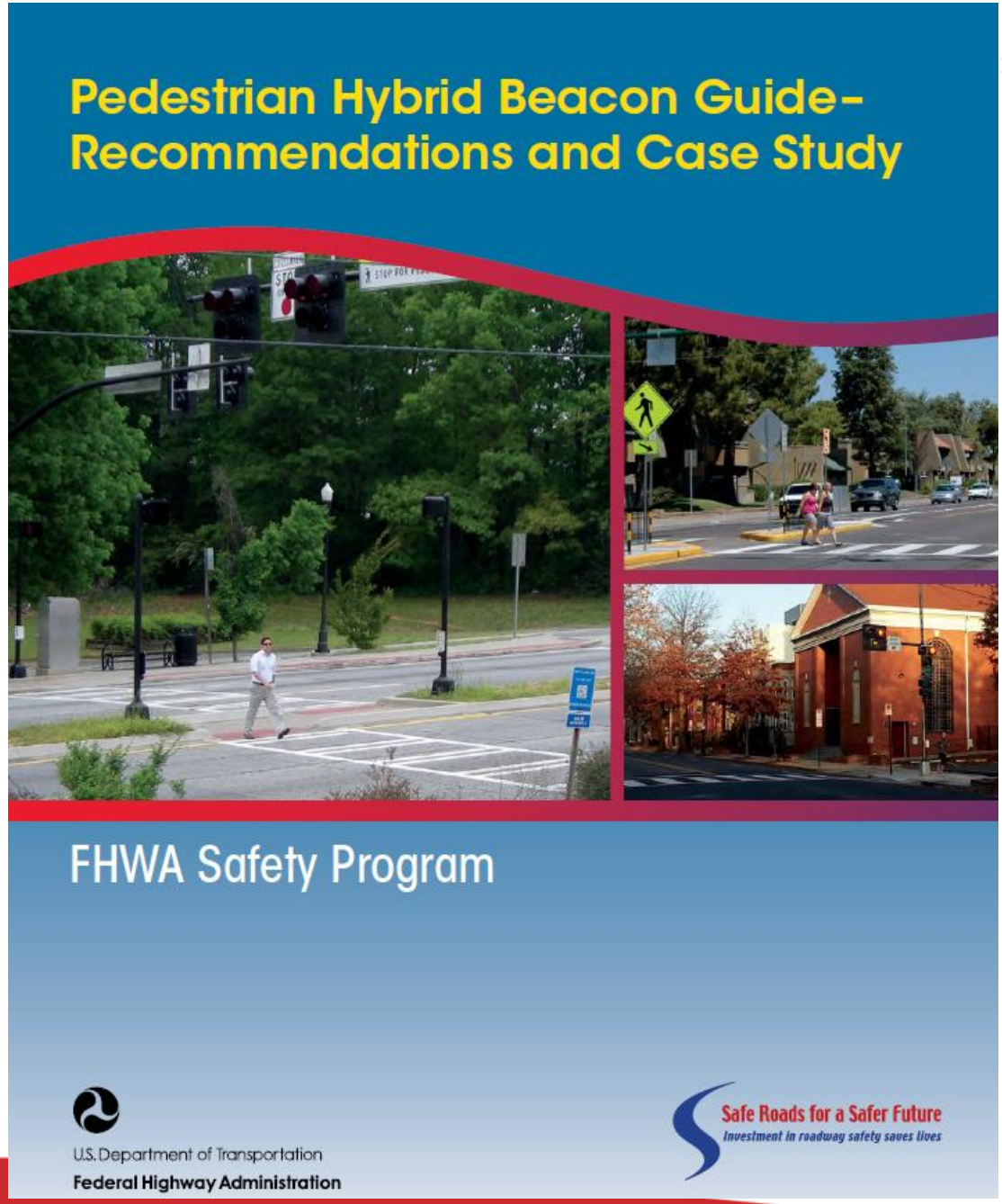
- Most pedestrian fatalities occur at mid-block crossings or on multi-lane roadways at non-signalized locations.

PHB Warrant - MUTCD



* Note: 20 pph applies as the lower threshold volume

- FHWA PHB Guide, 2014
- PHBs have been shown to significantly reduce pedestrian crashes. A Federal Highway Administration (FHWA) study published in 2010 found that pedestrian hybrid beacons can reduce pedestrian crashes by 69 percent and total crashes by 29 percent.
- http://safety.fhwa.dot.gov/ped bike



DC HAWK Brochure

How does a HAWK Signal Work?

What is a HAWK Signal?

A HAWK (High-Intensity Activated crossWalK) signal is a signal-beacon designed to help pedestrians safely cross busy streets.

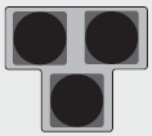
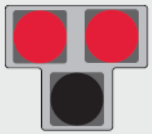
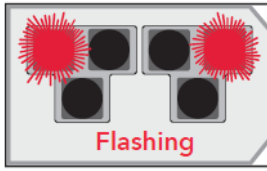
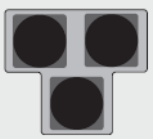
While different in appearance for motorists, for the pedestrian, this signal works like other push-button activated traffic signals in the District by stopping traffic with a red signal, allowing pedestrians to cross with a WALK signal. At certain locations, the signal can automatically detect the presence of pedestrians waiting to cross and will activate the signal.

HAWK signals can be installed on streets with regular traffic signals as part of the District's coordinated signal system.

Pedestrians

Will see this...	Will do this...
	Push button to call for WALK signal (some locations automatically detect pedestrians)
	Wait (It may take up to one minute for the signal to change)
	Wait
	Start crossing after you see the WALK signal (Be sure traffic has stopped)
	Continue Crossing (Countdown signal)
	Push the button to cross

Motorists

Will see this...	Will do this...
	Proceed
	Proceed with Caution (Signal has been activated)
	Slow down and prepare to STOP
	STOP!
	STOP! Then proceed with caution if clear
	Proceed

Rectangular Rapid Flashing Beacon (RRFB):

- Pedestrian actuated, solar powered, high intensity LED beacons that flash in a stutter pattern at approaching drivers
- 7 Locations in DC
- Interim Approval from FHWA (2008)

RRFB Evaluation Results- Baseline

BASELINE

Location: Brentwood Rd. & 13th St. NE

Treatment: HiViz CW (w/ ped pylon) Day_X_ Night ___

Date: 4/23/08 Time: 9:30-10:30 am

4/25/08 Time: 4:30-5:20 pm

Observers: Branyan/Goodno/Hefferan

Date/Crossings	Cars Yielding	Cars Not Yielding	Distance Cars yielded from crosswalk							Driver Passed Stopped Veh or Attempt	Car Behind Yielding Car Jams Brakes
			< 10 ft	Red 10ft-20ft	Orange 20ft-30ft	Yellow 30ft-50ft	Green 50ft-70ft	Blue 70ft-100ft	Red >100ft		
4/23:20	34	66	0	4	5	13	12	0	0	1	0
4/23:20	39	60	0	11	12	7	6	3	0	2	1
4/25:20	38	158	0	10	13	8	6	0	1	7	0
4/25:20	35	128	10	14	7	4	0	0	0	11	0
Totals	146	412	7%	27%	25%	22%	16%	2%	1%	21	1

Total vehicles: 558

41% of vehicles yielding 30' or farther from crosswalk

Overall Compliance rate: 26%

Best 20 crossings: 39%

Worst 20 crossings: 19%

RRFB Evaluation Results- 100 days

100-DAY FOLLOW UP

Location: Brentwood Rd. & 13th St. NE

Treatment: 2RFB + 1 Advance RFB Day_X_ Night ___

W/ advance stop lines. No Pylon

Dates: 8/14/08 Time: 9:30-10:30 am

8/21/08 Time: 4:30-5:07 pm

Obsrvs: Branyan/Goodno/Hefferan/Deutsch

Date/ Crossings	Cars Yielding	Cars Not Yielding	Distance Cars yielded from crosswalk							Driver Passed Stopped Veh or	Car Behind Yielding Car Jams
			< 10 ft	Red 10ft-20ft	Orange 20ft-30ft	Yellow 30ft-50ft	Green 50ft-70ft	Blue 70ft-100ft	Red >100ft		
8/14:20	50	11		3	7	2	16	8	4		
8/14:20	48	13	3	1	8	18	17	1	4	2	
8/21:20	58	13		3	10	23	20	1	1		
8/21:20	54	21		3	11	8	27	2	3		
Totals	210	58	1%	5%	17%	24%	38%	6%	6%	2	0

Total vehicles: 268

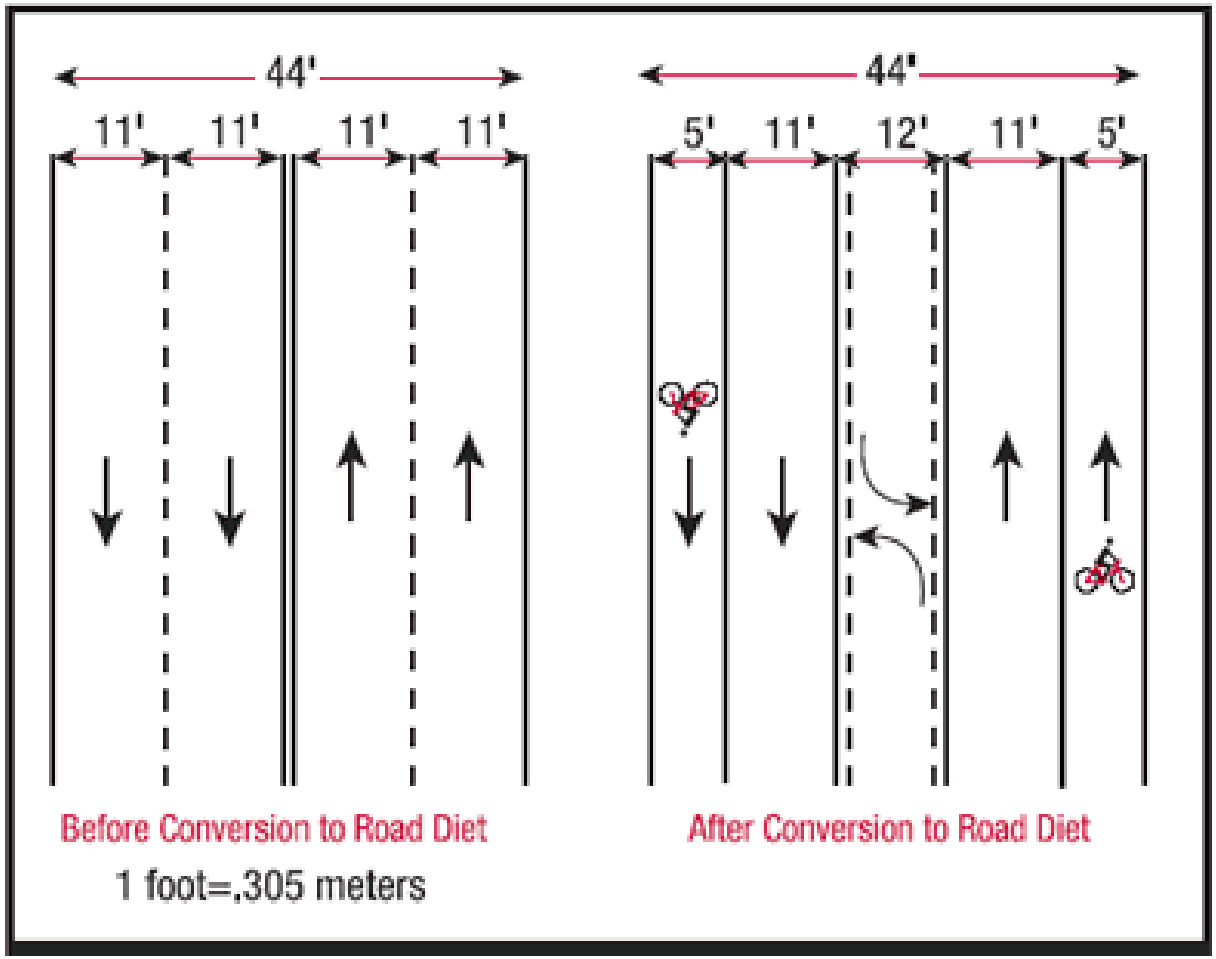
74% of yielding vehicles 30' or farther from crosswalk

Overall Compliance rate: 78%

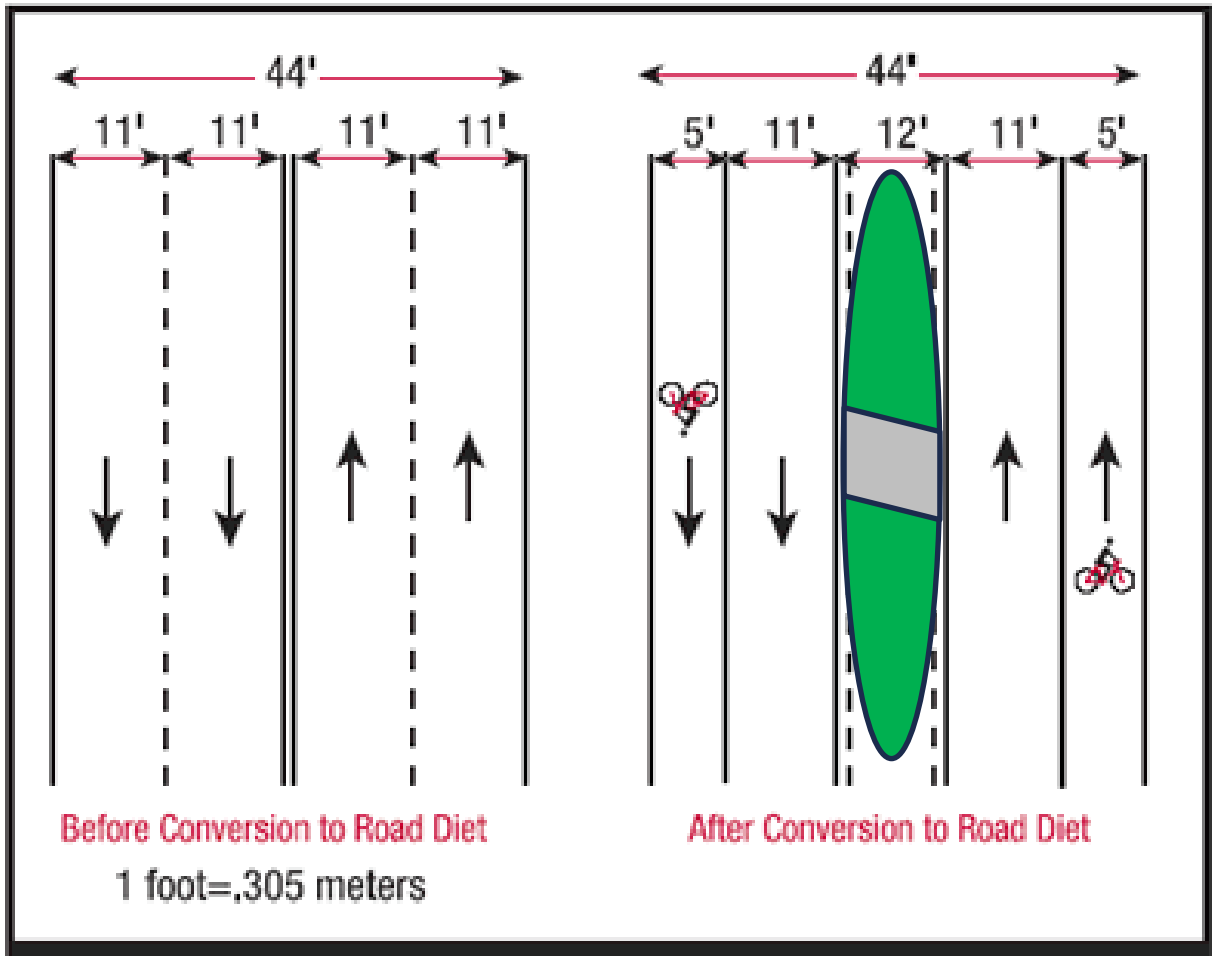
Best 20 crossings: 82%

Worst 20 crossings: 72%

Road Diets


44'
11'
11'
11'
11'
44'
5'
11'
12'
11'
5'
Before Conversion to Road Diet
After Conversion to Road Diet
1 foot=.305 meters

Road Diets


44'
11'
11'
11'
11'
44'
5'
11'
12'
11'
5'
Before Conversion to Road Diet
After Conversion to Road Diet
1 foot=.305 meters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Why Road Diets?

- Do you want to slow speeders, especially top end speeders?
- Do you want to reduce right angle, sideswipe and rear-end crashes? (29%-53%)
- Do you want to make it safer and easier for people to cross the street?
- Do you want to improve conditions for cycling?
- Do you want the street to support more non-motorized human activity?

Sherman Ave. NW Road Diet, 2013

.85 mile, mainly residential

<u>BEFORE:</u>

4 travel lanes

On street parking

No bike facility

No sidewalk buffer

Sherman Ave. NW Road Diet, 2013

<u>After:</u>

2 travel lanes

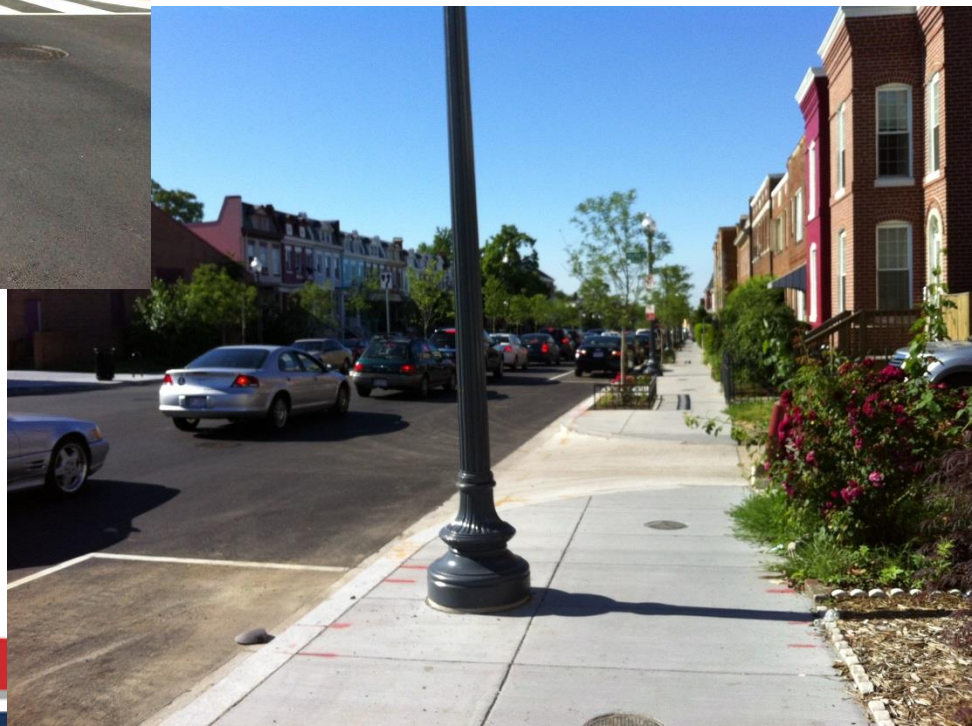
LT pockets

Raised, landscaped median

On street parking

14’ wide shared lane

Added 4 ft. tree/grass buffer to each side.



Sherman Ave. NW After:

- Example of the “give and take” required to “right size” a street and make a former auto-dominated corridor with poor pedestrian, bike and transit facilities function as a “complete street.”

Sherman Ave. NW Road Diet Evaluation Study:

- 85%ile Speeds (25 mph posted):
  - Before, northbound- 32 mph
  - After, northbound- 29 mph
  - Before, southbound- 35 mph
  - After, southbound- 28 mph
- Crashes:
  - Total crashes- 23% decline
  - Injury crashes- 44% decline
- Auto Mobility:
  - Traffic volumes: Before: 15,000 ADT. After: 13,000 ADT
  - Intersection delay: One LOS B before to D after. All others are LOS C or better.
- Bicycle LOC:
  - Before: D, After C+

Sherman Ave. NW Road Diet
Forward to the Past

1951

1964

2016

Road diet candidate guidelines (DPS-201 Course)

- ADT (Road Diet Candidate)
  - 23,000 or less (suburban)
  - 17,000 or less (urban)
- Peak hour peak direction volume (Road Diet Candidate)
  - 1,200 or less (suburban)
  - 950 or less (urban)
  - Other factors:
    - Percentage of left turns at intersection
    - VPH on side street
- These apply IF you want to accommodate existing traffic volumes (discuss…)
- Look for opportunities to implement Road Diets

WE ARE WASHINGTON DC

d. delivers

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District Department of Transportation

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