

Back to Basics – Speed Limits

ITRE
Institute for Transportation Research and Education

NCSITE Webinar
August 25, 2020

Overview

- Why are speeds important?
  - Mobility and Safety [Arterial and Local]
    - Speed of 0 = No Mobility [Congestion on interstates]
    - Speed Too High = Decreased Safety [Neighborhood street design]
- Setting speed limits
  - Systematically documenting engineering judgement while maintaining flexibility



Design Speed & Safety Impacts

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Design Speed

TABLE 1
Ranges for Design Speed

Type of Roadway	Terrain	Rural		Urban	
		US (mi/h)	Metric (km/h)	US (mi/h)	Metric (km/h)
Freeway	Level	70	110	50 min	80 min
	Rolling	70	110	50 min	80 min
	Mountainous	50–60	80–100	50 min	80 min
Arterial	Level	60–75	100–120	30–60	50–100
	Rolling	50–60	80–100	30–60	50–100
	Mountainous	40–50	60–80	30–60	50–100
Collector	Level	40–60	60–100	30+	50+
	Rolling	30–50	50–80	30+	50+
	Mountainous	20–40	30–60	30+	50+
Local	Level	30–50	50–80	20–30	30–50
	Rolling	20–40	30–60	20–30	30–50
	Mountainous	20–30	30–50	20–30	30–50

Source: A Policy on Geometric Design of Highways and

Source: USDOT. FHWA. *Mitigation Strategies for Design Exceptions*. July 2007.

TABLE 2
Relative Risk of Differential Speed Caused by Changes in Roadway Geometry

Speed Differential (ΔV)	Safety Risk
ΔV < 5 mi/hr	Low
5 mi/hr < ΔV < 15 mi/hr	Medium
ΔV > 15 mi/hr	High

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Speeds

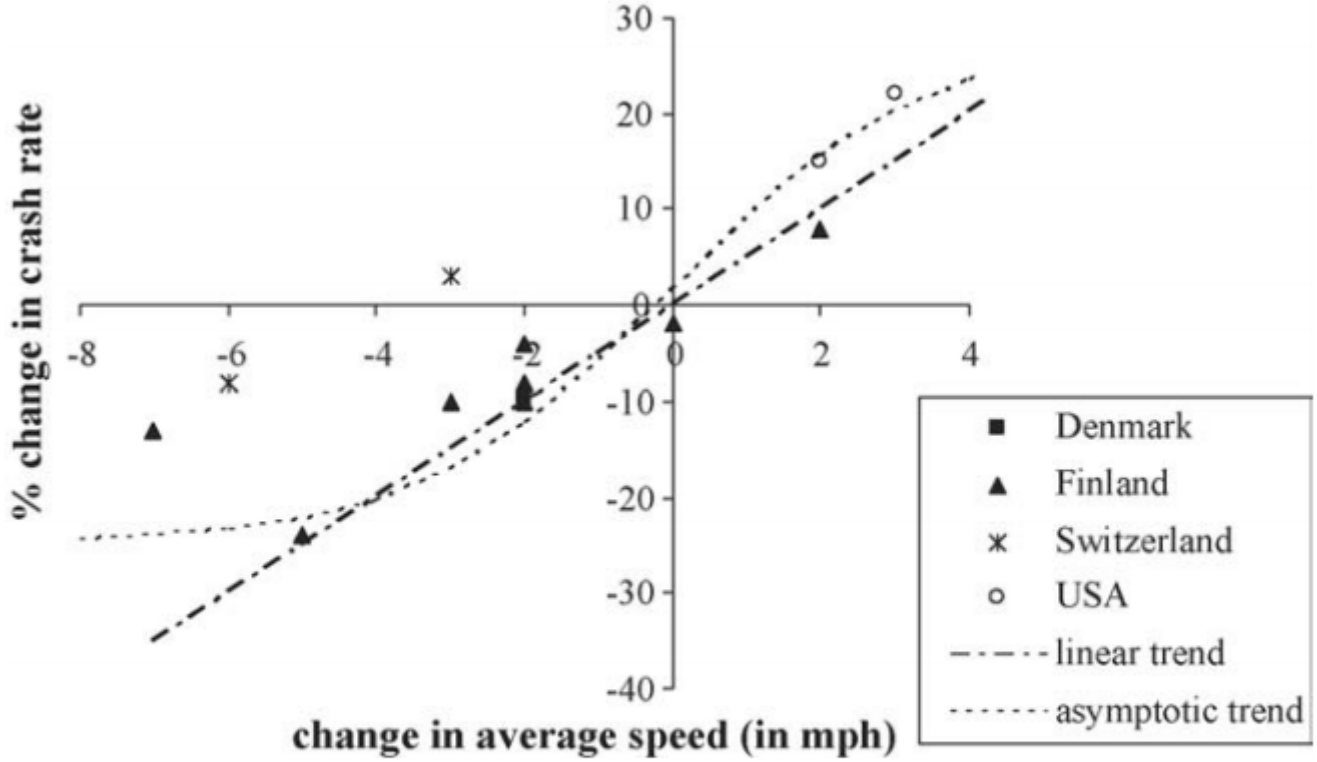


Fig. 3. 'Linear' and asymptotic relation between changes in average traffic speed and change in crash rate according to a meta-analysis of Finch et al. (1994).

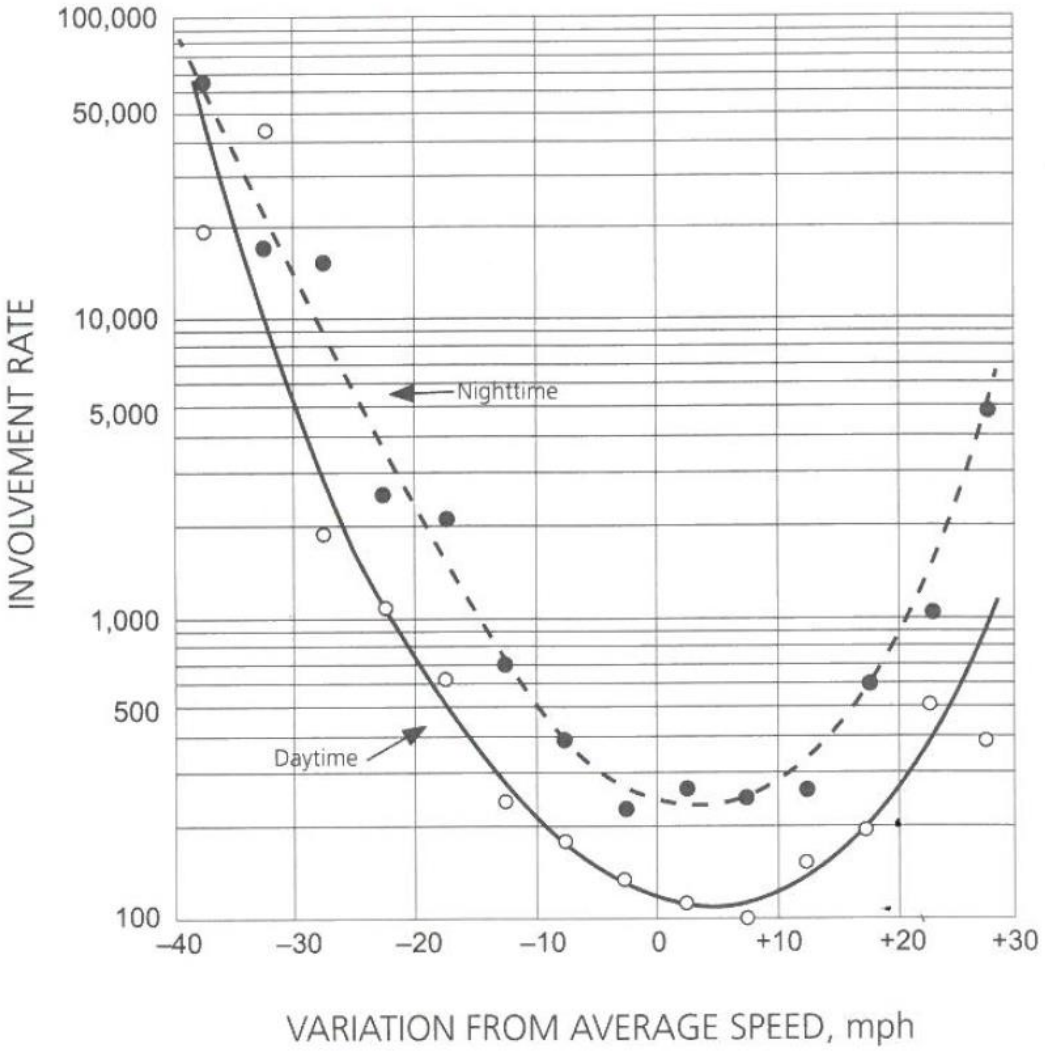
CMFs for Injury Crashes

Table 3E-2. Crash Modification Factors for Changes in Average Operating Speed (10)

Injury Crashes	$\bar{V}_0$ [mph]					
$\bar{V}_1 - \bar{V}_0$ [mph]	30	40	50	60	70	80
–5	0.57	0.66	0.71	0.75	0.78	0.81
–4	0.64	0.72	0.77	0.80	0.83	0.85
–3	0.73	0.79	0.83	0.85	0.87	0.88
–2	0.81	0.86	0.88	0.90	0.91	0.92
–1	0.90	0.93	0.94	0.95	0.96	0.96
0	1.00	1.00	1.00	1.00	1.00	1.00
1	1.10	1.07	1.06	1.05	1.04	1.04
2	1.20	1.15	1.12	1.10	1.09	1.08
3	1.31	1.22	1.18	1.15	1.13	1.12
4	1.43	1.30	1.24	1.20	1.18	1.16
5	1.54	1.38	1.30	1.26	1.22	1.20

NOTE: Although data used to develop these CMFs are international, the results apply to North American conditions.

Solomon Curve



(From Solomon's Figure 7) (22)

Figure 3E-3. Crash Involvement Rate by Variation from Average Speed (22)

Highway Safety Manual 1st Edition

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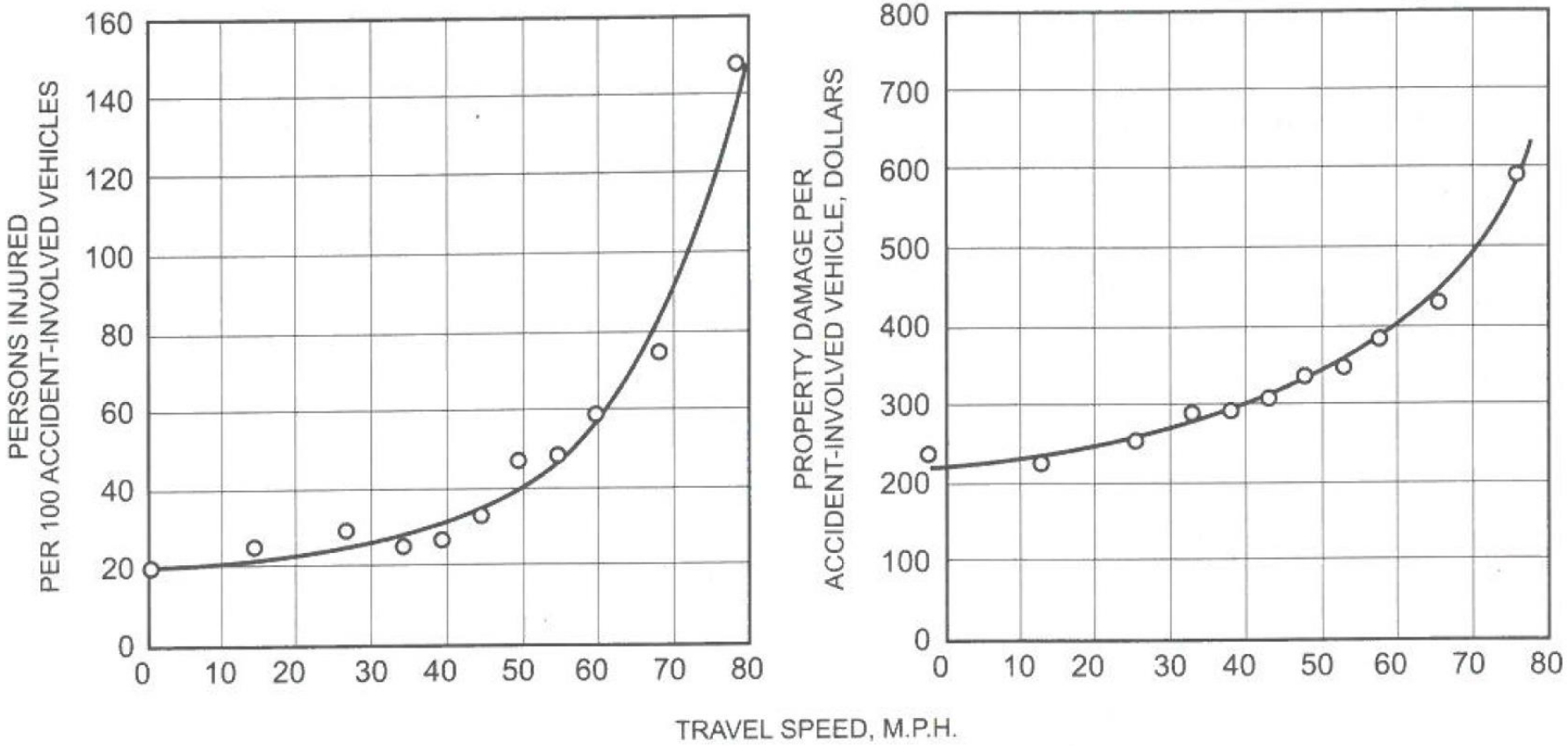
Injury and Property Damage



Note: The term *accident* is used in this graphic to remain consistent with the original source. The HSM does not use the term *accident* and AASHTO prefers the use of the term *crash*.

Fatal Injury Probability

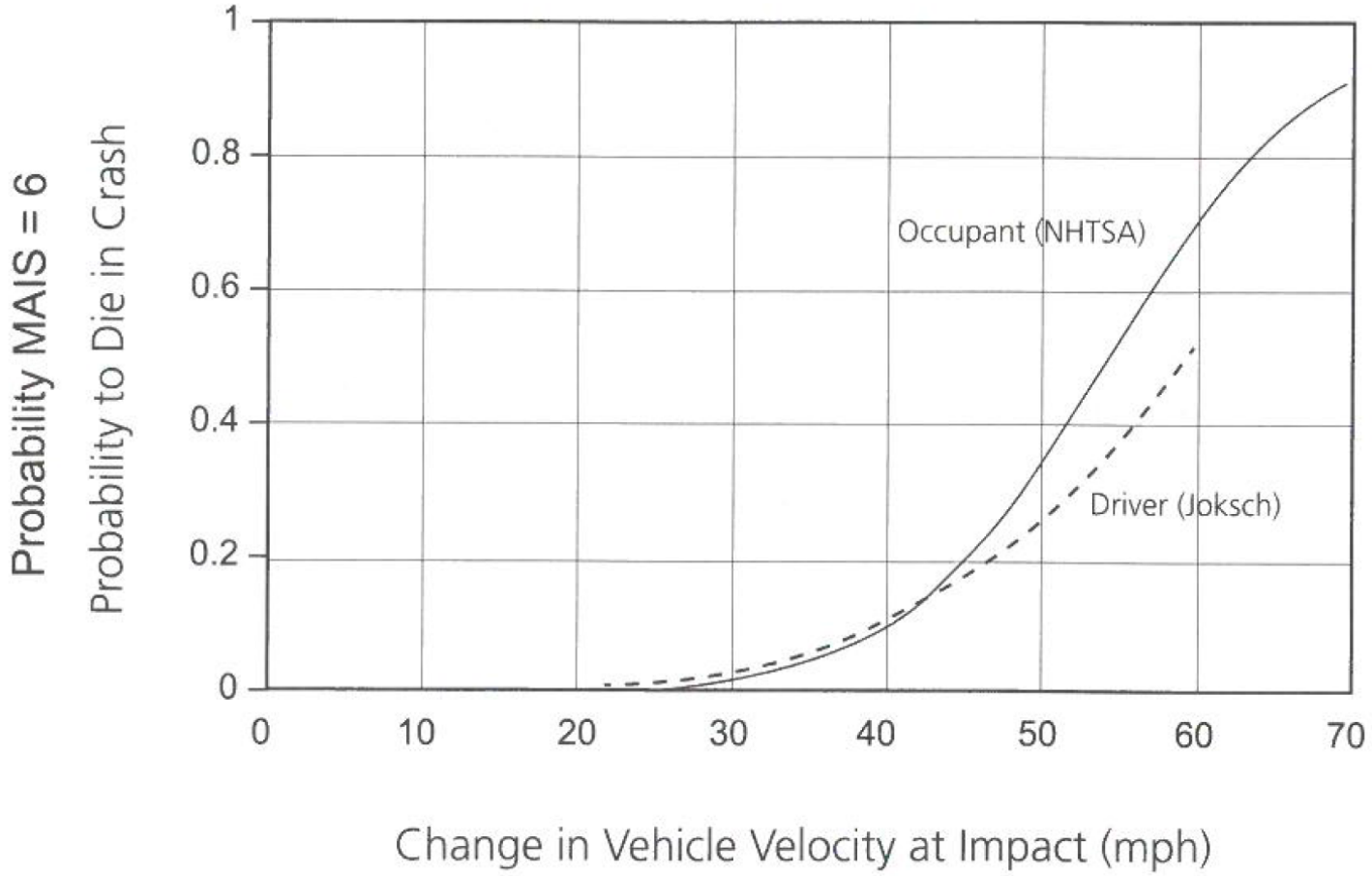
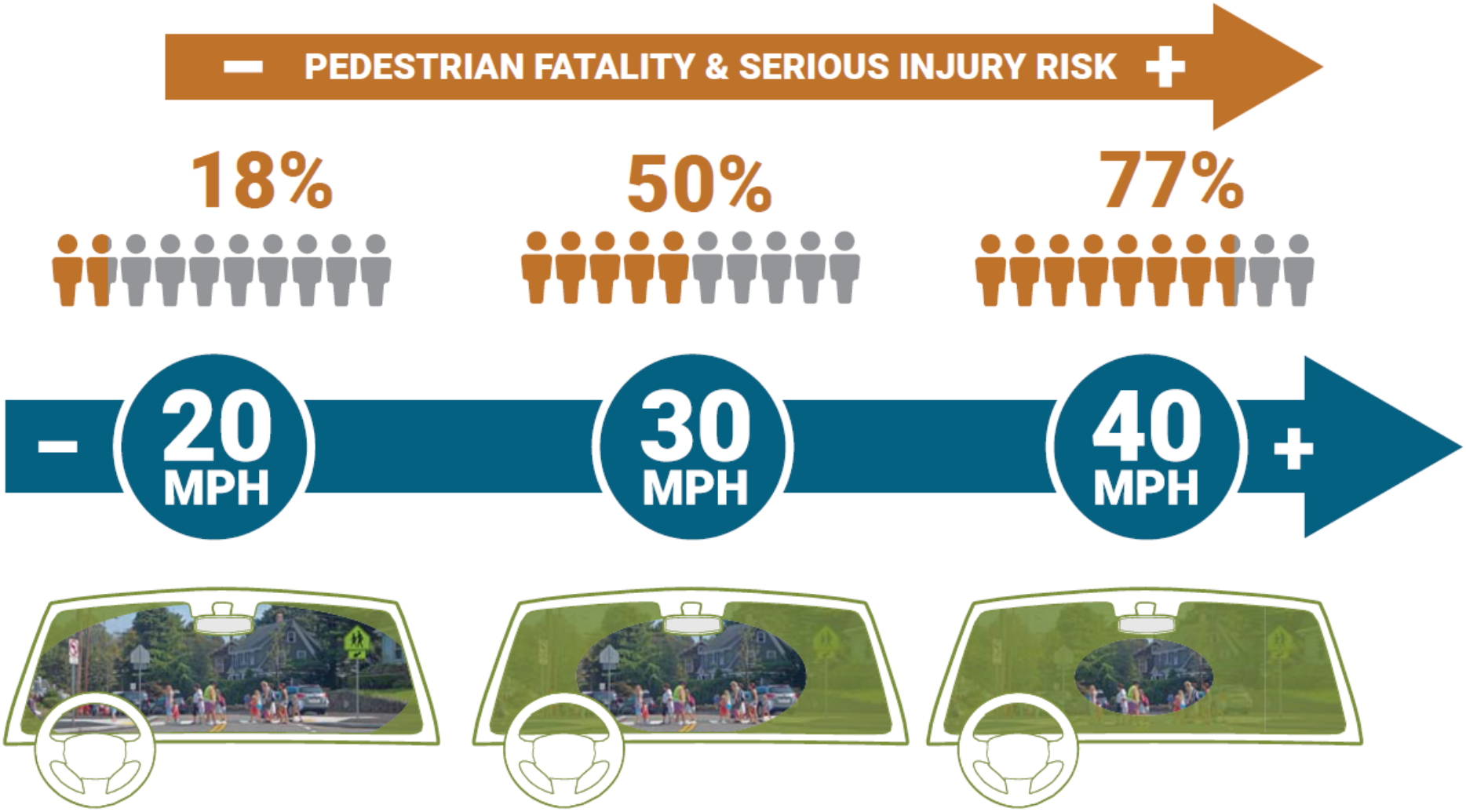


Figure 3E-5. Probability of Fatal Injury (MAIS = 6) to Drivers or Occupants by Change in Vehicle Velocity at Impact (14,20)



As motor vehicle speeds increase, the risk of serious injury or fatality for a pedestrian also increases ***(AARP Impact Speed and a Pedestrian's Risk of Severe Injury or Death 2011, p. 1)****. Also, motorist visual field and peripheral vision is reduced at higher speeds.*

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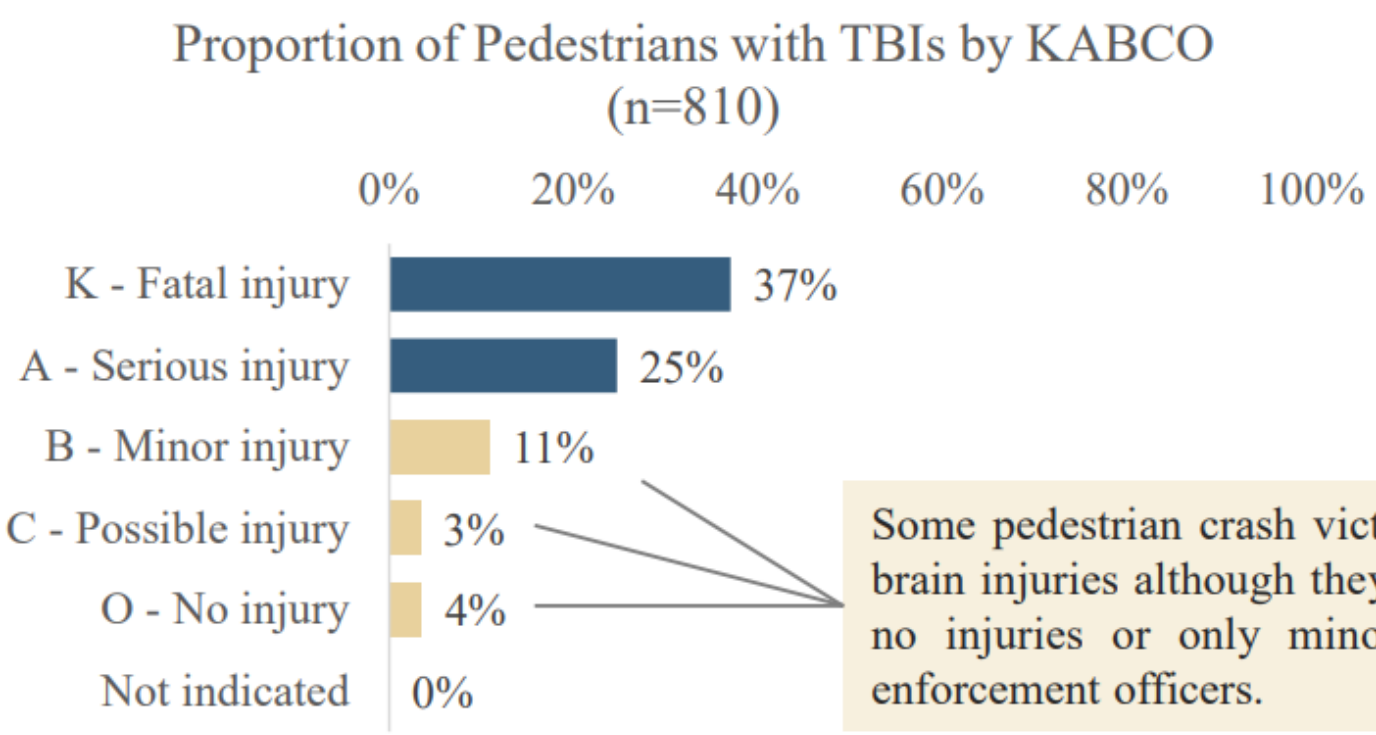
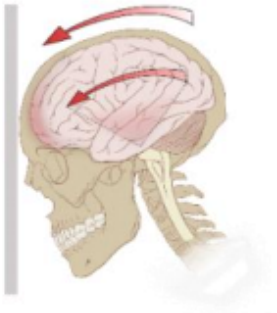
Achieving Multimodal Networks – Applying Design Flexibility & Reducing Conflicts. 2016. FHWA.

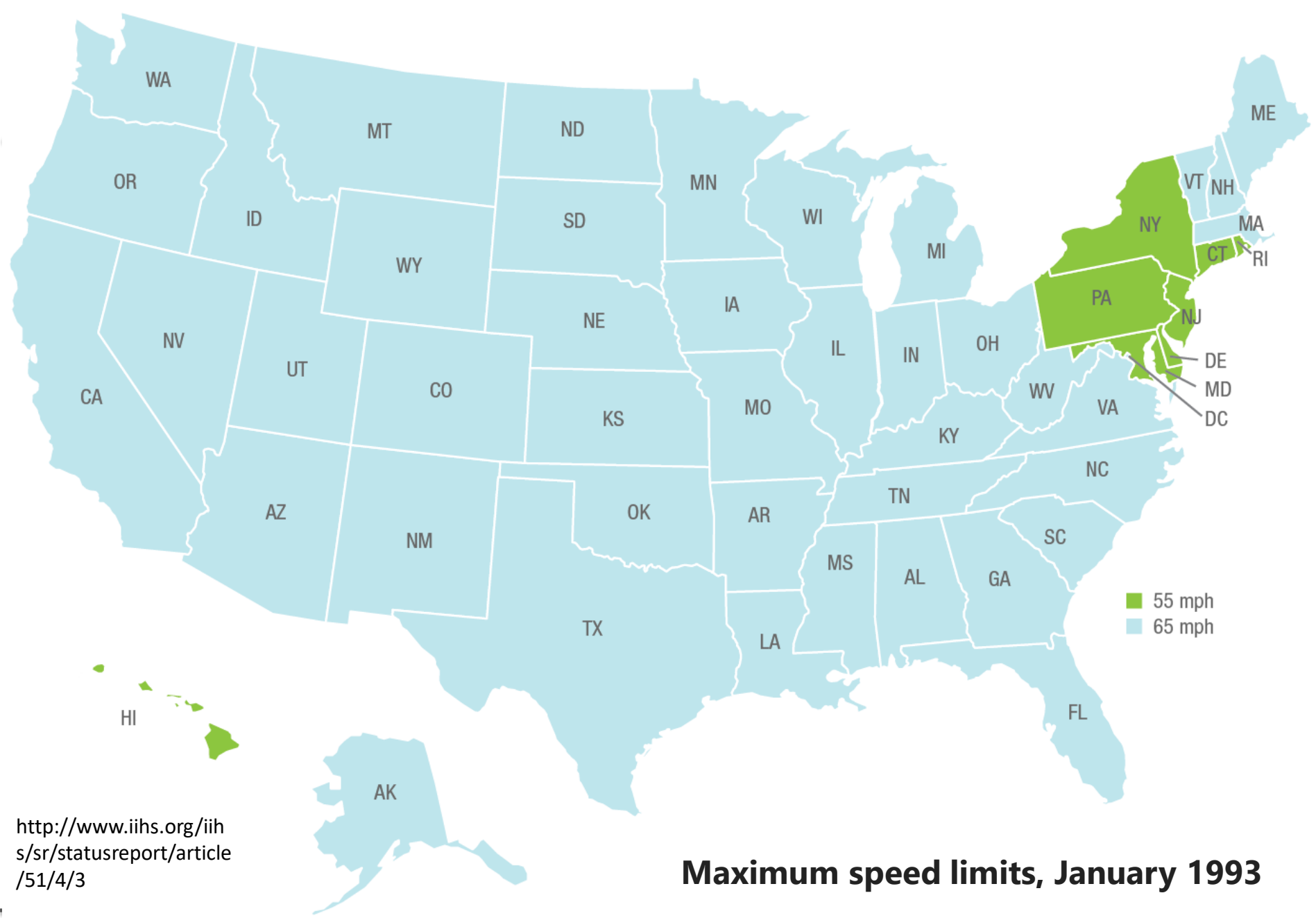
KABCO and Traumatic Brain Injury (TBI)





Some pedestrian crash victims had traumatic brain injuries although they appeared to have no injuries or only minor injuries to law enforcement officers.

http://cchi.web.unc.edu/files/2019/06/KABCO_FactSheet_2019.pdf



http://www.iihs.org/iihs/sr/statusreport/article/51/4/3

Maximum speed limits, January 1993

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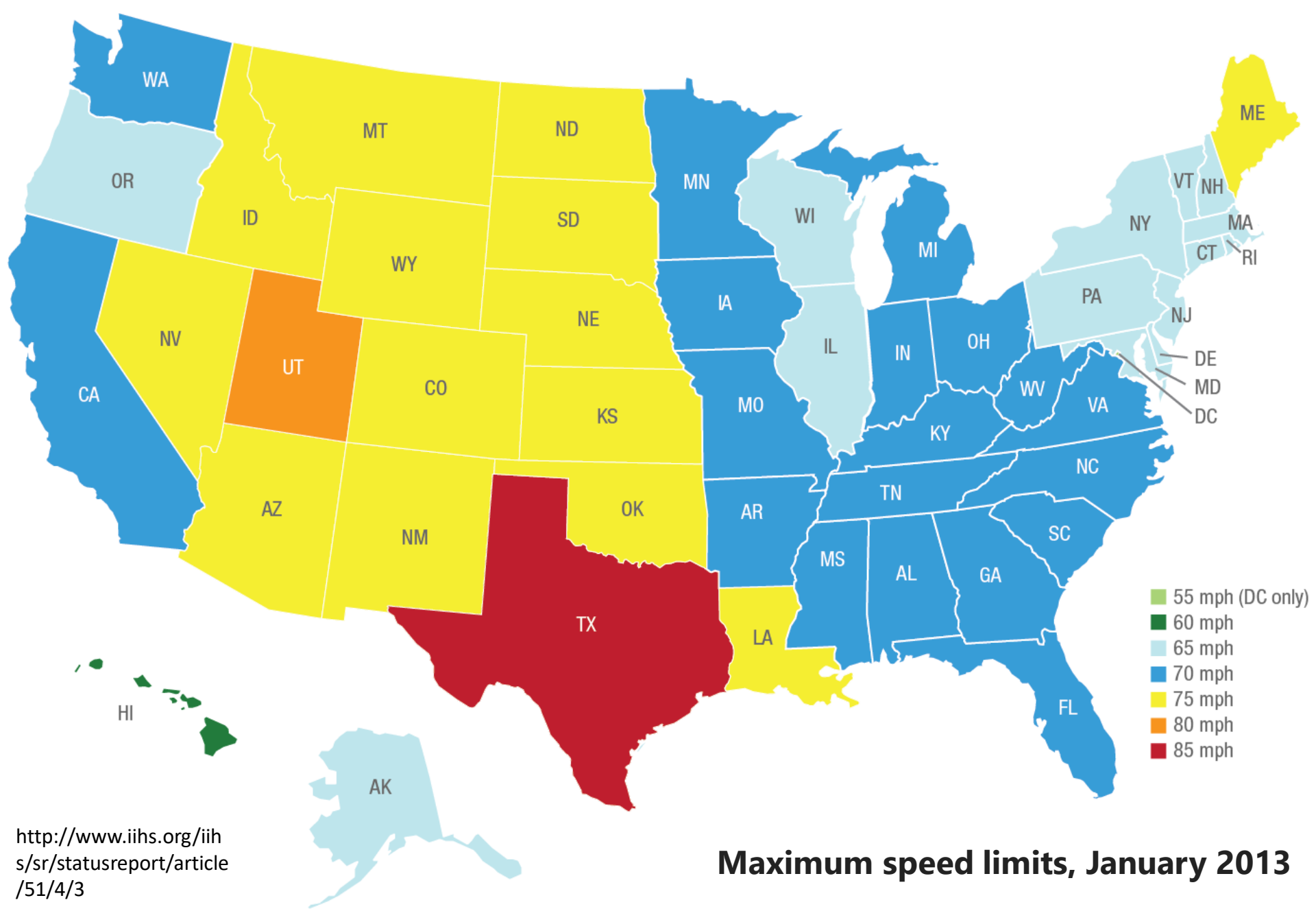

http://www.iihs.org/iihs/sr/statusreport/article/51/4/3

Maximum speed limits, January 2013

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Speed Limit Changes

- North Dakota bill (SB2057) to raise speed limits to 80 MPH
- Fiscal note details:

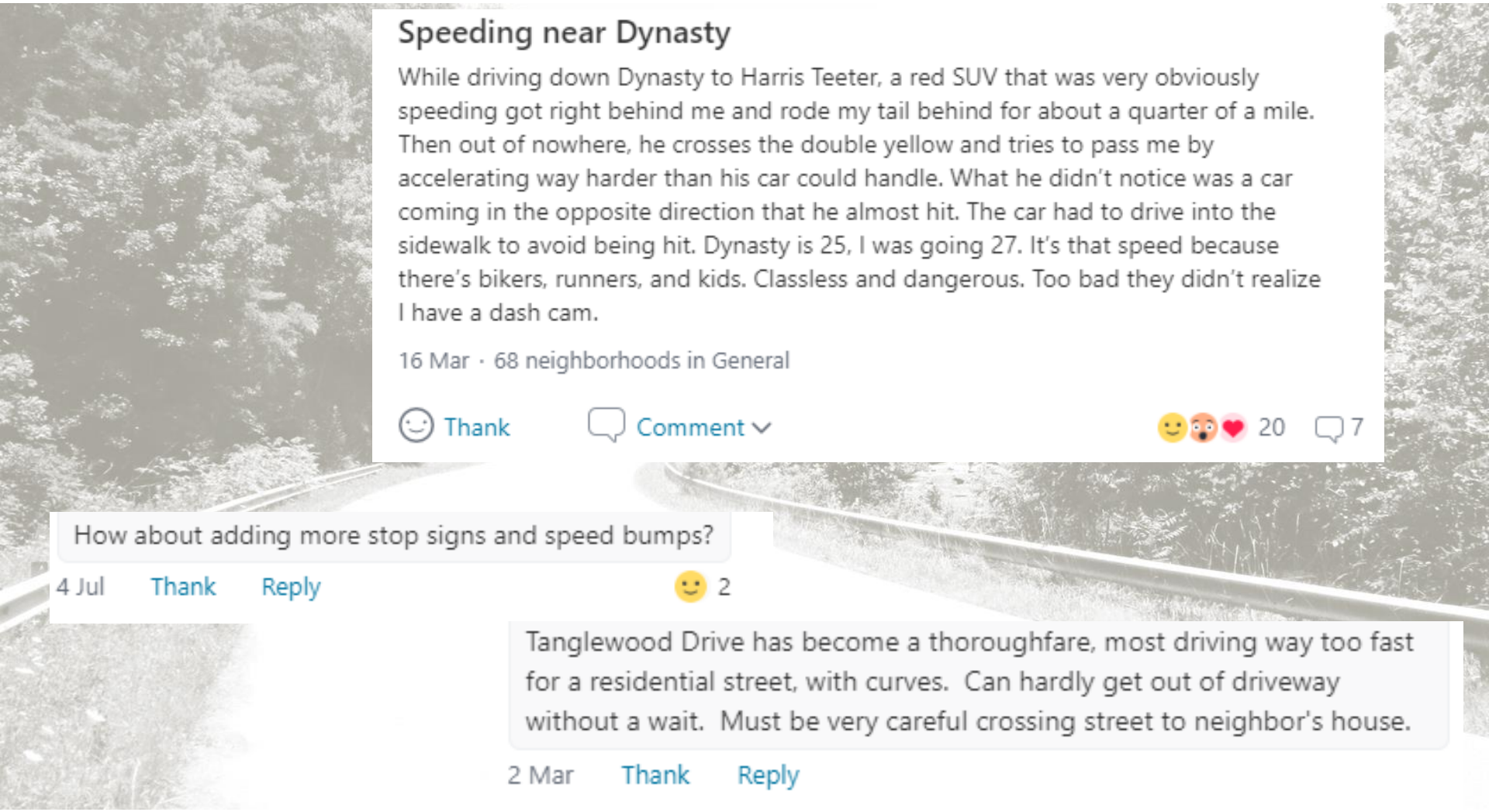
B. **Expenditures:** *Explain the expenditure amounts. Provide detail, when appropriate, for each agency, line item, and fund affected and the number of FTE positions affected.*

The initial fiscal impact that this bill will have is related to the need to change the speed limit signs on affected roadways. The estimated cost for the initial changes is $155,000.

After the initial impact, as the Department reconstructs the Interstate system or makes major improvements we must follow the standards set out in the AASHTO Green book on Geometric design and other Nationally recognized manuals. By increasing the speeds on the Interstate system, there are horizontal and vertical curves that would need to be reshaped, interchange ramps and acceleration or deceleration lanes would need to be lengthen, guardrail would need to be lengthen, speed limit signs would need to be replaced, box culverts and pipes would need to be lengthen, center bridge piers would need to be protected. As a result, after the initial impact, the longer term fiscal impact is estimated at $326.8 million.

http://www.legis.nd.gov/assembly/65-2017/fiscal-notes/17-0321-01000-fn.pdf

Public Complaints



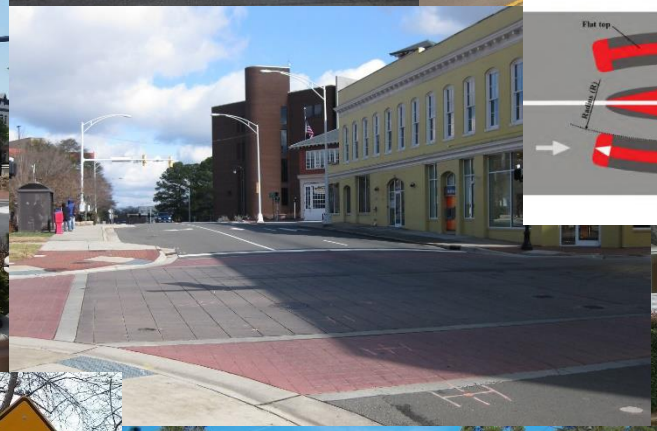

MAXIMUM
30
BEGINS
TRAFFIC CALMING ZONE
please drive slowly

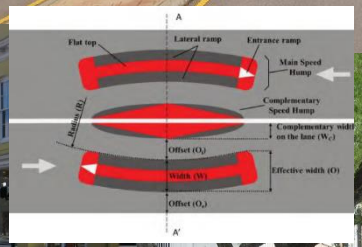





SPEED
LIMIT
25






A
Flat top
Lateral ramp
Entrance ramp
Main Speed Hump
Complementary Speed Hump
Complementary width on the lane (W_c)
Offset (O_1)
Width (W)
Effective width (O)
Offset (O_2)
A'

SPEED
HUMP


SPEED
LIMIT
25
YOUR
SPEED
28




SPEED
CUSHIONS
AHEAD
15
MPH

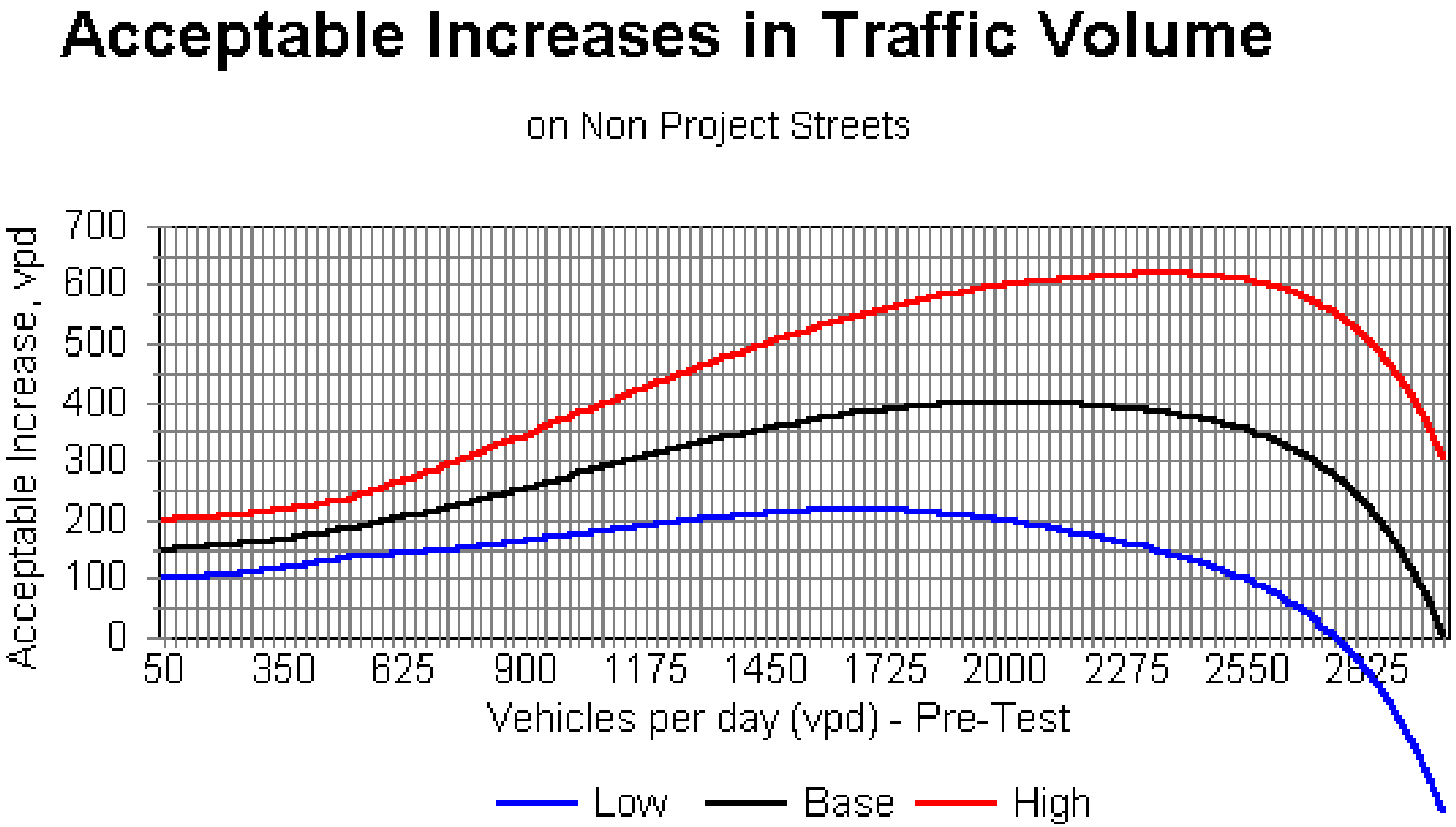





STOP


SPEED
HUMP
15

Implementation and Evaluation



Source: City of Portland. Impact Threshold Curve.
http://www.portlandoregon.gov/transportation/article/85375#curve



Setting Speed Limits

Developing Guidelines and Documentation of Engineering Studies for Establishing NC Speed Limits

NCDOT Research Project 2017-10 April 2018

https://connect.ncdot.gov/projects/research/Pages/ProjDetails.aspx?ProjectID=2017-10

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Speed Limits: NC Law

- Statutory
  - 35 mph inside municipal corporate limits
  - 55 mph outside municipal corporate limits
- Ordinance
  - Based on “an engineering and traffic investigation” by DOT

GS §20-141

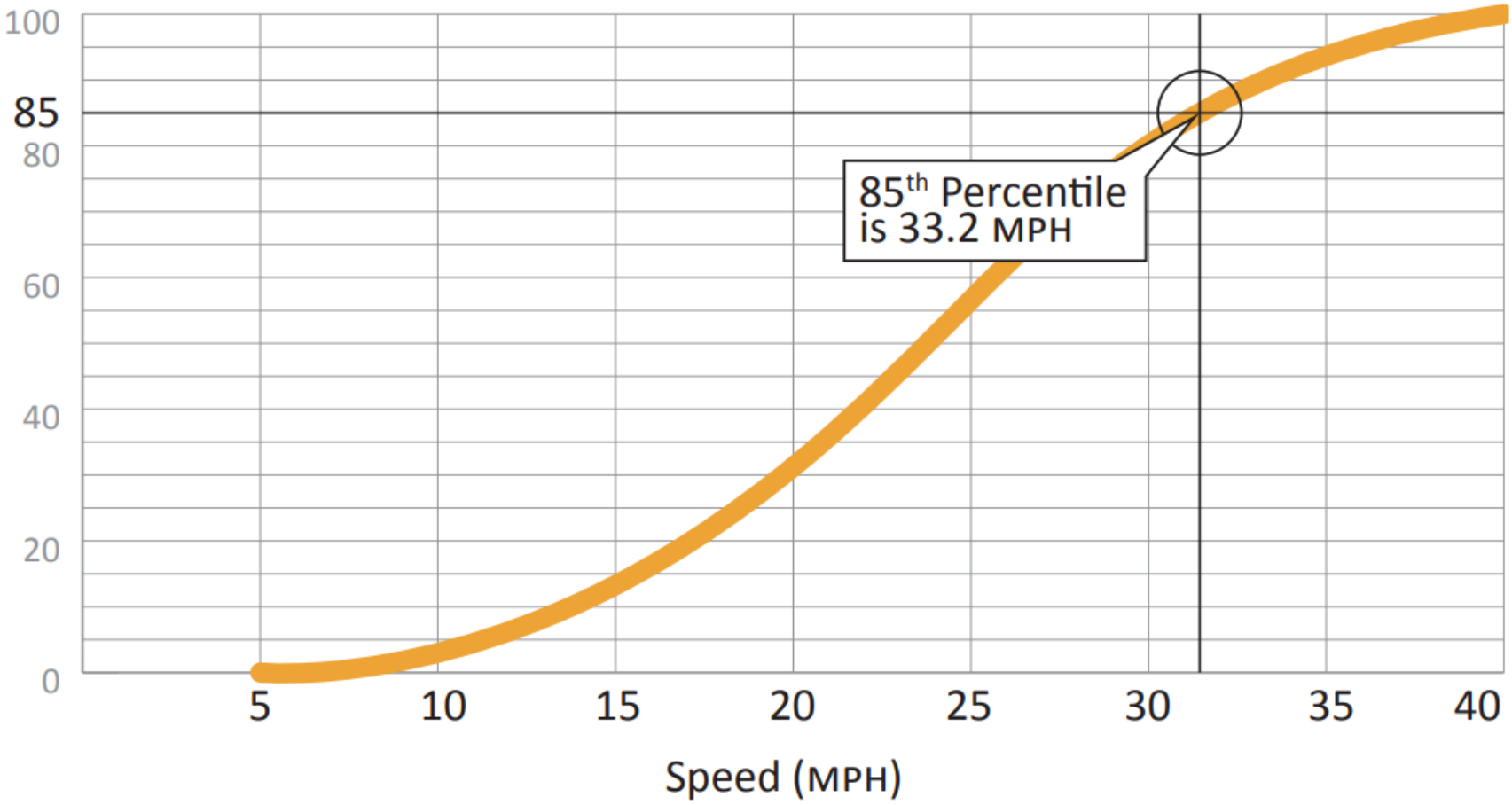
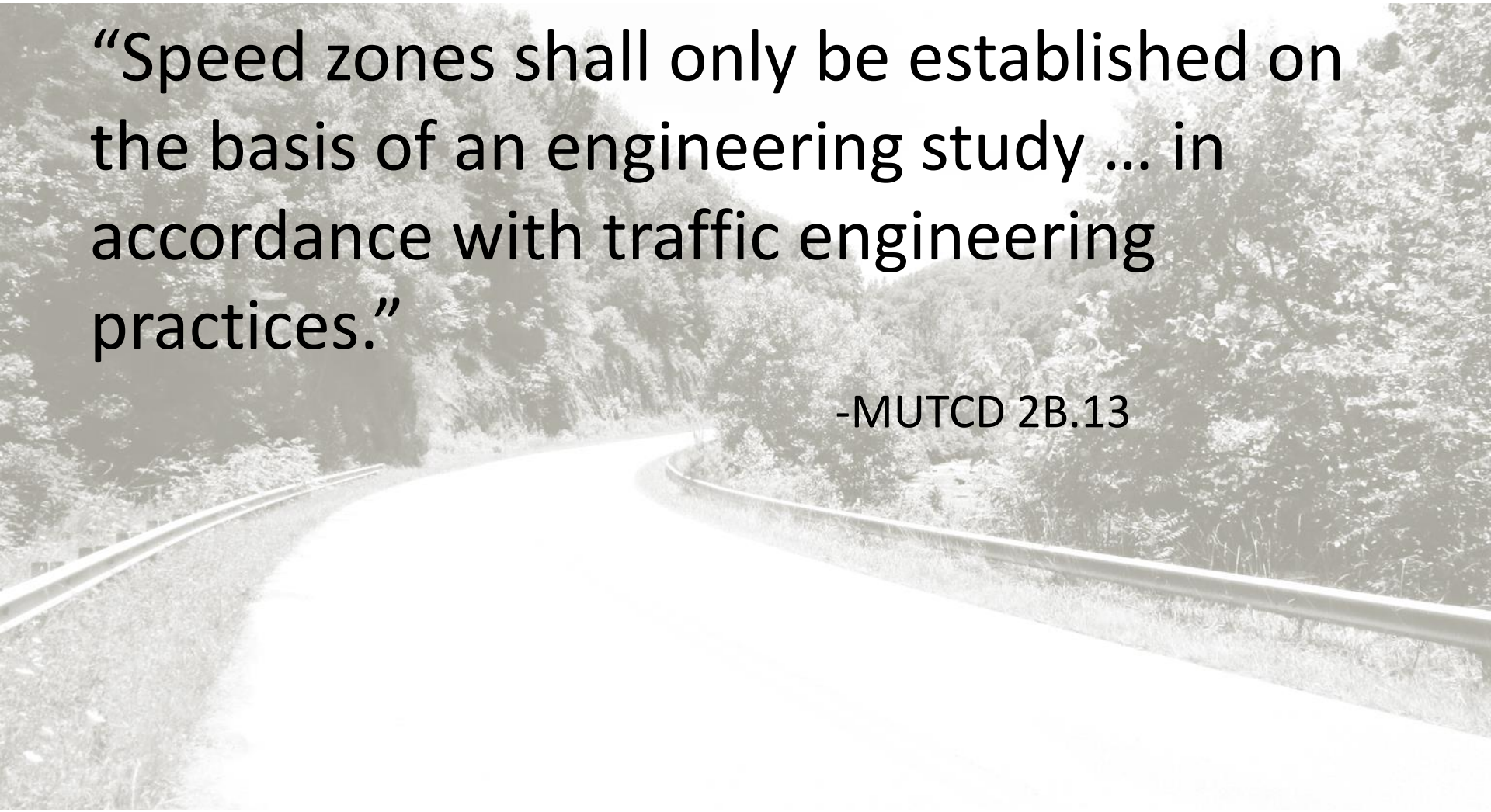


Figure 2. Graphical Depiction of 85th Percentile Speed.

What Constitutes a Traffic Study?



"Speed zones shall only be established on the basis of an engineering study … in accordance with traffic engineering practices."

-MUTCD 2B.13

NCDOT Policy

"It is policy to consider several topographic and traffic characteristics…[that] when considered together, should enable the investigator to arrive at a sound decision as to what speed limit is proper…"

-NCDOT Guidelines for the Establishment of Restrictive Speed Limits (1995)

Engineering Judgement

- Lack of prescriptive standard or equation
- Extensive list of factors to consider
  - Area type
  - Driveway/Intersection type & quantity
  - Multimodal facilities
  - Crash history
  - Surface treatment
  - Shoulders
  - Driving investigation
  - …

US Limits

- Expert System
- “Considerable effort has been expended to check the appropriateness of the maximum speed limit recommendations…[however] engineering experience and knowledge should be used…when interpreting the results.”

Challenges to Decisions

- Lawsuits by public challenging speed limits
- Problems arise if original engineer is unavailable to explain decision
- Variability in speed limit assessment and recording process

Process to Document Judgement

- Determine what information you need to collect
- Collect the information
- Analyze the information
- Render a decision

Speed Limit Decisions

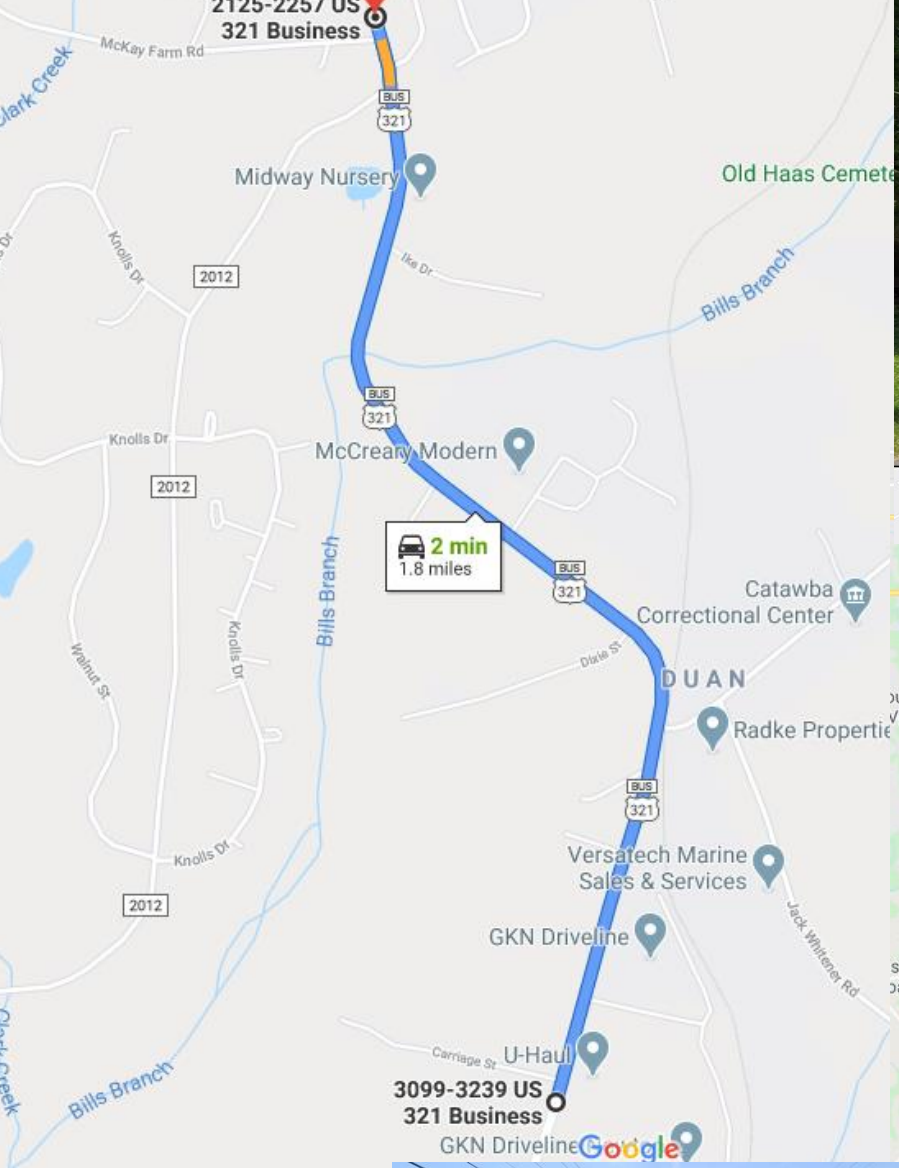
- Step 1: Determine needed information

The speed limit study should be conducted using the following steps. The completion of each item is at the discretion of the engineer.

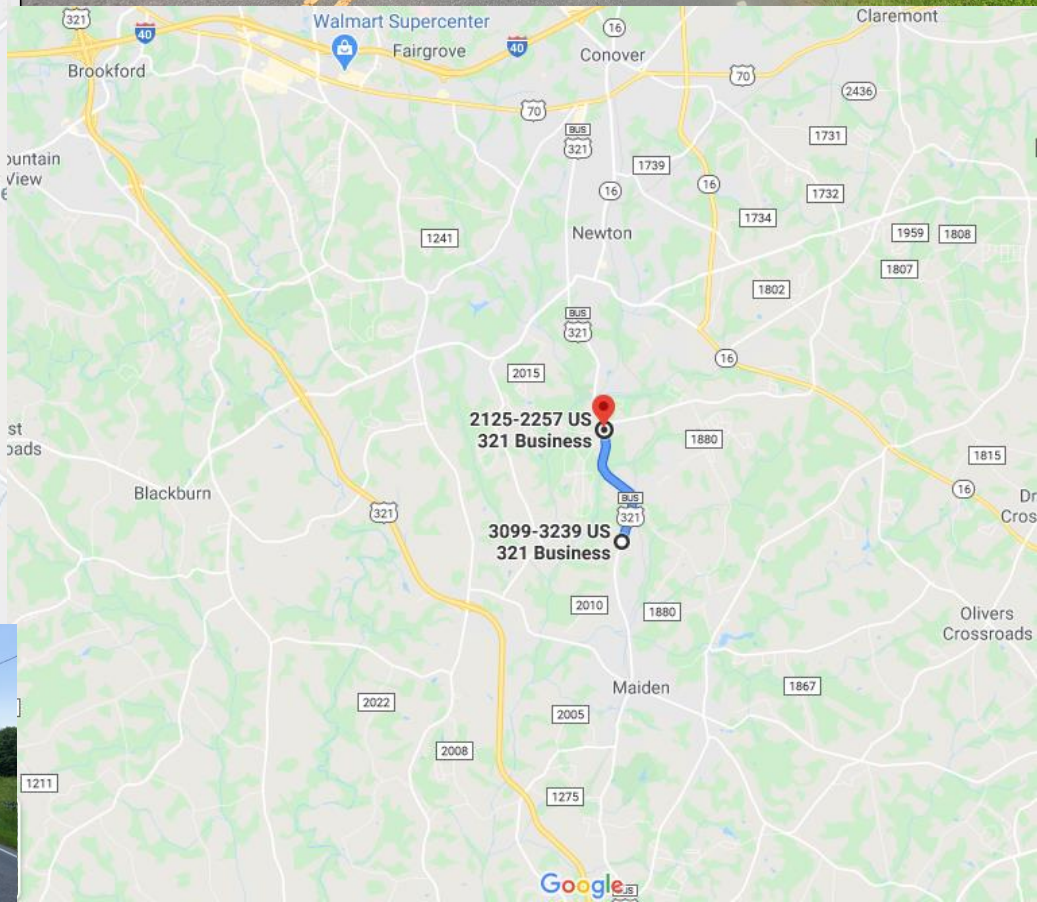
1. Determine the segmentation of the study road

   An initial review of aerial imagery, the crash report, and the roadway cross section should be conducted to determine if the roadway should be split into two or more segments. Reasons for segmenting the roadway may include:

   - Considerable change in driveway density
   - Considerable change in crash pattern
   - Considerable change in roadway cross-section outside of an intersection influence area
   - Considerable change in land use







Thanks to Byron Engle, PE (Div 12) for providing this example.



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Speed Limit Decisions

- Step 2: Collect the information

NCDOT Speed Limit Review - Data Collection OFFICE Worksheet **Draft Version 3**

Date: M M / D D / Y Y **Reference #:** _____ **Completed By:** _____

County: _____ **Municipality:** _____ **NCDOT Route ID:** _____

Study Road: _____ **Length:** _____ miles **Study Motivation:** _____

Study Segment Begins _____ _____ _____ of _____
(distance) *(units)* *(direction)* *(reference road)*

Study Segment Ends _____ _____ _____ of _____
(distance) *(units)* *(direction)* *(reference road)*

Current Speed Limit: _____ mph ☐ Statutory ☐ Ordinance # _____

Speed Limit Upstream of Starting Point: _____ mph ☐ Statutory ☐ Ordinance # _____

Speed Limit Downstream of Ending Point: _____ mph ☐ Statutory ☐ Ordinance # _____

Reset All Pages

NCDOT Speed Limit Review - Data Collection OFFICE Worksheet

Date: 9 / 25 / 2019 Reference #: Completed By: BKE

County: Catawba Municipality: NCDOT Route ID: 29000321018

Study Road: US 321 Business Length: 1.931 miles Study Motivation: District request

Current Speed Limit: 55 mph ☑ Statutory ☐ Ordinance # _____ **Terrain:** Rolling

Speed Limit Upstream of Starting Point: 45 mph ☐ Statutory ☑ Ordinance # 1058670

Speed Limit Downstream of Ending Point: 45 mph ☐ Statutory ☑ Ordinance # 1068236

Past Speed Studies

Date: _____ Result: _____

Road Classification & Area Type

Functional Class: Rural-Arterials-Principal-Other Princip **NCDOT Complete Street Area Type:** Rural Road

AADT: 9400 vehicles per day

Number of Driveways by Type: 6 Business 34 Residential 1 Other: SHP

Driveway Density: ☐ Consistent throughout segment ☐ Considerable variation throughout segment

Number of Intersections by Type: 0 Signalized 9 Unsignalized

Typical Building Offset to Roadway: ☐ Consistent _____ feet (approximate) ☑ Varies from 50 to 100 feet (approximate)

Multimodal Facilities	Y	N	
Are schools present along the segment?	☐	☑	Note:
Are parks or recreation areas present along the segment?	☐	☑	Note:
Are pedestrian facilities present along the segment?	☐	☑	Note:
Are transit facilities designated along the segment?	☐	☑	Note:
Are bicycle facilities designated along the segment?	☐	☑	Note:
Is on-street parking designated?	☐	☑	Note:

Crashes

Date: 7 / 1 / 14 to 6 / 30 / 19 TEAAS Mile Post: 4.270 to 6.201

Fatal: 0 A: 0 B: 1 C: 6 PDO: 12

Total Rate: 57.32 per 100 million VMT State-wide rate for road type: _____ per 100 million VMT

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NCDOT Speed Limit Review - Data Collection FIELD Worksheet

Date: 9 / 25 / 2019 Reference #: _____ Completed By: BKE

County: Catawba Current Speed Limit: 55 mph

Study Road: US 321 Business from SR 2010 to SR 1884

Surface Treatment

Typical Pavement Width: feet

Driving Investigation

Conduct a driving investigation of the segment and note any areas with potentially inadequate sight distance, vertical alignment, or horizontal alignment. Include comments on locations where travel speed is constrained. Attach ball-bank study sheet if needed.

Notes: Terrain limits sight distance to driveways and streets.

Recoverable Shoulder: ☐ Yes ☑ No Comment: drop off areas

Curb: ☐ Vertical ☐ Sloped ☐ None

Typical Distance to Roadside Hazards: ____ feet ☑ Varies from 6 to 50 feet

Roadsize Hazard Rating: 6

Driving Investigation

Conduct a driving investigation of the segment and note any areas with potentially inadequate sight distance, vertical alignment, or horizontal alignment. Include comments on locations where travel speed is constrained. Attach ball-bank study sheet if needed.

Notes: Terrain limits sight distance to driveways and streets.

Check as appropriate

Pedestrian Activity Observed/Expected:	☑ None	☐ Low	☐ Medium	☐ High
Bicycle Activity Observed/Expected:	☑ None	☐ Low	☐ Medium	☐ High
Truck Activity Observed/Expected:	☐ None	☐ Low	☑ Medium	☐ High

Operating Speed Study

Result of current operating speed study (this may include the results from US Limits 2):

Comfortable operating speed was between 45 mph and 50 mph

Purpose of Road

Explain the main purpose of the road. See user guide for examples.

It is an arterial that connects residents and manufacturing to other major arterials.

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NCDOT Speed Limit Review - Data Collection FIELD Worksheet (cont.)

Notes

Use this sheet to record any additional notes about the study segment or the data collection effort. Note any warning or regulatory signs missing or in visible need of replacement or repair. An image or drawing of the site may be provided at the bottom.

All signs are in place for curve warning plus chevrons. There is a State Highway Patrol station on the road as well as a driver testing facility.

Plan-view Sketch of Road Segment *Include major intersecting roads and label each intersection control type*

Photographs

Description of any photographs attached (complete as necessary)

Notes: _____

Attachments *Check as appropriate and list additional attachments*

- [x] Strip Analysis/Crash Data
- [x] Features Report
- [ ] Neighborhood Petition
- [ ] Photographs
- [ ] Speed Data
- [x] Ball Bank Study Form
- [ ] _____
- [ ] _____
- [ ] _____

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North Carolina Department of Transportation
Traffic Engineering Accident Analysis System
Strip Analysis Report

Study Criteria Summary

County: CATAWBA City: All and Rural
Date: 7/1/2014 to 6/30/2019 Study: CATAWBACOUNTYUS321BUS
Location: US 321 Business between Newton and Haiden, NC.

Report Details

Acc No	Crash ID	Milepost	Date	Accident Type	Total Damage	Injuries F	A	B	C	Condition R	L	W	Road Ch	Ci	Trfc Ctl Dv	Op
1	105873600	4.467	05/22/2019 14:17	LEFT TURN, SAME ROADWAY	$ 22000	0	0	0	1	1	1	1	1	0	13	1
Unit 1 : 1		Alchl/Drgs: 0														
Unit 2 : 1		Alchl/Drgs: 0														
Unit 3 : 1		Alchl/Drgs: 0														
2	105334461	4.781	12/26/ 15:0													
Unit 1 : 1		Alchl/Drgs: 0														
Unit 2 : 2		Alchl/Drgs: 0														
3	104453540	4.881	08/05/ 23:1													
Unit 1 : 4		Alchl/Drgs: 0														
4	105591348	4.881	08/30/ 16:3													
Unit 1 : 2		Alchl/Drgs: 0														
Unit 2 : 1		Alchl/Drgs: 2														
5	105634825	4.898	10/06/ 13:4													
Unit 1 : 1		Alchl/Drgs: 0														
Unit 2 : 1		Alchl/Drgs: 0														
6	104786185	4.981	07/02/ 16:5													
Unit 1 : 4		Alchl/Drgs: 0														
Unit 2 : 2		Alchl/Drgs: 0														
7	105559752	5.041	07/26/ 21:4													
Unit 1 : 4		Alchl/Drgs: 0														
Unit 2 : 4		Alchl/Drgs: 7														
8	105695048	5.441	11/30/ 22:3													
Unit 1 : 1		Alchl/Drgs: 0														

09/06/2019 All data presented in this criteria provided by the

North Carolina Department of Transportation
Traffic Engineering Accident Analysis System
Strip Analysis Report

Acc No	Crash ID	Milepost	Date	Accident Type	Total Damage	Injuries F	A	B	C	Condition R	L	W	Road Ch	Ci	Trfc Ctl Dv	Op
9	104192040	5.631	10/23/2014 17:06	FIXED OBJECT	$ 10320	0	0	0	1	1	1	1	7	0	13	1
Unit 1 : 2		Alchl/Drgs: 0		Speed: 45 MPH	Dir: N					Veh Mnvr/Ped Actn: 4				Obj Strk: 38		
10	105591534	5.831	08/27/2018 13:19	REAR END, SLOW OR STOP	$ 2500	0	0	0	0	1	1	1	3	0	13	1
Unit 1 : 2		Alchl/Drgs: 0		Speed: 5 MPH	Dir: S					Veh Mnvr/Ped Actn: 4				Obj Strk:		
Unit 2 : 4		Alchl/Drgs: 0		Speed: 0 MPH	Dir: S					Veh Mnvr/Ped Actn: 1				Obj Strk:		
			/2015 :32	REAR END, SLOW OR	$ 5000	0	0	0	0	1	1	1	3	0	13	1

Ball Bank Indicator Worksheet — Version 1

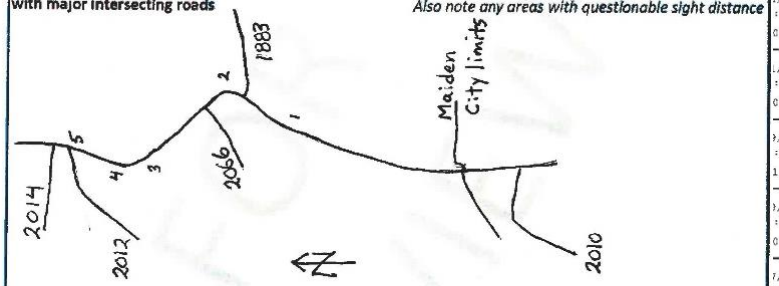
Date: 10 / 22 / 19 Reference #: Completed By: BKF

County: Catawba Co. Municipality:

Study Road: US 321 Bus Current Speed Limit: 55mph

Plan-view sketch of road segment with major intersecting roads

Number each horizontal curve (HC1, HC2, HC3, etc) Also note any areas with questionable sight distance



Presence of Advisory Speed Signs & Ballbank Indicator Readings

For each curve, note the posted advisory speed limit or that such sign is not present (NP)

For each curve, note if the BBI has a reading less than or greater than 12.0

Horizontal Curve	1	2	3	4	5	6	7	8	9	10	11	12
Advisory Speed Limit	AS	35	AS	35	AS	AS	AS	AS	AS	AS	AS	AS

50 50 Posted Speed

Curve		1	2	3*	4*	5	6	7	8	9	10	11	12
55	1st Drive	5	17	10	15	10		↑	↑	↑	↑	↑	↑
	Thru	5	18	10	20	10		↓	↓	↓	↓	↓	↓
45	2nd Drive	3	11	7	10	7		↑	↑	↑	↑	↑	↑
	Thru	3	14	9	12	8		↓	↓	↓	↓	↓	↓
	3rd Drive							↑	↑	↑	↑	↑	↑
	Thru							↓	↓	↓	↓	↓	↓

Posted Speed +5 MPH

Curve		1	2	3	4	5	6	7	8	9	10	11	12
	1st Drive	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Thru	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	2nd Drive	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Thru	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	3rd Drive	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Thru	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

Posted Speed -5 MPH

Curve		1	2	3	4	5	6	7	8	9	10	11	12
	1st Drive	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Thru	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	2nd Drive	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Thru	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	3rd Drive	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Thru	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

North Carolina Department of Transportation
Traffic Engineering Accident Analysis System
Strip Analysis Report

Summary Statistics

High Level Crash Summary

Crash Type	Number of Crashes	Percent of Total
Total Crashes	19	100.00
Fatal Crashes	0	0.00
Non-Fatal Injury Crashes	7	36.84
Total Injury Crashes	7	36.84
Property Damage Only Crashes	12	63.16
Night Crashes	4	21.05
Wet Crashes	3	15.79
Alcohol/Drugs Involvement Crashes	2	10.53

Crash Severity Summary

Crash Type	Number of Crashes	Percent of Total
Total Crashes	19	100.00
Fatal Crashes	0	0.00
Class A Crashes	0	0.00
Class B Crashes	1	5.26
Class C Crashes	6	31.58
Property Damage Only Crashes	12	63.16

Vehicle Exposure Statistics

Annual ADT = 9400

Total Length = 1.931 (Miles) 3.108 (Kilometers)

Total Vehicle Exposure = 33.14 (MVMT) 53.34 (MVKMT)

Crash Rate	Crashes Per 100 Million Vehicle Miles	Crashes Per 100 Million Vehicle Kilometers
Total Crash Rate	57.32	35.62
Fatal Crash Rate	0.00	0.00
Non Fatal Crash Rate	21.12	13.12
Night Crash Rate	12.07	7.50
Wet Crash Rate	9.05	5.62
EPDO Rate	213.61	132.73

09/06/2019 All data presented in this report comes explicitly from the Traffic Engineering Accident Analysis System based upon various input criteria provided by the report's creator. The onus is strictly upon the user of this report to exercise due diligence in interpreting and further representing this data. -4-

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Speed Limit Decisions

- Step 3: Analyze the information

Element	Not Evaluated/ Not Applicable	Supports Reducing Speed Limit	Supports No Change in Speed Limit	Supports Increasing Speed Limit	Check If Element is Critical
Road Classification & Area Type					☐
Driveways / Intersections / Offset					☐
Multimodal Facilities					☐
Crashes					☐
Surface Treatment					☐
Shoulders					☐
Driving Investigation					☐
Operating Speed Study					☐
Purpose of Road					☐
Neighborhood Petition					☐
Statutory Speed Limit					☐
Other:					☐

Guidance on Factors to Consider

Factor	An Increase in ___	Generally Supports	Notes
Road Classification & Area Type, Purpose of Road	Density, Urban	Lower Speeds	Review NCDOT Complete Streets Document
Driveways / Intersections / Offset	Access Density	Lower Speeds	40+ per mi for significant impacts
Multimodal Facilities	Ped, Bike Volume	Lower Speeds	
Crashes	Severe Injury Speed Related Crashes	Lower Speeds	
Surface Treatment	--	--	Consider speed limit change only temporarily until resurfacing
Shoulders	Shoulder Width	Higher Speeds	Benefits stop at 6ft/side
Alignment/Curves	Grade/Tight Curves	Lower Speeds	Ball Bank for Advisory speeds
Operating Speed Study	$50^{th}/85^{th}$ or other observed speeds	Higher Speeds	USLIMITS2 Flow Charts by Facility Type

NCDOT Speed Limit Review - Speed Limit Assessment Worksheet

Date: _____ **Reference #:** _____ **Completed By:** _____

County: Catawba **Current Speed Limit:** 55 mph

Study Road: US 321 Business from SR 2010 to SR 1884

This worksheet helps to record the elements considered by the engineer when determining a speed limit. For each element, place an X in the appropriate column depending on whether the element supports increasing the speed limit, decreasing the speed limit, or maintaining the current speed limit.

In the far column, check the box if the element is critical in determining the speed limit for this road.

Element	Not Evaluated/ Not Applicable	Supports Reducing Speed Limit	Supports No Change in Speed Limit	Supports Increasing Speed Limit	Check If Element is Critical
Road Classification & Area Type		✓			☑
Driveways / Intersections / Offset		✓			☐
Multimodal Facilities					☐
Crashes		✓			☐
Surface Treatment					☐
Shoulders					☐
Driving Investigation		✓			☑
Operating Speed Study					☐
Purpose of Road					☐
Neighborhood Petition					☐
Statutory Speed Limit					☐
Other:					☐
Other:					☐
Other:					☐

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Speed Limit Decisions

- Step 4: Render a decision

Comments and Discussion

Include any additional factors which influenced the recommended speed limit. This could include observed traffic conflicts, conditions not readily apparent to the driver (e.g. hidden driveways, schools, shopping centers, seasonal generators, or generators which create unique traffic conditions), or known tourist facility. It may also include consistency with other nearby similar roads.

_____

_____

_____ **Recommended Speed Limit:** _____ **mph**

Recommended Speed Limit: 45 **mph**

NCDOT Speed Limit Review - Speed Limit Determination Worksheet (cont.)

Comments and Discussion

Include any additional factors which influenced the recommended speed limit. This could include observed traffic conflicts, conditions not readily apparent to the driver (e.g. hidden driveways, schools, shopping centers, seasonal generators, or generators which create unique traffic conditions), or known tourist facility. It may also include consistency with other nearby similar roads.

This section is consistent with the adjoining 45 mph ordinance sections of US 321 Business. Utilities, trees, embankment, etc. all within 6 feet to 50 feet from the edge of pavement. The terrain limits sight distance to driveways, industrial entrances and streets. A driver license testing facility is located on these section.

Questions?



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