Advanced Design Flexibility Workshop

Session 7

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CONSTRAINED RIGHTS-OF-WAY

HRGreen ZAN ASSOCIATES

The Challenges

- Working in built urban context
- Building around environmental resources
- Accommodating multiple modes
- Avoiding right-of-way acquisition
- Designing a retrofit solution

Urban Areas Especially Challenging

- Much competition for space, particularly in urban areas
- Significant growth in walking, biking and transit ridership

Did you know that:

- Many downtown streets have 10’ lanes
- 9’ parking lanes are often used as traffic lanes during peak periods

Designing the "Footprint"

- How do we size the facility?
- How do we allocate the space?
- What performance requirements apply?

Putting the Pieces Together

There are many ways to "assemble" the elements of a Cross-Section

Elements are Interdependent

Finding the Flexibility

- Number of Lanes
- Space Allocation
- Lane Widths
- Shoulder Widths
- Clear Zones and Reaction Distance
- Hazard Mitigation

Options for Allocating Space

Widen about the centerline using our standard typical section

↓

Widen asymmetrically

↓

Develop new, independent centerline

↓

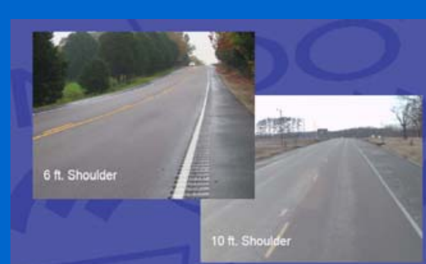
Vary alignment and width to fit

↓

"Outside in!" (German model)

Function & Influence of Lane Design

- Accommodates variation in lateral placement of vehicles in lane (and between lanes)
- Accommodates variation in widths of vehicles
- Influences traffic safety ("forgiving")
- Influences traffic operations (capacity)



Know the Vehicle Mix

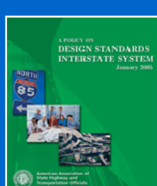
- Large trucks and buses: 8.5 ft maximum
- SUV/Small Truck: <7.5 ft
- Passenger vehicle: <6.5 ft
- Mirrors: 0.5-1.0 ft (but various heights)

Lane Width Design Values

Ranges for Lane Width

Type of Roadway	Rural		Urban	
	US (feet)	Metric (meters)	US (feet)	Metric (meters)
Freeway	12	3.6	12	3.6
Ramps (1-lane)	12–30	3.6–9.2	12–30	3.6–9.2
Arterial	11–12	3.3–3.6	10–12	3.0–3.6
Collector	10–12	3.0–3.6	10–12	3.0–3.6
Local	9–12	2.7–3.6	9–12	2.7–3.6

Source: A Policy on Geometric Design of Highways and Streets, AASHTO



Width of Traffic Lanes

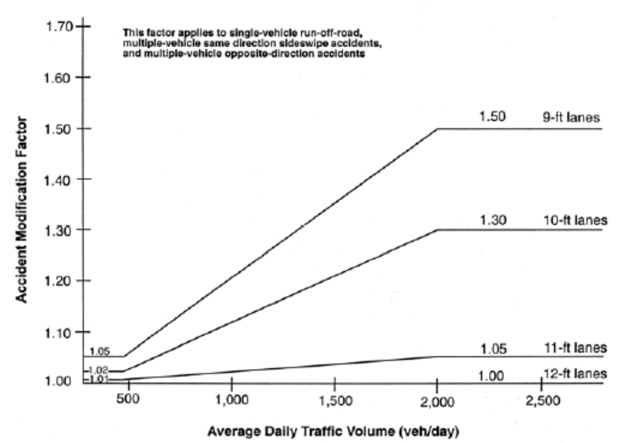
All traffic lanes shall be at least 3.6 m (12 ft) wide.

Lane Width and Risk

- Rural lane width design values based on risk-based approach (NCHRP 362)
- Less direct evidence of a safety benefit of wider lanes in urban areas
- Provide for a total cross section that considers left turning vehicles, medians, and the needs of pedestrians & bicyclists

Effects of Reduced Rural Lane Width

Accident Modification Factors for Lane Width on Rural Two-Lane Highways.
(Source: Prediction of the Expected Safety Performance of Rural Two-Lane Highways, FHWA)



Effects of Reduced Urban Lane Width

- *"The lane width effects in the analyses were generally either not statistically significant or indicated that narrower lanes were associated with lower rather than higher crash frequencies. There were limited exceptions to this general finding."*

Source: Potts et al., Relationship of Lane Width to Safety for Urban and Suburban Arterials, TRB 2007 Annual Meeting.

Lane Width Reductions on Freeways

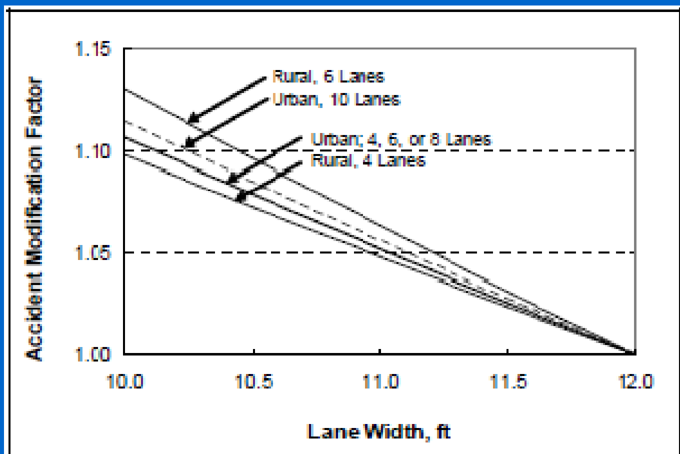


Figure 2-3. Lane Width AMF.

Effects of Reduced Freeway Lane Width

Operational Effects of Freeway Lane Widths

Lane width (ft)	Reduction in Free-Flow Speed (mi/h)
12	0.0
11	1.9
10	6.6

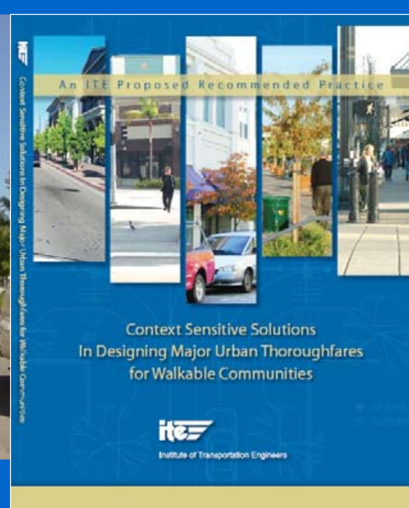
Lane Width Considerations

- Adjoining land uses (urban or rural)
- Other modes
- Operating speed
- Vehicle mix
- Specific crash history
- Cost

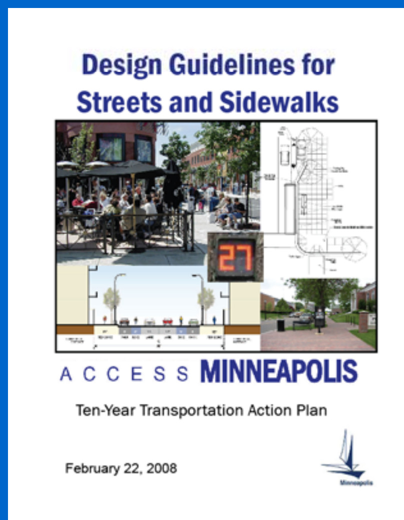
Cost of Excessive Street Width

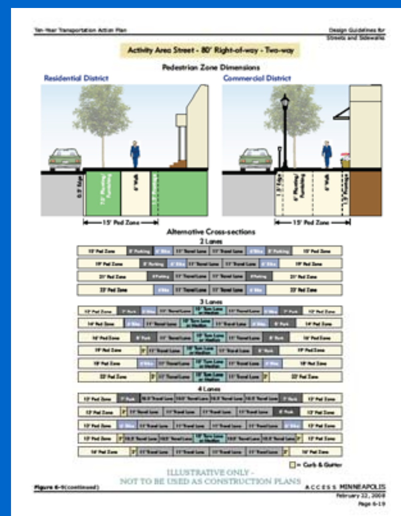
	Cost per 100	Ft. of Street
	24' Wide	36' Wide
5-inch Asphalt Paving/6-inch base	$6,800	$10,880
6-inch Curb and Gutter	1,265	1,265
4-inch Sidewalk	1,400	1,400
CONSTRUCTION	**$9,465**	**$13,545**
Land (at $100,00/acre)	5,600	8,400
TOTAL COST	**$15,065**	**$21,945**

Urban Settings

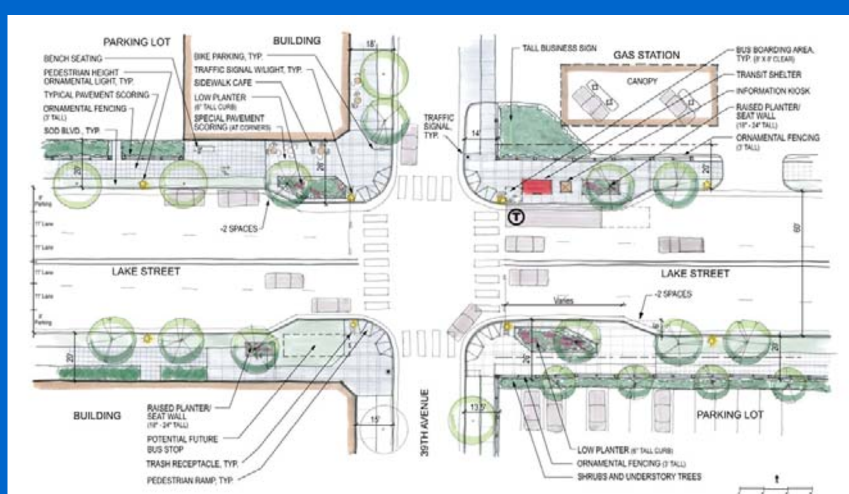


City of Minneapolis





LAKE STREET



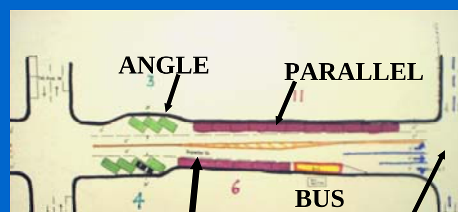
SUPERIOR ST. - DULUTH

Problems

- Minimal through traffic
- Shortage of parking
- Speeds too high
- Four driving lanes (capacity not needed)
- Not pedestrian friendly
- Context had changed

Solution

- One through lane/direction
- Angle parking
- Intersection capacityy
- Good parallel routes for possible diversions



Functions of a Shoulder

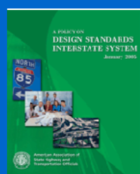
- Structural support for pavement
- Emergency refuge area
- Lateral clearance to hazards
- Recovery area for lane departures
- Maintenance or Enforcement use
- Room for pedestrians and bicyclists

Shoulder Width Design Values

Ranges for Minimum Shoulder Width

Type of Roadway	Rural		Urban	
	US (feet)	Metric (meters)	US (feet)	Metric (meters)
Freeway	4–12	1.2–3.6	4–12	1.2–3.6
Ramps (1-lane)	1–10	0.3–3.0	1–10	0.3–3.0
Arterial	2–8	0.6–2.4	2–8	0.6–2.4
Collector	2–8	0.6–2.4	2–8	0.6–2.4
Local	2–8	0.6–2.4	—	—

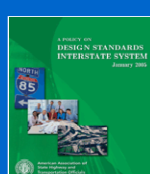
Source: A Policy on Geometric Design of Highways and Streets, AASHTO



The paved width of the right shoulder shall not be less than 3.0 m (10 ft).

On a four-lane section, the paved width of the left shoulder shall be at least 1.2 m (4 ft). On sections with six or more lanes, 3.0 m (IO ft) paved.

Shoulder Widths on Interstates



Where truck traffic exceeds 250 DDHV, a paved width of 3.6 m (12 ft) should be considered

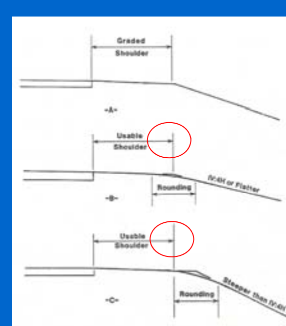
* FHWA interpretation: “should be considered” really means “shall” (mandatory)

Shoulder Design Principles

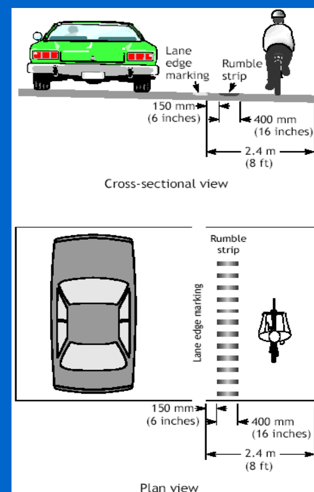
- Vehicle should clear traveled way by 2 feet
- Narrower shoulders are better than none at all
- Should be continuous place of refuge
- Rare exceptions for long structures
- Consider turnouts in severe topography

Shoulder Design Principles

- Can be paved, unpaved, or simply grass
- What's important is that they're usable



Shoulders for Shared Capacity



Shoulders for Added Capacity?

- Not normally considered an option to traditional widening for corridor capacity expansion
- Considered for achieving smoother flow, for sections of one mile or less
- Not recommended where large truck traffic is a significant proportion (5% to 10%) of peak period

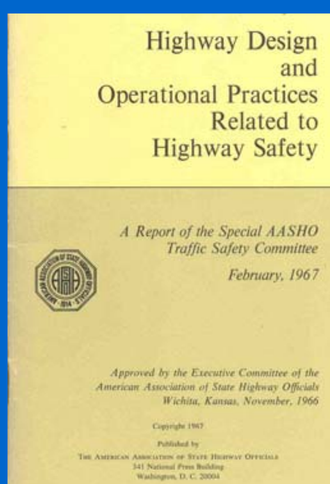
NCHRP Report 369

Dynamic Priced Shoulder Lanes

I-35W – UPA Project

Implemented in Fall 2009

The Clear Zone Concept



Highway Design and Operational Practices Related to Highway Safety

A Report of the Special AASHO Traffic Safety Committee

February, 1967

Approved by the Executive Committee of the American Association of State Highway Officials Wichita, Kansas, November, 1966

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Published by

The American Association of State Highway Officials
341 National Press Building
Washington, D. C. 20004

- "For adequate safety it is desirable to provide an unencumbered recovery area up to 30 feet from the edge of the travelled way"

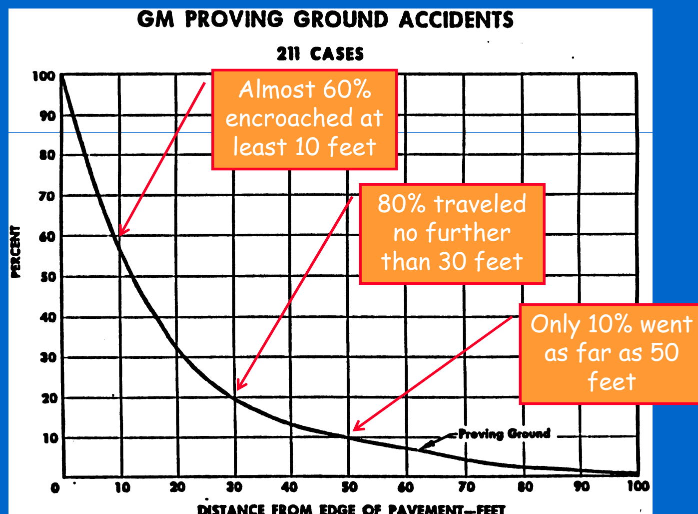
Scope of the Roadside Problem

About one in three of all highway fatalities is the result of a single vehicle run-off-the road crash

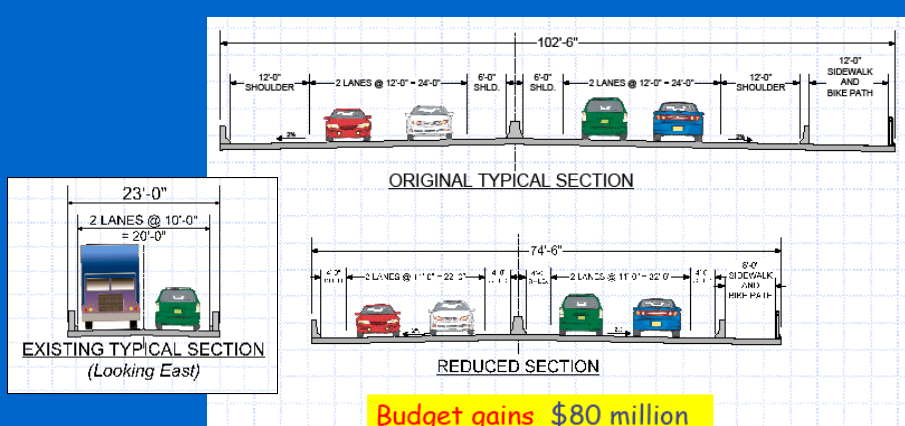
The Forgiving Roadside Approach

- Reduce the frequency of roadway departures
- Reduce the probability that encroachment will result in a crash
- Reduce the severity of a crash, if one does occur

Clear Zone Design Basis (from 1960s)



Consider Cost Implications



Source: Stamatiadis, University of Kentucky, Minnesota Design Forum, February 2009

Managing Risk Through Mitigation

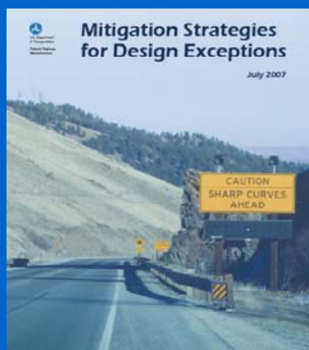


TABLE 3-3
Alternative Safety Mitigation Measures for Design Exceptions

Design Exception	Alternative Safety Mitigation Measures
Narrow lanes or shoulders	Pavement edge lines Raised reflective markers Delineators
Steep sideslopes, roadside obstacles	Roadside object markers Slope flattening Rounded ditches Obstacle removal Breakaway safety hardware Guardrail or crash cushions
Narrow bridge	Approach guardrail Pavement edge lines Warning signs and/or object markers
Poor sight distance at hill crest	Warning signs Obstacle removal Shoulder widening Driveway relocation
Sharp horizontal curve	Warning signs Shoulder widening Improved superelevation Slope flattening Pavement anti-skid treatment Obstacle removal Guardrail or crash cushions
Hazardous intersection	Upgrade intersection traffic control Warning signs Street lighting Pavement anti-skid treatment Speed controls Sight distance improvements

Mitigating Narrow Roads

- **The operational and safety effects of lane width are combined with those of other cross sectional elements.**
- **Knowledge of the total effects of lane width, shoulder width, and the roadside offers insights to mitigation when less than desirable lane widths may be necessary.**

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p.65

Mitigating Narrow Roads

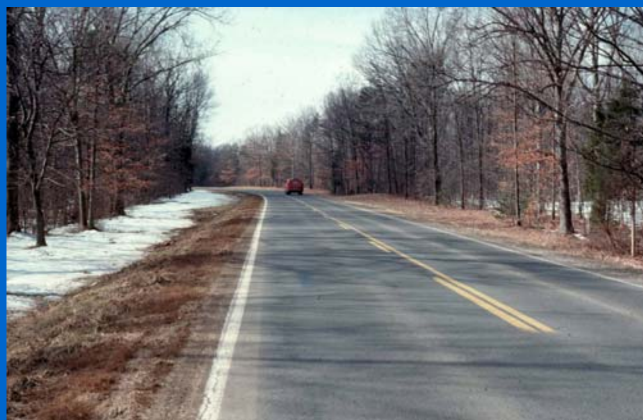
TABLE 22
Potential Mitigation Strategies

Design Element	Objective	Potential Mitigation Strategies
1. Design Speed	Reduce operating speeds to the design speed.	Cross-sectional elements to manage speed.
2. Lane Width & 3. Shoulder Width	Optimize safety and operations by distributing available cross-sectional width.	Select optimal combination of lane and shoulder width based on site characteristics.
	Provide advance warning of lane width reduction.	Signing.
	Improve ability to stay within the lane.	Wide pavement markings.
		Recessed pavement markings.
		Raised pavement markings.
		Delineators.
		Lighting.
		Centerline rumble strips.
		Shoulder rumble strips.
		Painted edgeline rumble strips.
	Improve ability to recover if driver leaves the lane.	Paved or partially-paved shoulders.
		Safety edge.
	Reduce crash severity if driver leaves the roadway.	Remove or relocate fixed objects.
		Traversable slopes.
		Breakaway safety hardware.
		Shield fixed objects and steep slopes.

Mitigating Narrow Roads

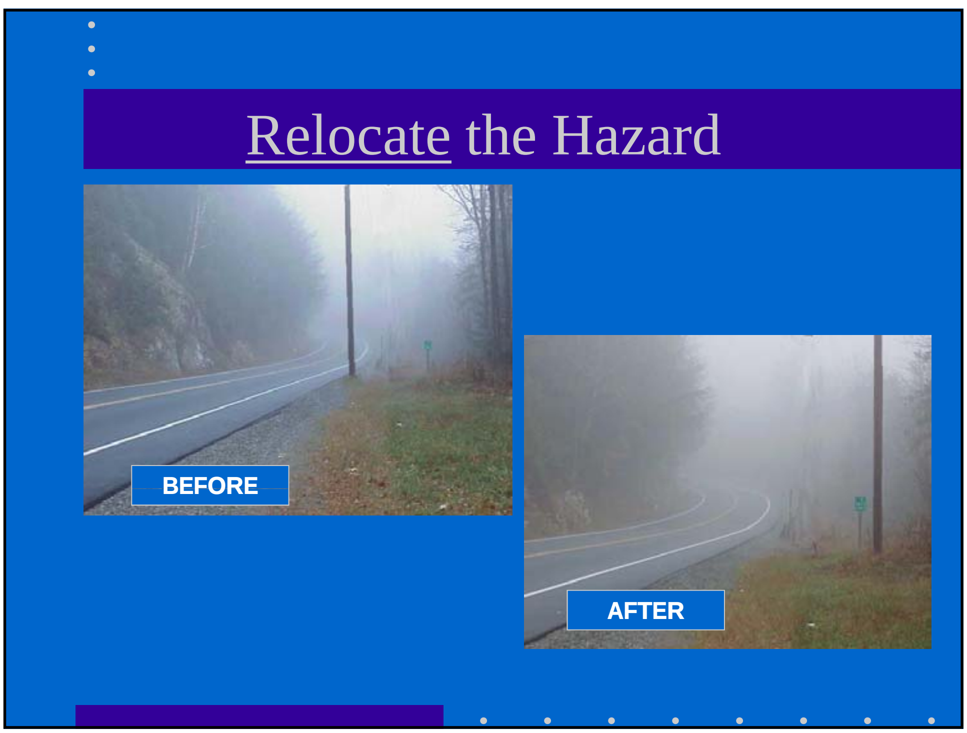
Consider Pavement Widening at Horizontal Curves

Assess the Risk



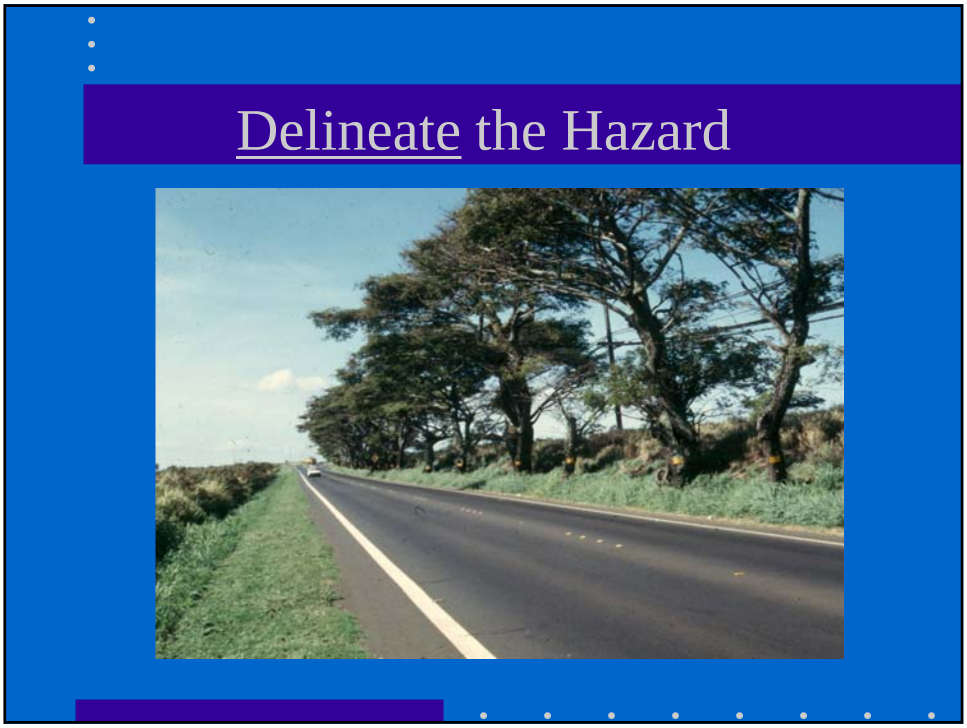
Recognize the Hazard

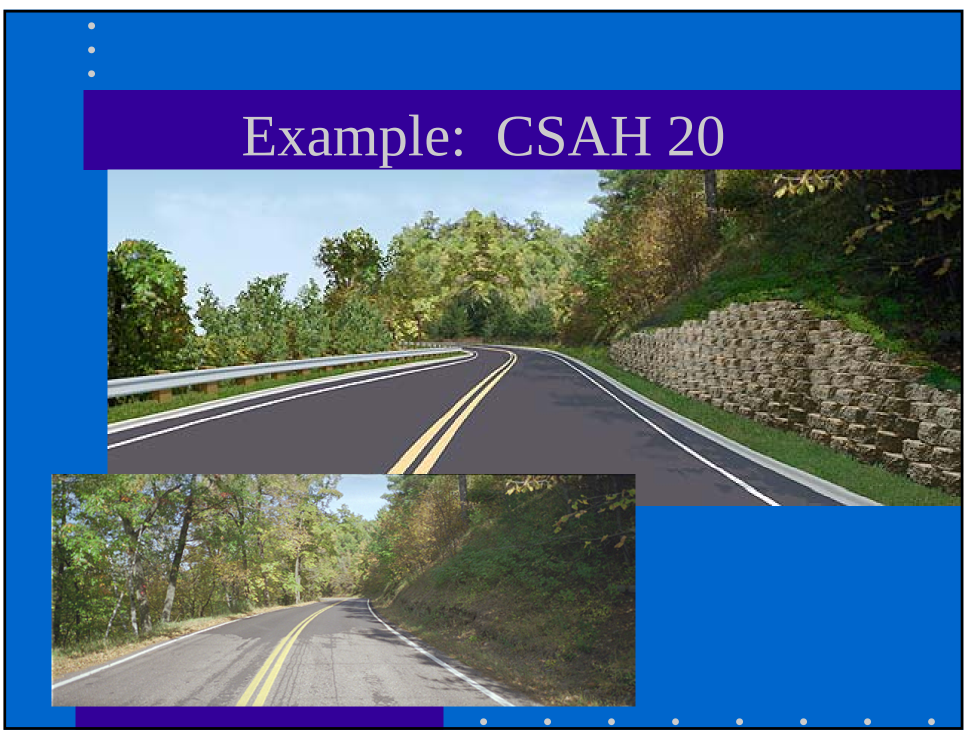

Remove the Hazard
BEFORE
AFTER
Digitally enhanced photograph


Relocate the Hazard
BEFORE
AFTER

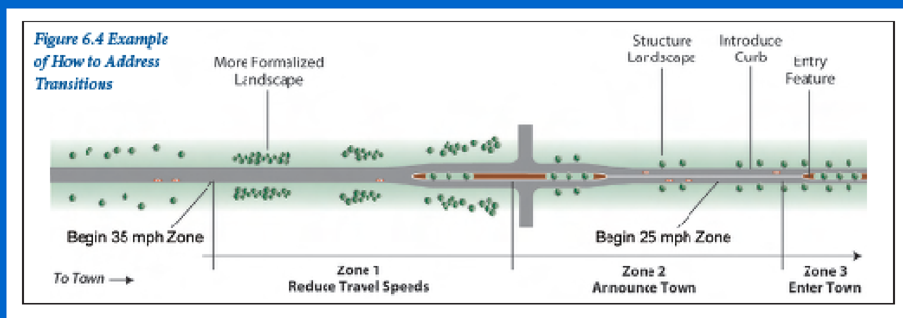
Reduce Impact Severity

Shield the Hazard


Delineate the Hazard


Example: CSAH 20

Addressing Transitions



Source: PennDOT, Smart Transportation Guidebook, March 2008

Speed Changes Are Critical


Visual Cues by Land Use/Activity


Visual Cues through Design
Princeton

Design Exceptions

If the decision is made to go forward with a design exception, it is especially important that measures to reduce or eliminate the potential impacts be evaluated and, where appropriate, implemented.

Tort Liability

- Document ALL critical design decision.
  - Why standard design what selected
  - How flexibility was used in a holistic context
  - Why Design Exception was justified

Exercise