

Median Barriers in North Carolina -- Long Term Evaluation

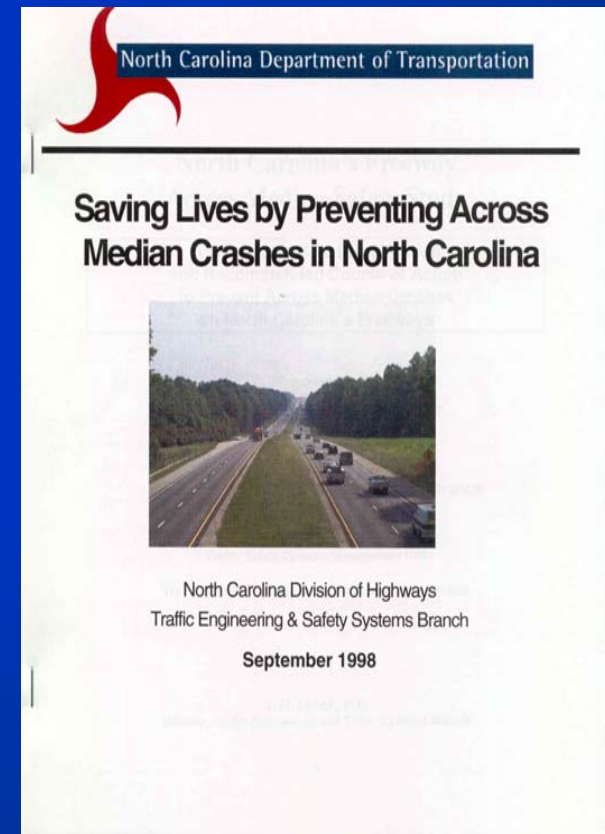
Safety Evaluation Group

Traffic Safety Systems Management Section



Background

- In 1998 North Carolina began a three pronged approach to prevent and reduce the severity of Across Median Crashes on freeways
 - Add median protection to freeways with historical crash problems (*Phase I*)
 - Systematically protect all freeways with median widths of 70 feet or less (*Phase II*)
 - Revise Design Policy to protect all future freeways with median widths of 70 feet or less (*Phase III*)



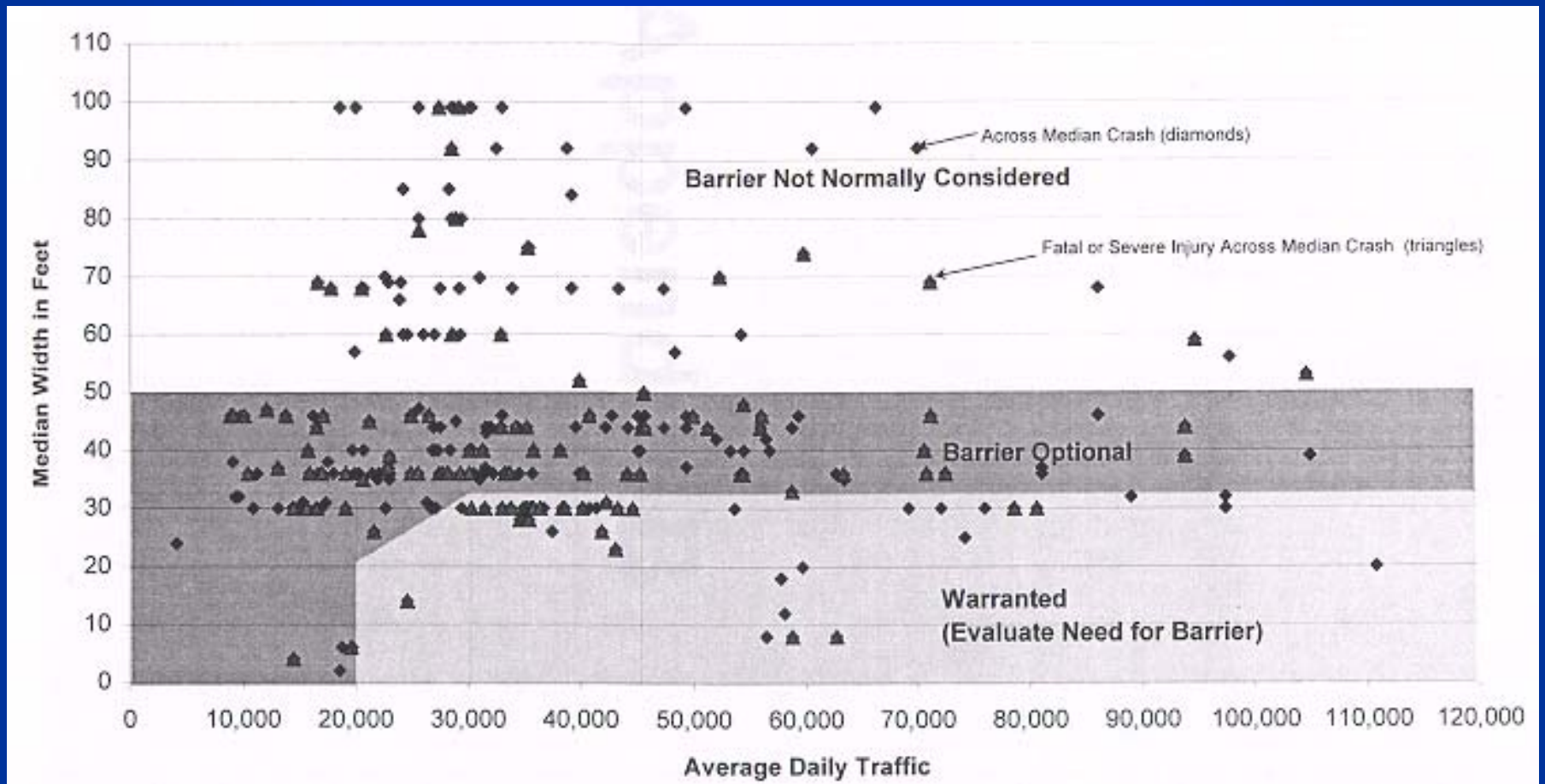
Background

- Initial Crash Data analyzed was from 1994 through 1997
 - Over 1,375 Miles of Full Control Sections of Freeway were reviewed
 - Over 10,000 Total Crashes were reviewed
 - Over 1,000 Across Median Crashes were Identified
 - For every one Fatal Across Median Crash there were 10 Non-Fatal Across Median Crashes
 - Across Median Crashes were 3 times more severe than other types of Freeway Crashes



Background

- Why was the 70 feet or less median width significant?

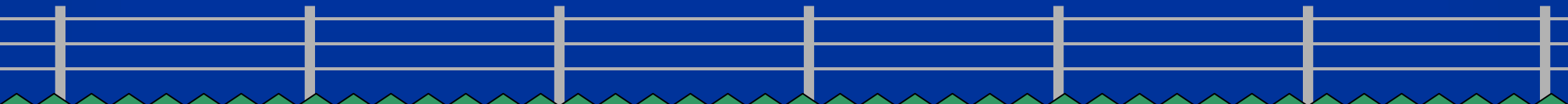


Background

- Why was the 70 feet or less median width significant (cntd.)?
 - There was no correlation to speed, median width, volume, time of day, or weather conditions for Across Median Crashes
 - Potential to eliminate approximately 95 percent of all Across Median Crashes

Background

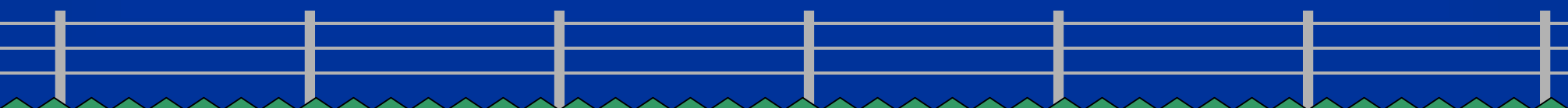
- 2000 - 2006 TIP included 58 Median Barrier Projects
 - Approximately 1000 miles of freeway
 - All Projects have been let or completed as of Spring 2004
 - Initial Projects were over a \$120 million dollar investment, not including reoccurring maintenance costs



Median Barrier Benefits

- Effect on Fatal Crashes and Fatalities

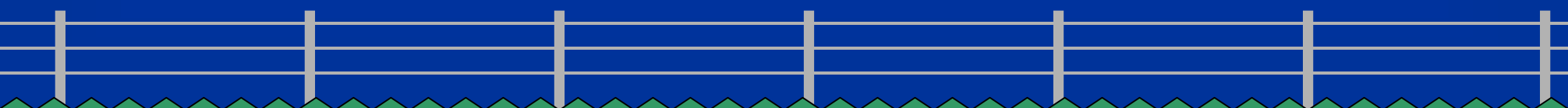
PHASE I AND PHASE II MEDIAN BARRIER PROJECT LOCATIONS							
Year	Fatal Crashes	X-Median Fatal Crashes	Percent of Total	Year	# of Fatalities	# of X-Median Fatalities	Percent of Total
1990	145	33	22.8	1990	177	47	26.6
1991	144	26	18.1	1991	188	44	23.4
1992	128	22	17.2	1992	147	31	21.1
1993	158	20	12.7	1993	196	38	19.4
1994	146	23	15.8	1994	179	36	20.1
1995	150	18	12.0	1995	177	28	15.8
1996	159	26	16.4	1996	189	40	21.2
1997	147	33	22.4	1997	194	47	24.2
1998	198	33	16.7	1998	229	47	20.5
1999	178	24	13.5	1999	207	30	14.5
2000	191	23	12.0	2000	226	36	15.9
2001	160	7	4.4	2001	183	11	6.0
2002	152	13	8.6	2002	173	14	8.1
2003	129	12	9.3	2003	146	13	8.9



Median Barrier Benefits

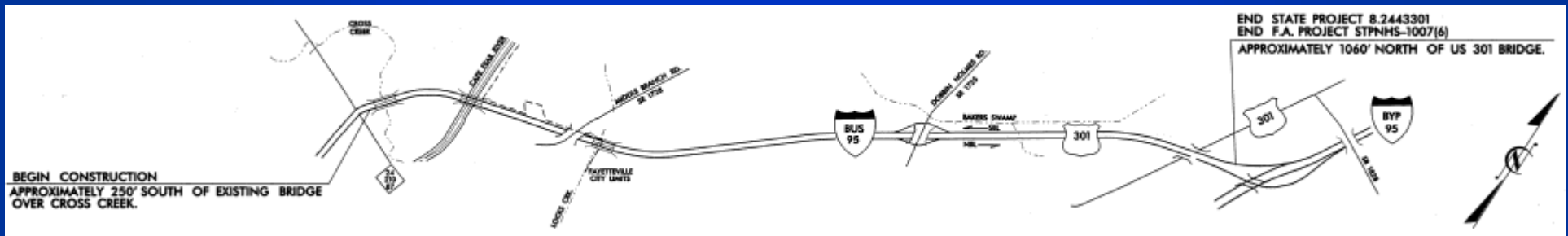
- Effect on Fatal Crashes and Fatalities (cntd.)
 - Estimated 59 Fatal Across Median Crashes have been avoided and 96 lives saved from January 1999 to December 2003
 - Results in crash costs savings of more than \$205 million in fatal crash cost alone
 - Across Median Fatal Crashes (5 Years Before to After)

	<u>Before</u>	<u>After</u>	<u>Percent (+/-)</u>
Fatal Crashes	133	79	- 40.6 %
Fatalities	198	104	- 47.5 %



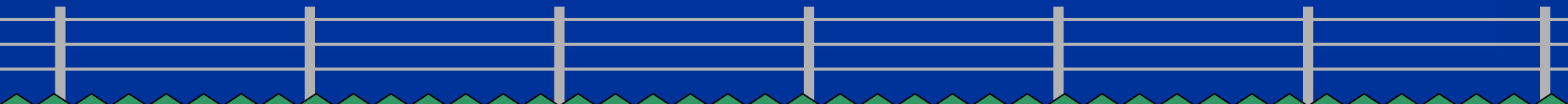
Median Barrier Benefits

- Long Term Median Barrier Evaluation
 - Before and After Crash Analyses
 - > Project locations being evaluated have at least three years of after crash data available from installation
 - Progress thus far:
 - > Analyzed 400 miles of median barrier projects



Median Barrier Benefits

- Long Term Median Barrier Evaluation (cntd.)
 - Median Barrier Types used on project locations
 - > Cable Barrier (175 miles evaluated)
 - > W-Beam Barrier (132 miles evaluated)
 - > W-Beam and Cable Barrier Mix (44 miles evaluated)
 - > W-Beam and Weak Post Barrier Mix (18 miles evaluated)
 - > Weak Post Barrier (31 miles evaluated)
 - Plan to provide a Before and After Analysis for each Median Barrier Type



Median Barrier Benefits

- Long Term Median Barrier Evaluation (cntd.)

MEDIAN BARRIER CRASH DATA (All Barrier Types)					
	Before	Crashes	After	Crashes	Percent (+/-)
	Period	per Year	Period	per Year	per Year
Average # of Years in Crash Analyses	6.77		3.56		
Average ADT within the Sections	29,100		37,300		
Number of Total Crashes	13,298	1,964	12,080	3,393	72.8
Number of Fatal Crashes	194	29	95	27	-6.9
Number of A Injury Crashes	578	85	224	63	-26.3
Number of B & C Injury Crashes	4,509	666	3,646	1024	53.8
Number of PDO Crashes	8,017	1,184	8,115	2,279	92.5
Number of Total X-Median Crashes	1070	158	114	32	-79.7
Number of Total Fatal Crashes	80	12	6	2	-85.7
Number of Total Median Barrier Hits	na	na	3,922	1,102	100.0
Percentage of Total	na	na	32.5%		
Number of Total Median Barrier Breaching	na	na	110	31	100.0
Percentage of Total	na	na	2.8%		

Median Barrier Benefits

- Long Term Median Barrier Evaluation (cntd.)

MEDIAN BARRIER CRASH DATA (Cable Barrier)					
	Before	Crashes	After	Crashes	Percent (+/-)
	Period	per Year	Period	per Year	per Year
Average # of Years in Crash Analyses	6.69		3.61		
Average ADT within the Sections	28,800		38,100		
Number of Total Crashes	4,685	700	4,934	1,367	95.2
Number of Fatal Crashes	63	9	36	10	5.9
Number of A Injury Crashes	208	31	78	22	-30.5
Number of B & C Injury Crashes	1,564	234	1,342	372	59.0
Number of PDO Crashes	2,850	426	3,478	963	126.2
Number of Total X-Median Crashes	364	54	75	21	-61.8
Number of Total Fatal Crashes	22	3	3	1	-74.7
Number of Total Median Barrier Hits	na	na	1,609	446	100.0
Percentage of Total	na	na	32.6%		
Number of Total Median Barrier Breaching	na	na	72	20	100.0
Percentage of Total	na	na	4.5%		

Median Barrier Benefits

- Long Term Median Barrier Evaluation (cntd.)

MEDIAN BARRIER CRASH DATA (W-Beam Barrier)					
	Before	Crashes	After	Crashes	Percent (+/-)
	Period	per Year	Period	per Year	per Year
Average # of Years in Crash Analyses	7.08		3.28		
Average ADT within the Sections	26,700		33,800		
Number of Total Crashes	4,949	699	3,517	1,072	53.4
Number of Fatal Crashes	57	8	25	8	-5.3
Number of A Injury Crashes	212	30	72	22	-26.7
Number of B & C Injury Crashes	1,728	244	1,175	358	46.8
Number of PDO Crashes	2,952	417	2,245	684	64.2
Number of Total X-Median Crashes	339	48	11	3	-93.0
Number of Total Fatal Crashes	23	3	2	1	-81.2
Number of Total Median Barrier Hits	na	na	1,039	317	100.0
Percentage of Total	na	na	29.5%		
Number of Total Median Barrier Breaching	na	na	11	3	100.0
Percentage of Total	na	na	1.1%		

Median Barrier Benefits

- Long Term Median Barrier Evaluation (cntd.)

MEDIAN BARRIER CRASH DATA (W-Beam and Cable Barrier)					
	Before	Crashes	After	Crashes	Percent (+/-)
	Period	per Year	Period	per Year	per Year
Average # of Years in Crash Analyses	7.14		3.39		
Average ADT within the Sections	29,700		38,400		
Number of Total Crashes	1,792	251	1,649	486	93.8
Number of Fatal Crashes	31	4	14	4	-4.9
Number of A Injury Crashes	73	10	29	9	-16.3
Number of B & C Injury Crashes	592	83	500	147	77.9
Number of PDO Crashes	1,096	154	1,106	326	112.5
Number of Total X-Median Crashes	145	20	9	3	-86.9
Number of Total Fatal Crashes	12	2	0	0	-100.0
Number of Total Median Barrier Hits	na	na	553	163	100.0
Percentage of Total	na	na	33.5%		
Number of Total Median Barrier Breaching	na	na	8	2	100.0
Percentage of Total	na	na	1.4%		

Median Barrier Benefits

- Long Term Median Barrier Evaluation (cntd.)

MEDIAN BARRIER CRASH DATA (W-Beam and Weak Post Barrier)					
	Before	Crashes	After	Crashes	Percent (+/-)
	Period	per Year	Period	per Year	per Year
Average # of Years in Crash Analyses	5.75		3.83		
Average ADT within the Sections	37,900		42,700		
Number of Total Crashes	673	117	598	156	33.4
Number of Fatal Crashes	19	3	10	3	-21.0
Number of A Injury Crashes	25	4	19	5	14.1
Number of B & C Injury Crashes	243	42	198	52	22.3
Number of PDO Crashes	386	67	371	97	44.3
Number of Total X-Median Crashes	87	15	7	2	-87.9
Number of Total Fatal Crashes	7	1	1	0	-78.6
Number of Total Median Barrier Hits	na	na	228	60	100.0
Percentage of Total	na	na	38.1%		
Number of Total Median Barrier Breaching	na	na	7	2	100.0
Percentage of Total	na	na	3.1%		

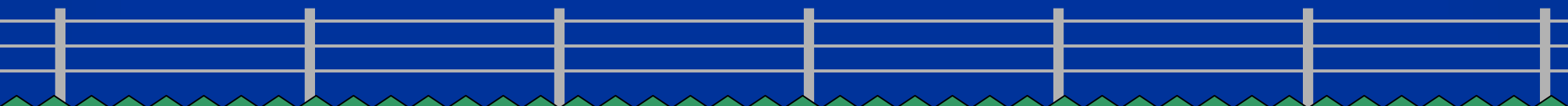
Median Barrier Benefits

- Long Term Median Barrier Evaluation (cntd.)

MEDIAN BARRIER CRASH DATA (Weak Post Barrier)					
	Before	Crashes	After	Crashes	Percent (+/-)
	Period	per Year	Period	per Year	per Year
Average # of Years in Crash Analyses	6.50		4.04		
Average ADT within the Sections	31,500		40,200		
Number of Total Crashes	1,199	184	1,382	342	85.4
Number of Fatal Crashes	24	4	10	2	-33.0
Number of A Injury Crashes	60	9	26	6	-30.3
Number of B & C Injury Crashes	382	59	431	107	81.5
Number of PDO Crashes	733	113	915	226	100.8
Number of Total X-Median Crashes	135	21	12	3	-85.7
Number of Total Fatal Crashes	16	2	0	0	-100.0
Number of Total Median Barrier Hits	na	na	493	122	100.0
Percentage of Total	na	na	35.7%		
Number of Total Median Barrier Breaching	na	na	12	3	100.0
Percentage of Total	na	na	2.4%		

Median Barrier Benefits

- Long Term Median Barrier Evaluation (cntd.)
 - Median Barrier Breaching Crashes (All Barrier Types)
 - > After Period Breaches 110
 - > Construction and After Period Breaches 125
 - Fatal Crashes 7 (6%)
 - A-Injury Crashes 9 (7%)
 - B-Injury Crashes 20 (16%)
 - C-Injury Crashes 26 (21%)
 - PDO Injury Crashes 63 (50%)
 - Vehicle Breaches 98
 - Debris/Tire Breaches 27



Median Barrier Benefits

- Long Term Median Barrier Evaluation (cntd.)
 - Crash Severity by Median Barrier Types from Hits

	<u>Barrier Hits</u>	<u>Average Severity</u>
> All Barrier Types	3,486	1.45
> Cable Barrier	1,592	1.31
> W-Beam Barrier	1,266	1.63
> Weak Post	567	1.44
> Concrete	67	1.64

- The lower the Average Severity the safer the median barrier type (Scale => 1 = PDO 5 = Fatal)

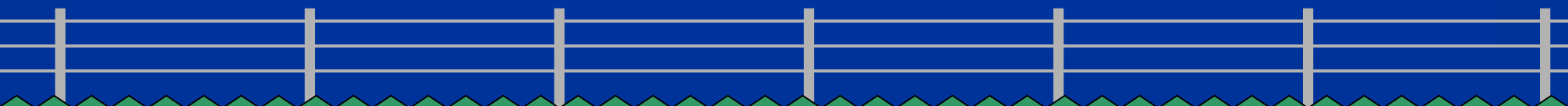


Median Barrier Issues

- Maintenance Concerns

<u>Barrier Types</u>	<u>Hits</u>	<u>Total Property Damage</u>	<u>State Property Damage</u>
All	3,486	\$ 22,428,070	\$ 1,867,048
Cable	1,592	\$ 9,599,568	\$ 955,763
W-Beam	1,266	\$ 8,778,927	\$ 488,260
Weak Post	567	\$ 3,669,675	\$ 419,775
Concrete	67	\$ 379,900	\$ 3,250

- Recovery of maintenance cost from drive-away vehicles
- Frequency of repairs to cable guardrail
- Mowing



Median Barrier Issues

- Cable Penetration Evaluation
 - Purpose of Project
 - To identify common characteristics that may influence the probability of a vehicle traveling over, under or through the cable guardrail
 - How?
 - Thorough investigation of each cable breaching crash
 - Factors Examined: Vehicle Type, Impact Angle, Initial Contact Between Vehicle and Barrier, and Site Characteristics

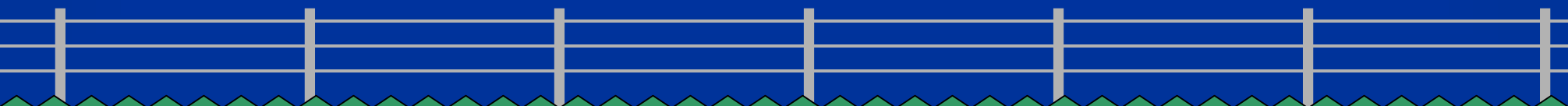


Median Barrier Issues

- Cable Penetration Evaluation

- Monitored 238 miles of freeway since Fall of 2001
- Reviewed over 91 potential penetration crashes
- Only 23 of these crashes qualified for this project.
 - Needed crash report, site visit, and vehicle inspection to qualify
 - The project goal was 30 crashes.

– Potential Crashes	91	Usable Crashes	23
> Front Side Hits	30 (33%)	> Front Side Hits	6 (26 %)
> Back Side Hits	61 (67%)	> Back Side Hits	17 (74 %)



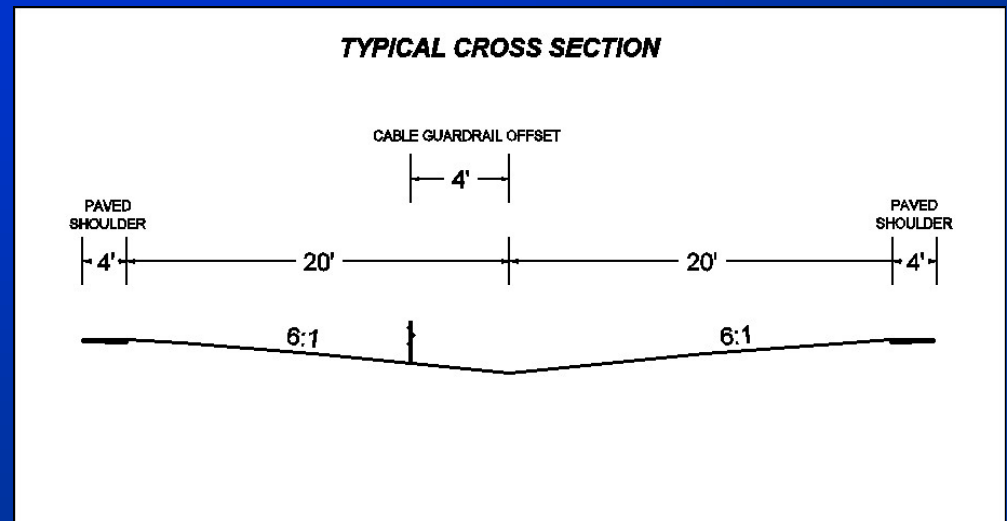
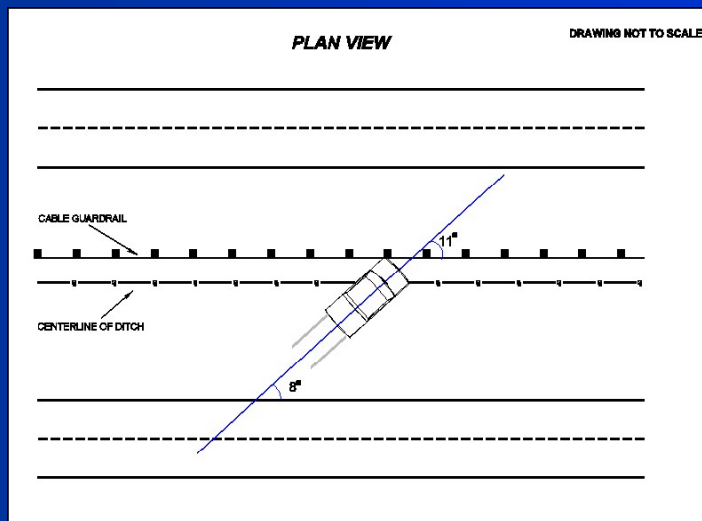
Median Barrier Issues

- Cable Penetration Evaluation (cntd.)
 - Vehicle Characteristics
 - > Full size sedans, sport utility vehicles, full size vans, tractor trailers, etc.....



Median Barrier Issues

- Cable Penetration Evaluation (cntd.)
 - Site Characteristics
 - > Typically 4' offset from the ditch centerline
 - > Two strands closest to traffic and one strand on ditch side
 - > Vast majority occur on tangent sections
 - > Impact angle 11 to 90 degrees



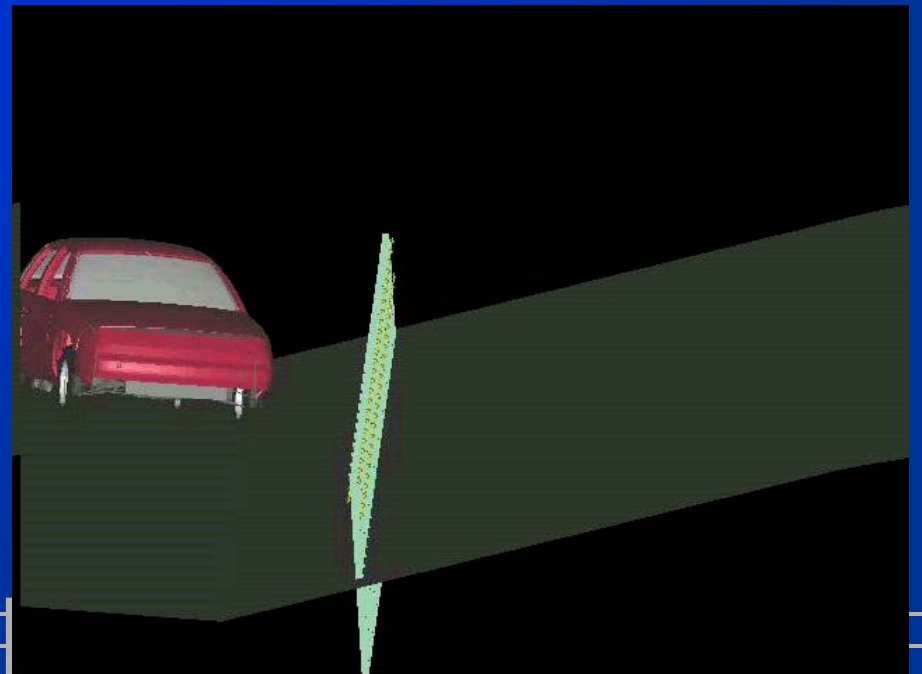
Median Barrier Issues

- Cable Penetration Evaluation (cntd.)
 - Common Themes
 - > Under-rides account for 90 percent of the breaching crashes



Median Barrier Issues

- Cable Penetration Evaluation (cntd.)
 - Analysis Results
 - > George Washington University has taken NCDOT data and placed it into a Finite Element Analysis Software to model our under-ride crashes
 - > Vehicles under-rode cable in the computer simulation



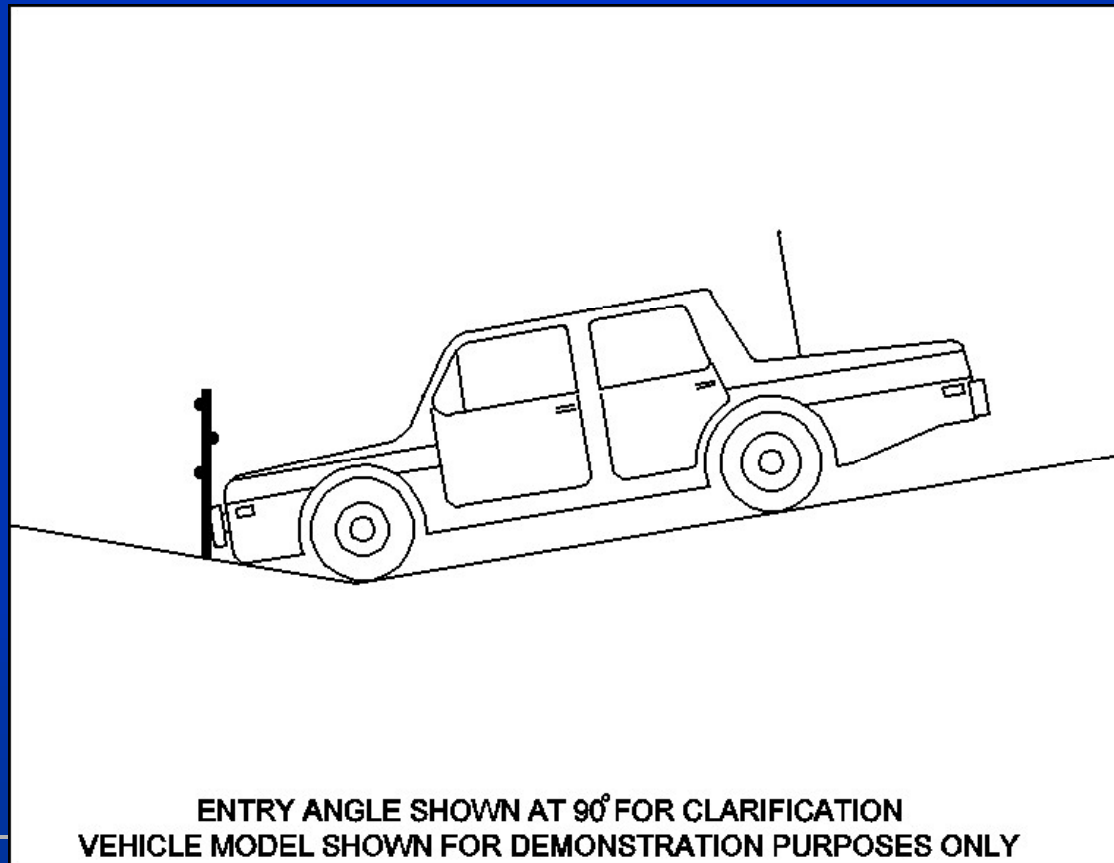
Median Barrier Issues

- Cable Penetration Evaluation (cntd.)
 - Analysis Results
 - > A Crown Victoria under-rod the cable in an actual crash test performed at Turner Fairbanks (4' offset)



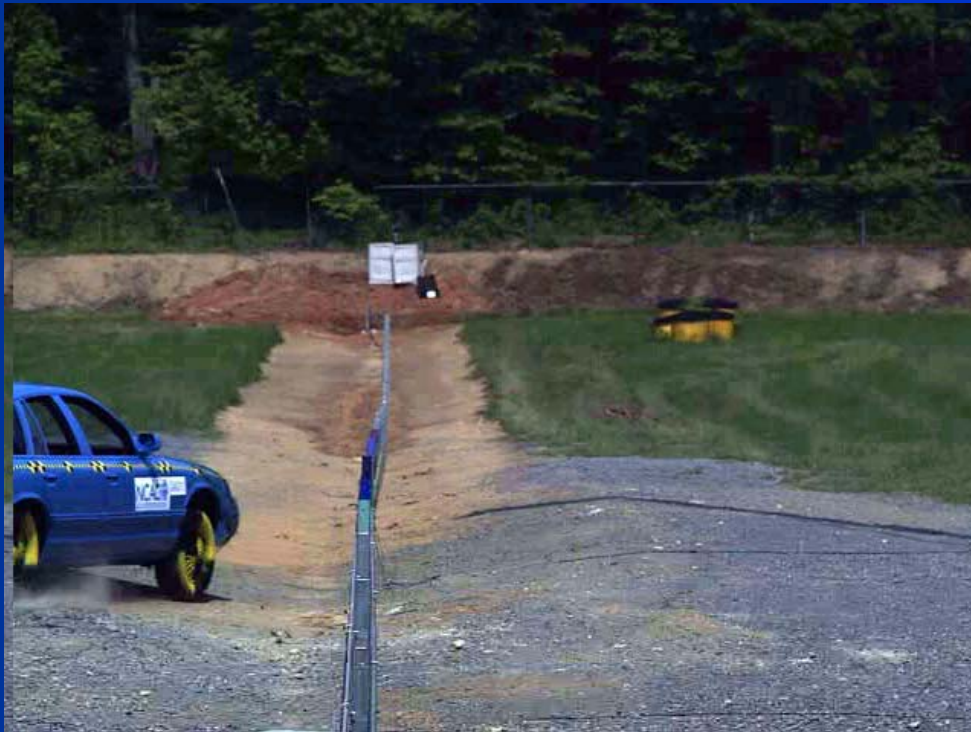
Median Barrier Issues

- Cable Penetration Evaluation (cntd.)
 - Analysis Results
 - > Vehicles Suspension Dynamics are the key to under-ride crashes



Median Barrier Issues

- Cable Penetration Evaluation (cntd.)
 - Analysis Results
 - > A Crown Victoria did not under-ride the cable in an actual crash test performed at Turner Fairbanks (1' offset)



Median Barrier Issues

- Cable Penetration Evaluation (cntd.)
 - Analysis Results
 - > A Crown Victoria did not under-ride the cable in an actual crash test performed at Turner Fairbanks (1' offset)



Median Barrier Issues

- Cable Penetration Evaluation (cntd.)
 - GWU Analysis Recommendations
 - > Add an additional cable - a fourth cable at a lower height
 - > Move the cable barrier systems to a 1' foot offset from the center of the ditch line
 - > Tie the three strands of cable together in some fashion to react like a netting system
 - TSSMU Analysis Recommendations
 - > Keep three strands of cable and increase the current 6" gap between cables to an 8" or 9" gap. Example for 8" gapping, keep the top cable at 33" and the middle cable at 25", placing the bottom cable at 17"



Median Barrier Issues

- Effects of Median Barrier on Highway Speeds
 - Highway Safety Research Center Study
 - > Spot speed data was collected from 51 freeway segments during off peak periods
 - > In general, motorist drove faster if the speed limit was higher
 - > In addition, motorist traveled faster in the left lane
 - > A higher percentage of drivers exceeded speed limits on 55 mph, 60 mph, and 65 mph sections, compared to 70 mph sections
 - > Data collected from this study did not seem to support the hypothesis that continuous median barriers lead to speeding
 - > Also, there was no evidence to indicate that continuous median barriers are associated with more speed related crashes



Median Barrier Issues

- Effects of Median Barrier on Emergency Response Times
 - Highway Safety Research Center Study
 - > Many emergency operators argue that continuous median barriers without emergency crossovers do lead to an increase in response times
 - > Very little data was available for response times
 - > Even agencies that record response times do not consistently record the location of the incidents and the routes followed by emergency vehicles
 - > The lack of data makes it very difficult to make a quantitative assessment of continuous median barrier effects on emergency response times
 - > With limited observations, Illegal Use of emergency crossovers did not seem to be a significant problem



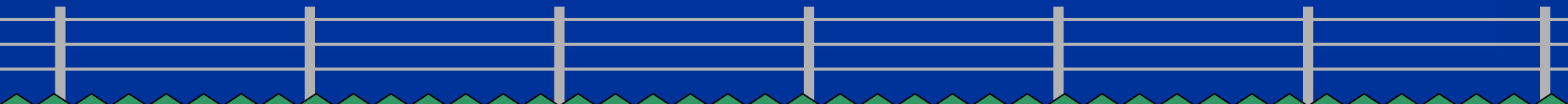
Median Barrier Issues

- NCDOT Median Crossover Guidelines
 - Fatal Crash at Emergency Crossover on I 26 in Henderson County on December 17, 2004



Median Barrier Issues

- NCDOT Median Crossover Guidelines (cntd.)
 - Effective on January 1, 2004
 - > Everyone was not 100 % happy
 - > Everyone was glad to see a revision
 - Interstate and Non-Interstate Highways with Full Control of Access
 - > No public-use median crossovers will be allowed
 - > U-turn median openings for use by authorized vehicles for the maintenance and policing of highway or emergency response can be allowed when an engineering study clearly indicates a need. The spacing of the median openings should abide by the following guidelines:



Median Barrier Issues

- NCDOT Median Crossover Guidelines (cntd.)
 - > U-turn median openings can be provided if a need has been determined and they can be added in a safe location where decision sight distance is available. When adding a crossover, it should be located at least one half mile from any overhead structure and at least one mile from the terminus of a ramp acceleration lane or deceleration lane. The median crossover should be signed appropriately.
 - > The minimum spacing of adjacent U-turn median crossovers between interchanges is three miles. However, spacing alone is not justification for a crossover.
 - > On urban freeways, the interchange spacing is generally close enough that openings are not warranted. Therefore, U-turn openings are not allowed. In addition, on facilities where acceptable gaps are unlikely due to high ADTs, U-turn openings are not allowed.



Median Barrier Issues

- NCDOT Median Crossover Guidelines (cntd.)
 - Emergency Crossover on I 40 near Asheville



QUESTIONS?

