HIGHWAY FACTORS FACTUAL REPORT
MEXICAN HAT, UTAH 1/6/-8
HWY08-MH012
(16) PAGES

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C. 20594

HIGHWAY GROUP FACTUAL INVESTIGATION NARRATIVE

A. ACCIDENT

Type:	Motorcoach, overturn
Date and Time:	January 6, 2008, 8:02 p.m. MST
Location:	Southbound US Rt. 163, near MP29 Mexican Hat, San Juan County, Utah
Vehicle #1:	2007 MCI Model J4500, 56-Passenger Motorcoach
Motor Carrier:	BUSCO, Inc. DBA Arrow Stage Lines
Fatalities:	9
Injuries:	44
NTSB#:	HWY-08-MH-012

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C. ACCIDENT SUMMARY

On January 6, 2008 about 3:30 p.m. MST a 2007 MCI 56-passenger motorcoach with 52 passengers on-board departed Telluride, CO enroute to Phoenix, AZ, as part of a 17-motorcoach charter. The motorcoach was returning from a three-day weekend of skiing. The motorcoaches were diverted to an alternate route that included US Route 191 and 163 in Utah, due to the closure of Colorado State Route 145 because of snow. Colorado State Route 145 is the normal route used from Telluride to Phoenix.

At about 8:02 p.m. MST the motorcoach was traveling southbound descending a 6 percent grade leading to a curve to the left, 1,800 feet north of milepost 29, at a driver reported speed of 65 mph. After entering the curve the motorcoach departed the roadway at a shallow angle striking the guardrail with the right rear wheel about 61 feet before the end of the guardrail.

The motorcoach began rotating in a counter clockwise direction as it descended an embankment. The motorcoach began to overturn and struck several rocks in a creek bed at the bottom of the embankment. The motorcoach came to rest on its wheels after overturning 360 degrees. During the rollover sequence the entire roof of the motorcoach separated from the body, and 51 of the 53 occupants were ejected. As a result, nine passengers were fatally injured, 43 passengers and the driver received various degrees of injuries from minor to serious.

The weather was cloudy and the roadway was dry at the time of the accident.

D: DETAILS OF THE INVESTIGATION

Research of weather data, construction history, average daily traffic, vehicle classification, traffic accident history, and fatal accident history was performed. Additionally, the highway's functional classification, highway design, speed limit, 85th percentile speed was obtained. The highway dimensions, grade, curvature, and scene evidence, was mapped by the Utah State Highway Patrol and the Utah Department of Transportation. Hand measurements were taken by the NTSB Highway group to verify key scene evidence. Additionally, the roadside was mapped to determine the precise slope on the roadside embankment. Also, a ball bank indicator test was run to evaluate whether a speed reduction was warranted in the curve.

PREFATORY DATA

1.1 ACCIDENT LOCATION

The accident occurred on U.S. Highway 163 (US 163), approximately 8.5 miles north of Mexican Hat, Utah in San Juan County, Utah near the entrance to the Valley of the Gods scenic area. This location is in the southern part of the State about 43 miles south of Blanding, Utah. (See Figure 1)

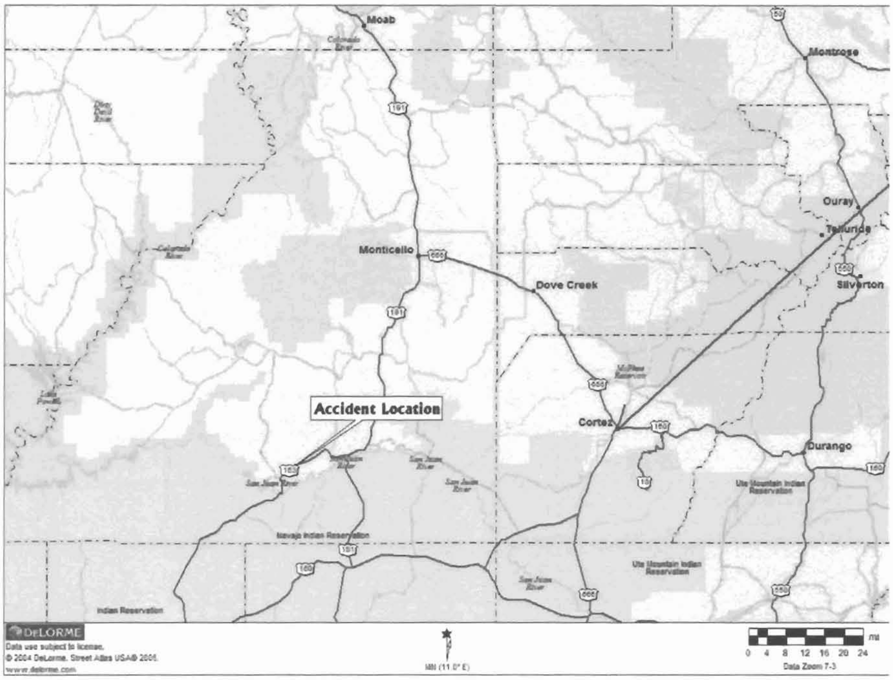

Figure 1

Weather Information

The Utah Department of Transportation dispatched two snowplow vehicles to the scene at the request of the San Juan County Sheriffs Office for debris removal. On January 6, 2008 at about 10:30 p.m. The air/road surface temperature instrument mounted in one of the trucks showed a road surface temp of 37 degrees F. with air temp of 41 degrees F.

Additionally, Utah Highway Patrol Troopers that responded to the scene indicated that the pavement was dry at the time of the accident.

According to the National Weather Service (NWS) automated observation system located at the Blanding Municipal Airport (KBDG), Blanding, Utah, approximately 30 miles northeast of the accident site, the temperature at 7:50 p.m. was 30 degrees. The sky was overcast and the dew point was 28 degrees. (For details see Human Performance Group Chairman's Factual Report).

General Information

US163 is a 60-mile section of road that runs northeast to southwest connecting U.S. Highway 191 south of Bluff Utah to U.S. Highway 160 in Kayenta, Arizona. The asphalt-paved road has 12-foot-wide lanes and narrow shoulders of 1-1.5 feet wide in the accident area. There are numerous curves and steep grades on this highway. The accident occurred at milepost 29. Near milepost 38 or 9 miles to the north there is a one-mile long 5 percent downgrade with a sharp horizontal curve that has a 35 mph advisory warning. Beginning near milepost 133 or 4 miles north of the accident area the highway begins a gradual descent. Over the 6,400 feet preceding the curve where the accident occurred, the highway averages a 4 percent downgrade.

Accident Area

The immediate approach to the curve where the accident occurred is on a 1,200-foot-long, 5.6 percent downgrade. The accident occurred on a 1,641-foot-long left curve that has a spiral transition and a 1,432-foot radius or approximately a 4-degree curve. The curve has a 6 percent superelevation or bank. A curve warning sign is posted approximately 750 feet in advance of the curve on the right-hand roadside. The sign is 12 feet from the road edge and the bottom of the sign is 7 feet above the pavement. The warning sign does not have a warning speed advisory and the speed limit is posted at 65 mph. The highway design plans indicate this section of roadway has a 60 mph design speed. In December 1996 ball-bank indicator tests were performed on this curve at the 65 mph speed limit and reading of less than the 10-degree angle were observed, indicating that a reduced advisory speed did not need to be posted on this curve[1]. (See Table1 Curve Design Data below)

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[1] "A Policy on the Geometric Design of Highways and Streets", 1994, AASHTO, Page 144

Design Speed (mph)	Maximum e	Maximum f	Total (e + f)	Maximum Degree of Curve	Rounded Maximum Degree of Curve	Maximum* Radius (ft)
20	.04	.17	.21	44.97	45.0	127
30	.04	.16	.20	19.04	19.0	302
40	.04	.15	.19	10.17	10.0	573
50	.04	.14	.18	6.17	6.0	955
55	.04	.13	.17	4.83	4.75	1,186
60	.04	.12	.16	3.81	3.75	1,528
20	.06	.17	.23	49.25	49.25	116
30	.06	.16	.22	20.94	21.0	273
40	.06	.15	.21	11.24	11.25	509
50	.06	.14	.20	6.85	6.75	849
55	.06	.13	.19	5.40	5.5	1,061
60	.06	.12	.18	4.28	4.25	1,348
65	.06	.11	.17	3.45	3.5	1,637
70	.06	.10	.16	2.80	2.75	2,083
20	.08	.17	.25	53.54	53.5	107
30	.08	.16	.24	22.84	22.75	252
40	.08	.15	.23	12.31	12.25	468
50	.08	.14	.22	7.54	7.5	764
55	.08	.13	.21	5.97	6.0	960
60	.08	.12	20	4.76	4.75	1,206
65	.08	.11	.19	3.85	3.75	1,528
70	.08	.10	.18	3.15	3.0	1,910
20	.10	.17	.27	57.82	58.0	99
30	.10	.16	.26	24.75	24.75	231
40	.10	.15	.25	13.38	13.25	432
50	.10	.14	.24	8.22	8.25	694
55	.10	.13	.23	6.53	6.5	877
60	.10	.12	.22	5.23	5.25	1,091
65	.10	.11	.21	4.26	4.25	1,348
70	.10	.10	.20	3.50	3.5	1,637
20	.12	.17	.29	62.10	62.0	92
30	.12	.16	.28	26.65	26.75	214
40	.12	.15	.27	14.46	14.5	395
50	.12	.14	.26	8.91	9.0	637
55	.12	.13	.25	7.10	7.0	807
60	.12	.12	.24	5.71	5.75	996
65	.12	.11	23	4.66	4.75	1206
70	.12	.10	.22	3.85	3.75	1528

NOTE: In recognition of safety considerations, use of e_{max} = 0.04 should be limited to urban conditions.
*Calculated using rounded maximum degree of curve.

Table III-6. Maximum degree of curve and minimum radius determined for limiting values of e and f, rural highways and high-speed urban streets.

Table 1

This was a low volume facility. Traffic counts showed the Average Daily Traffic (ADT) was 610 vehicles per day. UDOT engineers indicate that when the highway was first reconstructed from State Highway 42 in 1962 that it had an ultra-low ADT or less than 400 vehicles per day. The road is functionally classified as a secondary rural arterial.

Accident records for the six-year-period from 2002-2006 showed that 10 other accidents occurred along the four-mile-long segment from milepost 28-32. Four of these accidents were property damage only and six accidents involved injury. One accident occurred in the accident curve. There were no other fatal accidents. Also, only one of the accidents involved a truck, and there were no other bus accidents. Searching back 11 years to February 1997, UDOT engineers found that a fatal accident involving a passenger car had occurred in the accident curve. In that accident the driver was drunk with a Blood-Alcohol-Level (BAL) of 0.17 percent, and the reconstruction report showed that the driver was traveling approximately 93 mph when he lost control.

Maintenance records showed the pavement was last chip-sealed in 2004, and wet pavement friction testing in 2006 showed that the accident area had a wet skid number of 61 and an average rutting depth in the wheel paths of only 0.10 inches.

Due to the secondary classification, low accident rate, and low ADT, highway safety lighting was not warranted and was not provided.

Roadside Geometry

The right side of the road has a 27-inch-high W-beam guardrail erected. The guardrail is a weak post system that has 8-inch diameter concrete poles used to secure the guardrail at 12-foot, 6-inch intervals. The guardrails is located 4 feet to the right of the pavement edge and begins approximately 220 feet from where the spiral- curve begins. In this area the roadside has a slope of 2:1 or greater. The plans indicate the bottom of the slope is 36 feet below the road edge. The guardrail does not have a safety end treatment. UDOT engineers indicated that a large part of this road segment has 2:1 roadside slopes and that the original designer may have installed the guardrail design to keep errant vehicles from striking a culvert at the toe of the slope.

The guardrail is about 550-feet long and terminates about 772 feet from where the 1,641-foot-long curve begins. In the area where the guardrail terminates, the steep 2:1 embankment transitions into a fill area that rises in a mound about 3 feet high above the roadway. This mound continues for about 200 feet and then another embankment runs along side the highway. Field measurements showed that the area had a 1:3 slope, and a drainage ditch with 12-inch diameter rocks was located about 27 feet from the roadway edge. The desired clear zone for this road would be approximately 24 feet. However, the slope continued out past 30 feet so the clear zone would have to be extended. The highway plans from 1962 show that the bottom of the embankment has an average 1V:3H slope, and a survey performed after the accident confirmed that the slope was 1V:3H or flatter.

On January 14-15, 2008, the NTSB, UDOT, and the Utah Highway Patrol used a total station and Tinco Satellite survey equipment to take precise measurements of the slope, roadway, dashed yellow lines, guardrail, tire marks, ground scars, and vehicle debris. (See Figures 2,3,4, Scene Diagrams with elevation contours and profiles below)

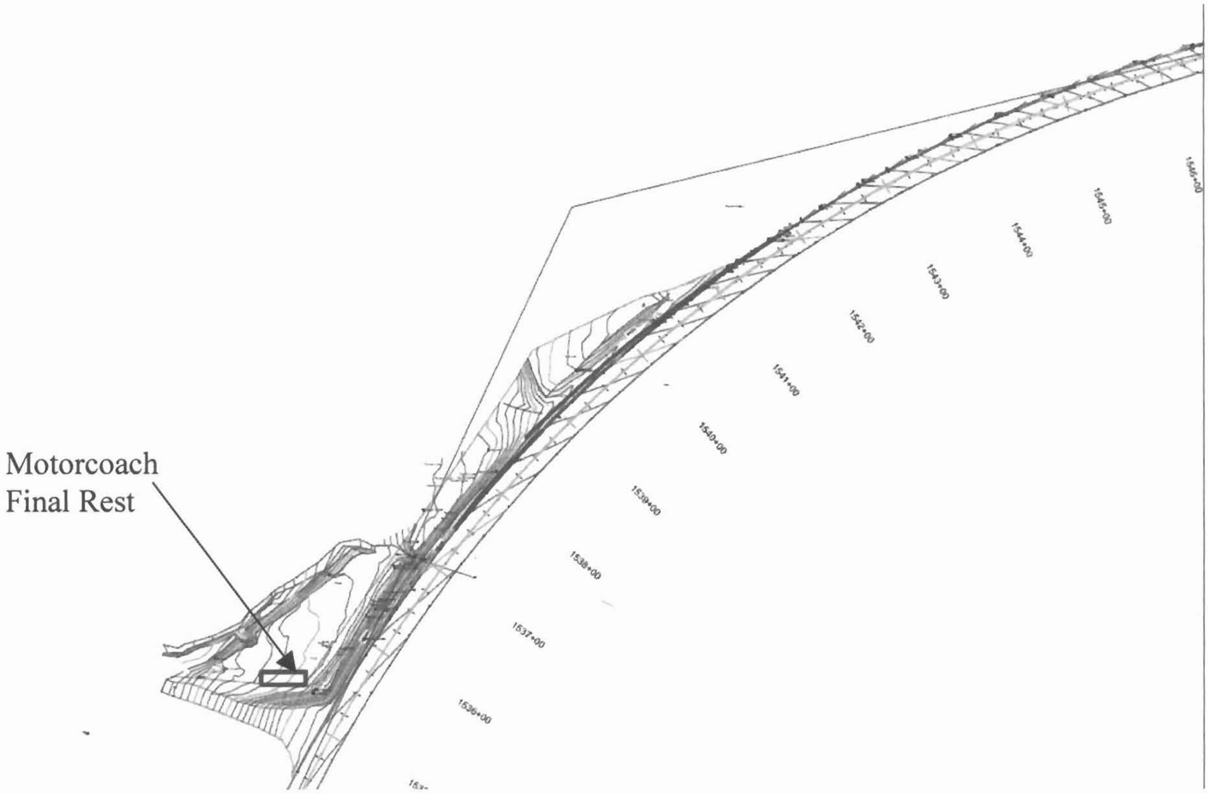


Figure 2.

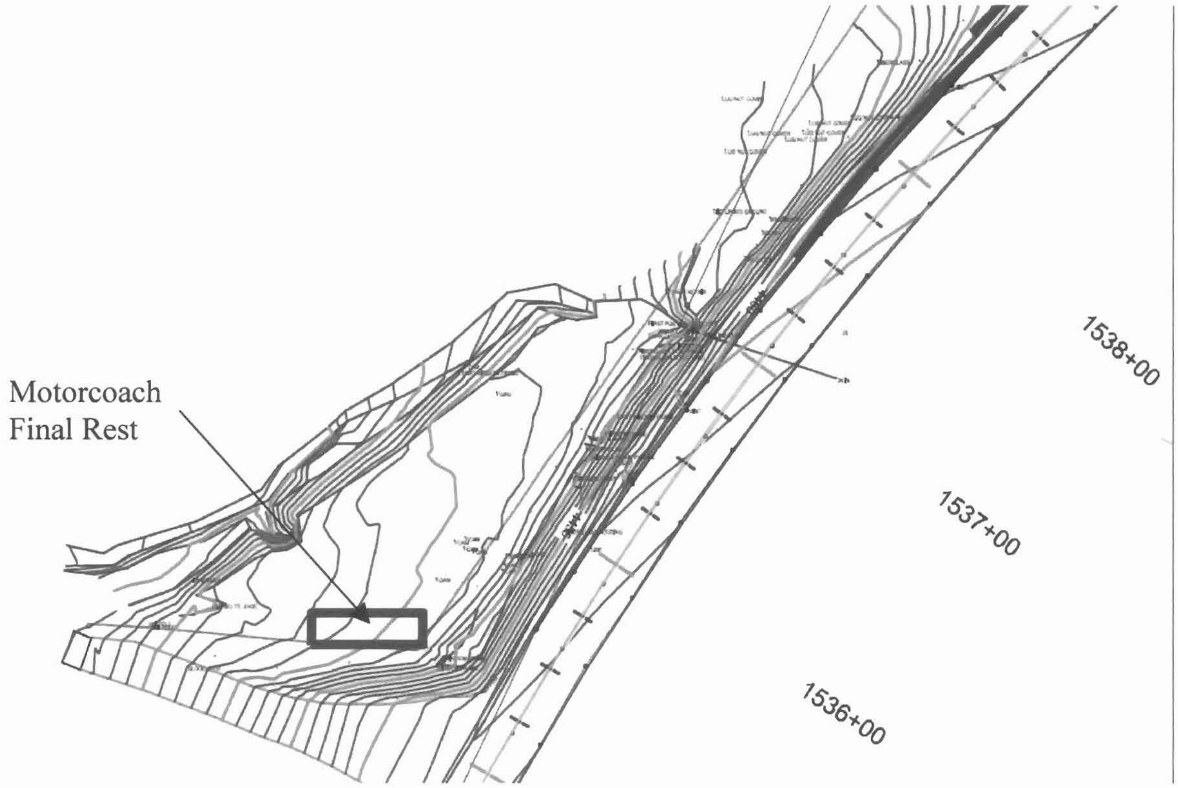


Figure 3.

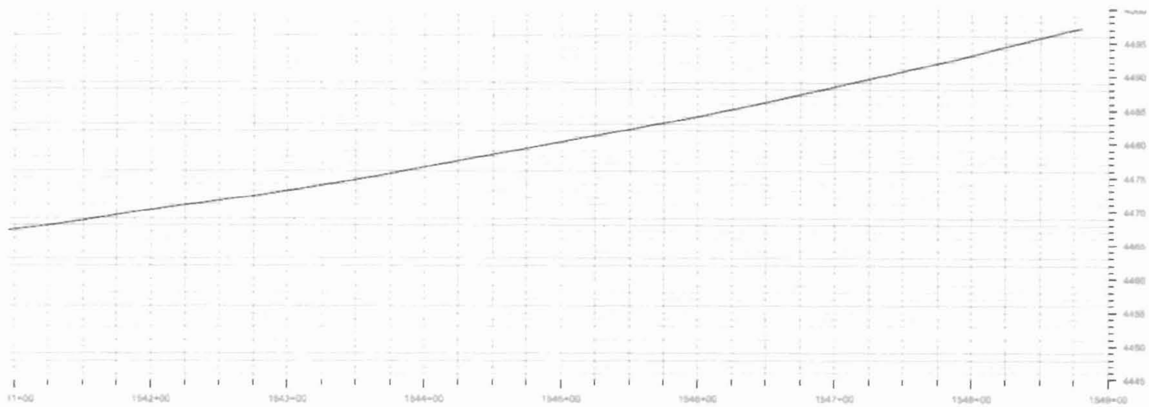


Figure 4.

Roadside Design Warrants for Embankments

The 2006 Roadside Design Guide published by the American Association of State Highway Traffic Officials (AASHTO) provides the following guidelines for roadside safety:

The Clear roadside Concept

In 1967 and 1974 AASHTO published a book, "Operational Practices Related to Highway Safety" that dealt with roadside safety. The 1974 edition indicated it was desirable to provide an unencumbered roadside recovery area that is as wide as practical on a specific highway section. Studies indicated that a width of 30 feet or more from the edge of the traveled way permits about 80 percent of the vehicles leaving a roadway out of control to recover. Subsequently, most highway agencies began to try to provide a traversable and unobstructed roadside area extending approximately 30 feet beyond the edge of the traveled way, particularly on high-speed roadways. Many obstacles located within this clear-zone distance were removed, relocated, re-designed, or shielded by traffic barriers. It soon became apparent, however, that in some limited situations where the embankment sloped significantly downward, a vehicle could encroach farther from the through traveled way; thus a 30-foot recovery area might not be adequate. Conversely, on most low volume or low speed facilities, a 30-foot recovery area was considered excessive and could seldom be justified for engineering, environmental, or economic reasons.

In 1977 the AASHTO Guide for Selecting, Locating, and Designing Traffic Barriers, modified the earlier clear zone concept by introducing variable clear-zone distances based on traffic volumes, speeds, and roadside geometry. Figure 3-1 can be used to determine the suggested clear zone distances for selected traffic volumes and speeds. (See Table 2 Below)

TABLE 3.1 (Cont'd)

[U.S. Customary Units]

DESIGN SPEED	DESIGN ADT	FORESLOPES			BACKSLOPES		
		1V:6H or flatter	1V:5H TO 1V:4H	1V:3H	1V:3H	1V:5H TO 1V:4H	1V:6H or Flatter
40 mph or less	UNDER 750	7 – 10	7 – 10	**	7 – 10	7 – 10	7 – 10
	750 – 1500	10 – 12	12 – 14	**	10 – 12	10 – 12	10 – 12
	1500 – 6000	12 – 14	14 – 16	**	12 – 14	12 – 14	12 – 14
	OVER 6000	14 – 16	16 – 18	**	14 – 16	14 – 16	14 – 16
45–50 mph	UNDER 750	10 – 12	12 – 14	**	8 – 10	8 – 10	10 – 12
	750 – 1500	12 – 14	16 – 20	**	10 – 12	12 – 14	14 – 16
	1500 – 6000	16 – 18	20 – 26	**	12 – 14	14 – 16	16 – 18
	OVER 6000	18 – 20	24 – 28	**	14 – 16	18 – 20	20 – 22
55 mph	UNDER 750	12 – 14	14 – 18	**	8 – 10	10 – 12	10 – 12
	750 – 1500	16 – 18	20 – 24	**	10 – 12	14 – 16	16 – 18
	1500 – 6000	20 – 22	24 – 30	**	14 – 16	16 – 18	20 – 22
	OVER 6000	22 – 24	26 – 32 *	**	16 – 18	20 – 22	22 – 24
60 mph	UNDER 750	16 – 18	20 – 24	**	10 – 12	12 – 14	14 – 16
	750 – 1500	20 – 24	26 – 32 *	**	12 – 14	16 – 18	20 – 22
	1500 – 6000	26 – 30	32 – 40 *	**	14 – 18	18 – 22	24 – 26
	OVER 6000	30 – 32 *	36 – 44 *	**	20 – 22	24 – 26	26 – 28
65–70 mph	UNDER 750	18 – 20	20 – 26	**	10 – 12	14 – 16	14 – 16
	750 – 1500	24 – 26	28 – 36 *	**	12 – 16	18 – 20	20 – 22
	1500 – 6000	28 – 32 *	34 – 42 *	**	16 – 20	22 – 24	26 – 28
	OVER 6000	30 – 34 *	38 – 46 *	**	22 – 24	26 – 30	28 – 30

* Where a site specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear-zone distances greater than the clear-zone shown in Table 3.1. Clear zones may be limited to 30 ft for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

** Since recovery is less likely on the unshielded, traversable 1V:3H slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of slope. Determination of the width of the recovery area at the toe of slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope. While the application may be limited by several factors, the foreslope parameters which may enter into determining a maximum desirable recovery area are illustrated in Figure 3.2.

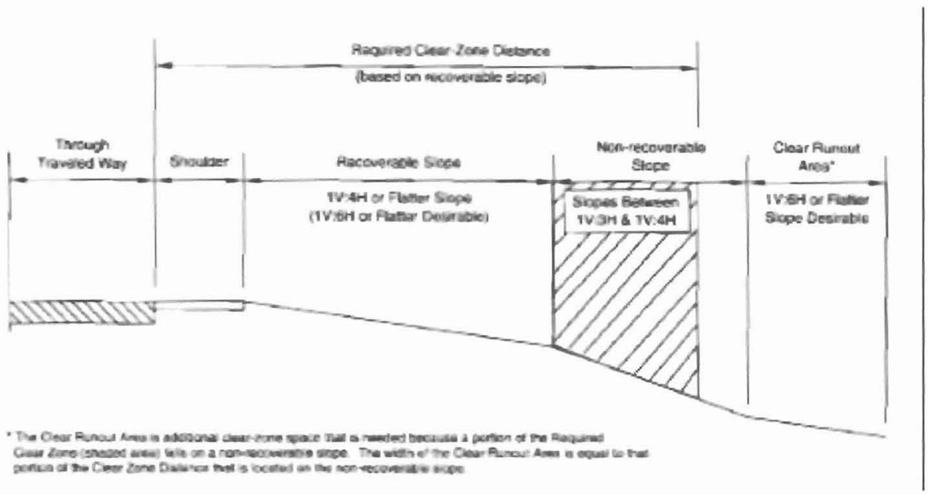


Table 2.

However, these tables only provide a general approximation of the needed clear-zone distances. The curves are based on limited empirical data that was extrapolated to provide a wide range of conditions. The designer must keep in mind site-specific conditions, design speeds, rural versus urban locations, and practicality. The distances from Figure 3.1 should suggest only the approximate center of a range to be considered and not a precise distance to be held as absolute.

If a roadside is not flat a motorist leaving the roadway will encounter a foreslope, a backslope, a transverse slope, or a drainage channel. Each of these features has an effect on a vehicles lateral encroachment and trajectory.

Foreslopes

Foreslopes parallel to the flow of traffic may be identified as recoverable, non-recoverable, or critical. Recoverable slopes are 1 foot Vertical to 4 foot Horizontal (1V:4H) or flatter. If such slopes are relatively smooth and traversable, the suggested clear zone distance may be taken directly from Figure 3.1. Motorists who encroach on recoverable foreslopes can generally stop their vehicle or slow then enough to return to the roadway safely.

A non-recoverable foreslope is defined as one that is traversable, but from which most vehicles will be unable to stop or return to the roadway easily. Vehicles on such slopes typically can be expected to reach the bottom. Foreslopes between 1V:3H and 1V:4H generally fall into this category. Since a high percentage of encroaching vehicles will reach the toe of these slopes, the clear-zone cannot logically end on the slope. Fixed obstacles will normally not be constructed along such slopes and a clear run-out area at the base is desirable.

A critical foreslope is one on which a vehicle is likely to overturn. Foreslopes steeper than 1V:3H generally fall into this category. If a foreslope steeper than 1V:3H begins closer to the traveled way than the suggested clear-zone distance for that specific roadway, a barrier might be warranted if the slope cannot readily be flattened. Barrier warrants for critical foreslopes are discussed in chapter 5 of the AASHTO Roadside Design Guide (RDG)

Roadside Barriers

A roadside barrier is a longitudinal barrier used to shield motorists from natural or man-made obstacles located along either side of a traveled way. The primary purpose of all roadside barriers is to prevent a vehicle from leaving the traveled way and striking a fixed object or terrain feature that is less forgiving than striking the barrier itself.

A series of standard crash tests are presented in National Cooperative Highway Research Program Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features (NCHRP Report 350) This report establishes 6 test levels (TL's) for longitudinal barriers to evaluate occupant risk, structural integrity of the barrier, and post-impact behavior of the vehicle for a variety of vehicle masses at varying speeds and angles of impact.

TL-1, TL-2, and TL-3 require successful tests of an 1,800-pound car impacting a barrier at an angle of 20 degrees and a 4,400-pound pickup truck impacting a barrier at an angle of 25 degrees, at speeds of 30, 45, and 60 mph. TL-4 adds a 17,600-pound single unit truck at an impact angle of 15 degrees and a speed of 50 mph. TL-5 substitutes an 80,000-pound tractor semi-trailer for the single unit truck, and TL-6 substitutes an 80,000-pound tractor semi-trailer (tanker). In this accident the motorcoach had a GVWR of 54,000 pounds.

For barrier approvals and performance acceptance, the designer is encouraged to contact the Federal Highway Administration's (FHWA) Office of Highway Safety and to access FHWA's website to view the acceptance letters for longitudinal barriers under NCHRP Report 350. (http://safety.fhwa.dpt.gov/fourthlevel/hardware/longbarriers.htm)

Barrier Warrants

Barrier Warrants are based on the premise that a traffic barrier should be installed only if it reduces the severity of potential crashes. Typically, guardrail warrants have been based on a subjective analysis of certain roadside elements or conditions. If the consequences of a vehicle striking a fixed object or running off the road are believed to be more serious than hitting a traffic barrier, then the barrier is considered warranted. While this approach can be used, often there are instances where it is not immediately obvious whether the barrier or the unshielded condition presents the greater risk. Furthermore, the subjective method does not directly consider either the probability of a crash occurring or the costs associated with shielded and unshielded conditions.

Warrants may also be established using a benefit-to-cost-analysis whereby factors such as design speed and traffic volume can be evaluated in relation to the barrier. Costs associated with the barrier (Installation costs, Maintenance costs, and crash costs) are compared to similar costs associated without barriers. This procedure is typically used to evaluate three options: (1) remove or reduce the area of concern so that it no longer requires shielding, (2) install an appropriate barrier, or (3) leave the area of concern unshielded.

Embankments

Embankment height and side slope are the basic factors considered in determining barrier need as shown in Figure 5 below.

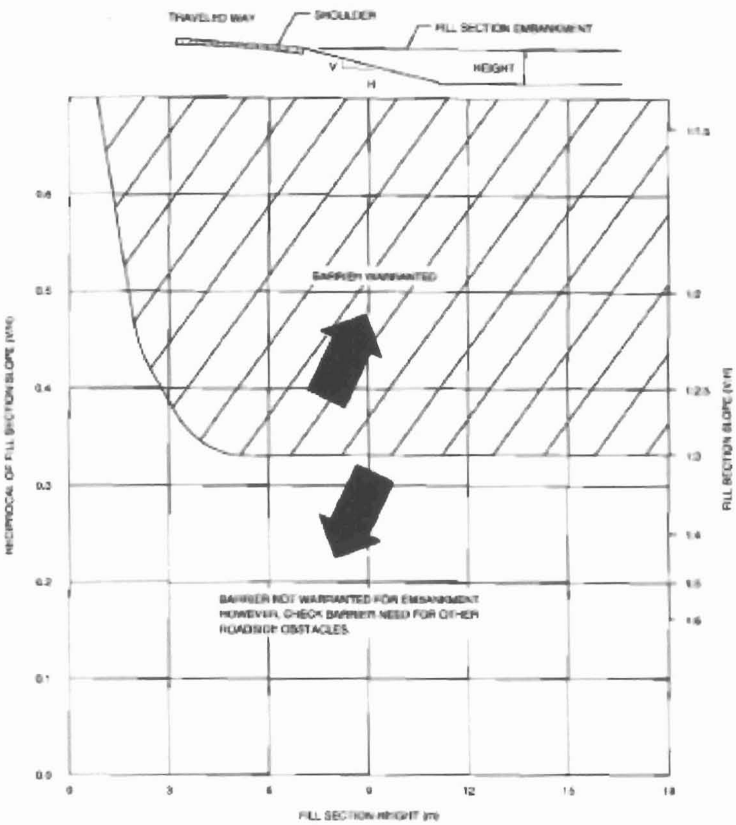


FIGURE 5.1a Comparative risk warrants for embankments (metric units)

Figure 5.

These criteria are based on studies of the relative severity of encroachments on embankments versus impacts with roadside barriers. Embankments with slope and height combinations on or below the curve do not warrant shielding unless they contain obstacles within the clear zone. Figure 5.1 however, does not take into account either the probability of an encroachment occurring or the relative cost of installing a traffic barrier versus leaving the slope unshielded. The embankment at the accident location had several rocks and a drainage ditch on the downslope in the clear zone.

After reviewing the embankment, UDOT advised they would evaluate the box culvert area, and guardrail standards only if a reconstruction project was slated for this area.

Scene Evidence

There were indentations on the bottom of the W-beam guardrail located about 14 inches above the pavement level. Also, these indentations were located 28 feet from the end of the guardrail. Also the crown from a fractured concrete post was observed about 61 feet from the end of the guardrail. Between these marks and the end of the guardrail one lug nut cover from the bus was found on the back-side of the guardrail. Another lug nut cover from the bus was found about 25 feet past the end of the guardrail on the right roadside before the downslope began. Also in this area about 70 feet south of the rail the right rear tag axle wheel cover was found. The lug nut covers protect the lug nuts from corrosion and serve to hold the wheel covers in place. Once the guardrail contact forced off the tag axle lug nut covers the wheel cover was free to fall off. All of this evidence was found prior to the bus traveling down the embankment.

Two sets of plow mars on the side slope showed the front tires were tracking near the top of the embankment and the rear tire furrows were farther down the embankment. One scar near the roadside showed the front of the bus impacted the ground with the bus angled at 37 degrees relative to the roadside. About 30 feet forward of that mark was an oval shaped indentation that was 7-foot-long by 5-foot-wide and 5 inches deep. This mark was next to the roadside where the front windshield was found. The other ground scars were photographed and measured by the Utah Highway Patrol. (See Figures 6, 7, Drawings Below)

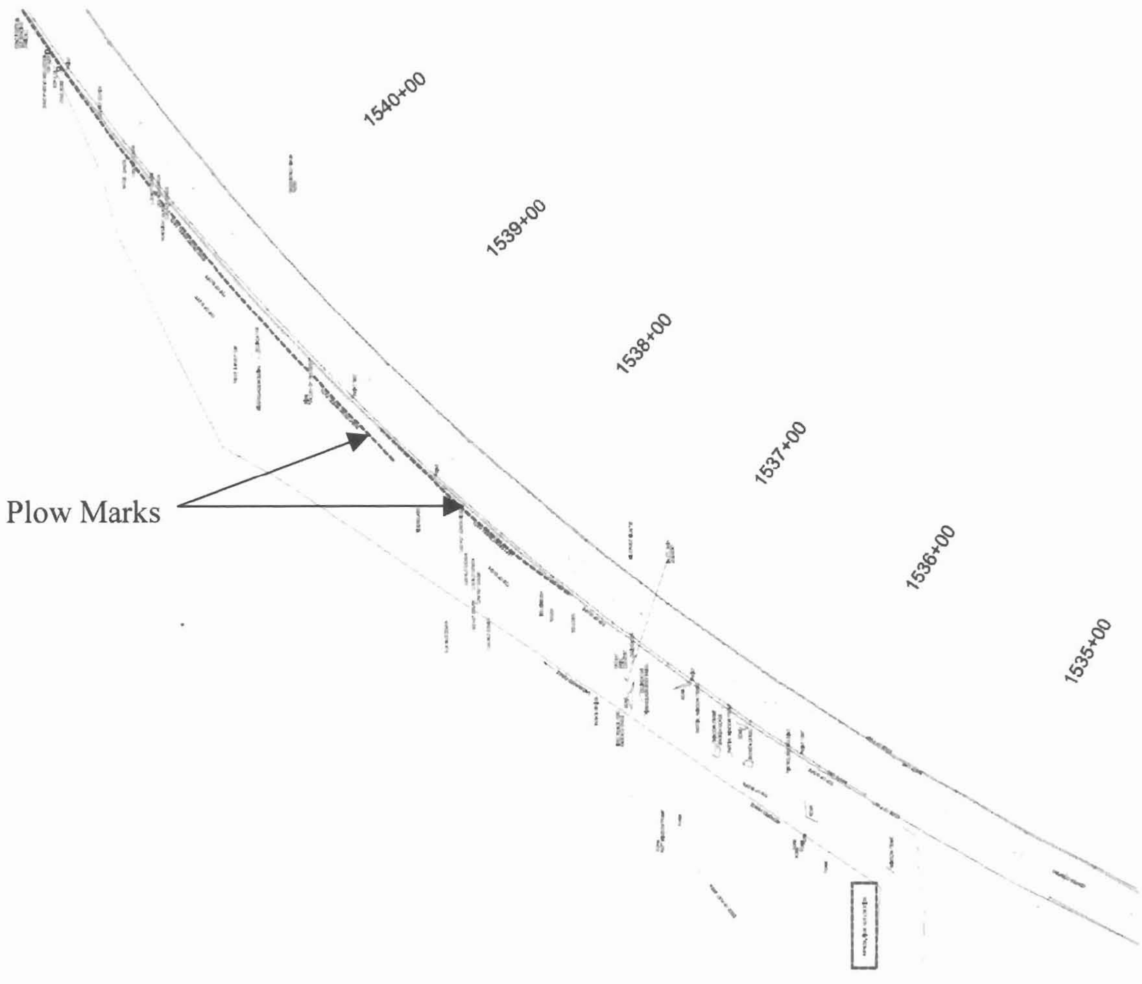
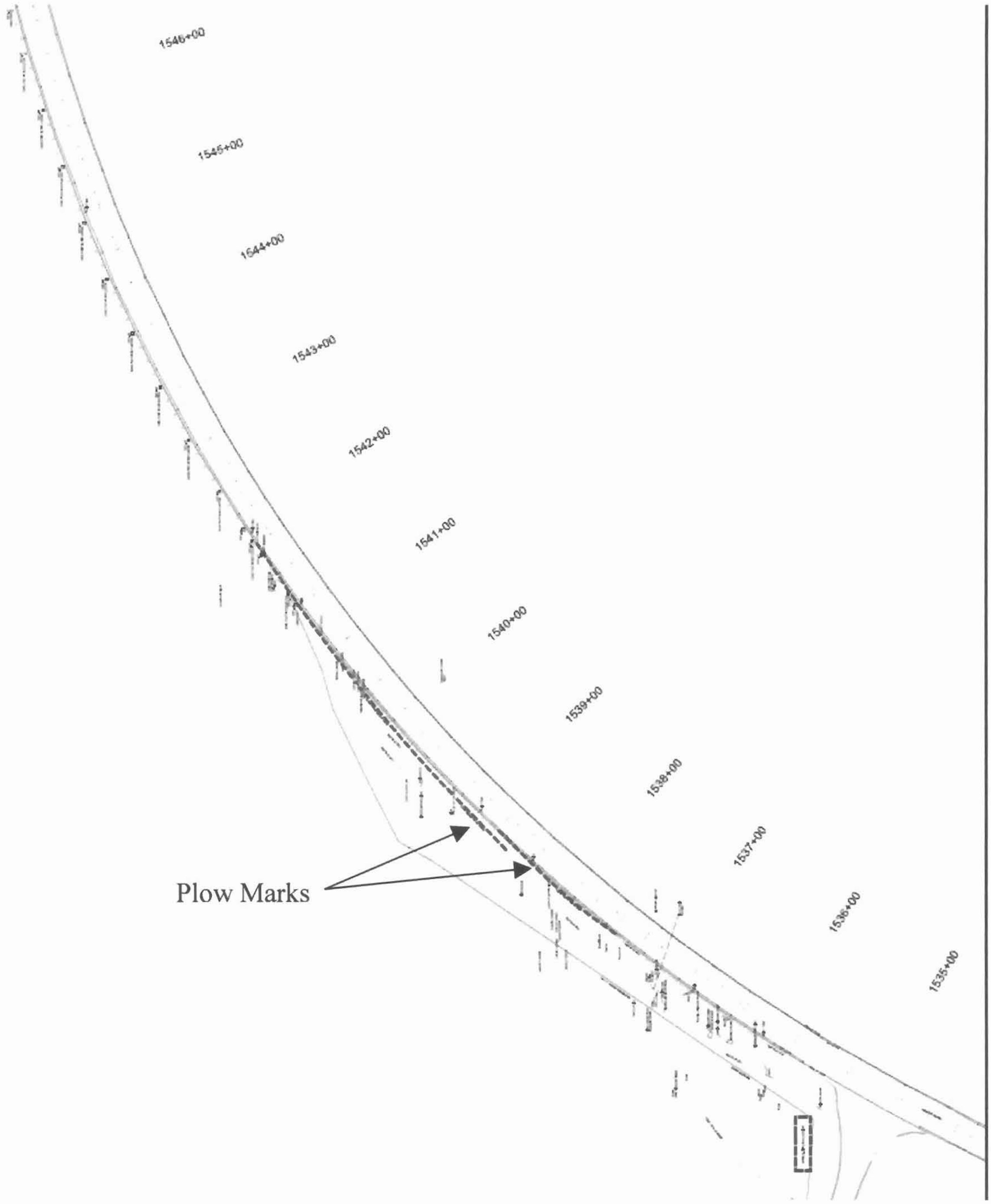


Figure 6.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Plow Marks

Figure 7.