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CALSPAN ON-SITE CHILD RESTRAINT SYSTEM CRASH INVESTIGATION
SCI CASE NO.: CA10004

VEHICLE: 2000 JEEP GRAND CHEROKEE LAREDO 4X4

LOCATION: NORTH CAROLINA

CRASH DATE: DECEMBER 2009

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. Abstract This on-site investigation focused on a high-back booster Child Restraint System (CRS) installed in the second row right seating position of a 2000 Jeep Grand Cherokee. The CRS was occupied by a 5-year-old female who was restrained by the vehicle's manual restraint system. The southbound Jeep departed the right side of the road due to driver distraction. The driver responded to the vehicle's errant trajectory by steering to the left and braking. The sudden steering maneuver resulted in a counterclockwise (CCW) yaw. The vehicle reentered and crossed over the road where it subsequently tripped, and rolled over one-quarter turn to the right. As the vehicle neared final rest, the vehicle's roof impacted a tree. The 27-year-old female driver was transported by ambulance to a local hospital where she was treated for muscle strain to her back and released. The 5-year-old female passenger was transported directly from the scene to a local hospital in a personal vehicle where she was treated for minor severity soft tissue injuries and released.			
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BACKGROUND

This on-site investigation focused on a high-back booster Child Restraint System (CRS) installed in the second row right seating position of a 2000 Jeep Grand Cherokee **(Figure 1)**. The CRS was occupied by a 5-year-old female who was restrained by the vehicle's manual restraint system. The southbound Jeep departed the right side of the road due to driver distraction. The driver responded to the vehicle's errant trajectory by steering to the left and braking. The sudden steering maneuver resulted in a counterclockwise (CCW) yaw. The vehicle reentered and crossed over the road where it subsequently tripped, and rolled over one-quarter turn to the right. As the vehicle neared final rest, the vehicle's roof impacted a tree. The 27-year-old female driver was transported by ambulance to a local hospital where she was treated for muscle strain to her back and released. The 5-year-old female passenger was transported directly from the scene to a local hospital in a personal vehicle where she was treated for minor severity soft tissue injuries and released.

Figure 1: Right front oblique view of the 2000 Jeep Grand Cherokee.

This crash was identified by the National Highway Traffic Safety Administration's (NHTSA) Crash Investigation Division (CID) through a search of the police reports collected by the General Estimates System (GES). Due to the Agency's interest in child passenger safety, the crash report was forwarded to the Calspan Special Crash Investigations (SCI) team on January 25, 2010 for follow-up investigation. Based on the rollover of the vehicle and the presence of an injured occupant of a CRS, this case was assigned for an on-site investigation on January 26, 2010. The field activities for this investigation were initiated on January 27, 2010. This investigation involved the inspection of the Jeep and the CRS, a detailed interview with the driver of the Jeep, and documentation of the crash scene.

SUMMARY

Vehicle Data - 2000 Jeep Grand Cherokee

The 2000 Jeep Grand Cherokee Laredo 4x4 was manufactured in September 1999 and was identified by Vehicle Identification Number (VIN): 1J4GW48S9YC (production sequence

deleted). The vehicle's odometer reading was approximately 223,699 km (139,000 mi). The four-wheel drive Jeep was powered by a 4.0-liter inline, 6-cylinder engine linked to a 4-speed automatic transmission. The braking system consisted of power-assisted front and rear disc brakes with four-wheel antilock. The side windows were closed at the time of the crash. The Jeep was equipped with Yokohama Geolander H/T tires on the front axle and Futura Adventurer H/T tires on the rear axle. All tires were size P235/65R17 and were mounted on five-spoke OEM-type alloy wheels. The manufacturer recommended tire size was P225/75R16 and the manufacturer recommended cold tire pressure was 228 kPa (33 PSI), front and rear. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Tire/Wheel Damage
Left Front	193 kPa (28 PSI)	6 mm (8/32 in)	None
Left Rear	179 kPa (26 PSI)	4 mm (5/32 in)	None
Right Rear	Tire flat	4 mm (5/32 in)	Tire de-beaded
Right Front	193 kPa (28 PSI)	6 mm (8/32 in)	None

There was mud embedded into the right front wheel and in the tire bead; however, the tire continued to hold air pressure.

The interior of the Jeep was configured with leather-surfaced five-passenger seating. The front bucket seats were separated by a center console and were equipped with adjustable head restraints. Both head restraints were in the full-down position at the time of the SCI inspection. The front seat tracks for the left and right seats were adjusted 3 cm (1.2 in) forward of the full-rear position. The front left seat back angle was 20 degrees aft of vertical. The front right seatback angle measured 29 degrees aft of vertical. The second row consisted of a split bench seat with folding backs. The second row seat cushions were designed to pivot forward and the rear seat backs would fold flat to form a flat cargo floor. The rear outboard seats were equipped with adjustable head restraints, both of which were in the full-down position at the time of the SCI inspection.

The interior occupant safety systems consisted of 3-point lap and shoulder belt systems for the four outboard seating positions and a lap belt for the rear center seating position. The second row was not equipped with the lower anchors of the Lower Anchors And Tethers for CHildren (LATCH) system. The Jeep was equipped with redesigned frontal air bags for the driver and front right passenger positions.

Crash Site

This crash occurred during the daylight hours of December 2009 on a rural two-lane, undivided, asphalt-surfaced north/south roadway. The environmental conditions at the time of the crash

were rain. The asphalt road surface was wet. The crash occurred at the end of a shallow left curve in a straight section of the road. The road had a negative 3.2 percent grade to the south. In the area of the crash, the road had recently narrowed from three lanes to two. The 3.2 m (10.5 ft) wide travel lanes were separated by double yellow centerlines. Grass roadsides, with a negative 3.2 percent grade, were located outboard of the road edge. The west roadside measured 1.7 m (5.6 ft) in width. To the west beyond the roadside, the terrain transitioned to an embankment with a negative 80 percent grade. The terrain along the Jeep's path of travel was rough and included a ditch that measured 1.1 m (3.6 ft) in wide and 45 cm (17.7 in) deep. The width of the east roadside measured 1.2 m (3.9 ft). Outboard the east roadside there was an embankment with a negative 75 percent grade that ended in a tree line. The tree line was located 7.1 m (27.1 ft) east of the road edge. The posted speed limit was 89 km/h (55 mph). The Jeep's path of travel was defined by tire marks on the grass roadsides. **Figures 2 and 3** are southbound trajectory views along the Jeep's path of travel. The Crash Schematic is included as **Figure 8** of this report.

Figure 2: Southbound trajectory view of the Jeep at the right roadside departure.

Figure 3: Southbound trajectory view of the Jeep at the left roadside departure.

Crash Sequence

Pre-Crash

The restrained 27-year-old female driver of the Jeep was operating the vehicle southbound at a driver-estimated speed of 89 km/h (55 mph). The 5-year-old female was restrained in a high-back booster CRS in the second row right position. The driver had departed her home and had traveled 9.3 km (5.8 miles) to the crash site. She stated in the interview that she had turned around to check on food items that she was transporting in the second row left seat. As a result of the inattention, the Jeep departed the roadway to the right. The Jeep driver reported that she applied the brakes and steered left in an attempt to regain the roadway. The SCI scene inspection determined that the Jeep traveled 19.6 m (64.3 ft) on the west roadside at which point diverging right tire marks indicated that the Jeep entered a slight counterclockwise (CCW) yaw. The Jeep continued to rotate CCW as it traversed the west roadside an additional 30.1 m (98.8 ft). The

Jeep reentered the road in a near broadside attitude. The Jeep crossed over the road with a southeast trajectory and departed the east roadside. The vehicle had rotated approximately 100 degrees CCW at the point of the east roadside departure.

Converging tire marks along the east roadside and down the embankment evidenced the Jeep's trajectory. The right side tires furrowed into the soft terrain of the roadside. The right front tire mark measured 13.7 m (44.9 ft) in length. The right rear tire mark measured 11.0 m (36.1 ft). The crash reconstruction determined the Jeep had rotated approximately 170 degrees CCW at the end of the marks.

Crash

The furrowing right tires tripped the Jeep into a right side leading rollover (Event 1). The Jeep rolled one-quarter turn to the right. The top plane of the vehicle then impacted a 20 cm (7.8 in) diameter tree (Event 2). The severity of this impact was minor. The tree was located within the tree line 7.1 m (27.1 ft) east of the roadway. The Jeep came to rest on its right side facing north against the tree. The interrupted rollover distance was 5 m (16.4 ft). **Figure 4** is a view of the tree line, the area of the rollover and the Jeep's final rest location.

Figure 4: Southeast trajectory view of the area of the rollover and the Jeep's final rest.

Post-Crash

At final rest, the Jeep was on its right side; therefore the right doors could not be opened. The driver and rear right passenger were unable to open the left doors of the vehicle to exit under their own power. The driver of the Jeep retrieved her cellular telephone and called the 9-1-1 emergency response system and her mother, who lived approximately 8 km (5 miles) from the crash site. Police, emergency medical, and tow personnel responded to the crash site and the emergency medical personnel opened the left doors. The driver was complaining of back pain. She was placed on a backboard and lifted out through the left front door opening. The rear right passenger was also assisted out of the vehicle.

The driver was transported by ambulance to a local hospital where she was treated and released from the emergency department the same day. Due to the length of time required to place the driver on a backboard and remove her from the vehicle, the rear right passenger was transported directly from the scene to the local hospital by the driver's mother. The child passenger was treated in the emergency department and released the same day. The Jeep was towed from the

scene due to disabling damage. It was then transferred to a regional vehicle salvage facility where it was inspected for this investigation.

2000 Jeep Grand Cherokee

Exterior Damage

The exterior of the Jeep sustained minor severity damage to the top plane and moderate severity damage to the right side plane as a result of this multiple impact crash. The damage from the rollover (Event 1) was limited to the right side and extended 140 cm (55.1 in) vertically from the door sill to the roof side rail and longitudinally 426 cm (167.7 in) from the right rear bumper corner to the right front bumper corner **(Figure 5)**. The maximum vertical and lateral crush was both located directly above the rear door seam at the junction of the right roof side rail and right C-pillar. The maximum lateral crush measured 3 cm (1.2 in) and the maximum vertical crush was 2 cm (0.8 in). The rear right glazing adjacent to the cargo area was disintegrated by the impact forces. All other side glazing and the windshield and backlight were not damaged in this crash. All of the vehicle doors remained closed during the crash and were operational post-crash. The CDC assigned for the rollover was 00RDAO2.

Figure 5: Right side damage resulting from the rollover.

Following the rollover, the top plane of the Jeep impacted a 20 cm (7.9 in) diameter tree (Event 2). The damage was located on the right side of the roof and the right roof side rail. The damage began 37 cm (14.6 in) aft of the B-pillar and extended rearward 27 cm (10.6 in). The tree impact damage extended laterally 29 cm (11.4 in). The maximum crush for this event was located 51 cm (20.1 in) aft of the B-pillar and measured 3 cm (1.2 in) in depth. The CDC assigned for the tree impact was 00TPRN2.

Interior Damage

The Jeep sustained minor severity interior damage that was attributed to occupant contact. The left side of the center console lid was scuffed. This contact was located 0-12 cm (0-4.7 in) aft of the front left corner and deformed to the right 3 cm (1.2 in). It was attributed to contact with the right side of the driver's hip and abdomen. The tilt steering was adjusted one position below full-up. The right side of the second row and the rear cargo area was stained by a spilled food item. There was no visible intrusion to the passenger compartment of the Jeep.

Manual Restraint Systems

The Jeep was equipped with manual 3-point lap and shoulder belt systems for the four outboard seating positions and a lap-only belt for the rear center seating position. The four lap and shoulder belt systems utilized continuous loop webbing which retracted onto Emergency Locking Retractors (ELR). The driver's position included a sliding latchplate and a height adjustable D-ring that was adjusted to a mid-position, 13 cm (5.1 in) below the full-up position. The driver used the safety belt at the time of the crash, which was supported by loading evidence on the belt webbing. This evidence consisted of a frictional abrasion on the webbing near the D-ring. The D-ring abrasion was located 90-94 cm (35.4-37 in) above the floor anchor.

The second row right seating position included a locking latchplate and a height adjustable D-ring that was adjusted to a mid-position, 9 cm (3.5 in) below the full-up position. The second row right belt was used with a high-back booster CRS at the time of the crash. Usage was evidenced by square imprints on the lower section of the webbing at the locations where the webbing contacted the belt path of the booster seat. Specifically, these square imprints were located 30-36 cm (11.8-14.2 in) and 67-73 cm (26.4-28.7 in) above the floor anchor. The belt webbing also contained a food stain that was located 19-111 cm (7.5-43.7 in) above the floor anchor.

Frontal Air Bag System

The Jeep was equipped with redesigned frontal air bags for the driver and front right passenger positions. The driver air bag was concealed within the center hub of the four-spoke steering wheel. The front right passenger air bag was a mid-mount design located within the right instrument panel. Both air bags were reported in the interview to be original equipment within the vehicle and have not been serviced. The frontal air bags did not deploy during this crash.

Child Restraint System

The CRS utilized in the second row right seating position was a Cosco/Dorel, Eddie Bauer Deluxe 3-in-1 that could be configured as a rear-facing infant CRS, a forward facing CRS, or a high-back booster CRS **(Figure 6)**. The 5-point harness had been removed and the CRS was used as a high-back booster seat at the time of the crash. The infant head stabilizing pillow was still attached to the CRS. The seat was manufactured on December 21, 2004 and was purchased new by the driver. The Model and Serial numbers were 22-755-MAC and AE2B000344, respectively. A stamp on the rear aspect of the shell showed that this seat should not be used after December 2012. The seat was designed with LATCH; however, the LATCH system was not used during this crash. The booster seat application of the CRS

Figure 6: View of the Eddie Bauer Deluxe 3-in-1 CRS.

was labeled for use by a child with a height and weight of 73-172 cm (29-52 in) and 14-46 kg (30-100 lb), respectively.

The vehicle's manual safety belt was used to secure the child and CRS during this crash. The lap portion of the belt was routed across the belt positioning channels located on both sides of the CRS shell. On the upper outboard aspects of the CRS were two shoulder belt height adjustment guides. The shoulder belt was routed through the lower right shoulder belt height adjustment guide. Inspection of the CRS identified a black transfer and wear of the CRS fabric covering that led to the lower height adjustment guide consistent with the safety belt being used in this seating position and using the lower height adjustment guide **(Figure 7)**. The CRS included two adjustable armrests. These armrests were adjusted in the up or stowed position at the time of this crash. The remainder of the CRS shell was inspected and no damage was found.

Figure 7: CRS lining wear indicating lower right height adjustment use.

The driver stated that the 5-year-old child passenger regularly buckled herself into the booster seat upon entering the vehicle and unbuckled herself when exiting the vehicle. On the day of the crash, the child had buckled the safety belt herself. The driver stated in the interview that the child passenger did not unbuckle the safety belt while the vehicle was in motion.

Driver Demographics/Data

Driver Age/Sex:	27-year-old female
Height:	168 cm (66 in)
Weight:	73 kg (160 lb)
Eyewear:	None
Seat Track Position:	Rear-track, 3 cm (1.2 in) forward of full-rear
Manual Safety Belt Use:	3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Egress from Vehicle:	Assisted by emergency medical personnel
Mode of Transport from Scene:	Ground ambulance
Type of medical treatment:	Transported, treated and released

Driver Injuries

Injury	Injury Severity (AIS update 98)	Injury Source
Muscle strain across mid-back	Minor (640478.1,7)	Impact forces

Source of injury data: Driver Interview. No record of treatment was found at the reported hospital.

Driver Kinematics

The 27-year-old female driver was seated in a rear-track position and was restrained by the manual 3-point lap and shoulder belt system. The driver reported that her left hand was at the 12 o'clock position on the steering wheel. The driver turned her body momentarily to the right to check on food items that she was transporting on the floor of the second row left seat position. The Jeep departed the roadway to the right. As the driver detected the roadway departure, she grasped the steering wheel with her right hand, applied the brakes and steered left in order to return to the roadway. As the Jeep traversed the roadside, the left steering maneuver caused the Jeep to yaw CCW.

The Jeep reentered and traveled across the roadway and then departed the left side of the road as the vehicle continued to rotate CCW. The right side tires furrowed into the roadside terrain and tripped into a right side leading rollover. As the vehicle decelerated laterally and rolled onto its right side, the safety belt system locked. The driver initiated a right trajectory within the front left seating position and her right hip loaded the center console. After the one-quarter turn rollover, the driver's upper body wrapped over the center console and her pelvis (that was restrained by the belt system). This movement resulted in the back strain. The minor severity tree impact to the top plane of the vehicle did not affect the kinematics of the driver.

At final rest, the driver unbuckled her safety belt and evaluated the rear right passenger. The driver released the safety belt of the child passenger. They were unable to open the left doors and exit the vehicle under her their power. Emergency medical personnel arrived and opened the left doors. Due to the back pain that the driver was experiencing, she was placed on a backboard and removed from the vehicle. The driver was transported by ground ambulance to a local hospital where she was treated in the emergency department and released the same day.

Second Row Right Passenger Demographics/Data

Passenger Age/Sex:	5-year-old female
Height:	122 cm (48 in)
Weight:	34 kg (74 lb)
Eyewear:	None
Seat Track Position:	Not adjustable
Manual Safety Belt Use:	3-point lap and shoulder belt used with Booster CRS
Usage Source:	Vehicle inspection
Egress from Vehicle:	Assisted by emergency medical personnel
Mode of Transport from Scene:	Personal vehicle directly from scene to a local hospital
Type of medical treatment:	Treated in the emergency department and released.

Second Row Right Passenger Injuries

Injury	Injury Severity (AIS update 98)	Injury Source
10 cm (4 in) contusion of the right hip	Minor (890402.1,1)	CRS shell

Source of injury data: Driver Interview. No record of treatment was found at the reported hospital.

Second Row Right Passenger Kinematics

The 5-year-old rear right passenger was restrained by the vehicle's 3-pont safety belt in the high-back booster CRS that was secured in the second row right seating position. As the vehicle decelerated laterally and the vehicle rolled to the right, the rear right passenger initiated a right trajectory within the rear right seating position. The passenger loaded the right side of the CRS with her right flank resulting in the contusion to her right hip. The minor tree impact to the top plane of the vehicle did not affect the kinematics of the child.

The driver unbuckled the safety belt securing the rear right passenger. Emergency medical personnel lifted the rear right passenger out of the vehicle through the left rear door. Due to the length of time needed to extricate the driver, a family member transported the rear right passenger directly from the scene to the emergency department of a local hospital. The child was examined and released the same day. Medical records were not available.

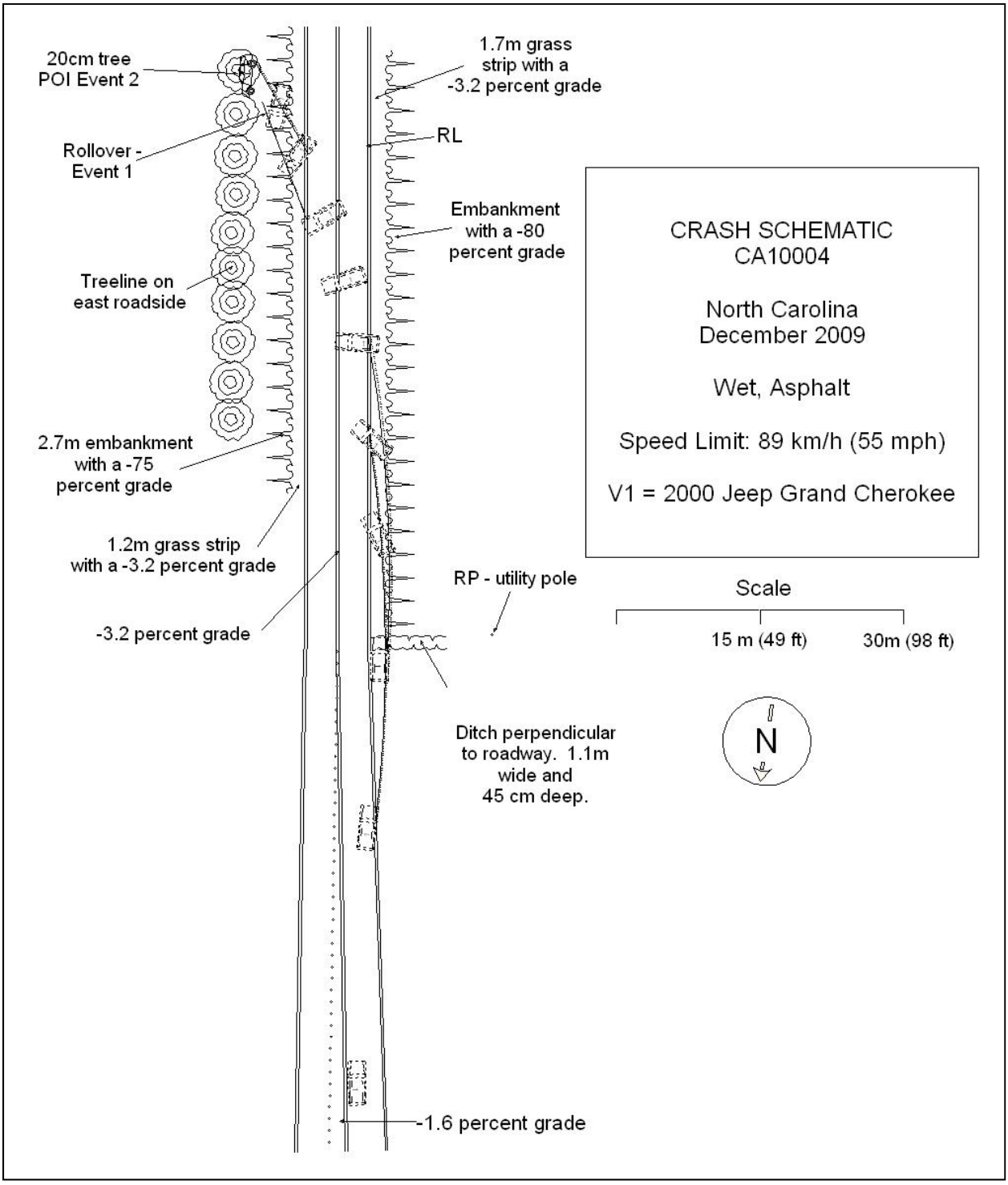

Figure 8: Crash Schematic