

**CRASH DATA RESEARCH CENTER**

Calspan Corporation  
Buffalo, NY 14225

**CALSPAN ON-SITE SCHOOL BUS CRASH INVESTIGATION**

**CASE NO.: CA04-006**

**VEHICLE: CHASSIS - 1997 INTERNATIONAL CONVENTIONAL  
BODY - 77 PASSENGER BLUEBIRD**

**LOCATION: MISSOURI**

**CRASH DATE: FEBRUARY 2004**

Contract No. DTNH22-01-C-17002

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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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**BODY – 77 PASSENGER BLUEBIRD**  
**LOCATION: MISSOURI**  
**CRASH DATE: FEBRUARY 2004**

**BACKGROUND**

This on-site investigation focused on the crashworthiness of the school bus body and the mechanisms of injury for the injured students. The bus was a 1997 International conventional chassis (**Figure 1**) that was equipped with a 77 passenger Bluebird body. The bus impacted the rear of a stopped single axle dump truck on a straight segment of road in a rural area with a posted speed limit of 89 km/h (55 mph). The dump truck was transporting cold patch asphalt material to be used for pothole repair. The two-man crew consisted of the driver and a road repair employee who was behind the truck prior to the crash. Witnesses reported that the driver



**Figure 1. Subject school bus.**

of the bus did not initiate braking actions prior to impact. The full frontal area of the bus impacted the rear hitch, frame, tailgate, and bed of the dump truck resulting in severe damage to the bus and moderate damage to the truck. The asphalt was displaced from the truck into the frontal interior area of the bus. The impact displaced the stopped dump truck 165 m (541') forward. The driver of the school bus was restrained by the manual 3-point lap and shoulder belt system. He sustained severe abdominal injuries and was transported to a regional trauma center where he was admitted in critical condition. The bus was occupied by 30 students with ages ranging from 6-15 years of age. A 15-year-old female student was standing on the bus between rows 2-4. She was displaced forward by the impact force and contacted the intruding frontal components. She was found deceased on the floor of the bus buried in the asphalt compound. Two additional students sustained fractures and were admitted to a local hospital where they were treated for their injuries. The remaining students onboard the bus sustained soft tissue contusions and were examined at a local hospital for possible injury and released. The driver of the dump truck loaded the back wall of the cab and the forward wall of the dump body and expired within hours of the crash.

This school bus crash was identified by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA). Due to the involved school bus and the resulting injuries to the student passengers the crash was assigned to the Calspan Special Crash Investigations (SCI) for an on-site investigation on February 26, 2004. The school bus, dump truck, and the crash site were inspected on March 14, 2004.

## SUMMARY

### *Crash Site*

The crash occurred on a two-lane road in a rural area during daylight hours (**Figure 2**). The asphalt road surface was 7.5 m (24.6') in width and was delineated by a broken yellow center line. Both edges of the roadway were bordered by stone shoulders and shallow drainage ditches. In the vicinity of the crash site, the roadway was straight and level. A right curve for westbound traffic terminated 0.4 kilometers (0.3 mile) east of the crash site. A four-leg intersection with four-way stop signs was located 1.6 km (1 mile) east of the crash site. At the time of this on-site SCI investigation, an



**Figure 2. Westbound view of the crash site.**

unimpeded line of site was measured at 0.6 kilometers (0.4 miles) east of the point of impact. It should be noted that a warning sign for the road repairs was placed at the west leg of the intersection, 1.6 km (1 mile) east of the point of impact. The posted speed limited was 89 km/h (55 mph). The scene schematic is included as (**Figure 14**) of this report.

### *Vehicle Data*

#### *School Bus*

The involved school bus was a 1997 International Model 3800 conventional chassis with a Bluebird body rated at 77 passengers. The chassis was manufactured 4/7/97 with a wheelbase of 701 cm (276") and was identified by Vehicle Identification Number (VIN): 1HVBBAAP9V (production sequence omitted). The odometer reading at the time of the inspection was unknown due to the instrument panel deformation. The bus was powered by a 7.3-liter turbo diesel engine linked to a 5-speed automatic transmission with a center instrument panel mounted selector lever. The bus was equipped with hydraulic front and rear disc service brakes without anti-lock. The Gross Vehicle Weight Rating (GVWR) was placarded as 13,517 kgs (29,800 lb) with a 4,536 kgs (10,000 lb) front axle rating and an 8,981 kgs (19,800 lb) rear axle rating. The bus was equipped with the recommended 265/75R22.5G tires at the front and dual rear axle positions. The front tires were Michelin Radial XZA-1 and the four rear tires were Michelin XDE. The recommended tire pressures were 758 kpa (110 PSI) for the front axle and 724 kpa (105 PSI) for the rear axle. The following table identifies the tire data that was recorded during the SCI inspection:

Position	Tread Depth	Tire Pressure	Tire Damage	Wheel Damage
LF	(15/32")	0 kpa	Side wall cut	None
RF	(15/32")	0 kpa	Side wall cut	None
LR Outer	(11/32")	620 kpa (90 PSI)	None	None
LR Inner	(11/32")	624 kpa (90.5 PSI)	None	None

RR Outer	(11/32")	600 kpa (87 PSI)	None	None
RR Inner	(11/32")	565 kpa (82 PSI)	None	None

The engine compartment of the school bus was covered with a one-piece fiberglass cowl that was hinged at the forward aspect. The fabricated steel diesel fuel tank was mounted to the outboard aspect of the right frame rail, aft of the right side door. The steel safety cage that surrounded the tank remained intact and was free of damage.

The Bluebird school bus body was manufactured on 5/97 and was configured as a 77 passenger (inclusive of driver) with 13 rows of high back seats. Rows 1-12 were 3-passenger bench seats while the 13th row consisted of two, 2-passenger bench seats. The right side door was a two-panel door that opened outward. The doors were hinged at the outboard aspects and closed to the center. Both door panels had two tempered glass panels. The doors were damaged as a result of the crash and were subsequently pulled opened and damaged further post-crash by a piece of construction equipment that was used to open the doors to provide access to the bus by rescue personnel. The right side doors were manually operated by a linkage arm that was mounted to the center instrument panel.

The bus was equipped with two emergency roof exits that were located at the centerline of the roof between the D-and E-pillars and the J-and K-pillars. The forward roof exit was closed at the time of the SCI inspection while the rear roof exit was opened. These units were not utilized during the extrication of the occupants and were not damaged by the crash forces.

Two emergency window exits were located on each side of the bus at the locations of the D- and E-pillars and J- and K-pillars. These windows were comprised of laminated glass and the frames were hinged which allowed the unit to push-out for emergency egress. A rear emergency door was located at the back of the bus and was hinged at the right side. This door was opened and utilized during the extrication of the child passengers.

The driver's compartment consisted of a high-back bucket seat with an integral head restraint that was mounted on a suspension base. A manual 3-point lap and shoulder belt provided occupant protection for the driver. A console to the left of the driver's position housed the controls for the lights, overhead caution lights and HVAC functions. The automatic transmission selector lever was mounted to the center mid instrument panel.

The high-back passenger seats were configured in two rows with a center isle. The seat cushions measured 42 x 98 cm (16.5 x 38.5") with 58 cm (22.75") in height seat backs. The lateral distance between the rows (center isle) was approximately 31 cm (12").

***2000 GMC Dump Truck***

The struck dump truck was a 2000 GMC C7500 series chassis cab that was equipped with a hydraulic dump body. The cab of the truck was a conventional, standard cab with a three-passenger bench seat. The chassis was manufactured on 4/00 and was identified by the following VIN: 1GDL7H1D4YJ (production number deleted). At the time of the

SCI inspection, the vehicle's odometer reading was 15,867 km (9,860 miles). The truck was powered by a 7.2-liter diesel engine linked to a 5-speed manual transmission with a floor-mounted shifter. A snowplow frame and hydraulic lift assembly was mounted to the front frame rails of the truck. The dump body measured 2.1 meters (7') in width, 3 meters (10') in length with 61 cm (24") sidewalls. The tailgate was hinged at the bottom aspect and was equipped with chains to adjust hinged positions. The dump body was identified as a Heil Body (manufacturer) with a Serial No. of 0002586 and a Model No. of SL5Y010. The GVWR of the truck was 13,608 kgs (30,000 lb), split at 4,989 kgs (11,000 lb) for the front axle and 8,618 kgs (19,000 lb) for the rear axle.

### ***Crash Sequence***

#### ***Pre-Crash***

The dump truck was used by a local municipality for pothole patch detail. On the day prior to this crash, it was reported that the two-person crew picked-up approximately 2,722 kgs (6,000 lb) of cold-patch asphalt product. The crew used approximately one-half of the material and returned to the highway facility. On the day of the crash, the crew attended a morning meeting and departed the facility later that day to repair additional potholes within their jurisdiction. It was estimated that as the truck departed the facility, approximately 1,361 kgs (3,000 lb) of asphalt product remained in the dump body of the truck.

The crew placed a work detail warning sign at the west leg of the four-leg intersection that was located 1.6 km (1 mile) east of the crash site. From this point, the crew traveled in a westerly direction and filled potholes along the westbound travel lane. The two-person crew operated with the driver remaining in the truck as the road repair employee worked from the rear aspect of the truck, shoveling cold-patch asphalt material from the dump body into the potholes. There were no traffic safety cones or warning devices placed immediately behind the truck. It should be noted that the dump body of the truck was raised approximately 15 cm (6") at the forward aspect of the body, which allowed the road repair employee to remove the cold-patch material from the truck. Additionally, the tailgate was chained to a horizontal position, extending beyond the rear of the dump body.

The school bus allegedly stopped at the four-leg intersection for the regulatory stop sign and proceeded in a westerly direction to discharge students at their respective residences. At the time, 30 students occupied the bus. The driver accelerated the vehicle in a westerly direction and negotiated a right curve for westbound traffic. This curve terminated 0.5 km (0.3 miles) east of the impending crash site. It should be noted that at the time of the SCI inspection of the crash scene, a clear line of site was afforded to a westbound driver of 0.6 km (0.4 mile) extending east of the point of impact. The site distance actually extended to more than 1.6 km (1 mile) beyond the crash site along the straight and level segment of the roadway. Witnesses following the school bus reported that the bus was traveling at approximately 80-89 km/h (50-55 mph).

The road repair employee of the highway crew observed the approaching school bus as he was filling a pothole (**Figure 3**). At this point in time, the bus was a significant

distance from the dump truck and was not a threat to the crew. The road repair employee reported to the investigating officer that as he was manually tamping the cold-patch material in the filled pothole, he again turned to observe the position of the approaching school bus. At this time, the bus was closing in on the back of the truck at travel speed. To avoid being struck by the bus the road repair employee ran to the roadside. Witnesses further reported that the bus did not display brake lights prior to the impact.

A 15-year-old female passenger of the school bus was assigned a seat on the left side of the bus in the tenth row. As the bus was traveling westbound, this student walked to the front of the bus to retrieve a tissue. Immediately prior to impact, this student turned and began to walk back to her seat. Students onboard the bus estimated that she was positioned between rows two and four at impact. This student possibly distracted the driver from his driving task. Although the driver was traveling in a westerly direction on the afternoon bus run, the sun was not reported as a factor in the crash as it was positioned at approximately 10-11 o'clock with respect to the travel direction of the bus.



**Figure 3. Location of the stopped dump truck and westbound approach of the school bus.**

### ***Crash***

The dump truck was positioned within the westbound travel lane when struck by the frontal aspect of the school bus (**Figure 4**). Based on witness statements to the investigating police officers, the impact speed of the bus was within the 80-89 km/h (50-55 mph) speed range. The full frontal area of the bus impacted the rear of the dump truck in a 12/6 o'clock impact configuration. The initial contact against the back of the dump truck and the extended tailgate fractured the fiberglass cowl of the bus and displaced the cowl in a rearward direction. The front bumper of the bus was crushed from the impact with the rear trailer



**Figure 4. Area of impact between the dump truck and subject school bus.**

hitch frame assembly and rear tires of the truck. The impact fractured the welds of the hitch and separated the hitch assembly. The left frame rail of the bus engaged the truck's rear axle differential housing immediately left of center. The tailgate of the truck was displaced and separated which allowed the frontal aspect of the bus to become engaged against the rear of the dump body. The displaced cowl impacted the exterior aspect of the windshield header/bulkhead of the bus, deforming this component to a maximum depth of 38 cm (15"). The gasket-mounted windshield was fractured by this contact and separated from the bus.

The loose cold-patch asphalt material remained momentarily fixed in space as the dump truck was accelerated forward by the impact force. The bus continued forward through the asphalt debris. The majority of the loose cold-patch material collected in the engine compartment area of the bus and entered the bus through the windshield opening. An additional amount of the asphalt was displaced onto the roof of the bus.

The dump truck was redirected forward and traveled in an arcing trajectory to its left due to the forward displacement of the rear axle. The left wheelbase was reduced in length, which induced a rear axle steering input to the truck. The truck traversed the westbound travel lane and the south shoulder, coming to rest off-road approximately 39.2 m (128.6') west of the point of impact (**Figure 5**). The front tires furrowed into the ground which identified the vehicle's trajectory and final rest position. At rest, the dump truck was facing in a southwesterly direction.



**Figure 5. Final rest of the struck dump truck.**

The front tires of the school bus were punctured by the engagement against the rear of the truck. A counterclockwise steering angle was induced to the front axle of the bus, which resulted in a left arcing trajectory of the bus as it traveled forward. The front tires marked on the asphalt road surface that identified the vehicle's trajectory to final rest (**Figure 6**). The two parallel arcing tire marks traversed the westbound travel lane, terminating at the south road edge. The tire marks on the stone shoulder were eroded by a road grader that was summoned to the scene to level out the displaced cold patch asphalt debris. The bus came to rest approximately 21.9 m (71.9') southwest of the initial point of impact. At rest, the bus was facing in a southwesterly direction, diagonal to and blocking the travel lanes.



**Figure 6. Path to final rest for the school bus.**

### ***Post-Crash***

Witnesses to the crash stopped at the crash site to offer assistance. A local Sheriff's Deputy was the first responding office to the crash site. The State Highway Patrol was summoned to the scene with the first arriving officer from this department arriving within 20 minutes of the crash. The witnesses and emergency responders boarded the bus through the rear emergency door and began to evacuate the bus of the student passengers, while providing treatment to the injured occupant's onboard the bus. While treating an

injured child in the front of the bus, the responders observed a hand protruding from the mass of asphalt that was on the floor of the bus. The responders began to shovel out the asphalt to free the driver and the body of the fatally injured 15-year-old female passenger.

A backhoe was driven to the crash site from a concrete plant that was located west of the crash site. The equipment was used to open and remove the right side doors from the bus to aid in the treatment and extrication of the occupants. Rescue personnel used hydraulic equipment to cut the right D- and E-pillars from the bus.

All injured occupants were transported by ambulance and private vehicles to local hospitals. The driver of the bus was admitted to the intensive care unit where he was treated for his internal injuries. Two child passengers were admitted for treatment of facial and extremity fractures. The remaining 27 students were treated for minor soft tissue injuries and released.

The driver of the struck dump truck was removed from the vehicle by rescue personnel and transported to a regional trauma center where he expired several hours following the crash.

### ***Vehicle Damage***

#### ***School Bus – Exterior***

The frontal exterior of the school bus sustained severe damage as a result of the impact with the rear of the stopped dump truck (**Figure 7**). The direct damage involved the front bumper, engine cowl, frame, tires, suspension components, radiator and the radiator support. The fiberglass engine cowl was fractured and displaced rearward into the front cowl of the bus at the base of the windshield and the bulkhead area located above the windshield header.



**Figure 7. Frontal damage to subject school bus and bumper level crush profile.**

The direct contact damage on the front bumper began 100 cm (37.6") right of center and extended 192 cm (75.6") to the left corner. The impact deformed both ends of the bumper rearward resulting in a combined direct and induced damage length of 182 cm (71.5"). Maximum crush measured 57 cm (22.5") located at the left bumper corner. A crush profile was documented at bumper level and was as follows: C1 = 57 cm (22.5"), C2 = 16 cm (6.1"), C3 = 16 cm (6.4"), C4 = 8 cm (3.1"), C5 = (3"), C6 = 24 cm (9.5").



**Figure 8. Overhead view of cowl deformation.**

The wiper cowl area was crushed rearward by the rearward displacement of the engine cowl and the subsequent engagement against tailgate of the dump truck (**Figure 8**). The lateral width of the cowl area was 206 cm (81”) which extended from A-pillar-to-A-pillar. Maximum crush at the level of the cowl was 33 cm (12.8”) located 41 cm (16.2”) inboard of the left A-pillar. The crush profile at this level was as follows: C1 = 21 cm (8.3”), C2 = 33 cm (12.8”), C3 = 27 cm (10.8”), C4 = 22 cm (8.5”), C5 = 19 cm (7.3”), C6 = 2 cm (0.9”).

The above mentioned engine cowl was displaced vertically and rearward as it engaged the windshield/bulkhead area of the bus body. This area sustained a maximum crush value of 38 cm (15”). The width of the bulkhead area measured 196 cm (77”) that spanned A-pillar to A-pillar. The crush profile at this bulkhead (**Figure 9**) was as follows: C1 = 0 cm, C2 = 34 cm (13.4”), C3 = 38 cm (15”), C4 = 36 (14.3”), C5 = 27 cm (10.8”), C6 = 0 cm.

The impact displaced the body/chassis alignment of the school bus. The body of the bus continued forward as the chassis of the bus engaged the rear of the truck. This resulted in approximately 31 cm (12”) of forward displacement of the bus body as evidenced by the separation at the rear of the body/chassis, and by slide marks on the frame at the bracket locations that held the body to the frame (**Figure 10**).

The cold patch asphalt material that was transported in the dump body of the struck truck was displaced from the vehicle by the impact. As a result of the forward momentum of the bus, the loose asphalt material was collected by the bus. The material was scattered over the engine compartment, roof, and penetrated through the fractured and separated windshield into the interior of the bus. This is further discussed in the *Interior* section that follows.

The initial impact with the stopped dump truck fractured and separated the engine cowl from the bus. The engagement of the cowl against the frontal structure of the bus fractured and separated the gasket-mounted windshield. The right side doors were jammed closed due to the deformation of the cowl area. All door glazing was shattered. Rescue personnel cut the upper right D- and E-pillars from the vehicle and removed the window units at the C-F pillar locations.



**Figure 9. Windshield header crush profile.**



**Figure 10. View of body chassis separation at the rear.**

### ***School Bus – Interior***

The interior of the bus sustained moderate damage that was associated with intrusion of frontal components, occupant contact with the seat backs, and intrusion of the asphalt material.

The driver loaded the manual belt system as he responded to the frontal crash forces. A subtle D-ring transfer was noted to the belt webbing that was subsequently cut by rescue personnel. He was subsequently engaged by the intruding steering wheel rim and the asphalt. The wheel rim was pulled forward by rescue personnel during the extensive extrication. The driver's seat back was deflected rearward by his loading from the intrusion. At the time of the SCI inspection, the seat back was deflected (bent) approximately 40 degrees aft of vertical. The driver's knees contacted the lower instrument panel as evidenced by two distinct areas of deformation to the steel component. **Figure 11** is an overall view of the driver's area deformation.



**Figure 11. View of driver's area deformation.**

The T-handle to the center mounted transmission selector lever was fractured from probable contact by the upright female passenger. This passenger also loaded the center mounted door release lever/linkage arm. Body fluid (blood) was noted to the struck handle. Although not supported by contact evidence due to the severity of damage, the upright passenger probably engaged the intruding engine cowl. She was subsequently knocked to the floor and buried by the intruding asphalt material.



**Figure 12. Center instrument panel contacts from the 15-year-old female passenger and final rest area for this occupant.**

It was reported by the first responders that the driver was covered to his waist in the loose asphalt cold patch material. At his position, the asphalt was approximately 61 cm (24") in depth from the floor of the bus. The material completely covered the driver's seat cushion. The deceased child passenger was buried under the asphalt material (**Figure 12**). She was found lying on the center isle at the forward aspect of the bus, covered by approximately 61 cm (24") of the cold patch material. The asphalt material extended to the third row seats. At these locations, the material was approximately 31 cm (12") deep on both the center floor and seat cushions.

The frontal components of the bus intruded into the passenger compartment. The following table identifies the magnitude of the intrusions for the various positions/areas.

<b>Intruded Area</b>	<b>Component</b>	<b>Direction</b>	<b>Magnitude</b>
Driver's Compartment	Left instrument panel	Longitudinal	35 cm (13.6")
Driver's Compartment	Hub of steering column	Longitudinal	38 cm (15")
Driver's Compartment	Header/Bulkhead	Longitudinal	13 cm (4.9")
Front center area	Center instrument panel	Longitudinal	35 cm (13.8")
Front center area	Header/Bulkhead	Longitudinal	23 cm (9.1")
Right door area	Right instrument panel adjacent to right A-pillar	Longitudinal	3 cm (1.1")
Right door area	Header/Bulkhead	Longitudinal	11 cm (4.4")

The high-back passenger seats were loaded by the intruding asphalt and the rear-seated passengers. All seat backs that were loaded by the unrestrained child passenger's and were deflected forward to various degrees. The fabric coverings displayed scuff marks and stretching from the passenger loading.

***GMC Dump Truck – Exterior***

The bus impacted the rear plane of the stopped dump truck. The direct contact involved the rear tailgate of the truck that was extended to a near horizontal position, the rear axle, left rear tires, and the rear aspect of the dump body (**Figure 13**). Additionally, the bus impacted and fractured the fabricated trailer hitch and frame assembly that was welded to the rear truck frame rails. The impact deformed and separated the tailgate from the dump body and crushed the rear edge of the dump body at the right corner to a depth of 24 cm (9.5"). The frontal engagement to the tires and differential assembly displaced the rear axle of the truck forward. The right wheelbase was elongated to 436 cm (171.5") while the left wheelbase measured 391 cm (154").



**Figure 13. Damage area of the struck dump truck.**

***GMC Dump Truck – Interior***

The interior of the dump truck sustained moderate severity damage that was associated with driver contact points. There was no crash induced damage or intrusion of the occupant compartment. The driver's back loaded the seatback, which deformed the seat back against the rear wall of the cab to a depth of 10 cm (4"). His head impacted and

fractured the tempered backlight glazing. The driver's head continued rearward with respect to the truck as the truck was accelerated forward. As a result, his head impacted the steel front wall of the dump body. Although not visible at the time of the SCI inspection, the investigating officer noted that a scuffmark was present on the body wall. The driver slumped to his right and came to rest on the seat cushion. Body fluid was present on the seat back.

***Occupant Demographics***

***Driver – School Bus***

Age/Sex: 66-year-old/Male  
 Height: Not currently available  
 Weight: Not currently available  
 Manual Restraint Usage: 3-point lap and shoulder belt system  
 Usage Source: Observation of first responders, vehicle inspection  
 School Bus Driving Experience: 2.5 years  
 Bus Experience (this vehicle): 2.5 years  
 Bus Route Experience: 2.5 years  
 Previous Driving Experience: Retired professional truck driver  
 Mode of Transport From Scene: Ambulance to a local hospital where he was stabilized and transferred to a regional trauma center  
 Type of Medical Treatment: Admitted to the Intensive Care Unit of the hospital

***Driver Injuries***

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Injury Mechanism</b>
Lacerated liver, NFS	Moderate (541820.2,1)	Intruding steering wheel rim
Lacerated spleen, NFS	Moderate (544220.2,2)	Intruding steering wheel rim
Lacerated kidney, NFS	Moderate (541620.2,9)	Intruding steering wheel rim
Lacerated bladder, NFS	Moderate (540620.2,8)	Intruding steering wheel rim
Lacerated bowel, NFS	Moderate (541420.2,8)	Intruding steering wheel rim
Facial lacerations	Minor (290600.1,9)	Intruding asphalt/windshield

*Source – School bus insurance agent*

***Driver Kinematics***

The driver of the school bus was seated in a high back seat and was restrained by the manual 3-point lap and shoulder belt system. At impact, he initiated a forward trajectory and loaded the belt system. The steering column was displaced rearward by the crash, which resulted in intrusion of the lower steering wheel rim into the driver's compartment. His abdominal region loaded the wheel rim which resulted in the abdominal injuries noted

above. His knees contacted and deformed the lower instrument panel on each side of the steering column. The intruding asphalt contacted the driver and covered his lower extremities to the height of his waist. The combination of the asphalt and the rearward displacement of the steering column resulted in a rearward deflection of his seat back.

The seat back displacement positioned his head in the path of the left side, first row child passenger. Although unconfirmed by medical records, the child passenger possibly contacted the driver's head with his facial region. This child sustained extensive dental fractures, a mandible fracture, and facial lacerations. There were no reported injuries to the driver from this suspected contact. He did sustain facial lacerations that were attributed to glass and asphalt intrusion.

***Child Passenger Data/Injury Table***

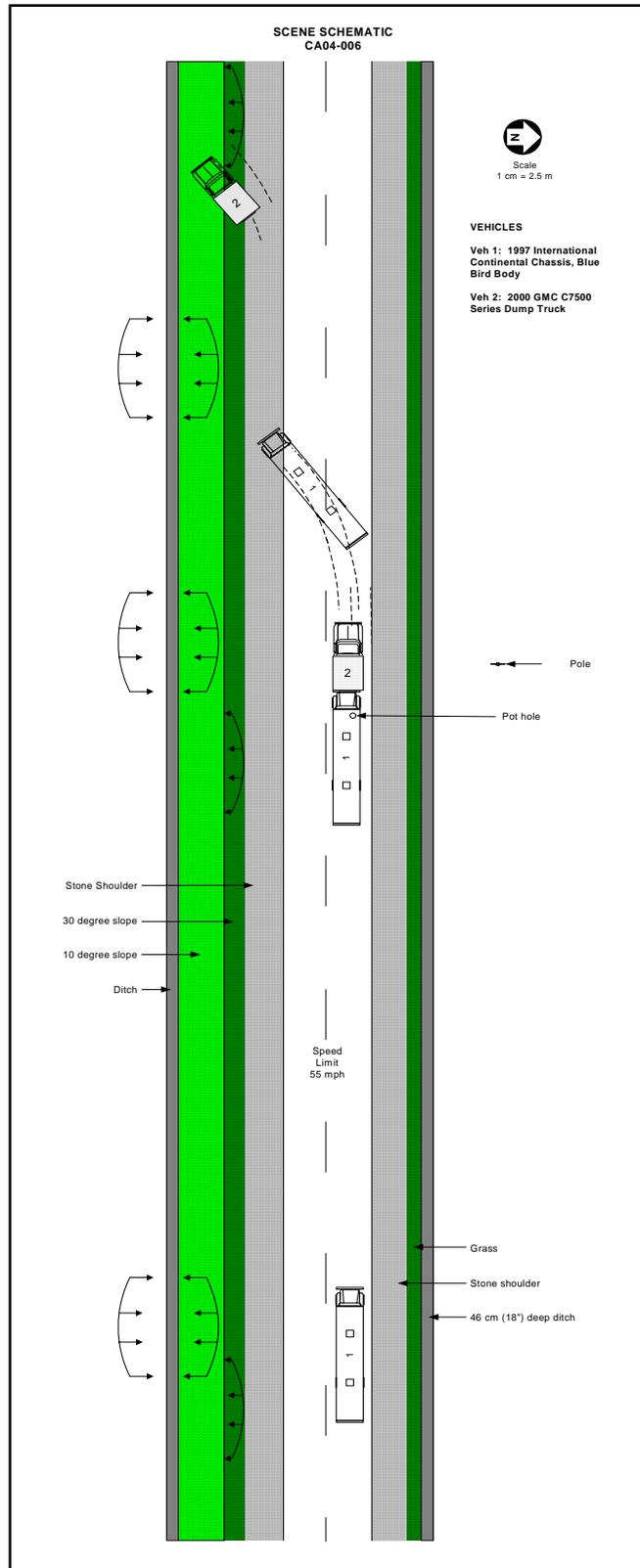
<b>Age/ Sex</b>	<b>Approximate Position on School Bus</b>	<b>Injury</b>	<b>Injury Severity (AIS 98)</b>	<b>Injury Source</b>
15-year old female	Standing in center aisle between the 2 <sup>nd</sup> and 4 <sup>th</sup> rows of seats	Fatal	Unknown	Unknown
11-year old male	Left side, 1 <sup>st</sup> row	Fractured mandible	Minor (250600.1,9)	Driver
7-year old male	Left side, 2 <sup>nd</sup> row	Contusions	Minor (990400.1,9)	Front seat back
7-year old male	Left side, 2 <sup>nd</sup> row	Contusions	Minor (990400.1,9)	Front seat back
8-year old male	Right side, 2 <sup>nd</sup> row	Contusions	Minor (990400.1,9)	Front seat back
9-year old male	Right side, 2 <sup>nd</sup> row	Contusions	Minor (990400.1,9)	Front seat back
8-year old female	Left side, 3 <sup>rd</sup> row	Contusions	Minor (990400.1,9)	Front seat back
7-year old female	Right side, 3 <sup>rd</sup> row	Contusions	Minor (990400.1,9)	Front seat back
10-year old female	Right side, 3 <sup>rd</sup> row	Contusions	Minor (990400.1,9)	Front seat back
9-year old male	Left side, 4 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back
7-year old male	Left side, 4 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back
6-year old female	Left side, 6 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back
12-year old female	Left side, 6 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back
9-year old male	Left side, 7 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back

13-year old female	Right side, 7 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back
9-year old female	Right side, 8 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back
12-year old female	Left side, 9 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back
12-year old female	Right side, 9 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back
14-year old male	Left side, 12 <sup>th</sup> row	Contusions	Minor (990400.1,9)	Front seat back
13-year old male	Right side, 13 <sup>th</sup> row	Fractured clavicle	Moderate (752200.2,9)	Front seat back
11-year old female	Unknown	Contusions	Minor (990400.1,9)	Front seat back
10-year old male	Unknown	Contusions	Minor (990400.1,9)	Front seat back
11-year old female	Unknown	Contusions	Minor (990400.1,9)	Front seat back
7-year old male	Unknown	Contusions	Minor (990400.1,9)	Front seat back
12-year old female	Unknown	Contusions	Minor (990400.1,9)	Front seat back
10-year old male	Unknown	Contusions	Minor (990400.1,9)	Front seat back
13-year old female	Unknown	Possible mandible injury	N/A	Front seat back
7-year old female	Unknown	Contusions	Minor (990400.1,9)	Front seat back
14-year old female	Unknown	Contusions	Minor (990400.1,9)	Front seat back
7-year old female	Unknown	Contusions	Minor (990400.1,9)	Front seat back

### ***Passenger Kinematics***

A 15-year-old female was standing in the center isle of the school bus between the second and forth rows at the time of the crash. She walked to the front of the bus to retrieve a tissue and was returning to her seat when the crash occurred. This child initiated a forward trajectory and impacted the center instrument panel; door lever assembly, transmission selector lever, and the intruding engine cowl and windshield. She was subsequently knocked to the floor of the bus by the intruding asphalt material and buried by the material to a depth of approximately 61 cm (24"). She sustained multiple injuries from the crash and expired. This passenger was not discovered by the first responders until they initiated treatment to a front-seated passenger. At this point, the deceased child's hand and foot was noted to have protruded from the asphalt material. She was uncovered and attempts to revive her were unsuccessful.

The remaining 29 passengers onboard the school bus were seated in the high-back seats, some in their assigned seats and others seated at various locations. At impact, all of the children initiated forward trajectories and loaded the forward seat backs. There was evidence of occupant contact points at nearly all seat positions. These contact points involved scuffmarks with stretching of the vinyl seat back fabric and forward deflection of the seat back frames. Two child passengers sustained reported fractures of the face and clavicle while the remaining passengers sustained various levels of soft tissue contusions.



**Figure 14: Scene Schematic**