



**Virginia Commonwealth University  
Transportation Safety Training Center  
Crash Investigation Team**

Report Number 195 – November 2005

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**ABSTRACT**

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The crash described in this report occurred when a school bus ran off the pavement of a rural secondary highway. The shoulders were narrow and a drainage ditch ran parallel to the road. The right wheels of the bus rolled into a ditch, causing the bus to tip to one side. As it continued forward, the upper right front corner of the bus collided with several trees. The crash resulted in one fatality, a student seated directly behind the driver. Several students had injuries severe enough to require transport to a hospital; others were bruised. The bus was damaged extensively.

This crash illustrates the hazards of driving while inattentive, drowsy and/or medically impaired; the potential dangers of narrow, rural secondary highways; and the benefits of compartmentalization in school bus design. The pros and cons of seat belt equipment on school buses are also addressed, along with passenger response and on-scene management after a crash.

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**SYNOPSIS**

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**Day, time, season:** Wednesday, 7:10 a.m., winter

**Road, weather:** Dry, cloudy

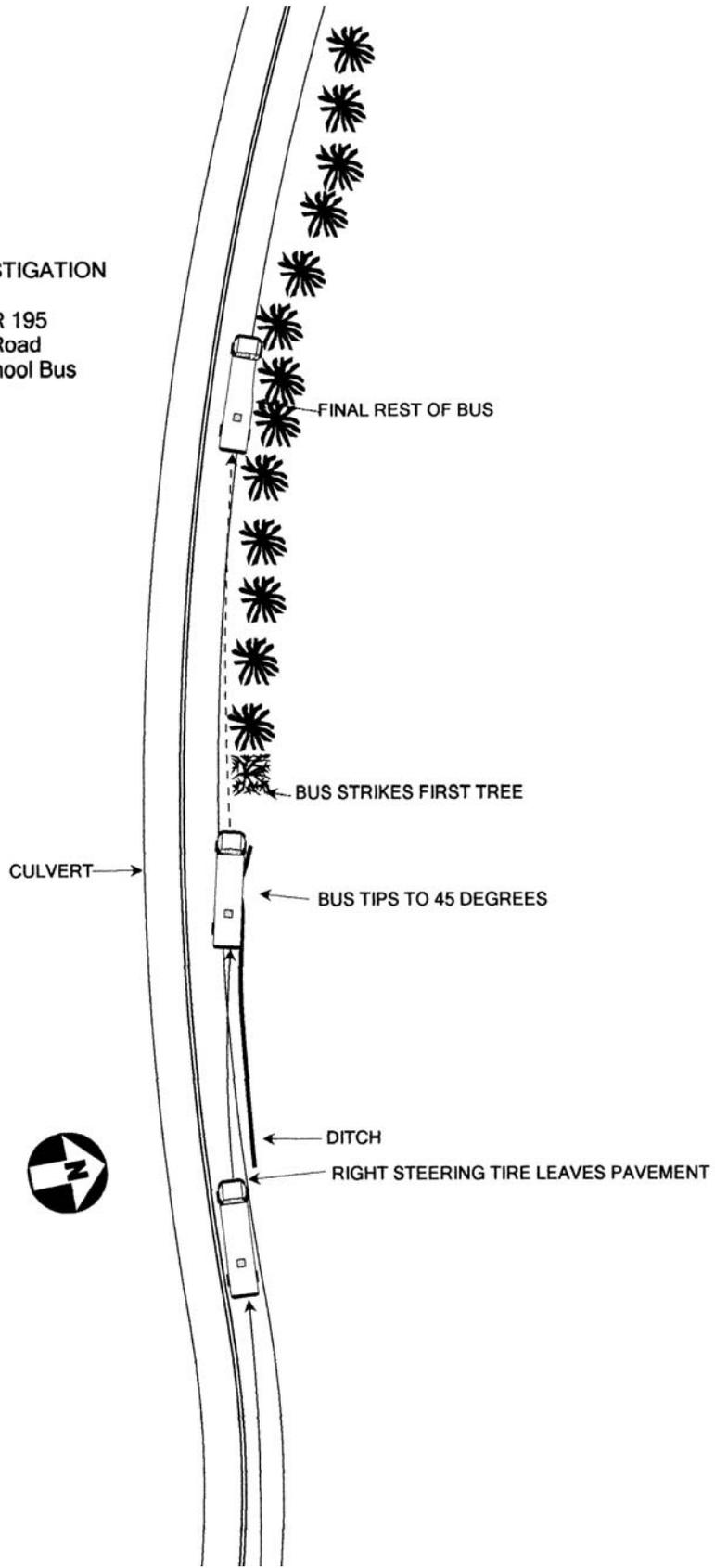
**Summary:** The school bus was being driven west on a rural two lane secondary highway. The vehicle ran off the right pavement edge and into a drainage ditch, then struck a tree.

**Severity:** One fatality (passenger), seven injuries, property damage to bus.

**Probable cause:** Driver inattention, sleepiness, fatigue or a medical cause.

**Significant points:** School bus design, compartmentalization; seat belt use; driving while drowsy and/or under the influence of drugs; rural road design.

VIRGINIA CRASH INVESTIGATION  
TEAM  
REPORT NUMBER 195  
Rural Secondary Road  
1997 International School Bus



## CRASH DESCRIPTION

On a Wednesday morning in February at approximately 7:10 a. m., a 1997 International school bus with a Bluebird body was traveling west on a two lane secondary highway. The rural road is a series of curves and straight sections and is relatively level. The bus had just traversed a gentle left curve and was beginning to enter a gentle curve to the right. The area of the crash site is located within a reduced speed zone. The speed limit increases from 35 mph to 45 mph; however, the bus was limited to 35 mph by statute as it traveled from stop to stop along its assigned route. The roadway is 21 feet wide, asphalt paved, and marked with yellow double solid lines in the center; there are no fog (white) lines demarcating the pavement edges. The roadway just east of the scene is bordered on the south by a wooded area that opens into a grassy yard. On the north, a narrow gravel and grass shoulder drops down into a ditch that runs parallel to the travel lane. The center of the ditch line to the pavement edge ranges from a beginning width of two and a half feet and widens to a maximum of almost four feet. The ditch itself is approximately two feet across and varies in depth, starting at about a foot below the pavement edge. It continues to deepen to a maximum of three and a half feet where it intersects with a drainage pipe that passes beneath the road. Beyond the pipe opening, the ditch again becomes shallower. The far bank of the ditch rises as an embankment that varies in height from six inches to about three feet above the road surface. Near the center of the curve, a small copse of gum and evergreen trees sits atop a low elevation of the embankment. To the right of the embankment, a grassy area opens to a cut over cornfield. The alignment of the highway and the borders restrict visibility around the curve for drivers coming from both directions.

The 37-year-old female driver was traveling her regular route in her usual vehicle. She had made several stops and had picked up 18 passengers, who were seated throughout the bus. The students all attended the county public high school or middle school, which are located adjacent to each other. Prior to entering the curve, the right tires of the bus departed the pavement at a shallow angle and began traveling across the narrow gravel and grass shoulder. The right front tire dropped into the drainage ditch. This caused the bus to veer further off the road and tilt to the right approximately 45 degrees. The bus continued west with no evidence of skidding or locked wheels in the

grass or on the pavement. As the vehicle approached the point where the drainage pipe intersects the ditch, the right front fender, wheel and side of the bus began scraping the embankment, stripping away vegetation. After passing the pipe, and still rolling west, the bus began to right itself as the ditch became shallower. The bus traveled approximately 100 feet with the right wheels off the pavement and approached the copse of trees. At this point, the embankment was low, about six inches higher than the road, and the trees were only 4 feet from the pavement edge. Prior to the bus regaining its normal vertical position, it struck a gum tree with the right front, top-most corner of the box body.

The top corner of the bus began to collapse upon impact with the tree. The windshield of the bus is composed of two independent glass segments; the right half dislodged from its mounting and was found in the ditch. The left segment cracked but remained in place. The bus continued its forward movement, the tree and its branches continuing to encroach into the right bus wall. The roof area began buckling toward the rear and downward into the passenger compartment as the crash progressed. The normal entry door was compressed and deformed, rendering it inoperable. The right side windows of the bus shattered and fragmented in sequence from the first through the fourth seat, spraying glass shards into the passenger compartment, where they struck some of the students. The roof continued to buckle, exposing jagged pieces of metal into the interior and causing the roof-mounted emergency hatch to pop out. The hatch was found in the ditch between the struck tree and the final resting place of the bus. The bus continued west an additional 100 feet, brushing against evergreen trees, before coming to rest facing west, its left tires in the road and both right wheels in the ditch.



*Photo#1 View looking west in the direction the bus was traveling. Photo was taken prior to the point where the bus ran off the road. Note the narrow shoulders and the proximity of the trees and embankment to the road. Also, note that visibility around the corner is obscured.*



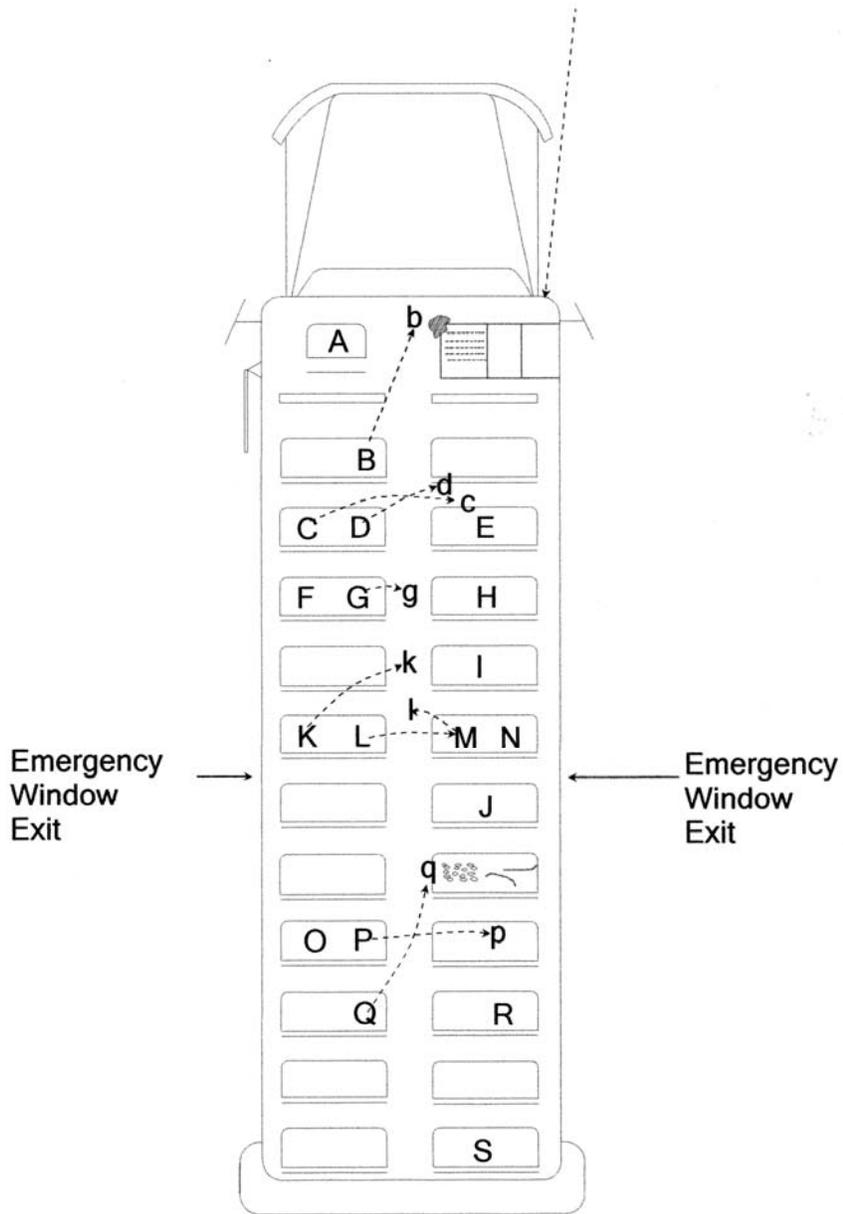
*Photo #2 A closer view of the path the bus was traveling. Note the shallow angle of the impression made by the right front tire as the bus left the pavement.*

A 16-year-old male (B on Diagram 2) was seated in the first seat on the left side, directly behind the bus driver. Fellow passengers stated that he sat facing to the right, with his feet in the aisle and his head turned toward his right, looking over the seatback toward the rear of the bus. He had been engaged in conversation with the two passengers seated directly behind him. When the right side of the bus dropped into the ditch, he was propelled out of his seat and into the aisle. The impact with the first tree threw him forward into the floor-mounted gearshift, the emergency brake handle and the dashboard. He landed on the floor, partially under the dash, in a slouched position, facing the back of the bus (b on Diagram 2). He was bleeding from his ears, nose and mouth, a result of injuries that would prove to be fatal.

Five other students were seated in aisle seats on the left side of the bus, scattered from the front to the back, and all were thrown from their seats. One female student who was seated alone, nine seats back (Q on Diagram 2), received serious injuries. She was thrown out into the aisle as the bus leaned to its right and then she was propelled forward two seats (q) when the bus collided with the tree. She suffered a large cut to the side of her face. Several seats in front of this student, another girl (L) was thrown from her left aisle seat. She collided with a male student sitting directly across the aisle (M), striking her head against his, and fracturing his nose. The three others were tossed from their aisle seats (D, G, and P), hitting the seats to their right with their backs and shoulders before falling to the floor between the rows. Two of these students suffered minor to moderate bruising.

Two of the four students in window seats on the left side of the bus were also ejected into the aisle. One girl had been sitting in the second bench behind the driver (C). During the crash sequence, she was thrown to her right and over her seatmate (D), who had been knocked down into the aisle. She struck her head above her right eye, probably on a seatback, and then landed in the aisle as well. The second student, a male (K), was sitting further back, next to the girl who bumped heads with another student. This young man was thrown forward and over into the seat in front of him, which had been empty. At some point, he struck something with the center of his forehead, resulting in a bruise.

FIRST CONTACT  
WITH TREE AND  
BUS BODY



CAPITAL LETTERS INDICATE SEATING POSITION  
Lower case letters indicate approximate post crash position

*Diagram 2—Bus Seating Chart*

He ended up kneeling in the aisle with his hands over his head, trying to protect himself from shattering glass. The two other students seated by the windows on the left side of the bus, one in the third seat (F) behind the driver and one towards the back (O), remained in their seats and were uninjured.

Seven students sat on the right side of the bus, spread out from the front to the back. Surprisingly, the passengers seated on the seats in the right front area suffered mainly minor injuries from flying glass. Most sensed the impending crash and either bent forward or leaned sideways in the seat and covered their heads. Some were injured only because they had to crawl on the fragmented glass to escape from the bus. One middle school student seated about four seats back on the right (I) had a laceration on the back of his head.

The elder sister of the girl who suffered the serious facial cut was seated in the rear of the bus (S) in the last seat on the right side. One of four siblings riding the bus that morning, she reported seeing her sister (Q) “go flying” during the crash sequence and began moving toward her before the bus came to rest. She directed one brother (O) to help with her sister by holding pressure on the wound and told the other brother (P) to open the rear emergency exit. She and her brothers then helped their sister get off the bus, while directing other students out as well. At the front of the bus, the sister (D) of another injured student (I) sought him out and, after realizing that he was bleeding, began taking charge to get him off the bus and then seek medical attention. The driver also told the students to get off the bus. The teen who had opened the emergency exit assisted the smaller students and others who needed help. The students all exited the bus in an orderly fashion.

The driver remained in her seat with the fatally injured student slumped on the floor beside her. The driver compartment of the bus was intact, but she had difficulty getting out of her seat. She put her feet up on the dash and pushed her seat far enough back to ease the pressure from her locked seat belt. Noting the serious injury to the student beside her, she told him to lie still and she exited the bus.



***Photo #3 Right side view of the bus showing the damage to the roof, door and right windows near the front.***

Traffic began to form behind the bus. The driver of the first car did not see the crash, but she observed the bus rolling to a post-crash stop. She remembered seeing the brake lights but not the overhead flashers. This driver was a teacher who was known to many of the students on board, and she had emergency medical training. Her first impression was that the bus had stopped to pick up a student. She realized there was a problem when the rear emergency exit opened and students began jumping from the back. She immediately got out of her car and offered first aid. She then began organizing the students, separating the injured from the uninjured and obtaining names. Later, she helped keep track of the passengers as their parents were notified and they were picked up.

Further back in the line of traffic, an off-duty paramedic and a deputy sheriff were traveling in their private vehicles. They too had the impression the bus had stopped to take on passengers. After a few moments and no movement of traffic, they both alighted from their respective vehicles and saw that the rear door of the bus was open. The deputy summoned fire and rescue via a hand held county radio. While assessing the situation, he observed students rendering first aid and comforting one another. He looked around and

asked about the driver, noticing a woman standing nearby with a blank look on her face. The woman did not identify herself as the driver at that time. One student screamed something about someone inside the bus and he and the paramedic entered the bus to find the sole remaining student, unconscious and bleeding. The paramedic called and requested helicopters to transport the most seriously injured students, then he began conducting a triage to assess the priority of treatment of the injured. The deputy collected first aid equipment and re-entered the bus. He and another medically trained bystander stayed with the teen until additional help arrived and this victim could be removed for transport.

The most seriously injured student was transported via helicopter to a major trauma center some 40 miles west and died about twelve hours later, after life support was removed. Five other students were transported to various local hospitals, either by helicopter or ambulance, where they were treated for their injuries. Most were released later that day, although a couple were kept for further treatment and observation. Some students did not experience much pain from their bruising until a day or two after the crash, a normal occurrence.

While sheriff's deputies and troopers directed traffic, a state trooper began his investigation of the crash. The bus was towed to the county's school maintenance lot and the scene was cleared in approximately 3 hours.

## REMARKS

The bus involved in this crash was a 1997 International with a conventional style cab. The tires and brakes were examined and appeared to be well within inspection and code specifications. The vehicle displayed a current inspection approval sticker. The tires on the rear axle were retreads. The top right front corner was the initial point of impact with the tree; the resulting collision compressed the body to the rear and downward, buckling the roof both inside and out. The right half of the windshield had popped out and the doorframe had collapsed, rendering the bi-fold door inoperable. The glass in the first four side windows on the right side had broken and fragmented, and the fragments were strewn about the interior of the bus. Despite the crush damage to the front of the bus and even with part of the ceiling intruding into the right interior compartment, most of the passenger space remained intact and open. Even the driver's compartment was relatively unaffected.



*Photo #4 Interior of the front half of the bus. Note the angled buckling of the ceiling and the exposed metal on the right side.*

The bench seats stayed firmly moored to the floor and only the partition in front of the first seat on the right side showed any deformation from the collision force. None of the seats showed any contact damage as a result of the students striking them. The padding on these seats undoubtedly prevented more serious injuries than the bruising some experienced.

Two of the students who were thrown from their seats suffered the most serious injuries. Blood from one injured survivor (Q) was located on the seventh seat back on the right. It also pooled on the floorboard directly beneath the seat, both in front of and behind the wheel well. This student was thrown the furthest from her original position, but the Team was unable to determine what material on the bus caused her laceration. The student who was fatally injured suffered a severe skull fracture with brain injury. Because he sat sideways with his feet in the aisle, the padded wall separating him from the driver's area afforded him little protection. When the bus tipped to the right, he came out of his seat into the aisle just as it opens into the entry area between the driver and the stairwell. When the bus impacted with the tree, he was only a short distance from the unforgiving dash area. He became a human projectile, initially striking a single vital area (his head) against a hard, fixed part of the bus interior (the dash) with the full force of impact. The fact that he was heavier than most students, 230 pounds, increased the energy forces acting upon his body, and thus the severity of his injuries. His blood was found on the floorboard and in the stairwell at the normal entry door.

The Virginia Crash Investigation Team's "Special Report 19: School Bus Crash Evaluation Study" addresses a number of factors that can affect bus safety, including compartmentalization, which benefited some but not all passengers in this crash. Because the bus tipped to one side early in the crash sequence, all but two students on the left side were ejected from their seats. Compartmentalization was mainly beneficial to those on the right, along with two who had been sitting by windows on the left, with seatmates in the aisle position. When the bus collided with the tree, the students' bodies continued their forward momentum, impacting the padded backs of the seats in front of them. The seatbacks deformed, as designed, partially absorbing some of the forces. The rest of the deceleration energy was dispersed across large areas of their torsos. Within this group, the only significant injuries were from a broken nose (M), the result of being

struck by an ejected student, and a laceration of the scalp (I). This injured student was seated in an area where the metal ceiling of the bus buckled and intruded down into the passenger compartment; however, the specific cause of the cut could not be matched to his injury.

Special Report Number 19 also addresses the issue of seat belt installation in buses: “At present, the overwhelming evidence indicates that school buses should not be equipped with lap belts.” While the conclusion regarding lap belts is accepted throughout the transportation safety field, the potential benefits and disadvantages of combination lap/shoulder belts are still debated. The report noted: “Most recent studies and opinions from safety officials indicate that lap/shoulder belts are not yet compatible with compartmentalization and thus they are not recommended.” When considered in light of this crash, lap/shoulder belt availability may have had mixed consequences.

First, the level of use would be a concern. These students were of middle and high school age and, based on research from a pilot program, only about 50% of the bus passengers in that age group are likely to wear combination belts. In this specific case, several students reported sleeping on the bus, including one who said he was slouching down in the seat with his knees braced against the seatback in front of him. Other students moved around, changing seats at different stops. Their probability of being belted would have been low. In addition, the fatally injured student may have found wearing a safety belt difficult. At six feet four inches and 230 pounds, he probably felt cramped sitting faced forward in a regular seat. Sitting with his knees to one side or with his feet in the aisle gave him more legroom, but such a position would not have been easy to maintain if he had tried to wear a belt as well.

A second concern is that some students who remained in their seats may have suffered injuries that were more serious if they had been belted. Even though a lap/shoulder belt would have kept them in their seats, research has shown that the belts would have stretched during the sudden deceleration of impact, allowing for significant forward movement. With compartmentalized design, the students would have had less than two feet of clearance to the seat in front of them. They would not have hit the seatbacks with as much force as an unbelted person, but any area of impact would have been concentrated around the head and neck. Students who were ejected, if belted, would

have remained in their seats. They would have been less likely to collide with other students but, again, would have been exposed to hitting their heads on the seatbacks. Since the cause of the lacerations received by two students is unknown (whether they were cut by metal hanging from the roof or by flying glass and debris), the effect of seatbelt use on limiting their injuries is unknown. Finally, the students sitting in the front of the bus on the right side may have been adversely affected if they wore combination belts. These students ducked down in their seats as they saw the collision with the trees. The shoulder component of the belt may have prohibited or slowed their ability to twist down and to the side, exposing them more fully to the intruding branches, shattering glass and twisting metal. If belts had been available and worn by passengers on this bus, the risk to some students may have decreased, but others would probably have been more seriously injured.

Rural roads often fail to allow much room for error on the part of drivers. While the drainage ditch beside this road is an important feature to assure that the road remains clear of running or standing water during and after storms, it can become a hazard as well. The depth of the ditch, combined with the narrow shoulders along this stretch of road, increase the risk of damage and injury for those who drift off the pavement. If not for the embankment, the bus would have tipped over onto its side prior to hitting the trees. The trees and their proximity to the shoulder are a second, potentially destructive hazard common to rural roads. As the bus continued forward, beginning to right itself as the ditch became shallower, the driver had the opportunity to regain control. The trees, dense and unforgiving fixed objects, blocked her path and caused the energy of the forward momentum to be transferred to the occupants inside. There are no “narrow shoulder” signs or other warnings along this area of road to advise drivers of any possible hazard, although individuals familiar with the rural area know that such conditions are common. As testimony to their safety practices and driving skills, school bus drivers in the Commonwealth log hundreds of thousands of miles on rural roads each year with only rare instances of problems. Although not a factor at the time of this crash, a few months later this ditch was covered in a dense growth of grass and brush, obscuring its true depth from drivers.



***Photo #5 The drainage ditch had a depth of 3-1/2 feet where it intersects with a drainage pipe that passes beneath the road. This picture was taken several months after the crash. Note how grass and brush hide the ditch from view.***

Although the bus was equipped with an onboard audio/video recording system, there was no tape in the machine at the time of this collision. The driver's explanation for the absence of a tape was that she was on medical leave at the beginning of the school year and did not resume her route until later. Another driver started the season and the regular driver assumed that a tape was in the machine when she came back to work. There had been no calls for the tape from her machine due to any disciplinary matters or complaints on the bus after that, so no one realized that the tape was absent.

The driver of the bus was operating her usual vehicle along her assigned route on the day of the crash. She had no prior convictions on her driving record. The School Board had not received any complaints regarding her driving behavior; however, one parent had complained verbally and in writing about her frequent tardiness in picking up the students in the morning. In contrast to that, on the day of the crash, the driver was a few minutes early and two students along the route had to run to catch the bus. One of those students was the fatal victim, the other his brother. During post-crash interviews, students generally reported that the driver operated the vehicle in a safe manner and

required that they act in safe and appropriate ways while riding. Several reported one incident of the bus sliding on a slippery road during the winter, but generally, they did not express any concerns with her driving skills.

The driver had gastric bypass surgery at the end of the previous summer, prior to the beginning of the school year. She had been released to come back to work in the early fall, but she had visited the doctor since, complaining about having trouble staying awake and blacking out. She did not report any of these medical concerns to her supervisor. During interviews, several students reported that she often appeared tired or fatigued while driving. They stated that the fatal victim usually sat up front and often engaged the driver in conversation, sometimes in an attempt to keep her from nodding off to sleep. He was reputed to have a regular, ongoing friendly banter with the bus driver.

The driver informed the investigating Trooper and school officials that she had seen a green Camaro approaching from the opposite direction and traveling on her side of the road. She indicated that she had flashed her headlights at this vehicle and then had to take evasive action to avoid striking it. The pattern of the wheel marks and the shallow angle of departure from the roadway are not consistent with evasive maneuvering. They are consistent, however, with vehicles that drift off the road when drivers are inattentive or fall asleep. Additionally, in spite of the driver reporting that she had enough time to signal the oncoming car, she failed to stop or slow the bus prior to leaving the road. None of the surviving passengers reported her shouting any type of warning that something was about to happen. The fact that the trees and the configuration of the roadway curves would have hidden an oncoming vehicle in the bus driver's field of vision also contradicts her story. In the opinion of the Team members, this driver ran off the road as a result of inattention and not to avoid another vehicle.

In addition to reacting adaptively to minimize their injuries during the crash, the student passengers on this bus responded in an extremely organized fashion after the bus came to rest. Siblings sought out and took care of each other, insisting that the injured get help. Older students helped the younger ones. They organized themselves to get out of the bus without anyone being further injured and with little guidance from the bus driver, who had difficulty removing her safety belt and was somewhat dazed in the aftermath of the crash. The students notified first responders that someone in the bus was

in dire need of assistance immediately upon their arrival. By happenstance, a school official, an emergency medical system official and a law enforcement official were on scene within minutes of the crash. They began summoning reinforcements and more advanced help and equipment immediately. They also coordinated the activities of the uninjured students, keeping them safely off the road, recording information and ensuring that they had transportation away from the scene. Working with the police and others, most of these students called their parents on borrowed cell phones and arranged to be picked up. The post-crash actions of the passengers and the first witnesses on the scene ensured that this tragedy was not magnified.

## RECOMMENDATIONS

1. Those associated with transportation safety and training use the findings in this report to illustrate the following:
  - A. Motor vehicle operators should, at all times, pay attention to the driving task. This is especially important on roadways with narrow widths and when driving larger vehicles.
  - B. Motor vehicle operators driving on narrow secondary roads should be constantly vigilant for off-road hazards, such as ditches and fixed objects close to the pavement, as well as for on-coming vehicles.
  - C. Drivers should be aware of their physical and mental condition prior to beginning operation of a motor vehicle, and they should refrain from driving when they are fatigued or drowsy, ill, or taking medication (or other substances) that may affect their alertness and their judgment.
2. The Department of Education / Pupil Transportation Services, private school districts and others associated with student transportation services should use the information in this report to address the following:
  - A. In addition to requiring a medical approval to return to work, school transportation supervisors should monitor drivers returning from medical leave to assure a satisfactory and safe level of performance.
  - B. Reports of continued tardiness by school bus drivers should be investigated to rule out medical problems, including chronic sleep deprivation or fatigue.
  - C. System rules should require that any time a driver takes initial possession of a bus to transport students, the driver place in the recorder a new videotape marked to identify both that driver and that bus.
  - D. Officials should continue to monitor research and new technologies that can improve safety in student transportation, including research on three point safety belt systems.
3. The Virginia Department of Transportation should continue upgrading secondary roads through highway construction and rehabilitation.