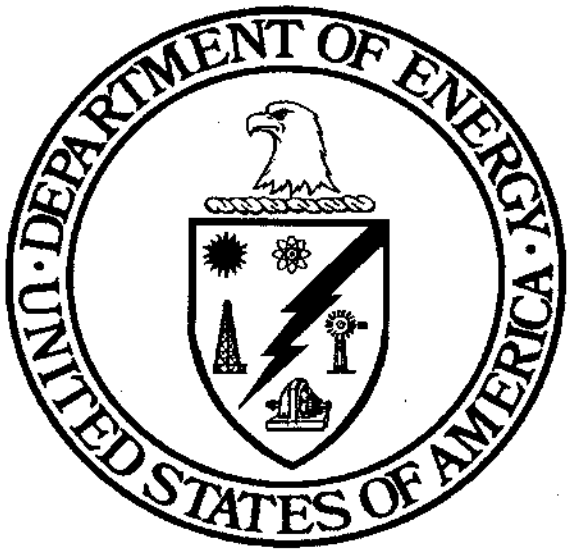
Final Report **September 1998**

Type B Accident Investigation Board Report August 5, 1998 Load Haul Dump Accident at U16b Tunnel Nevada Test Site



Nevada Operations Office

Unclassified

This report is an independent product of the Load Haul Dump Accident Investigation Board appointed by Gerald W. Johnson, Manager, Nevada Operations Office, U. S. Department of Energy.

The Board was appointed to conduct a Type B Investigation of this accident and prepare a report in accordance with DOE Order 225.1A, *Accident Investigations.*

The discussions of facts, as determined by the Board, and the views expressed in the report do not assume and are not intended to establish the existence of any duty at law on the part of the U. S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

On August 13, 1998, I established a Type B Accident Investigation Board to investigate the load haul dump accident at the Nevada Test Site that resulted in injury to a Bechtel Nevada employee.

The Board's responsibilities have been completed with respect to this investigation. The analysis; identification of direct, contributing, and root causes; and the development of conclusions and judgements of need were done in accordance with DOE Order 225.1A, *Accident Investigations.*

I accept the findings of the Board and authorize the release of this report for general distribution.

9/28/98

G. W. Johnson
Manager
Nevada Operations Office

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TABLES AND FIGURES

ACRONYMS

BN	**Bechtel Nevada**
CS	**Construction Station**
CPR	**Cardiopulmonary Resuscitation**
DOE	**U. S. Department of Energy**
DSWA	**Defense Special Weapons Agency**
ESH	**Environment, Safety and Health**
GFI	**Ground Fault Interrupter**
HA	**Hazard Assessment**
IEEE	**The Institute of Electrical and Electronic Engineers**
LHD	**Load Haul Dump**
M&O	**Management and Operating**
MPC	**Mining Power Center**
MSHA	**Mine Safety and Health Administration**
NEC	**National Electric Code**
NTS	**Nevada Test Site**
NV	**Nevada Operations Office**
ORPS	**Occurrence Reporting Processing System**
OSHA	**Occupational Safety and Health Administration**
PA	**Public Address**
PHA	**Preliminary Hazard Assessment**
ROPS	**Rollover Protective Structure**

GLOSSARY OF TUNNEL AND MINING TERMS

Alpine Miner	**An electrically powered mining machine**
Back	**The ceiling of a tunnel or mine**
Invert	**The floor of a tunnel or mine**
Load Haul Dump	**A machine, similar to a front end loader, used to remove muck from a tunnel or mine.**
Muck	**Loose, excavated rock**
Portal	**The horizontal entrance of a tunnel or mine**
Rib	**The sides or walls of a tunnel or mine**
Shifter	**A mining foreman**

PROLOGUE
INTERPRETATION OF SIGNIFICANCE

The nonfatal industrial accident at the Nevada Test Site (NTS) on August 5, 1998, at 11:23 a.m., occurred when a load haul dump (LHD) snagged a water hose which had been strung across U16b tunnel. The accident resulted in extensive injury to the head of the LHD operator. Lack of hazard recognition skills contributed to the accident. The hose was hung in an elevated position for safety and good housekeeping purposes as required by Bechtel Nevada (BN) safety rules. However, the hose was not hung such that it could not be damaged by construction activities or equipment as also required by the same BN safety rule. The elevated hose was not recognized as a hazard by the employees who hung the hose, or by the LHD operator. The hazard of these hoses to the LHD operator was not recognized in the BN hazard assessment for the work in U16b.

Three root causes to this accident were identified. BN employees did not recognize the hazard associated with the hoses as hung across the tunnel. BN employees did not exercise individual responsibility. BN management did not fully enforce compliance with BN General Safety Rules. Although safety rules required that the hose be elevated and out of the path of construction equipment, BN workers were not in full compliance with the rule.

BN provides underground safety training to all employees who work, or regularly go, underground. However, the training is focused on how to exit the tunnel in the event of an emergency such as a fire and not to hazard recognition. Additionally the hazard recognition training offered to employees does not specifically address hazards associated with the underground construction operations.

This accident highlights the importance of an Integrated Safety Management (ISM) approach to operations. Although BN has made significant progress in defining and establishing ISM, there were lapses in four of the five core functions of ISM in this accident. There is a need for thorough and systematic oversight by the contractor and the Department of Energy to ensure effective implementation of the core functions and principles of ISM.

It is clear that the management controls and practices have met the basic requirements for oversight, assessment, and the identifications of needs for safe day-to-day operations. It is also evident that BN has been successful in institutionalizing a safety culture at the NTS. However, these activities must be comprehensive, and fully implemented at the working level, in order to maximize operational safety.

EXECUTIVE SUMMARY

INTRODUCTION

This is the Type B Accident Investigation Board report of an industrial accident at the Nevada Test Site (NTS), U16b tunnel in which a Bechtel Nevada (BN) employee suffered a compressed skull fracture as a result of being struck on the head by a valve and fitting assembly on the end of a hose which had been broken from a water pipe by a moving piece of construction equipment. There were no eye witnesses to this accident. In conducting it's investigation, the Accident Investigation Board used various analysis techniques including barrier analysis, change analysis, event and causal factor analysis, and root cause analysis. The Board inspected and photographed the accident scene, reviewed events surrounding the accident, took custody of evidence and initial interview statements, and conducted extensive interviews and document reviews to determine the factors that contributed to the accident.

ACCIDENT DESCRIPTION

The accident occurred at approximately 11:23 a.m. on Wednesday, August 5, 1998 at the NTS, in U16b tunnel, when an employee who was removing muck from the tunnel snagged a water hose with a load haul dump (LHD) machine he was operating. The LHD stretched the hose until the hose and attached valve and fitting assembly broke off the water supply line to which they were connected. When released the valve and fitting assembly was propelled by the contracting hose and struck the LHD operator in the head. The LHD proceeded down the tunnel where it struck the conveyor attached to an electrically operated Alpine Miner continuous mining machine and partially severed the Alpine Miner's 480 volt power supply cable. Upon impact with the Alpine Miner, the unconscious injured employee was partially ejected from the LHD. He was removed from the LHD by two coworkers, one of whom received three electric shocks. When they could not detect any vital signs his coworkers immediately commenced cardiopulmonary resuscitation and summoned emergency medical assistance. The accident resulted in a compressed skull fracture to the injured employee's head, which required surgery, and eight days of hospitalization. The employee who was shocked while removing the victim from the LHD was not injured.

CAUSAL FACTORS

The direct cause of the accident was contact by the LHD with a temporary service water hose suspended across the tunnel.

Root causes of the accident were: 1) BN workers did not recognize the hazard associated with the hoses as hung across the tunnel, 2) BN workers did not exercise individual responsibility, and 3) BN management did not fully enforce compliance with the BN General Safety Rules.

Contributing causes of the accident were: 1) The U16b hazard assessment was less than adequate, 2) BN worker training was less than adequate, and 3) BN management did not detect an adverse trend of similar accidents/incidents.

CONCLUSIONS AND JUDGEMENTS OF NEED

Table ES-1 presents the conclusions and judgements of need determined by the Board. Conclusions of the Board are those considered significant and are based upon facts and relevant analysis. Judgements of need are managerial controls and safety measures believed by the Board to be necessary to prevent or minimize the likelihood or severity of a recurrence of this type of accident. Judgements of need flow from the conclusions and are intended to guide managers in developing follow up actions.

Table ES-1, CONCLUSIONS AND JUDGEMENTS OF NEED

CONCLUSION	JUDGEMENT OF NEED
Low level ground fault protection for personnel electrical safety is not required for 480v systems by government or industry standards.	BN needs to evaluate feasibility of installing low level ground fault protection for personnel safety on 480/240v construction power systems.
BN employee training on BN General Safety Rules, hazard recognition, and safety related lessons learned is less than adequate.	BN needs to ensure that all employees are adequately trained in BN General Safety Rules, hazard recognition, and safety lessons learned.
BN emergency response vehicles made wrong turns enroute to the accident scene.	BN needs to ensure that emergency response vehicles are able to proceed directly to remote work locations on the NTS.
Compliance with BN General Safety Rules was less than adequate.	BN needs to ensure employees comply with all General Safety Rules
BN on scene first aid and CPR administered to the injured employee by coworkers was excellent.	None
BN First Aid and CPR Training Program is commendable.	None
No evidence that the hard hat was not worn or improperly worn.	None
LHD design (including ROPS) was not a factor.	None
Whether LHD operator was or was not conscious prior to accident cannot be determined. There is no medical evidence that the victim had a stroke, seizure, cardiac problem or blood deficiency to the brain. There is no history of diabetes or prior dizziness. There is no medical information to support the victim received electrical shock or CO or other chemical exposures.	None
The Preliminary Hazard Assessment and Hazard Assessment for U16b did not recognize hazards to equipment operators, such as, from impact, collision, entanglement, or rollover.	BN needs to ensure future Preliminary Hazard Assessments and Hazard Assessments address hazards to equipment operators.
BN management did not recognize hazardous trends of three previous underground equipment accidents/incidents.	BN needs to fully implement the Integrated Safety Management System Core Function of Feedback and Improvement.
There were lapses in four of the Five Core Functions of Integrated Safety Management	NV needs to ensure that BN fully implements Integrated Safety Management in accordance with their approved schedule.

Type B Accident Investigation Board Report on the August 5, 1998, Load Haul Dump Accident at the Nevada Test Site, U16b Tunnel

1.0 INTRODUCTION

1.1 BACKGROUND

On August 5, 1998, at approximately 11:23 a.m., a BN employee received extensive head injuries while operating a 3.5 cubic yard capacity LHD in the U16b tunnel at the NTS. The injured employee was given CPR by coworkers, stabilized by paramedics, transported by ambulance to Desert Rock Airport where he was transferred to an air ambulance and taken to a hospital in Las Vegas, Nevada.

On August 5, 1998, a Bechtel Nevada employee received extensive head injuries while operating a load haul dump.

On the day of the accident BN commenced a company investigation of the accident. On August 11, 1998 the accident was reported to the Occurrence Reporting Processing System (ORPS) as occurrence report number NVOO-BNLV-NTS-1998-0018.

On August 13, 1998, due to the severity of the injury and the duration of hospitalization, Gerald W. Johnson, Manager, Nevada Operations Office (NV) established a Type B Investigation Board to investigate the accident and injury to the BN employee in accordance with DOE Order 225.1A, Accident Investigations. Appendix A is a copy of the Manager's appointment letter.

On August 13, 1998, the Nevada Operations Office established a Type B Investigation Board.

1.2 FACILITY DESCRIPTION

The NTS was established in 1950 by the U. S. Atomic Energy Commission as an on-continent national proving grounds for nuclear weapons. The NTS is currently managed by BN under contract to the U. S. Department of Energy. The NTS is located in southern Nevada 65 miles northwest of Las Vegas, on approximately 1350 square miles of land (figure 1). The principle missions of the NTS are to: 1) conduct subcritical experiments and other hazardous experiments and activities in support of the DOE Stockpile Stewardship Program; 2) provide remote and secure locations and

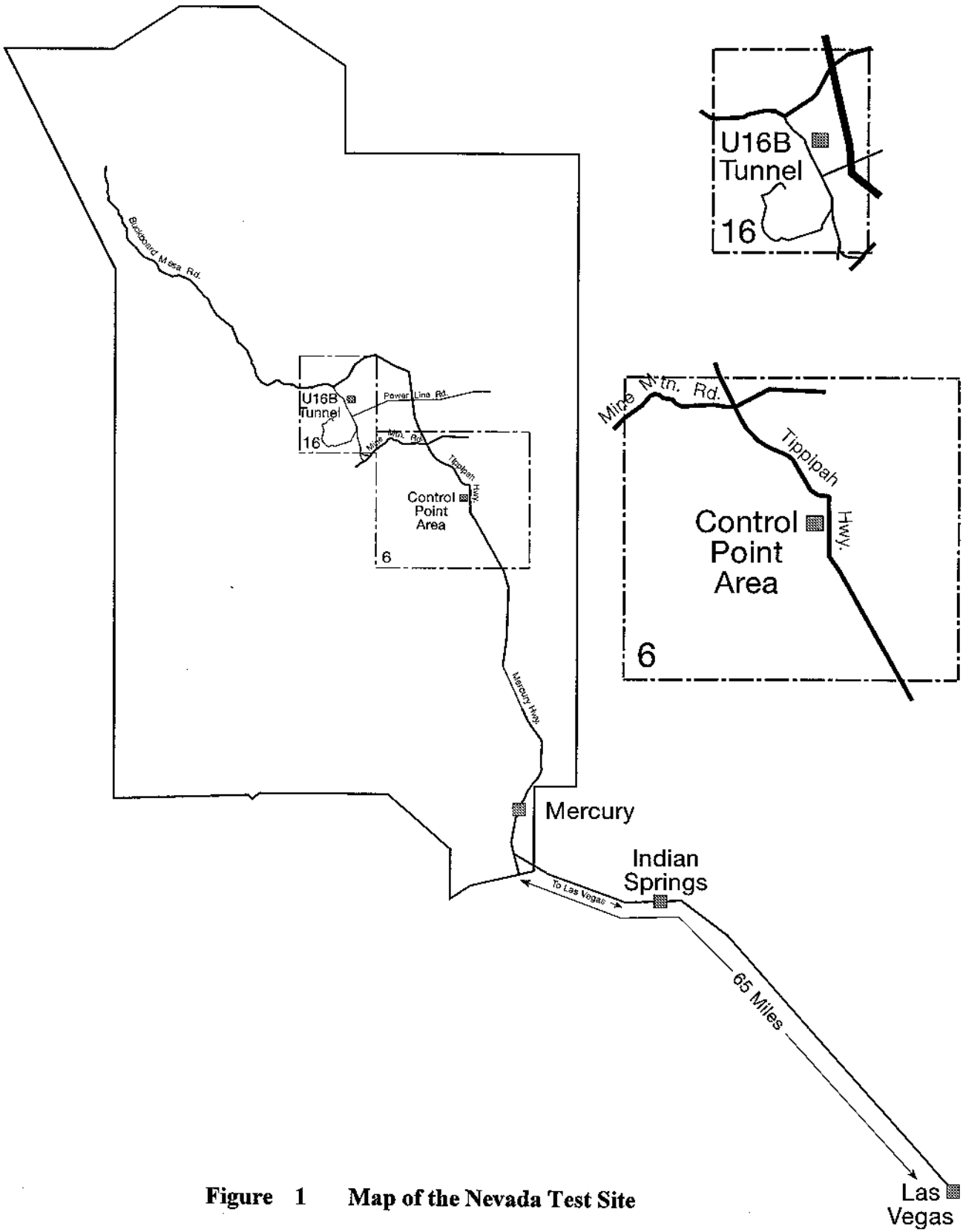

Figure 1 Map of the Nevada Test Site

facilities, and support to other federal agencies for the conduct of hazardous experiments and other activities in support of national security programs; 3) support environmental restoration, ground water characterization, and low-level radioactive waste management programs; and 4) support the Yucca Mountain Site Characterization Project.

U16b tunnel is under construction by BN in Area 16 of the NTS in support of a Defense Special Weapons Agency (DSWA) program. Area 16 is located near the center of the NTS about 35 miles north and west of Mercury, NV. As Management and Operating (M&O) Contractor BN also provides emergency medical and fire protection services to the NTS. For Area 16 these services are provided from the fire station in Area 6, approximately 15 miles from U16b. Wackenhut Services Incorporated provides all NTS security services under contract with DOE/NV.

U16b tunnel is under construction by Bechtel Nevada in support of a Defense Special Weapons Agency program.

1.3 SCOPE, PURPOSE AND METHODOLOGY

The Board began its investigation on August 13, 1998, and submitted this report to the Manager on September 9, 1998.

The scope of the Board's accident investigation included all activities required to review and analyze the circumstances surrounding the accident in order to determine the cause(s) or probable cause(s). During the investigation the Board inspected and photographed the accident scene, collected evidence, reviewed documentation prepared by BN, reviewed critical events leading to the accident, reviewed the emergency response, conducted extensive interviews with appropriate individuals, and performed events and causal factors analysis. The Board evaluated the adequacy of the contractor's safety management systems and work control practices relevant to the accident, and developed conclusions and judgements of need.

The scope of the accident investigation included all activities required to review and analyze the accident in order to determine the cause(s) or probable cause(s).

The purpose of the investigation was to identify causal factors of the accident, including deficiencies, if any, in safety management systems. The investigation report will also provide the DOE community with lessons learned to promote program improvement and reduce the potential for similar accidents.

The purpose of this investigation was to identify causal factors of the accident and inform the DOE community of any lessons learned.

2.0 ACCIDENT DESCRIPTION AND CHRONOLOGY

2.1 Accident Background

BN is the M&O contractor for operations at the NTS. The injured employee is a mucking machine operator employed full time by BN. He operates a LHD or similar construction equipment full time. He has been employed by BN since 1996 and had been employed at the NTS by the previous M&O contractor for more than 20 years. He is considered by his coworkers to be highly responsible and skilled in the operation of a LHD. He has demonstrated safe work practices in the past.

Bechtel Nevada has been the M&O contractor for the NTS since 1996.

The tunnel is being constructed in support of a DSWA project. Accordingly, a DSWA engineering technician was present at the portal monitoring tunneling activities at the time of the accident.

2.2 Accident Description and Chronology of Events

The U16b tunnel (figure 2) has been under construction since January, 1998. On the morning of August 5, 1998, a decision was made to begin construction of a keyway in an alcove on the right side of the tunnel at approximately Construction Station (CS) 1+75. A water and air hose connected to water and air lines on the left rib of the tunnel were hung up the left rib, across the back, and down the right rib. These hoses provided water and air to a jackleg drill and had initially been laid across the invert. However, the BN Shifter had directed the two miners operating the drill to string them overhead to prevent damage to the hoses from the LHD running over them as it passed while removing muck from behind Alpine Miner at CS 2+76. When the hoses were hung they were not held as tight to the ribs as reasonably possible. During the time the hoses were being hung, the LHD was removing muck from the tunnel's inside muck staging area at CS 1+15 to the outside muck pile. After the air and water hoses had been hung from the back, the LHD resumed mucking.

Two hoses were hung across the tunnel to provide water and air to a jackleg drill.

The hoses were not held as tight to the tunnel ribs as reasonably possible.

The accident occurred while the injured employee was hauling muck from the conveyor at the back of an Alpine

The accident occurred as the LHD was returning to the Alpine Miner for its twelfth load.

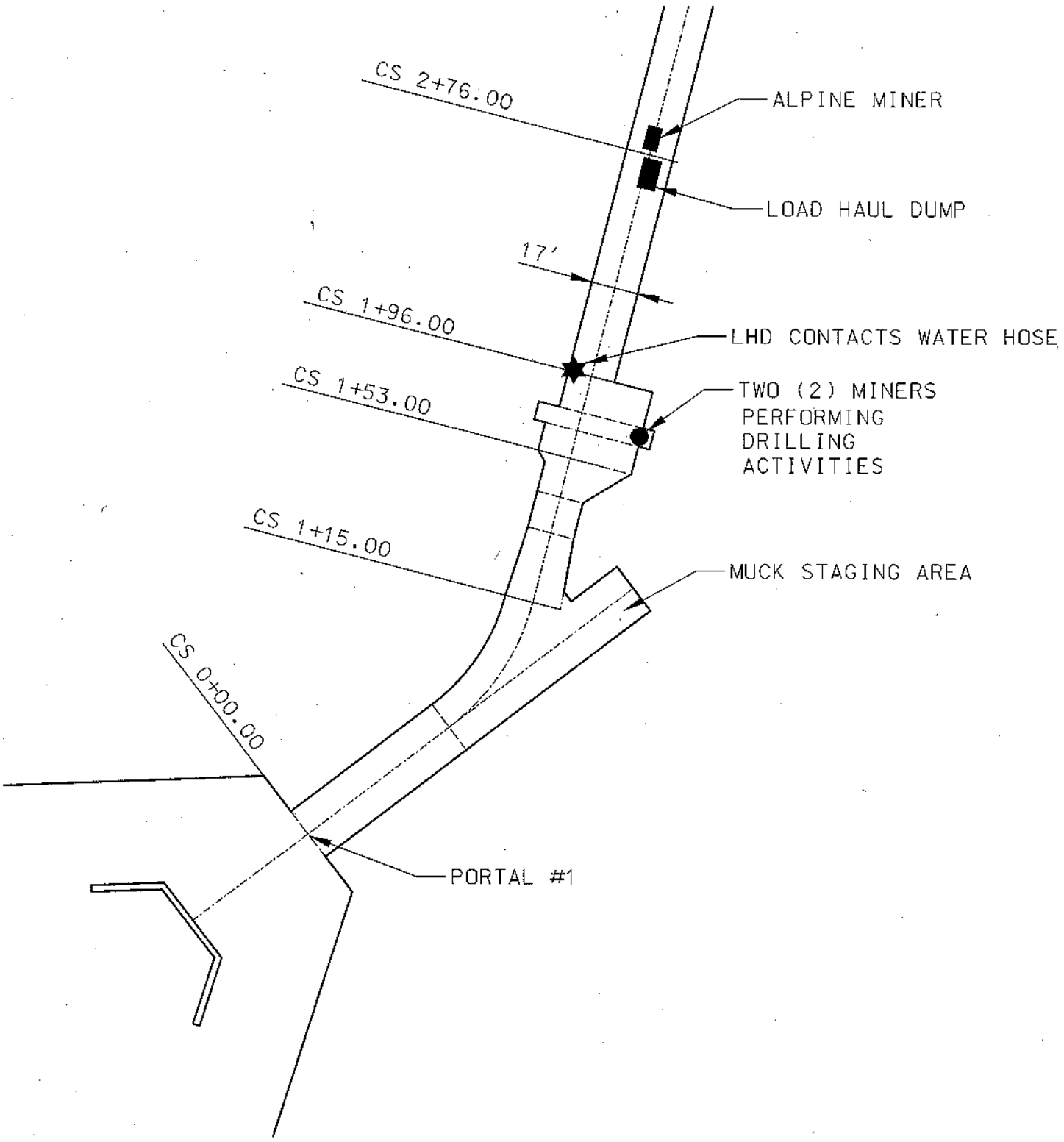

Figure 2 Plan of U16b Tunnel Portal 1

Figure 3, Photograph of Best Accident Reconstruction

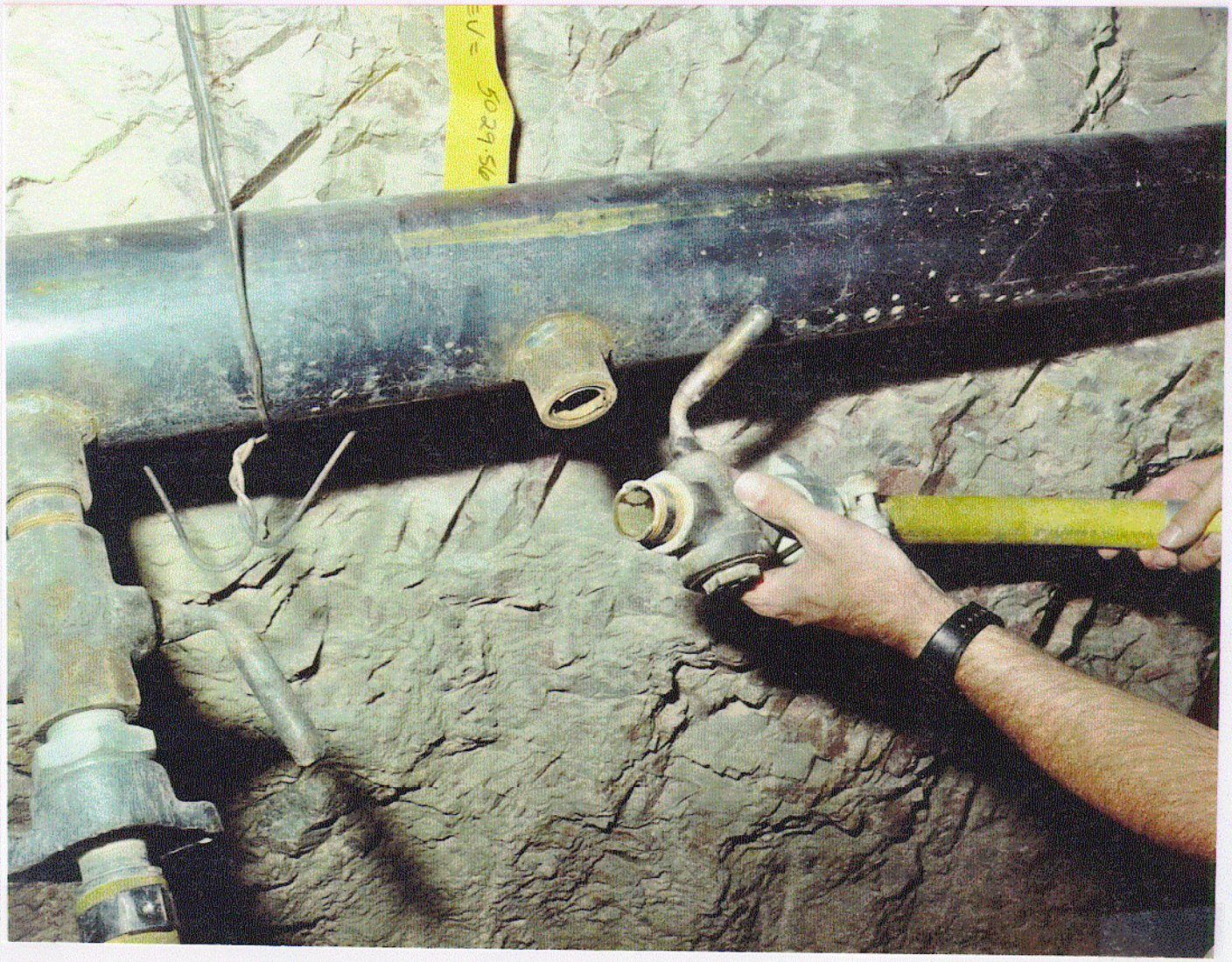

Figure 4, Photograph of Valve Assembly, Water Pipe, and Failed Nipple

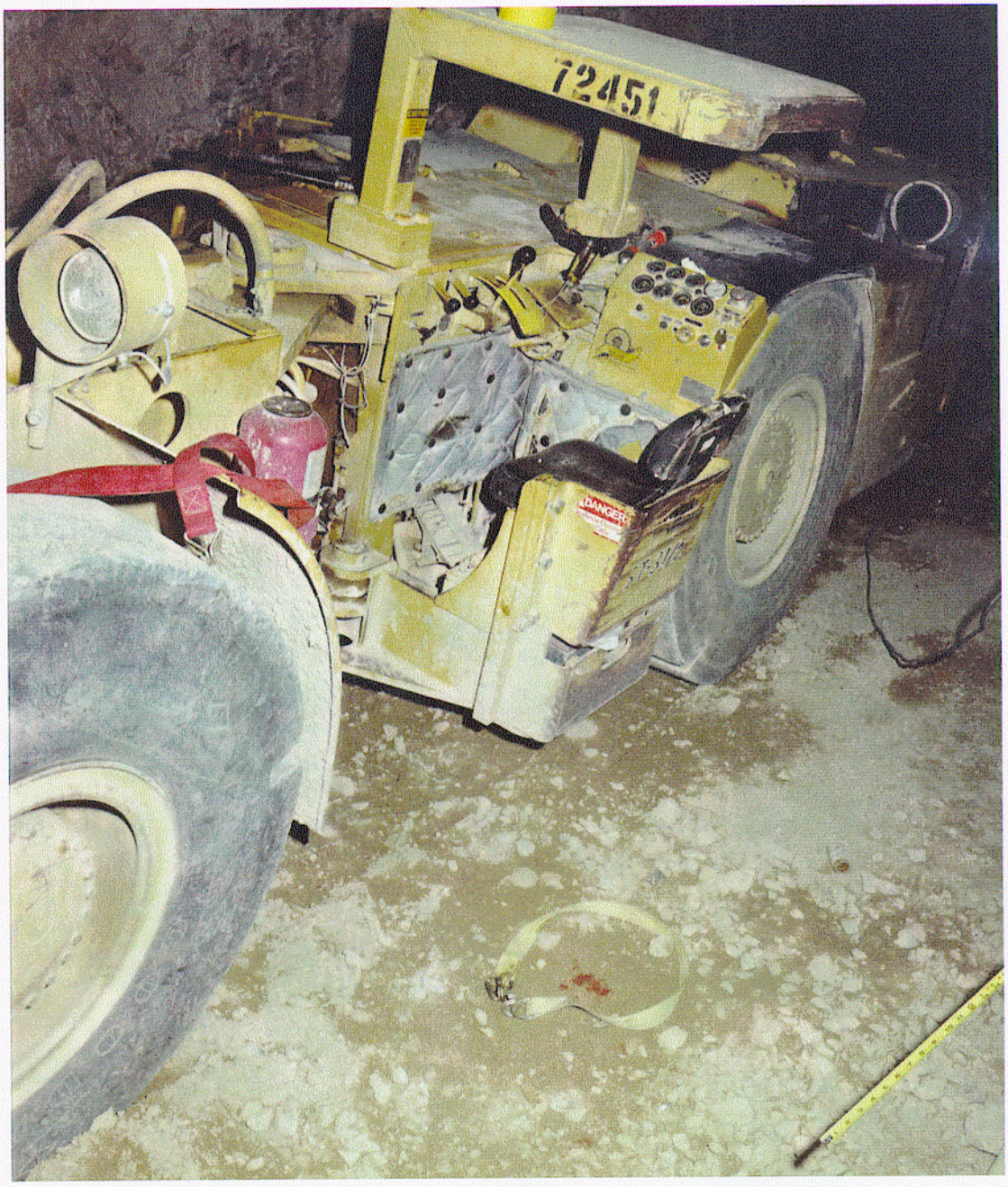

Figure 5, Photograph of LHD Operator's Cab

Miner to a muck pile in the tunnel. He had successfully completed 11 round trips and was returning to the Alpine Miner for another load when the LHD's rollover protective structure (ROPS) snagged and stretched a water hose that had been strung across the tunnel's back in support of the keyway construction. A best reconstruction revealed that the hose was approximately 40 inches from the tunnel's left rib at the height of the ROPS on top of the LHD (figure 3).

The LHD snagged and stretched the water hose until the valve assembly at the end of the hose broke.

Tension on the hose caused failure of the steel pipe nipple which connected the valve assembly at the end of the hose to a 4-inch steel water supply line (figure 4). When the nipple failed, the valve assembly was propelled toward the LHD by the contracting hose. The valve assembly struck the LHD operator (injured employee) on the back of the head. The LHD and injured employee proceeded to travel forward to CS 2+76 where it struck the conveyor attached to the back of the Alpine Miner. When the LHD struck the conveyor it damaged the conveyor frame, partially severed the 480 volt electric trailing power cable to the Alpine Miner energizing the LHD frame, and knocked the Alpine Miner operator (Miner A) from the Alpine Miner. The collision with the Alpine Miner also caused the injured employee to be partially ejected from the LHD.

The valve assembly was propelled toward the LHD by the contracting hose. The LHD operator was struck on the back of the head.

The LHD continued down the tunnel until it collided with the Alpine Miner.

The impact damaged the Alpine Miner, knocked the Alpine Miner operator off his machine, cut the Alpine Miner power cable, and partially ejected the LHD operator.

Miner A went around to the back of the Alpine Miner where he observed the LHD in contact with the conveyor and the injured employee lying on his back on the invert with his legs still in the operator cab (figure 5). Miner A called for help and Miners B and C, who were working on the keyway in the alcove responded. Miner A then observed that the injured employee was not breathing and directed Miner C to call for emergency medical assistance. Miner C went to the tunnel's public address (PA) system and made an emergency announcement for medical assistance while Miner B assisted Miner A in removing the injured employee from the LHD. During the course of removing the injured employee from the LHD, Miner B received three separate electric shocks when he made contact with the LHD. Miners A and B checked the injured employee and were not able to detect any vital signs. Accordingly, they started cardiopulmonary resuscitation (CPR).

The injured employee was unconscious and not breathing.

Coworkers called for emergency medical assistance.

One coworker received three electric shocks when he contacted the LHD.

Coworkers performed CPR on the injured employee.

Upon hearing the PA announcement, the Shifter called his supervisor, the Construction Superintendent, by telephone to pass on the information and to ask the Superintendent to call for emergency medical assistance. The Superintendent telephoned the NTS Emergency Dispatch Center and requested an ambulance and paramedics. Also upon hearing the PA announcement, the DSWA representative ran to the scene of the accident. Upon arrival he relieved Miner B who was performing CPR chest compressions on the injured employee. Just prior to being relieved, Miner B told Miner C that he had been shocked and directed him to deenergize the Alpine Miner power supply. Miner C went to the portal and disconnected the power supply to the Alpine Miner. After about two to three minutes, the injured employee was observed to be breathing on his own.

The Superintendent telephoned for emergency medical assistance.

The power supply to the Alpine Miner was disconnected.

After 2 to 3 minutes the injured employee began breathing on his own.

Miner B was taken to the BN medical facility in Mercury, NV where he was observed and released. It was determined that the electric shocks he received while removing the injured employee from the LHD had not caused any injury.

2.3 Emergency Response

The injured employee's coworkers and the DSWA representative appraised the injured employee's status, summoned help and administered CPR successfully at the scene of the accident prior to arrival of medical personnel.

The emergency call was received by the Mercury Fire Department Dispatch at 11:25 a.m. An ambulance and fire engine departed Area 6 at 11:26 a.m. While the emergency response vehicles were traveling to the U16b tunnel they received radio instructions telling them which roads to take and the location of the tunnel. However, both the fire engine and the ambulance missed turns and had to back track short distances to U16b. Upon arrival at the scene, the paramedics checked the condition of the injured employee, stabilized him, and began transport. While in route, appropriate medical protocols were followed by the paramedics including requesting an air ambulance for transport to a hospital in Las Vegas due to deteriorating vital signs. In Area 6 the ambulance crew was relieved by an another crew dispatched from Mercury who continued transporting the injured

The dispatched ambulance and fire engine missed turns to U16b and had to back track short distances.

An air ambulance was requested due to deteriorating vital signs.

employee to Desert Rock Airport in Area 22. This is a standard NTS practice.

On a road near Desert Rock Airport the ambulance crew transferred the injured employee to a commercial air ambulance helicopter. The helicopter transported the injured employee to Valley Hospital in Las Vegas, NV where he was admitted and treated. The injured employee required two surgeries to relieve pressure and remove bone fragments from his brain. There was no medical evidence of injury due to electric shock. The injured employee was released from Valley Hospital on August 13, 1998, to continue recuperation at home. When later interviewed the injured employee reported that he expects a medical release to return to work on or about October 1, 1998.

The injured employee was transported to Valley Hospital in Las Vegas, NV.

The injured employee was released from the hospital on August 13, 1998, and expects to return to work about October 1, 1998.

2.4 Investigative Readiness

The accident scene was secured and controlled by BN personnel at approximately 12:30 p.m., on August 5, 1998. The Alpine Miner and its power supply were locked and tagged out and a temporary barrier was placed to preserve the accident scene. At this time BN notified NV and initiated an accident investigation. Witnesses were interviewed, photographs were taken, and physical evidence was secured. Custody of the evidence, photographs, and witness statements, as well as a preliminary investigation report which included a daily log of all BN activities at the scene, were transferred to the Board on August 13, 1998.

The accident scene was secured and controlled by BN.

3.0 FACTS

3.1 Accident

Construction of the tunnel in support of a DSWA project had begun in January, 1998. Activities planned for August 5, 1998, in this tunnel were: 1) operation of an Alpine Miner electrically powered continuous mining machine at about CS 3+00, 2) removal of muck from a pile at the end of the conveyor at the back of the Alpine Miner by a LHD, and 3) construction of a keyway using a jackleg drill in an alcove at CS 1+75. Prior to the morning of the accident, alcove keyway construction had been planned for a future day. At the

beginning of the workday, it became apparent that keyway construction could be started that morning. The shifter contacted the superintendent who approved commencement of keyway construction.

To support the jackleg drill both an air and water hose were connected to 4-inch steel pressurized air and service water lines on the left rib at CS 1+96. The two hoses were hung overhead to allow the LHD to continue to travel through the tunnel without running over and damaging them. The air and water hoses were identical 1-inch (interior diameter), steel reinforced, heavy duty industrial hoses, rated at 1000 psi. They have both the properties to be stretched and sufficient strength to resist damage in the environment where they are used. The hoses were being used for their intended purposes. These hoses were hung overhead from the tunnel's left rib to the right rib to and connected to the jackleg drill in the alcove in the right side of the tunnel. When the hoses were hung, they were not held as tight to the rib as they could have been. The Board's best reconstruction indicates the water hose was approximately 40 inches from the left rib at the height where it was snagged by the LHD. There was approximately 11 feet of clearance between the left and right vertical portions of the hose. After the hoses were hung the injured employee began hauling muck from the Alpine Miner to the tunnel muck staging area at CS 1+15 while the miners who hung the hoses proceeded to begin drilling with the jackleg drill to construct the keyway in the alcove at CS 1+75.

The Board's best reconstruction indicates that the water hose was about 40 inches from the left rib at the height where it was snagged by the LHD.

The accident happened when the LHD snagged the water hose at CS 1+96 as the LHD was returning to the Alpine Miner for the twelfth load. The hose was stretched by the moving LHD until the threaded 1-inch steel pipe nipple holding the valve at the end of the hose to the 4-inch steel water pipe failed. The tension on the hose also permanently stretched the nylon straps used to support the hose about one inch, and deformed the wire mesh bolted to the tunnel back, and to which the nylon straps were hooked, about 6 inches. The 4-inch steel water pipe was rotated about 45 degrees by the tension on the hose. It is not known how far the LHD traveled after snagging the hose before the pipe nipple broke, but the injured employee's safety glasses were found on the invert about 23 feet in the direction of travel at CS 2+19.

The tension on the hose permanently stretched the nylon straps and wire mesh which were supporting it.

When the nipple failed, the valve assembly on the broken end of the hose was propelled by the rapidly contracting hose toward the LHD striking the operator on the back of the head. During the investigation, hair was found adhering to the clamp which attached the valve to the hose (figure 6). After investigating the accident scene, and reconstructing the hose arrangement to its best ability, the Board concluded that it is unlikely that the LHD traveled more than 10 feet after snagging the hose before the pipe nipple broke. The LHD continued to travel down the tunnel with the injured employee on board until it collided with the conveyor at the back of the Alpine Miner at CS 2+76.

When the valve assembly on the end of the hose broke free, it was propelled toward the LHD and struck the operator on the back of the head.

The LHD traveled down the tunnel carrying the unconscious operator until it collided with the Alpine Miner.

The LHD bucket dented the Alpine Miner's conveyor frame causing less than $10,000 in damage. The bucket also impacted the Alpine Miner's 3-phase 480 volt trailing power cable which was suspended on straps attached to the conveyor, breaking one of the straps and cutting through the cable's protective outer jacket and the insulation on the B-phase conductor (figure 7). When the LHD came to rest the trailing power cable was pinched between the conveyor frame and the LHD bucket. The bucket was in contact with the trailing power cable, but not with the frame of the Alpine Miner's conveyor (figure 8).

The LHD caused less than $10,000 damage to the conveyor at the back of the Alpine Miner.

The bucket of the LHD cut the Alpine Miner's trailing power cable and contacted a conductor which energized the LHD frame.

The Alpine Miner and conveyer were grounded to the trailing power cable's common electrical ground. The Alpine Miner's power supply system is designed to trip if either the ground on the Alpine Miner (including attached conveyor), or the ground in the trailing power cable was lost. The common ground wire was not cut or interrupted, therefore the Alpine Miner's power supply did not trip on loss of ground. The power supply system is also designed with a ground fault interrupter (GFI) to trip on a 25 ampere ground fault current on any one of the three phases. No electrical fault path to ground was made in this accident because the LHD bucket did not cut through the trailing power cable sufficiently to make contact with both the B phase and either the common ground wire or the Alpine Miner frame. A ground fault current of 25 amperes was not established, therefore the Alpine Miner's power supply GFI did not trip.

The Alpine Miner's power supply did not trip.

The Alpine Miner's power supply has a ground fault interrupter set to trip at 25 amps.

There were four BN employees in the tunnel and one DSWA

representative at the portal area outside the tunnel at the time of the accident. None of the injured employee's coworkers or the DSWA representative observed the accident. The injured employee has no recollection of the events before or after the accident. The first indication of trouble was when Miner A was knocked off of the Alpine Miner and Miners B and C were sprayed with water from the broken water line. Prior to the accident, the BN Shifter had completed a safety walk through this tunnel, directed Miners B and C to hang the air and water hoses overhead to protect them from damage, and departed to continue his walk through at two other locations with active work in the U16b complex. He had not returned to check their work prior to the accident.

There were no witnesses to the accident.

The injured employee has no recollection of the accident.

The day of the accident was the first day back at work after the injured employee had taken leave to attend the funeral of his mother in Ohio. The employee appeared normal to his coworkers the day of the accident. The injured employee was highly respected as a safe and skillful equipment operator. Virtually all of the injured employee's coworkers were of the opinion that he was probably unconscious prior to contacting the water hose. The Board found no evidence to support this but the possibility cannot be ruled out. The injured employee was not wearing the LHD's installed seat belt. The Board could not determine if the injured employee was wearing a hard hat. The injury was to a part of the head not normally protected by a hard hat (figure 9).

Emergency care given to the injured employee by his coworkers and BN emergency medical personnel was timely and effective. The Board noted that there were no signs directing traffic to U16b. Prior to 1996 the previous NTS M&O contractor did post such signs. Any delay caused by missed turns by the emergency response vehicles was no more than a few minutes and had no apparent effect on consequences in this accident.

Emergency care given to the injured employee was timely and effective.

The Board reviewed the LHD's maintenance history and the results of a detailed mechanical inspection conducted by BN after the accident. The Board also interviewed the person who operated the same LHD the previous day. No evidence of mechanical failure of the LHD was found.

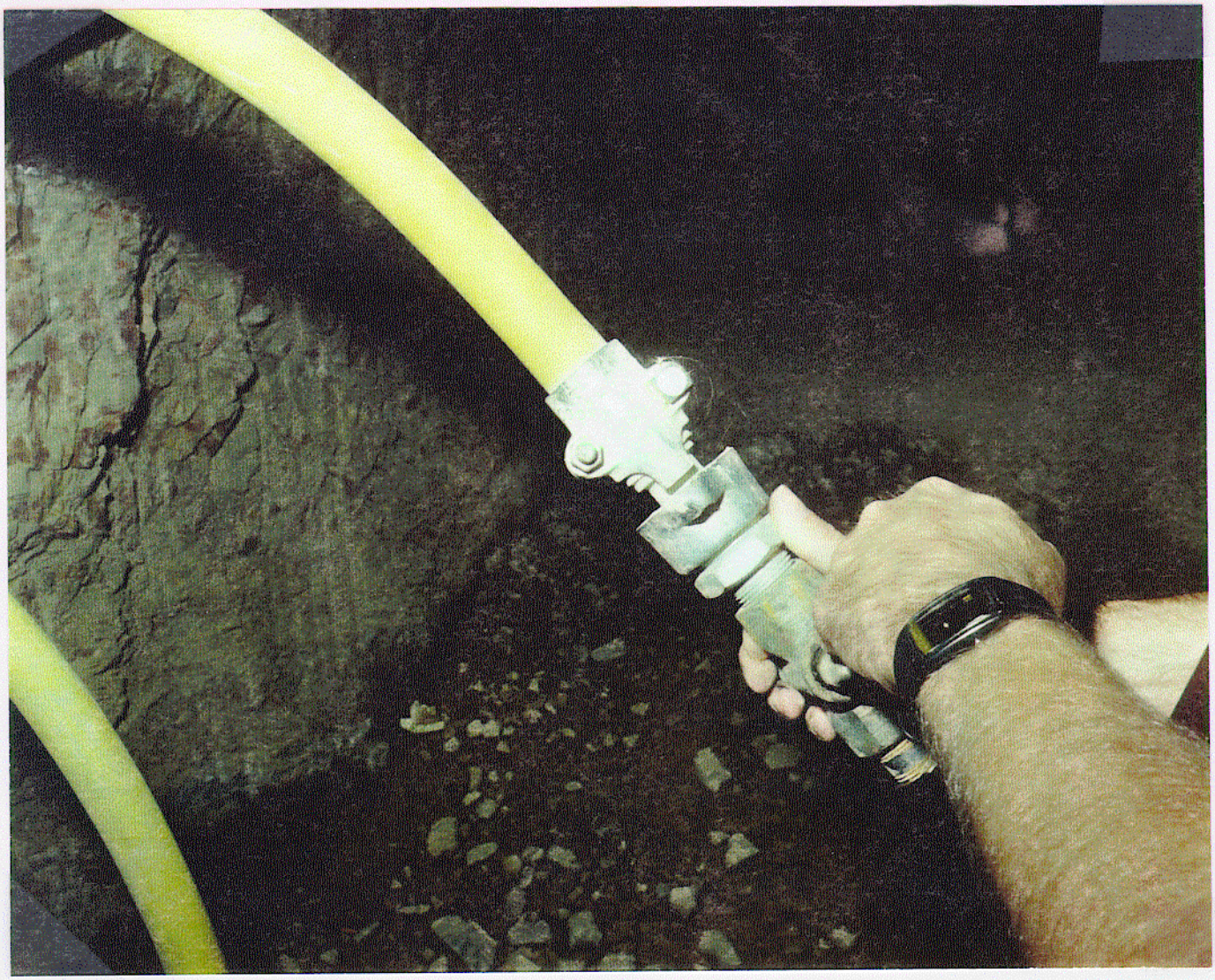

Figure 6, Photograph of Hair Adhering to Valve Assembly

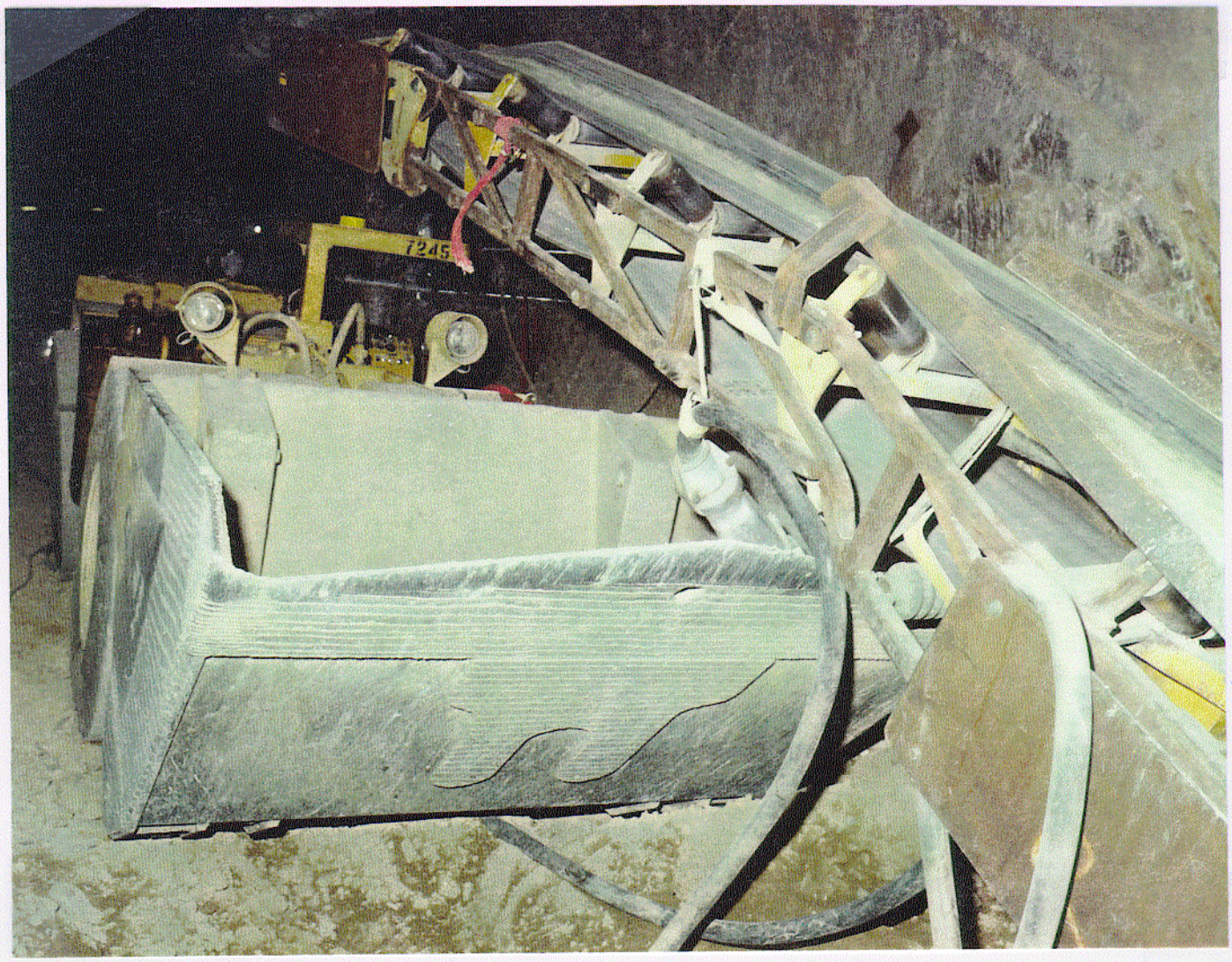

Figure 7, Photograph of LHD in Contact with Alpine Miner

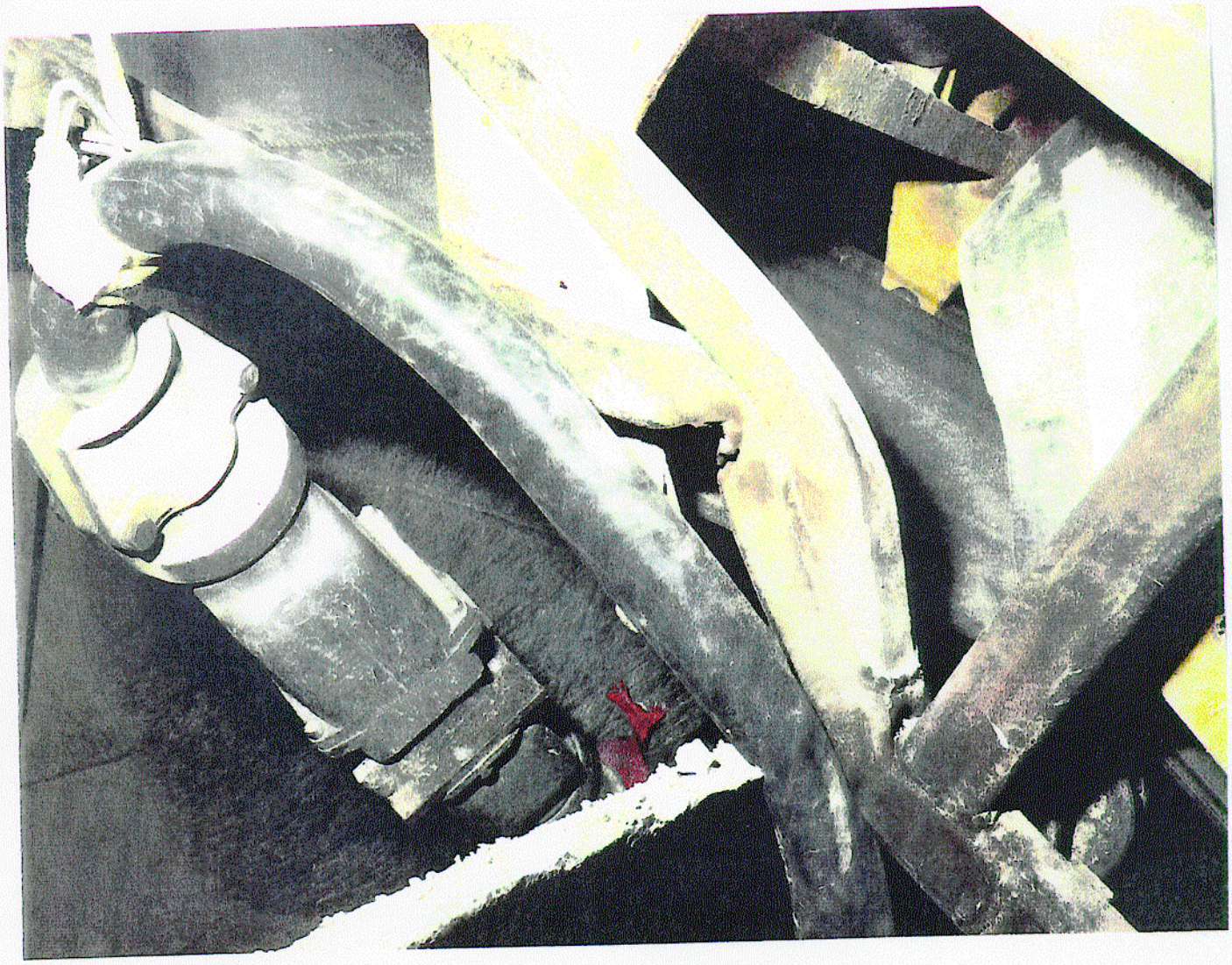

Figure 8, Photograph of Power Cable Damaged by LHD

Approximate Location of Depressed Skull Fracture

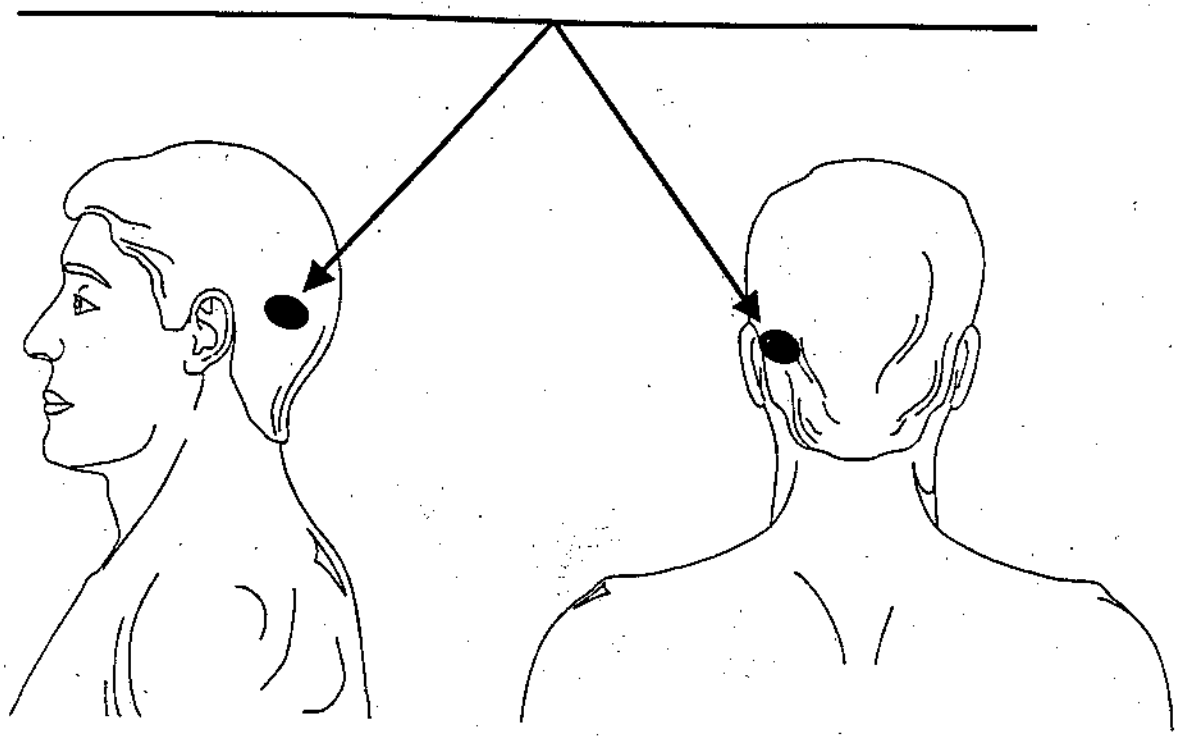

Figure 9 Drawing of Location of Head Injury

3.2 Accident History

The Board reviewed the ORPS and BN Accident/Incident report files. All accidents involving operating equipment, nonuse of seat belts, electrical shock, and head injury at the NTS since BN became the M&O contractor, as well as all accidents and injuries of any nature in U16b tunnel or involving the injured employee were also reviewed. The Board found the following:

There were no similar or closely related accidents involving seat belts, head injuries, or electrical shock.

The injured employee had not been previously involved in an accident since becoming a BN employee in 1996.

There had been one prior nonaccident occupational injury at U16b involving back strain due to improper lifting.

The Board found three related accidents/incidents involving operation of underground equipment at the NTS within the last year.

The Board did find three related BN accidents/incidents at the NTS involving underground equipment operation within the last year. All three occurred in the U1a Complex in Area 1. None of the incidents involved personnel injury or more than $10,000 damage. These incidents were:

1) On October 28, 1997, an operator of a one-ton LHD misjudged a turn at an intersection of two drifts, over corrected, and collided with a metal raceway on the opposite rib. Besides the raceway, 29 scientific diagnostic cables were damaged. Prior to the accident the operator was aware that there was some "sloppiness" in the LHD steering system, yet continued to operate the machine. Later investigation confirmed mechanical problems with the LHD steering system.

2) On January 18, 1998, another LHD operator was making a turn at an intersection of two drifts and misjudged the turning clearances. A bolt on the back of the LHD snagged and damaged a metal bracket and a piece of plywood attached to the rib. The plywood had been placed over some cables at a particularly narrow area to protect them from such an impact.

3) On July 23, 1998, a forklift operator backed out of a drift and snagged and broke a low hanging fiber-optic cable.

3.3 Oversight

3.3.1 BN Oversight

The BN Shifter is always present at U16b when work is in progress.

The BN Shifter is continuously present at U16b while work is in progress. This accident occurred in U16b Tunnel Portal 1, however, construction is underway at three separate portals at U16b which physically separates the workers under the Shifter's control. The total number of workers present at U16b does not exceed about 15 at any one time and the separate work locations are relatively close together and within a reasonable span of control for the shifter. Such an arrangement is not uncommon in the construction and mining industries.

The BN Superintendent is responsible for tunneling and construction activities at both U16b tunnel and U12p tunnel in Area 12. These two job locations are approximately 10 miles apart. The Superintendent is physically present at U16b once or twice per day for up to several hours at a time depending on the scope and complexity of the day's work. When not present at U16b the Superintendent is immediately available by telephone or radio and usually less than 15 minutes away by vehicle.

The BN Construction Department Manager has assigned to his department a full-time safety professional who routinely visits all active BN construction locations. As the Construction Manager's representative this safety professional visits U16b at least once per week and had been present the previous day.

Visits to U16b by BN Safety Professionals were routine and one had occurred the previous day.

Independent safety oversight within BN at the NTS is performed by the Environment, Safety and Health (ESH) Division under the BN Assistant General Manager for ESH. ESH Division representatives routinely visit all active BN construction locations. A senior ESH Division manager had previously visited U16b and had been present the day before the accident.

3.3.2 DSWA Oversight

A DSWA engineering technician is assigned to U16b tunnel. This individual is primarily responsible for overseeing quality and progress, and as serving as the "customers" on-site representative for addressing technical questions or resolving construction issues. The assigned individual is normally physically located at the immediate entrance to the portal of the tunnel where this accident occurred and is experienced and qualified to observe safety infractions. He was present at U16b Tunnel Portal 1 at the time of the accident.

A DSWA representative was present at the portal at the time of the accident.

DSWA and its predecessor agencies has been present at the NTS since its formation in 1950, and has been involved in the construction of tunnels and underground test beds since 1960. Because of the adverse impact that construction accidents have on DSWA programs and schedules one of the principle "deliverables" or expectations of DSWA is a safe operation. Therefore the assigned representative is expected by DSWA management to bring any safety issues to the immediate attention of DSWA management, NV and BN. He also has the authority to stop work and request resolution of any observed safety or health issue.

Operational safety is one of the deliverables that DSWA expects from BN.

3.3.3 DOE/NV Oversight

Line management responsibility for support to Department of Defense Work-for-Others at the NTS is through a Project Manager assigned to the Site Operations Division under the Assistant Manager for National Security. A separate qualified Facility Representative for U16b is also assigned within the Site Operations Division. The Facility Representative is not responsible for schedule or other programmatic commitments. The Facility Representative is stationed at the NTS. He visits U16b about every other day and was present the previous day.

The NV Facility Representative visits U16b about every other day and was present the previous day.

Independent DOE/NV safety oversight is performed by the NV ESH Division under the Assistant Manager for Technical Support. Safety surveillances of work locations across the NTS are regularly scheduled. There had been three regular surveillances at U16b since construction began in January, 1998, the last of which had been conducted the previous day. The surveillance on August 4, 1998, was conducted by the

There had been three regular safety surveillances at U16b by NV since January, 1998, including one on the day before the accident.

Safety Team Leader, and was the first since the tunnel had been advanced far enough to go underground.

3.4 Training and Qualifications

In October, 1997, a hazard assessment was completed by BN for the U16b tunnel construction which identified relevant training and experience of BN employees and management. BN has a training matrix to track employee training course requirements and attendance. The BN employees involved in this accident were current on required training. All BN employees were trained and well versed in their authority to stop work at any time if they observed unsafe conditions.

The BN employees involved in this accident were current on required training.

BN employee training is supplemented by weekly safety training meetings. These meetings provide a forum to discuss safety related issues, provide supplemental training, and share in lessons learned. On a monthly basis all Construction Department Accident/Incident Reports are summarized and reviewed at a weekly safety meeting. However, no employee interviewed could specifically recall discussing or reviewing the three prior equipment accidents/incidents in U1a. The Board reviewed the curricula of BN Underground Worker Training and Hazard Recognition Training and found that the specific hazards and BN General Safety Rules relevant to this accident were not addressed. Area familiarization training for emergency response personnel is routine at the NTS. A different ambulance crew had been observed at U16b by DOE/NV personnel the previous day. Yet, on the day of the accident both an ambulance and fire truck traveling by different routes to U16b had some difficulty finding their way.

The Board reviewed the curricula of BN Underground Worker Training and Hazard Recognition Training and found that the specific hazards and BN General Safety Rules relevant to this accident were not addressed.

3.5 Documents

The Board reviewed the BN ESH Manual for procedures relating to the hanging of hoses in underground operations. BN Procedure M-All-050, 5.1.18 requires that for good housekeeping and personnel safety electrical cables, welding leads, cords, wires, and other temporary systems be kept off the walking surface in elevated positions. BN Procedure M-A11-001, 5.7.7 also requires temporary systems to be kept elevated *such that they cannot be damaged by construction*

BN procedures require that temporary systems to be kept elevated such that they cannot be damaged by construction activities or equipment. BN procedures also require seat belts to be worn in all vehicles and equipment when installed.

activities or equipment [emphasis added]. BN Procedure M-All-001, 5.4 requires seat belts to be worn in all vehicles and equipment when installed. The Board found that if these BN procedures had been fully implemented, they would have prevented or mitigated the injuries in this accident.

The Board reviewed OSHA, MSHA, NEC, and IEEE electrical safety standards, as well as the NTS Underground Safety Standards, NV-353, and found no requirement for low level ground fault protection for the purpose of personnel electrical safety except for single-phase 120 volt systems.

There is no government or industry standard that requires low level ground fault protection for personnel safety in systems similar to the Alpine Miner's power supply.

3.6 Hazard Assessment

A Preliminary Hazard Assessment (PHA) for the planned U16b tunnel excavation using a BN Project Activity PHA Checklist was performed on October 15, 1997. The PHA was conducted to identify hazards associated with underground construction activities and to ensure adequate protective measures were placed to protect the worker, the public, and the environment.

The PHA documented the U16b site specific work activities, hazards, and controls. The PHA addressed road and portal area surface construction, tunnel construction and ground support. Based on the PHA Checklist a Hazard Assessment (HA) was prepared. The HA included by reference the BN ESH Manual and assumed that all BN General Safety Rules would be followed. The PHA and HA adequately addressed the hazards involved in the routine surface and underground activities necessary to construct U16b tunnel and its associated surface works with one exception. While the PHA and HA recognized the hazard to personnel from moving construction equipment, they did not address the hazards to the operators of moving equipment from collisions, entanglements, and rollovers.

The U16b PHA and HA did not address hazards to equipment operators from collisions, entanglements, and rollovers.

4.0 ACCIDENT ANALYSIS

4.1 Amelioration

The board concluded that the emergency response from the injured employee's coworkers, the DSWA representative and

the emergency response personnel was adequate with the following two exceptions.

First, the damage to the Alpine Miner's trailing power cable was not observed prior to attempting the removal of the injured employee from the LHD, and electric power to the Alpine Miner was not deenergized as soon as it was known that the LHD frame was energized. When Miner B received the first shock he recoiled and tried to reach the injured employee's legs from a slightly different angle. Upon receiving the second shock he recoiled and decided that he was going to remove his injured coworker even if that meant receiving additional shocks. Failure to deenergize the Alpine Miner power supply as soon as the LHD frame was found to be energized had the potential to result in severe injury or electrocution.

Injury or death due to electric shock was a potential in this accident.

Second, both the fire engine and ambulance missed turns and had to back track short distances before getting to U16b. The Board determined that the time lost in failing to travel directly to the tunnel was not significant in this accident. However, failure by emergency crews to be able to respond directly to an accident site has the potential to result in failure to provide prompt medical attention.

The short time lost by the ambulance failing to drive directly to U16b was not significant in this accident.

The injured employee's coworkers and the DSWA representative assessed the injured employee's condition and successfully performed CPR at the accident site prior to arrival of emergency response personnel. Upon arrival, the paramedics provided an immediate medical evaluation and appropriate care. The transport of the injured employee to Valley Hospital in Las Vegas was timely and responsive.

4.2 Accident Scene Preservation

Within about 40 minutes of the injured employee departing the scene by ambulance, a senior BN safety professional arrived at U16b to barricade the scene, lock out equipment, and investigate the accident. Prior to his arrival BN workers had located and preserved some key pieces of evidence and ensured that the scene was undisturbed. These actions were based on initial reports that the injured employee had suffered a health related emergency (heart attack or stroke).

On the day of the accident BN began an accident investigation.

Over the next few days as part of the BN accident investigation, various pieces of equipment were collected, moved, operated, tested, measured or otherwise disturbed. Prior to doing so BN thoroughly photographed the original position and condition of the scene with one exception.

The BN preliminary investigation report records that the injured employee's hard hat was found near the operator's seat of the LHD. Photographs taken by BN do not show the hard hat in this location. The Board found the hard hat preserved along with the injured employee's personal effects in the BN construction trailer at U16b. Some of the interviews with BN personnel indicated that the hard hat was found located on top of the back of the LHD in a location and manner to suggest it had been placed there prior to the accident. The inference being that the injured employee was not wearing a hard hat at the time of the accident. Other interviews indicated that the injured employee was never seen operating the LHD without a hard hat. The Board determined that without documented visual evidence of the exact location of the injured employee's hard hat no finding that he was not wearing his hard hat could be substantiated.

The Board could make no determination that the injured employee was not wearing his hard hat.

The Board formally collected the following physical evidence at the accident scene on August 13, 1998: the hose end and valve assembly with some hair attached; two nylon hose hanging straps; and samples of the hose residue on the LHD ROPS. The Board received from BN the following: two damaged portions of the Alpine Miner trailing power cable and BN photographs of the accident scene. The Board concluded that although efforts were taken to document the evidence and preserve the accident scene, controls were not sufficient to prevent information relevant to the accident from being disturbed, i.e. the victims hard hat.

Hair was found adhering to the clamp on the end of the broken hose.

It should be noted that a crucial piece of physical evidence was the several pieces of human hair found adhering to the clamp that attached the valve assembly to the hose. Without this evidence it may have been impossible to determine if the head injury was caused by the hose or ejection from the LHD on impact. The Board commends the BN investigators for finding and preserving this evidence early in their investigation.

4.3 Barrier Analysis

The safety barriers between the injured employee and contact with the hose and valve, the ground, and electric shock included worker judgement and skill, physical barriers, administrative barriers and management barriers. These barriers are presented in summary form in Table 1 and are discussed below.

4.3.1 Individual Judgment

Individuals are responsible for their safety and the safety of others. The injured employee should have been aware of the requirement to wear the installed seat belt when operating equipment. This is mandated by OSHA for all equipment with installed ROPS and by BN General Safety Rules for all equipment and vehicles. Failure to comply with this requirement resulted in the injured employee being ejected from the LHD and striking the ground with his head when it impacted the Alpine Miner. Whether this caused additional injury cannot be established but the potential for serious injury was high. In addition, the potential to have fallen from the LHD when moving and being crushed by the moving vehicle was also significant.

Failure to wear the installed seat belt resulted in the LHD operator being ejected and striking his head.

The two BN workers in the alcove who installed the water hose that was snagged did not judge it to be a hazard or subject to damage by the LHD. The LHD operator who was injured also passed through the hanging hoses at least twenty previous times the day of the accident (ten round trips) and did not judge it to be a hazard or ask that it be moved out of the way. However, the BN General Safety Rules require that temporary systems be kept off walking surfaces in an elevated position where they cannot be damaged by construction activities and equipment. The hose as installed clearly could be and was damaged by the LHD. As installed, there was approximately 11 feet of clearance between the hanging hoses. This complies with industry guidelines which recommend clearance equal to 175% of equipment width. Under most circumstances this should have been sufficient for the LHD to pass safely. Yet, if installed in such a way to maximize clearance as much as 16 feet of clearance could have been made available. The alcove workers and LHD

The BN workers who installed the water hose and the LHD operator did not judge it to be a hazard or subject to damage by the LHD.

There was approximately 11 feet of clearance between the hanging hoses which meets industry guidelines for LHD operation.

operator judged the hose installation to be "good enough" and relied on the skill of the operator to avoid the hanging hoses.

The hoses were not hung in full compliance with BN General Safety Rules.

The Board finds that the alcove workers did not hang the hose in full compliance with the BN General Safety Rules and that the LHD operator did not wear the installed seat belt in compliance with the BN General Safety Rules. The Board also finds that the alcove workers and LHD operator did not recognize the hoses as hung to be a hazard to the equipment operator or nearby workers, thus they did not maximize equipment clearances. The alcove workers and LHD operator relied on the skill of the LHD operator to avoid the hoses.

The Board was not able to determine the direct cause of the LHD operator contacting the water hose, however three scenarios were speculated.

The maximum speed of the LHD is limited to about 15 miles per hour unloaded. The Board determined that excessive speed by the operator could not be a causal factor. The Board was not able to determine the direct cause of the LHD operator contacting the water hose, however three scenarios were speculated.

1) The LHD operator may have been driving close to the left side of the tunnel to provide extra clearance for the two workers in the alcove at the right side of the tunnel. As he passed the alcove he may have turned to look at them to ensure sufficient clearance. It should be noted that equipment operators are required to be aware of the location of personnel around them at all times. While turned away from the direction of travel the LHD may have snagged the water hose. 2) The LHD operator may have been inattentive due to the recent death of his mother or for some other human factor, and not paying close attention to his position relative to the hanging hose. 3) The LHD operator may have been unconscious prior to contacting the hose due to an unknown medical problem. Although possible there is no medical evidence to support this third scenario.

The Board determined that although a medical condition may have been the reason for the LHD operator failing to avoid the water hose, it is most likely the result of either distraction or inattention. The Board also found that although the LHD operator was highly skilled and experienced, a momentary loss of situational awareness or other operator error probably occurred and caused this accident.

4.3.2 Physical Barriers

The Board identified and evaluated the following physical barriers to injury to determine if there was a barrier failure: injured employee's hard hat, 480 volt trailing power cable insulation, and LHD seat belt.

The Board evaluated 3 physical barriers to the accident: hard hat, power cable insulation, and LHD seat belt.

4.3.2.1 Hard Hat

The Board determined that the injured employee was struck on a part of the head not normally protected by a hard hat. The injured employee's hard hat met the ANSI approved standard for mining activities. There is no substantiated evidence that the injured employee was not wearing his hard hat. The injured employee's hard hat is not considered a failed physical barrier.

The injured employee's hard hat is not considered a failed physical barrier.

4.3.2.2 Electrical Insulation

The Board evaluated the electrical insulation on the 480 volt trailing power cable to the Alpine Miner which was cut by the lip of the LHD bucket. The power cable is rugged and designed for the underground environment in which it was used. However, it was not designed to withstand direct impact from a large piece of equipment and to do so would be impractical. The power cable insulation is not considered a failed physical barrier.

The power cable insulation is not considered a failed physical barrier.

4.3.2.3 Seat Belt

The Board evaluated the seat belt installed in the LHD and determined that it was operational but not used by the injured employee. This is a failure to follow BN General Safety Rule M-A11-001, 5.4 and 29CFR 1926.602(a)2.I (OSHA) requirements for operation of equipment with installed ROPS. The Board determined that failure to wear the seat belt resulted in the injured employee being ejected from the LHD. Impact with the ground may have contributed to the employee's injuries and there was significant potential for him to have fallen from the LHD while moving and been crushed. Failure to use the installed seat belt may have increased the severity of the LHD operator's head injury and could have resulted in his death.

Failure to use the installed seat belt may have increased the severity of the LHD operator's head injury and could have resulted in his death.

4.3.3 Administrative Barriers

The Board identified and evaluated the following administrative barriers to injury to determine if there was a barrier failure: mechanical design of the LHD and its attached ROPS, electrical design of the mining power center (MPC) and GFI circuitry, and BN work procedures for hanging utility hoses across a tunnel.

The Board evaluated 3 administrative barriers to this accident: LHD and ROPS design, MPC and GFI design, and BN work procedure for hanging utility hoses.

4.3.3.1 LHD and ROPS Design

The Board evaluated the mechanical design of the LHD and its attached ROPS to determine if they contributed to the accident. The hose apparently snagged on the left leading edge of the ROPS. The LHD has numerous projections, such as fenders, muffler, headlights, etc. on which the hose could have snagged (figure 5). In general the LHD is not designed to deflect obstructions and it would be impractical to do so. Avoidance of obstructions requires the operator to recognize clearances, maintain situational awareness, and skillfully operate the LHD. The ROPS attached to the LHD is designed only for rollover protection not to protect the operator from falling objects or projectiles. LHDs of this model are available both with and without an installed ROPS depending on use. In general LHDs of this size are not available with an enclosed or protective cab which would be impractical. The Board determined that the LHD and ROPS designs were not a failed administrative barrier.

The Board determined that the LHD and ROPS designs were not a failed administrative barrier.

4.3.3.2 MPC and GFI Design

The Board evaluated the electrical design of the MPC and GFI cabinet to determine if they contributed to the accident. The MPC is a 4160 volt to 480 volt, three phase, step down transformer with associated breakers. It is a commercially available, off the shelf, power supply typical to the mining industry. Commercial MPCs are generally available both with and without GFI circuitry. The MPC in use at U16b did not have internal GFI circuitry, there was a separate GFI cabinet installed at the output of the MPC. The Board determined that the MPC design was not a failed administrative barrier.

The Board determined that the design of the MPC was not a failed administrative barrier.

The Board determined through interviews, a Board-directed BN study of the system, and review of equipment catalogs that the GFI cabinet had been designed and constructed by the previous NTS M&O contractor to provide both continuous ground circuit monitoring protection and ground fault protection.

The GFI cabinet is equipped with a continuous ground circuit monitor. This circuitry continuously monitored the common ground circuit of the 480 volt electrical power supply to the Alpine Miner. If resistance on this common ground circuit ever became unacceptably high, indicating loss of the common ground, the 480 volt power to the Alpine Miner would be tripped. This ground circuit monitor was designed to assure continuous grounding of the Alpine Miner and its trailing power cables for both personnel and equipment protection. The Board determined that the ground circuit in the trailing power cable was never broken. Therefore ground protection to the Alpine miner and trailing power cable was not lost and the ground circuit monitor protection operated as designed. The Board determined that design of the ground monitor circuit was not a failed barrier.

The Board determined that design of the ground monitor circuit was not a failed barrier.

The ground fault protection was designed to protect equipment from relatively high ground faults. This GFI cabinet was set to trip at 25 amperes of ground fault current on any one phase. Manufacture's literature indicated that other settings of 5, 10, 50, or 100 amperes were available. The Board determined that the lowest available setting of 5 amperes would not be sufficient to protect personnel from electric shock. The Board determined that during the accident the currents that produced the electrical shocks to Miner B were less than 25 amperes, therefore the GFI did not trip the power to the Alpine Miner. The Board also determined that since the electric shocks to Miner B caused no injury they were probably in the milliampere range and therefore had the GFI been designed with the lowest available setting of 5 amperes the GFI still would not have tripped. The Board determined that the GFI circuitry was intended to protect equipment from relatively high ground fault currents not personnel from low level faults. The installed GFI circuitry operated as designed.

The Board determined that the reason that the designers never included personnel protection from low level ground faults in the design of the GFI cabinet was that personnel ground fault protection was not in the design criteria provided by DSWA as approved by NV. The Board further determined that the grounding system as designed met all existing requirements of IEEE Standard 142, Recommended Practice for Grounding of Industrial and Commercial Power Systems. The Board further determined that there is no requirement in existing national standards (OSHA, MSHA, NEC) or the NTS Underground Safety Standard (NV-353) to install low level ground fault protection in any power systems other than 120 volt single phase circuits. The Board determined that this lack of a national standard requiring low level ground fault protection for personnel electrical safety to be a contributing cause for the electric shock to Miner B. The Board considers this to be a potential administrative barrier failure.

The Board determined that the lack of a national standard requiring low level ground fault protection for personnel electrical safety to be a contributing cause for electric shock to one employee. The Board considers this to be a potential administrative barrier failure.

4.3.3.3 Work Procedure

The Board evaluated the BN work procedures to determine if they were adequate. The Board found that there was no specific written work procedure for hanging utility hoses or power cords from one side of a tunnel to the other. This is considered a skill of the craft. The Board concurs that a written procedure is not required and that journeymen workers should be able to accomplish this work as a skill of the craft. However, there is a written BN procedure on General Safety Rules that applies to all work. General Safety Rule M-A11-001, 5.7.7 states: "...temporary systems shall be kept off walking surfaces in an elevated position where they...*cannot be damaged by construction activities or equipment* [emphasis added]". The Board determined that not fully complying with this written safety rule was a failed administrative barrier.

The Board determined that not fully complying with a BN safety rule was a failed administrative barrier.

4.3.4 Management Barriers

The Board identified and evaluated the following management barriers to injury to determine if there was a barrier failure: oversight, hazard assessment, worker training, and feedback and improvement.

The Board evaluated four management barriers in this accident: oversight, hazard assessment, worker training, and feedback/improvement.

4.3.4.1 Oversight

The Board evaluated oversight of the work at U16b by BN, DSWA on site representation, and NV. The Board found that the BN shifter had recognized the hazard associated with the air and water hoses to the jackleg drill and had directed the hoses to be elevated up and out of the way during his morning safety walk. He then departed the area to continue his safety walk through and did not return prior to the accident. The Board considers the direct supervision of this work to be adequate and not a failure of a management barrier.

The Board considers the direct supervision of this work to be adequate and not a failure of a management barrier.

The Board further evaluated oversight by the BN, DSWA, and NV organizations. A complete description of the Board's findings on management oversight is made above in section 3.3. The Board also evaluated the work planning for the drilling activities associated with the alcove keyway construction. Because operation of a jackleg drill is a routine activity in underground construction at the NTS, the Board concluded planning for the work, although brief, was adequate and not a failed management barrier. The Board determined that compliance with BN General Safety Rules was less than adequate and a failure of a management barrier in this accident.

The Board determined that compliance with BN General Safety Rules was less than adequate and a failure of a management barrier.

4.3.4.2 Hazard Assessment

The BN checklist (Form 0182) for performing PHAs includes numerous potential hazards associated with routine NTS surface and underground construction activities. The checklist recognizes the hazard to workers from nearby construction equipment. However as discussed above, the checklist does not recognize the hazard to operators of construction equipment from collisions, entanglements, and rollovers. Due to this oversight the HA for U16b did not recognize or describe the needed controls for all of the hazards associated with equipment operation. Knowing the hazards associated with the work to be performed is one of the five core functions of good Integrated Safety Management. The Board determined the U16b HA was less than adequate and that this was a failed management barrier in this accident.

The Board determined that the U16b HA was less than adequate and that this was a failed management barrier.

4.3.4.3 Worker Training

The Board evaluated the training of BN workers involved in this accident. The Board found noncompliance with two BN General Safety Rules requiring seat belt usage and requiring temporary systems to be elevated where they cannot be damaged by equipment. The Board also determined that neither BN Underground Worker Training nor BN Hazard Recognition Training given to these employees specifically addresses the hazards associated with the suspension of temporary systems.

The Board determined that BN worker training on General Safety Rules, underground worker training, hazard recognition training, and safety lessons learned training was less than adequate. The Board further determined that worker training was a failed management barrier.

The Board found that there have been three related incidents involving a piece of operating equipment, either a LHD or forklift, contacting and damaging an elevated system in the U1a underground complex elsewhere on the NTS. While individually these prior incidents may have been reviewed at weekly safety meetings, the Board could find no evidence that training on lessons learned from these incidents were given to the BN employees involved in this accident. The Board determined that BN worker training on General Safety Rules, underground worker training, hazard recognition training, and safety lessons learned training was less than adequate. The Board further determined that worker training was a failed management barrier in this accident.

4.3.4.4 Feedback and Improvement

One of the core functions of good Integrated Safety Management is feedback and improvement. This is more than a lessons learned training program. Good feedback and improvement requires that management not only understand root causes of individual accidents and incidents, but that they analyze and recognize systemic failures and adverse trends.

BN adequately shares the lessons learned in individual accidents with its employees by reviewing them at safety meetings. However, in three prior incidents ranging back to October 28, 1997, underground equipment impacted the rib or snagged cables in U1a. BN management did not recognize the adverse trend in these accidents. If they had done so, feedback into the HA and lessons learned training may have permitted stronger emphasis in the importance of keeping

BN management did not recognize a subtle adverse trend of similar accidents.

tunnel systems as close to the rib and back as possible and to the need for due care to when operating equipment underground. The Board recognized that the adverse trend was subtle and perhaps difficult to perceive until looked for in this investigation, however, the trend was there and BN management missed it. The Board determined that BN feedback and improvement was less than adequate and that this was a failed management barrier in this accident.

The Board determined that BN feedback and improvement was less than adequate and a failed management barrier.

5.0 CHANGE ANALYSIS

A change analysis was conducted to determine any changes or differences that may have been causal factors in this accident. An analysis of changes and differences was performed to determine if they could be, directly or indirectly, factors in the accident. Table 2 presents this information in summary form.

As a result of interviews with the injured employee's coworkers and supervisor, the Board determined that the day of the accident being the injured employee's first day back at work after one week of leave was not a causal factor. However, the Board could not rule out inattention as a causal factor. His coworkers and Shifter agreed that he appeared normal. The injured employee was interviewed but he has suffered short term memory loss and does not remember the events on the day of the accident.

As a result of a site inspection, the Board determined that the presence of a muck pile at the alcove which intruded slightly into the main drift was not a factor in the accident. The muck pile was very shallow and would not have presented an obstacle for the LHD, which could have driven over it with ease and without discomfort, or loss of control, on the part of the injured employee.

The Board concluded that the manner in which the air and water hoses were hung from the left rib to the right rib was a factor in the accident. The hoses were not strung in accordance with BN General Safety Rule M-A11-001, Paragraph 5.7.7 which requires that temporary systems be kept off walking surfaces in an elevated position where they cannot be damaged by construction equipment.

The Board concluded that the manner in which the air and water hoses were hung from the left rib to the right rib was a factor in the accident.

Table 1, BARRIER ANALYSIS WORKSHEET

Hazard	Direct Barrier (Barrier Type)	Possible Contributing Factors to Failure	Possible Root Causes of Failures	Loss or Potential Loss Event	Evaluation
Valve and hose	Hard hat (physical barrier)	Victim struck on part of head not protected by hard hat	Hard hat design or how hat was positioned on head	Head injury	No evidence hard hat not worn or worn improperly. Hard hat met ANSI approved standard for mining activities. No commercially available hard hat would have protected area impacted.
Valve and hose	LHD ROPS design (administrative)	Weld bead at front left corner of LHD ROPS is a potential snag point.	Design / construction error. ROPS and LHD have many projections that could snag obstructions.	Head injury	LHD as designed has numerous projections that are potential snag points. The equipment is not designed to deflect obstructions. Avoidance of obstructions requires operator to recognize clearances, maintain situational awareness, and skillfully operate the LHD.
Valve and hose	LHD design (administrative)	LHD does not have enclosed operator cab.	Design or specification error.	Head injury	ROPS is designed as roll over protection for operator not to protect from falling objects or projectiles. LHD is available with no ROPS if used only underground. ROPS is required if LHD is also operated above ground, which is the case with the LHD involved in the accident. In general LHDs are not available with enclosure or protective cabs.
Valve and hose	Hose hanging work procedure (administrative)	Hose not held closer to the rib of the tunnel.	Failure to follow existing procedures, ie, damaged water hose was not hung in full compliance with BN General Safety Rule M-A11-001, 5.7.7.	Head injury	BN General Safety Rule reads:...temporary systems shall be kept off walking surfaces in an elevated position where they ...cannot be damaged by construction activities or equipment. Good underground construction practice dictates that utility hoses and power cables be held as close as reasonably possible to the rib/back in order to maximize equipment clearances and work areas. In this incident clearance was adequate (about 11 feet) between hanging hoses. However, as much as 16 feet of clearance could have been made available if hoses were hung as tight to the rib as reasonably possible.
Valve and hose	Hazard recognition (Worker judgement/skill)	Workers did not recognize hoses as hung as a hazard to equipment operator or nearby workers, thus they did not maximize equipment clearances.	Misjudged hoses not to be a risk and over reliance on the skill of LHD operator to avoid hoses.	Head injury	Workers and supervisors need to pay attention to installation details. They should not rely solely on operator skill to avoid accidents. Good housekeeping should always be maintained. Clearances around work areas and equipment should be maximized.

Table 1, BARRIER ANALYSIS WORKSHEET

Hazard	Direct Barrier (Barrier Type)	Possible Contributing Factors to Failure	Possible Root Causes of Failures	Loss or Potential Loss Event	Evaluation
Valve and hose	Line management onsite presence (management)	Lack of supervision or oversight.	Inadequate supervison or oversight presence at the job site.	Head injury	The BN Shifter was continously present while work was in progress at U16b. The BN Superintendent was present once or twice daily. The BN Construction Manager's safety representative visited routinely and had been present the previous day. NV Facility Representative visited at least every other day, and had visited the previous day with the NV ESH Divison Safety Team Leader who was conducting a regularly scheduled safety surveillance. This was at least the third such safety surveillance since operations began at U16b in January 1998. Lack of line management presence at the job site is not considered an issue or barrier failure.
Valve and hose	LHD operator skill (Worker judgement/skill)	Distraction by alcove workers Inattention Blackout prior to accident	Human factors Human factors Medical problem	Head injury	There are no actual witnesses to the accident. Three senarios have been speculated. 1) The LHD operator may have been holding close to the left rib to give a wide berth to the two miners working in the alcove in the vicinty of the accident and as he passed them he turned to look at them to ensure sufficient clearance and snagged the hose that struck him. 2) He may have been inattentive due to the stress of his mother's recent death or another human factor, and not paying close attention to his position relative to the hoses. Or 3), he may have been unconscious due to a medical problem before he made contact with the hose. Although possible, there is no medical evidence to support 3), therefore it is discounted. Both 1) and 2) remain possible but the root cause of the LHD making contact with the water hose remains unknown.
Fall from LHD	Seat belt (Physical)	LHD operator was partially ejected from LHD upon impact with Alpine Miner. His head struck the ground. The operator did not wear installed seat belt.	Failure to follow existing procedures, ie, seat belt not worn, as required in BN General Safety Rule M-A11-001, 5.4.	Potential for head injury when striking ground, or potentially being run over by LHD.	OSHA and BN General Safety Rule requires that installed seat belts be worn on all equipment with ROPS. Had the operator been restrained by seat belt he would have been protected from ejection. Use of seat belts, like personal protective equipment, is primarily the responsibility of the individual worker. However, management needs to emphasize the importance and enforce the use.

Table 1, BARRIER ANALYSIS WORKSHEET

Hazard	Direct Barrier (Barrier Type)	Possible Contributing Factors to Failure	Possible Root Causes of Failures	Loss or Potential Loss Event	Evaluation
Electric current	Insulation on 480v conductor (physical)	Insulation cut by lip of LHD bucket	Unconscious LHD operator	Potential electric shock injury or death to LHD operator and rescuers.	Insulation of 480v power cable is not designed to protect conductors from such an impact. Installed ground fault interrupter system (GFI) is designed to trip at 25 amps for the purpose of equipment protection not for personnel protection.
Electric current	Design of Mining Power Center (MPC) and Ground Fault Interrupter Cabinet (GFI) (administrative)	MPC and GFI system not designed to protect personnel from low level faults. System was designed only to protect equipment from relatively large faults.	Personnel protection was not specified or included in system design criteria.	Potential electric shock injury or death to LHD operator and rescuers.	Original purpose of GFI design was to protect equipment not personnel. Ground fault protection for personnel is required by OSHA and NV 353 only for 120 v. single phase systems. This was a 480v. 3-phase trailing power lead for the Alpine Miner hence not required and not specified to the designers.
Valve and hose; ground	Worker training (management)	BN training on General Safety Rules, Underground Worker, Hazard Recognition, and Safety Lessons Learned was less than adequate	Management inattention to worker training needs	head injury	There was noncompliance with two BN General Safety Rules indicating lack of training. Neither BN underground worker training nor BN hazard recognition training specifically addressed the hazard associated with hanging hoses. Three related incidents involving LHD or forklift in U1a not part of lessons learned training.

Table 2, CHANGE ANALYSIS WORKSHEET

	Change or Difference		Analysis	
Factor	**Planned/normal**	**Present**	**Difference**	**Evaluation**
First day at work after one week of leave	Normal work day	Normal work day	none	The injured employee had taken one week off work to attend his mothers funeral in Ohio. Although this was the victim's first day back after taking leave, it was a planned day back at work and the employee appeared normal to his supervisor and coworkers. It is possible that the combination of being the first day back and having returned from his mother's funeral may have caused the victim to be less focused on his duties, but there is no evidence to support this.
Small muck pile in the alcove across from the water and air hoses	Main drift clear of muck piles	Main drift was partially blocked by the muck pile	Reduction of effective width of travel way	The muck pile had been placed in the alcove earlier in the day by the victim and intruded approximately 2 feet into the main drift. However the muck pile was very shallow and did not present an obstacle to the LHD, which could easily drive over it. The muck pile was not a causal factor to the accident.
Water and air hoses strung overhead	Overhead hoses do not intrude into travel way	The hoses were about 40 inches from the rib at the height of the ROPS on the LHD	Reduced main drift clearance	The air and water hoses were not strung as close to the rib as they reasonably could have been. This resulted in a reduction of the clearance for the LHD to travel past the water header station where the hoses were strung. The LHD contact with the hose was the initiating event of the accident sequence. Stringing the hoses in a manner which failed to provide maximum main drift clearance was a causal factor to the accident.

6.0 CAUSAL FACTORS

The direct cause of the accident was contact of the LHD's ROPS with the 1-inch water hose connected to the 4-inch water line on the left rib at CS 1+96. As discussed above the Board speculated three senarios that may have led to the accident. The Board determined that although a medical condition may have been the reason for the LHD operator failing to avoid the water hose, it is most likely the result of either distraction or inattention. The Board also determined that although the LHD operator was highly skilled and experienced, a momentary loss of situational awareness or other operator error probably occurred.

There were, however, identifiable contributing causes (causes that would not by themselves, have prevented the accident but are important enough to be recognized as needing corrective action) and root causes (the fundamental causes that, if corrected, would prevent recurrence of this and similar incidents).

Figure 10 is the Events and Causal Factors Chart used to analyze the causal factors in this accident. Table 3 presents causal factors in summary form.

Root causes of the accident.

Root causes of the accident were:

BN employees did not recognize the hazard associated with the hoses as hung across the tunnel.

BN employees did not exercise individual responsibility.

BN management did not fully enforce compliance with the BN General Safety Rules.

Contributing causes of the accident.

Contributing causes of the accident were:

The U16b hazard assessment was less than adequate.

BN worker training was less than adequate.

BN management did not detect an adverse trend of similar accidents/incidents.

Figure 10, Events and Causal Factors Chart

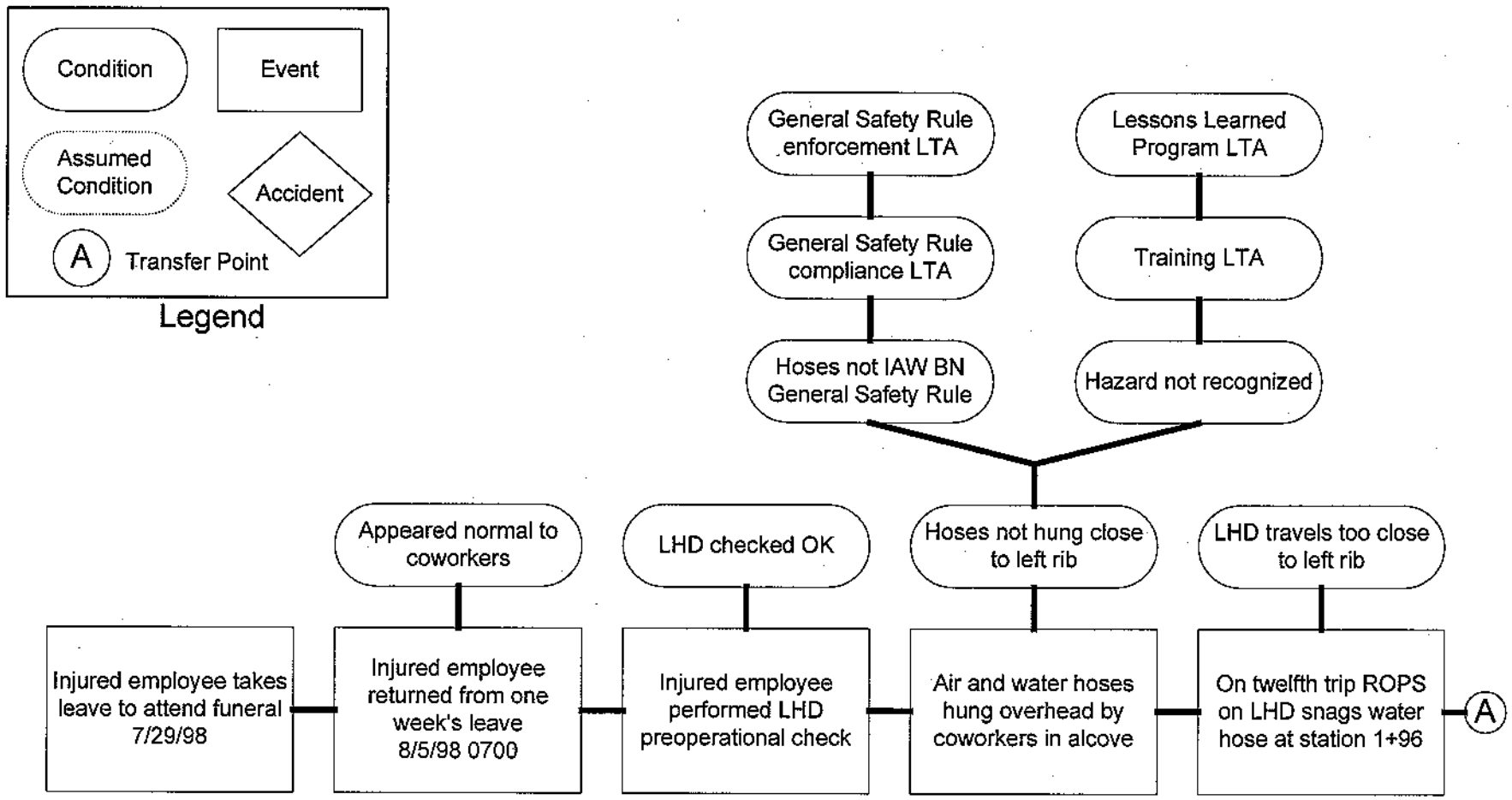

Figure 10, Events and Causal Factors Chart

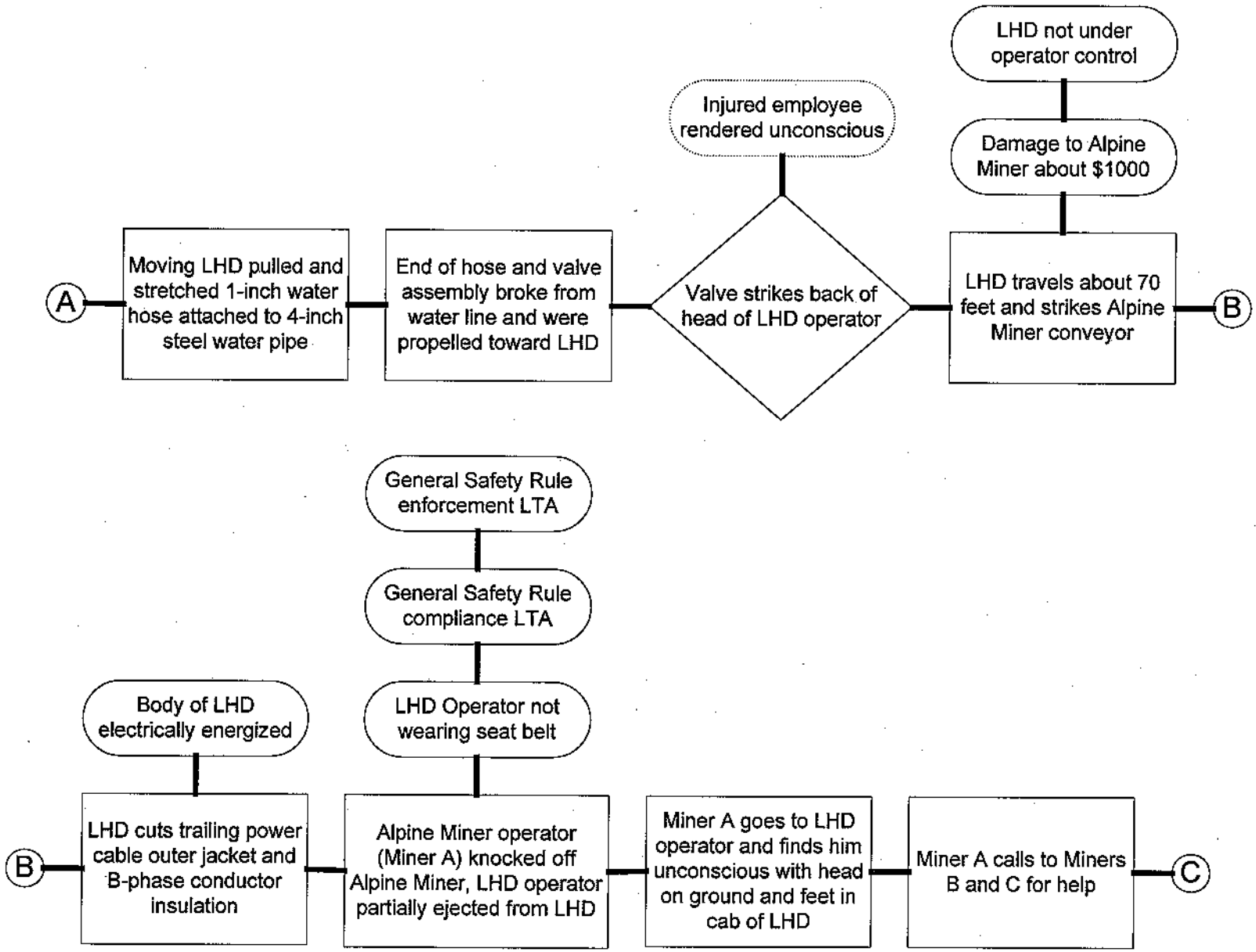

Figure 10, Events and Causal Factors Chart

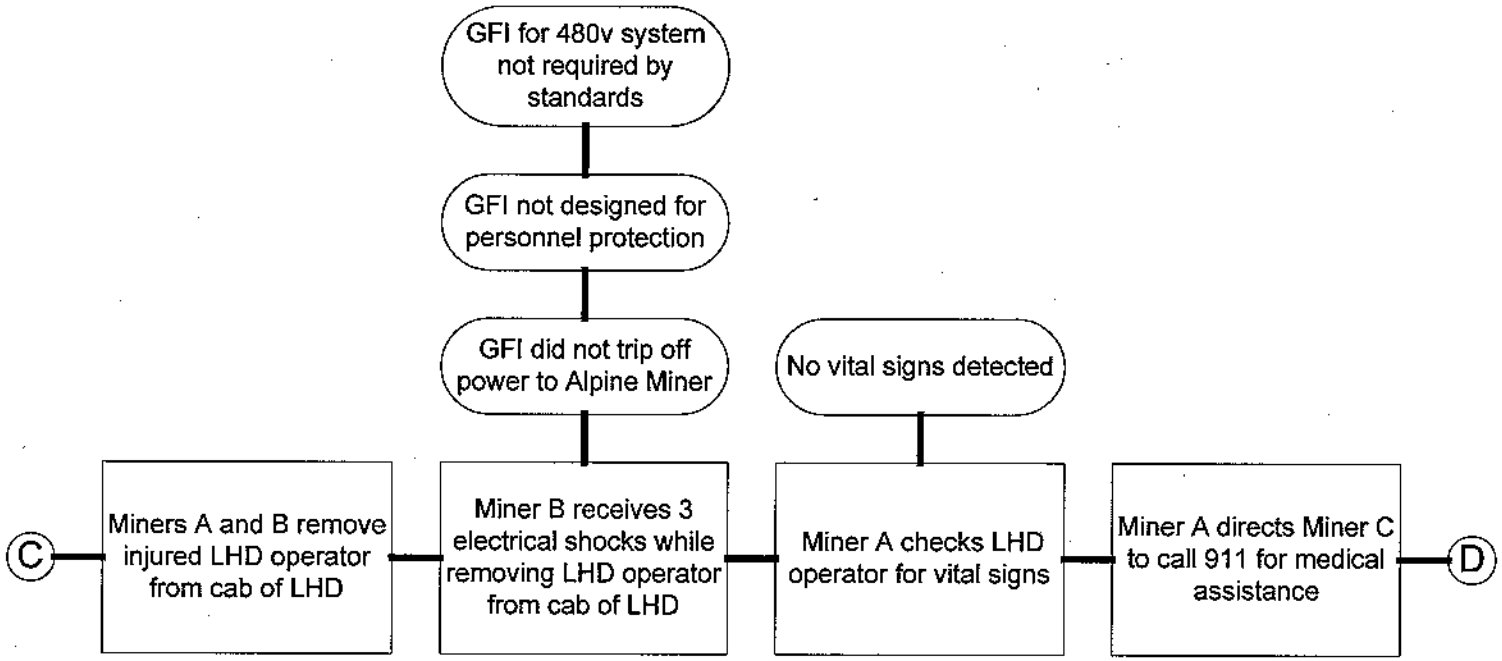

Figure 10, Events and Causal Factors Chart

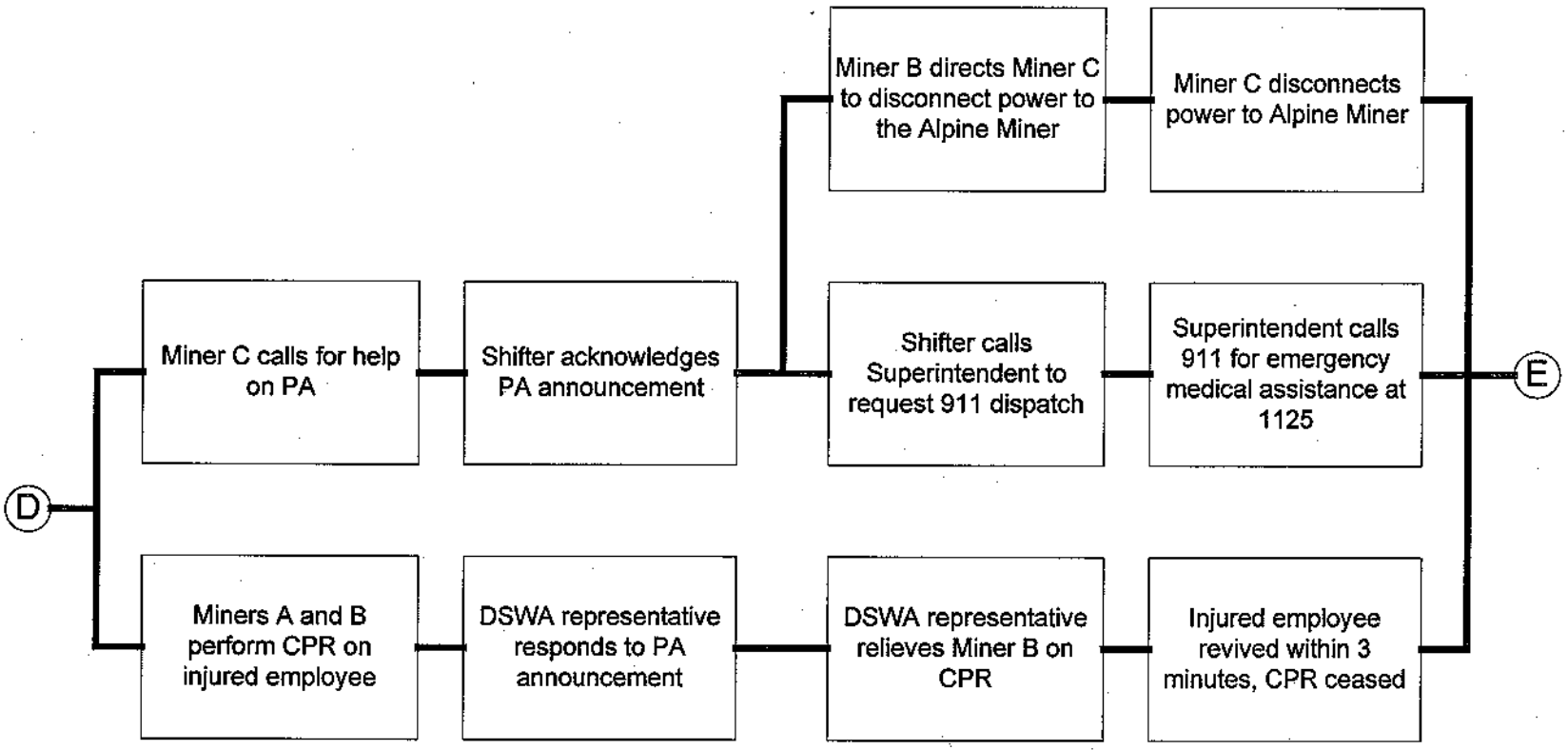

Figure 10, Events and Causal Factors Chart

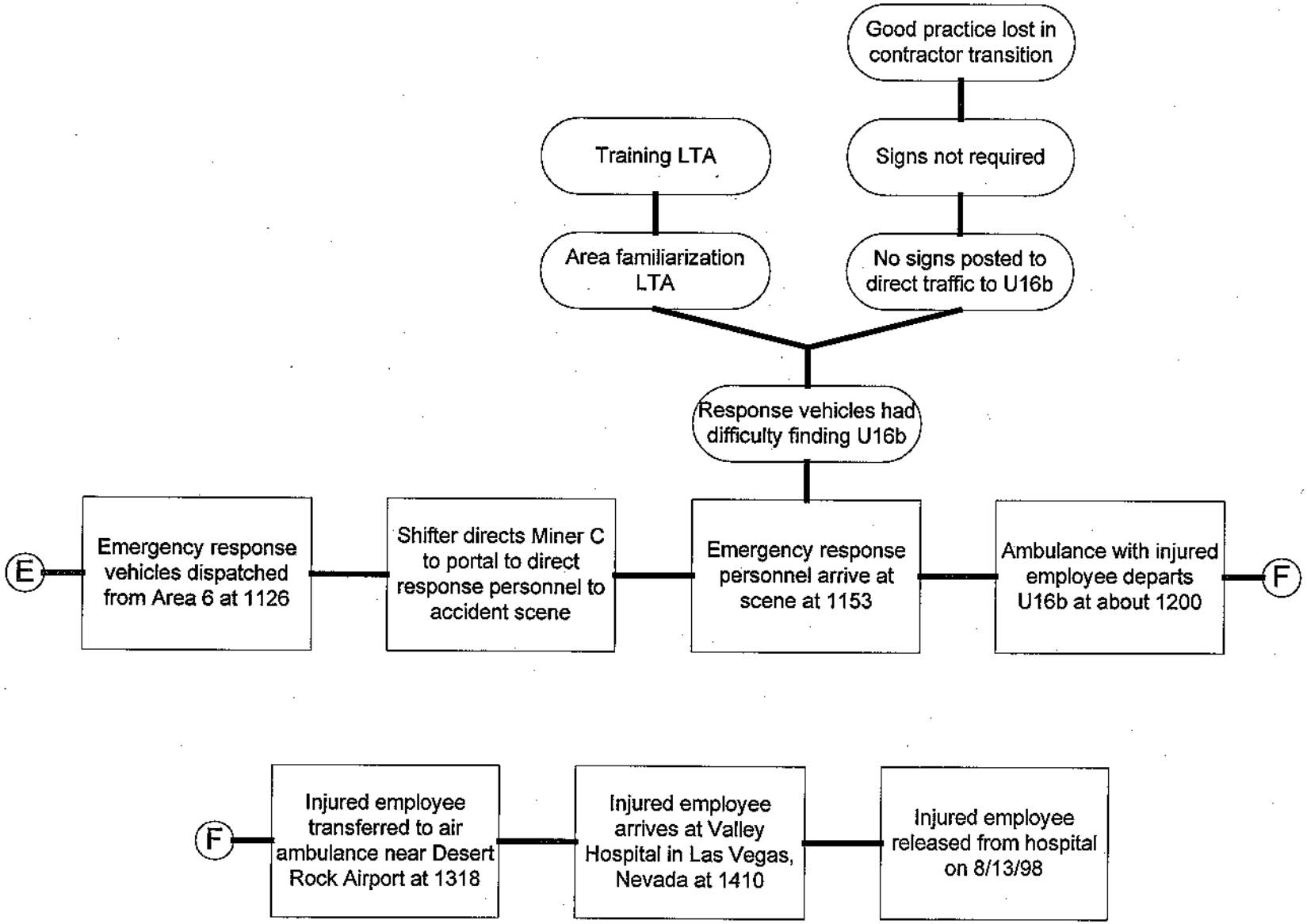

TABLE 3, CAUSAL FACTOR ANALYSIS

ROOT CAUSES	DISCUSSION
BN employees did not recognize the hazard associated with the hoses as hung across U16b.	The hoses were hung in a position such that they could be and did become entangled in the LHD as it passed while removing muck from the Alpine Miner. Neither the two workers who hung the hoses nor the LHD operator who had passed by the hoses at least 20 times recognized the hoses to be a potential hazard.
BN employees did not exercise individual responsibility to comply with the BN General Safety Rules.	BN General Safety Rules require that temporary systems be elevated in such a manner that they cannot be damaged by construction equipment. This clearly was not the case in this accident. All employees are responsible to know and follow all safety rules and to perform their work safely.
BN management did not fully enforce compliance with the BN General Safety Rules.	Ultimate responsibility for ensuring that employees fully comply with all safety rules and perform their work safely falls on management.
CONTRIBUTING CAUSES	**DISCUSSION**
The U16b tunnel HA was less than adequate.	The U16b tunnel PHA and HA recognized the hazard to workers from moving construction equipment. However, the PHA and HA did not recognize the hazard to equipment operators from collisions, entanglements, and rollovers. Hence the HA did not address the controls needed to mitigate or prevent this accident.
BN worker training was less than adequate.	BN worker training for Underground Workers, Hazard Recognition, General Safety Rules, and Safety Lessons Learned was not sufficient to address knowledge needed by U16b workers to prevent this accident. Area Familiarization training for emergency response workers was not sufficient for them to travel directly to U16b.
BN management did not recognize an adverse trend of similar accidents in U1a.	Feedback and imrovement is a core function of Integrated Safety Management. If the subtle trend of three equipment accidents in U1a snagging or impacting cables had been detected management would have been able to feedback this knowledge to the U16b HA and the worker safety lessons learned training.

7.0 INTEGRATED SAFETY MANAGEMENT

On July 30, 1998, BN submitted its Integrated Safety Management System Description Document. NV returned comments to BN on August 21, 1998. BN is committed to the following schedule for full implementation of Integrated Safety Management:

BN implementation schedule for Integrated Safety Management.

Phase I self assessment	First quarter FY 1999
Implementation complete	End of FY 1999
Phase II self assessment	During FY 2000

The five core functions of good Integrated Safety Management are: 1) know and understand the work to be performed, 2) understand and analyze the hazards of the work, 3) implement the necessary controls to allow the work to be done safely, 4) perform the work in a safe manner, and 5) implement feedback and improvement for future work. In this accident the Board identified lapses in four of the five core functions.

In this accident the Board identified lapses in four of the five core functions of Integrated Safety Management.

1) Know the work: BN knew and understood the planned work at U16b.

2) Know the hazards: BN did not fully understand and analyze in the U16b HA the hazards associated with the hanging hoses or to the operators of construction equipment due to collisions, entanglements, and rollovers.

3) Implement controls: Two BN General Safety Rules were not fully implemented at U16b, specifically, the requirement to elevate the hoses such that they cannot be damaged by equipment and to wear installed seat belts.

4) Work safely: The accident was a result of or made worse by unsafe practices.

5) Feedback: BN did not recognize a subtle adverse trend of underground equipment contacting systems suspended on the rib or back in U1a and feed this information back into the HA for U16b and the lessons learned training for U16b workers and supervisors.

8.0 CONCLUSIONS AND JUDGEMENTS OF NEED

This section identifies the conclusions and judgements of need determined by the Board as a result of using accident analysis methods as described in Section 4.0. Conclusions of the Board are those considered significant and are based upon facts and relevant analysis. Judgements of need are managerial controls and safety measures believed by the Board to be necessary to prevent or minimize the likelihood or severity of a recurrence of this type of accident. Judgements of need flow from the conclusions and are intended to guide managers in developing follow up actions. Table 4 presents the conclusions and judgements of need made by the Board.

Table 4 presents conclusions and judgements of need.

Table 4, CONCLUSIONS AND JUDGEMENTS OF NEED

CONCLUSION	JUDGEMENT OF NEED
Low level ground fault protection for personnel electrical safety is not required for 480v systems by government or industry standards.	BN needs to evaluate feasibility of installing low level ground fault protection for personnel safety on 480/240v construction power systems.
BN employee training on BN General Safety Rules, hazard recognition, safety related lessons learned is less than adequate.	BN needs to ensure that all employees are adequately trained in BN General Safety Rules, hazard recognition, and safety lessons learned.
BN emergency response vehicles made wrong turns enroute to the accident scene.	BN needs to ensure that emergency response vehicles are able to proceed directly to remote work locations on the NTS.
Compliance with BN General Safety Rules was less than adequate.	BN needs to ensure employees comply with all General Safety Rules
BN on scene first aid and CPR administered to the injured employee by coworkers was excellent.	None
BN First Aid and CPR Training Program is commendable.	None
No evidence that the hard hat was not worn or improperly worn.	None
LHD design (including ROPS) was not a factor.	None
Whether LHD operator was or was not conscious prior to accident cannot be determined. There is no medical evidence that the victim had a stroke, seizure, cardiac problem or blood deficiency to the brain. There is no history of diabetes or prior dizziness. There is no medical information to support the victim received electrical shock or CO or other chemical exposures.	None
The Preliminary Hazard Assessment and Hazard Assessment for U16b did not recognize hazards to equipment operators, such as, from impact, collision, entanglement, or rollover.	BN needs to ensure future Preliminary Hazard Assessments and Hazard Assessments address hazards to equipment operators.
BN management did not recognize hazardous trend of three previous underground equipment accidents/incidents.	BN needs to fully implement the Integrated Safety Management System Core Function of Feedback and Improvement.
There were lapses in four of the five Core Functions of Integrated Safety Management	NV needs to ensure that BN fully implements Integrated Safety Management in accordance with their approved schedule.

9.0 BOARD SIGNATURES

9-28-98

John M. McGrail
Accident Investigation Board Chair
U.S. Department of Energy
Nevada Operations Office

Date

9-28-98

Charles E. White
Trained Accident Investigator
U.S. Department of Energy
Nevada Operations Office

Date

9-28-98

Thomas J. Conley
Board Member
U.S. Department of Energy
Nevada Operations Office

Date

9-28-98

Darrel G. McPherson
Board Member
U.S. Department of Energy
Nevada Operations Office

Date

9-28-98

Michael Remington
Board Member
U.S. Department of Energy
Nevada Operations Office

Date

APPENDIX A

Department of Energy
Nevada Operations Office
P. O. Box 98518
Las Vegas, NV 89193-8518

AUG 13 1998

Joseph N. Fiore, AMNS, DOE/NV, Las Vegas, NV

ESTABLISHMENT OF A TYPE B INVESTIGATION BOARD

I hereby establish a Type B Investigation Board to investigate the August 5, 1998, injury to a Bechtel Nevada (BN) employee who was operating a mucker at the Nevada Test Site (NTS). BN is a contractor to the U.S. Department of Energy, Nevada Operations Office (DOE/NV). The following individuals are appointed to the Board in the indicated capacity:

1. Chairperson: John M. McGrail, Director, Stockpile Stewardship Division (STD), DOE/NV

2. Trained Accident Investigator: Charles E. White, General Engineer, Environment, Safety & Health Division (ESHD), DOE/NV

3. Board Members:

   a. Thomas J. Conley, General Engineer, Emergency Management Division, DOE/NV

   b. Michael D. Remington, Safety and Occupational Health Specialist, ESHD, DOE/NV

   c. Darrel G. McPherson, Logistics Management Specialist, Site Operations Division, DOE/NV

4. Advisors:

   a. Tom Burmeister, Safety/Health Services Manager, Environment, Safety, and Health Division, BN

   b. Ronald E. Costin, M.D., MPH, Acting Site Occupational Medical Director, BN

   c. Sharon A. Hejazi, General Attorney, Office of Chief Council, DOE/NV

   d. Richard D. Rumrill, Civil Engineering Technician, Technical Engineering Group, Nevada Operations, Field Command DSWA

   e. Stewart A. Thomas, General Engineer, Site Operations Division, DOE/NV

5. Administrative Support: Gina L. Hill, Secretary, STD, DOE/NV

The Board will be assisted by advisors and consultants and other personnel as determined by the Chairperson.

The scope of the Board's investigation will include, but not be limited to, identifying all relevant facts; analyzing the facts to determine the direct, contributing, and root causes of the accident; developing conclusions; and determining the judgements of need that, when implemented, reduce the probability of a similar recurrence. The investigation will be conducted in accordance with DOE Order 225.1A and will specifically address the roll of DOE and contractor organizations and management systems as they may have contributed to the accident. The scope will include the adequacy of the contractor's safety management system and the application of lessons learned from similar accidents within the department.

The Board will provide my office with periodic reports on the status of the investigation but will not include any conclusions until an analysis of all the causal factors have been completed. Draft copies of the factual portion of the investigation report will be submitted to the contractor and operations offices for factual accuracy review prior to report finalization.

Four copies of the draft report should be provided to me by September 9, 1998, for review prior to its preparation in final form. Any delay to this date shall be justified and forwarded to this office. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report.

By copy of this memorandum, I am advising the supervisors of each of the Board members that this assignment is full time until the investigation and report are completed. The advisors to the Board shall assist the Board in the investigation on a priority basis and provide input to the Chairman as requested.

G. W. Johnson
Manager

ESHD:CEW-8386
SHM-8

cc:
P. N. Brush, DOE/HQ (EH-1) FORS
D. M. Miotla, DOE/HQ (DP-13) GTN
G. S. Podonsky, DOE/HQ (EH-2) 270
V. H. Reis, DOE/HQ (DP-1) FORS
D. L. Vernon, DOE/HQ (EH-21) GTN
L. J. Ashbaugh, DSWA, Mercury, NV
J. T. Mitchell, BN, Las Vegas, NV
DOE/NV Principal Staff