
**Type A Accident
Investigation Board Report
on the June 20, 1997,
Construction Fatality
at the
Brookhaven National Laboratory
Upton, New York**



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July 1997

**Office of Oversight
Environment, Safety and Health
U.S. Department of Energy**

This report is an independent product of the Type A Accident Investigation Board appointed by Tara O'Toole, M.D., M.P.H., Assistant Secretary for Environment, Safety & Health, U.S. Department of Energy.

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

The discussion 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 June 20, 1997, I appointed a Type A Accident Investigation Board to investigate the June 20, 1997, Construction Fatality at Brookhaven National Laboratory, located in Upton, New York. The responsibilities of the Board have been satisfied with respect to this investigation. The analysis, identification of contributing and root causes, and judgments of need reached during the investigation were performed in accordance with DOE Order 225.1, *Accident Investigations*.

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

Tara O'Toole, M.D., M.P.H.
Assistant Secretary
Environment, Safety and Health

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ACRONYMS AND INITIALISMS

| | |
|-------|--|
| AUI | Associated Universities, Inc. |
| BHG | DOE Brookhaven Group |
| BNL | Brookhaven National Laboratory |
| CFR | Code of Federal Regulations |
| CI | BNL Construction Inspector |
| CSE | BNL Construction Safety Engineer |
| CSS | BNL Construction Safety Specialist |
| DOE | U.S. Department of Energy |
| EH | DOE Office of Environment, Safety and Health |
| EMT | Emergency Medical Technician |
| ER | DOE Office of Energy Research |
| ES&H | Environment, Safety, and Health |
| FAR | Federal Acquisition Regulations |
| IFB | Invitation for Bids |
| IUOE | International Union of Operating Engineers |
| LIUNA | Laborer's International Union of North America |
| OSHA | U.S. Occupational Safety and Health Administration |
| OSMD | BHG Operations and Safety Management Division |
| PC | BNL Project Coordinator |
| PMD | BHG Project Management Division |
| PPE | Personal Protective Equipment |
| S&EP | BNL Safety and Environmental Protection Division |

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EXECUTIVE SUMMARY

INTRODUCTION

A fatal accident at a construction site at the Brookhaven National Laboratory (BNL) was investigated in which a construction laborer was accidentally run over by a heavy construction wheel loader when it backed during a grading operation. In conducting its investigation, the Accident Investigation Board (the Board) used various analytical techniques, including accident analysis, barrier analysis, and event and causal factors analysis. The Board observed performance tests of key equipment and installed safety systems, inspected and photographed the accident scene, reviewed events surrounding the accident, collected and analyzed physical evidence, and conducted extensive interviews and document reviews to determine the factors that contributed to the accident. Relevant management systems that could have contributed to the accident were evaluated within the framework of the Department of Energy's applicable guiding principles of safety management. The Board did not find any violations of applicable standards.

ACCIDENT DESCRIPTION

Shortly before 9:00 a.m. on Friday, June 20, 1997, on a construction site at BNL, a construction laborer was accidentally run over by a wheel loader as it was backing during a soil grading operation. This grading was in preparation for the day's planned work of excavation and placement of a concrete manhole structure at the downstream terminus of the project, as authorized in a contract awarded by BNL to the Bi-County Construction Corp. The only people at the site at that time were the Laborer, whose job was to measure elevations during grading using a laser survey instrument, and the wheel loader Operator, who was also the contractor's site superintendent. Upon contact with the wheel loader, the Laborer instantly sustained fatal crushing injuries to his torso and head.

CAUSAL FACTORS

The Board identified a single root cause for the accident, the elimination of which would have prevented the fatality:

- Lapse of judgment.

In addition, three contributing causes that may have increased the likelihood of the accident, without individually causing the accident, were identified:

- Possible discounting of hazards associated with routine work
- Possible impairment of the Laborer (e.g., blood alcohol level of 0.02% and adult attention deficit hyperactivity disorder)
- Laborer not wearing high visibility clothing.

CONCLUSIONS AND JUDGMENTS OF NEED

Table ES-1 presents the conclusions and judgments of need determined by the Board. The conclusions are those the Board considered significant and are based upon facts and pertinent analytical results. Judgments of need are managerial controls and safety measures believed by the Board to be necessary to prevent or minimize the probability or severity of a recurrence of this type of accident. Judgments of need are derived from the conclusions and causal factors and are intended to assist managers in developing followup actions.

Table ES-1. Conclusions and Judgments of Need

| CONCLUSIONS | JUDGMENTS OF NEED |
|---|---|
| <p>The Board limited its evaluation of safety management systems to BNL's Plant Engineering Division and found it had an effective system to ensure that construction work on this project was properly planned and associated hazards were identified, analyzed, and controlled.</p> | <p>None.</p> |
| <p>BNL did not have objective criteria to evaluate the eight safety submittals required by this project's Invitation for Bids, nor did BNL use documentation of past contractor performance to evaluate prospective bidders for this project. Although the Board determined that this did not contribute to this accident, continuation of this practice could increase the likelihood of a recurrence.</p> | <p>There is a need for BNL to incorporate the following revision to its procurement procedure:</p> <ul style="list-style-type: none"> • Contractor performance on completed construction projects should be evaluated in accordance with FAR 36.201 • These evaluations, along with the application of objective criteria to safety submittals required by the IFB, should be used to assess bidders' ability to safely perform work. |
| <p>The Contractor could not implement the substance abuse testing provisions of its approved safety plan, due to its collective bargaining agreements.</p> | <p>There is a need for BNL to implement a policy to ensure contractors' substance abuse programs on future projects are fully enforceable and comply with the FAR 52.223-6 "Drug-Free Workplace" clause.</p> <p>There is a need for the Contractor to resubmit, for BNL approval, a revised substance abuse program that truly reflects limitations imposed by its collective bargaining agreements with unions involved in the sewer upgrade project.</p> |
| <p>The routine nature of the morning's planned grading work may have led to complacency and reduced attention to the back-up hazard of heavy equipment.</p> | <p>There is a need for all BNL organizations and BNL's Contractor/Vendor Orientation to emphasize and reinforce the fact that any operation involving heavy equipment can inflict serious or fatal injury despite the existence of a functioning reverse-signal alarm or the use of a spotter.</p> <p>There is a need for the DOE Office of Worker Safety (EH-5) to issue a safety bulletin regarding the hazards of heavy equipment operations and appropriate control measures.</p> |

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1.0 INTRODUCTION

1.1 BACKGROUND

On June 20, 1997, shortly before 9:00 a.m., a construction worker (referred to as “the Laborer”) was fatally injured as a result of being run over by a front-end loader (referred to as “the wheel loader” being operated by “the Operator”) at the Brookhaven National Laboratory (BNL).

On June 20, 1997, Tara O’Toole, M.D., M.P.H., Assistant Secretary for Environment, Safety and Health, U.S. Department of Energy (DOE), appointed a Type A Accident Investigation Board (referred to as “the Board”) to investigate the accident in accordance with DOE Order 225.1, *Accident Investigations* (see Appendix A).

1.2 FACILITY DESCRIPTION

The Brookhaven National Laboratory was established in 1947 as a multi-program laboratory to conduct basic and applied research in physical, biomedical, and environmental sciences. BNL’s current mission is to support implementation of DOE’s scientific and technical role as described in the National Energy Strategy. In support of this mission, the Laboratory operates two nuclear reactors for experiments and for medical research and treatment purposes. It also constructs, operates, and upgrades national particle research accelerator facilities for high-energy nuclear physics, chemistry, biology, and materials research.

The Laboratory is situated on a wooded 5,265-acre site in central Long Island, New York (see Exhibit 1-1 with the construction area in which the accident occurred highlighted). The Laboratory has about 3,150 employees and close to an equal number of visiting scientists and students who work at BNL each year.

On June 20, 1997, a construction contractor worker was fatally injured after being run over by a front-end loader.

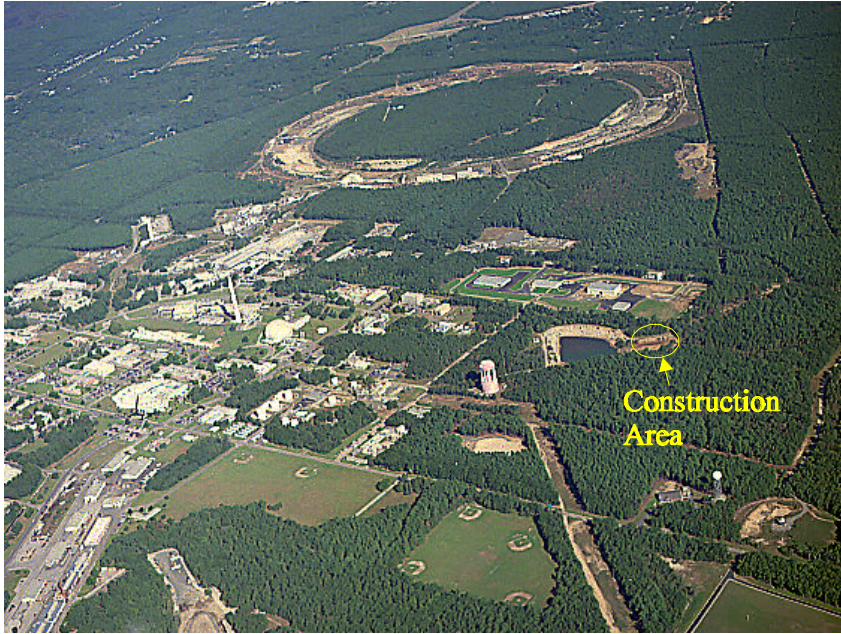


Exhibit 1-1. The Brookhaven National Laboratory Site

Contractor activities at BNL are managed by the DOE Brookhaven Group (BHG), which reports to the Office of the Secretary of Energy and receives support services from the Chicago Operations Office. The cognizant DOE secretarial office is the Office of Energy Research (ER). The DOE Offices of Environmental Management, and Nuclear Energy, Science and Technology also have funded programs in areas of decontamination and decommissioning, environmental restoration, and nuclear and reactor facilities.

Associated Universities, Inc. (AUI), as a DOE prime contractor, has operated BNL since its founding in 1947. In May 1997, the Secretary of Energy terminated the contract with AUI, effective upon award and transition to a successor. The Secretary appointed the Richland Operations Office Manager as the Executive Manager of BHG to oversee BNL operations during the transition, expected to last about six months. The Executive Manager reports directly to the Secretary.

The second phase of a major construction program is under way to improve the sanitary wastewater system by upgrading the site's sewage treatment plant and rehabilitating its sanitary sewer lines. The pipe rehabilitation consists of in situ relining of structurally sound clay pipe, replacement of structurally unsound pipe, and minor point repairs. Clearing along the sewer line right-of-way, including tree removal in forested areas, began on June 3, 1997.

The work was being done to rehabilitate the site's sanitary sewer lines.

At the time of the accident, grading was being performed along the sewer line right-of-way.

The work was being performed by the Bi-County Construction Corp. (referred to as “the Contractor”), which is primarily engaged in the construction of water and sewer mains. It is a union contractor employing truck drivers, represented by the Teamsters, Local No. 282; laborers, represented by the Laborer’s International Union of North America (LIUNA), Local No. 1298; and heavy equipment operators, represented by the International Union of Operating Engineers (IUOE), Local No. 138. The Contractor is classified as a small business, employing between 12 and 15 people in the field and another 10 in the office. It has been in business for 13 years.

1.3 SCOPE, PURPOSE, AND METHODOLOGY

The Board began its investigation on June 22, 1997, completed the investigation on July 11, 1997, and submitted its report to the Assistant Secretary for Environment, Safety and Health on July 16, 1997.

The **scope** of the Board’s investigation was to review and analyze the circumstances of the accident to determine its cause. The Board also evaluated the adequacy of safety management systems and work control practices of DOE, BNL and the Contractor, as they relate to the accident.

The **purposes** of this investigation were to determine the cause of the accident including deficiencies, if any, in safety management systems, and to assist DOE in understanding lessons learned to improve safety and reduce the potential for similar accidents.

The Board conducted its investigation using the following **methodology**:

- Facts relevant to the accident were gathered through interviews, document and evidence reviews, and examination of physical evidence.
- Safety equipment on the wheel loader involved in the accident was tested for operability.

The Type A accident investigation began on June 22, 1997.

The investigation determined the cause of the accident and developed judgments of need to prevent recurrence.

- Event and causal factors charting¹ and barrier analysis² techniques were used to analyze facts and identify the accident's cause.
- Based on analysis of the information gathered, judgments of need for corrective actions to prevent recurrence were developed.

2.0 FACTS AND ANALYSIS

2.1 ACCIDENT DESCRIPTION AND CHRONOLOGY

2.1.1 Background and Accident Description

Onsite activity on the sewer line upgrade project began on May 27, 1997, with the arrival of some of the heavy equipment. Site clearing began on June 3, 1997. The primary work items accomplished during the first weeks of the project were pipeline layout and clearing along its right-of-way, including tree removal in forested areas. The project was on schedule and approximately 20 percent complete; there were no undue schedule pressures.

On the day of the accident, June 20, 1997, two work items were scheduled:

- Continue grading of several hundred feet of the sewer line right-of-way.
- Excavation for and placement of a pre-cast concrete manhole structure at the downstream terminus of the project.

The grading work was being performed to resolve two known safety concerns. First, since the original ground elevation at the accident site was approximately seven feet above the planned invert elevation (i.e., the elevation of lowest point of pipe), grading was necessary to reduce trench depth to less than five feet; a deeper trench would have required a protective system (e.g., sloping, shoring, or shielding) in accordance with the U.S. Occupational Safety and Health Administration's (OSHA) excavation standard for construction, 29 CFR 1926, Subpart P. Keeping the trench less than five feet deep had the added benefit

Site grading was needed to limit the trench depth and to allow clearance under an electrical power line.

¹ Charting depicts the logical sequence of events and conditions (causal factors) that allowed the event to occur.

² Barrier analysis reviews hazards, the targets (people or objects) of the hazards, and the controls or barriers that management control systems put in place to separate the hazards from the targets. Barriers may be administrative, physical, or supervisory/management.

of avoiding unnecessary encroachment upon the outflow structure of an adjoining cooling water recharge basin (i.e., a pond).

Second, the grading operation was to ensure adequate clearance for excavating equipment working under a 69 kilovolt electrical power line, located approximately 150 feet south of the accident site and crossing over the future sewer line. This safety concern had been the subject of several meetings and letters between BNL and the Contractor. Rather than waiting until late July before the line could be deenergized, the Contractor decided, with BNL's concurrence, to use a smaller excavator than originally intended and to remove any excess overburden necessary to ensure a vertical working clearance of 10' 8" between the machine and the power line, in accordance with 29 CFR 1926.600(a)(6). This decision to remove excess overburden enabled pipe installation to begin immediately at manhole number 189 (the downstream terminus of the project), without unnecessary delay. Starting work at this location would ensure proper connection to existing rehabilitated lines without compromising safety.

On the morning of the accident, both the Operator and Laborer arrived at the job site at approximately 7:00 a.m. After briefly discussing the day's work plan, the Laborer set up the laser level to check elevations, while the Operator performed a brief inspection of the wheel loader (see Exhibit 2-1). They left the job site about 7:40 a.m. The Operator picked up site access badge applications that five contractor employees needed to take BNL's Contractor/Vendor Orientation that morning. While at the Construction Inspector's (CI's) office, the Operator discussed the day's plan with the CI before returning to the job site and commencing grading operations.

The Laborer met the five employees at the Laboratory main gate, gave them the applications, and escorted them to the orientation at 8:30 a.m. He then returned to the job site, arriving at approximately 8:40 a.m. After briefly discussing with the Operator the work that had progressed in his absence, the Laborer used a tripod-mounted laser level to determine the elevation of completed grading work at the future location of manhole number 189. The early morning work was identified as "minor site grading and cleanup," to be completed before the other workers returned from the orientation (approximately 10:30 a.m.). Once all workers were present, excavation and placement of manhole number 189 (and, possibly, one 20 foot length of sewer pipe) was planned for the remainder of the day.

The early morning work on the day of the accident was identified as minor site grading and cleanup.



Exhibit 2-1. Wheel Loader

2.1.2 Accident Reconstruction and Analysis

The accident occurred shortly before 8:59 a.m. during site grading operations. The Laborer was on the west side of the pipeline's cleared right-of-way at Station 1+00, a point marked by an orange survey stake 100 feet upstream from the project's downstream terminus (the downstream terminus being the future site of manhole number 189), and adjacent to the cooling water recharge basin outflow structure (see Figure 2-1). Since the Operator and the Laborer were the only two people at the construction site, there were no direct accounts of the Laborer's final movements. During an interview with the Board, the Operator recalled that the last time he saw him, the Laborer was checking the elevation near future manhole number 189, which was in front and to the right of the wheel loader. Based upon the physical evidence at the scene and discussions with the Suffolk County Medical Examiner, the Board determined that the Laborer was either facing the wheel loader while standing next to the survey stake at Station 1+00 or walking past the stake with his back to the wheel loader. If the Laborer had been waiting for the wheel loader to pass before he took a grade measurement at that location, he probably would have been facing the wheel loader.

However, if the Laborer had been moving to a location to the south or intending to cross the path of the wheel loader after it passed, he may have been walking with his back to the wheel loader on a path he believed to be outside the path of the oncoming wheel loader.

The Operator and the Laborer were working alone.

The Operator last saw the Laborer in front and to the right of wheel loader.

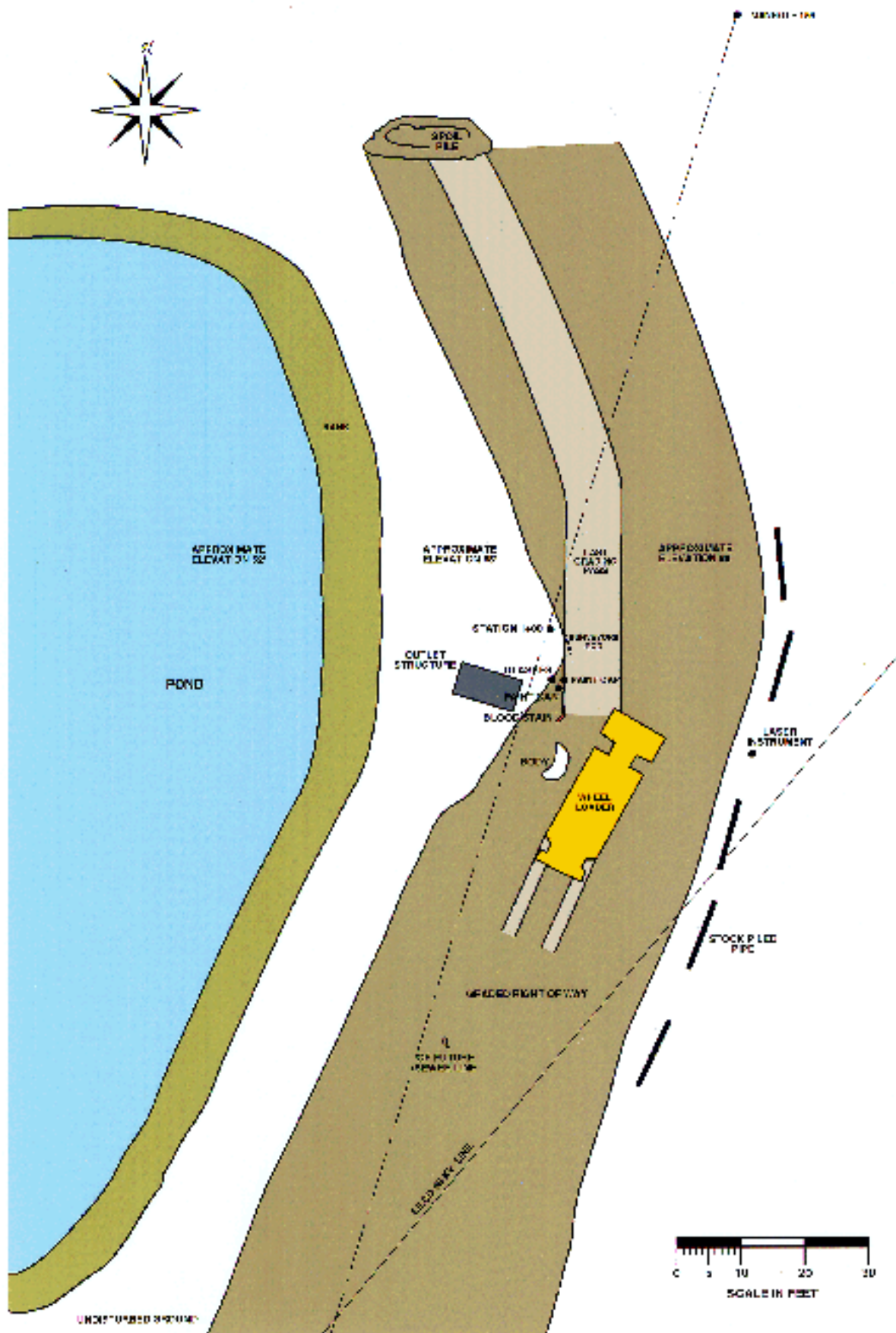


Figure 2-1. Accident Scene Diagram

The Operator had just dumped the wheel loader's bucket of dirt in the spoil pile. Then, with the wheel loader in reverse gear and moving up to 4.5 miles per hour (6.6 feet per second), the Operator dragged the bucket to smooth out the rough grade. About 55 feet from the spoil pile (and 20 feet north of the stake), the Operator turned the wheel loader slightly to the left, putting its left side in line with the Laborer (see Exhibit 2-2). The wheel loader's tracks showed that it again turned slightly near the stake, swinging the wheel loader's rear end to the left. At this location the recharge basin's outflow structure narrowed the grading zone (see Exhibit 2-3). The evidence is not conclusive as to whether the Laborer 1) slipped or tripped into the path of the wheel loader while stepping back out of the way and falling on his back, or 2) was struck in the back as he was walking away and spun around to land on his back in the path of the wheel loader. The Laborer was run over by at least one of the left tires of the wheel loader. Not aware of what had happened, the Operator continued back approximately 45 feet and then began moving forward on a new path just east and to the right of the previous pass. After moving

The Laborer was run over by at least one of the left tires.



Exhibit 2-2. View of Accident Scene from Spoil Pile Facing South

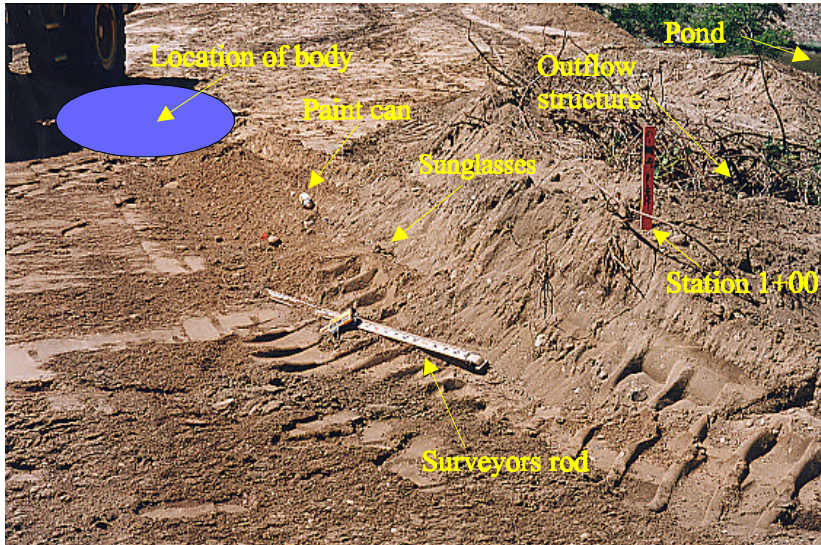


Exhibit 2-3. Closeup View of Accident Scene

forward for about 25 feet, the Operator saw the surveyor's rod on the ground, stopped the wheel loader, opened the cab's door, and saw the Laborer lying on the ground to the left of the wheel loader.

2.1.3 Chronology of Events

Figure 2-2 summarizes the chronology of significant events.

2.1.4 Emergency Response and Investigative Readiness

At 8:59 a.m., the Operator used the cellular telephone in his truck to call the BNL emergency number, simultaneously activating the BNL Police and Fire Rescue Groups. Four emergency medical technicians (EMTs) who are members of the BNL Fire Rescue Group were dispatched in a BNL ambulance at 9:01 a.m. and were the first responders to arrive at the accident scene three minutes later. A BNL Fire Rescue Group truck with two firemen arrived approximately 30 seconds after the ambulance. The first EMT to assess the medical condition of the Laborer observed that he had apparent major trauma to the head and upper body, was not breathing, and had no pulses. Based upon the severity of the Laborer's injuries, the EMT determined that resuscitation attempts would be futile; three other EMTs assessed the Laborer's condition and concurred with the first EMT's assessment. The EMTs then assessed the condition of the Operator and found him to be physically unharmed, but he had become emotionally upset upon realizing that the Laborer was beyond medical assistance.

The first emergency responders arrived within five minutes of the Operator's call.

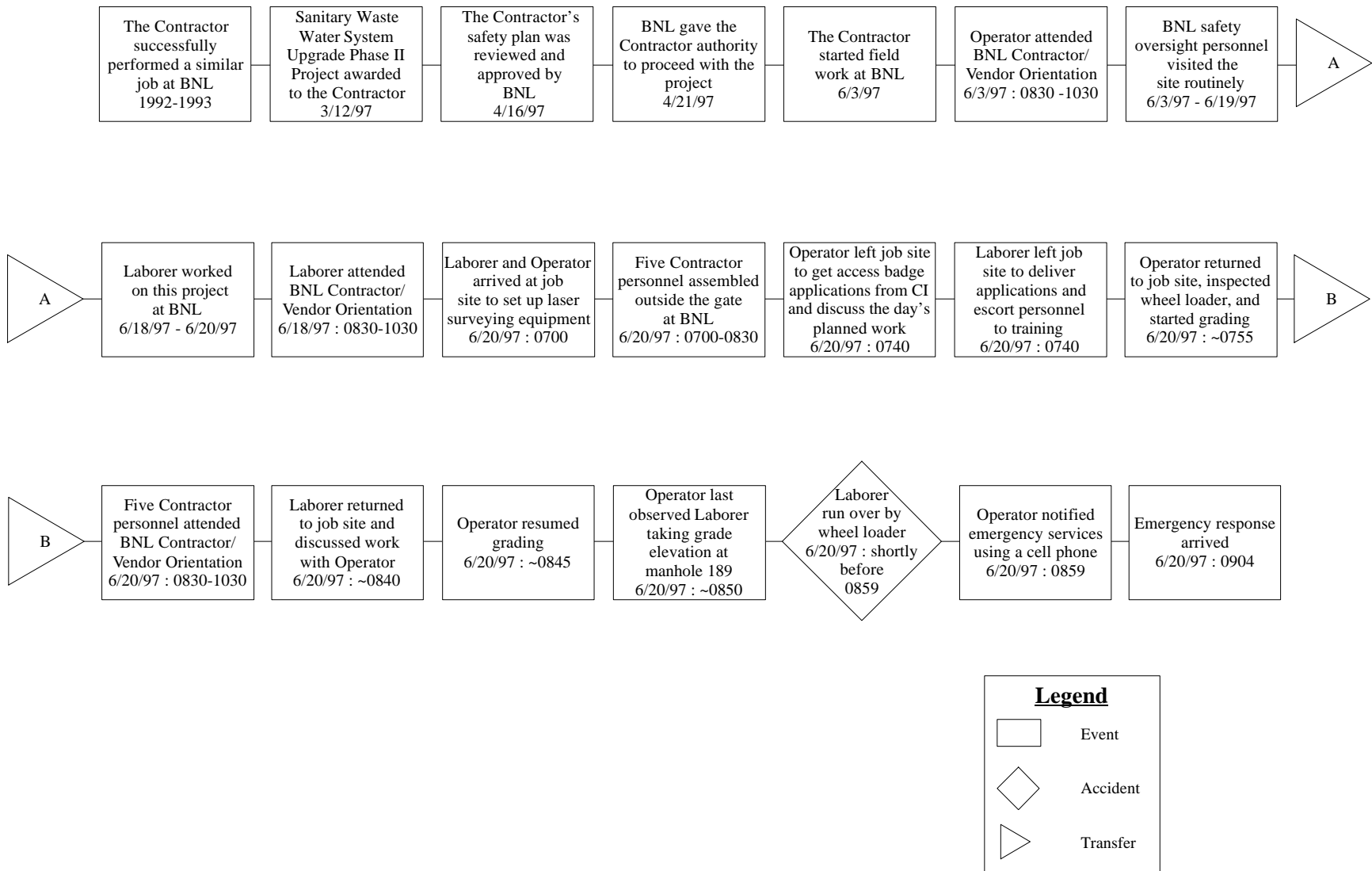


Figure 2-2. Summary Events Chart and Accident Chronology

In accordance with the BNL Incident Command System, a BNL Police Group Lieutenant became the Incident Commander. While en route to the accident scene, he notified the Suffolk County Police. Upon arrival at the accident scene, he isolated the area and established an access control point for the scene, controlled by a member of the BNL Police Group. The duties of the access control officer were to record the names of personnel who were authorized by the Incident Commander to enter the accident scene.

The first Suffolk County Police Officer arrived at the accident scene at 9:21 a.m. and established a crime scene area by restricting access to the primary area of interest within the isolated area. The crime scene area was established to preserve and account for all physical evidence in the immediate area, pending the determination of the cause of the Laborer's death by the Suffolk County Office of the Medical Examiner.

Homicide detectives from the Suffolk County Police Department arrived at the scene at approximately 10:00 a.m., spoke with the Operator about the accident, and requested a written statement of his recollection of events immediately preceding the accident. The Operator completed his statement and gave it to the detective. Based upon professional judgment, experience, and observation of the Operator, the detectives decided that there was no probable cause to request the Operator to submit to an alcohol or drug measurement test.

At 10:17 a.m., a representative of the Suffolk County Medical Examiner's Office arrived at the accident scene and at 10:30 a.m., after examining the Laborer, determined the cause of death to be accidental. He removed the Laborer from the accident scene at 11:00 a.m.

The Suffolk County Police Department finished collecting its evidence and returned custody of the scene to BNL at 12:27 p.m. Custody was subsequently transferred to BHG. BNL and BHG considered requesting an alcohol or drug test of the Operator, but decided against it based on the determination of no probable cause by the Suffolk County Police and the belief that there was no legal basis. The Board assumed custody of the accident scene on the morning of June 23, 1997, and returned the scene to BHG late the following day. The accident scene was secured and maintained by the BNL Police Group until the Board released its custody of the scene.

There was no probable cause for an alcohol or drug measurement test.

The cause of death was determined to be accidental.

2.1.5 Medical Analysis

The Chief Medical Examiner of Suffolk County performed an autopsy of the Laborer approximately four hours after the accident. The Examiner determined the cause of death to be multiple injuries and the manner of death to be accidental, confirming his representative's assessment at the scene.

The Laborer

The Suffolk County Medical Examiner informed the Board that the Laborer's injuries consisted of a large, fatal crushing injury to the head, neck, and upper torso, with maximal crushing force patterned diagonally across the body from the right side of the chest upward and leftward. Multiple pelvic fractures were also present. A diagram of surface lesions recorded by the Medical Examiner at time of autopsy showed that surface lesions (abrasions and lacerations), indicative of points of impact, were patterned in two areas:

- Two discrete lesions on the back (posterior) of the body: 1. A 3" transverse, linear abrasion of the small of the back extending from the midline to the right. 2. A large, deep abrasion of the left upper, outer buttock (2.5" x 4").
- Extensive abrasions and contusions across the front of the body from the thighs to the right side of the face.

The Medical Examiner informed the Board that the large lesions on the back were likely points of initial impact between the Laborer and the wheel loader, suggesting that he was struck from behind, turned as he was falling, and was then run over by the wheel loader while lying on his back with his head turned to the left. The Medical Examiner informed the Board that the back lesions could also have resulted from contact with machinery following the crush injury. The Medical Examiner informed the Board that biochemical analyses of vitreous (i.e., eye) fluid indicated that the Laborer was not dehydrated at the time of death.

According to information obtained from acquaintances and the Laborer's physician, the Laborer was in good physical health. The Laborer did not have any known vision or hearing impairments. He was taking an antidepressant, paroxetine, but the dosage and frequency of this medication could not be determined. He had not been clinically depressed for two months prior to the accident. He had not complained of any side effects from this

The Laborer sustained fatal crushing injuries.

The Laborer's injuries were consistent with being struck in the back.

The Laborer did not have any known vision or hearing impairments.

A small amount of an antidepressant was found in the Laborer's liver.

medication. A small amount of paroxetine was found in the liver during the autopsy.

According to the Laborer's physician, he had also been diagnosed as having adult attention deficit hyperactivity disorder (ADHD), a condition marked by hyperactivity, short attention span and easy distractibility. Studies in the medical literature suggest that ADHD may be a risk factor for accidents and injuries. However, there was no evidence found to suggest that ADHD had interfered with the Laborer's past job performance.

An acquaintance informed the Board that the Laborer had consumed beer on the night before the accident. The Medical Examiner's toxicological report showed that a residual blood alcohol concentration of 0.02% (or 20 milligrams/deciliter) was present at the time of death. This concentration, the equivalent of that found after consuming one drink, is not a level associated with gross intoxication. However, it is a level cited as the lower threshold at which measurable central nervous system effects can be observed, including increased reaction time, diminished fine motor control, and impaired judgment (reference: Goodman and Gilman's Pharmacological Basis of Therapeutics, Pergamon Press, New York, 1990, p. 377). A blood alcohol level of 0.02% is consistent with the consumption of nine to twelve 12-ounce beers the evening before the accident, according to metabolic calculations described in Goodman and Gilman, and Harrison's Principles of Internal Medicine. According to the Physician's Desk Reference, the antidepressant the Laborer was taking, paroxetine, "does not increase the impairment of mental and motor skills caused by alcohol."

Co-workers informed the Board that the Laborer appeared alert and in good spirits on the morning of the accident and showed no signs of intoxication. The Board concluded that the effects of alcohol or ADHD may have been factors in this accident, but the degree to which each contributed, if at all, could not be determined.

The Operator

The Board interviewed the Operator, who stated that he was in good health except for high blood pressure for which he took propranolol; he also informed the Board that he had no side effects from this medication. His New York driver's license showed no restrictions for corrective lenses. The Operator did not have any known vision or hearing impairments. The Operator stated that he

The Laborer had adult attention deficit hyperactivity disorder (ADHD).

The Laborer's blood alcohol level was 0.02% at the time of the accident.

The contribution of alcohol or ADHD to the accident could not be determined with certainty.

The Operator did not have any known vision or hearing impairments.

had not recently consumed alcohol or other recreational drugs. Co-workers informed the Board that the Operator did not appear intoxicated on the day of the accident. Moreover, the Suffolk County Police Department homicide detective who interviewed the Operator at the scene of the accident determined that there was no need to request an alcohol or drug test of the Operator. Although the lack of drug and alcohol testing precludes certainty, the Board concluded that the Operator did not have any medical or physical conditions that could have contributed to the accident.

2.2 HAZARDS, CONTROLS, AND MANAGEMENT SYSTEMS

2.2.1 Management Systems

The following facts address management issues that relate to the accident.

Responsibility

ER is assigned landlord responsibility for BNL. ER's Office of Laboratory Policy and Infrastructure Management is specifically responsible for the funding and schedule of project line items for infrastructure maintenance and upgrades.

Project management responsibilities were defined.

Through the Joint Program Direction on Project Management document, dated January 1996 (transmitted by ER-65 Memorandum, subject: "Joint Program Office Direction on Project Management," dated February 16, 1996), ER assigned project management responsibilities for line item projects less than \$50 million to the field elements normally located at a laboratory, such as BHG. This direction was developed jointly by the Offices of Defense Programs, Energy Research, Environmental Management, and Nuclear Energy to supplement DOE Order 430.1, *Life Cycle Asset Management*, and to provide integrated policy, direction, and information necessary for successful project management.

Within BHG, environment, safety, and health (ES&H) oversight is the responsibility of the BHG Operations and Safety Management Division (OSMD). Construction project management oversight, including construction project safety oversight, is specifically assigned to the BHG Project Management Division (PMD) in accordance with BHG Procedure BHG-5.01, *Environment, Safety & Health (ESH) Representative Program Component - Brookhaven Group Operational Surveillance Program*, dated

September 24, 1996. Functionally, BHG OSMD has responsibility for overseeing the operations of the BNL Plant Engineering Division, while BHG PMD has responsibility for construction safety oversight on its assigned projects, and for keeping OSMD informed of any significant ES&H issues.

Within BNL, there are two functional organizations, one focusing on research activities and the other on infrastructure, operations and administration. The sanitary system upgrade project falls under the purview of the Plant Engineering Division and, specifically, the Engineering and Construction Services Division. Engineering aspects are covered by the Project Coordination Group, and field oversight is provided by the Construction Services Group. Further, the Construction Safety Specialist (CSS), located within Plant Engineering's Safety, Training and Quality Group, supplements the Construction Services Group for field oversight of construction safety. In addition, the BNL Safety and Environmental Protection (S&EP) Division provides matrixed oversight through the Construction Safety Engineer (CSE).

Procurement

The Invitation for Bids (IFB) for this contract was issued on January 29, 1997. This solicitation was set aside for small business (as are all BNL fixed-priced construction contracts under \$3 million, unless a waiver is granted due to work complexity or other exigencies). Interested bidders were required to submit bids no later than February 25, 1997.

The IFB required bidders to furnish the following eight submittals relating to corporate safety performance along with their bids for this contract: “ 1) Experience Modification Rate (Workers Comp. Claim Summary), 2) Lost Time Frequency Rate, 3) Lost Runs for the past 3 years including Subcontractors, 4) Recordable Incident Rate, 5) OSHA violation in the past 3 years, 6) Copy of OSHA 200 Log and C2^S (Description of Injuries) for the past three years, 7) A copy of your corporate safety plan, and 8) Name and Telephone No. of your safety representative.”

The Contractor was the second lowest bidder with a bid of \$479,501. The apparent low bidder submitted a bid in the amount of \$471,680, but failed to provide complete safety program documentation as required by the IFB. Missing were the required Worker's Compensation Insurance Experience Modifier Rate for the previous three years, Lost Time Frequency Rates and Recordable Incident Rate.

The Contractor was selected over a lower bidder whose safety documentation was inadequate.

The Contractor submitted the required safety program documentation, but BNL had no objective criteria for evaluating this information. The Contractor had worked for BNL in the past, as the prime contractor on a completed sewer line rehabilitation contract and as a subcontractor on several other construction projects. Site procurement, project, and safety personnel described the Contractor's performance on this past work as "above average," although a post-completion contractor evaluation report could not be found. For the above noted safety reasons, plus technical concerns with the apparent low bidder's proposed pipe liner system, a fixed-price, lump sum contract was awarded to the Contractor on March 17, 1997, after successful post-bid negotiations had reduced the contract price to \$471,500.

The Contractor's performance on prior work for BNL was above average.

The Sewage Treatment Plant Upgrade, which was the other Sanitary Wastewater System Upgrade project active at the time of the accident, had a similar procurement history. This contract was ultimately awarded to the third lowest bidder, after the apparent low and second lowest bidders were deemed non-responsive because they did not meet the contract's qualification criteria (which had been preestablished for this contract due to its size and complexity) in several areas, including Lost Time Frequency Rates and Recordable Incident Rate. This decision resulted in the award of the contract to the third lowest bidder for \$3,247,156, when the apparent low bid was \$2,678,000.

Safety Program Requirements

At the time of this solicitation, BNL was contractually obligated to adhere to, and to enforce on its contractors, the construction safety provisions of DOE Order 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*. This requirement was formalized by Modification No. M342 to BNL's contract with DOE, dated May 28, 1996. In addition to specifying construction safety program requirements for DOE and its contractors, this order specifies compliance with 29 CFR 1926, *Safety and Health Regulations for Construction*.

The Contractor's Construction Safety Plan was approved by BNL.

The contract's supplementary conditions required the Contractor to submit a Construction Safety Plan within two weeks after the contract was signed and before commencing any work on the site. The contract specified that this plan would be reviewed and approved by the Plant Engineering and S&EP Divisions, that no payments would be made until the plan was approved, and that BNL could exercise its stop-work authority for contractor failure

to comply with applicable OSHA requirements and BNL ES&H standards. The required content of this plan included, but was not limited to, the following:

- Identity of person responsible for overall job site safety
- Identity of person designated as “Competent Person” per OSHA’s Excavation Standard
- Employee training in the recognition and avoidance of unsafe conditions and safety regulations applicable to the project, including weekly “tool box” talks
- Certification of the safe operating condition and proper maintenance of earth moving equipment, cranes, and other such equipment
- Frequent and regular inspections of the job site
- Flowdown of applicable project safety requirements to subcontractors.

In addition to submission of a project safety plan, the contract required several other actions or submittals that addressed construction safety, including:

- Attendance of contractor and subcontractor employees at a 75-minute orientation covering BNL and OSHA safety requirements
- Submission and approval of a shoring and bracing plan for project excavations, as well as manufacturer’s data on trench boxes
- Approval of all cranes, boom trucks, and lifting equipment prior to use
- Compliance with additional safety instructions of BNL’s S&EP Division.

The General Provisions of this contract incorporated by referencing the “Drug-Free Workplace” clause found under the Federal Acquisition Regulations (FAR) 52.223-6. The Contractor’s approved safety plan addressed substance abuse in a manner consistent with this clause. However, subsequent review by the Board revealed that the Contractor’s substance abuse testing program (testing is not required per the referenced clause) was not enforceable for some of its bargaining-unit employees.

The General Provisions also included FAR 52.236-05, Material and Workmanship, which allows BNL to remove any contractor employee deemed “incompetent, careless, or otherwise objectionable.” The Contractor’s approved safety plan also

The Contractor’s substance abuse testing program was not enforceable for some of its bargaining-unit employees.

permits the Contractor to remove any employee whose working ability, alertness, or coordination is compromised by drugs or alcohol.

Safety Oversight

BHG PMD responsibilities are stated in the PMD Internal Procedures; construction safety oversight is delineated in Chapter 8 of these procedures, “Safety Surveillance of Construction Projects.” The PMD Project Engineer for the sanitary system upgrade typically oversees 15-20 general plant projects and 10 line item projects. While the Project Engineer had visited the sewage treatment facility on occasion, his previous oversight of the pipe replacement contract had consisted of reviewing BNL oversight reports.

Functionally, BNL has four individuals who perform direct oversight of the sewer line rehabilitation project: the Project Coordinator (PC), the CI, the CSS, and the CSE. The BNL PC is ultimately responsible for the design of the project and all project deliverables, including budget, schedule, safety, and quality performance. The CI is responsible for assuring that the project is completed in conformance with the design specification. The CSS is responsible for monitoring contractor adherence to contract construction safety requirements by conducting and documenting routine safety inspections of the job site. The CSE is responsible for BNL construction safety program management oversight, including the review of project-specific health and safety documents, such as the Safety Plan and the Excavation and Rigging Plans. The PC typically visits project sites once a week, or more, as necessary. The CI typically visits a project site several times a day. Depending on the type and complexity of operations, the BNL CSS typically visits project sites daily or more frequently. The BNL CSE visits a site upon request, or as he deems necessary.

In the weeks preceding the accident, the PC and CSS visited the site several times per week, and the CI was on site as often as several times per day, including four times on the day before the accident.

The Contractor’s safety responsibility for this project was formally assigned to the Construction Superintendent, who was also the designated “Competent Person” for ES&H issues and the Operator of the wheel loader at the time of the accident.

Safety oversight responsibilities were defined.

The Construction Inspector visited the site four times on the day before the accident.

Analysis of Management Systems

The framework for analysis of management systems consisted of the following safety management principles, described in DOE Policy 450.4, *Safety Management System Policy*:

- Line management responsibility for safety
- Clear roles and responsibilities
- Competence commensurate with responsibility
- Balanced priorities
- Identification of safety standards and requirements
- Hazard controls tailored to work being performed
- Operations authorization.

Line Management Responsibility for Safety

DOE line management responsibility for construction safety clearly flows from the ER Program Office of Laboratory Policy and Infrastructure Management (ER-7) to BHG and to BNL. Responsibility for construction safety is specifically assigned to the Project Engineering organization in BHG; this assignment is appropriate for construction projects, where integration should occur at the project level. For this particular project, prime responsibility for the project and its safety oversight fell to the PC within BNL's Plant Engineering Division, Engineering and Construction Services Division, Project Coordination Group. The PC's support resources assist in overseeing the project's completion in a manner that assures protection of workers and the public, a high quality product, and compliance with specifications. The Board concluded that these resources were being used appropriately on this project.

Clear Roles and Responsibilities

Roles and responsibilities are clearly defined in BHG and BNL procedures. The PC has full responsibility for the completion of the project, but is supported by other BNL personnel through BNL's matrix organization. The management structure in place for this project established clear roles and responsibilities for the PC and supporting staff (e.g., the CSS, the CI, and the CSE).

The Board concluded that there were no ambiguities in either the written or understood responsibilities of the Contractor personnel assigned to this project.

The seven safety management principles for management systems were analyzed.

Line management organizations were responsible for safety.

BHG, BNL and Contractor roles and responsibilities were clearly defined and understood.

Competence Commensurate with Responsibility

Upgrading the BNL sewer lines is a relatively straightforward civil engineering project. The BHG Project Engineer's education, certification as a Professional Engineer, and experience qualified him to fulfill his responsibilities on his assigned projects. The BNL PC was highly qualified to fulfill his responsibilities by virtue of his education, certification, and experience, which included many years in the environmental and wastewater engineering fields. The BNL PC also had capable construction safety personnel who supported him in project oversight.

Project and training records, as well as interviews with BNL and the Contractor staff, led the Board to conclude that Contractor personnel with assigned safety responsibilities were competent to perform their assigned duties.

Although the Board agrees that the contract was awarded to a competent contractor, the continued practice of awarding construction contracts without an evaluation using established safety criteria could lead to future problems. Furthermore, BNL's inability to locate the Contractor's performance evaluation, prepared after completion of the Contractor's first prime contract with BNL in June 1993, suggests that it was not used during the bid evaluation process. Although such evaluations are not specifically required by FAR 36.201 for fixed-price construction contracts under \$500,000, FAR 9.105-1 recommends their use (if available) as a part of the bid evaluation process. Such documentation, if available, is clearly more useful than personal memory, particularly if the contractor in question had only performed one prime contract nearly four years ago.

Balanced Priorities

The BHG Project Engineer's priorities for construction safety on this particular project appeared to be reasonable in consideration of his project load. His review of BNL project oversight reports showed appropriate attention to the project and its progress up to the time of the accident, which was limited to site clearing and grading. The BNL PC's priorities on this project rightfully included the overhead power line, trench safety, and ensuring proper tie-in at manhole number 189. The CSS's attention to and the CI's involvement in the early stages of the project were indicative of responsible oversight.

BNL and Contractor personnel with assigned safety responsibilities were competent to perform their duties.

Priorities for construction safety were reasonable.

Identification of Safety Standards and Requirements

The contract clearly states that the Contractor must comply "...with the safety regulations of both the OSHA Standards (29 CFR 1926/1910) and BNL Environment, Health and Safety Standards"* and requires "...a letter or certificate of compliance indicating that the contractor is aware of, and has reviewed, and will comply with" these standards. BNL received this certification letter from the contractor on May 12, 1997.

The Contractor certified its intent to comply with applicable safety standards.

The FAR "Drug Free Workplace" clause was incorporated by reference in the solicitation's General Provisions, but its somewhat obscure location and manner of invocation within the specifications resulted in a less than thorough review of the Contractor's substance abuse prevention policies contained within the Contractor's safety plan. Though testing is not specifically required by the referenced FAR clause, the Contractor's approved plan included substance abuse testing. However, these provisions were not enforceable for employees represented by LIUNA and IUOE, of which the Laborer and the Operator were members.

BNL and the Contractor had the ability to remove any employee for apparent intoxication. The Board concluded, based on reports of the Laborer's appearance and demeanor on the morning of the accident, that there was no reason for either BNL or the Contractor to have done so.

Hazard Controls Tailored to Work Being Performed

BNL's process for ensuring that hazard controls on construction projects are tailored to the work being performed includes the requirement to submit, for BNL's approval, plans for critical project items (i.e., shoring and bracing plan, trench box manufacturer's data, and rigging plan) and to attend a preconstruction meeting to review project activities and associated hazard control measures. These planned hazard control measures were addressed in the approved safety plan. The Laborer and Operator had received individual copies of this plan, as evidenced by written acknowledgment of receipt.

Hazard control measures were addressed in the Contractor's approved safety plan.

Operations Authorization

Contractual provisions are in place to ensure that the safety plan and other required safety documents are submitted to and approved by BNL prior to commencement of work on the

* 29 CFR 1910, *Occupational Safety and Health Standards*

construction job site. There are also a variety of contractual provisions requiring advance notice and authorization of specific project activities after commencement of project work. For example, all earthwork and rigging operations on the project required a minimum of 48 hours of advance notice. For the job site activity ongoing at the time of the accident, the work scope, associated hazards, and planned control measures either had been submitted to and approved by BNL or discussed with appropriate BNL staff before work began (e.g., the required digging permit had been approved).

Based on the facts and analysis, the Board determined that the management systems in place at the time of the accident were satisfactory for the project scope.

2.2.2 Work Planning And Controls

The analysis of work planning and controls focused on the contract's safety and health requirements, and whether the Contractor's implementation resulted in effective planning of the project work and control of anticipated hazards. The framework for analysis consisted of the five core safety management functions described in DOE Policy 450.4:

- Define the scope of work
- Identify and analyze the hazards associated with the work
- Develop and implement hazard controls
- Perform work within controls
- Provide feedback on adequacy of controls and continuous improvement in defining and planning work.

These five core safety management functions provide the necessary structure for any work activity that could affect the public, the workers, or the environment. The rigor in addressing these functions depends on the type of work activity and the hazards involved. An analysis of work planning and controls for the grading operation applicable to the accident in relation to the five core safety management functions follows.

Define the scope of work

The work planned for the day of the accident included two significant work items, grading of the sewer line right-of-way and the excavation for and placement of a precast concrete manhole structure at the downstream terminus of the project. This had

The management systems in place were satisfactory for the project.

The five core safety management functions for work planning and controls were analyzed.

been clearly communicated to the CI by the Operator on the morning of the accident.

Identify and Analyze the Hazards Associated With the Work

All recognized hazards had been adequately addressed by the Contractor's written safety program and in BNL's Contractor/Vendor Orientation. The required preconstruction meeting was held with the Contractor and BNL on March 28, 1997. Among the topics discussed were the project safety and health requirements and safety hazards. Specific items discussed included trenching and excavation, buried ammunition from pre-1947 Camp Upton activities, and confined-space entry.

All recognized hazards had been adequately addressed.

An overall job hazard analysis was conducted to identify hazards that might be encountered during the project. The Contractor's safety plan addresses hazards commonly found on a construction site, as well as specific hazards that could be found on this particular job. For example, hoisting and rigging, and trenching and excavation were addressed in supplemental documentation.

Develop and Implement Hazard Controls

The Contractor's employees had been instructed in the recognition and avoidance of potential safety hazards. This included training outside of BNL, BNL's Contractor/Vendor Orientation, and periodic tool box talks with Contractor employees.

The Contractor's employees had been trained on safety hazards.

The primary hazards anticipated on this project were those associated with trenching and excavation. Contractor employees received specific instruction on OSHA's trenching and excavation standard at a National Utility Contractors Association Competent Person Course held on May 23, 1997. Other hazards commonly associated with this type of construction are confined-space entry (for which the Operator and the Laborer had received instruction), and hazards of heavy equipment operation, including the need for a reverse-signal alarm (which was specifically addressed by the BNL Contractor/Vendor Orientation).

With regard to the particular hazard resulting in the accident, the Contractor's written safety program states that "No employee shall use any motor vehicles, earthmoving, or compacting equipment having an obstructed view to the rear unless vehicle has a reverse-signal alarm distinguishable from the surrounding noise level, or vehicle is backed up only when an observer signals it is safe to do so."

Additionally, the Contractor's safety plan includes a drug and alcohol program. This program states in part that,

- "... employees must not report for duty under the influence of any drug, alcoholic beverage, intoxicant or narcotic or other substance (including legally prescribed drugs and medicines) which will in any way adversely affect their working ability, alertness, coordination, response, or adversely affect the safety of others on the job."
- "The taking of blood, urine, or saliva samples for testing may...be required from any person on company premises or workplace who is suspected of being under the influence of drugs or alcohol, who is involved in a vehicle accident, or who is injured in the course of employment."

The Contractor's owner and safety manager stated that according to collective bargaining agreements with the local labor unions, this program legally can be enforced only for the Teamsters. LIUNA and IUOE do not have this language in their agreements, but the Long Island Contractors Association, of which the Contractor is a member, is working to include such provisions in future labor agreements.

The Contractor's drug and alcohol program cannot be enforced with all its bargaining units.

Although there is no specific language in these agreements that requires substance abuse testing, the owner stated that the Contractor's practice is that if he hears "hearsay" that someone is drunk or drinking on the job, he gives a warning to the employee. If there is a second instance, the person is fired. If he sees anyone drinking, that person is fired. The owner stated that he has let people go before for either drinking or being drunk on a job, but this had not happened on this contract with BNL.

Perform Work Within Controls

The Contractor had obtained the proper digging permit for the excavation work to be performed. The Operator and the Laborer discussed the day's planned activities before starting work. The Operator had performed his daily operational check of the wheel loader, and no problems were identified.

The Operator and the Laborer discussed the day's planned activities.

The engineering control for this grading work, the reverse-signal alarm, was functioning at the time of the accident. However, the effectiveness of such alarms may be compromised if ground personnel become accustomed to the sound of this alarm and do not respond. Other engineering controls exist to address

The reverse-signal alarm was functioning at the time of the accident.

the Operator's obstructed view to the rear on such equipment. These include discriminating proximity alarms and rear-viewing video cameras, neither of which appear in the OSHA standard applicable to the wheel loader. It is not clear to the Board that either of these would have proven to be more effective in a construction environment than a reverse-signal alarm or a spotter.

The administrative controls intended to maintain a safe working distance between the wheel loader and the Laborer failed. These controls, widely recognized as fundamental to heavy equipment operation, are described in the wheel loader manufacturer's Operations Manual as follows:

- Applicable to the Laborer, "No person may enter the operating area of the machine when it is in operation without first notifying the operator. If a person has to enter the operating area of the machine in order to carry out a certain job, he or she must take great care."
- Applicable to the Operator, "If a person is within the operating area of the machine, the operator must take care and operate the machine only when he can see the person, or, if the person, through clear signals, has told the operator where he or she is."

These controls were portrayed on a warning decal affixed to the wheel loader's left rear bumper, were discussed at BNL's Contractor/Vendor Orientation (which both the Laborer and the Operator had attended), and were emphasized in several training activities completed by the Laborer and the Operator (see Section 2.2.4). In addition, the Contractor's owner stated that the importance of these controls is continuously emphasized.

An item of personal protective equipment (PPE) that may have been appropriate for this work was high visibility clothing. Though not required by 29 CFR 1926.651(d) for this work (as it would have been had the work exposed the employee to public vehicular traffic), the Board determined that its use might have assisted the Operator in seeing the Laborer.

Provide Feedback on Adequacy of Controls and Continuous Improvement in Defining and Planning Work

The Contractor had worked at BNL on Phase I of the sanitary system upgrade in 1992. On that project the CSS documented several safety violations, one on November 11, 1992, for which a bulldozer that the Contractor was using was not equipped with a reverse-signal alarm. The Contractor promptly corrected all of

A warning decal affixed to the wheel loader's left rear bumper failed.

There had been no onsite safety violations on this project.

these violations. The Contractor’s responsiveness to these past violations was a factor in BNL’s “above average” assessment of its past performance during bid evaluation for this project. For this current job, the Contractor had received no onsite safety violations, but one of its subcontractors had a bulldozer prohibited from coming on BNL property because of a cracked windshield and fluid leakage.

2.2.3 Equipment Safety

Vehicle

The vehicle used for the excavation was a Volvo 120C wheel loader (see Table 2-1). The wheel loader was purchased new on December 13, 1996.

Table 2-1. Volvo 120C Wheel Loader Specifications

| | | |
|-----------------|---|----------------|
| Width | Vehicle 8’9” | Bucket 9’4” |
| Length | Vehicle 21’4” | w/Bucket 26’1” |
| Height | Vehicle 11’2” | Bucket 19’0” |
| Weight | 40,700 lb. | |
| Steering | Load-sensing hydrostatic articulated steering with power amplification. Articulation ± 40 Degrees. | |
| Traveling Speed | 1 st Gear = 4.5 mph 2 nd Gear = 8.3 mph 3 rd Gear = 15.7 mph 4 th Gear = 22.0 mph (forward only) | |
| Cab | One interior and two exterior rearview mirrors. Sound level measurements performed in accordance with the following standards ISO ⁽¹⁾ /CD 3471, SAE ⁽²⁾ J1040, ISO 3449, and SAE J231 found sound levels in the cab 72 dBA with exterior sound levels of 106 dBA. | |

⁽¹⁾ ISO - International Standards Organization

⁽²⁾ SAE - Society of Automotive Engineers

The OSHA standard specifically applicable to wheel loader reverse operations, 29 CFR 1926.602 (a)(9)(ii), specifies that: “No employer shall permit earthmoving or compacting equipment which has an obstructed view to the rear to be used in reverse gear unless the equipment has in operation a reverse signal alarm distinguishable from the surrounding noise level or an employee signals that it is safe to do so.” There are no other relevant national standards (e.g., American National Standards Institute or American Society of Mechanical Engineers) applicable to the manufacture, operation, and maintenance of this class of equipment, as there are for mobile cranes and forklifts.

The wheel loader was in compliance with applicable OSHA standards.

The manufacturer’s recommended daily preventive maintenance requirements are to check the engine oil level, hydraulic system oil level, coolant level, functional control lamps, traveling lights, working lights, reverse signal alarm, leakage, and tire pressure. There was no formal documentation of these inspections. Part of the bargaining agreement with the IUOE Local No. 138 (which represents the operators of heavy equipment), allows the use of ½ hour of compensated time daily to perform the required inspection of the equipment.

Upon arrival of the Volvo 120C wheel loader at the BNL, the CSS checked for a functioning reverse-signal alarm, fluid leakage, and visual distortion of the glass windows. All checks were satisfactory.

On June 11, 1997, warranty service was performed on the wheel loader for a hydraulic leak at the approximate center of the machine, and the O-rings on the hydraulic steering valve were replaced. The machine was functionally checked after the replacement, and no leaks were detected. Service personnel recorded that the wheel loader had 416 hours in service at the time of repair. It had approximately 450 hours at the time of the accident.

Photographs and inspection of the wheel loader by the Board verified that a “warning reversing machine” decal was affixed to the left side of the wheel loader’s rear bumper.

The reverse-signal alarm was functioning satisfactorily when checked by the Board on June 24, 1997. Since the accident scene had been preserved and maintained under 24-hour surveillance from the time of the accident, the Board concluded that the

The reverse-signal alarm was operative at the time of the accident.

reverse-signal alarm was operative at the time of the accident. The reverse-signal alarm was directional, significantly louder in the danger zone of a reversing vehicle. The Board further noted that, as a result of both the engine noise and reverse-signal alarm being directed toward the rear of the wheel loader, an operator during a test heard a spoken voice of a Board member from behind, above the equipment noise during simulated grading operations.

On June 24, 1997, audiometric testing was performed by a BNL certified industrial hygienist in the presence of the Board. Sound levels measured inside and outside the cab at both idling and high engine speed were consistent with those recorded under controlled conditions and listed in the manufacturer's specifications. Another test showed that the reverse-signal alarm was clearly distinguishable from the surrounding noise during simulated grading operations.

Based on the above information, the Board concluded that there was no equipment defect that contributed to the accident.

Leveling Device Used by the Laborer

The leveling device is a laser system, the Laserplane 220 Transmitter, with a rod-mounted Model 1177 Laser-Eye Receiver, manufactured by Spectra-Physics Laserplane, Inc. This system is a surveying instrument that enables one person to take accurate elevation measurements, unlike a conventional surveyor's level that requires two people. The United States Center of Devices for Radiological Health has classified the system as a Class 1 laser. This is the safest classification available for a laser, as the laser energy is similar to that found in a compact disc player. There are no requirements for eye protection when using this system. The Board concluded that this device did not impair the Laborer's vision.

2.2.4 Personnel Training and Qualifications Training

Tables 2-2 and 2-3 indicate the recent and relevant training and instructions that were provided by the Contractor to the Operator and the Laborer.

Sound tests showed that the reverse-signal alarm was clearly distinguishable during simulated grading operations.

The laser leveling device did not impair the Laborer's vision.

Table 2-2. Training and Instructions Received by the Operator

| DATE | TRAINING COURSE/ACTIVITY |
|-------------|---|
| 1992 | (10 Hr.) Construction Safety and Health Course |
| 09-25-96 | Sent out Excavation Checklist to supervisors and foremen |
| 10-15-96 | Crane and Crane Safety mailings |
| 04-07-97 | Sent out safety sheet on flammable & combustible liquids |
| 04-18-97 | Training on the Contractor's Safety Program; received AGC ⁽¹⁾ safety definition sheet |
| 04-24-97 | ATSSA ⁽²⁾ Flagging Handbook sent out to workers |
| 05-01-97 | Discussion on cresol & patching material for bridge; MSDS ⁽³⁾ & PPE ⁽⁴⁾ discussed |
| 05-23-97 | (6 hr.) NUCA's ⁽⁵⁾ Competent Person Training (includes Excavation Safety) |
| 06-03-97 | BNL Contractor/Vendor Orientation |
| 06-03-97 | Received copy of the Contractor's Safety Plan |
| 06-16-97 | Discussion on confined-space entry |
| 06-17-97 | AGC Construction Handbook handed out |

- (1) Associated General Contractors
- (2) American Traffic Safety Signal Association
- (3) Material Safety Data Sheet
- (4) Personal Protective Equipment
- (5) National Utility Contractors Association

Table 2-3. Training and Instructions Received by the Laborer

| DATE | TRAINING COURSE/ACTIVITY |
|-------------|---|
| 08-21-96 | Discussion on fall protection; provided with safety harnesses & lanyards; when/how to use, scaffolding safety |
| 09-25-96 | Sent out Excavation Checklist to supervisors and foremen |
| 10-15-96 | Crane and Crane Safety mailings |
| 04-07-97 | Sent out safety sheet on flammable & combustible liquids |
| 04-24-97 | ATSSA Flagging Handbook sent out to workers |
| 05-01-97 | Discussion on cresol & patching material for bridge; MSDS sheet & PPE discussed |
| 05-23-97 | (6 hr.) NUCA's Competent Personal Training (includes Excavation Safety) |
| 06-07-97 | Tool Box Talk Training on Safety Plan, Excavation Standard; received copy of the Contractor's Safety Plan |
| 06-09-97 | Discussion on confined-space entry; watched video |
| 06-17-97 | AGC Construction Handbook handed out |
| 06-18-97 | BNL Contractor/Vendor Orientation |

Based on the training records provided, the Board concluded that the training of the Operator and the Laborer was adequate for the work they were performing at the time of the accident.

The Operator and the Laborer were adequately trained.

Qualifications

The Operator has 17 years of experience. Although the Operator did not have any formal training on this wheel loader, he had thousands of hours operating this class of equipment and 40 to 60 hours of experience in operating this one. The Operator stated that the wheel loader's controls were not significantly different from those of other wheel loaders he had operated. A second operator made a similar statement.

The Laborer had 11 years of experience and had been a foreman for the last five years. He had the training and experience necessary to be qualified for the job being performed. No additional job-specific qualifications for the Laborer were determined to be necessary by the Board.

Based on these facts, the Board concluded that both the Operator and the Laborer were qualified for the work they were performing at the time of the accident.

The Operator and the Laborer were qualified for the work.

2.3 BARRIER ANALYSIS

A barrier analysis was conducted to identify barriers associated with the accident. This analysis addressed administrative systems, management systems, and physical systems in place to isolate and avoid hazards. Evaluation of these systems indicated that most of the systems worked adequately. One barrier did not, maintaining a safe working distance between the Laborer and the wheel loader. Successful performance of this barrier would have prevented the accident.

Administrative, management, and physical barriers were examined.

This barrier failed in that a safe distance was not maintained between the wheel loader and the Laborer. This barrier may have failed for many reasons. It may have been due to the Operator's reliance on the reverse-signal alarm to warn personnel of the intended path of the wheel loader. The Laborer may have become complacent about the reverse-signal alarm and thus did not maintain a safe distance from the wheel loader. The Board concluded that there was a lack of visual contact between the Operator and the Laborer.

One administrative barrier failed, maintaining a safe working distance between the wheel loader and the Laborer.

2.4 CAUSAL FACTORS

The **root cause** of the accident is the fundamental cause that, if eliminated or modified, would prevent recurrence of this and similar accidents. There were also **contributing causes** that individually did not cause the accident, but did increase the likelihood of the accident and are important enough to be recognized as needing corrective action. The causal factors are identified on Table 2-4, with a short discussion for each cause.

The root cause of the accident was a lapse of judgment.

Table 2-4. Causal Factors Analysis

| Root Cause | Discussion |
|---|--|
| Lapse of judgment. | <p>The Operator backed the wheel loader without knowing the location of the Laborer. The Operator assumed the Laborer was in a safe location.</p> <p>The Laborer did not get out of the path of the backing wheel loader. This could be attributed to 1) the Laborer not being aware of the wheel loader backing towards him, 2) being aware, but thinking he was clear, or 3) being aware, but stumbling while trying to get out of the path of the wheel loader.</p> |
| Contributing Causes | Discussion |
| Possible discounting of hazards associated with routine work. | The characterization of the work as minor site grading and cleanup may have led to complacency, or a lapse of judgment. |
| Possible impairment of the Laborer (e.g., blood alcohol level of 0.02% and adult attention deficit hyperactivity disorder). | Medical evidence suggests that the Laborer's ability to recognize the danger and get out of the way of the wheel loader may have been impaired. |
| Laborer not wearing high visibility clothing. | Had the Laborer been wearing high visibility clothing and been in the Operator's field-of-view, the Laborer might have been seen by the Operator. |

3.0 CONCLUSIONS AND JUDGMENTS OF NEED

Conclusions are a synopsis of those facts and analytical results that the Board considers especially significant. **Judgments of need** are managerial controls and safety measures believed necessary to prevent or minimize the probability or severity of a recurrence. They flow from the conclusions and are directed at guiding managers in developing corrective actions. Table 3-1 summarizes the Board’s conclusions and judgments of need.

Table 3-1. Conclusions and Judgments of Need

| CONCLUSIONS | JUDGMENTS OF NEED |
|---|---|
| <p>The Board limited its evaluation of safety management systems to BNL’s Plant Engineering Division and found it had an effective system to ensure that construction work on this project was properly planned and associated hazards were identified, analyzed, and controlled.</p> | <p>None.</p> |
| <p>BNL did not have objective criteria to evaluate the eight safety submittals required by this project’s Invitation for Bids, nor did BNL use documentation of past contractor performance to evaluate prospective bidders for this project. Although the Board determined that this did not contribute to this accident, continuation of this practice could increase the likelihood of a recurrence.</p> | <p>There is a need for BNL to incorporate the following revision to its procurement procedure:</p> <ul style="list-style-type: none"> • Contractor performance on completed construction projects should be evaluated in accordance with FAR 36.201 • These evaluations, along with the application of objective criteria to safety submittals required by the IFB, should be used to assess bidders’ ability to safely perform work. |
| <p>The Contractor could not implement the substance abuse testing provisions of its approved safety plan, due to its collective bargaining agreements.</p> | <p>There is a need for BNL to implement a policy to ensure contractors’ substance abuse programs on future projects are fully enforceable and comply with the FAR 52.223-6 “Drug-Free Workplace” clause.</p> <p>There is a need for the Contractor to resubmit, for BNL approval, a revised substance abuse program that truly reflects limitations imposed by its collective bargaining agreements with unions involved in the sewer upgrade project.</p> |
| <p>The routine nature of the morning’s planned grading work may have led to complacency and reduced attention to the back-up hazard of heavy equipment.</p> | <p>There is a need for all BNL organizations and BNL’s Contractor/Vendor Orientation to emphasize and reinforce the fact that any operation involving heavy equipment can inflict serious or fatal injury despite the existence of a functioning reverse-signal alarm or the use of a spotter.</p> <p>There is a need for the DOE Office of Worker Safety (EH-5) to issue a safety bulletin regarding the hazards of heavy equipment operations and appropriate control measures.</p> |

4.0 BOARD SIGNATURES

Edward Blackwood

DOE Accident Investigation Board Chairperson
U.S. Department of Energy
Office of Environment, Safety & Health

Date: _____

Ferdinand (Ray) Schwartz, P.E.

DOE Accident Investigation Board Member
U.S. Department of Energy
Office of Energy Research

Date: _____

Craig Schumann

DOE Accident Investigation Board Member
U.S. Department of Energy
Argonne Group Office

Date: _____

Michael Saar

DOE Accident Investigation Board Member
U.S. Department of Energy
Chicago Operations Office

Date: _____

Patrick Finn, P.E.

DOE Accident Investigation Board Member
U.S. Department of Energy
Office of Environment, Safety & Health

Date: _____

Richard Lasky

DOE Accident Investigation Board Member
U.S. Department of Energy
Office of Environment, Safety & Health

Date: _____

5.0 BOARD MEMBERS, ADVISORS, AND STAFF

| | |
|-------------------------------|---|
| Chairperson | Edward Blackwood, DOE, Nuclear and Facilities Safety, EH-3 |
| Member | Ferdinand (Ray) Schwartz, DOE, ES&H Technical Support, ER-8 |
| Member | Craig Schumann, DOE, Argonne Group Office |
| Member | Michael Saar, DOE, Chicago Operations Office |
| Member | Patrick Finn, DOE, Occupational Safety and Health Policy, EH-51 |
| Member | Richard Lasky, DOE, Oversight Planning and Analysis, EH-23 |
| Advisor | Dennis Vernon, DOE, Security Evaluations, EH-21 |
| Medical Advisor | Joseph Falco, M.D., M.P.H. |
| Analytical Support | Jeffrey Oakley, Battelle Oak Ridge |
| Analytical Support | Steven Hoey, Brookhaven National Laboratory |
| Technical Writer | Michael Duffy, Battelle Columbus |
| Technical Editor | Kathleen Moore, Battelle Columbus |
| Administrative Support | Barbara Harshman, DOE, Security Evaluations, EH-21 |
| Administrative Support | Marcia Taylor, Battelle Columbus |

APPENDIX A

APPOINTMENT MEMORANDUM FOR TYPE A ACCIDENT INVESTIGATION
