U.S. Department of Energy

Office of Health, Safety and Security

Accident Investigation Report

Fall from Fixed Ladder at Building 830at Brookhaven National Laboratory on June 29, 2012

August 2012

Brookhaven Site Office
U.S. Department of Energy
Upton, New York

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Disclaimer

This report is an independent product of the Accident Investigation Board appointed by Frank J. Crescenzo, Acting Site Manager, Brookhaven Site Office, U.S. Department of Energy on July 11, 2012.

The Accident Investigation Board was appointed to perform an investigation of this accident and to prepare an investigation report in accordance with Department of Energy Order225.1B, *Accident Investigations*.

The discussion of facts, as determined by the Accident Investigation Board, and the views 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.

Release Authorization

On July 11, 2012, I established adobe Accident Investigation Board to investigate the June 29, 2012, fall injury from a fixed ladder at Building 830 at Brookhaven National Laboratory (BNL) that resulted in the injury of a sheet metal worker. The Accident Investigation Board's responsibilities have been completed with respect to this investigation. The analysis process, identifications of causal factors, and development of judgments of need were performed during the investigation in accordance with DOE O 225.1B, *Accident Investigations*. I accept the findings of the Accident Investigation Board and authorize the release of this report for general distribution.

Frank J. Crescenzo
Acting Site Manager, Brookhaven Site Office

9/14/12
Date

Executive Summary

On June 29, 2012, at approximately 2:35 p.m., a Brookhaven Sciences Associates maintenance metals worker was climbing a fixed ladder located on the exterior of Brookhaven National Laboratory Building 830. The worker lost three-points of contact with the fixed ladder and fell from a height of approximately 15-feet landing on asphalt pavement.

Because of the severity of the resulting injury and the prognosis of hospitalization of the worker in excess of five days, on July 11, 2012, the Department of Energy's Office of Science Brookhaven Site Office Acting Manager formally appointed a Department of Energy Accident Investigation Board. The Board was tasked with identifying all relevant facts to determine the direct, root, and contributing causes of the accident; developing conclusion; and determining Judgments of Need that, when implemented, should prevent recurrence of the accident. The Board initiated the accident investigation on July 17, 2012.

The Board concluded this accident was preventable. The direct cause of the accident was the worker falling from the fixed ladder after losing three points of contact and then striking asphalt pavement. Unfortunately the injured worker was not available to the Board. The worker did not respond to repeated requests made by the Board for an interview, nor did the worker respond to a written request for information. As such the facts of this accident are limited to the physical evidence found at the scene and witness statements.

The Board identified the root cause of this accident to be the Brookhaven Science Associates (BSA) hazard recognition process failing to identify the inherent risk associated with elevated work when climbing a fixed ladder. Five contributing causes were also identified: BSA failed to satisfy 29 CFR 1910 fixed ladder requirements as required by 10 CFR 851;the BSA Tier 1 safety inspection process is inadequate for the identification of unsafe conditions and practices; the BSA employee concerns program is not being utilized as a means of challenging unsafe conditions; the BSA work planning and control process was not followed for identifying work hazards and developing controls for this task; and the BSA work planning and control process failed to provide adequate hazard recognition which led to a false judgment that elevated work is low hazard work.

Table ES-1 contains the set of conclusions derived from the analytical results performed during this accident investigation for determining what happened, and why it happened. Also listed in Table ES-1 are Judgments of Need determined by the Board as managerial controls and safety measures necessary to prevent or minimize the probability or severity of a recurrence.

Table ES-1: Conclusions and Judgments of Need

Conclusion	Judgment of Need
The Board concluded that the BSA fixed ladder safety program is not compliant with 10 CFR 851 and BSA's own safety program documentation. BSA had not effectively integrated its 10 CFR 851 program elements for addressing inspections, hazard controls, and training, for fixed ladders. The BSA SBMS requirement for annual fixed ladder inspections was not followed. Also, there was no technical inspection criteria established for, or training provided to, safety personnel to conduct a compliant inspection process for fixed ladders.	**(JON 1)** BSA needs to revise SBMS to ensure fixed ladder inspection criteria are included to ensure compliance with ANSI14.3 and 29 CFR 1910.27.
The Board concluded there is no established Job Risk Analysis for generic climbing of a fixed or portable ladder.	**(JON 2)** BSA needs to document (through job risk analyses) the hazards associated and recommended controls for elevated work when performed on or access from all fixed ladders.
The Board concluded Facilities and Operations (F&O) Procedure EP-ES&H-006, Work Planning and Control relies on the preparer to consult the SBMS Graded Approach Subject Area. It is not clear how the preparer of the Worker Order could incorporate this subject area into work planning since it did not reference work at elevated heights. The Board concluded Work Order EP-892181 did not receive review to ensure the adequacy of the risk/hazard evaluation of the planned work.	**(JON 3)** BSA needs to revise the work planning and control process to categorize work according to all recognized hazards, and to reduce the practice of defaulting to worker planned work even when significant hazards are present.

Conclusion	Judgment of Need
The Board concluded that over a period of years there were multiple missed opportunities to have identified and corrected the deficiencies in the BSA fixed ladder safety program. Initially under application of ANSI A14.3-1956in 1962 when the ladder was constructed and again in 1968 when the ladder was relocated, then in 1973 when OSHA 29 CFR 1910 became a requirement, and lastly under the BSA requirements for annual inspections.	**(JON4)** BSA needs to implement a comprehensive fixed ladder inspection program that identifies deficiencies and ensures implementation of effective corrective actions.
The Board concluded there was a missed opportunity in the training module to inform the employee of the hazards associated with the work activities involving fixed ladders.	**(JON 5)** BSA needs to revise their ladder safety training module to detail the hazards and safe use of all ladders.
The Board concluded not all employees are attending required ladder safety training before attempting to access fixed ladders.	**(JON 6)** BSA needs to ensure all supervisors have verified that subordinates have completed all requirements as identified by their Job Training Assessment.
The Board concluded the Tier 1 process as designed and currently being used did not address this fixed ladder.	**(JON 7)** BSA needs to develop an effective safety and health inspection program for identifying workplace hazards and implementing effective controls for ensuring compliance with contractual requirements established by 10 CFR 851.
The Board concluded F&O management did not formally communicate their expectations for implementing the F&O Procedure EP-ES&H-006, Work Planning and Control for work estimation in hazardous (elevated) areas. The Board found the F&O work planning and control process is inadequate to identify hazards associated with work estimates at heights and did not provide the necessary controls to implement this work safely.	**(JON 8)** BSA needs to revise work planning and control requirements to ensure that during all phases of performing work (including estimation) hazards are effectively evaluated and appropriate controls are implemented.

Conclusion	Judgment of Need
The Board concluded that the work planning and control process "worker planned work" used a graded approach for this estimation effort and allowed for elevated work to be considered as low hazard work. The Board concluded the work planning and control process failed to provide adequate hazard recognition which led to a false judgment that elevated work is low hazard work. The Board concluded the BSA work control process was not followed for work estimation being conducted though it presented the same hazards as actually performing the permitted work, i.e., caulking of duct housing. The Board concluded the work planning and control process failed to provide adequate hazard recognition which led to a false judgment that elevated work is low hazard work. The Board concluded BNL's SBMS Procedure for Fall Protection, Rev 1.3, needs to apply to all elevated work and that even if the work being performed is not associated with the planned work and is outside the scope of the work package, the fall hazard exists and still needs to be addressed.	
The Board concluded there were multiple missed opportunities to identify and correct the hazards associated with this work activity. The failure of multiple safety system components, i.e., hazard recognition, work planning and control (WPC), Employee Concerns, Tier 1 inspections, Safety Observation Program, lessons learned incorporated into work packages; which were not adequately integrated.	**(JON 9)** BSA needs to ensure SBMS hazard recognition and feedback mechanisms are integrated for effective communication of risks associated with fixed ladders.

Conclusion	Judgment of Need
The Board concluded BSA safety systems were not sufficiently integrated to support worker safety. The Board concluded the safety management systems reviewed are not adequately integrated to identify and correct this fixed ladder. The Board concluded there were multiple missed opportunities to identify and correct the hazards associated with the work. The Board concluded that this form of elevated work was not performed under a work permit and has required specific knowledge beyond "Skill of the Craft" performance.	

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Acronyms and Abbreviations

ALD	Assistant (or Associate) Laboratory Director
ANSI	American National Standards Institute
BHSO	Brookhaven Site Office
BMH	Brookhaven Memorial Hospital
BTMS	Brookhaven Training Management System
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates
CFR	Code of Federal Regulations
CON	Conclusion
DOE	U.S. Department of Energy
EMT	Emergency Medical Technician
ES&H	Environment, Safety and Health
FCE	Facility Complex Engineer
FCM	Facility Complex Manager
FPM	Facility Project Manager
F&O	Facilities and Operations
FRA	Facility Risk Assessment
GIF	Gamma Irradiation Facility
IFM	Integrated Facility Management
ISMS	Integrated Safety Management System
ISMSD	Integrated Safety Management System Description
HPI	Human Performance Improvement
JAF	Job Assessment Form
JON	Judgments of Need
JRA	Job Risk Assessment
JTA	Job Training Assessment
MMW	Maintenance Metal Worker
O	Order
OMC	Occupational Medicine Clinic
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
SBMS	Standards Based Management System
SHSD	Safety and Health Services Division

SC	Office of Science
SME	Subject Matter Expert
SRD	Site Resources Division
WPC	Work Planning and Control
WSHP	Worker Safety and Health Program

References

ANSI A14.3-1956, *Safety Code for Fixed Ladders,* American National Standards Institute

Code of Federal Regulations (CFR) 10 CFR 851, *Worker Safety and Health Program,* Department of Energy

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

29 CFR 1926, *Safety and Health Regulations for Construction,* Occupational Safety and Health Administration

DOE Order 225.1B, *Accident Investigations,* dated March 2011

DOE Standard DOE-STD-1063 (Chg 1), *Facility Representative*, dated March 2012

DOE Handbook DOE-HDBK-1028-2009, Human Performance Improvement Handbook, Volumes 1 and 2, dated June 2009

1.0 Introduction

On July 11, 2012, Frank J. Crescenzo, Acting Manager of the U.S. Department of Energy (DOE), Office of Science (SC), Brookhaven Site Office (BHSO), informed the management of Brookhaven Science Associates, LLC (BSA), a DOE Accident Investigation Board (Board) would be established to investigate the June 29, 2012, the Safeguards and Verification Implementation Building (Building 830) fixed ladder fall injury at Brookhaven National Laboratory (BNL) (see Appendix A). The accident resulted in a BSA Site Resources Division (SRD) Maintenance Metal Worker (MMW) being hospitalized in excess of five days.

On July 11, 2012, the Board was formally appointed (Appendix A). This report documents the facts of the accident and the analyses and conclusions of that investigation. The Board was on site at BNL July 17-20, 2012, collecting evidence and conducting interviews.

The investigation was performed in accordance with DOE O 225.1B, *Accident Investigations*, using the methodology contained within. In summary:

- Facts relevant to the accident were gathered through interviews and reviews of documents and evidence;
- The event scene and equipment involved were inspected, and photographs were obtained;
- Facts were analyzed to identify the causal factors, using event and causal factors analysis, barrier analysis, root cause analysis, change analysis, and Integrated Safety Management analysis;
- Judgments of Need (JONs) for corrective actions to prevent recurrence were developed to address the causal factors of this event.

1.1. Background

The fixed ladder involved in this accident is located on the exterior of the northeast portion of Building 830, near the center of the south wall of "Lab 17" (see the red arrow on Figure 1).The fixed ladder from which the MMW fell is the single permanent access point to all Building 830 roof levels.

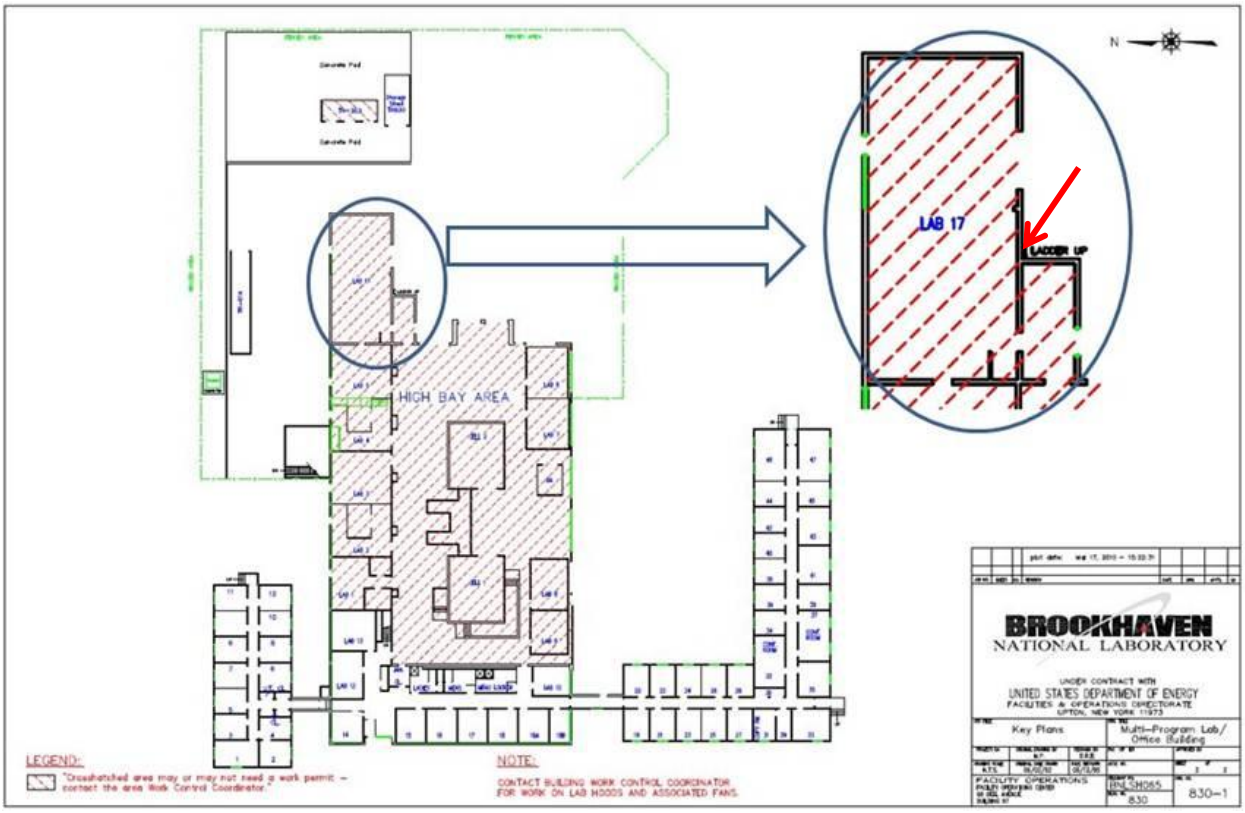


Figure 1: Fixed Ladder Location at Building 830

Building 830 opened as the High Intensity Radiation Development Laboratory in 1962. In 1968, Lab 17 was added to the northeast corner of the building to house the Gamma Irradiation Facility (GIF). The fixed ladder involved in this accident was originally located on what is now the west wall of Lab 17 to access the roof level of the adjacent high bay area. With the addition of Lab 17 in 1968, the section of fixed ladder impacted by this addition was removed and reinstalled to its current position (see Figure 1). This included securing the ladder to the south wall, installing a grated step-off platform at the new roof level, and adding associated handrails at the grated step-off platform.

At the time of the original installation of the fixed ladder, the applicable design standard was American National Standards Institute (ANSI) A14.3-1956, *Safety Code for Fixed Ladders*. When the ladder was relocated in 1968, ANSI A14.3-1956 was still the applicable design standard; however, that relocation did not ensure consistency with ANSI A14.3. With the enactment of the Occupational Safety and Health Act of 1970, ANSI A14.3-1956 was adopted as the applicable design standard to be used for enforcement of29 CFR 1910, *Occupational Safety and Health Standards*. Today the ladder remains non-compliant with 29 CFR 1910.

During the 1980's or 1990's, a lockable side-hinged gate was installed onto the left rail of the fixed ladder to prevent accessing the roof above Lab 17. This gate is made of ¼ inch thick aluminum plate. The gate is attached directly to the ladder by hinges fixed to its left rail. A hasp is installed on the right rail of the ladder to permit the gate to be locked. When closed, the gate laps over both side rails and covers the first eight rungs; thus likely preventing inadvertent access to the roof if padlocked. This was done as a radiological control measure when it was realized there was a possibility of unexpected radiation exposure to persons on the roof at a time when samples were being loaded into or removed from the GIF pool. The radiation exposure for which the gate was installed no longer exists.

Figure 2: Current Location of the Fixed Ladder on Building 830, Lab 17

Finally, during the early 1990's, for the purpose of providing power to a nearby storage area, a run of 1 inch rigid metal conduit was attached to the exterior of the south wall of Lab 17.The conduit runs up vertically and immediately adjacent to the left rail starting at approximately the mid-point of the 18-1/2 foot fixed ladder. It then turns to the right and runs horizontally at a level of the same height of the fourth rung down from the grated step-off platform of the fixed ladder. (Figure 2) The distance between the conduit and the fourth ladder rung is less than seven inches.

1.2. Standards Based Management System

The Standards-Based Management System (SBMS) is a BSA web-based program that codifies the overall information hierarchy including internal and external requirements for the Laboratory. SBMS provides BSA staff with policies, standards of performance, and Laboratory-wide procedures and guidelines that are current, accurate, and relevant to their work. All work in the Laboratory must be completed following the minimum requirements as specified in the SBMS policies, standards of performance, subject areas, and program descriptions. SBMS Subject Areas provide procedures by which to perform work. SBMS does not deliver facility-, organization-, or program-specific operating procedures, guidance, and requirements. SBMS provides the baseline BSA requirements for developing, delivering, and controlling such internal operating procedures and documents. There are 29 SBMS management systems (which includes

Training and Qualification, Worker Safety and Health, and Work Planning and Control). Each management system has a listing of subject areas which are supported by associated implemented procedures and exhibits.

1.3. Status of ANSI and OSHA Compliance

Ten topical areas concerning fixed ladders were reviewed, each topical area was compared to the ANSI A14.3- 1956, *American National Standard for Ladders – Fixed – Safety Requirements*, and the OSHA requirements for Fixed Ladders (29 CFR 1910.27). As illustrated by the table in Appendix C, there are five areas where the ladder was found to be out of compliance with OSHA requirements and/or ANSI Standards.

When the fixed ladder was re-installed in 1968, OSHA requirements did not exist however the designer should have relied uponANSIA14.3-1956. Issues concerning noncompliance to the ANSI A14.3 – 1956 standard include the 36 inch width of the ladder extension rails above the platform and the non-uniform distance between the first rung and the pavement. OSHA promulgated 29 CFR 1910.27 roughly in 1973, incorporating the majority of requirements described in the ANSI A14.3-1956.

The 1992 installation of conduit behind the ladder violated the seven inch clearance requirement described in both the ANSI A14.3-1956 and 29 CFR 1910.27. Further the installation of a ladder guard onto the left ladder rail violated both the ANSI A14.3-1956 and 29 CFR 1910.27, which requires a fifteen inch clearance on either side of the vertical centerline on the fixed ladder. Since the top rung of the ladder is not flush with the platform, the fixed ladder does not meet this requirement described in ANSI A14.3-1956and 29 CFR 1910.27.

The Board concluded that over a period of years there were multiple missed opportunities to have identified and corrected the deficiencies in the BSA fixed ladder safety program. Initially under application of ANSI A14.3-1956in 1962 when the ladder was constructed and again in 1968 when the ladder was relocated, then in 1973 when OSHA 29 CFR 1910 became a requirement, and lastly under the BSA requirements for annual inspections. **(JON 4)**

1.4. Worker Training

SBMS Subject Area, Training and Qualifications, Section 1, Determining Training and Qualification Requirements, states:

"The supervisor, work planner, line manager, Training Coordinator must review existing job-specific training programs against the Criteria for Determining Additional Job Qualification Requirements and confirm that they are at the appropriate level of rigor for the needs identified."

Brookhaven Training Management System (BTMS) provides computer based instruction on a number of safety subject areas. Workers who climb are expected to complete the ladder safety course found on BTMS. The ladder safety course found in BTMS is simplistic; it discusses ladder safety in general and utilizes a construction Union's video as part of the training program. Although training discusses basic ladder safety such as three points of contact, it does not

specifically outline the safety requirements for fixed ladders nor does it identify potential hazards associated with fixed ladders. There is no required refresher or re-training date associated with this course.

The Job Training Assessment (JTA) is a listing of a worker's training requirements as determined by the supervisor as necessary to complete their tasks within that job title. Review of the JTAs for the MMW, FPM, and FCE involved in the June 29, 2012 accident found the training for the MMW was current; however, not so for the FPM and FCE. The FPM had one "incomplete" and two "expired" training courses. The FPM did not complete ladder safety training until after the June 29, 2012 accident. The FCE who was a relatively new employee had twelve "incomplete" training courses at the time of the accident. This included the Ladder Safety course which was not completed until after the June 29, 2012 accident.

1.5. Medical Criteria and Clearance

10 CFR 851 requires the contractor to establish and implement a medical surveillance program. Prior to a worker receiving a medical examination, BSA requires the worker's Supervisor to complete a Job Assessment Form (JAF). This form requires the Supervisor to:

- Define the physical demands (strenuous exertion, continuous walking or standing or awkward postures) of the worker as essential or non-essential or not applicable;
- List the job responsibilities; and
- Evaluate the environmental conditions such as climbing or working at heights, heat stress or handling materials.

Once the JAF is completed it is forwarded to the Occupational Medicine Clinic (OMC) for review and to support the worker's medical evaluation.

Through the OMC, BSA has established a medical surveillance program to meet the requirements of 10 CFR 851. There are twenty different medical surveillance examinations found on the OMC web site. There are additional criteria for specialized work activities such as entering confined spaces or working at heights. The MMW received a Material Handler Medical Surveillance examination on June 15, 2011. The examination components for this examination include a medical and work history, a physical examination, visual acuity and audiometric testing. Examination components for the specialized work activity "work at heights" would be similar, i.e., medical and work history and physical examination but would include a resting electrocardiogram. Based on the medical protocol for Material Handler Medical Surveillance, the MMW was not scheduled to receive a repeat examination until December 15, 2012.

1.6. Work Planning and Control

The BSA SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Introduction, Part 2, describes the three approaches for work planning and control. They are: 1) worker planned, 2) prescribed and 3) permit planned. The work being conducted at the time of the accident was considered "worker planned work" that recognizes the skill levels and technical capabilities of the workers. This type of work further states: "Worker planned job activities do

not require the level of rigor detailed in permit planned work". The Board reviewed the BSA Procedures and the referenced work order and found the work order was prepared consistent with the SBMS procedure.

Further, SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection 2.2, *Defining/Determining the Work Planning Level*, states: "The Work Requestor provides a complete, accurate, and detailed description of the work or service required." It further states that the description of work is to include: "Any special instructions, considerations, known area hazards, required training, and access requirements."

F&O Procedure DF-ESH-006, Rev.3, *Work Planning and Control System*, provides instruction for the prioritization, screening, planning and preparation of Field Work Packages for worker planned work. The goal of F&O is that all work is planned, every job is pre-briefed as to hazards and their mitigation and all work is performed safely and properly. This policy statement requires work to use the five core functions of Integrated Safety Management System (ISMS).

1.7. BNL Organization

BNL is organized into nine Directorates, each headed by an Assistant or Associate Laboratory Director (ALD), who reports to the Laboratory Director (Figure 3).

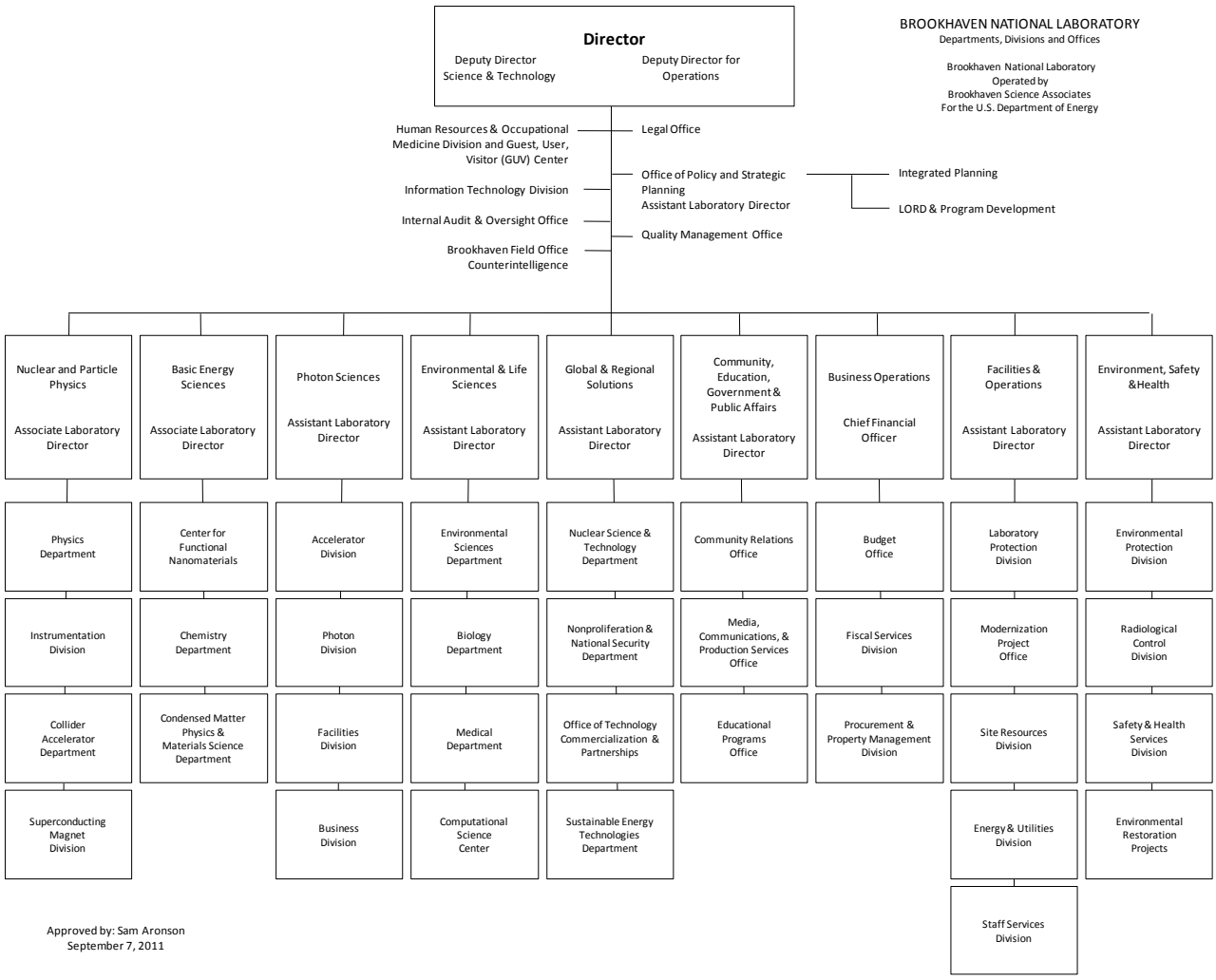


Figure 3: BNL Directorates (September 2011)

The Facilities & Operations Directorate (F&O) includes security, property protection, physical plant maintenance, utilities, project planning and modernization. SRD is one of the five F&O Divisions reporting directly to the F&O ALD. (Figure 4)

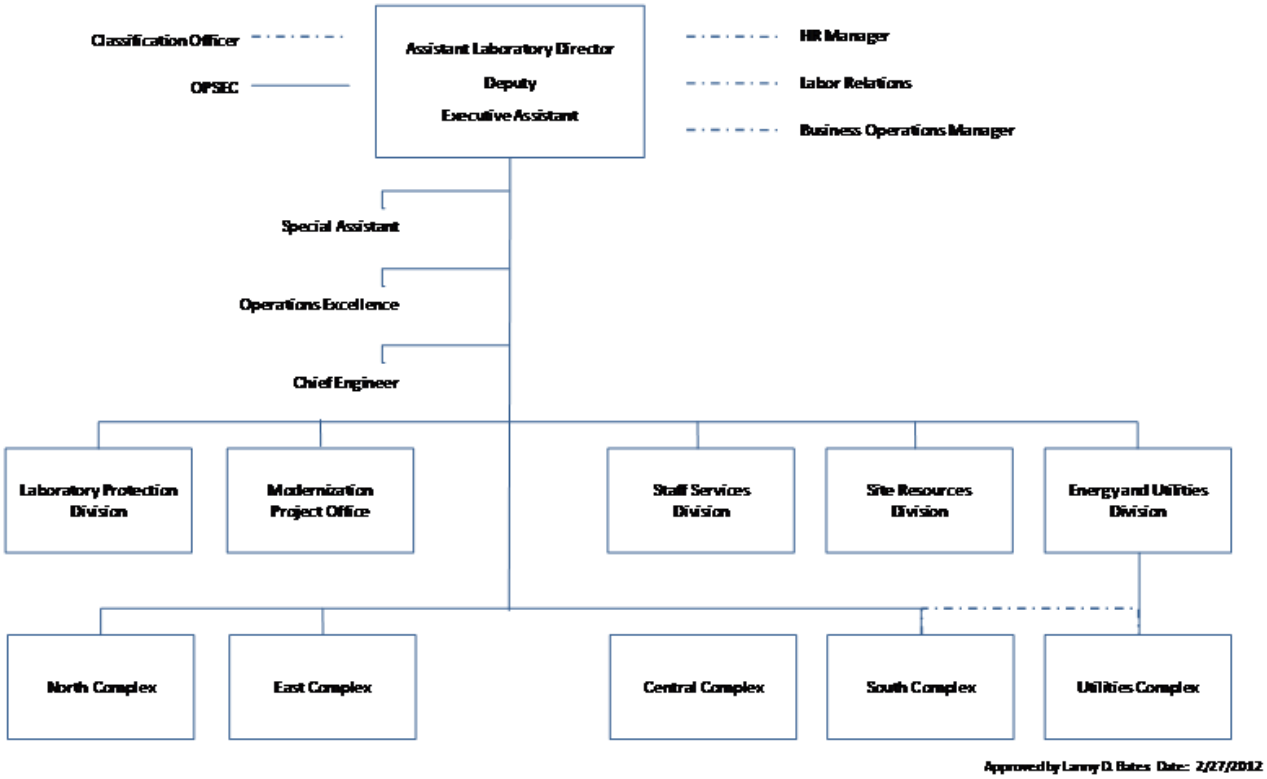


Figure 4: Organization for the F&O Directorate (February 2012)

Since October 2010, the F&O ALD has implemented a management program known as Integrated Facility Management (IFM). IFM is designed to permit F&O to manage and maintain the 350 plus buildings on the BNL complex. IFM reorganized BNL into five facility complexes (Utilities, South, Central, East, and North), each of which is managed by a Facility Complex Manager (FCM) supported by a core team responsible for all the facilities within their complex (Figure 5). Within this core team is a Facility Project Manager (FPM). The FPM is the primary person to contact for resolving maintenance issues and arranging for work to be performed. The FPM will screen, prioritize, schedule, and authorize the associated work to ensure its completion. The five IFM FCMs report directly to the F&O ALD.

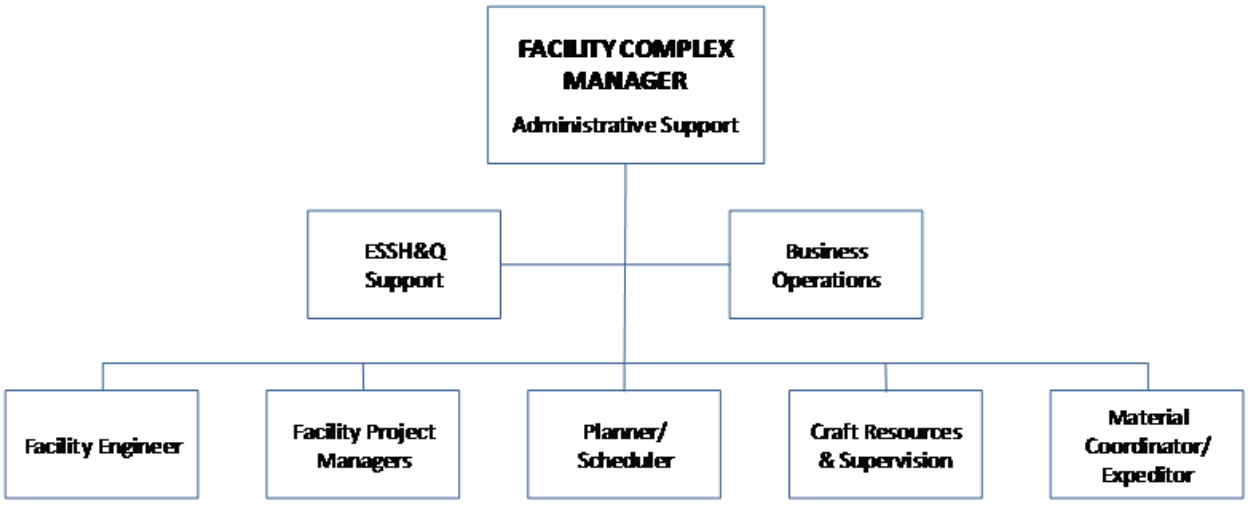


Figure 5: Typical IMF Complex Organizational Structure

1.8. BNL Organization and Site Resources Division

The Manager of SRD reports directly to the F&O ALD (Figure 6). The Fabrications Services General Supervisor reports directly to the SRD Manager. One of the two supervisors reporting to the Fabrication Services General Supervisor is the Welding/Sheet Metal Supervisor. The MMW involved in this accident is a member of the Sheet Metal Shop and was considered a "lead man" with reporting responsibilities to the Fabrication Services General Supervisor.

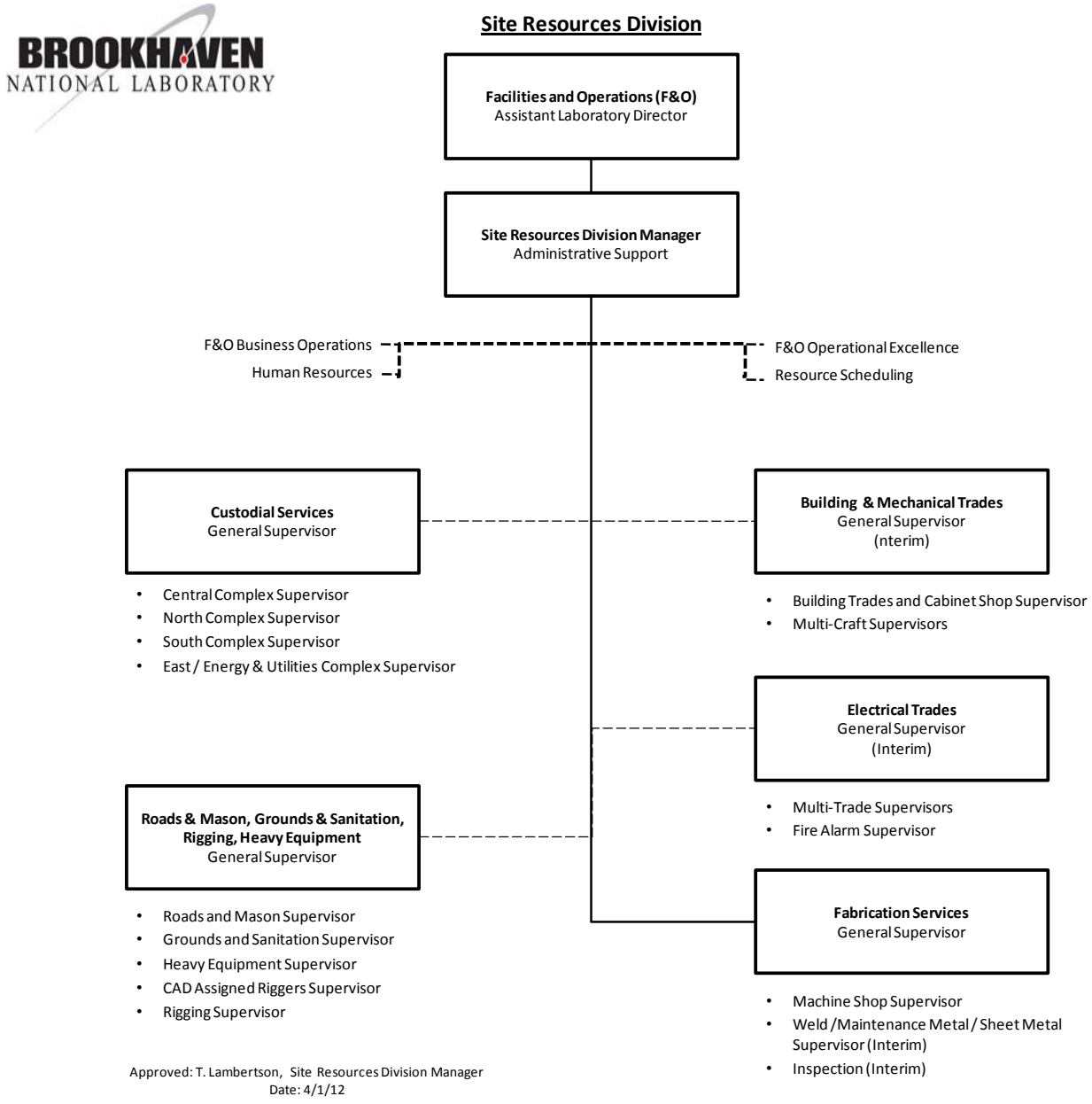


Figure 6: Organization for the Site Resources Division (April 2012)

1.9. DOE Organization and the Facilities and Operations Directorate

BHSO has assigned a Facility Representative to oversee the activities of the F&O Directorate. The BHSO Facility Representative conducts oversight through formal assessments, surveillances, and observations of work activities within the F&O Directorate. The BHSO Facility Representative has achieved full qualification with the DOE standard DOE-STD-1063 (Chg 1), *Facility Representative*, in accordance BHSO Procedure, BHSO-PPP-07, *Facility Representative Qualification and Training*. BHSO Facility Representative day-to-day oversight

is accomplished in accordance with BHSO Procedures, BHSO-OA-01, *Conducting Environment, Safety and Health Assessments*, and BHSO-OA-02, *Conducting Environment, Safety and Health Surveillances*.

1.10. Scope, Conduct, and Methodology

The AIB began its activities on July 17, 2012 and submitted the final report to the Acting BHSO Manager on September 7, 2012. The scope of the Board's investigation was to:

- Identify all relevant facts;
- Analyze the facts to determine the direct, contributing, and root causes of the accident;
- Develop conclusions; and
- Determine the actions that, when implemented, should prevent the recurrence of a similar accident.

Additionally, the AIB was tasked through the appointment memorandum with evaluating:

- The adequacy of the BSA investigation and review including causal analysis, issue identification and suggested corrective actions (both interim and long-term); and
- Inadequacies associated with BSA's Contractor Assurance System that led to the injury.
- In accordance with the appointment memorandum, the Board initially requested BSA to schedule a face-to-face interview with the injured employee. The family of the injured employee eventually made contact with the Board, through the employee's union representative, and asked that the Board contact the lawyer retained by the family to arrange a face-to-face interview. As such, the Board's legal representative made a request through the injured employee's attorney, for that interview. The injured employee was still in a medical facility at the time and the injured employee's attorney was unable to schedule the requested interview before the Board left BNL.
- In a final attempt to interview the injured employee, the Board prepared a set of written questions and requested the injured employee respond to each question accordingly. The Board, through its legal representative, told the injured employee's attorney that the Board's objective was not to fix blame for the accident, but to determine why this accident occurred, what caused it, and how the Board might bring about improvements to prevent it from happening again. It was also explained that the Board was only seeking information typically collected during a face-to-face meeting, i.e., "tell us what happened". The Board asked that this information be prepared in a narrative style and put in a chronological format starting with the time the worker arrived at BNL through to the time of the fall. Since the Board wouldn't be present to ask follow-up questions, a set of 22 specific questions were prepared.
- This set of questions was forwarded to the injured employee's attorney by the Board's legal representative. A reply, without answers to the Board's questions, was eventually

received from the injured employee's attorney noting that the injured employee was back in the hospital. Therefore, it was anticipated by the Board that receiving any response from the injured employee would likely be again significantly delayed. Due to the need to complete the accident investigation report in a timely manner, the Board decided to forego the injured employee's input and finalize the accident investigation to the best of the Board's ability with the information on-hand.

Table 2: Accident Investigation Terminology

Accident Investigation Terminology
A **causal factor** is an event or condition in the accident sequence that contributed to the unwanted result. There are three types of causal factors: direct cause(s), which is the immediate event(s) or condition(s) that caused the accident; root causes(s), which is the causal factor that, if corrected, would prevent recurrence of the accident; and the contributing causal factors, which are the causal factors that collectively with the other causes increase the likelihood of an accident, but that did not cause the accident.
The **direct cause** of an accident is the immediate event(s) or condition(s) that caused the accident.
Root causes are the causal factors that, if corrected, would prevent recurrence of the same or similar accidents. Root causes may be derived from or encompass several contributing causes. They are higher-order, fundamental causal factors that address classes of deficiencies, rather than single problems or faults.
Contributing causes are events or conditions that collectively with other causes increased the likelihood of an accident but that individually did not cause the accident. Contributing causes may be longstanding conditions or a series of prior events that, alone, were not sufficient to cause the accident, but were necessary for it to occur. Contributing causes are the events and conditions that "set the stage" for the event and, if allowed to persist or recur, increase the probability of future events or accidents.
Event and causal factors analysis includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the accident to occur), and the use of deductive reasoning to determine the events or conditions that contributed to the accident.
Barrier analysis reviews the hazards, the targets (people or objects) of the hazards, and the controls or barriers that management systems put in place to separate the hazards from the targets. Barriers may be physical or administrative.
Change analysis is a systematic approach that examines planned or unplanned changes in a system that caused the undesirable results related to the accident.
Human Performance Improvement (HPI) /Error precursor analysis identifies the specific error precursors existing at the time of or prior to the accident. Error precursors are unfavorable factors or conditions embedded in the job environment that increase the chances of error during the performance of a specific task by a particular individual or group of individuals. Error precursors create an error-likely situation that typically exists when the demands of the task exceed the capabilities of the individual or when work conditions aggravate the limitations of human nature.

1.11. Facility Description – Brookhaven National Laboratory

BNL, established in 1947 at Upton, New York, is an Office of Science multi-program national laboratory operated by BSA. BNL is situated on 5,265-acre site located on the east end of Long Island. BNL has a staff of approximately 3,000 scientists, engineers, technicians, and support staff, and hosts over 4,000 guest researchers annually. BSA has been the BNL prime contractor since March 1998.

BSA supports four DOE strategic missions, which includes:

- To conceive, design, and operate complex, leading-edge, user-oriented facilities in response to the needs of DOE and the international community of users;
- To carry out basic and applied research in long-term, high-risk programs at the frontier of science;
- To develop advanced technologies that address national needs and transfer them to other organizations and to the commercial sector;
- To disseminate technical knowledge, educate new generations of scientists and engineers, maintain technical capabilities in the nation's workforce, and to encourage scientific awareness in the general public.

In support of these missions BSA operates several user facilities, including but not limited to, the Relativistic Heavy Ion Collider, the National Synchrotron Light Source, the Center for Functional Nano-materials, the NASA Space Radiation Laboratory, and a number of other research facilities involved in chemistry, biology, physics and material sciences. To support the research function, BSA has established a number of ancillary support organizations with functions in support of the BSA science and technology and environmental restoration missions.

2.0 The Accident

2.1. Background

On the day of the accident, prior to the MMW falling from the ladder, BSA had declared a heat stress day. At the time of the accident, the heat stress advisory called for 15 minutes of rest for every 45 minutes of continuous work. Throughout the day of the accident BSA Meteorologists were recording air temperatures of approximately 90º Fahrenheit with high humidity. Wind was light out of the east-northeast. It was sunny with little or no clouds. Prior to meeting the FPM and FCE at Building 830, the MMW spent the workday processing paperwork in an air-conditioned office at Central Shops (Building 479).

A physician from the BNL Occupational Medicine Clinic familiar with the medical history of the MMW was interviewed by the Board and was of the opinion that the MMW had no medical condition that influenced the occurrence of this accident.

2.2. Accident Description

On the day of the accident, the FPM and the FCE for the IFM East Complex met with the MMW at Building 830 to discuss work planned to be performed on the roof over Lab 17. Specifically the MMW was assigned the task of caulking and sealing around a rooftop duct housing where the caulking had deteriorated. Working with the FPM and FCE, the MMW was asked to inspect the caulking and duct housing, and estimate the tools, materials and time necessary to complete the repair. It was agreed the three employees would go onto the roof over Lab 17 by use of the nearby fixed ladder, but only one person would ascend the ladder at a time. It was also agreed that the climb to the top would not involve carrying any tools or other equipment. The three decided the MMW would climb up first, followed by the FCE, and lastly the FPM. The FPM and the FCE observed the MWW initiate his climb, but then began a side conversation several feet away from the fixed ladder. Moments later the attention of the FCE and FPM was redirected toward the fixed ladder when they heard the MMW mutter something. When they looked up, they observed the MMW holding onto the right ladder rail with only his right hand.

As best can be determined by the facts collected by the Board, the worker lost three points of contact when nearing the top of the fixed ladder. At this time, the FPM and FCE both acknowledged the MMW's feet being at the fourth ladder rung from the grated step-off platform at the top of the fixed ladder. Though the Board could not confirm what the MMW was attempting to do when he began to lose the three points of contact, the Board is of the opinion the MMW was soon to transition from the ladder rungs to moving onto the grated step-off platform located just above the roof level.

The loss of three points of contact created bodily motion that caused the MMW to pivot around the right rail of the ladder; swinging the MMW's body 180º to his right, putting his back against the wall of Building 830. As the employee lost hold of the right side rail of the ladder and began to fall, the MMW's left foot shortly thereafter struck a wall mounted light located roughly 48 inches to the right of the fixed ladder. This contact knocked the wall light off of its exterior mounted electrical box. After striking the wall mounted light, the MMW continued to fall feet first toward the asphalt pavement.

2.3. Medical Report Summary

Upon arrival at the accident scene, BNL EMTs evaluated the injured party. The EMTs did not observe any open fractures, bleeding or swelling at the time of their arrival. The injured party arrived at Brookhaven Memorial Hospital (BMH) at 1533 and was admitted through the institution's Emergency Room. Based on the evidence collected, the medical care and services provided to the injured employee were appropriate.

2.4. Event Chronology

A timeline of significant events is detailed in Appendix B, *June 29, 2012 Ladder Fall Event Chronology*.

3.0 Facts and Analysis

3.1. Emergency Response

After the MMW fell, the initial actions taken by the FPM and FCE were appropriate. The FPM and FCE immediately verified the physical well-being of the MMW. The FPM called the BNL emergency telephone number (2222) at 1439 to inform the BNL emergency dispatcher of the accident and requested BNL Fire/Rescue respond to Building 830. Based on a review of statements related to the accident, the injured MMW attempted to stand following the fall, but was instructed by the FCE and the FPM to remain on the asphalt pavement. The FCE noted the MMW was conscious and attempting to keep his face off of the asphalt pavement because it had been heated throughout the day by sunlight. To alleviate the MMW of this possible source of discomfort, the FCE retrieved a baseball glove (taken from one of the nearby vehicles), wrapped it with several disposable plastic shopping bags for extra padding, and placed it under the MMW's head. In doing this, the MMW raised his head slightly to allow for it to be comfortably positioned. They remained with the MMW while awaiting arrival of BNL Fire/Rescue.

At 1440, the BNL emergency dispatcher requested that an ambulance respond to Building 830. Overhearing the radio transmission, the Chief of BNL Fire/Rescue, who happened to be driving on site, responded to the scene of the accident at Building 830. The Chief of BNL Fire/Rescue arrived on the scene at 1442, and reported to BNL Fire/Rescue that the injured MMW was alert but would be required to be immobilized. At 1443, the BNL ambulance arrived on scene. The BNL Fire/Rescue Emergency Medical Technicians (EMTs) responding to Building 830 observed the injured party lying on his right side on the asphalt pavement. The BNL Fire/Rescue EMTs were at the accident scene for approximately 20 minutes. In that time they took control of the injured employee, evaluated the extent of the injuries experienced, and then stabilized the injured MMW for transport. The injured employee was placed onto a back board; a cervical collar was placed around the employee's neck, and the MMW was put into the BNL Fire/Rescue ambulance.At1503 the BNL Fire/Rescue ambulance left the accident scene to transport the patient to BMH. The BNL Fire/Rescue ambulance arrived at BMH Emergency Room at 1533.

Upon the departure of the injured MMW, the Chief of BNL Fire/Rescue released the accident scene to the BNL Safety and Health Services Division (SHSD) so they could initiate an informal investigation. The accident scene was preserved to the extent possible, evidence was collected, and initial witness statements were taken.

3.2. Post-Event Accident Scene Preservation and Management Response

From testimony and review of the contractor's records the Board learned that SHSD took control of the accident scene immediately after the victim was transported off-site. Several BSA employees responded to the site shortly after the incident. SHSD personnel conducted witness interviews and took written witness statements, collected physical evidence, and preserved the accident scene to the extent possible. At the direction of SHSD, F&O electricians' de-energized the circuit feeding the wall luminary knocked off by the falling MMW, secured the wiring and placed a cover plate over the open electrical box. The gloves worn by the MMW and his personal effects, (eyeglasses, badge and cap) were initially secured by SHSD. The injured

employee's personal effects were later put under the control of the BNL Protective Force. The vehicle driven by the injured worker was taken and secured by SRD.

On July 9, 2012, the BNL Assistant Laboratory Director for Environment, Safety and Health formally convened an investigation team and tasked the members with conducting a thorough investigation of the fall injury to determine root causes and to develop corrective and preventive actions to preclude recurrence. Subsequent actions taken by SHSD immediately following the accident and over the next several days in support of the BSA accident investigation team included an inspection of the area immediately surrounding the fixed ladder and an inspection of the fixed ladder. This involved examining the fixed ladder for slick spots or foreign materials which may have contributed to the fall. Likewise they inspected the MMW's vehicle, clothing and work gloves. They also documented status of the ladder for compliance with applicable regulatory and national consensus standard compliance. All evidence collected through this effort was shared with the Board once it was established on July 11, 2012. On July 17, 2012 the Board arrived at BNL and released control of the accident scene to the Board. As can be best determined, BSA took all necessary actions to ensure preservation of the accident scene and for the collection of evidence for transitioning to the DOE accident investigation.

3.3. Supervision and Oversight of Work

The Board interviewed the direct line supervisor, and employees associated with the work to be performed. Both the supervisor and employees indicated that they considered the work to be skill of the craft type of work. The Board determined that the direct supervisor, nor the IFM East Complex Environment, Safety and Health (ES&H) Representative were present at the time work was initiated the day of the accident.

The Board was not provided documentation of any supervisor, or ES&H Representative, observation relating to work associated with fixed ladders. Documentation of inspections of facility fixed ladders was also not provided to the Board.

The Board examined the BSA internal requirements and procedures for the supervision of work, as related to this accident. BSA's SBMS Procedure for Fall Protection, Rev 1.3, dated, May 30, 2006, states that the Fall Protection Procedure does not apply when workers are inspecting, investigating, or looking at workplace conditions, before or after the start of work.

BSA's internal procedure supports the task as written, and as described by the workers involved, as low hazard, skill of the craft work. Therefore, the SBMS procedure for fall protection would not apply. This would have included; assessing the job and facility for fall hazards, preparing a job hazard analysis, and using fall arrest devices. Work performed out of scope of the planned work would still require supervision, hazard analysis, and the use of fall protection as specified in the BSA SBMS Fall Protection Procedure.

The Board concluded that BNL's SBMS Procedure for Fall Protection, Rev 1.3, needs to apply to all elevated work, and that even if the work being performed is not associated with the planned work and is outside the scope of the work package, the fall hazard exists and still needs to be addressed. **(JON 8)**

3.4. 10 CFR Part 851 DOE Worker Safety and Health Program

10 CFR 851, *Worker Safety and Health Program* is the regulatory framework that DOE requires its contractors to have a program description in place to address how the contractor approaches the development, management, and implementation of a compliant worker safety and health program (WSHP). This program and associated documents, promote compliance with worker safety and health regulatory requirements including, 29 CFR 1910and 29 CFR 1926, *Safety and Health Regulations for Construction*).

Specifically, each WSHP under 10 CFR 851 should provide cross-references to implementing systems, programs, and subject areas. It also should describe how the contractor integrates worker safety and health requirements with other related worker protection activities, under an Integrated Safety Management System (ISMS) approach.

The Board, in its investigation considered the BSA framework for effective worker protection and the integration of safety and health-related functional areas, relevant to this accident including: work planning, hazard analysis and fixed ladder safety.

The Board concluded that the BSA fixed ladder safety program is not compliant with 10 CFR 851 and BSA's own safety program documentation. BSA had not effectively integrated its 10 CFR 851 program elements for addressing inspections, hazard controls, and training, for fixed ladders. The BSA SBMS requirement for annual fixed ladder inspections was not followed. Also, there was no technical inspection criteria established for, or training provided to, safety personnel to conduct a compliant inspection process for fixed ladders. **(JON 1)**

The Board concluded there were multiple missed opportunities to identify and correct the hazards associated with this work activity. The failure of multiple safety system components, i.e., hazard recognition, work planning and control (WPC), Employee Concerns, Tier 1 inspections, Safety Observation Program, lessons learned incorporated into work packages; which were not adequately integrated. **(JON 9)**

3.5. Integrated Safety Management Analysis

The BSA Integrated Safety Management System Description (ISMSD) is documented in SBMS, which is the primary system of setting institutional standards and requirements at BSA. The ISMSD is maintained as a living document that is reviewed annually and updated as necessary to reflect the current status of the operating contract, system improvements, and changed conditions and requirements.

The major components of the SBMS are the management systems, subject areas, and implementing procedures. The SBMS also contains a number of guides, exhibits, and references to aid with implementation of the standards and requirements in SBMS. The Board reviewed the current SBMS management systems and subject areas that provide requirements and expectations for ES&H, training, and planning, conducting, authorizing, and controlling work.

The Board also reviewed F&O policies, procedures, practices, and management direction in implementing SBMS requirements in work planning and control, hazard analysis, training, and feedback and improvement. This review was conducted to ensure that gaps in requirements or implementation did not contribute to, or fail to adequately control, the hazards associated with the fall from the fixed ladder at Building 830.

Core Function 1 - Define the Scope of Work

Work Order EP-892181 was initiated by the IFM East Complex FPM on June 6, 2012. Work Order EP-892181 described the work to be performed at Building 830 as, "Caulk and seal around duct housing where caulking is dry and weathered and seeping air while units are still running. Instructions within the work order provided the following: "Work request must be completed prior to replacing the HEPA Filters for Labs 2&4. The labeling of the ducts are missing but Lab 2 duct is one the north side parallel to the parking area and Lab 4 is against the high bay wall in middle. If at all possible, please assess and caulk all ducts as needed. Expected delivery of HEPA Filters is Tuesday, June 26, with scheduling to follow". Work Order EP-892181 was being completed in conjunction with two other work orders calling for replacing high efficiency particulate air filters for Laboratories 2 and 4, and making general roof repairs. Work Order EP-892181 was entered by the IFM East Complex FPM into the BSA work tracking system (Maximo) on June 22, 2012.

On June 29, 2012 the IFM East Complex FPM and FCE began a walk down of the work order to scope the job and begin preparing for the work activity. They contacted the MMW and requested they all meet at Building 830 to estimate the costs of performing this work as detailed in Work Order EP-892181. At that meeting, the IFM East Complex FPM, the FCE, and the MMW discussed accomplishing the intended task of providing the cost estimation for the work detailed by Work Order EP-892181, but no indication they signed Worker Order EP-892181 since it was for re-caulking of the duct housing. No Work Order was prepared for performing the cost estimate for Work Order EP-892181.

Facilities and Operations (F&O) personnel, specifically the FPM, did not identify "estimating" as work to be done. The FPM made a phone call to the MMW and FCE and requested to meet at the job site location to estimate the work. A work request for conducting the estimation task was not completed. This estimation effort was considered "worker planned work" which allows the requestor to take a graded approach toward work planning. The F&O Work Planning and Control Procedure, DF-ESH-006 states worker planned work shall meet the evaluation for "low hazard work" in work aspect, complexity and coordination. Personnel did not identify the additional hazards associated with climbing a fixed ladder as elevated work. It's not clear what the performance expectations of F&O management were concerning the implementation of Work Planning and Control for estimation of a work task at an elevated level.

The Board found F&O management did not formally communicate their expectations for implementing the F&O Procedure EP-ES&H-006, Work Planning and Control for work estimation in hazardous (elevated) areas. **(JON 8)**

Core Function 2 - Analyze the Hazards

Work Order EP-892181 was classified as "Worker Planned Work" meaning it was performed by craft personnel using the "skill of the craft" concept. During testimony, the FPM stated the work was considered and interpreted as acceptable risk and would be managed as worker planned work, i.e., low hazard. This resulted in a judgment that elevated work, i.e., climbing a fixed ladder was low hazard work. The work planning and control process allows the requestor to make a determination about the type of work to be performed. In this case, the original work order (caulking and sealing of duct housing) was followed and the determination that was used for this job "worker planned work" did not identify the associated hazards with climbing a fixed ladder. Therefore, the work control process did not ensure worker protection. The work planning and control process places a lot of responsibility in "worker planned work" and thereby relies on inherent worker skills and training. A discussion on the level of understanding of safety and risk by BSA personnel related to climbing fixed ladders found there is a general lack of understanding related to the full scope of work and the hazards and risk associated with fixed ladders. BSA personnel interviewed conveyed that climbing a ladder is considered a normal skill and requires only normal training. BSA personnel did not readily recognize that evaluating work, as in this case, requires work planning. In addition, F&O recognized and managed elevated work, in this case, climbing a fixed ladder, as a low hazard work activity. The F&O work planning process failed to identify hazards associated with estimating work when done at elevated surfaces or heights and did not implement the necessary controls for this task.

The Board found the F&O work planning and control process is inadequate to identify hazards associated with work estimates at heights and did not provide the necessary controls to implement this work safely.**(JON 8)**

No specific Job or Facility Risk Assessment concerning the use of or climbing fixed ladders has been developed by the F&O Directorate nor could a Job Risk Assessment (JRA) be located for elevated work involving portable ladders. Consequently, F&O supervision did not possess any references associated with the risk of elevated work. Facilities and Operations Procedure DF-ESH-006, entitled Work Planning and Control outlines the requirements for worker planned work. The procedure relies on the reader to review the document entitled Application of the Graded Approach for Work Planning and Experimental Review found in the SBMS Graded Approach Subject Area. Elevated work is not listed in the referenced attachment found in the SBMS Graded Approach Subject Area.

The Board concluded that the work planning and control process "worker planned work" used a graded approach for this estimation effort and allowed for elevated work to be considered as low hazard work.**(JON 8)**

The work as presented and scoped in Work Order EP-892181 was determined by the FPM to be worker planned work and allowed acceptance of risk and managed as low hazard work. The Board found the F&O work planning and control process was not followed because it did not

adequately address hazards of elevated work and did not provide the necessary controls to implement this work safely. The work activity that the FPM, FCE and MMW were conducting required they climb a fixed ladder to estimate the work. Because the original work order allowed for worker planned work and this activity, i.e., estimation, was being conducted under the existing work order which did not provide the workers additional resources or expertise to recognize elevated work activity to be hazardous. This resulted in a judgment that elevated work, climbing a fixed ladder, was low hazard and the planning and control process did not provide adequate worker protection.

The Board concluded the BSA work control process was not followed for work estimation being conducted though it presented the same hazards as actually performing the permitted work, i.e., caulking of duct housing. **(JON 8)**

The Board concluded the work planning and control process failed to provide adequate hazard recognition which led to a false judgment that elevated work is low hazard work. **(JON 8)**

The Board found the work planning and control process failed to provide adequate hazard recognition which led to a false judgment that elevated work is low hazard work. **(JON 8)**

The Board concluded that there is no established Job Risk Analysis for generic climbing of a fixed or portable ladder. **(JON 2)**

The Board concluded the F&O Procedure EP-ES&H-006, Work Planning and Control relies on the preparer to consult the SBMS Graded Approach Subject Area. It is not clear how the preparer of the Worker Order could incorporate this subject area into work planning since it did not reference work at elevated heights. **(JON 3)**

Core Function 3 - Develop and Implement Controls

Controls for protecting the worker come in many forms. Two administrative controls were reviewed by the Board: procedures and pre-job briefings. F&O procedure DF-ESH-006 has definitions and descriptions for pre-job briefings and forms to be used for different work packages. There is a specific form for a pre-job briefing for worker planned work, i.e., section 5.21 of F&O procedure DF-ESH-006.

The work for this activity was rated as low hazard work and was considered worker planned work. The FPM makes the determination and approves for scheduling. The FPM and the FCE

may participate in the preparation of the Field Work Package as described in sections 6.3 and6.4 of F&O procedure DF-ESH-006. The planner/scheduler responds to the work requests, confirms the screening level and develops the work package. The ES&H representative would be included in the work package development for work requiring a permit. When this work order, not a work package, was rated it did not get ES&H review nor was a JRA prepared. This control feature was missed based on hazard recognition associated with preparing a work order not a work package.

The Board found Work Order EP-892181 did not receive review to ensure the adequacy of the risk/hazard evaluation of the planned work. **(JON 3)**

Job Supervisors conduct daily pre-job briefings with the workers for the day's work. F&O workers are required to attend the pre-job briefing and ensure they understand the task. Workers are required to acknowledge on the pre-job brief that they understand the tasks and the controls, .i.e., Section 6.9 in DF-ESH-006. In this event, the MMW was the employee climbing the fixed ladder. The pre-job briefing was limited to a short discussion about the work to be performed and the only discussion about the hazard, "climbing the ladder" was limited to who would go first. The IFM East Complex FPM and FCE indicated that they discussed the climb and the FPM wanted to go last because the FPM was uncomfortable climbing this ladder and did not want to slow the others down. Personal protective equipment for this task was not included in the pre-job briefing nor was it indicated in the work order under pre-job meeting topics. F&O personnel are required to use safety shoes while on site. The Board found the MMW was the only individual using gloves because they were identified in testimony and as articles recovered following the incident.

Multiple BSA employees expressed a dislike for the fixed ladder involved in this accident. F&O procedure DF-ESH-006, Section 7.0, discusses the Human Performance aspects and Human Factors as a control and consideration when people perform work. One of the top ten error traps listed in the procedure section was, "first work day after time off". During testimony the Board learned that the injured employee had just returned from a day off. Testimony provided by the General Supervisor indicated the worker had requested a day off on June 28, 2012 which was approved by the General Supervisor. The Human Performance aspects are contained in the Work Order being used for this work activity, i.e. page 5 of 6. The Board recognized there was no Work Order for the estimation effort and therefore had to rely on the Work Order for caulking and sealing. The requirements for this Work Order, i.e., HPI Error Traps were not discussed (first working day after days off).

The "Am I Ready" check list as provided in DF-ESH-006, Section 7, was not mentioned during testimony. The Board found the pre-job briefing and discussion about potential hazards, i.e., climbing fixed ladders was either not recognized or not fully discussed. Further, in section 7.2, Precaution and limitations instructs personnel to identify hazards for moderate to high hazard work. A Facility Risk Assessment (FRA) for the facility and a JRA associated with the tasks should have been reviewed or performed. However, this work activity and the associated elevated work were not considered and this work activity did not have a JRA. This control point or step was missed based on the work rating was made.

Worker planned work at BNL allows low hazard work to be performed without the requirement of a written procedure (Prescribed Planned Work), Work Plan, or permit. In addition, when preparing for and performing worker planned work, ISMS applies, i.e., Section 7.9, DF-ESH-006). Worker planned work places a greater reliance on worker skill levels, qualifications, training, ES&H support and experience levels. BSA did not recognize the skill level required for elevated work, climbing a ladder above six feet, the hazard level changes for the worker and additional controls would be necessary.

The Board concluded there were multiple missed opportunities to identify and correct the hazards associated with this work activity. The failure of multiple safety system components, i.e., hazard recognition, work planning and control (WPC), Employee Concerns, Tier 1 inspections, Safety Observation Program, lessons learned incorporated into work packages; which were not adequately integrated. **(JON 9)**

In SBMS Subject Area, Work Planning and Control for Experiments and Operations, Section 3, Worker Planned Work, Step 4, workers are to consider several items before starting work. There is note in the procedure that indicates staff can request proposed work be performed under permit planned work or re-evaluation of the tasks hazards. The opportunity to request an additional evaluation of task hazard was not utilized.

Other BSA Safety Management Systems were found to lack the rigor and integration to ensure worker safety. For example, during Board interviews and document reviews, the Board found several opportunities for improvement with the employee concerns program, Tier 1 inspections, safety hotline and the safety observations program. The Board was encouraged that these systems exist but testimony and interviews of employees and supervisors found that many do not use these systems and issues related to this ladder were specifically brought forward yet they were not used to identify the hazards associated with this fixed ladder. The Board did not find any reference to this fixed ladder being identified within any of the BSA Safety Management Systems. The BSA SBMS procedures allowed several opportunities for staff to initiate actions to identify and control hazards including, but not limited to work planning and control, and subject matter expert support. Because this ladder and its associated hazards went unrecognized for so long, the Board found that BSA safety systems were not sufficiently integrated to support worker safety.

The Board concluded BSA safety systems were not sufficiently integrated to support worker safety. **(JON 9)**

SBMS Subject Area, *Training and Qualifications*, Section 1, *Determining Training and Qualification Requirements,* states, "The supervisor, work planner, line manager, Training Coordinator must review existing job-specific training programs against Criteria for Determining Additional Job Qualification Requirements and confirm that they are at the appropriate level of rigor for the needs identified." The MMW and IFM East Complex FPM had completed the required ladder safety training; however, the IFM East Complex FCE had not. The Board found

the FCE training for ladder safety was conducted after the accident. In addition, the Board found the FPM and the FCE were delinquent in maintaining their Job Training Assessment. The Board can only conclude personnel are not maintaining training requirement.

Core Function 4 - Perform Work within Controls

SBMS Subject Area, Work Planning and Control for Experiments and Operations allows for three approaches for planning and controlling work. Each approach recognizes the need to rely on an increasing the level of rigor in conducting work as hazards are identified and controlled. The BSA work planning and control process allows for the use of a combination of processes; for example, a planned experiment will require an Experimental Safety Review but may also need a work permit to assemble the experiment. Regardless of the process used, scoping of the work requires looking at the entirety of the work to be performed.

As previously stated, the worker planned work relies on the skills of the employee and thus places a greater emphasis on employee training and expertise. The Board looked into several BSA Safety Management Systems and concluded there were multiple missed opportunities for BSA and its' employees to identify and correct hazards associated with this work activity. The processes reviewed did not provide an opportunity for success in identifying non-compliances with this fixed ladder. Various mechanisms such as the Tier 1 Inspections Program, the Employee Concerns Program, the Safety Observation Program, Lessons Learned Program, assessments and surveillance findings, and access to subject matter experts (SME) were available to employees to openly question the ladder's compliance status, but were not used. BSA does not possess a method to consolidate safety information from various safety management systems in an integrated manner to provide one consistent output of information.

The Board concluded the Safety Management systems reviewed were not adequately integrated to identify and correct this fixed ladder. **(JON 9)**

SBMS Subject Area, Training and Qualifications program has a stated purpose to: "ensure BSA employees are trained and qualified to perform their assigned tasks and job functions". Established training requirements and qualifications related to education, experience and training are matched with job responsibilities, facility hazards and job tasks and can be found in the employees Job Training Assessment Form. The Training and Qualifications Subject Area requires the supervisor to address Medical Clearance exams, External Certifications and position descriptions for any supplemental or job-specific training needs. Employees are required to complete their training requirements prior to independent assignment of work. The injured employee's training record for climbing ladders was reviewed by the Board and was found current with respect to climbing ladders. However, the training course for climbing ladders was reviewed by the Board and found to be limited in providing hazard identification information concerning climbing fixed ladders. Although the Board found "three points of contact" being emphasized in the training, other aspects concerning safety requirements pertinent to fixed ladders were not discussed.

The Board concluded there was a missed opportunity in the training module to inform the employee of the hazards associated with the work activities involving fixed ladders. **(JON 5)**

Worker training for climbing ladders was reviewed by the Board and found to be very basic and while available to the worker, was not of sufficient breadth or depth to instill adequate understanding of the importance of the proper climbing technique for personal safety. The training module did refer to the"3-points of contact" technique but the Board believes greater emphasis should be placed on this technique to ensure workers understand the importance of the technique, specifically related to climbing fixed ladders. The training module was not consistent with SBMS Subject Area, Fall Protection, Section 8, *Using Fixed Ladders*, Step 2, requires supervisors to ensure staff are trained on fixed ladders. Step 4 requires the incorporation of engineered fall protection systems where feasible. Outside of these four procedural steps there is no additional guidance or technical information available to assist the worker or supervisor. For example; when should BSA staff "incorporate engineered fall protection systems?" Had it not been for the MMW falling from the fixed ladder, the East Complex FCE would most likely continue to climb this fixed ladder.

The Board concluded not all employees are attending required ladder safety training before attempting to access fixed ladders. **(JON 6)**

Hazard recognition of climbing a fixed ladder and the risk involved with heights was not adequately addressed. Use of safety shoes is required by the F&O organization however, the choice of gloves (PPE) for climbing was not addressed in the work order, i.e., page 4 of 6. The work order does allow for the use of PPE as needed and provides a place for the requestor to specify PPE. Additional PPE for this work activity was not required but was used by the MMW.

The SBMS PPE Subject Area doesn't mention the use of regular cotton or leather gloves for routine physical abrasions. BSA did not comply with 29 CFR 1910.132 (d), Hazard Assessment (assess the workplace and determine what personal protective equipment is required), 29 CFR 1910.132 (d) (2), Certification (certify in writing the work place hazard assessment has been performed) and 29 CFR 1910.132 (f), Training (train each employee and certify in writing they are trained). BSA is aware of this requirement however, training and selection of PPE to prevent hand abrasions is not addressed. The Board reviewed the MMW training record and did not find evidence of training for abrasion hazards to the hands. The Board did find training on respirators and chemical resistant gloves.

Core Function 5 - Provide Feedback and Improvement

BSA's ISMS does not adequately identify or provide for an adequate hazards analysis for this fixed ladder. Facility modifications, design, equipment modifications, inspections, training and SMEs that are integral parts of an ISMS and did not identify and correct issues related to this fixed ladder that was on-site, moved, modified, and used numerous times over forty years. Previous work activities that required the use of this ladder did not identify non-compliances

related to the ladder construction. Use of SMEs as a reach back capability did not occur and therefore the hazards associated the ladder went un-analyzed. This was a result of the failure of multiple safety system components, i.e., Employee Concerns, Tier 1 inspections, Safety Observation Program, lessons learned, for cause assessments, multi-topic assessments, assessment, surveillance findings and corrective actions; which were not integrated for this fixed ladder.

The Board concluded there were multiple missed opportunities to identify and correct the hazards associated with the work. **(JON 9)**

The Board reviewed Tier 1 inspections over a period of approximately seven years (2005-2012) and found there were over twenty five thousand entries in the Tier 1 database. A search of the database did not identify this fixed ladder. Non-compliances related to the fixed ladder were identified after the accident indicating that BSA personnel with fixed ladder expertise were available, if they had been requested to inspect the ladder or the ladder had been recognized as a hazard. The general nature of these "observational inspections" did not assist personnel in the identification of this fixed ladder hazard. The Tier 1 process is an "expertise based" process and its success is conditional on the knowledge, skills and abilities of the individual conducting the inspection. The Tier 1 process does not provide adequate technical criteria for hazard recognition, i.e., fixed ladders. The Board did not find any compliance inspections of this fixed ladder. The Board did not find any reference to an inspection of this fixed ladder in the Tier 1 database. The Board learned that Employee and Management perceptions varied on use, intent and purpose of Tier 1 inspections. Currently, the Tier 1 process is not consistent with the required procedure described by the SBMS Tier I Subject Area. The Tier 1 inspection process is designed to capture the physical aspects, hazards and conditions of the plant. Based on the number of entries in the Tier 1 system, no entries concerning the deficiencies of this fixed ladder were identified. It was stated to the Board by more than one interviewee that based on the general purpose and observational nature of the Tier 1 process, the fixed ladder compliance issues would not have been identified.

The Board found the Tier 1 process as designed and currently being used did not address this fixed ladder. **(JON 7)**

Since the June 29, 2012 accident, BSA has made an effort to address deficiencies in fixed ladders across the site. BSA informed the Board that it would conduct an extent of condition for all fixed ladders and the Board is encouraged by BSA's proactive efforts.

SBMS, Subject Area, *Work Planning and Control for Experiments and Operations,* Subsection 2.6, *Post Job Review, Feedback and Improvement,* requires a post job review be held to solicit worker feedback when using a work permit. A work permit was not used on this work activity and a post job review was not required.

Formal BSA ES&H Oversight is driven by the SBMS, Subject Area, *Worker Safety and Health Management System, Environment, Safety, Health, and Quality (ESH&Q) Tier 1 Inspections*. Tier 1 inspections are line organization oversight activities conducted periodically for the purpose of self-identifying ESH&Q vulnerabilities.

The guidance for conducting Tier 1 inspections is found in the BSA ESH&Q Inspections (Tier 1) website. This site includes a general two page deficiency table for conducting Tier 1 inspections and a specialized guide for electrical safety issues. In addition, the SHSD web site contains Tier 1 statistics. The general guide for conducting Tier 1 inspections does not provide guidance to the user to consider the safety aspects or analysis, nor does it encourage the use of SMEs to assist with hazard recognition or safety requirements. Interviews with site personnel from workers to management indicated the Tier 1 process would not have caught the fixed ladder compliance issues. The Board found that Tier 1 reports and assessments were a missed opportunity for identifying and getting feedback on the building inspections specifically for fixed ladders. The Board concluded design deficiencies with the fixed ladder, which should have been addressed as far back as 1968, were not captured by any safety assessment or surveillance until this accident.

Since the accident, BSA has made an effort to address deficiencies in fixed ladders. The Board is encouraged by BSA's proactive stance to determine the extent of condition.

Three prior events were found in the DOE lessons learned system (subject area of the DOE web) and were available for BSA review and use prior to the accident. There was no evidence provided to the Board that suggested these events were within the BSA Lessons Learned Subject Area or communicated to the other organizations with the laboratory. They were:

- Lawrence Livermore – 2007, employee fell from a fixed ladder. Report indicates he lost his balance. In addition:
    - Worker training did not instill adequate understanding of the importance of the proper climbing technique for personal safety, nor ensure proper use of the "3-points of contact" technique.
    - Use of LLNL's prescribed "3-points of contact" climbing technique positions the worker to recover from a missed step without falling.
    - The worker was dependent on generic hazard analysis developed for his general job description.
- Oak Ridge – 2001, employee fell from a fixed ladder. Report indicates he lost his footing.
    - Failed to adequately identify and analyze the hazards introduced by the change in methodology for completing the work associated with the ladder and the level of PPE being worn while climbing the ladder.
    - Alternative methods for safely accomplishing the work were not adequately addressed.

- Sandia – 2001, employee fell from a fixed ladder. Report does not provide a specific cause but does suggest loss of focus while descending.
    - Tasks that are often considered low hazard and routine by personnel performing those tasks may still have the potential to result in significant injuries
    - A moment's loss of focus, lose three point contact to the ladder

These three lessons learned were not captured by the Laboratory's Lessons Learned database; hence they could not be shared with BSA employees.

In addition, BSA has experienced two significant events in the last eight months preceding this event. The Scissor Lift Fall and Tree Felling events both had significant work related and work planning issues that were considered causal factors. Twenty two additional events and ORPS reports were available for review prior to the accident and were included in the contractor's accident investigation documentation.

A review of the ORPS reports found there was sufficient information available for instructions or pre-cautions in a work package for BSA staff to make an informed decision on risk relative to climbing a fixed ladder. As stated earlier, a work package was not prepared for this work activity.

3.6. Human Performance Improvement Analysis

The goal of Human Performance Improvement (HPI) is to facilitate the development of a facility structure that recognizes human attributes and develops defenses that proactively manage human error and optimize the performance of individuals, leaders, and the organization. The Department's *Human Performance Improvement Handbook Volumes 1 and 2 (*DOE-HDBK-1028-2009), describes the HPI tools available for use at DOE sites. There is no specific requirement for sites to implement a *Human Performance Improvement Program* and the Board was not looking at HPI from the perspective of program implementation. The Board evaluated Human Performance to determine if it played a part in this accident. Human error is not a cause of failure alone, but rather the effect or symptom of deeper trouble in the system. A review of Human Performance is a review of an individual's abilities, tasks, and operating environment to determine if the organization supports them for success.

The significance, or severity, of a particular event lies in the *consequences* suffered by the physical plant or personnel, not the error that initiated the event. The error that causes a serious accident and the error that is one of hundreds with no consequence can be the same error that has historically been overlooked or uncorrected. In most cases, for a significant event to occur, multiple breakdowns in defenses must first occur. Whereas human error may trigger an event, it is the number and extent of flawed defenses that dictate the severity of the event. The existence of many flawed defenses is directly attributable to weaknesses in the organization or management control systems. The *Anatomy of an Event Model* (Figure 7) illustrates the elements that exist before an event occurs and is a very useful model to guide the analysis of an event from an HPI perspective. The elements analyzed are the flawed defenses that allowed the event to occur or did not mitigate the consequences of the event; the error precursors that existed;

the latent organizational conditions that allowed those to be in existence; and finally the vision, beliefs and values of management and workers.

Much of the information provided in this section is based on the analysis of the events, conditions, processes, and barrier information previously presented in this report.

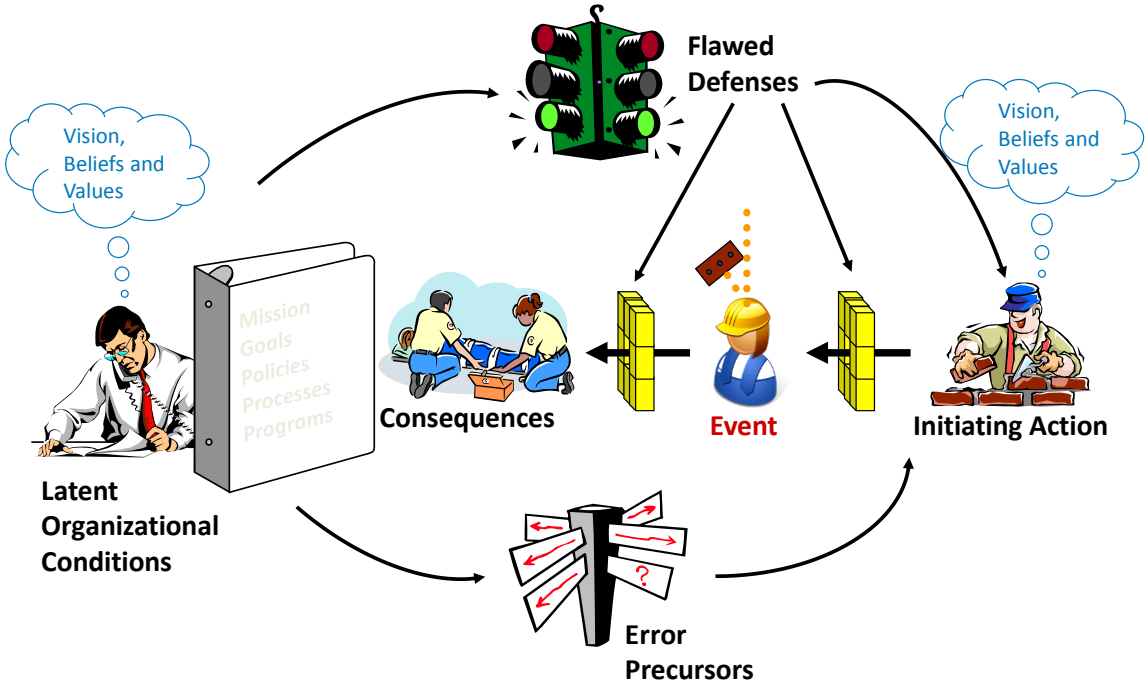


Figure 7: Anatomy of an Event Model

The Board sought to understand the nature of the human error associated with this accident, to determine the appropriate response to the error. Analysis of events in many different types of industry has shown that between 60 and 90% of major accidents, have some type of human error as a contributing cause. Of these human errors, only about 30% are due to the active mistake or error of an individual and the remaining 70% are due to weaknesses that exist in the organization that supports or directs the work.

The Board identified the precursor conditions that contributed to human error and the potential organizational weaknesses. This helped the Board to identify not only any systemic problems, but also to point out where human fallibility may have contributed. Equally important is the opportunity to identify and anticipate the likelihood of human error in the future and to strengthen barriers to those failures. Understanding the performance mode the worker was in when he made the error is essential to developing the response to the accident.

Appendix D contains the Barrier Analysis which is keyed to human performance improvement error precursors, and safety management systems (organizational) weaknesses.

The Board was provided testimony from employees and supervisors performing the work involving the accident that the work was considered to be, "Skill of the Craft" based. From the perspective of HPI, in "Skill mode", actions associated with highly practiced actions in a familiar situation usually executed from memory. Because the worker is highly familiar with the task, little attention is required, and the worker can perform the task without significant conscious thought.

Rather, in this accident, the Board believes that the worker more likely was performing the task in Knowledge Mode. In knowledge mode, worker actions are often in response to an unfamiliar situation, (the non ANSI/OSHA compliant ladder design that was different from the expected). This could be new task or a previously familiar task (climbing the fixed ladder) that has changed in an unanticipated manner, (difficulty in climbing and ability to maintain three points of contact). No compensatory barrier, for performing in Knowledge mode was provided to the worker such as; a work permit, job safety analysis, or detailed work instruction.

Rather than using known rules, the worker is trying to reason or even guess their way through the situation. This human error likely occurred when the worker was eye level with the platform, and unable to determine the safe way to ascend to the platform, as a consequence of non-compliant ladder design, lost the three points of (hand and .or foot) contact necessary to be safe and fell. In such situations human errors can be as frequent as one in two, literally a coin flip.

The Board concluded that this form of elevated work was not performed under a work permit and has required specific knowledge beyond "Skill of the Craft" performance. **(JON 9)**

3.7. Department of Energy Programs and Oversight

BHSO oversight consists of formal assessments, and less formal operational awareness, and surveillance activities that include information analysis, and observations. Assessments and surveillances are conducted according to BHSO Operational Awareness Program procedures BHSO-OA-01 and BHSO-OA-02. Oversight consists of formal surveillances and assessments, and informal observations.

There are three types of BHSO ES&H assessments. Independent assessments are done entirely by BHSO or other DOE personnel. Collaborative assessments are conducted jointly by BHSO and BSA. Observed assessments are done by BSA, but observed by BHSO.

Surveillances are less formal BHSO oversight. Surveillances are described as a subset of operational awareness activities that also encompass analysis of information from non-assessment types of activities. Some surveillance activities are planned and others occur as a part of general operational awareness activities. BHSO Facility Representatives may observe work being done while conducting other activities on the site, or may decide to observe work as a result of communication with BSA personnel informing them of noteworthy activities. BHSO Facility Representatives have encountered no difficulty in observing work at BNL, either formally or informally, and have access to the BSA databases.

The participation of a BHSO Facility Representative in a BSA Tier 1 inspection is typically a risk-based decision influenced by known events, regulatory requirements, the need to maintain operational awareness, or simply because concerns held by the Facility Representative as representing a higher risk. Because Tier 1 inspections are scheduled by each BNL organization, the frequency by which any particular type of work might be scheduled for self-inspection can vary.

3.8. Summary of Causal Factor Analysis

3.8.1. Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all tasks. A barrier is any management or physical means used to control, prevent, or impede the hazard from reaching the target (i.e., persons or objects that a hazard may damage, injure, or harm). The results of the barrier analysis are integrated into the events and causal factors chart to support the development of causal factors. Appendix D contains the Board's Barrier Analysis of physical and management barriers that did not perform as intended as thereby contributed to the accident.

3.8.2. Events and Causal Factor Analysis

The Events and Causal Factors Analysis is a systematic process that uses deductive reasoning to determine causal factors of an accident. Causal factors are the significant events and conditions that produced or contributed to the direct cause, the contributing causes, and root cause(s) of the accident. The Board created an Events and Causal Factors Chart (Appendix E) to assist in determining the causal factors of this accident.

3.8.2.1. Direct Cause

The direct cause is the immediate event or condition that caused the accident or event. The Board concluded that the direct cause was the employee fell from the fixed ladder after losing three points of contact, striking the asphalt pavement.

3.8.2.2. Contributing Causes

Contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the event but which did not cause this event. The Events and Causal Factors Chart (Appendix E) shows the five contributing causes and associated facts identified for this accident:

- BSA failed to satisfy 29 CFR 1910 fixed ladder requirements as required by 10 CFR 851;
- the BSA Tier 1 safety inspection process is inadequate for the identification of unsafe conditions and practices;
- the BSA employee concerns program is not being utilized as a means of challenging unsafe conditions;

- the BSA work planning and control process was not followed for identifying work hazards and developing controls for this task; and
- the BSA work planning and control process failed to provide adequate hazard recognition which led to a false judgment that elevated work is low hazard work.

3.8.2.3. Root Cause

Root causes are the events or conditions that, if corrected, will prevent recurrence of this and similar events. The Board identified the root cause of this event as the BSA hazard recognition process failed to identify the inherent risk associated with elevated work when climbing a fixed ladder. The Board concluded that if this management process had been implemented, and if BSA had ensured it was implemented effectively, BSA workers would have been better prepared for work assignments involving climbing fixed ladders.

4.0 Conclusion and Judgments of Need

Judgments of Need (JONs) JONs are the managerial controls and safety measures determined by the Board to be necessary to prevent or minimize the probability or severity of a recurrence. These JONs are linked directly to the causal factors derived from the facts and analysis. They form the basis for CAPs, which must be developed by line management. The Board's conclusions and JONs are listed in Table3.

Table 3: Conclusions and Judgments of Need

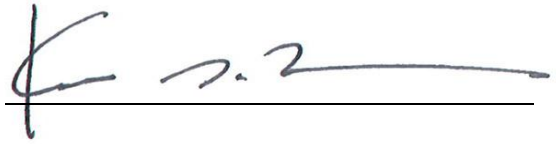
Conclusion	Judgment of Need
The Board concluded that the BSA fixed ladder safety program is not compliant with 10 CFR 851 and BSA's own safety program documentation. BSA had not effectively integrated its 10 CFR 851 program elements for addressing inspections, hazard controls, and training, for fixed ladders. The BSA SBMS requirement for annual fixed ladder inspections was not followed. Also, there was no technical inspection criteria established for, or training provided to, safety personnel to conduct a compliant inspection process for fixed ladders.	**(JON 1)** BSA needs to revise SBMS to ensure fixed ladder inspection criteria are included to ensure compliance with ANSI14.3 and 29 CFR 1910.27.
The Board concluded there is no established Job Risk Analysis for generic climbing of a fixed or portable ladder.	**(JON 2)** BSA needs to document (through job risk analyses) the hazards associated and recommended controls for elevated work when performed on or access from all fixed ladders.

Conclusion	Judgment of Need
The Board concluded Facilities and Operations (F&O) Procedure EP-ES&H-006, Work Planning and Control relies on the preparer to consult the SBMS Graded Approach Subject Area. It is not clear how the preparer of the Worker Order could incorporate this subject area into work planning since it did not reference work at elevated heights. The Board concluded Work Order EP-892181 did not receive review to ensure the adequacy of the risk/hazard evaluation of the planned work.	**(JON 3)** BSA needs to revise the work planning and control process to categorize work according to all recognized hazards, and to reduce the practice of defaulting to worker planned work even when significant hazards are present.
The Board concluded that over a period of years there were multiple missed opportunities to have identified and corrected the deficiencies in the BSA fixed ladder safety program. Initially under application of ANSI A14.3-1956in 1962 when the ladder was constructed and again in 1968 when the ladder was relocated, then in 1973 when OSHA 29 CFR 1910 became a requirement, and lastly under the BSA requirements for annual inspections.	**(JON4)** BSA needs to implement a comprehensive fixed ladder inspection program that identifies deficiencies and ensures implementation of effective corrective actions.
The Board concluded there was a missed opportunity in the training module to inform the employee of the hazards associated with the work activities involving fixed ladders.	**(JON 5)**BSA needs to revise their ladder safety training module to detail the hazards and safe use of all ladders.
The Board concluded not all employees are attending required ladder safety training before attempting to access fixed ladders.	**(JON 6)** BSA needs to ensure all supervisors have verified that subordinates have completed all requirements as identified by their Job Training Assessment.
The Board concluded the Tier 1 process as designed and currently being used did not address this fixed ladder.	**(JON 7)** BSA needs to develop an effective safety and health inspection program for identifying workplace hazards and implementing effective controls for ensuring compliance with contractual requirements established by 10 CFR 851.

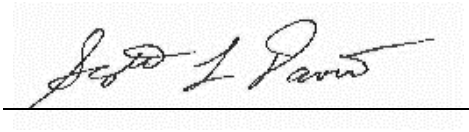
Conclusion	Judgment of Need
The Board concluded F&O management did not formally communicate their expectations for implementing the F&O Procedure EP-ES&H-006, Work Planning and Control for work estimation in hazardous (elevated) areas. The Board found the F&O work planning and control process is inadequate to identify hazards associated with work estimates at heights and did not provide the necessary controls to implement this work safely. The Board concluded that the work planning and control process "worker planned work" used a graded approach for this estimation effort and allowed for elevated work to be considered as low hazard work. The Board concluded the work planning and control process failed to provide adequate hazard recognition which led to a false judgment that elevated work is low hazard work. The Board concluded the BSA work control process was not followed for work estimation being conducted though it presented the same hazards as actually performing the permitted work, i.e., caulking of duct housing. The Board concluded the work planning and control process failed to provide adequate hazard recognition which led to a false judgment that elevated work is low hazard work. The Board concluded that Brookhaven National Laboratory (BNL)'s SBMS Procedure for Fall Protection, Rev 1.3, needs to apply to all elevated work, and that even if the work being performed is not associated with the planned work and is outside the scope of the work package, the	**(JON 8)** BSA needs to revise work planning and control requirements to ensure that during all phases of performing work (including estimation) hazards are effectively evaluated and appropriate controls are implemented.

Conclusion	Judgment of Need
fall hazard exists and still needs to be addressed.	
The Board concluded there were multiple missed opportunities to identify and correct the hazards associated with this work activity. The failure of multiple safety system components, i.e., hazard recognition, work planning and control (WPC), Employee Concerns, Tier 1 inspections, Safety Observation Program, lessons learned incorporated into work packages; which were not adequately integrated. The Board concluded BSA safety systems were not sufficiently integrated to support worker safety. The Board concluded the safety management systems reviewed are not adequately integrated to identify and correct this fixed ladder. The Board concluded there were multiple missed opportunities to identify and correct the hazards associated with the work. The Board concluded that this form of elevated work was not performed under a work permit and has required specific knowledge beyond "Skill of the Craft" performance.	**(JON 9)** BSA needs to ensure SBMS hazard recognition and feedback mechanisms are integrated for effective communication of risks associated with fixed ladders.

5.0 Accident Investigation Board Signatures



Karl G. Moro, Chairperson*
DOE Accident Investigation Board
U.S. Department of Energy
Office of Science Chicago Office



Scott L. Davis
DOE Accident Investigation Board
U.S. Department of Energy
Office of Science

David Pegram*
DOE Accident Investigation Board
U.S. Department of Energy
Office of Health, Safety and Security

Christopher Seniuk*
DOE Accident Investigation Board
U.S. Department of Energy
Office of Science Brookhaven Site Office

* DOE Trained Accident Investigator

6.0 Accident Investigation Board Members and Advisors

Chairperson	Karl G. Moro, Office of Science - Chicago Office
Member	Scott L. Davis, Office of Science
Member	David Pegram, Office of Health, Safety and Security
Member	Christopher Seniuk, Office of Science - Brookhaven Site Office
Advisor	Robert Koedam, Office of Science - New Brunswick Laboratory
Technical Writer	Susan M. Keffer, Project Enhancement Corporation

Appendix A: Accident Investigation Board Appointment Memorandum

Department of Energy
Brookhaven Site Office
P.O. Box 5000
Upton, New York 11973

JUL 11 2012

Karl Moro
Safety and Technical Services
Office of Science
Chicago Office

SUBJECT: APPOINTMENT OF A DEPARTMENT OF ENERGY (DOE) INVESTIGATION TEAM TO INVESTIGATE THE JUNE 29, 2012 FALL AT BUILDING 830 FROM A FIXED LADDER AT BROOKHAVEN NATIONAL LABORATORY (BNL)

References:
1. Memorandum from J. McBrearty, SC-3 to F. Crescenzo, SC-BHSO, Subject: Independent Evaluation Team Tasking, dated July 10, 2012
2. Memorandum from G. Goode, BSA to Distribution, Subject: Investigation and Causal Analysis of Fall at Bldg. 830, Fixed Ladder

On June 29, 2012, an injury occurred at BNL's Building 830. While a sheet metal worker was climbing a fixed ladder to walk down a future job he fell approximately 15 feet to the pavement. The worker suffered injuries and was hospitalized for longer than five calendar days.

An investigation was initiated by Brookhaven Science Associates (BSA). According to the charge letter, that investigation is to focus on the cause for the accident and to include a review of contractual requirements and oversight implementation. The BSA investigation team was directed to begin on July 2, 2012 and to deliver a final report by July 25, 2012. BHSO has been observing the BSA investigation.

In accordance with DOE Order 225.1B "*Accident Investigation*" I hereby appoint you to chair a DOE led accident investigation board to investigate this accident. In addition to being guided by DOE Order 225.1B, in particular I want the Accident Investigation Board to evaluate the following:

- Adequacy of the BNL investigation and review including causal analysis, issue identification and suggested corrective actions (both interim and long-term);
- Inadequacies associated with BNL's Contractor Assurance System that led to the incident.

You shall provide BHSO management with periodic reports on the status of the investigation but will not include any findings or arrive at any premature conclusions until an analysis of all the causal factors have been completed. Draft copies of the factual portion of the report will be submitted to BSHO and the contractor for factual accuracy review prior to report finalization.

The final report should be provided to me by August 10, 2012. Any delay in this date shall be justified and forwarded to BHSO. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report. If you have any questions, please call me at (631) 344-3433.

Frank J. Crescenzo
Acting Site Manager

cc: J. McBrearty, SC-3, FORS
M. Jones, SC-31, GTN
C. Lewis, HS-31, FORS
R. Purucker, SC-CH
K. Moro, SC-CH
L. Sadler, SC-CH
J. Eng, SC-BHSO
R. Desmarais, SC-BHSO
C. Seniuk, SC-BHSO
J. Cracco, SC-BHSO
S. Aronson, BSA
M. Bebon, BSA
L. Bates, BSA
G. Goode, BSA
R. Costa, BSA

Appendix B: Chronology of the Fixed Ladder Fall at Building 830 Event

Table B-1: Chronology of the Accident

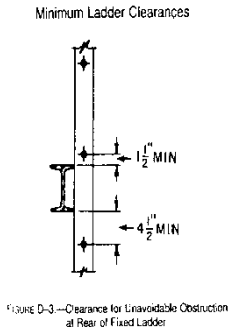
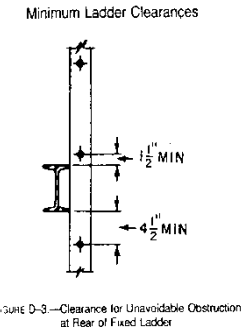
Date	Time	Event
Circa 1962	-	Building 830 is constructed
Circa 1968	-	Lab 17 addition is constructed and existing fixed ladder relocated at Building 830 to present location
May 10, 2010	-	MMW completes ladder training (no expiration on training)
June 6, 2012		Work Order # EP 892181 is initiated
June 22, 2012	-	Work Order # EP 892181 entered into Maximo
June 29, 2012		MMW arrives back to work
June 29, 2012		FPM and FCE decide to conduct a walk-down of the task and contact the MMW
June 29, 2012	1413	BSA declares a "heat stress day"
June 29, 2012	1420	FPM and FCE for East Complex meet and discuss the estimated costs of work
June 29, 2012		FPM, FCE and MMW on site and conduct a pre-job briefing to discuss the intended task
June 29, 2012	-	MMW begins ascent of ladder, at 15 feet above the pavement, MMW begins losing three points of contact
June 29, 2012	~1435	MMW fall from fixed ladder striking asphalt pavement
June 29, 2012	1439	FPM calls Emergency Dispatcher (2222) to report fall injury
June 29, 2012	1441	Ambulance dispatched and en route to accident scene
June 29, 2012	1443	Ambulance arrives at accident scene - EMTs evaluate MMW
June 29, 2012	1444	Fire/Rescue contacts Emergency Dispatcher and requests Safety to respond to secure site
June 29, 2012	1449	Laboratory Protection Officers arrive at scene

Date	Time	Event
June 29, 2012	1503	Ambulance leaves scene, transporting MMW to Brookhaven Memorial Hospital
June 29, 2012	1503	Safety takes charge of accident scene and began to collect data
June 29, 2012	1533	Ambulance arrives at BMH at and MMW is admitted
June 29, 2012	1540	Laboratory Protection observed site cleared of personnel
July 2, 2012		BSA Accident Investigation Committee formed and charged with finding the cause of the accident
July 5, 2012		MMW hospitalized for more than five days
July 11, 2012		Acting BHSO Site Manager appoints DOE Accident Investigation Board

Appendix C: Compliance of the Fixed Ladder

Table C-1: Compliance Status of the Fixed Ladder

Topic	ANSI A14.3 1956 Requirements	OSHA 1910.27 Requirements	Compliance Status
Rung Diameter	All rungs shall have a minimum diameter of three-fourths inch for metal ladders.	All rungs shall have a minimum diameter of three-fourths inch for metal ladders. [1910.27(b)(1)(i)]	The involved ladder meets this requirement.
Distance Between Rungs	The distance between rungs, cleats, and steps shall not exceed 12 inches and shall be uniform throughout the length of the ladder.	The distance between rungs, cleats, and steps shall not exceed 12 inches and shall be uniform throughout the length of the ladder. [1910.27(b)(1)(ii)]	The distance between the pavement and the first rung is not twelve inches, therefore not compliant with OSHA.
Distance Between Ladder Rails	The minimum clear length of rungs or cleats shall be 16 inches.	The minimum clear length of rungs or cleats shall be 16 inches. [1910.27(b)(1)(iii)]	The involved ladder meets this requirement.
Gripping Surfaces Free of Burrs, Sharp Edges	Side rails which might be used as a climbing aid shall be of such cross sections as to afford adequate gripping surface without sharp edges, splinters, or burrs.	Side rails which might be used as a climbing aid shall be of such cross sections as to afford adequate gripping surface without sharp edges, splinters, or burrs. [1910.27(b)(2)]	The involved ladder meets this requirement.
Clear Width to the Vertical Center Line of the Fixed Ladder	A clear width of at least 15 inches shall be provided each way from the centerline of the ladder in the climbing space.	A clear width of at least 15 inches shall be provided each way from the centerline of the ladder in the climbing space, except when cages or wells are necessary. [1910.27(c)(2)]	The Ladder Guard (preventing access) is mounted to the left ladder rail; there is no clear width of 15 inches on the left side of the ladder; therefore not compliant with OSHA, ANSI A14.3-1956.

Topic	ANSI A14.3 1956 Requirements	OSHA 1910.27 Requirements	Compliance Status
Permitted Clearance Behind the Fixed Ladder	The distance from the centerline of rungs, cleats, or steps to the nearest permanent object in back of the ladder shall be not less than 7 inches, except that when unavoidable obstructions are encountered, minimum clearances as shown in figure D-3 shall be provided.  FIGURE D-3.—Clearance for Unavoidable Obstruction at Rear of Fixed Ladder	The distance from the centerline of rungs, cleats, or steps to the nearest permanent object in back of the ladder shall be not less than 7 inches, except that when unavoidable obstructions are encountered, minimum clearances as shown in figure D-3 shall be provided.  FIGURE D-3.—Clearance for Unavoidable Obstruction at Rear of Fixed Ladder [1910.27(c)(4)]	The 1992 installation of the electrical conduit violates the seven inch clearance requirement; therefore not compliant with OSHA, ANSI A14.3-1956.
Step Across Distance Between Fixed Ladder Rung and Platform or Landing	The step-across distance from the nearest edge of ladder to the nearest edge of equipment or structure shall be not more than 12 inches, or less than 2 1/2 inches.	The step-across distance from the nearest edge of ladder to the nearest edge of equipment or structure shall be not more than 12 inches, or less than 2 1/2 inches. [1910.27(c)(6)]	The involved ladder meets this requirement.

Topic	ANSI A14.3 1956 Requirements	OSHA 1910.27 Requirements	Compliance Status
Top Rung of Ladder Flush with Landing, Platform or Parapet	The top rung of the ladder must be flush with the parapet, floor or the platform.	The top rung flush with landing are illustrated in some of the drawings, but not discussed in the standard. Where a man has to step a distance greater than 12 inches from the centerline of the rung of a ladder to the nearest edge of structure or equipment, a landing platform shall be provided. The minimum step-across distance shall be 2 1/2 inches. [1910.27(d)(2)(i)]	The top rung of the involved ladder is not flush with the platform; therefore it does not meet the ANSI A14.3 - 1956requirement.
Height and Width of Ladder Extension Rails	The ladder rail extensions shall extend 3 1/2 feet above parapets and landings. Ladder extension widths shall not be less than 18 or more than 24 inches clearance between ladder rail extensions.	The side rails of through ladder extensions shall extend 3 1/2 feet above parapets and landings. For through ladder extensions, the rungs shall be omitted from the extension and shall have not less than 18 or more than 24 inches clearance between rails. [1910.27(d)(3)]	The height of the extension rails meet the OSHA and ANSI requirements (it is 38 inches and is required to be 42 inches) but the width between the extension rails does not meet any of the ANSI or OSHA requirements, therefore not compliant with OSHA, ANSI A14.3-1956.
Preferred Pitch of Fixed Ladders	The preferred pitch of fixed ladders shall be considered to come in the range of 75º and 90º with the horizontal.	The preferred pitch of fixed ladders shall be considered to come in the range of 75º and 90º with the horizontal. [1910.27(e)(1)]	The involved ladder meets this requirement.

Appendix D: Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all tasks. A barrier is any means used to control, prevent, or impede a hazard from reaching a target, thereby reducing the severity of the resultant accident or adverse consequence. A hazard is the potential for an unwanted condition to result in an accident or other adverse consequence. A target is a person or object that a hazard may damage, injure, or fatally harm. Barrier analysis determines how a hazard overcomes the barriers, comes into contact with a target (e.g., from the barriers or controls not being in place, not being used properly, or failing), and leads to an accident or adverse consequence. The results of the barrier analysis are used to support the development of causal factors.

Table D-1. Barrier Analysis

Hazard: Fixed Ladder		**Target: Worker**		**Context**
What Were the Barriers?	**How Did Each Barrier Perform?**	**Why Did the Barrier Fail?**	**How Did the Barrier Affect the Accident?**	**HPI/ISM**
Ladder Design Standard (ANSI-14.3-1956)	Failed to apply and verify requirements	Initial design did not position the last rung level to the platform; the width between the ladder extension rails was 36 inches instead of 24 inches, and the ladder extension rails were only 38 inches high, instead 42 inches	Although the design of the ladder not compliant with the standard, the Board was unable to meet with the injured worker to confirm the impact of the flawed designed	TD#6: Interpretation of requirements GP#6: Engineering controls not tailored to work

Hazard: Fixed Ladder		Target: Worker		Context
What Were the Barriers?	**How Did Each Barrier Perform?**	**Why Did the Barrier Fail?**	**How Did the Barrier Affect the Accident?**	**HPI/ISM**
29 CFR 1910 Compliance	Failed to apply and verify requirements	Seven inch set back was reduced to 6.5 inches by electrical conduit installed in early 1990s Electrical conduit installed 0.5 inches above the ladder rung Requirement is immovable objects can be installed 4.5 inches above the ladder rung or 1.5 inches below the ladder rung 15 inch minimum clearance from vertical center line of rung reduced by installation of ladder guard	Although the design of the ladder not compliant with the standard, the Board was unable to meet with the injured worker to confirm the impact of the flawed designed	TD#6: Interpretation of requirements GP#6: Engineering controls not tailored to work
SBMS Requirement for Annual Fixed Ladder Inspections	Failed to be implemented	BSA did not meet the annual requirement for fixed ladder inspections	Annual inspections could have found and corrected the design deficiencies	CF#3: Develop and implement hazard controls
SBMS Subject Area for Walking Working Surfaces (Fixed Ladders)	Failed to specify criteria for annual inspections	BSA criteria for fixed ladder inspections does not exist in SBMS	Deficient ladder would have been recognized and corrected	CF#2: Identify and analyze hazards

Hazard: Fixed Ladder		Target: Worker		Context
What Were the Barriers?	**How Did Each Barrier Perform?**	**Why Did the Barrier Fail?**	**How Did the Barrier Affect the Accident?**	**HPI/ISM**
Quality Assurance, verification of implementation of fixed ladder inspection requirement	Failed to recognize that the annual inspections were not performed	BSA did not validate the implementation of the procedures associated with fixed ladder inspections	Permitted deficient conditions to persist over numerous years	CF#5: Feedback and improvement
Employee Concerns	Failed, employees did not communicate their concerns through the Employee Concerns Program	There is apprehension by employees not to express concerns. Employees accepted conditions as existed	Missed opportunities to identify deficient fixed ladder	CF#5: Feedback and improvement
Work Planning & Control	Failed, it did not address elevated work	F&O determined this task was low hazard worker planned work	SBMS Graded Approach matrix does not identify elevated work	CF#2: Develop and analyze hazards GP#5: Recognize hazards and establish controls TD#6: Interpretation requirements TD#8: Lack of or unclear standards

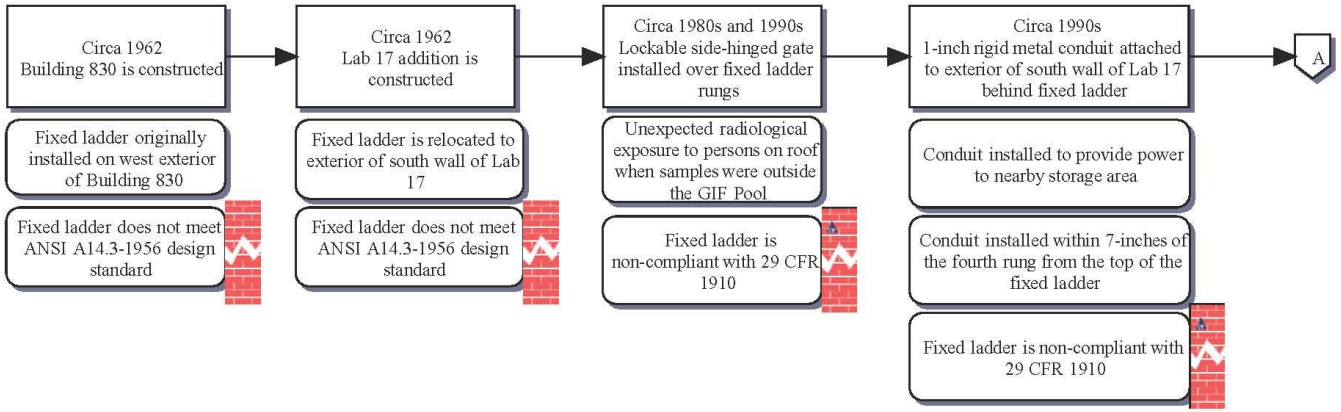
Hazard: Fixed Ladder		**Target: Worker**		**Context**
What Were the Barriers?	**How Did Each Barrier Perform?**	**Why Did the Barrier Fail?**	**How Did the Barrier Affect the Accident?**	**HPI/ISM**
SBMS Subject Area, Work Planning & Control	Failed to follow the Work Planning and Control Subject Area, which includes completing the work permit	Presumption that work was considered low hazard work	Missed opportunities to identify hazards and establish controls	CF#2: Develop and analyze hazards CF#3: Develop and implement controls CF#4: Perform work within controls CF#5: Feedback and improvement GP#5: Recognize hazards and establish controls TD#6: Interpretation requirements
Tier 1 Inspections	Failed to recognize deficient fixed ladder	Tier 1 inspection criteria was interpreted not to include fixed ladders	Missed opportunities to identify deficient fixed ladder	CF#5: Feedback and improvement HM#5: Mindset, preconceived idea
Integrated Hazard Recognition Process	Fixed ladder compliance is not recognized	The expectation for determining fixed ladder compliance is not understood	Missed opportunities to identify deficient fixed ladder	CF#5: Feedback and improvement HM#5: Mindset, preconceived idea

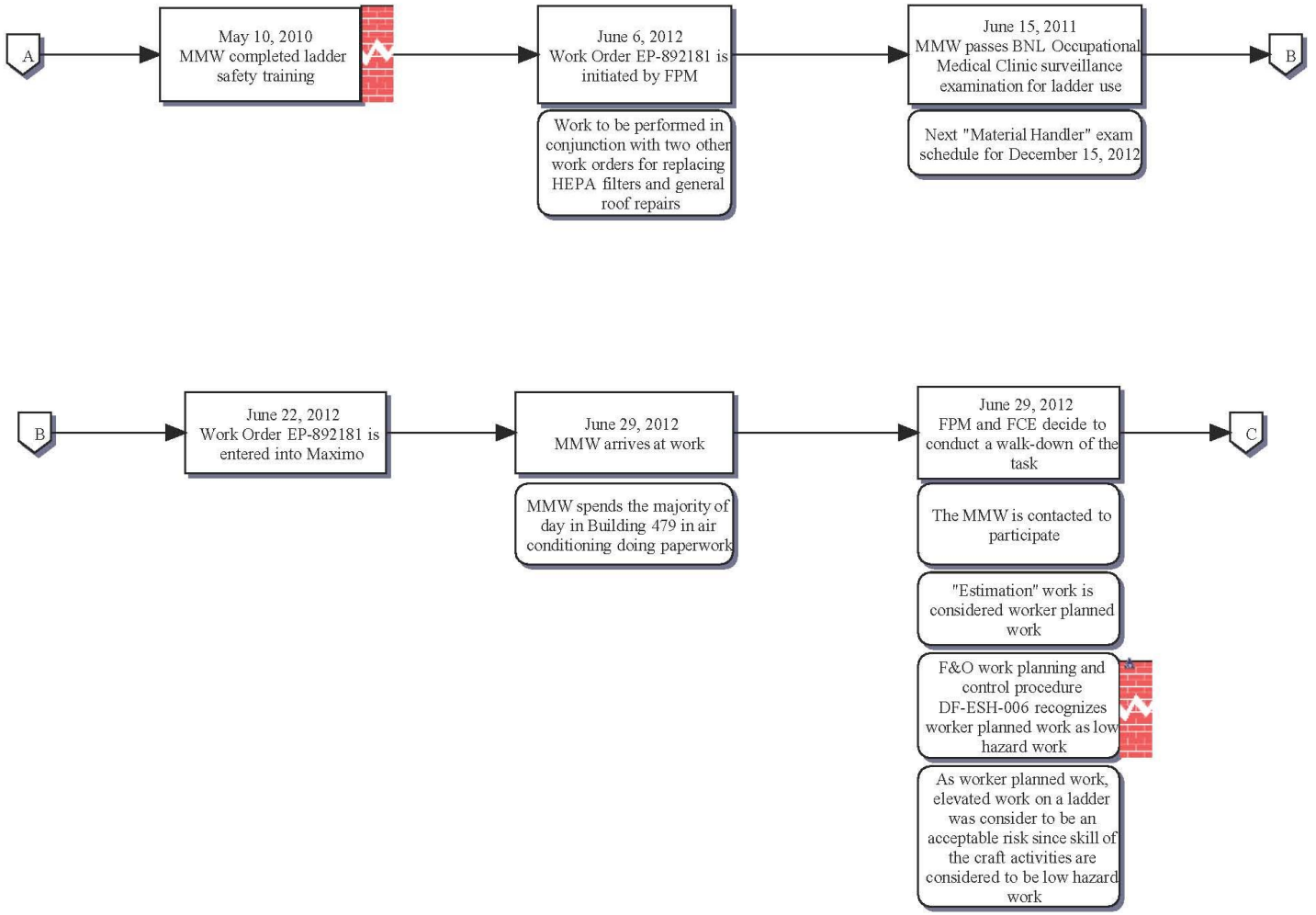
Hazard: Fixed Ladder		**Target: Worker**		**Context**
What Were the Barriers?	**How Did Each Barrier Perform?**	**Why Did the Barrier Fail?**	**How Did the Barrier Affect the Accident?**	**HPI/ISM**
BSA Ladder Safety Training	Failed; fixed ladders are not explicitly addressed	Never included in training module	Hazards associated with use of fixed ladders were not addressed	GP#3: Competence commensurate with responsibility TD#7: Unclear goals, roles, and responsibilities
Integration of Safety Management System elements	Failed; systems did not identify fixed ladders as a safety significant issues	Multiple safety management systems are not integrated or utilized	Missed opportunities to identify deficient fixed ladder	CF#5: Feedback and improvement HM#5: Mindset, preconceived idea

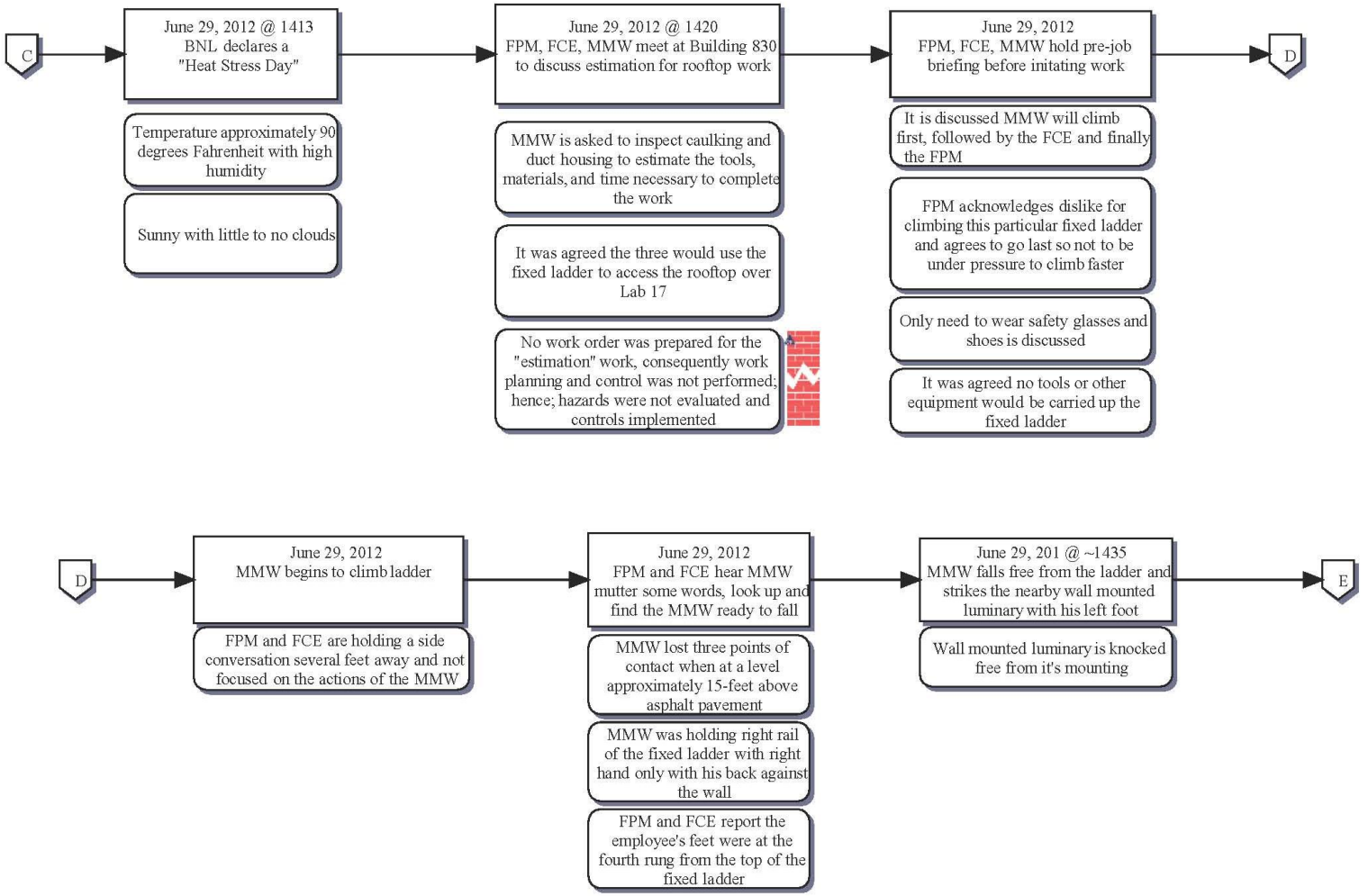
Appendix E: Events and Causal Factor Analysis

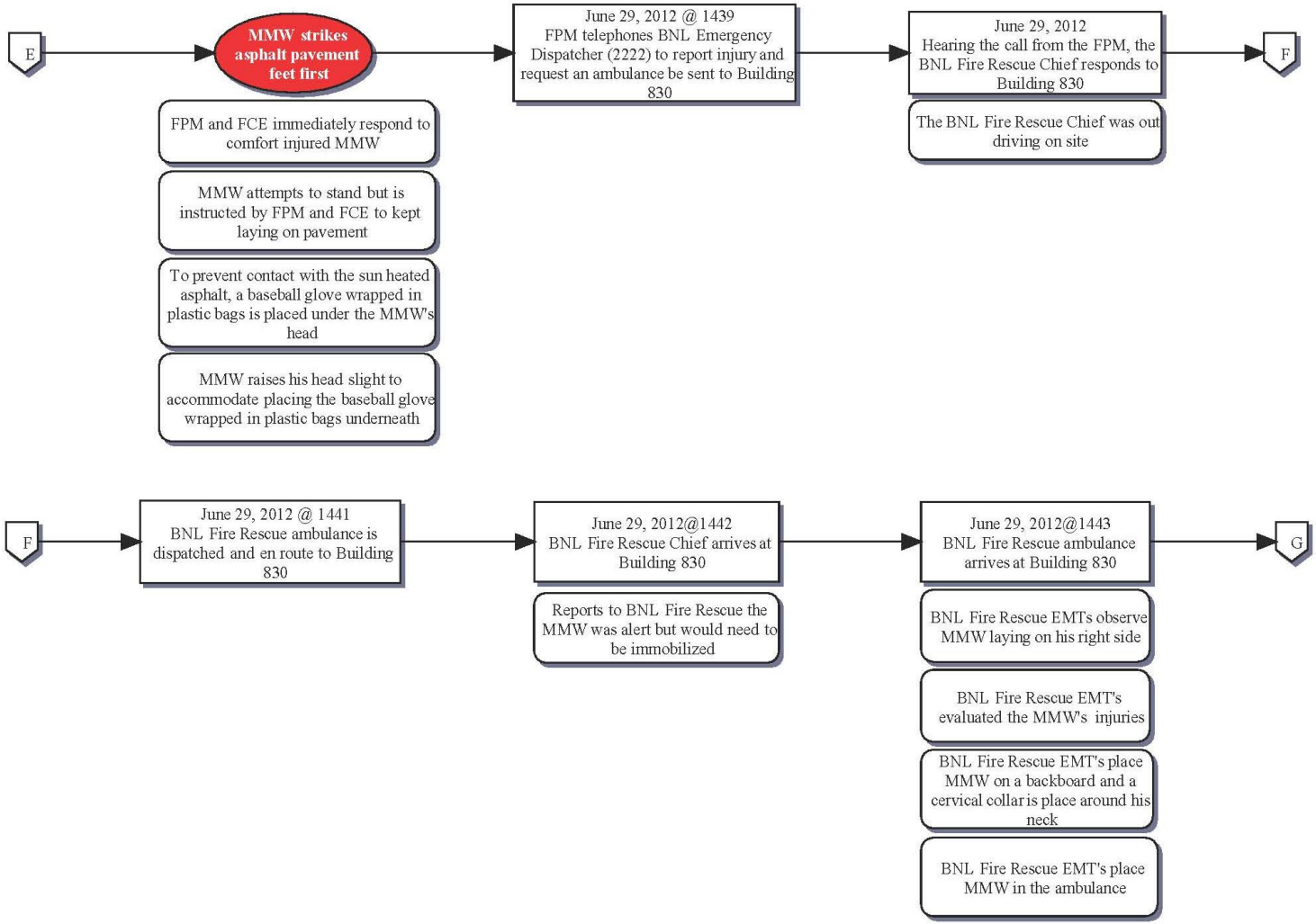
An events and causal factors analysis was performed in accordance with the DOE Workbook *Conducting Accident Investigations*. The events and causal factors analysis requires deductive reasoning to determine those events and/or conditions that contributed to the accident. Causal factors are the events or conditions that produced or contributed to the accident, and they consist of direct, contributing, and root causes. The direct cause is the immediate event(s) or condition(s) that caused the accident. The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the accident, but which did not solely cause the accident. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar accidents. The causal factors are identified in Table E-1.

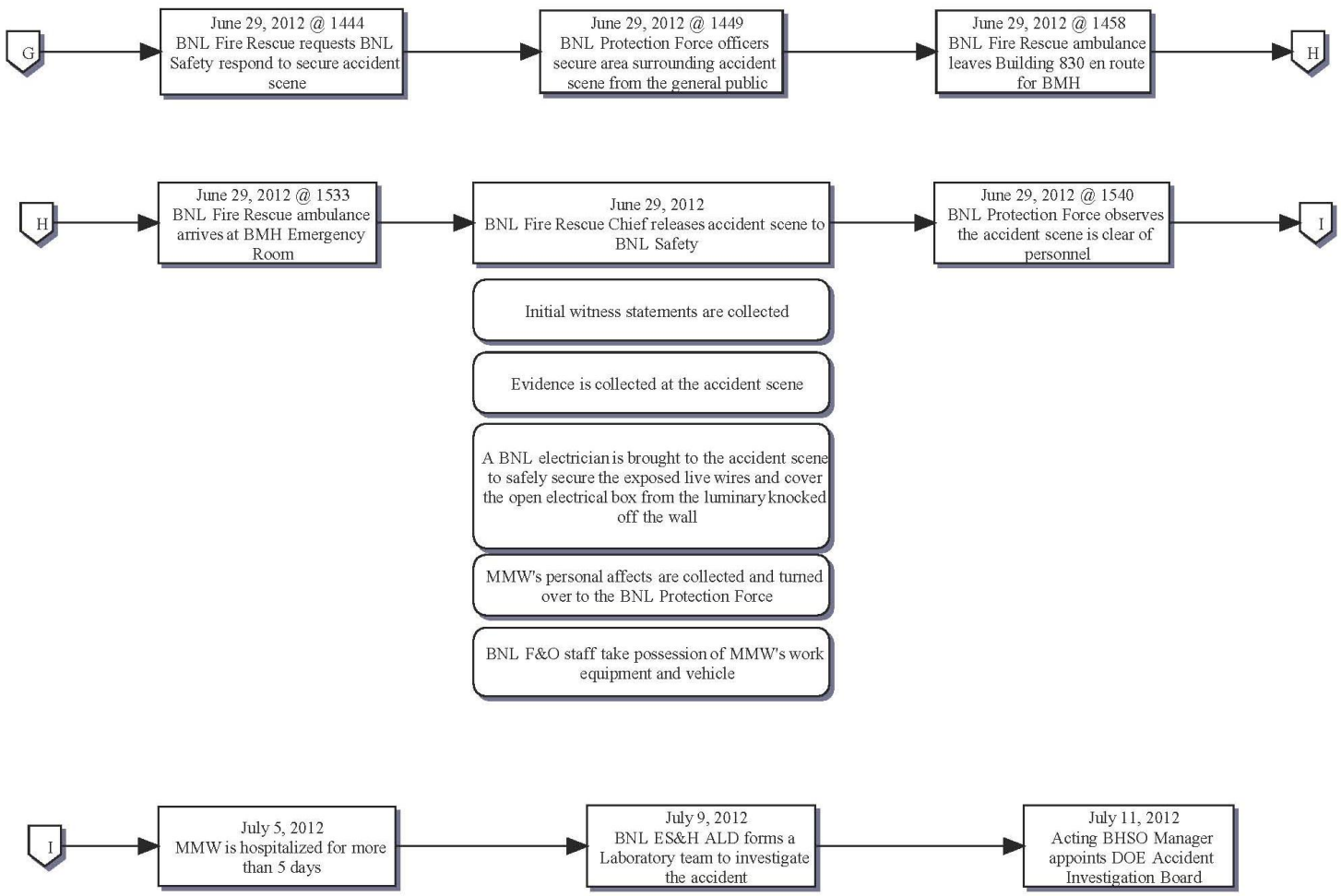
Table E-1: Events and Causal Factor Chart




A
May 10, 2010
MMW completed ladder safety training
June 6, 2012
Work Order EP-892181 is initiated by FPM
Work to be performed in conjunction with two other work orders for replacing HEPA filters and general roof repairs
June 15, 2011
MMW passes BNL Occupational Medical Clinic surveillance examination for ladder use
Next "Material Handler" exam schedule for December 15, 2012
B
B
June 22, 2012
Work Order EP-892181 is entered into Maximo
June 29, 2012
MMW arrives at work
MMW spends the majority of day in Building 479 in air conditioning doing paperwork
June 29, 2012
FPM and FCE decide to conduct a walk-down of the task
The MMW is contacted to participate
"Estimation" work is considered worker planned work
F&O work planning and control procedure DF-ESH-006 recognizes worker planned work as low hazard work
As worker planned work, elevated work on a ladder was consider to be an acceptable risk since skill of the craft activities are considered to be low hazard work
C


C
June 29, 2012 @ 1413
BNL declares a
"Heat Stress Day"
Temperature approximately 90 degrees Fahrenheit with high humidity
Sunny with little to no clouds
June 29, 2012 @ 1420
FPM, FCE, MMW meet at Building 830 to discuss estimation for rooftop work
MMW is asked to inspect caulking and duct housing to estimate the tools, materials, and time necessary to complete the work
It was agreed the three would use the fixed ladder to access the rooftop over Lab 17
No work order was prepared for the "estimation" work, consequently work planning and control was not performed; hence; hazards were not evaluated and controls implemented
June 29, 2012
FPM, FCE, MMW hold pre-job briefing before initating work
D
It is discussed MMW will climb first, followed by the FCE and finally the FPM
FPM acknowledges dislike for climbing this particular fixed ladder and agrees to go last so not to be under pressure to climb faster
Only need to wear safety glasses and shoes is discussed
It was agreed no tools or other equipment would be carried up the fixed ladder
D
June 29, 2012
MMW begins to climb ladder
FPM and FCE are holding a side conversation several feet away and not focused on the actions of the MMW
June 29, 2012
FPM and FCE hear MMW mutter some words, look up and find the MMW ready to fall
MMW lost three points of contact when at a level approximately 15-feet above asphalt pavement
MMW was holding right rail of the fixed ladder with right hand only with his back against the wall
FPM and FCE report the employee's feet were at the fourth rung from the top of the fixed ladder
June 29, 201 @ ~1435
MMW falls free from the ladder and strikes the nearby wall mounted luminary with his left foot
Wall mounted luminary is knocked free from it's mounting
E


E
MMW strikes asphalt pavement feet first
June 29, 2012 @ 1439
FPM telephones BNL Emergency Dispatcher (2222) to report injury and request an ambulance be sent to Building 830
June 29, 2012
Hearing the call from the FPM, the BNL Fire Rescue Chief responds to Building 830
F
FPM and FCE immediately respond to comfort injured MMW
MMW attempts to stand but is instructed by FPM and FCE to kept laying on pavement
To prevent contact with the sun heated asphalt, a baseball glove wrapped in plastic bags is placed under the MMW's head
MMW raises his head slight to accommodate placing the baseball glove wrapped in plastic bags underneath
The BNL Fire Rescue Chief was out driving on site
F
June 29, 2012 @ 1441
BNL Fire Rescue ambulance is dispatched and en route to Building 830
June 29, 2012@1442
BNL Fire Rescue Chief arrives at Building 830
June 29, 2012@1443
BNL Fire Rescue ambulance arrives at Building 830
G
Reports to BNL Fire Rescue the MMW was alert but would need to be immobilized
BNL Fire Rescue EMTs observe MMW laying on his right side
BNL Fire Rescue EMT's evaluated the MMW's injuries
BNL Fire Rescue EMT's place MMW on a backboard and a cervical collar is place around his neck
BNL Fire Rescue EMT's place MMW in the ambulance


G
June 29, 2012 @ 1444
BNL Fire Rescue requests BNL Safety respond to secure accident scene
June 29, 2012 @ 1449
BNL Protection Force officers secure area surrounding accident scene from the general public
June 29, 2012 @ 1458
BNL Fire Rescue ambulance leaves Building 830 en route for BMH
H
H
June 29, 2012 @ 1533
BNL Fire Rescue ambulance arrives at BMH Emergency Room
June 29, 2012
BNL Fire Rescue Chief releases accident scene to BNL Safety
June 29, 2012 @ 1540
BNL Protection Force observes the accident scene is clear of personnel
I
Initial witness statements are collected
Evidence is collected at the accident scene
A BNL electrician is brought to the accident scene to safely secure the exposed live wires and cover the open electrical box from the luminary knocked off the wall
MMW's personal affects are collected and turned over to the BNL Protection Force
BNL F&O staff take possession of MMW's work equipment and vehicle
I
July 5, 2012
MMW is hospitalized for more than 5 days
July 9, 2012
BNL ES&H ALD forms a Laboratory team to investigate the accident
July 11, 2012
Acting BHSO Manager appoints DOE Accident Investigation Board