

Accident Investigation Board

**Building 488 Tree Felling Injury at
Brookhaven National Laboratory**

March 5, 2011



April 2011

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

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**Accident Report for the Building 488 Tree Felling Injury
at Brookhaven National Laboratory, March 5, 2011**

Disclaimer

This report is an independent product of the Accident Investigation Board appointed by Michael D. Holland, Manager, Brookhaven Site Office, U.S. Department of Energy on March 8, 2011.

The Accident Investigation Board was appointed to perform an investigation of this accident and to prepare an investigation report in accordance with DOE O 225.1B, *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.

**Accident Report for the Building 488 Tree Felling Injury
at Brookhaven National Laboratory, March 5, 2011**

Release Authorization

On March 8, 2011, I established an Accident Investigation Board to investigate the March 5, 2011, Building 488 tree felling injury at Brookhaven National Laboratory that resulted in the injury of a Brookhaven National Laboratory Site Resources Division Building and Grounds Utility 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



Michael D. Holland
Manager, Brookhaven Site Office

Accident Report for the Building 488 Tree Felling Injury at Brookhaven National Laboratory, March 5, 2011

Executive Summary

On Saturday, March 5, 2011 at approximately 10:20 a.m., a Brookhaven National Laboratory Building and Grounds Utility Worker was felling a pine tree while elevated in a 60-foot articulating and telescoping boom lift approximately 20-feet above the ground on the south side of Building 488. As the gas-powered, 20-inch chainsaw being used by the employee cut through the tree trunk, an approximately 8-foot long, 18-inch diameter, 520 pound section of tree trunk fell toward the aerial lift, striking the employee's right forearm, and compressing it against the top railing of the aerial lift basket.

Because of the severity of this injury and the prognosis of hospitalization of the employee in excess of 5 days, on March 8, 2011, the Department of Energy's Office of Science Brookhaven Site Office Manager formally appointed an Accident Investigation Board. The Accident Investigation Board was tasked with identifying all relevant facts to determine the direct, root, and contributing causes of the accident; developing conclusions; and determining Judgments of Need that, when implemented, should prevent recurrence of the accident. The Accident Investigation Board initiated the accident investigation on March 10, 2011.

The Accident Investigation Board concluded that this accident was preventable. The direct cause of this accident was the uncontrolled fall of the tree trunk section after it was cut loose from the pine tree. As best could be determined, the piece of trunk section struck the employee because the aerial lift basket was positioned at a place where gravity would cause the trunk section to fall. Though the trunk was leaning to the north/northeast (toward Building 488), it was believed that the employee expected the trunk section to fall away from the aerial lift basket after completing a downward angled (southeast to northwest) through-cut. However, as that cut was completed, gravity immediately allowed the already leaning trunk section to fall to the north/northeast and onto the employee.

The Accident Investigation Board identified two root causes: the Facilities and Operations Directorate failed to conduct thorough hazard analyzes and implement effective work controls for protecting workers performing tree felling work; and the Facilities and Operations Directorate failed to ensure workers possessed needed skills to perform tree felling work, and have knowledge of industry work practices so as to recognize unsafe conditions. Three contributing causes were also identified: F&O failed to manage tree felling as greater than low ESS&H risk work; F&O inadequately communicated management expectations on the use of a work permit for safely planning tree felling; and F&O failed to ensure JRA-SI-SITEMAINT-16 addresses the hazards associated with tree felling work performed while elevated by an aerial lift.

Table 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 1 are Judgments of Need determined by the Accident Investigation Board as managerial controls and safety measures necessary to prevent or minimize the probability or severity of a recurrence.

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Table 1: Conclusions and Judgments of Need

Conclusion	Judgment of Need
<ul style="list-style-type: none"> • JRA-SI-SITEMAINT-16 was inadequate in identifying the hazards and controls for felling large trees from an aerial lift. • A more consistent approach to the application of the requirements in Step 2 of SBMS Subject Area, <i>OHSAS 18001 Program</i>, Section 1, Facility, Area, and Job Risk Assessments, would have been to develop a separate JRA for felling large trees. • BNL is not complying with 29 CFR 1910.266(h)(2) requirements for manual tree felling. 	<ul style="list-style-type: none"> • There is a need for Facilities and Operations to develop and implement a separate Job Risk Assessment for felling trees that: <ul style="list-style-type: none"> – Details performing work while elevated in an aerial lift; – Incorporates controls matched to all 29 CFR 1910.266(h)(2) requirements; and – Adopts use of applicable safe work practices of American National Standards Institute Z133.1-2006, <i>American National Standard for Arboricultural Operations – Safety Requirements</i>, to aid in controlling potential energy, i.e., wedges, and ropes, and determining the manageable mass of tree sections (based on species, diameter, and length).
<ul style="list-style-type: none"> • GSG workers operating chainsaws were not wearing all PPE as required by JRA-SI-SITEMAINT-16. • SBMS Subject Area, <i>Work Planning and Control for Experiments and Operations</i>, Section 4, <i>Work Observations</i>, does not require line management work observations be conducted at any periodicity. • F&O line managers are not conducting work observations as required by SBMS Subject Area, <i>Work Planning and Control for Experiments and Operations</i>, as part of work planning and control process evaluation. 	<ul style="list-style-type: none"> • There is a need for Facilities and Operations to revise SBMS Subject Area, <i>Work Planning and Control for Experiments and Operations</i>, Section 4, <i>Work Observations</i>, and implement the need to establish a frequency for performing work observations of on-going work to ensure supervisors have implemented controls established in Job Risk Assessments, and that those controls are appropriate to facilitate the safe performance of that work.

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Conclusion	Judgment of Need
<ul style="list-style-type: none"> • The lack of a step-by-step work plan violates the intent of the work permit requirements in SBMS Subject Area, <i>Work Planning and Control for Experiments and Operations</i>, Subsection 2.4 <i>Permit Planned Work Hazard Identification, Analysis and Controls</i>. • Use of the word “should” in the Step 5 of Subsection 2.4 <i>Permit Planned Work Hazard Identification, Analysis and Controls</i> relies too much on the background, training, and discretion of the WCC and/or supervisor filling out the work permit. • The lack of clear direction for maintaining the size and length of tree trunk sections demonstrates that the work plan and work permit was inadequate for the scope of work. • Use of a single through-cut to fell trunk sections with a diameter in excess of 5-inches as well as the use of a push stick was not consistent with work practices and requirements for this type of work. • F&O management communication for their expectations in using the work permit for tree work was inadequate. • Because the work planning process did not establish a maximum allowable mass of cut tree trunk section, and did not consider the release of potential energy and the influences of gravity on the falling tree trunk sections, had the physical location of the aerial lift basket varied slightly, this accident might have resulted in a more serious injury. 	<ul style="list-style-type: none"> • There is a need for Brookhaven National Laboratory to revise the Standards Based Management System Subject Area, <i>Work Planning and Control for Experimental and Operations</i>, Subsection 2.4, <i>Permit Planned Work Hazard Identification, Analysis and Controls</i>, Step 5, to specify what criteria and level of detail is required in writing work plans. • There is a need for Facilities and Operations to develop and implement a step-by-step work plan for tree felling which addresses the 29 CFR 1910.266(h)(2) requirements, and safe work practices stated in the American National Standards Institute Z133.1-2006, <i>American National Standard for Arboricultural Operations – Safety Requirements</i>. • There is a need for Facilities and Operations to document and formally issue clear direction to planners, supervisors and workers on their requirements and expectations for use of a work permit for felling trees.
<ul style="list-style-type: none"> • F&O managed tree felling as low ES&H risk work. • The view of F&O management as stated in F&O Procedure EP-ES&H-006H, <i>Craft Screen Criteria for Work Permit</i>, is that tree felling is low hazard risk work. 	<ul style="list-style-type: none"> • There is a need for Facilities and Operations to revise Procedure EP-ES&H-006H, <i>Craft Screen Criteria for Work Permit</i>, to correctly classify tree pruning, trimming and removal as greater than “low risk” work. • There is a need for Facilities and Operations to document in procedure EP-ES&H-006H, <i>Craft Screen Criteria for Work Permit</i>, the methodology to be used for determining what work is considered low, moderate, or high risk work. • There is a need for Facilities and Operations to utilize its methodology for determining if work is considered low, moderate, or high risk and determine if work previously identified as low-risk by the Site Resources Division was appropriately determined.
<ul style="list-style-type: none"> • GSG workers were unable to operate equipment provided to summon emergency assistance. 	<ul style="list-style-type: none"> • There is a need for Brookhaven National Laboratory to ensure workers receive instruction in the use of portable communication devices intended for summoning emergency assistance, and are proficient in the use of those devices.

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Conclusion	Judgment of Need
<ul style="list-style-type: none"> • Though aerial lift was frequently used for GSG tree felling work, the BGUW JTA did not require qualification on use of aerial lifts. • Aerial lift training for the BGUW operating the aerial lift during this accident had expired. • GSG Supervisor never compared the BGUW JTA against the JRA to determine the adequacy of employee training needs. • No written record exists of the GSG worker training conducted in response to the July 2007 tree felling incident to determine what information was presented. • Use of the ISA videotapes for tree felling is not managed as an F&O required training course. • GSG Workers and Supervisor were not adequately trained on the hazards and controls for felling a large tree from an aerial lift. • F&O WCCs and ES&H Coordinator are not aware of the requirements in ANSI Z133.1-2006, <i>American National Standard for Arboricultural Operations – Safety Requirements</i>. • F&O management corrective actions stemming from the July 2007 tree felling incident causal analysis was a missed opportunity for establishing needed training and qualifications expectations for GSG workers performing tree felling work. • F&O line managers and ES&H subject matter experts reviewed Work Permit SM-11-003 and signed it that all hazards and risk had been identified and all hazards controlled. 	<ul style="list-style-type: none"> • There is a need for Facilities and Operations to establish and implement formal training for tree felling that incorporates the requirements of 29 CFR 1910.266(h)(2) and applicable safe work practices of American National Standards Institute Z133.1-2006, <i>American National Standard for Arboricultural Operations – Safety Requirements</i>. • There is a need for Facilities and Operations to include as part of the work planning process that supervisors documenting they have matched Job Training Assessments against Job Risk Assessments, and then against the work to be performed to ensure training and qualifications for the hazards likely to be encountered are established and are met. • There is a need for Facilities and Operations to ensure all training provided to its workers is documented and includes a course outline, copies of provided handouts, and the list of attendees, and that training is documented on the worker's Job Training Assessment. • There is a need for Facilities and Operations to train supervisors, planners, and environment, safety and health subject matter experts to ensure they possess needed skills to recognize potential hazards and how to implement the hierarchy of controls for minimizing or eliminating those hazards.
<ul style="list-style-type: none"> • F&O management did not ensure preservation of the accident scene in accordance SBMS requirements. 	<ul style="list-style-type: none"> • There is a need for Brookhaven National Laboratory to revise the Standards Based Management System requirements for preservation of an accident scene to: <ul style="list-style-type: none"> – Require communication with essential Laboratory personnel for establishing authoritative control of an accident scene; – Eliminate the potential of subjective decision-making about preserving evidence; and – Specify responsibilities of on-scene supervision for preserving and collecting of evidence. • There is need for Brookhaven National Laboratory to train line managers and delegates on the need and purpose for preserving evidence at an accident scene, and ensure they are knowledgeable of the applicable Standards Based Management System requirements.

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Conclusion	Judgment of Need
<ul style="list-style-type: none">The April 2010 Tier 1 assessment was a missed opportunity for challenging the existing practices for performing tree felling work by verifying the content of JRA-SI-SITEMAINT-16 against the work plan, the adequacy of work permit risk rating determination, and the effectiveness of the work plan at recognizing hazards and established mitigating controls.	<ul style="list-style-type: none">There is a need for Brookhaven National Laboratory to assess Facilities and Operations performance at conducting work inspections and work observations of worker planned and permitted work to determine if those efforts are effective at driving ES&H improvements.There is a need for Facilities and Operations to assess the effectiveness of all corrective actions implemented since July 2007 related to events stemming from worker planned work or permitted work to ensure that those corrective actions have been effective at resolving the associated issues and underlying causes.

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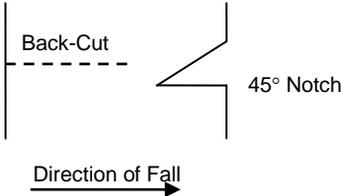
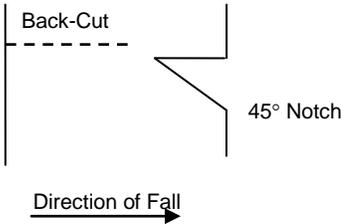
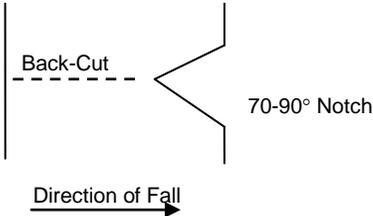
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Acronyms and Abbreviations

AIB	Accident Investigation Board
ALD	Assistant or Associate Laboratory Director
ANSI	American National Standards Institute
ATS	Action Tracking System
BGUW	Building Grounds Utility Worker
BHSO	Brookhaven Site Office
BNL	Brookhaven National Laboratory
BSA	Brookhaven Sciences Associates, LLC
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EMT	Emergency Medical Technician
ES&H	Environment, Safety and Health
ESS&H	Environment, Safety, Security and Health
ESSH&Q	Environment, Safety, Security, Health and Quality
F&O	Facilities and Operations Directorate
FCM	Facility Complex Manager
FPM	Facility Project Manager
GSG	Grounds and Sanitation Group
IFM	Integrated Facility management
ISA	International Society of Arboriculture
ISMDS	Integrated Safety Management System Description
JON	Judgments of Need
JRA	Job Risk Assessment
JTA	Job Training Assessment
L/SO	Laborer/Safety Observer
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
SBMS	Standards Based Management System
SC	Office of Science
SRD	Site Resources Division
STOP	Safety Observation Program
WCC	Work Control Coordinator

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Tree Felling Terms Used in this Report

Back-Cut	The cut made in a tree limb or trunk on the side opposite the intended direction of fall.
Bucking	The act of sawing trees, limbs, or both, into smaller sections once they are on the ground.
Conventional Notch	<p>A directional felling cut into the side of a tree, facing the intended direction of fall and consisting of a horizontal face cut and an angle cut above it, creating a notch of approximately 45 degrees.</p> 
Humboldt Notch	<p>A directional felling cut into the side of a tree, facing the intended direction of fall and consisting of a horizontal face cut and an angle cut below it, creating a notch of approximately 45 degrees. A Humboldt cut is usually reserved for larger trees on steep slopes.</p> 
Open-Face Notch	<p>A directional felling cut into the side of a tree, facing the intended direction of fall and consisting of two cuts creating a notch greater than 70 degrees.</p> 
Wedge	A piece of material with two sides meeting at an angle; used to raise or split objects by applying a driving force, such as a hammer, to start the tree falling and influence the direction of the fall.

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1.0 Introduction

1.1. Background

On March 8, 2011, Michael D. Holland, Manager of the U.S. Department of Energy (DOE), Office of Science (SC), Brookhaven Site Office (BHSO), informed the management of Brookhaven National Laboratory (BNL), an Accident Investigation Board (AIB) would be established to investigate the March 5, 2011 tree felling injury at BNL. The accident resulted in a BNL Site Resources Division (SRD) Building and Grounds Utility Worker (BGUW) being hospitalized in excess of five days.

The tree involved in this accident was a white pine, approximately 60-feet tall, located on the south side of Berkner Hall (Building 488). The pine tree was leaning approximately 15 degrees from plumb to the north/northeast; toward Building 488 and over a nearby walkway.



Figure 1: Pine Tree to be Felled (February 2011)

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The need for removal of this pine tree originated from an informal employee safety concern which feared the leaning pine tree might fall onto and damage Building 488, and/or strike and injure pedestrians on the nearby walkway. Figure 1 details the location of the pine tree in relationship to the perimeter of Building 488.

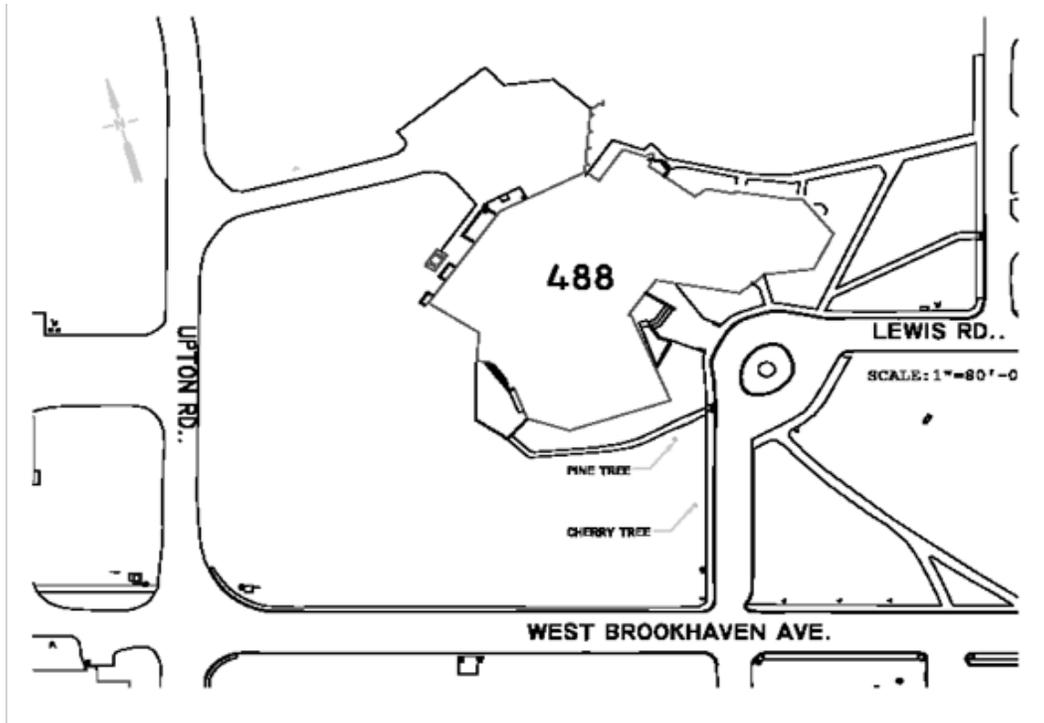


Figure 2: Exterior of Building 488

On March 8, 2011, the AIB was formally appointed (Appendix A). This report documents the facts of the accident and the analyses and conclusions of that investigation. The AIB was on-site at BNL March 10-18, 2011, collecting evidence and conducting interviews.

2.0 The Accident

On Saturday, March 5, 2011 at approximately 10:20 a.m., a BNL BGUW was felling a pine tree while elevated in a 60-foot articulating and telescoping boom lift (aerial lift) approximately 20-feet above the ground on the south side of Building 488. As the gas-powered 20-inch chainsaw cut through the tree trunk, an approximately 8-foot long, 18-inch diameter, 520 pound section of tree trunk fell toward the aerial lift, striking the BGUW's right forearm, and compressing the arm against the top railing of the aerial lift basket.

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2.1. Scope, Conduct, and Methodology

The AIB began its activities on March 10, 2011 and submitted the final report to the BHSO Manager on April 29, 2011. The scope of the AIB'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.

Table 2: Accident Investigation Terminology

A **causal factor** is an event or condition in the accident sequence that contributes to the unwanted result. There are three types of causal factors: direct, which is the immediate event(s) or condition(s) that caused the accident; root cause(s), which is the causal factor(s) 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 which did not cause the accident.

Events and causal factors analysis includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the event to occur), and using deductive reasoning to determine the events that contributed to the accident.

Barrier analysis is a review of 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.

Root cause analysis is a technique that identifies the underlying deficiencies that, if corrected, would prevent the same or similar accidents from occurring.

Judgments of Need are the managerial controls and safety measures necessary to prevent or minimize the probability or severity of a recurrence of an accident.

Requirements verification analysis is a forward/backward analysis process to ensure that all portions of the report are accurate and consistent in the flow of facts to analysis to conclusions to the Judgments of Need

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3.0 Brookhaven National Laboratory

3.1. Facility Description

BNL, established in 1947 at Upton, New York, is an Office of Science multi-program national laboratory operated by Brookhaven Science Associates, LLC (BSA). BNL is situated on a wooded, 5,265-acre site located on the east end of Long Island, New York. 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.

BNL 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 BNL 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, BNL has established a number of ancillary support organizations with functions in support of the BNL science and technology and environmental restoration missions.

3.2. 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).

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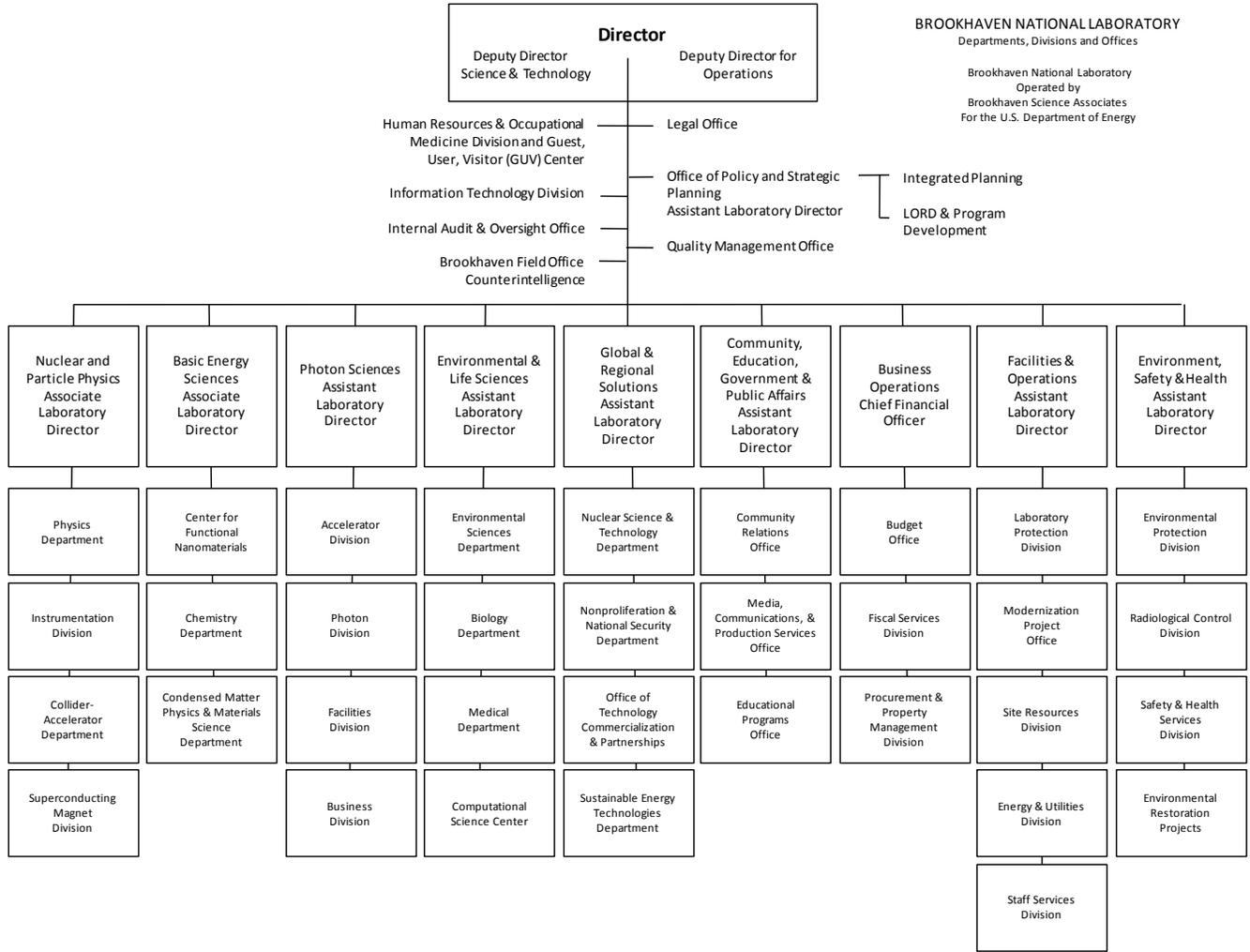


Figure 3: BNL Directorates (March 2011)

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)

On October 1, 2010, the F&O ALD implemented a new management program termed 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. Within this core team is a Facility Project Manager (FPM), the primary person to contact for resolving maintenance issues. The five IFM FCMs report directly to the F&O ALD.

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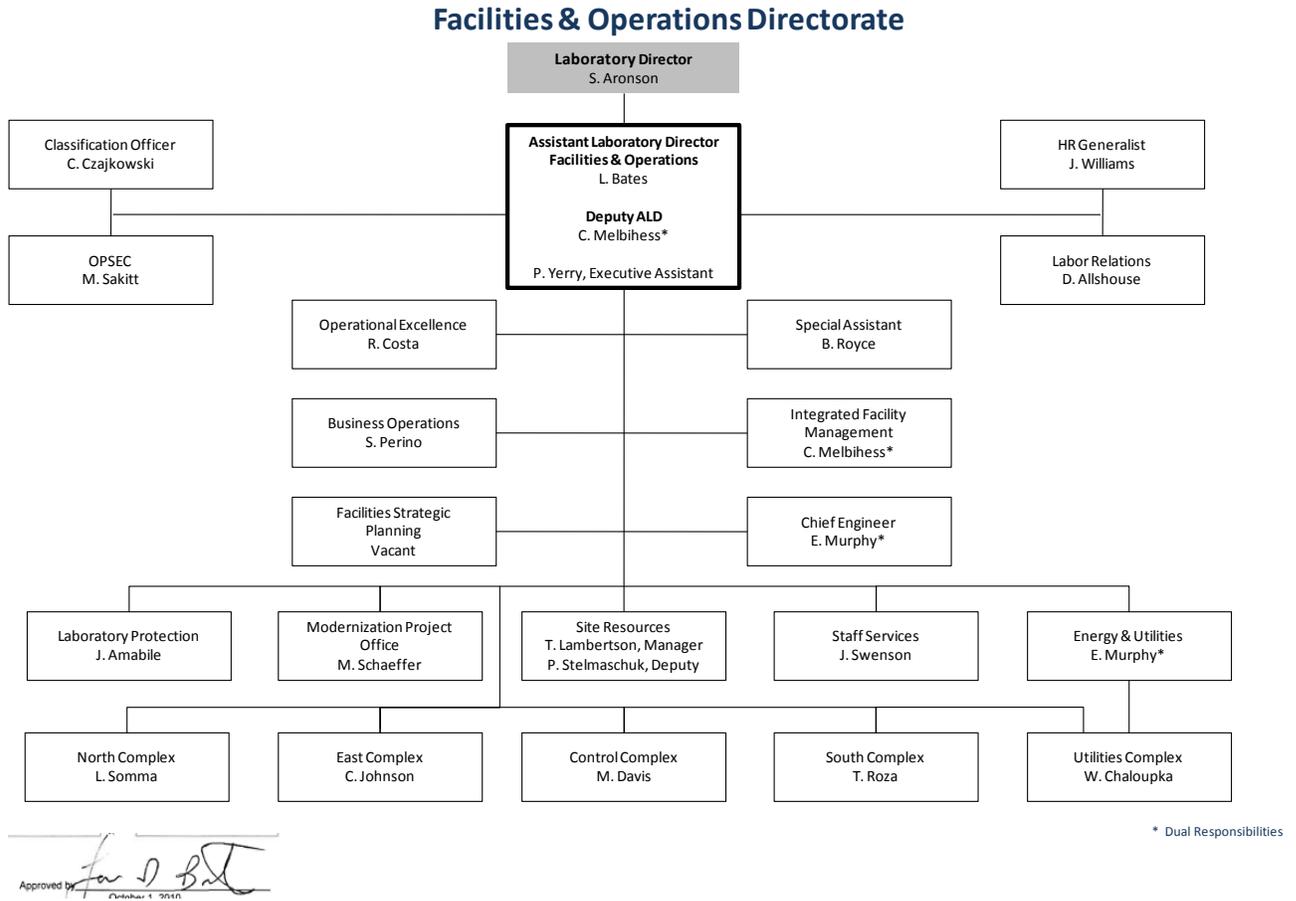


Figure 4: Organization for the F&O Directorate (October 2010)

3.2.1. BNL Organization and Site Resources Division

The Manager of SRD reports directly to the F&O ALD (Figure 5). The Roads and Mason, Grounds and Sanitation, Rigging, Heavy Equipment General Supervisor reports directly to SRD Manager. One of the five supervisors reporting to the General Supervisor is the Grounds and Sanitation Group (GSG) Supervisor. The GSG is typically assigned tree felling work. However, on occasion BNL has contracted tree felling work with a nationally known tree service company. It was explained that the reason the work was contracted was due to the recognized risk imposed by the trees to be felled being in close proximity to existing BNL structures.

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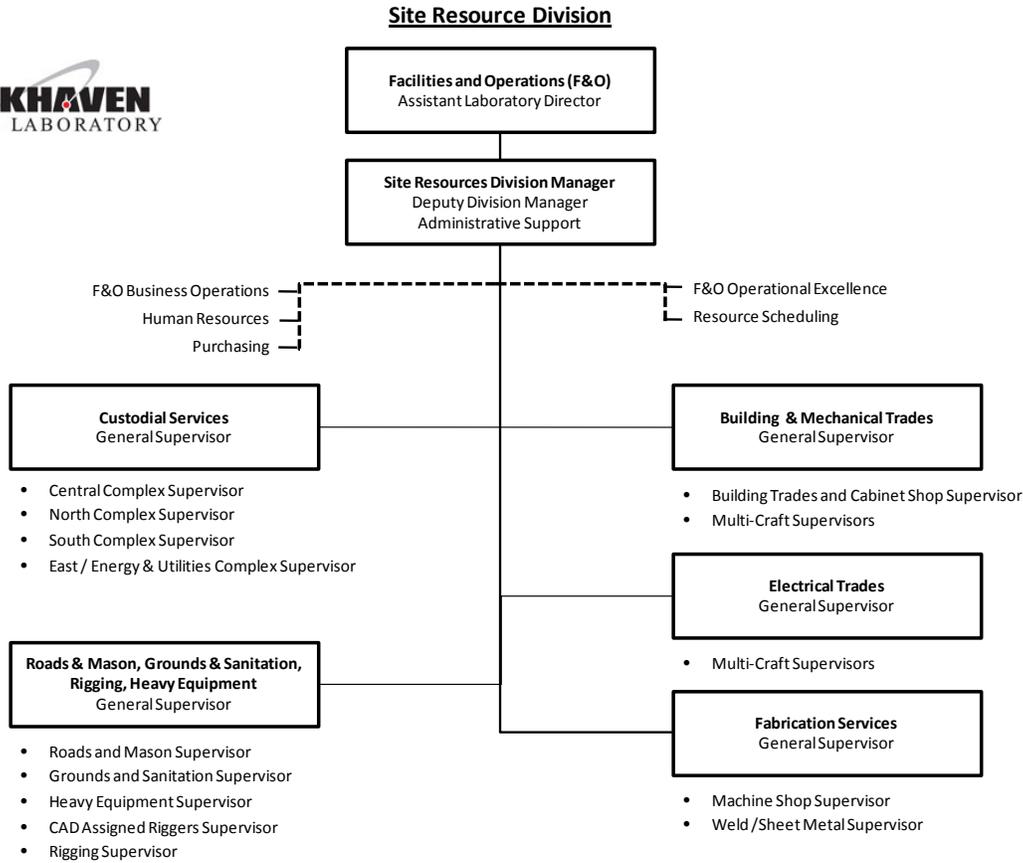


Figure 5: Organization for the Site Resources Division (March 2011)

3.2.2. 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 DOE-STD-1063, *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*.

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;

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- 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.

4.0 FACTS AND ANALYSIS

4.1. ACCIDENT FACTS

4.1.1. Accident Description

On Saturday, March 5, 2011 at approximately 10:20 a.m., a BNL BGUW was felling a pine tree with a 20-inch gas-powered chainsaw while elevated in a 60-foot articulating and telescoping boom lift (aerial lift) approximately 20-feet above the ground on the south side of Building 488. As the chainsaw cut through the tree trunk, an approximately 8-foot long, 18-inch diameter, 520 pound section of tree trunk fell toward the aerial lift, though the BGUW attempted to push the trunk section away using the left hand, it continued to fall where it struck the BGUW's right forearm. The trunk section compressed the BGUW's right forearm against the top railing of the aerial lift basket, and then fell to the ground. The severity of the resulting contact caused the BGUW's right hand to release hold of the idling chainsaw, which dropped the ground.



Figure 6: Trunk Section that Struck BGUW

As best can be determined by the facts collected by the AIB, the piece of trunk section struck the BGUW because the aerial lift basket was positioned at a place where gravity would cause the trunk section to fall. Though the trunk was leaning to the north/northeast (toward Building 488), it was believed that the BGUW expected the trunk section to fall away from the aerial lift basket after completing a downward angled (southeast to northwest) through-cut. As the through-cut was completed, gravity immediately allowed the already leaning trunk section to fall to the north/northeast.

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4.1.2. Background

The Job Risk Assessment, JRA-SI-SITEMAINT-16, *Cutting Tool Operations (Chainsaw/Gas Powered Pole Saw Operations)* applicable to BNL tree felling work was revised in late August 2007 as a corrective action stemming from a July 2007 tree felling incident. In this incident, a tree felled by a GSG work crew contacted a 2400-volt energized overhead conductor resulting in the loss of power to Building 452. Corrective actions associated with this event included worker re-instruction on tree cutting techniques, i.e., the use of notch-cuts when tree felling.

JRA-SI-SITEMAINT-16 was further revised in June 2010 following an April 2010 accident involving a finger laceration from contact with the rotating blade of a gas-powered pole saw. Although the JRA-SI-SITEMAINT-16 discussed the hazards associated with tree felling and the use of wedges, it never fully described the cutting methods, i.e., creating a notch, nor did it describe evaluating the fall direction, how the weight of a limb or trunk to be felled could affect the task, nor did it describe performing tree felling work with a chainsaw while elevated in a aerial lift.

BNL as a DOE contractor must comply with applicable requirements of 10 CFR 851, *Worker Safety and Health Program*. This includes compliance with 29 CFR 1910, *Occupational Safety and Health Standards*. Review of 29 CFR 1910.266, *Logging Operations*, was found it mostly to pertain to commercial logging activities, but it establishes safety practices, means, methods and operations for all types of logging, regardless of the end use of the wood.. The requirements of 29 CFR 1910.266(h)(2), *Manual Felling*, were applicable to the work performed that led to this accident. Review of JRA-SI-SITEMAINT-16 found it contained controls for manually felling trees that include the need to establish a safety zone 1-1/2 times the height of the tree being felled, and having a planned retreat path. These are consistent with the 29 CFR 1910.266(h)(2) requirements, but JRA-SI-SITEMAINT-16 does not include controls to address all of the 29 CFR 1910.266(h)(2) requirements for tree felling work.

BNL is not complying with 29 CFR 1910.266(h)(2) requirements for manual tree felling.

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Table 3: 29 CFR 1910.266 (h)(2) Manual Tree Felling Requirements

- Before felling is started, the feller shall plan and clear a retreat path. The retreat path shall extend diagonally away from the expected felling line unless the employer demonstrates that such a retreat path poses a greater hazard than an alternate path. Once the backcut has been made the feller shall immediately move a safe distance away from the tree on the retreat path.
- Before each tree is felled, conditions such as, but not limited to, snow and ice accumulation, the wind, the lean of tree, dead limbs, and the location of other trees, shall be evaluated by the feller and precautions taken so a hazard is not created for an employee.
- Each tree shall be checked for accumulations of snow and ice. Accumulations of snow and ice that may create a hazard for an employee shall be removed before felling is commenced in the area or the area shall be avoided.
- When a spring pole or other tree under stress is cut, no employee other than the feller shall be closer than two trees lengths when the stress is released.
- An undercut shall be made in each tree being felled unless the employer demonstrates that felling the particular tree without an undercut will not create a hazard for an employee. The undercut shall be of a size so the tree will not split and will fall in the intended direction.
- A back-cut shall be made in each tree being felled. The back-cut shall leave sufficient hinge wood to hold the tree to the stump during most of its fall so that the hinge is able to guide the tree's fall in the intended direction.
- The back-cut shall be above the level of the horizontal facecut in order to provide an adequate platform to prevent kickback. Exception: The back-cut may be at or below the horizontal facecut in tree pulling operations. This requirement does not apply to open face felling where two angled facecuts rather than a horizontal facecut are used.

4.1.2.1. Background of Building 488 Work Order

Conference Services in Building 488 contacted the Central Complex IMF FPM and requested removal of the leaning tree for fear that it might fall onto Building 488 and/or onto pedestrians using the walkway on the south side of Building 488. The Central Complex IMF FPM then issued Work Order EP-846648 on February 15, 2011, which authorized the work to proceed. Work Order EP-846648 was signed by the Central Complex IMF FPM on February 15, 2011.

The GSG Supervisor was initially made aware of the pine tree to be felled on February 15, 2011. On that day, the GSG Supervisor and the F&O Environment, Safety and Health (ES&H) Coordinator went to familiarize themselves with the job site and photograph the tree. The GSG Supervisor commenced the work planning process on February 15, 2011. Work Permit SM-11-003 would include removal of the leaning pine tree, and an approximately 8-inch diameter

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cherry tree located 45-feet south of Building 488 along the walkway on the west side of Lewis Road.

On March 3, 2011, the GSG Supervisor obtained reviewer signatures from the SRD Division Manager, the F&O ES&H Coordinator, the F&O Work Control Coordinator (WCC), and a Safety and Health Services Division Industrial Hygienist matrixed to support F&O work attesting that all the hazards and risks that could impact ESS&H have been identified and the hazards will be controlled according to BNL requirements.

F&O line managers and ES&H subject matter experts reviewed Work Permit SM-11-003 and signed it that all hazards and risk had been identified and all hazards controlled.

The GSG Supervisor held a pre-job briefing on March 3, 2011 with the GSG Crew Leader assigned to the tree felling work, and the two GSG BGUWs who would be felling the pine tree. It was explained that the two BGUWs would use a 60-foot aerial lift to first remove limbs as they moved from the bottom of the tree up through use of the aerial lift, and then they would cut off sections of the bare tree trunk from the top of the tree down through continued use of the aerial lift. Four other workers would serve as safety observers during the cutting to prevent unauthorized access to the work area, and then as laborers to clean up downed limbs and trunk sections when use of the chainsaw ceased.

As part of this pre-job briefing, the GSG Supervisor, the GSG Crew Leader, and the two GSG BGUWs walked down the intended job site and signed Work Permit SM-11-003 indicating they read and understood the hazards and permit requirements. The GSG Supervisor determined BGUW-1 and BGUW-2 were the most qualified to operate the 16-inch and 20-inch chainsaws, and the BGUW-2 most qualified to operate the aerial lift.

On March 4, 2011, the GSG Supervisor obtained the final reviewer signature from the IMF FPM. The GSG Supervisor then signed off the work permit the same date indicating that conditions were appropriate to start work.

On March 5, 2011, the GSG Crew Leader met all six GSG workers assigned to perform the tree felling at the job site. The four workers, who would each serve as a laborer and safety observer (L/SO), did not attend the pre-job briefing on March 3, 2011. These workers did participate in the tool box meeting conducted by the GSG Crew Leader prior to the start of tree felling at the job site on March 5, 2011, and signed Work Permit SM-11-003 indicating they read and understood the hazards and permit requirements.

BNL Standards Based Management System (SBMS) Subject Area, *Work Planning and Control for Experiments and Operations*, outlines the requirements for permit planned work. The use of the work permit is required for work that is rated medium or high risk for any one of the three factors: environment, security, safety and health (ESS&H) risk, job complexity, and work coordination. The determination for ESS&H risk, job complexity and work coordination is made by the WCC and/or the work team. Sometime after the July 2007 tree felling incident, F&O management decided to require the use of a work permit for the felling of large trees

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It is not clear what the performance expectations of F&O management were in regards to implementing the use of the work permit for felling large trees since there was never any written direction to the WCCs, supervisors, or workers on how it was to be implemented. F&O procedure EP-ES&H-006H, *Craft Screen Criteria for Work Permit*, dated September 2010, classified tree pruning, trimming and removal as “Low Risk” work. Part two (on page one of the work permit form), *ESS&H Analysis*, requires the WCC or designee to identify hazards, facility concerns, work controls, specific training requirements, and to assess the level of risk. All 21 tree felling work events occurring during calendar year 2010 were reviewed (which included 10 involving use of an aerial lift). The work permit prepared for each of these events rated the work as low risk. Per SBMS Subject Area, *Work Planning and Controls for Experiments and Operations*, if the ESS&H risk, job complexity and work coordination levels are low, the WCC, Service Provider, and Authorizer (i.e., the Departmental Supervisor, WCC, or other designee) are to sign the work permit at the end of part two. No signatures were recorded at the end of part two for Work Permit SM-11-003; instead, part three (on page two of the work permit form) was filled out with the appropriate signatures indicating the hazards and risks that could impact ESS&H had been identified, a walk-down completed and the hazards controlled according to BNL requirements. Page two of the work permit form is not required to be filled out for work rated as low risk.

F&O management did not formally communicate their expectations on the use of work permits when performing tree felling work.

F&O Procedure EP-ES&H-006H, *Craft Screen Criteria for Work Permit*, screens tree felling as a low hazard risk.

F&O managed tree felling as low ES&H risk work.

The WCC is to provide information to the service provider that identifies the workers who are to walk-down the task, and verify the walk-down of the task has been completed. Review of Work Permit SM-11-003 found that the GSG Supervisor was acting as both requestor and service provider. The GSG Supervisor, acting as the service provider is the individual who predominantly identifies the hazards associated with the task and the appropriate controls to be implemented. The SRD Manager and the WCC reviewed and signed the Work Permit SM-11-003 on March 3, 2011.

SBMS Subject Area, *Work Planning and Controls for Experiments and Operations*, states the work permit “should” contain a detailed work plan; however, SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Exhibit, *Instructions for Filling Out the Work Permit*, states “A written description must detail the jobs and any precautions to be taken”. The work plan and special working conditions described in Work Permit SM-11-003 did not identify

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the hazards associated with felling a tree while in an aerial lift. However, these requirements only apply to moderate and high hazard work. Since this was rated as a low risk work these requirements are not applicable.

4.1.3. Environmental Conditions

At the time of the accident on March 5, 2011, BNL Meteorologists recorded generally mild conditions. The temperature was approximately 53°F at ground level. Wind was from the southwest at approximately 11 mph (measured at 10 meters above the ground). Skies were cloudy, with no precipitation.

4.1.4. Personal Protective Equipment and Clothing Requirements

Personal protective equipment (PPE) required to be worn when using a chainsaw as detailed by JRA-SI-SITEMAINT-16 includes a hard hat, safety glasses, face shield, protective clothing, leather gloves, cut-resistant high top work boots, ear plugs and ear muffs, and chainsaw chaps. Work Permit SM-11-003 specifically required the use of high-visibility vests (for the L/SOs because of their traffic control role), but use of face shields and chaps were not identified as necessary PPE. Workers indicated they were wearing safety shoes, gloves, safety glasses, hard hats, and double hearing protection, and the interviews indicated the four L/SOs were wearing high-visibility vests. However, there was no confirmation that the two BGUWs operating the chainsaws were wearing chainsaw chaps, or donning a face shield while performing that work.

GSG workers operating chainsaws were not wearing all PPE as required by JRA-SI-SITEMAINT-16.

The JRA also required the use of fall protection while working from an aerial lift. This requirement was identified on Work Permit SM-11-003. GSG workers working at Building 488 at the time of the accident acknowledged use of fall protection being worn by the BGUWs in the aerial lift.

4.2. Description of Events Preceding Accident

On March 5, 2011, at 7:00 a.m., the seven-person GSG work crew (BGUW-1, BGUW-2, L/SO-1, L/SO-2, L/SO-3, L/SO-4, and GSG Crew Leader) assigned to complete the work described by Work Permit SM-11-003 gathered at BNL. The GSG Supervisor was not present at the Laboratory at the time of this work. After collecting the necessary equipment to perform the assigned work, the GSG work crew arrived at the job site outside Building 488 between 7:30 and 8:00 a.m. At that time the GSG Crew Leader conducted a tool box meeting on the proposed work activities for L/SO-1, L/SO-2, L/SO-3, and L/SO-4 since they did not attend the March 3, 2011 pre-job briefing. Upon completion of the tool box meeting the four signed Work Permit SM-11-003 indicating they read and understood the hazards and permit requirements.

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At this same time, the aerial lift was driven by BGUW-2 from the parking lot on the east side of Building 488, and parked at the job site at the south side of Building 488 where it was readied for use. According to interviews conducted, L/SO-2, L/SO-3, and L/SO-4 felled the cherry tree noted on Work Permit SM-11-003 from the ground using a notch-cut without incident. Afterwards, L/SO-2, L/SO-3, and L/SO-4 returned to the area around the pine tree.

BGUW-1 readied the two chainsaws for use. L/SO-1, L/SO-2, L/SO-3, and L/SO-4 barricaded the work area with barrier tape to establish the "safety zone" required by JRA-SI-SITEMAINT-16. The dining area adjacent to the work area within Building 488 was also closed off as a precautionary measure. Additionally, Type I barricades were installed on Lewis Road preventing vehicles from entering the area adjacent to the job site.

Once all the workers donned their personal protective equipment, L/SO-1, L/SO-2, L/SO-3, and L/SO-4 took up their assigned positions, and BGUW-1 and BGUW-2 began to remove the tree limbs from ground level, working upward using the aerial lift. BGUW-1 and BGUW-2 shared the use of the 16-inch chainsaw to remove the tree limbs starting at ground level and working up to the top of the pine tree. As prescribed by JRA-SI-SITEMAINT-16, whenever cutting operations from the aerial lift ceased, the laborers/safety observers would then clear the cut tree limbs out of the "safety zone" and collected them for later disposal.

At approximately 9:30 a.m., BGUW-1 and BGUW-2 in the aerial lift completed cutting of tree limbs, and ceased their aerial lift use for a morning break. Following the morning break, at approximately 10:00 a.m. BGUW-1 and BGUW-2 re-entered the aerial lift with the 20-inch chainsaw and began cutting sections of the bare tree trunk. At that time the GSG Crew Leader left the job site at Building 488 to follow-up on other work underway on-site, but left instructions that L/SO-1 would be in-charge of the tree felling work.

Starting at the top of the trunk, BGUW-1 began to cut trunk sections. As each section was cut, the aerial lift was lowered and positioned for the next cut. BGUW-2 operated the aerial lift and positioned it at the direction of BGUW-1. When not operating the aerial lift, BGUW-2 described standing behind BGUW-1 and using a "push stick" to guide the direction of the fall for each trunk section as they were cut free. There was no reference to use of a "push stick" in the JRA, training, or briefings. Trunk sections of approximately 2- to 8-feet in length were being cut using a continuous through-cut technique. Of the pine tree trunk sections recovered from the BNL landscape waste disposal area, no evidence of notch-cutting was found.

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It was planned that BGUW-1 and BGUW-2 would fell the remaining approximately 20-foot trunk section from ground level after they removed a final trifurcated trunk section while in the aerial lift. This remaining trunk section would then be short enough that it would not strike Building 488 when felled. BGUW-2 positioned the aerial lift basket at the north/northeast side of the trunk at the direction of BGUW-1.



Figure 7: Position of the Aerial Lift at Time of Accident

As BGUW-1 began cutting through the final section of tree trunk, BGUW-2 was standing immediately behind applying pressure to the tree trunk section being cut with the “push stick”. As the single through-cut was completed, the approximately 8-foot long, 18-inch diameter, 520 pound section of tree trunk fell towards the aerial lift basket and BGUW-1.

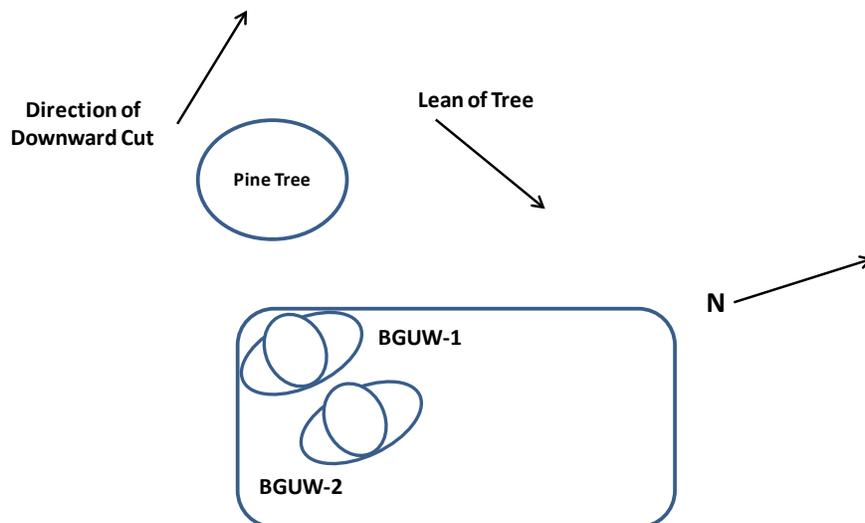


Figure 8: Position of Workers and Aerial Lift Basket at Time of Accident

A timeline of significant events is detailed in Appendix B, *Tree Felling Injury Event Chronology*.

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4.2.1. Emergency Response

The employee sustained the injury at approximately 10:20 a.m. After several minutes needed to lower the aerial lift to ground level and remove the fall protection equipment worn by BGUW-1, BGUW-2, the injury to BGUW-1 was quickly examined. It has been noted that the GSG Crew Leader had left the job site at the start of the job to follow-up on other work being conducted on-site and left instructions that L/SO-1 would be in-charge of the tree felling work. The L/SO-1 attempted to contact the BNL Fire/Rescue Group Headquarters (Building 599) to request emergency medical care, but was unable to complete the call using the pre-programmed BNL emergency telephone number (2222) on the BNL provided Nextel phone. L/SO-1 admitted having difficulty using the pre-programmed emergency number, but still did not dial 2222 on the phone. These phones were issued to address concerns raised by workers in the field for needing to immediately summon emergency assistance.

GSG workers were unable to operate equipment provided to summon emergency assistance.

Because of the difficulty with using the pre-programmed emergency number, and since the BNL Fire/Rescue Group Emergency Medical Technicians (EMTs) in Building 599 was roughly one block from the job site, L/SO-1 decided to drive BGUW-1 to Building 599. Before leaving for Building 599, L/SO-1 made phone contact with the GSG Crew Leader indicating he was taking BGUW-1 to Building 599.

The BNL Fire/Rescue Group recorded BGUW-1 arriving at Building 599 at 10:34 a.m. BGUW-1 was evaluated by BNL Fire/Rescue Group EMTs and at 10:45 a.m. transported by BNL ambulance to Stony Brook University's Health Sciences Center. The BNL ambulance arrived at the Stony Brook University's Health Sciences Center Emergency Room at 11:12 a.m. and BGUW-1 was admitted for in-patient care.

Shortly after BGUW-1 and L/SO-1 left the job site for Building 599, the GSG Crew Leader returned to the job site. The GSG Crew Leader called the GSG Supervisor who was at home to inform him of the injury. The GSG Supervisor arrived at the job site at approximately 11:00 a.m. The GSG Supervisor made notification calls to SRD line management and the BHSO Facility Representative.

4.2.2. 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." Though the Job Training Assessment (JTA) serves as an aid; it still requires the supervisor, work planner or line manager to review existing job-specific training requirements and confirm the worker meets them. SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection 2.2,

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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.”

Review of the JTA prepared for the BGUW job classification found it does not require this classification of worker to complete BNL aerial lift training. Review of the JTA for BGUW-2, who was operating the aerial lift during the accident, possessed expired BNL aerial lift training. Since this was not a requirement within the JTA, the GSG Supervisor never received electronic notification of the training expiration. Per F&O Procedure DF-ESH-006, Work Planning & Control System, Subsection 6.7, the job supervisor is to ensure that personnel assigned to perform work included in the field work packages have completed all specified training related to the hazards identified prior to start of work. The GSG Supervisor never compared the BGUW JTA against the work to be performed to determine if the JTA was adequately matched to the work being performed. Though the GSG Supervisor did note under *Training Requirements (List Specific Training Requirements)*, of part two (on page one of Work Permit SM-11-003) “Manlift, Fall Protection, Chainsaw” training was required. The GSG Supervisor stated when interviewed he believed the employees involved with the Building 488 tree felling work were currently trained.

Though the aerial lift was frequently used for GSG tree felling work, the BGUW JTA did not require qualification on use of aerial lifts.

Aerial lift training for the BGUW operating the aerial lift during this accident had expired.

GSG Supervisor never compared the BGUW JTA against the JRA to determine the adequacy of employee training needs.

As part of the corrective actions for the July 2007 tree felling incident, GSG workers were to receive a briefing on tree felling safety. One of the corrective actions from this event (BNL ATS 3811.1.1) was to instruct GSG workers in the use of notches during tree felling activities. This training was reported to have been completed, but there is no written record of what transpired; so it could not be determined to what extent tree notching may have been discussed. All workers interviewed indicated they have received training on tree felling and chainsaw safety. Most interviewees indicated they have seen videotapes on chainsaw safety and tree felling within the last year however the videotape training was not documented. This videotape collection, *Chainsaws: Safety, Maintenance, and Cutting Techniques*, was developed by the International Society of Arboriculture (ISA). However, since this tree felling training was not formalized, it was not tracked through JTAs.

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No written record exists of the GSG worker training conducted in response to the July 2007 tree felling incident to determine what information was presented.

Use of the ISA videotapes for tree felling is not managed as an F&O required training course.

The ISA videotape training fully described methods of feeling trees and removing limbs, including safe removal of tree trunk sections. The videotape training specifically called for the use of notches and kerf cuts when felling sections of tree trunks. Based on a visual review of the cuts made to the tree trunk, no notches were noted; the workers cut the tree trunk sections with single through-cuts.

Following the April 2010 accident involving a gas-powered pole saw, a gas-powered chainsaw/pole saw safety program was developed by F&O. GSG workers received initial training on gas-powered chainsaws and pole saw use in June 2010, which was later revised and held again during February 2011.

The GSG Supervisor had completed the course *Safety Leadership and the Supervisor*, on December 22, 2010 as part of the BNL Certificate in Supervision Program. This one-hour web course covers the roles and responsibilities of supervisors at Brookhaven regarding safety management, including the importance of modeling safe behavior and how inappropriate actions on the part of the supervisor can create a more hazardous work environment. It covers the importance of focusing on workers – not the statistics. It discusses the importance of training and open communication for imparting the vision of a safe workplace and influencing safe behaviors. This course also describes techniques for hazard assessment, an overview of accident investigation, and stresses injury prevention through the setting of clear, achievable goals. The content titled, *Steps to Performing Job Safety Analysis*, starts with watching the work and breaking it down in to steps, and then evaluating those steps by identifying and describing the hazards and potential accidents in each step of the work. This then includes additional references to the types of hazards (e.g., radiation, electrical kinetic, etc) that might be encountered, the types of accident that might occur (e.g., struck-by, caught-n, etc.), and finally error precursors for the work. This training provides the fundamental knowledge for conducting a hazard analysis; other more in-depth training or requirements for a practical demonstration of this knowledge was not found in the BNL training course catalog. However, the training also notes that in addition to involving the workers in the hazards analysis, it is important that supervisors also rely on safety and subject matter experts to help with identifying risks and the best controls to protect against risks. GSG Supervisor also completed *Conducting STOP Safety Audits*, on May 22, 2006, and *Reducing Accidents and Injuries in the Workplace*, on September 15, 2004.

The F&O WCC completed *Reducing Accidents and Injuries in the Workplace*, on July, 28, 2004, *Safety Leadership and the Supervisor*, on January 13, 2006, and *Conducting STOP Safety Audits*, on May 22, 2006. The F&O WCC completed the BNL Certificate in Supervision Program on March 30, 2006.

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4.2.3. BNL Oversight

Formal BNL ES&H Oversight is driven by the SBMS, Subject Area, *Worker Safety and Health Management System, Environment, Safety, Security, Health, and Quality (ESSH&Q) Tier 1 Inspections*. Tier 1 inspections are line management oversight activities conduct periodic self-inspections to identify ESSH&Q vulnerabilities and determine conformance with 10 CFR 851. The line organization's Responsible Manager designates a Team Leader and determines the level of training required by team appointees to be able to recognize hazards and compliance violations. The team typically includes the ES&H Coordinator, Facility Support Representative, Environmental Compliance Representative, F&O Facility Project Manager or designee, and subject matter experts or other knowledgeable persons.

The guidance for conducting Tier 1 inspections is found in documents available on the BNL ESSH&Q Inspections (Tier 1) website. This site includes a general two page checklist-format guide for conducting Tier 1 inspections; a number of specialized guides for Tier 1 inspections of specific hazards; and access to reports and statistics. The general guide for conducting Tier 1 inspections does not prompt the person using it to consider the adequacy of any type of safety analysis which may have been done regarding the work being inspected.

The only Tier 1 inspection of tree cutting or trimming activity that the AIB was able to locate involved the felling of a tree in the west parking lot of Building 902 that used the same methods as those used in this accident. Several of the same GSG workers involved in this accident were observed working during this Building 902 tree felling job. The Inspection team consisted of the GSG Supervisor, the BHSO Facility Representative, the F&O WCC, and a Safety and Health Services Division Facility Support Representative matrixed to support the F&O work. This tree was removed without incident. The only observation made for that work was that lanyards used to tether the workers in the aerial lift bucket needed to be of the adjustable type.

The BNL Safety Observation Program (STOP) is a web-based tool that serves to encourage management to get away from their desks and into the field to interact with their staff with a safety focus, and to identify leading indicators cultural status, possible precursors to accidents and other safety related incidents. STOP can be used to cite safe practices and commend the workers following them, and is to be used to point out problems and potential risks and help workers to identify a safer way to work. Only two STOP observations were reported related to tree work. In April 2010 the possibility of tree branches falling from a dump trunk were reported. It was then reported in October 2010 that it was observed that all workers involved in a tree/vegetation clearing job at the East Princeton Avenue firebreak "had proper PPE, and the road was guarded (signs and workers) at both ends to ensure that vehicles didn't come in com [sic] through. There was good oversight of the work by the support workers and supervisor."

All work at BNL done under a Work Permit is required to follow the process outlined in SBMS Subject Area, *Work Planning and Control for Experiments and Operations: Section 2, Work Planning and Control for Operations, Subsection 2.4, Permit Planned Work Hazard Identification, Analysis, and Controls*. Subsection 2.4 outlines the process for developing, reviewing, and approving BNL work permits. Included are extensive requirements for oversight of the work by multiple persons, both within and independent of the organization conducting the

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work. In SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Section 4, *Work Observations*, line organizations are supposed to conduct work observations as part of the BNL work planning and control process evaluation. It includes the statement that it applies to BNL line management, and includes that the line manager is to be trained in observation techniques for conducting these work observations. Recommended topics to be discussed with workers are also provided. There is no requirement for having to conduct these observations at any periodicity. The AIB was not able to find any written evidence of SRD Line Management work observations for tree felling and trimming.

SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Section 4, *Work Observations*, does not require line management work observations be conducted at any periodicity.

F&O line managers are not conducting work observations as required by SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, as part of work planning and control process evaluation.

SBMS Management System, *Work Planning and Control*, Exhibit, *Work Control Self-Assessment*, provides open-ended questions in 11 areas as a means to obtain feedback and improvement. Some of these questions do address the adequacy of the planning process, such as work matching the hazards observed and the quality of the work permit. The AIB found no evidence that this exhibit had been used in tree felling and trimming operations.

4.2.4. DOE 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 BNL. Observed assessments are done by BNL, 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 BNL 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 BNL databases.

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The participation of a BHSO Facility Representative in a BNL 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. The BHSO Facility Representative overseeing F&O operations participated in the formal Tier 1 inspection of the tree felling in the west parking lot of Building 902 on April 8, 2010.

4.2.5. Investigation Readiness

The BNL contract contains the DOE O 225.1A, *Accident Investigations*, dated November 26, 1997. The Contractor Requirements Document in that version requires BNL to maintain readiness to respond to accidents, mitigate the consequences, and to preserve and document the accident scene. SBMS Subject Area, *Injury and Illness—Notification and Analysis*, Section 2, *Preserving the Scene for the Analysis*, establishes the means for BNL to be prepared to perform these functions in the event of an accident. Those at an accident scene are to “consider” securing it when the injury or illness is (or may be) recordable; and if evidence could be lost prior to completing an analysis of the accident; when there is personnel traffic in the area; and if investigators need to leave the area. Step 1 of Section 2 states that individuals present at the time of the accident must not contaminate the scene, remove, relocate, or clean anything until official release of the accident scene. Additionally, SBMS Exhibit, *First Actions at Scene of Event*, further enhances the appropriate actions to be taken in the event of an accident. This includes taking the subsequent actions following a recordable injury or illness of preserving the accident scene as much as possible, and collecting evidence and initial witness statements.

After this accident occurred, the GSG workers rightly focused on obtaining emergency medical care for the injured employee. Within 10 minutes of the occurrence of the injury, the GSG Crew Leader made telephone notification of the GSG Supervisor about the injury. In turn the GSG Supervisor made immediate notifications of the injury to the F&O ES&H Coordinator and SRD Manager. Approximately 30 minutes later the GSG Supervisor traveled from his home and arrived at the job site.

Soon after the accident, the scene was largely undisturbed according to witness statements. The GSG Supervisor responded from home and took photographs of the job site; though by that time the aerial lift had already been relocated from the accident scene as evidenced by the GSG Supervisor’s photographs. Sometime following the GSG Supervisor photographing the job site, the GSG work crew cleared the accident scene of all equipment and removed all tree limbs and trunk sections to the BNL landscape waste disposal area. When and why the GSG work crew was permitted to clean up of the accident scene could not be ascertained. There is no evidence that the accident scene was ever put under the control of any particular representative of BNL management on March 5, 2011.

At 8:30 a.m. on March 7, 2011, the BNL Safety Engineering Group first became aware of this accident and immediately secured the accident scene and proceeded with collecting and

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preserving evidence. An attempt was made to ascertain the actual location of the aerial lift at the time of the accident by matching the known width of the aerial lift tires with tire tracks observed in the soil at the job site. Unfortunately the GSG work crew had used a skid steer during their clean up the job site. This obliterated any possible tire tracks left by the aerial lift. This determination was further hampered by rainfall that occurred after the accident and before the accident scene was secured by the BNL Safety Engineering Group. As a result the BNL Safety Engineering Group held a recreation of the accident scene to best determine the physical location of the equipment and GSG workers at the time of this accident.

F&O management failed to ensure preservation of the accident scene in accordance with the SBMS requirements.

The *Type B Accident Investigation Board Report for the October 9, 2009 Employee Injury at Building 1005H*, reached a conclusion that the scene of that accident was not preserved and not appropriately transitioned to the DOE AIB, but did not specify a corresponding JON.

The accident was categorized by BNL according to the DOE Occurrence Reporting and Processing System (ORPS) requirements at 11:00 a.m. on March 5, 2011. See ORPS SC--BHSO-BNL-BNL-2011-0005. Likewise, the injury was tentatively documented by BNL in the DOE Computerized Accident Injury Reporting System, but the reporting update is awaiting finalization pending completion of this investigation.

On March 7, 2011, BNL initiated its own accident investigation of the Building 488 tree felling injury; however, that investigation was suspended on March 8, 2011 when BHSO announced the appointment of a DOE AIB. Also on March 7, 2011, the SRD Manager instructed the Roads and Mason, Grounds and Sanitation, Rigging, Heavy Equipment Section General Supervisor to officially stop work on all elevated tree work until further notice. On March 14, 2011, the F&O ALD expanded that instruction to include all tree work except for emergency purposes, but added that the emergency work would require approval by him or his designee.

4.3. ANALYSIS

4.3.1. 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 C contains the AIB's Barrier Analysis of physical and management barriers that did not perform as intended and thereby contributed to the accident.

4.3.2. Change Analysis

Change analysis examines planned or unplanned changes that caused undesirable results related to the accident. This process analyzes the difference between what is normal or

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expected and what actually occurred before the accident. The results of the change analysis conducted by the AIB are integrated into the events and causal factors chart to support the development of causal factors. Appendix D contains the AIB's Change Analysis and reinforces the Barrier Analysis.

4.3.3. 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 AIB created an Events and Causal Factors Chart (Appendix E) to assist in determining the causal factors of this accident.

4.3.3.1. Direct Cause

The direct cause is the immediate event or condition that caused the accident or event. **The AIB concluded that the direct cause was the uncontrolled fall of the tree trunk section after it was cut loose from the pine tree.**

4.3.3.2. 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 three contributing causes and associated facts identified for this accident: **F&O failed to manage tree felling as greater than low ESS&H risk work; F&O inadequately communicated management expectations on the use of a work permit for safely planning tree felling; and F&O failed to ensure JRA-SI-SITEMAINT-16 addresses the hazards associated with tree felling work performed while elevated by an aerial lift.**

4.3.3.3. Root Cause

Root causes are the events or conditions that, if corrected, will prevent recurrence of this and similar events. The AIB identified two root cause of this event: **F&O failed to conduct thorough hazard analyzes and implement effective work controls for protecting workers performing tree felling work; and F&O failed to ensure workers possessed needed skills to perform tree felling work, and knowledge of industry work practices so as to recognize unsafe conditions.** The AIB concluded that if a comprehensive hazard analysis had been performed and corresponding mitigating controls implemented, and if BNL ensured workers were experienced and effectively trained to perform their assigned work, BNL workers would have been better protected during tree felling work. BNL management and BHSO oversight activities need to increase emphasis on the effectiveness of hazard recognition in the performance of worker planned work.

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4.3.4. Integrated Safety Management

The BNL Integrated Safety Management System Description (ISMSD) is documented in the SBMS, which is the primary system of setting institutional standards and requirements at BNL. 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 AIB 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 AIB 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 Building 488 tree felling injury.

4.3.4.1. Define Scope of Work

Work Order EP-846648 for tree felling was initiated by the Central Complex IMF FPM on February 15, 2011. Work Order EP-846648 specified removal of a tree that was leaning, on the northeast side of Building 488. The tree was found to be on the south side of the building, an error caught by the GSG Supervisor during the job walk down at Building 488. Work Order EP-846648 identified the tree felling as “worker planned work”. “Worker planned work” (previously referred to as “skill of the craft”) is considered low hazard work. The requirements for “worker planned work” are detailed in SBMS Subject Area, *Work Planning and Control for Experiments and Operations*. The GSG Supervisor identified this task as requiring a work permit after reviewing Work Order EP-846648 and walking down the job on February 15, 2011. Prior to the July 2007 tree felling incident, felling a large tree could be planned as “worker planned work”, a process which does not require additional supervisory or ES&H review. F&O line management made the decision following the July 2007 tree felling incident to require the use of a work permit when felling large trees.

The GSG Supervisor, the F&O ES&H Coordinator, GSG Crew Leader, BGUW-1 and BGUW-2, met on March 3, 2011, to complete Work Permit SM-11-003 and conduct a pre-job brief. From interviews with the GSG Supervisor, GSG Crew Leader, BGUW-1 and BGUW-2, topics discussed were: placement of barricades to prevent access to the work areas and areas where limbs would fall, placement of the aerial lift, proper PPE, and the work plan. The SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection, 2.4, *Permit Planned Work Hazard Identification, Analysis and Controls*, Step 5 states that a detailed work plan “should” be written which has “steps that define how to do the work” and “hazard controls and mitigation strategies and/or operational limits imposed”.

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Use of the word “should” in the Step 5 of Subsection 2.4, *Permit Planned Work Hazard Identification, Analysis and Controls* relies too much on the background, training, and discretion of the WCC and/or supervisor filling out the work permit.

In Work Permit SM-11-003, the work plan only documents comments on using the aerial lift to fell the pine tree by cutting limbs going up and trunk sections going down, clearing cut limbs and debris from around the pine tree, and also cutting down a nearby cherry tree. In the *special conditions* section, the only comments listed concerned barricading off access to the work area and the use of plywood (reportedly to protect the nearby walkway). The actual step-by-step direction and process or procedure to be followed in the cutting of the tree trunk sections is not addressed.

The lack of a step-by-step work plan violates the intent of the work permit requirements in SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection 2.4 *Permit Planned Work Hazard Identification, Analysis and Controls*.

In a review of the other 10 tree felling work permits which used an aerial lift during calendar year 2010, only two of these provided any written direction or comment in the work plan related to the specific task of cutting tree trunk sections from an aerial lift. It was stated that the tree trunk sections should be cut in 4- to 5-foot sections in one of those work permits, and 4- to 6-foot sections in the other. There was no documented comment in the work plan for the tree felling activity at Building 488 for addressing the size of tree trunk sections when cutting from the aerial lift. Many of the tree trunk sections that were available to the AIB for review were cut well in excess of 7-feet. The actual tree trunk section that injured the BGUW was approximately 8-feet in length.

Two of the GSG workers present during the March 3, 2011 pre-job brief were asked if there was any direction given on what the size or length of the tree trunks should be, or not exceed, when cutting. One employee mentioned there was no specific direction given to the workers on the length of tree trunk to be cut, and the other worker didn't believe it was mentioned. Workers interviewed agreed that the length of tree trunk sections to be cut was not addressed at the toolbox meeting the morning of the accident. When asked if there was a standing rule or understanding on the length of tree trunk sections cut from a aerial lift, one employee said it was common to keep the lengths to between 2- to 4-foot, one stated it was 4- to 6-foot, and the other worker did not believe there was any informal standing direction or understanding on the size of tree trunk sections that could be cut from an aerial lift. In interviews, the GSG Supervisor stated he has always emphasized a conservative approach to the length of the tree trunk sections and that they should be kept between 4- and 6-feet. The ISA training videotapes discuss the need for the work plan to address the length, tree species and condition of the tree to be felled prior to its removal. The size of the tree trunk sections have a significant potential impact on the safety of workers in the aerial lift as larger sections are

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proportionately heavier and harder to control and therefore more of a hazard to the workers in the aerial lift.

The lack of clear direction for maintaining the size and length of tree trunk sections demonstrates that the work plan and work permit was inadequate for the scope of work.

GSG Workers and Supervisor were not adequately trained on the hazards and controls for felling a large tree from an aerial lift.

In July 2007, a GSG work crew was cutting down a number of trees around Building 96 in preparation of demolition of that building. The felling of a 10-inch diameter tree resulted in that tree swaying in an unanticipated direction and making contact with a 2400-volt energized overhead conductor causing a loss of electrical power at Building 452. All trees, including the tree that contacted the 2400-volt energized overhead conductor, were felled from the base using an incomplete notch-cut. In felling the tree involved in the July 2007 tree felling incident, the notch-cut was only partially completed prior to making a back-cut. As a result, the tree began to lean in the direction it was intended to be felled, but due to the incomplete notch-cut, the tree then sprung back in the opposite direction and contacted a 2400-volt energized overhead conductor. On examination of the other previously felled trees, it was observed that many of the smaller diameter trees were felled with incomplete notch-cuts. This is not the correct method for felling a large tree. If a notch-cut is properly completed, the notched piece of wood is removed to facilitate the desired direction the tree should fall.

The work plan never discussed the type of process used or the type of cut to be used in removing tree trunk sections or felling the trees outside Building 488. Notch-cutting is the preferred professional method for felling trees. It was determined in interviews that notching tree trunk sections was not the method used by the GSG while in an aerial lift, but instead they have historically cut the tree trunk sections with a single through-cut at an angle to which they had determined would fell the trunk section in the direction they wanted. In addition, another common practice for assisting in felling tree trunk sections from an aerial lift was the use of a push stick. The push stick is also not mentioned in the work plan or JRA.

Section 8.5, *Tree Removal*, of ANSI Z133.1-2006, *American National Standard for Arboricultural Operations – Safety Requirements*, calls for notches to be used on all trees and trunks greater than 5-inches in diameter (measured at breast height). It further calls for notches and back-cuts to be made at a height that enables the chainsaw operator to safely begin the cut, control the tree or trunk, and have freedom of movement for escape.

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Table 4: ANSI Z133.1-2006 Tree Notching Practices

- Notches shall be used on all trees and trunks greater than 5-inches in diameter measured at breast height.
- Notches and back-cuts shall be made at a height that enables the chainsaw operator to safely begin the cut, control the tree or trunk, and have freedom of movement for escape.
- The notch-cut shall be a conventional notch, and open-face notch, or a Humboldt notch.
- Notches shall be 45 degrees or greater and large enough to guide the fall of the tree or trunk to prevent splitting.
- Notch depth should not exceed one-third the diameter of the tree.
- The back-cut shall not penetrate into the predetermined hinge area.
- With a conventional notch or Humboldt notch, the back-cut shall be 1-inch to 2-inches above the apex of the notch to provide an adequate platform to prevent kick-back of the tree trunk. With an open-face notch, the back-cut should be at the same level as the apex of the notch.
- The two cuts that form the notch shall not cross at the point where they meet.

Several ISA videotapes on various types of tree trimming and felling have been purchased for training and information on *Chainsaws: Safety, Maintenance, and Cutting Techniques*. None of these ISA videotapes teach a technique for felling tree trunk sections with the use of only a single through-cut to control the direction of the fall. These videotapes do instruct the use of notch-cuts to determine and control the direction for felling trees. They also do not teach or demonstrate the use of a push stick. ANSI Z133.1, Section 8.5 and the ISA videotapes do mention using ropes or wire cable to help control the direction in which the tree sections will fall. The employees interviewed were vague and inconsistent in their recollection on whether they had viewed these videotapes. Some recalled seeing the videotapes on felling a tree from the base but not the other videos. Some didn't recall seeing the videotapes. With the exception of notching large trees when felling from the base, they were equally vague when asked if they recalled anything they had learned from the videotapes. The GSG Supervisor was unsure how many workers might have viewed the videotapes and when exactly he might have shown the videotapes. The GSG Supervisor recalled it being used as part of toolbox session but could not provide documentation for such training. The GSG Supervisor was also not sure if he only showed the videotape on felling a tree from the base. Interviews with the F&O ES&H Coordinator, WCCs and the supervisor confirmed that they were not aware of the existence of the ANSI Z133.1, since this was never a requirement in the contract or identified in the SBMS. The viewing of the ISA videotapes was informal training and no record was available to determine who might have attended

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the viewings. The viewing of the videotapes is not part of an established F&O training course.

F&O WCCs and ES&H Coordinator are not aware of the requirements in ANSI Z133.1.

Use of a single through-cut to fell trunk sections with a diameter in excess of 5-inches as well as the use of a push stick was not consistent with work practices and requirements for this type of work.

F&O line management made the decision in September 2007 in response to the July 2007 tree felling incident to require the use of a work permit when felling large trees. SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection 2.4, *Permit Planned Work Hazard Identification, Analysis and Controls*, is required to be used when the ESS&H risk, job complexity and work coordination are assessed to be a moderate or high risk. SBMS does state that the work permit can be used for low hazard work as an aid in coordinating such work. Since no formal documentation could be provided to the AIB, the intent of F&O management is not known for requiring the use of a work permit to plan work when felling large trees (nor was "large tree" defined). Work Permit SM-11-003, and all other large tree felling work conducted during calendar year 2010 was consistently scored as a low risk for ESS&H risk, job complexity, and work coordination. The requirement in SBMS on permitted work does not require the second page of the work permit form to be completed for work rated low for ESS&H risk, job complexity, and work coordination. The second page of the work permit is used to document the supervisory, WCC, and ES&H coordinator reviews for moderate and high hazard work as well as the work plan. The F&O management decision to require the use of a work permit was not a part of the formal documented corrective action plan for the July 2007 tree felling incident and no documented direction from management could be found explaining the intent or providing direction on the execution of this decision. From interviews with F&O management, the GSG Supervisor, the F&O ES&H Coordinator, and F&O WCCs, the intent seems to have been to assure the work would be reviewed by the front line supervisor and/or WCC, and ES&H professionals.

F&O management communication for their expectations in using the work permit for tree work was inadequate.

One of the documented corrective actions from the July 2007 tree felling incident involved a briefing of WCCs by the Plant Engineering (now F&O) Work Control Manager. The corrective action as written indicates the intent of the briefing was to "...review...the proper classification levels of ESS&H risk, job complexity, and work coordination when planning work and properly controlling hazards identified in and near the work area". Two WCCs and the F&O Work Control Manager when interviewed were vague on what

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exactly was covered at this briefing since no documentation exists on what was covered. Only an attendance sheet with the signatures of those who attended was made available to the AIB. What was inferred from interviews was that this briefing centered around assuring co-located hazards, such as the existence of energized overhead conductors, were adequately covered in the work permit and risk scored appropriately for co-located hazards.

4.3.4.2. Analyze Hazards

All tree felling work permits reviewed for calendar years 2010 and 2011 rated the ESS&H risk as low. The ESS&H risk, job complexity, and work coordination is required to be assessed and documented by SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection 2.4, *Permit Planned Work Hazard Identification, Analysis and Controls*. The direction in Subsection 2.4 does stop short of requiring work requesters and WCCs to review JRAs when using the work permit, but in Step 2 of Subsection 2.4 it notes that if a JRA does not exist for the work scope, the work requester or designee should seek help in developing one. This is different for work that is prescribed (controlled by a procedure or other document). In SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection 2.3, *Prescribed Work Identification, Analysis, and Controls*, Step 2 of this procedure requires the JRA or Facility Risk Agreement to be reviewed. Regardless of the lack of clear direction in Subsection 2.4 for using the JRA, in practice the reliance on the JRA has become pervasive for identification of hazards and controls in planning.

It was learned through interviews with F&O WCCs and the F&O ES&H Coordinator, that the risk rating for felling large trees was historically viewed as a low hazard based on the experience of the workers felling large trees. This view is institutionalized in F&O procedure EP-ES&H-006H, *Craft Screen Criteria for Work Permit*, which classifies tree pruning, trimming and removal as “low risk” work. Although not documented, the intended use of the F&O line management required work permit for tree felling after the July 2007 tree felling incident may have been to assure more rigorous reviews from the F&O WCCs, supervisors and the F&O ES&H Coordinator. In interviews with the GSG Supervisor, WCCs and workers, it was discovered that the only experience they had with tree felling was the experience they have gained at BNL. Additionally the only training provided to the GSG workers on tree felling was viewing the ISA videotapes. The WCCs and supervisor were not aware of ANSI Z133.1 and therefore were not adequately aware or trained on the hazards and controls for felling large trees.

The view of F&O management as stated in F&O Procedure EP-ES&H-006H, *Craft Screen Criteria for Work Permit*, is that tree felling is low hazard risk work.

SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection 2.4, *Permit Planned Work Hazard Identification, Analysis and Controls*, does mention the JRAs but fails to require planners to view them in assessing risk. The JRAs, even if used by those planning work, are open to subjective judgments since they do not

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give a clear rating for an activity that would easily translate to a final work permit rating of low, moderate or high. However, the JRA does give a severity rating for an activity both without controls and with controls in place. JRA-SI-SITEMAINT-16 addresses a range of activities that use powered cutting tools to include felling large trees. The JRA does an adequate job of listing the hazards and controls, in general, for chainsaws, but it fails to list the specific task steps in the cutting trunk sections from an aerial lift, and incorporating controls to address all requirements of 29 CFR 1910.266(h)(2).

Since the controls were primarily administrative and based on SBMS definitions for low, moderate, or high risk, the ESS&H risk rating should have been rated as moderate, if not high risk.

JRA-SI-SITEMAINT-16 was inadequate in identifying the hazards and controls for felling large trees from an aerial lift.

SBMS Subject Area, *OHSAS 18001 Program, Section 1, Facility, Area, and Job Risk Assessments*, Step 2, requires the work planner to incorporate “hazards associated with each task...” as well as the “Frequency that each step/task is performed.” SBMS is moot in providing additional direction on defining just how detailed or to what level a job needs to be broken out into specific task steps. One of the corrective actions that resulted from July 2007 tree felling incident was to include felling large trees as part of JRA-SI-SITEMAINT-16. One line was added to address the hazards and controls related to felling trees, but the actual task steps for felling the tree are not included in JRA-SI-SITEMAINT-16. The hazard identified was “Uncontrolled Fall”, but since the actual task steps, such as the cutting of the tree trunk sections, is not listed and therefore no controls related to protecting the workers in the aerial lift are discussed.

A more consistent approach to the application of the requirements in Step 2 of SBMS Subject Area, *OHSAS 18001 Program, Section 1, Facility, Area, and Job Risk Assessments*, would have been to develop a separate JRA for felling large trees.

4.3.4.3. Develop and Implement Controls

Controls for protecting the public, buildings and infrastructure, and those working on the ground from being struck by falling limbs, tree trunk sections, and other debris or equipment were adequately implemented. Controls on chainsaw usage such as training and experience for operating a chainsaw were also adequate. The pre-job walk-downs, pre-job briefings and toolbox briefings did an effective job of identifying and implementing these controls. However, despite the lack of a documented training program for GSG workers involved in felling large trees, the primary control relied upon to protect the workers in the aerial lift was their experience of not having an accident.

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Another control that could have been used to assure sections of tree trunks cut from an aerial lift would be calculating the maximum allowable mass of the tree trunk sections being cut to ensure they are small enough to minimize the hazard exposure of workers in the aerial lift basket. However, this control was never identified in formal documents such as JRA-SI-SITEMAINT-16, nor consistently documented in work plans. This lack of formal hazard control was further reinforced by tree felling being viewed as a low hazard job and therefore did not require additional controls.

Because the work planning process did not establish a maximum allowable mass of cut tree trunk section, and did not consider the release of potential energy and the influences of gravity on the falling tree trunk sections, had the physical location of the aerial lift basket varied slightly, this accident might have resulted in a more serious injury.

4.3.4.4. Perform Work within Controls

SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection 2.4 *Permit Planned Work Hazard Identification, Analysis, and Controls*, outlines the process for developing, reviewing, and approving BNL work permits. Included are extensive requirements for oversight of the work by multiple persons, both within and independent of the organization conducting planned work. SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, states that line organizations are supposed to conduct work observations as part of the BNL work planning and control process evaluation. No documented evidence could be found of F&O management, SRD supervision, or WCCs work observations for tree felling and trimming. The GSG Supervisor has in the past observed tree trimming and tree felling work. In interviews with the AIB, he stated that when observing this type of work, and especially with work of BGUW-1 and BGUW-2, that the work was being done safely, effectively, and with the tree trunk sections being cut with the 4- to 6-foot limits.

Even if more formal documented work observation had been conducted, it's unlikely that added oversight would have resulted in changes to work practices. Supervisors, WCCs, and the ES&H representative were not aware of the requirement in ANSI Z133.1 or familiar with the work practices demonstrated and discussed in the IAS videotapes. The only personnel with any tree felling experience were the GSG crew members.

4.3.4.5. Provide Feedback and Improvement

The cause codes identified in the ORPS report for the July 2007 tree felling incident, *Human Performance Less than Adequate – Skill Based Error and Rule Based Error* as well as *Work Organization and Planning Less Than Adequate*, were credible and well supported by the evidence. See ORPS SC-BHSO-BNL-PE-2007-0003. One of the corrective actions taken as a result of the July 2007 tree felling incident was to hold a toolbox training session to emphasize the need to complete the notch-cut correctly. This training was conducted but there is no documentation available to review what was

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covered. In interviews with WCCs, the emphasis for the corrective actions from the July 2007 tree felling incident were centered on the failure to complete the notch-cut and the failure in the planning process for adequately accounting for energized overhead conductors. Even though the causal factors clearly indicated that the skill of the worker was less than adequate for the task in removing this tree, the causal analysis appears not to have been extended to evaluate the extent of worker performance and skill on to other aspects of tree felling. The causal analysis also failed to identify any applicable standards for the felling of large trees.

F&O management corrective actions stemming from the July 2007 tree felling incident causal analysis was a missed opportunity for establishing needed training and qualifications expectations for GSG workers performing tree felling work.

SBMS Subject Area, *Work Planning and Control for Experiments and Operations*, Subsection 2.6, *Post Job Review, Feedback and Improvement*, requires when using a work permit, a post job review be held to solicit worker feedback. In interviews with the GSG Supervisor, he stated that he routinely conducts post-job briefs but that the employees in GSG are reluctant to provide any written feedback and rarely ever offer any verbal feedback. WCCs emphasized that employees working for GSG and its predecessor organization have always been reluctant to provide any feedback.

The only assessment conducted of tree felling or trimming was a Tier 1 inspection done on April 8, 2010. This Tier 1 assessment was of a tree felling activity near the west parking lot of Building 902. This work used the same methods as those used in the Building 488 tree felling accident. Several of the same GSG workers involved in the Building 488 tree felling incident were involved with the Building 902 west parking lot tree felling job. The Inspection team consisted of the GSG Supervisor, a BHSO Facility Representative, F&O ES&H Coordinator, and a Safety and Health Services Facility Support Representative matrixed to support F&O work. SBMS Subject Area, *Environment, Safety, Security, Health and Quality (Tier 1) Inspections*, Section 2, *Conducting Environment, Safety, Security, Health and Quality (Tier 1) Inspections*, Step 3, refers to use of the *ESSH&Q (Tier 1) Inspection Deficiency Category Table*, as a guide for common ES&H inspection deficiencies. There is no direction included for conducting a Tier 1 inspection that would focus on assuring that a JRA, work permit, and/or work plan have appropriately been evaluated for hazards and risk, and controls as part of work planning and control.

The April 2010 Tier 1 assessment was a missed opportunity for challenging the existing practices for performing tree felling work by verifying the content of JRA-SI-SITEMAINT-16 against the work plan, the adequacy of work permit risk rating determination, and the effectiveness of the work plan at recognizing hazards and established mitigating controls.

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This tree was removed without incident. The only observation made for that work was that lanyards used to tether the workers in the aerial lift bucket needed to be of the adjustable type. The result of this Tier 1 also indicate that supervisors, and both BNL and BHSO ES&H professionals were not aware of ANSI Z133.1 or fully cognizant of the safe work practices in the ISA videotapes.

5.0 Conclusion and Judgments of Need

The AIB concluded that the March 5, 2011 Building 488 tree felling injury was preventable. The AIB identified two root causes: F&O failed to conduct thorough hazard analyzes and implement effective work controls for protecting workers performing tree felling work; and F&O failed to ensure workers possessed needed skills to perform tree felling work, and knowledge of industry work practices so as to recognize unsafe conditions. Three contributing causes were also identified: F&O failed to manage tree felling as greater than low ESS&H risk work; F&O inadequately communicated management expectations on the use of a work permit for safely planning tree felling; and F&O failed to ensure JRA-SI-SITEMAINT-16 addresses the hazards associated with tree felling work performed while elevated by an aerial lift.

Conclusion	Judgment of Need
<ul style="list-style-type: none"> • JRA-SI-SITEMAINT-16 was inadequate in identifying the hazards and controls for felling large trees from an aerial lift. • A more consistent approach to the application of the requirements in Step 2 of SBMS Subject Area, <i>OHSAS 18001 Program</i>, Section 1, Facility, Area, and Job Risk Assessments, would have been to develop a separate JRA for felling large trees. • BNL is not complying with 29 CFR 1910.266(h)(2) requirements for manual tree felling. 	<ul style="list-style-type: none"> • There is a need for Facilities and Operations to develop and implement a separate Job Risk Assessment for felling trees that: <ul style="list-style-type: none"> ▪ Details performing work while elevated in an aerial lift; ▪ Incorporates controls matched to all 29 CFR 1910.266(h)(2) requirements; and ▪ Adopts use of applicable safe work practices of American National Standards Institute Z133.1-2006, <i>American National Standard for Arboricultural Operations – Safety Requirements</i>, to aid in controlling potential energy, i.e., wedges, and ropes, and determining the manageable mass of tree sections (based on species, diameter, and length).
<ul style="list-style-type: none"> • GSG workers operating chainsaws were not wearing all PPE as required by JRA-SI-SITEMAINT-16. • SBMS Subject Area, <i>Work Planning and Control for Experiments and Operations</i>, Section 4, <i>Work Observations</i>, does not require line management work observations be conducted at any periodicity. • F&O line managers are not conducting work observations as required by SBMS Subject Area, <i>Work Planning and Control for Experiments and Operations</i>, as part of work planning and control process evaluation. 	<ul style="list-style-type: none"> • There is a need for Facilities and Operations to revise SBMS Subject Area, <i>Work Planning and Control for Experiments and Operations</i>, Section 4, <i>Work Observations</i>, and implement the need to establish a frequency for performing work observations of on-going work to ensure supervisors have implemented controls established in Job Risk Assessments, and that those controls are appropriate to facilitate the safe performance of that work.

Accident Report for the Building 488 Tree Felling Injury at Brookhaven National Laboratory, March 5, 2011

Conclusion	Judgment of Need
<ul style="list-style-type: none"> • The lack of a step-by-step work plan violates the intent of the work permit requirements in SBMS Subject Area, <i>Work Planning and Control for Experiments and Operations</i>, Subsection 2.4 <i>Permit Planned Work Hazard Identification, Analysis and Controls</i>. • Use of the word “should” in the Step 5 of Subsection 2.4 <i>Permit Planned Work Hazard Identification, Analysis and Controls</i> relies too much on the background, training, and discretion of the WCC and/or supervisor filling out the work permit. • The lack of clear direction for maintaining the size and length of tree trunk sections demonstrates that the work plan and work permit was inadequate for the scope of work. • Use of a single through-cut to fell trunk sections with a diameter in excess of 5-inches as well as the use of a push stick was not consistent with work practices and requirements for this type of work. • F&O management communication for their expectations in using the work permit for tree work was inadequate. • Because the work planning process did not establish a maximum allowable mass of cut tree trunk section, and did not consider the release of potential energy and the influences of gravity on the falling tree trunk sections, had the physical location of the aerial lift basket varied slightly, this accident might have resulted in a more serious injury. 	<ul style="list-style-type: none"> • There is a need for Brookhaven National Laboratory to revise the Standards Based Management System Subject Area, <i>Work Planning and Control for Experimental and Operations</i>, Subsection 2.4, <i>Permit Planned Work Hazard Identification, Analysis and Controls</i>, Step 5, by specifying what criteria and level of detail is required in writing work plans. • There is a need for Facilities and Operations to develop and implement a step-by-step work plan for tree felling which addresses the 29 CFR 1910.266(h)(2) requirements, and safe work practices stated in the American National Standards Institute Z133.1-2006, <i>American National Standard for Arboricultural Operations – Safety Requirements</i>. • There is a need for Facilities and Operations to document and formally issue clear direction to planners, supervisors and workers on their requirements and expectations for use of a work permit for felling trees.
<ul style="list-style-type: none"> • F&O managed tree felling as low ES&H risk work. • The view of F&O management as stated in F&O Procedure EP-ES&H-006H, <i>Craft Screen Criteria for Work Permit</i>, is that tree felling is low hazard risk work. 	<ul style="list-style-type: none"> • There is a need for Facilities and Operations to revise Procedure EP-ES&H-006H, <i>Craft Screen Criteria for Work Permit</i>, to correctly classify tree pruning, trimming and removal as greater than “low risk” work. • There is a need for Facilities and Operations to document in procedure EP-ES&H-006H, <i>Craft Screen Criteria for Work Permit</i>, the methodology to be used for determining what work is considered low, moderate, or high risk work. • There is a need for Facilities and Operations to utilize its methodology for determining if work is considered low, moderate, or high risk and determine if work previously identified as low-risk by the Site Resources Division was appropriately determined.
<ul style="list-style-type: none"> • GSG workers were unable to operate equipment provided to summon emergency assistance. 	<ul style="list-style-type: none"> • There is a need for Brookhaven National Laboratory to ensure workers receive instruction in the use of portable communication devices intended for summoning emergency assistance, and are proficient in the use of those devices.

Accident Report for the Building 488 Tree Felling Injury at Brookhaven National Laboratory, March 5, 2011

Conclusion	Judgment of Need
<ul style="list-style-type: none"> • Though aerial lift was frequently used for GSG tree felling work, the BGUW JTA did not require qualification on use of aerial lifts. • Aerial lift training for the BGUW operating the aerial lift during this accident had expired. • GSG Supervisor never compared the BGUW JTA against the JRA to determine the adequacy of employee training needs. • No written record exists of the GSG worker training conducted in response to the July 2007 tree felling incident to determine what information was presented. • Use of the ISA videotapes for tree felling is not managed as an F&O required training course. • GSG Workers and Supervisor were not adequately trained on the hazards and controls for felling a large tree from an aerial lift. • F&O WCCs and ES&H Coordinator are not aware of the requirements in ANSI Z133.1-2006, <i>American National Standard for Arboricultural Operations – Safety Requirements</i>. • F&O management corrective actions stemming from the July 2007 tree felling incident causal analysis was a missed opportunity for establishing needed training and qualifications expectations for GSG workers performing tree felling work. • F&O line managers and ES&H subject matter experts reviewed Work Permit SM-11-003 and signed it that all hazards and risk had been identified and all hazards controlled. 	<ul style="list-style-type: none"> • There is a need for Facilities and Operations to establish and implement formal training for tree felling that incorporates the requirements of 29 CFR 1910.266(h)(2) and applicable safe work practices of American National Standards Institute Z133.1-2006, <i>American National Standard for Arboricultural Operations – Safety Requirements</i>. • There is a need for Facilities and Operations to include as part of the work planning process that supervisors documenting they have matched Job Training Assessments against Job Risk Assessments, and then against the work to be performed to ensure training and qualifications for the hazards likely to be encountered are established and are met. • There is a need for Facilities and Operations to ensure all training provided to its workers is documented and includes a course outline, copies of provided handouts, and the list of attendees, and that training is documented on the worker's Job Training Assessment. • There is a need for Facilities and Operations to train supervisors, planners, and environment, safety and health subject matter experts to ensure they possess needed skills to recognize potential hazards and how to implement the hierarchy of controls for minimizing or eliminating those hazards.
<ul style="list-style-type: none"> • F&O management did not ensure preservation of the accident scene in accordance SBMS requirements. 	<ul style="list-style-type: none"> • There is a need for Brookhaven National Laboratory to revise the Standards Based Management System requirements for preservation of an accident scene to: <ul style="list-style-type: none"> – Require communication with essential Laboratory personnel for establishing authoritative control of an accident scene; – Eliminate the potential of subjective decision-making about preserving evidence; and – Specify responsibilities of on-scene supervision for preserving and collecting of evidence. • There is need for Brookhaven National Laboratory to train line managers and delegates on the need and purpose for preserving evidence at an accident scene, and ensure they are knowledgeable of the applicable Standards Based Management System requirements.

**Accident Report for the Building 488 Tree Felling Injury
at Brookhaven National Laboratory, March 5, 2011**

Conclusion	Judgment of Need
<ul style="list-style-type: none">The April 2010 Tier 1 assessment was a missed opportunity for challenging the existing practices for performing tree felling work by verifying the content of JRA-SI-SITEMAINT-16 against the work plan, the adequacy of work permit risk rating determination, and the effectiveness of the work plan at recognizing hazards and established mitigating controls.	<ul style="list-style-type: none">There is a need for Brookhaven National Laboratory to assess Facilities and Operations performance at conducting work inspections and work observations of worker planned and permitted work to determine if those efforts are effective at driving ES&H improvements.There is a need for Facilities and Operations to assess the effectiveness of all corrective actions implemented since July 2007 related to events stemming from worker planned work or permitted work to ensure that those corrective actions have been effective at resolving the associated issues and underlying causes.

**Accident Report for the Building 488 Tree Felling Injury
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6.0 Accident Investigation Board Signatures

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



April 28, 2011

Matthew B. Cole, Member*
DOE Accident Investigation Board
U.S. Department of Energy
Office of Science Headquarters



April 28, 2011

Thomas M. McDermott*
DOE Accident Investigation Board
U.S. Department of Energy
Office of Science Chicago Office



April 28, 2011

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



April 28, 2011

* DOE Trained Accident Investigator

**Accident Report for the Building 488 Tree Felling Injury
at Brookhaven National Laboratory, March 5, 2011**

7.0 Accident Investigation Board Members and Advisors

Chairperson	Karl G. Moro, Office of Science Chicago Office
Member	Matthew B. Cole, Office of Science Headquarters
Member	Thomas M. McDermott, Office of Science Chicago Office
Member	Christopher Seniuk, Office of Science Brookhaven Site Office
Legal Advisor	Louis F. Sadler, Office of Science Chicago Office
Technical Writer	Sue Keffer, Project Enhancement Corporation
Advisor	Steven Kane, Brookhaven National Laboratory
Technical Consultant	Edward Sierra, Brookhaven National Laboratory

**Accident Report for the Building 488 Tree Felling Injury
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**Appendix A:
Accident Investigation Board Appointment Memorandum**



Department of Energy

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

MAR 03 2011

Dr. Samuel H. Aronson
Brookhaven Science Associates, LLC
Brookhaven National Laboratory
Upton, New York 11973

Dear Dr. Aronson:

**SUBJECT: TYPE B INVESTIGATION – APPOINTMENT OF TYPE B ACCIDENT
INVESTIGATION BOARD TO INVESTIGATE THE MARCH 5, 2011 INJURY AT
BROOKHAVEN NATIONAL LABORATORY (BNL)**

As a result of the subject incident, I have requested a Type B Accident Investigation be performed. The following Department of Energy Subject Matter Experts have been appointed to the Board:

Karl Moro (Chair)
Safety and Technical Services
Office of Science - Chicago

Matthew Cole
Environment, Safety and Health Division
Office of Science – SC-31

Thomas McDermott
Safety and Technical Services
Office of Science - Chicago

Christopher Seniuk
Operations Management Division
Office of Science – Brookhaven Site Office

Louis Sadler, Office of Chief Counsel, Chicago Office will support the Board as the legal liaison. The investigation and preparation of the resulting report will conform to the Department of Energy (DOE) Order 225.1A, *Accident Investigation*, requirements. The scope of the Board's investigation is to include identifying all relevant facts; analyzing the facts to determine the direct, contributing, and root causes of the incident; developing conclusions; and determining judgments of need that, when implemented, should prevent the recurrence of the incident. The Board will address the role of contractor organizations and Integrated Safety Management Systems, including human performance elements, as they may have contributed to the overall accident. The scope will also include an analysis of the application of lessons learned from similar accidents within the Department.

**Accident Report for the Building 488 Tree Felling Injury
at Brookhaven National Laboratory, March 5, 2011**

Dr. S. Aronson

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MAR 08 2011

Please ensure that full support is provided to the Board in the fulfillment of its responsibilities including appointment of a point of contact to act as a liaison to facilitate Board requests. A copy of the final investigation report will be submitted to me by April 8, 2011.

If you have any questions, please contact me at (631) 344-3424 or Robert L. Desmarais, of my staff, at (631) 344-5434.

Sincerely,



Michael D. Holland
Site Manager

cc: K. Moro, SC-CH
M. Dikeakos, SC-BHSO
B. Desmarais, SC-BHSO
M. Bebon, BSA
D. Gibbs, BSA
G. Goode, BSA
M. Israel, BSA
M. Marx, BSA

**Accident Report for the Building 488 Tree Felling Injury
at Brookhaven National Laboratory, March 5, 2011**

Appendix B: Tree Felling Injury Event Chronology

Date	Time	Event
February 15, 2011	-	Work Order EP-846648 for tree felling is issued by the FPM for the Central Complex.
March 3, 2011	-	Work Permit SM-11-003 for felling pine tree and cherry tree at Building 488 is prepared by the GSG Supervisor.
March 3, 2011	-	The GSG Supervisor holds pre-job briefing and job site walk-through with the F&O ES&H Coordinator, BGUW-1, BGUW-2, and GSG Crew Leader.
March 4, 2011	-	The GSG Supervisor signs Work Permit SM-11-003 that "conditions are appropriate to start work."
March 5, 2011	Between 0730 and 0800	The GSG Work crew arrives at Building 488 to complete tasks dictated by Work Permit SM-11-003.
March 5, 2011	-	The GSG Crew Leader conducts tool box safety briefing at job site for L/SO-1, L/SO-2, L/SO-3, and L/SO-4.
March 5, 2011	-	The L/SO-1, L/SO-2, L/SO-3, and L/SO-4 sign Work Permit SM-11-003.
March 5, 2011	-	The GSG work crew begins setting up job site safety zone per Work Permit SM-11-003.
March 5, 2011	-	The L/SO-2, assisted by L/SO-3, and L/SO-4, fell cherry tree per Work Permit SM-11-003
March 5, 2011	-	The L/SO-2, L/SO-3, and L/SO-4 load cherry tree limbs and "bucked" trunk into the light-duty dump truck and return to work involving felling pine tree.
March 5, 2011	-	The BGUW-2 moves aerial lift from parking lot east of Building 488 to job site.
March 5, 2011	-	The four L/SOs take up assigned work positions for pedestrian and traffic control.
March 5, 2011	-	The BGUW-1 and BGUW-2 commence the removal of limbs from pine tree through shared use of gas-powered 16-inch chainsaw. BGUW-2 operates the aerial lift and positions aerial lift basket at the direction of BGUW-1 as they move up to the top of the tree.
March 5, 2011	~0930	The BGUW-1 and BGUW-2 complete removal of limbs from pine tree, and BGUW-2 lowers the aerial lift basket to the ground to take mandated work break.

**Accident Report for the Building 488 Tree Felling Injury
at Brookhaven National Laboratory, March 5, 2011**

Date	Time	Event
March 5, 2011	~0930	The four GSG L/SOs remove cut limbs that have fallen within the safety zone, and load it into a light-duty dump truck.
March 5, 2011	1000	The BGUW-2 raises aerial lift near top of approximately 60-foot tall stripped pine tree trunk, and positions aerial lift basket at the direction of the BGUW-1.
March 5, 2011	~1000	The GSG Crew Leader leaves Building 488 to monitor other active job sites. Before leaving the GSG Crew Leader designates L/SO-1 as job lead.
March 5, 2011	-	The BGUW-1 starts cutting tree trunk sections using the 20-inch gas-powered chainsaw, while the BGUW-2 is using a "push stick" to apply pushing pressure to the trunk sections being cut.
March 5, 2011	-	The BGUW-1 uses 20-inch gas-powered chainsaw to cut numerous trunk sections, while the BGUW-2 operates the aerial lift and positions the aerial lift basket at the direction of the BGUW-1 - working in combination through approximately 30-feet of trifurcated trunk.
March 5, 2011	-	The BGUW-2 returns aerial lift basket to the ground so BGUW-1 can refuel the 20-inch gas-powered chainsaw.
March 5, 2011	-	The BGUW-2 raises aerial lift to make final elevated cut of standing 30-feet of tree trunk.
March 5, 2011	-	The BGUW-1 instructs BGUW-2 to locate the aerial lift basket adjacent to the northeast side of the standing 30-feet of tree trunk.
March 5, 2011	-	The BGUW-1 is facing the northeast side of the standing 30-feet of tree trunk makes a through-cut using the 20-inch gas-powered chainsaw moving the blade from southeast to northwest in a downward motion. BGUW-2 continues using a "push stick" to apply pushing pressure to the trunk section being cut.
March 5, 2011	~1020	The BGUW-1 is struck on the right forearm by the falling tree trunk section. The tree trunk section falls to the ground. BGUW-1 lets go of the idling 20-inch gas-powered chainsaw which falls to the ground.
March 5, 2011	-	The BGUW-2 immediately lowers the aerial lift basket to ground.
March 5, 2011	-	The BGUW-2 and L/SO-1 help BGUW-1 out of aerial lift basket and out of fall protection equipment, and take actions to determine any possible injury.

**Accident Report for the Building 488 Tree Felling Injury
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Date	Time	Event
March 5, 2011	-	The L/SO-1 attempts to use BNL provided Nextel phone to call the BNL Fire/Rescue Group for emergency medical care, but is unsuccessful at dialing the BNL emergency notification number (2222).
March 5, 2011	-	The L/SO-1 recognizes the need for emergency medical care, and calls GSG Crew Leader about injury and say's "Meet us at the fire house."
March 5, 2011	-	The L/SO-1 transports BGUW-1 to the BNL Fire/Rescue Group at Building 599.
March 5, 2011	~1030	The GSG Crew Leader calls GSG Supervisor at home and informs him of the injury. GSG Supervisor leaves home and returns to BNL.
March 5, 2011	-	The GSG Supervisor notifies Site Resources line management, and F&O ES&H Coordinator of the injury.
March 5, 2011	-	The GSG Crew Leader returns to Building 488 job site and remaining work crew starts cleaning up work site by removing tools, relocating aerial lift back to parking area east of Building 488, and clear area of cut branches and trunk sections. Cut limbs and cut trunk sections are taken to the BNL landscape waste disposal area.
March 5, 2011	1034	The L/SO-1 and BGUW-1 arrive at Building 599. BGUW-1 is examined by BNL Fire/Rescue Group EMTs.
March 5, 2011	1045	The BNL Fire/Rescue Group transports BGUW-1 (with L/SO-1) to the Stony Brook University's Health Sciences Center via the BNL Fire/Rescue Group ambulance.
March 5, 2011	~1100	The GSG Supervisor arrives at Building 488 job site.
March 5, 2011	1112	The BGUW-1 arrives at the Stony Brook University's Health Sciences Center Emergency Room.
March 5, 2011	1154	The GSG Supervisor notifies BHSO Facility Representative of the injury.
March 5, 2011	1213	The BNL Fire/Rescue Group ambulance returns to Building 599.
March 5, 2011	1215	Supervisor emails BNL Site Resource Division line management, and BNL quality assurance and ES&H contacts details of injury.
March 7, 2011	-	SRD Manager formally suspends all tree felling work performed while elevated in an aerial lift.
March 7, 2011	-	BNL initiates accident investigation

**Accident Report for the Building 488 Tree Felling Injury
at Brookhaven National Laboratory, March 5, 2011**

Date	Time	Event
March 8, 2011	-	BHSO stops BNL accident investigation and appoints DOE AIB.
March 10, 2011	-	DOE AIB arrives on-site.
March 14, 2011	-	F&O ALD formally suspends all tree work.

**Accident Report for the Building 488 Tree Felling Injury
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Appendix C: Barrier Analysis

What was the barrier?	Why did the barrier fail?	How did the barrier affect the accident?
Lessons Learned		
July 2007 tree felling incident corrective actions	The use of notch-cuts for felling trees was improperly executed	Did not allow BGUW-1 to establish control of the direction of falling tree trunk sections
Ten CY2010 tree felling work permits	Tree felling evaluated as low risk work based on previous experience	GSG workers did not possess the needed skills and experience for safely felling trees
Post-job briefings	Did not generate worker feedback through discussion of performance of assigned work	Unsafe work practices performed during prior tree felling work were not corrected for this work
Training and Qualification		
Use of ANSI Z133.1, <i>American National Standard for Arboricultural Operations - Safety Requirements</i>	This consensus standard was not known by F&O line management	GSG supervision and workers did not possess the needed skills and experience for safely felling trees
ISA, <i>Chainsaws: Safety, Maintenance, and Cutting Techniques</i> , Videotapes	Workers did not demonstrate basic tree felling skills	GSG workers did not possess the needed skills and experience for safely felling trees
Policies and Procedures		
SBMS Subject Area, <i>Work Planning and Control for Experiments and Operations</i> , Section 2.4, <i>Permit Planning Work Hazard Identification, Analysis, and Controls</i>	A detailed work plan was not written to define how to do the work, the hazard controls and mitigation strategies and/or operational limits imposed	An inadequate hazard analysis conducted and associated work controls were not established
F&O management mandated use of work permits for tree felling work	F&O management expectations for use of work permits were not communicated	An inadequate hazard analysis conducted and associated work controls were not established

**Accident Report for the Building 488 Tree Felling Injury
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What was the barrier?	Why did the barrier fail?	How did the barrier affect the accident?
Engineering Controls		
Performing notch-cuts	Not used	Did not allow BGUW-1 to establish control over the direction of falling tree trunk sections
Use of rope to assist controlling the direction of falling tree trunk sections	Not used	Forced redirection of falling tree trunk sections away from BGUW-1 was not accomplished
Use of aerial lift to safely position workers	Aerial lift basket was located below leaning tree trunk	Location of aerial lift basket placed BGUW-1 in the path of the falling tree trunk section
Administrative Controls		
JRA-SI-SITEMAINT-16, <i>Cutting Tool Operations (Chainsaw/Gas Powered Pole Saw Operations)</i>	Did not incorporate hazards and controls associated with tree felling work while elevated in an aerial lift	There was not a comprehensive set of work controls to reference for tree felling work
F&O Procedure EP-ES&H-006H, <i>Craft Screen Criteria for Work Permit</i>	F&O line management required work permit reviews/approvals did not verify adequate determination for ESS&H risk, job complexity, and work coordination	An inadequate hazard analysis conducted and associated work controls were not established
Pre-Job Briefing	Work controls discussed were based on prior tree felling experiences performed without a formal work hazard analysis	GSG Supervisor did not possess a comprehensive set of work controls to reference for tree felling work
Personal Protective Equipment		
JRA-SI-SITEMAINT-16, <i>Cutting Tool Operations (Chainsaw/Gas Powered Pole Saw Operations)</i>	Not all required personal protective equipment was worn during tree felling	There was no affect on this accident
BNL Oversight		
Work Permit SM-11-003	Required F&O line management work permit reviews/approvals did not verify adequate determination for ESS&H risk, job complexity, and work coordination	An inadequate hazard analysis conducted and associated work controls were not established

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What was the barrier?	Why did the barrier fail?	How did the barrier affect the accident?
Tier 1 review of April 2010 tree felling work	GSG Supervisor and F&O ES&H professionals failed to challenge existing practices used for tree felling work while elevated in an aerial lift	An inadequate hazard analysis conducted and associated work controls were not established
DOE Oversight		
Tier 1 review of April 2010 tree felling work	BHSO Facility Representative failed to challenge existing practices used for tree felling work while elevated in an aerial lift	An inadequate hazard analysis conducted and associated work controls were not established

**Accident Report for the Building 488 Tree Felling Injury
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Appendix D: Change Analysis

Factors	What were the barriers?	How did each barrier perform?	Why did the barriers Fail?	How did the barrier affect the accident?
Conditions, occurrences, activities, equipment	Worker planed work authorized by work permit	The work permit was adequately authorized	N/A	N/A
	Work permit hazard analysis and work controls identified and risks assessed	Barriers for pedestrian traffic, damage to structures and for GSG crew adequate. Hazards for working with chainsaw identified, hazards to structures and pedestrians as well as GSG crew identified. Hazard analysis and control and assessed level of risk to workers in man lift were inadequate	Hazard posed by felling tree trunk sections to aerial lift crew not identified on work permit nor were the appropriate requirements and controls	Inadequate controls resulted in tree trunk section falling in unanticipated direction
	Work plan	Work plan not adequate lacked specific step-by-step instruction for felling tree	Work practice for cutting lengths of trunk sections was informal and subjective, and inconsistently interpreted by workers	A work plan that formally determining the manageable mass of cut lengths of trunk sections could have minimized the employee injury
	Work practice: Use of single angled downward cut to control the direction in which the tree trunk sections would fall with the assistance of a push stick	Work Practice inadequate for controlling the direction in which the trunk section was expected to fall	Notch-cuts are the preferred method of arborists for controlling the direction the section should fall. Notch-cuts are also required by ANSI Z133.1 for felling trunk sections or removing limbs greater than 5" in diameter	The common work practice was inadequate in controlling the direction that the tree trunk section would fall

**Accident Report for the Building 488 Tree Felling Injury
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Factors	What were the barriers?	How did each barrier perform?	Why did the barriers Fail?	How did the barrier affect the accident?
Occurred, identified, facility status, schedule	Work request form submitted by IMF FMP for worker planned work.	Adequate and met requirements.	N/A	N/A
	GSG Supervisor and the F&O ES&H Coordinator walk-down job and Supervisor identifies work as requiring Work Permit	Adequate and met requirements	N/A	N/A
Physical location, environmental conditions	60-foot tree is located 25-feet from Bldg 488 with a 15 degrees lean toward building	N/A	N/A	N/A
	Clear and mild day	N/A	N/A	N/A
Staff involved, training, qualifications, experience, supervision	GSG Supervisor, F&O ES&H Coordinator, GSG Crew Leader, BGUW-1 and BGUW-2 conduct pre-job brief at work site	Inadequate, the pre-job brief failed to effectively identify the hazard to the workers in the aerial lift and did not provide formal enough direction on the size limits for felling the tree trunk sections	GSG Supervisor and F&O ES&H Coordinator were unaware ANSI Z133.1 and the GSG workers had not learned and adopted the work practices in the ISA training videotapes	Lack of knowledge and reliance on past experience contributed to the accident by making the pre job inadequate
	GSG Supervisor, F&O ES&H Coordinator and training on felling large trees	Inadequate	GSG Supervisor, F&O ES&H Coordinator and GSG workers lack formal training on felling large trees and were unaware of requirements	Lack of knowledge of proper work practices and requirements and reliance on past experience contributed to the accident
	GSG workers have institutional training on the use of chainsaws and aerial lift	Adequate	N/A	N/A

**Accident Report for the Building 488 Tree Felling Injury
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Factors	What were the barriers?	How did each barrier perform?	Why did the barriers Fail?	How did the barrier affect the accident?
	GSG Supervisor and workers have viewed ISA training videotapes on various types of tree trimming and felling	Inadequate	Did not learn and implement the work practices on tree felling in the ISA training videotapes	Proper work practices were not implemented
	F&O ES&H Coordinator and WCCs training and knowledge on requirements for tree felling. GSG supervision relied on the practices and experience of the GSG workers in felling large trees	Inadequate	F&O ES&H Coordinator and WCCs had no knowledge of the ANSI Z 133.1 safe work practices and had never viewed the ISA training videotapes	Proper work practices, requirements, and controls were not in implemented
Control chain, hazard analysis, controls	Established SBMS work control process modified by F&O management some time after July 2007 tree felling incident to require work permit for felling large trees	Inadequate, the requirement and expectation for using the work permit never formally documented by F&O management	The requirement for using the work permit did not result in better hazard recognition and control	N/A
	SBMS states, work plan <i>"should"</i> provide a detailed work plan with <i>"steps that define how to do the work and that also identify those responsible for doing each task"</i>	Inadequate, no detailed step-by-step work task description for tree felling	The use of the word <i>"should"</i> in a requirement leaves it up to the discretion of the work planner and supervisor regardless of experience and knowledge of requirements governing the work	Contributed to an inadequate work plan

**Accident Report for the Building 488 Tree Felling Injury
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Factors	What were the barriers?	How did each barrier perform?	Why did the barriers Fail?	How did the barrier affect the accident?
	Corrective actions from 2007 tree felling incident required JRA to address tree felling	JRA inadequate	JRA did not address task specific steps and hazards, such as the type of cut to be executed, the use of a push stick, the size of the tree trunk sections. The JRA also did not document a hazard to workers in a aerial lift from the weight of falling tree trunk sections	Contributed to an inadequate understanding of the hazards and a perceived low as an ESS&H risk
	All tree felling work is listed as low ESS&H risk in the in F&O procedure EP-ES&H-006H, <i>Craft Screen Criteria for Work Permit</i>	Inadequate, tree felling large tree trunk sections from an aerial lift is not low hazard safety risk. Potential for serious bodily harm and possible death for workers struck by large tree trunk sections	Resulted in inadequate controls being implemented because it was always assessed as low ESS&H risk in the work planning process	Resulted in inadequate controls being implemented

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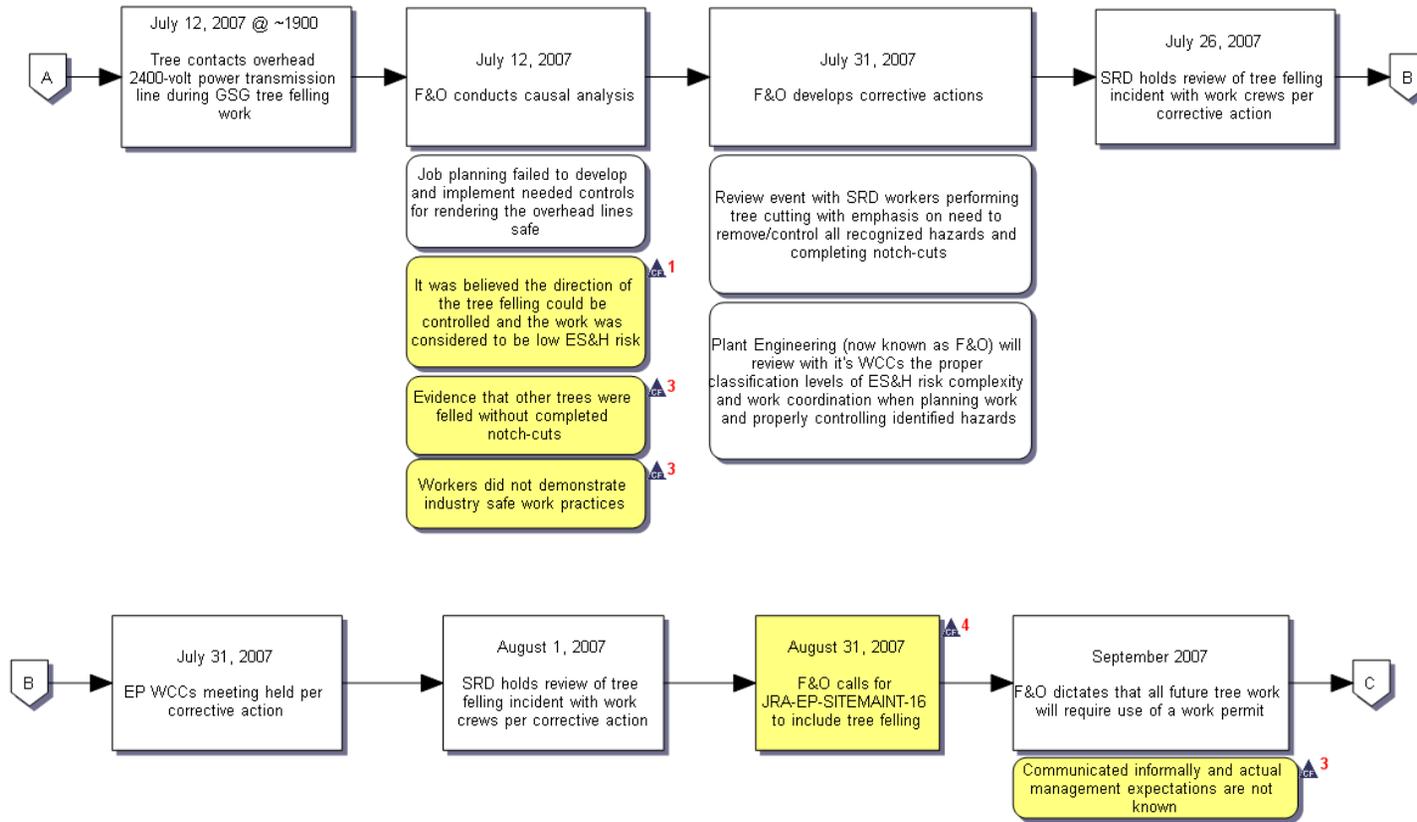
Appendix E: Events and Causal Factors Chart

Causal Factor	Events
<p>1. F&O failed to manage tree felling as greater than low ESS&H risk work</p>	<ul style="list-style-type: none"> • It was believed the direction of the tree felling could be controlled and the work was considered to be low ESS&H risk • Work permit ESS&H risk, job complexity, and work coordination all rated as low, based on previous job experience • Work viewed as low-risk since it was worker-planned-work • Work Permit SM-11-003 is issued by GSG Supervisor without detailed work plan as required by SBMS Subject Area, <i>Work Planning and Control for Experimental and Operations</i>, Subsection 2.4 • F&O procedure EP-ES&H-006H, <i>Craft Screen Criteria for Work Permit</i>, which classifies tree pruning, trimming and removal as “low risk” work • Work Controls discussed based on prior deficient tree felling safe practices
<p>2. F&O inadequately communicated management expectations on the use of a work permit for safely planning tree felling</p>	<ul style="list-style-type: none"> • Communicated informally and actual management expectations are not known • Detailed work plan required for permitted work per SBMS Subject Area, <i>Work Planning and Control for Experimental and Operations</i>, Subsection 2.4

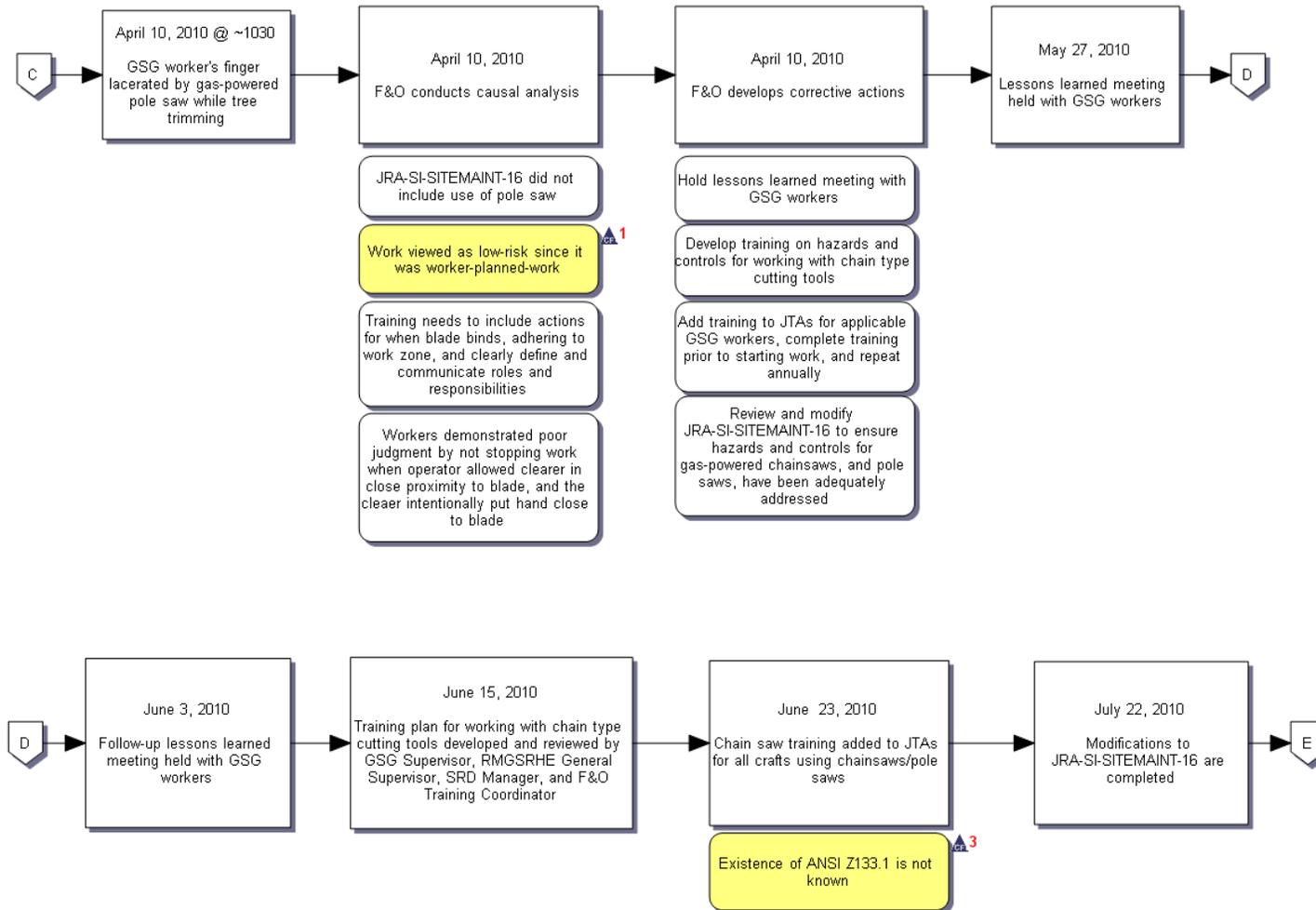
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Causal Factor	Events
3. F&O failed to ensure workers possessed needed skills to perform tree felling work, and knowledge of industry work practices so as to recognize unsafe conditions	<ul style="list-style-type: none"> • Evidence that other trees were felled without completed notch-cuts • Standing in aerial lift basket on the north/northeast side of tree trunk and makes through-cut with 20-inch gas-powered chainsaw • Numerous trunk sections cuts at varying lengths through approximately 40-feet of trifurcated trunk • Existence of ANSI Z133.1 is not known • Workers did not demonstrate industry safe work practices • JRA requires no personnel in safety zone other than saw man • Not all required PPE is worn • Aerial lift is positioned below the leaning tree trunk section
4. F&O failed to ensure JRA-SI-SITEMAINT-16 addresses the hazards associated with tree felling work performed while elevated by an aerial lift	<ul style="list-style-type: none"> • F&O calls for JRA-EP-SITEMAINT-16 to include tree felling work • JRA-SI-SITEMAINT-16 does not include tree felling from aerial lift
5. F&O failed to conduct thorough hazard analyzes and implement effective work controls for protecting workers performing tree felling work	<ul style="list-style-type: none"> • F&O WCC and SRD Manager sign Work Permit SM-11-003 without detailed work plan as required by SBMS Subject Area, <i>Work Planning and Control for Experimental and Operations</i>, Subsection 2.4 • Detailed work plan required for permitted work per SBMS Subject Area, <i>Work Planning and Control for Experimental and Operations</i>, Subsection 2.4 • Pre-job briefing and walk through by GSG Supervisor, F&O ES&H Coordinator, BGUW-1, BGUW-2, and Crew Leader

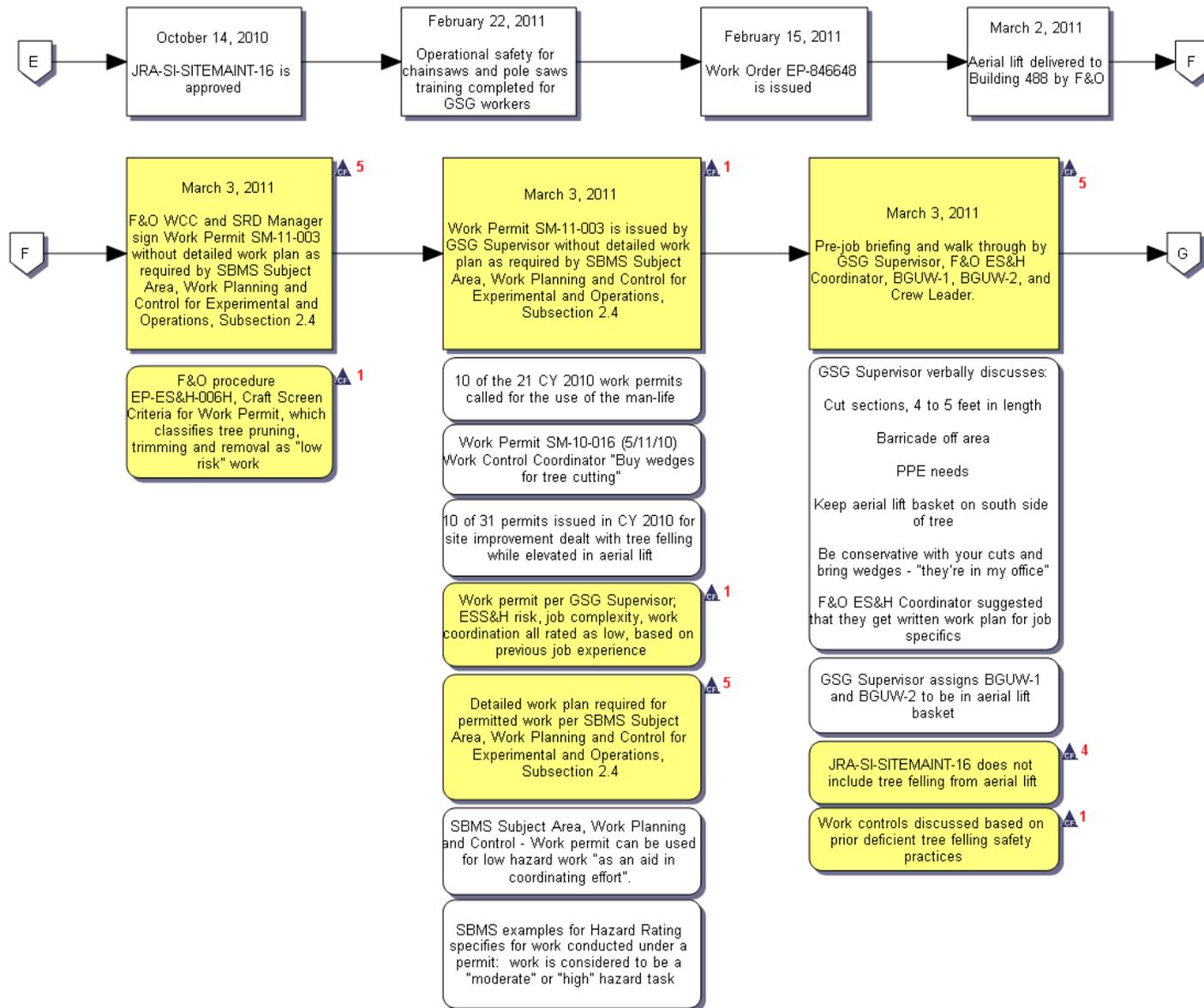
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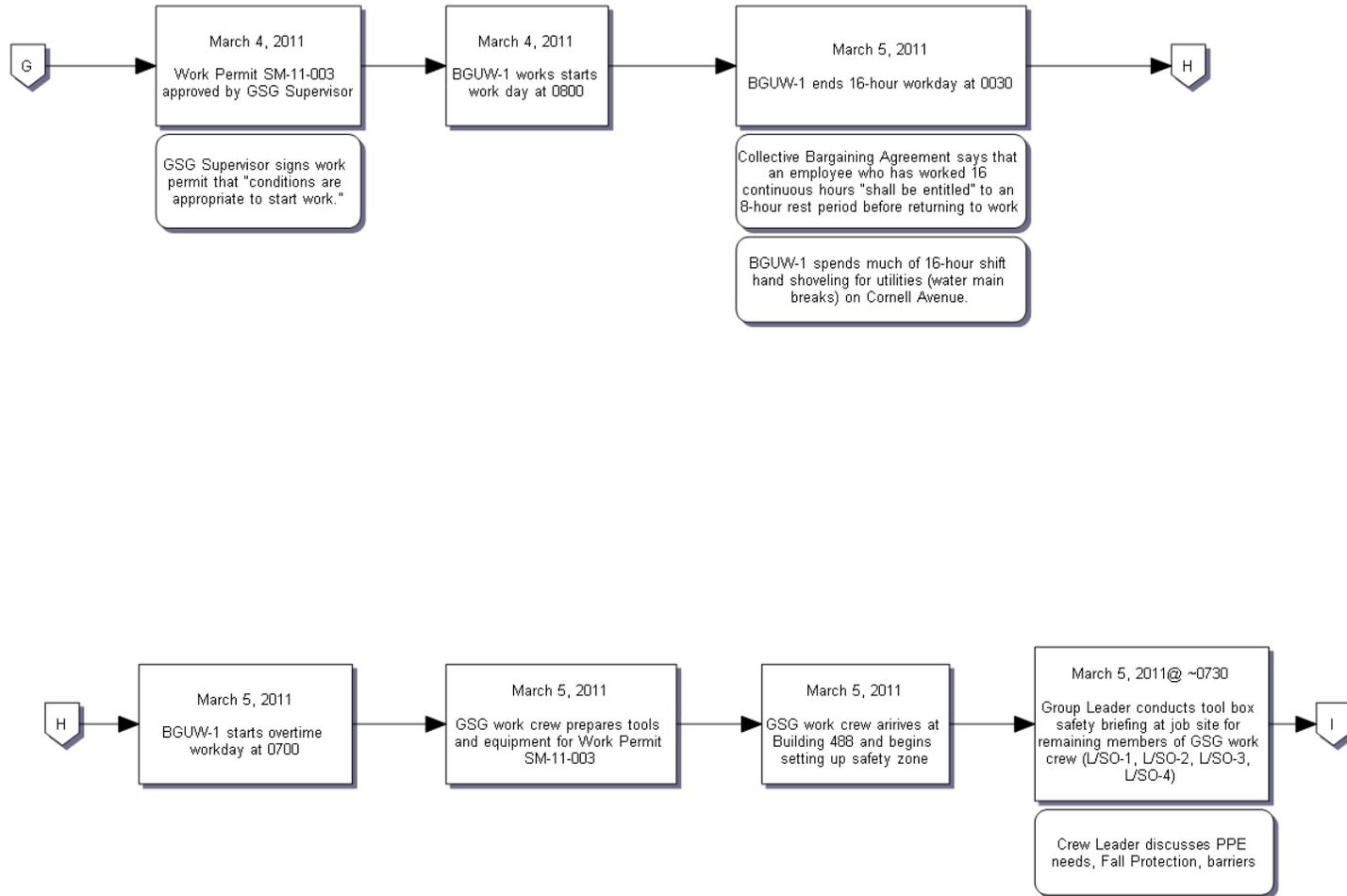
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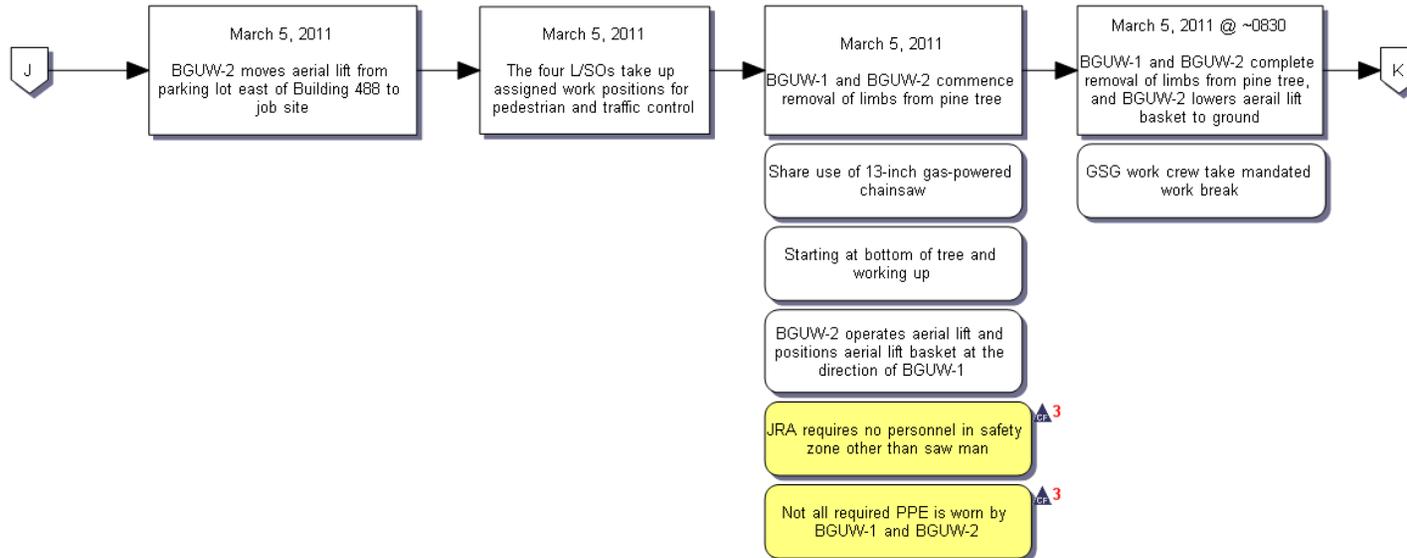
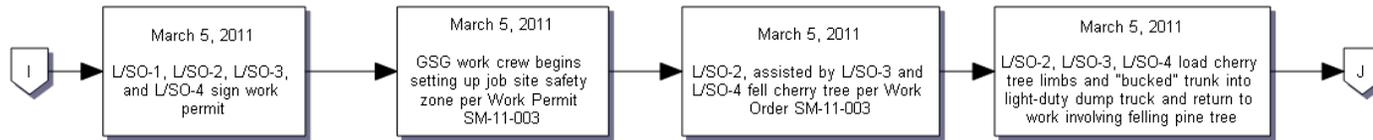
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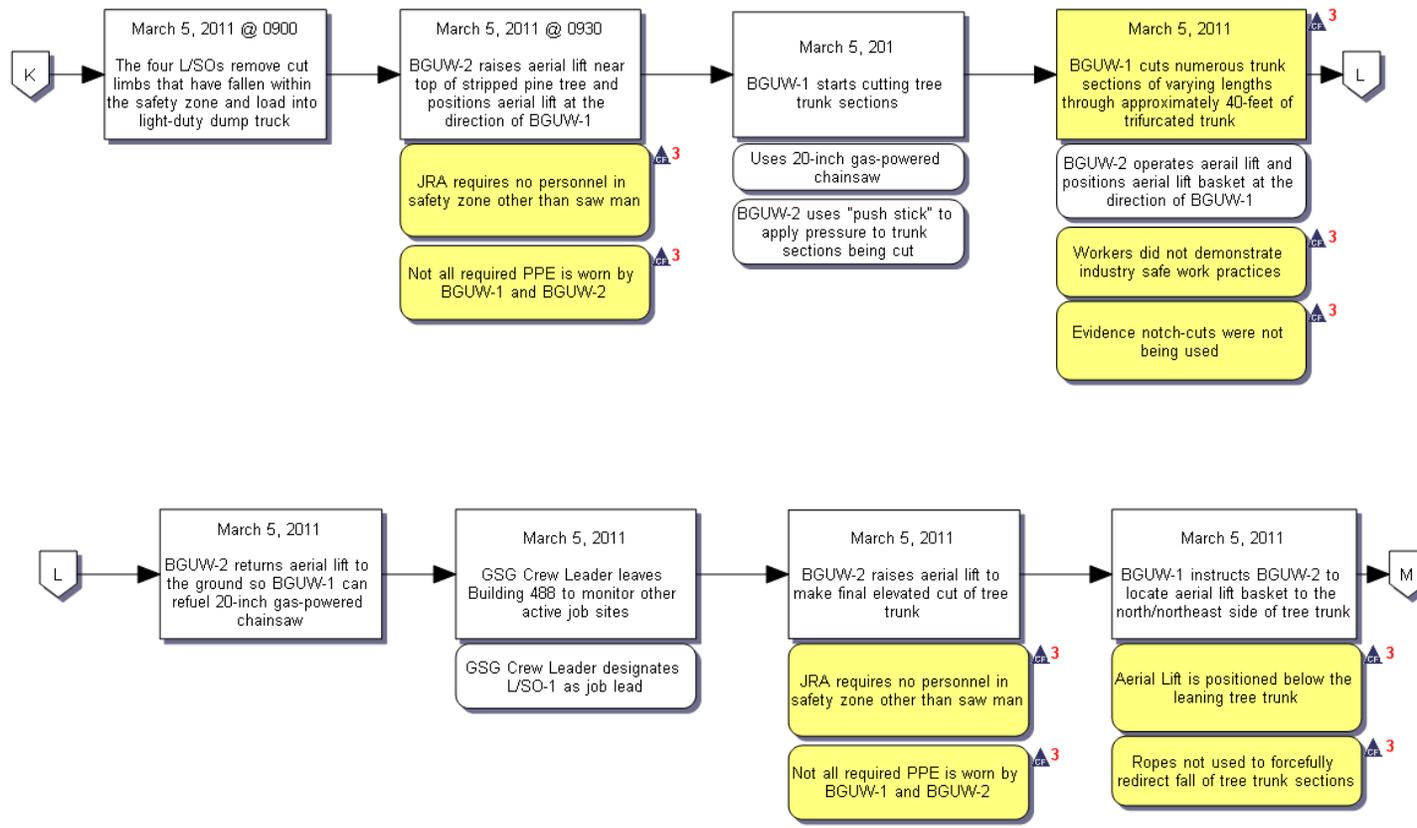
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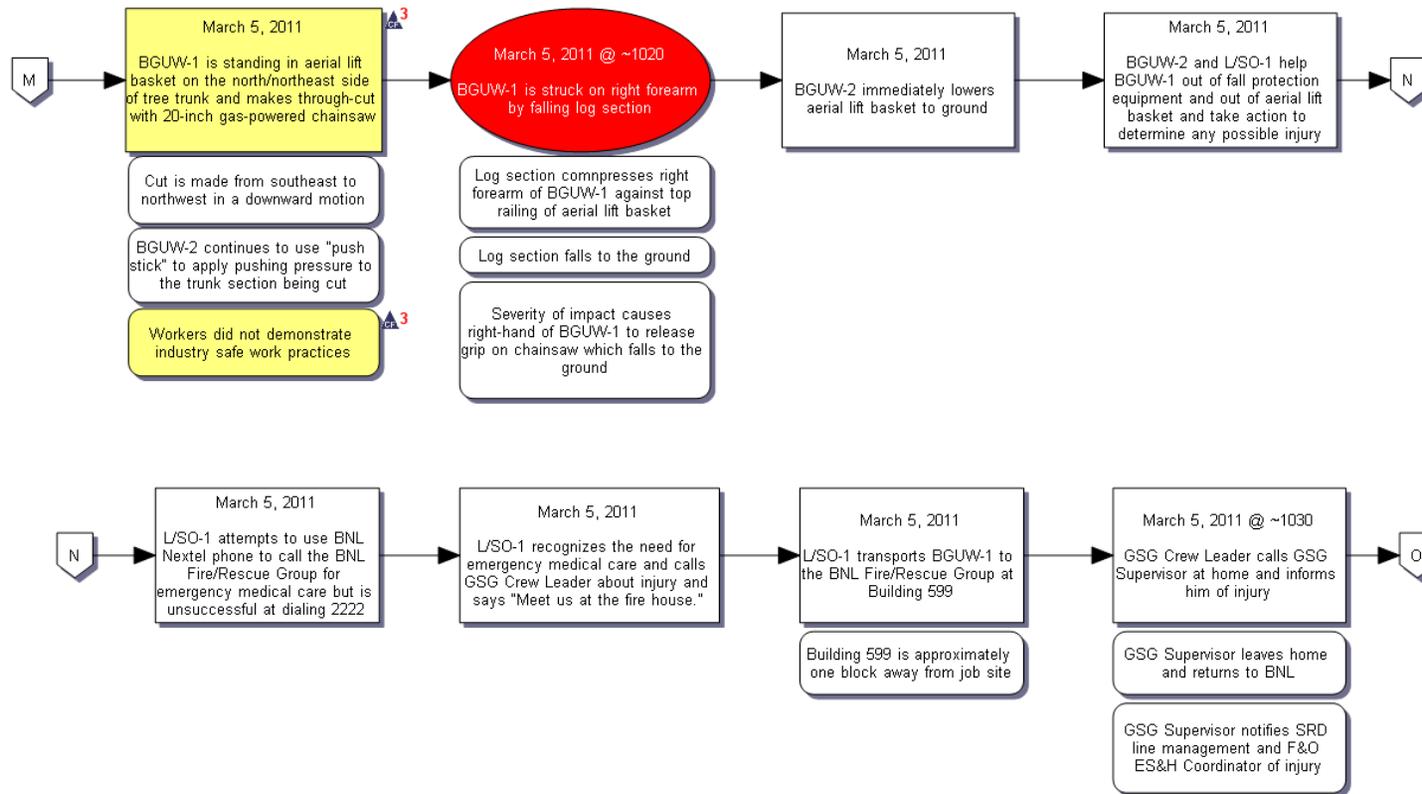
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