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Type B Accident Investigation Board Report on the Worker Injury at the BNFL Inc. East Tennessee Technology Park Three-Building Decontamination and Decommissioning and Recycle Project Site

Oak Ridge Operations
U.S. Department of Energy

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RELEASE AUTHORIZATION

This report is an independent product of the Type B Investigation Board appointed by Steven D. Richardson, Acting Manager, Oak Ridge Operations Office, U.S. Department of Energy (DOE). The Board was appointed to perform a Type B investigation of these incidents and to prepare an investigation report in accordance with DOE Order 225.1A, *Accident Investigations*.

The discussion of facts, as determined by the Board, and the views expressed in the report are not necessarily those of DOE and do not assume and are not intended to establish the existence of any legal causation, liability, or 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.

INDEPENDENT REPORT

On April 2, 1999, I appointed a Type B Accident Investigation Board to investigate the March 26, 1999, injury to an employee of IDM Environmental Corporation, subcontractor to BNFL Inc., at the East Tennessee Technology Park, located in Oak Ridge, Tennessee. The responsibilities of the Board have been satisfied with respect to this investigation. The analysis, identification of contributing and root causes, and judgments of need reached during the investigation were performed in accordance with U.S. Department of Energy Order 225.1A, *Accident Investigations.*

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

Steven D. Richardson
Acting Manager
U.S. Department of Energy Oak Ridge Operations Office

Date Accepted: _____

CONTENTS

TABLES, FIGURES, AND EXHIBITS

Page

ACRONYMS, ABBREVIATIONS, AND INITIALISMS

ACB	air circuit breaker
AMAU	Assistant Manager for Assets Utilization
AMESQ	Assistant Manager for Environment, Safety, and Quality
BNFL	BNFL Inc.
CFR	*Code of Federal Regulations*
COR	contracting officer's representative
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
EMS	Emergency Medical Services
ES&H	environment, safety, and health
ETTP	East Tennessee Technology Park
EWP	enhanced work planning
HASP	health and safety plan
HSO	health and safety officer
IDM	IDM Environmental Corporation
IG	instruction guide
ISMS	integrated safety management system
JLG	manufacturer of a manlift system for aboveground work
ORO	Oak Ridge Operations Office
ORR	operational readiness review
PM	project manager
PSS	plant shift superintendent
QA	quality assurance
SMS	safety management system
SOP	standard operating procedure
STR	subcontract technical representative
THA	task hazard analysis

EXECUTIVE SUMMARY

INTRODUCTION

On March 26, 1999, at approximately 11:00 a.m., an employee of IDM Environmental Corporation (IDM) was injured by a flying piece of chainlink fence during the demolition of the K-33 Switchyard at East Tennessee Technology Park (ETTP). At the time of the accident, he and a coworker were egressing a work area at Building K-791 North in the K-33 Switchyard where they had been removing buss bars from air circuit breaker (ACB) cabinets. This work was conducted under contract with BNFL Inc. (BNFL). The injury resulted in a 6-day hospitalization and follow-on outpatient treatment for the worker. Accordingly, an investigation of the accident was initiated with the appointment of Type B Accident Investigation Board (hereafter referred to as "the Board.")

INTEGRATED SAFETY MANAGEMENT SYSTEMS (ISMSs)

The specific ISMS pertaining to the contract with BNFL was developed prior to the finalization of the U.S. Department of Energy (DOE) acquisition regulation clause, Title 48 of the *Code of Federal Regulations*, Part 970.5204-2. The ISMS requirements were implemented by BNFL via a safety management system (SMS). DOE's SMS verification of BNFL is currently scheduled for late summer/early fall of 1999, with the validation scheduled for a later date.

BNFL's SMS requirement was, in turn, included in the subcontract with IDM. The Board concluded that the elements of an ISMS program were in place for the overall work scope covered by these contracts. However, implementation of the SMS program broke down in the enhanced work planning process (EWP) for work resulting from the interface of two ongoing operations at the same work site.

ROOT AND CONTRIBUTING CAUSES

The Board identified as a root cause for the accident the failure of IDM management to implement an adequate EWP process that includes task hazard analysis (THA), as required by the BNFL contract with DOE and the IDM subcontract with BNFL. Contributing to this, BNFL failed to ensure appropriate follow-on actions by IDM to correct identified deficiencies. In addition, DOE failed to identify deficiencies in the BNFL and IDM process due to the lack of an adequate oversight program consisting of audits, assessments, and surveillance.

The Board also identified several contributing causes that may have increased the likelihood of the accident without individually causing the accident. These contributing causes, which are listed in ***Table ES-1***, include:

- the lack of safety barriers and a delineated safe egress route at the work site,
- the lack of recognition of the potential hazards resulting from the simultaneous operation of the two tasks of demolition and buss bar removal,
- the lack of worker training in the specific work task procedures, and
- the lack of communications between the workers at the job site.

Table ES-1. Causal Factor Analysis

Contributing Causes	Discussion
Lack of definition of requirements in IDM Standard Operating Procedure (SOP) 11.0, MSO, *Mobile Shear Operations*	Failure to clearly define "close proximity" in this procedure allowed the ironworkers to be in an unsafe work zone.
Worker safety	Failure to implement requirements for worker safety at the north end of the roof slab resulted in the lack of a safe egress route from the roof slab and a lack of safety barriers to delineate a safe work zone for the shear operation.
THA	Failure to perform a THA on the revisions to work resulting from the interface of Instruction Guide (IG) 4.1 and IG 12.2a was a contributing cause to the accident.
EWP	The EWP process for the work resulting from the interface of IG 4.1 and IG 12.2a was deficient in that a step-by-step process to complete the work addressing methods of accomplishment, a THA, and controls to mitigate the hazards were not produced for hazardous changes to IGs. Control procedures commensurate with the original scope of IG 4.1 and IG 12.2a were not applied to field changes resulting in the interface of these IGs.
Supervision/management	Supervision at the work site was less than adequate because the IDM foreman did not address hazards caused by the interface of two existing IGs and did not coordinate changes at the work site caused by the exchange of empty/full scrap metal bins. IDM management failed to ensure that field changes at the work site were subject to control measures commensurate with those applied to the original scope of work. IDM management failed to ensure that changes caused by the interface of work elements from two IGs were adequately addressed by revisions to the EWP as required by the IDM quality assurance (QA) plan.
Worker training	There is no evidence ironworkers were trained on the procedures (IDM SOP 11, IG 4.1, and IG 12.2a) required at the job site. Lack of training on job-specific procedures resulted in the workers being unaware of the THA mitigations in the IGs.
Worker actions	The ironworkers did not exercise stop work authority for the work resulting from the interface of IG 4.1 and IG 12.2a, did not realistically understand hazards present at the work site, and could not communicate with the trackhoe/shear operator.
Communications	There were no means of communication present at the work site to enable ironworkers and the trackhoe/shear operator to exchange information regarding work site activities or to provide for clear, expeditious communications during notification and emergency response.

Table ES-1. Causal Factor Analysis (continued)

Root Cause	Discussion
Implementation of EWP	**IDM** • Failed to implement requirements for EWP and THA where hazardous changes had been introduced to existing IGs. The IDM EWP process requires that field changes be subject to control procedures commensurate with those applied to the original scope of work. This process should have required formal revisions to IG 4.1 and IG 12.2a, including a THA and appropriate revisions to controls at the work site. **BNFL** • Failed to apply a sufficiently formal set of controls to the IDM subcontract to cause the removal of hazards from the work site. • Failed to enforce requirements for improvements to the IDM EWP process and THAs when a QA assessment identified a need for improvements. The BNFL EWP process does not specifically require the same control procedures for field changes as required for the original scope of work. This led to a failure to enforce the need for improvements in EWP and THA at IDM. Although BNFL monitored several EWP sessions during which IDM developed IGs, there is no evidence of follow-up surveillance of the EWP process to ensure that hazardous changes to existing IGs were properly mitigated. **DOE** • Failed to develop an independent surveillance system to identify deficiencies in the BNFL and IDM EWP processes. • Failed to recognize that BNFL applied an informal set of controls to the IDM subcontract based on their perception of risk associated with the job.

CONCLUSIONS AND JUDGMENTS OF NEED

Presented in ***Table ES-2*** are the conclusions and judgments of need determined by the Board. The conclusions are items that the Board considers to be significant and are based upon facts and pertinent analytical results. Judgments of need are managerial controls and safety measures believed by the Board to be necessary to prevent or minimize the probability of recurrence of this type of incident. Judgments of need are intended to assist managers in developing follow-up actions.

Table ES-2. Conclusions and Judgments of Need

Conclusions	Judgments of Need
IDM An EWP process was in place at IDM that, if properly implemented, could have identified revisions required for IG scope of work, THA, worker safety, and stop work applications.	**IDM** • IDM needs to be trained on the EWP process and its implementation.
Deficiencies existed in the IDM ironworkers' ability to cope with changes at the work site because they were not trained on the procedures and IGs required, were unable to respond safely to changes in directions from the foreman, were unable to communicate with the trackhoe/shear operator regarding their respective locations, and did not understand the need to enact stop work authority.	• IDM workers need to be trained on procedures and IGs. • IDM workers need to understand the use of stop work authority. • IDM needs to provide communications for the trackhoe/shear operator and workers in the vicinity of the operations.
Management processes existed at IDM that, if properly implemented, could have recognized the need to revise IG 4.1 and IG 12.2a for work scope changes and THA, provided directions on evaluation of hazards present at the work site, and emphasized the need for stopping work when questions existed. Deficiencies in worker safety existed at the work site because the supervisor did not recognize the impact of changes in work assignments, changes in work scope on hazards and controls, and changes in the work environment caused by an unplanned visitor.	• IDM management needs to implement the requirements of EWP as defined in their QA plan, especially in regard to work scope changes and THAs, and emphasize the need for stopping work when questions are raised at the specific work site.
BNFL BNFL's safety program surveillance of IDM activities noted safety findings but did not examine the work processes that resulted in the findings. Such an examination, if adequately implemented, could have led to a root cause determination that might have prevented this accident.	**BNFL** BNFL management needs to implement a safety program which requires their staff to fully investigate all findings to reach a decision on the most basic causes for the safety violation.
BNFL did not recognize its QA assessment findings of IDM and safety findings from surveillances of IDM activities as potential precursors symptomatic of a breakdown in the EWP process.	BNFL management needs to: • Ensure that the appropriate staff receive copies of all findings relevant to their area of oversight. • Assess the significance of all findings in regard to ongoing operations. • Track and trend safety findings.

Table ES-2. Conclusions and Judgments of Need (continued)

Conclusions	Judgments of Need
BNFL's QA program allowed 46 days to pass prior to the issuance of a memorandum to IDM regarding the QA assessment findings. BNFL did not provide IDM with a firm due date for response and did not initiate a verification of IDM corrective actions.	BNFL's QA program should establish formal guidelines under their implementation of the graded approach that define time frames for: • Submittal of reports to subcontractors. • Response to findings from subcontractors. • Verification of subcontractors' corrective actions.
DOE Oak Ridge Operations Office (ORO) DOE line management failed to recognize that BNFL applied an informal set of controls to the IDM subcontract commensurate with BNFL's perception of the risk associated with the job. As a result, DOE line management assumed a level of review was being applied to IDM that would have assured review commensurate with the hazard. Using this assumption, DOE line management did not emphasize oversight of IDM to either the facility representatives or the environment, safety, health, and quality (ESH&Q) matrix support staff.	**DOE-ORO** DOE line management needs to develop an oversight program that allows both flexibility and independence, while ensuring its scope is commensurate with both the task hazard and the oversight provided by the contractor. This program should not limit the support staff in either process or area for review, but instead should encourage cooperation between both DOE and contractor staff.
DOE findings from the operational awareness visits had no apparent flow to upper management unless the line manager felt they needed to be transmitted forward. In addition, concerns or trends of significant issues have not been emphasized for lessons learned.	The Assistant Manager for Environment, Safety, and Quality (AMESQ) organization should ensure that DOE findings from this project are provided to the ESH&Q corporate staff accountable for developing lessons learned for the ORO. Trends identified from the lessons learned analyses should be disseminated across ORO for use by all program managers.
No clear line of independent oversight in the ESH&Q area exists. Staff and managers suffer from unclear roles and responsibilities.	DOE-ORO management needs to develop an oversight program for this type of project that clearly defines ESH&Q roles and responsibilities. This program would then need to be communicated to all employees.

SUMMARY

The Board acknowledges the cooperation and assistance provided by the personnel of IDM, BNFL, and DOE during this investigation. Information and requested documents were provided in a timely and open manner, which greatly facilitated the efforts of this Board. It is also noted that IDM and BNFL took action to initiate system and safety improvements while this investigation was in progress.

Type B Accident Investigation Board Report on the Worker Injury at the BNFL Inc. East Tennessee Technology Park Three-Building Decontamination and Decommissioning and Recycle Project Site

1.0 INTRODUCTION

1.1 Background

On March 26, 1999, at approximately 11:00 a.m., an ironworker apprentice employed by IDM Environmental Corporation (IDM) was injured by a flying piece of chainlink fence. At the time of the accident, he and a coworker were egressing a work area at Building K-791 North in the K-33 Switchyard where they had been removing buss bars from air circuit breaker (ACB) cabinets. The K-33 Switchyard is located at the East Tennessee Technology Park (ETTP) Three-Building Decontamination and Decommissioning (D&D) and Recycle Project site, which is operated by BNFL Inc. (BNFL) under contract no. DE-AC05-97OR22576 to the U.S. Department of Energy (DOE). ***Figure 1-1*** shows the Three-Building D&D and Recycle Project site's location at ETTP and delineates the area where the accident occurred.

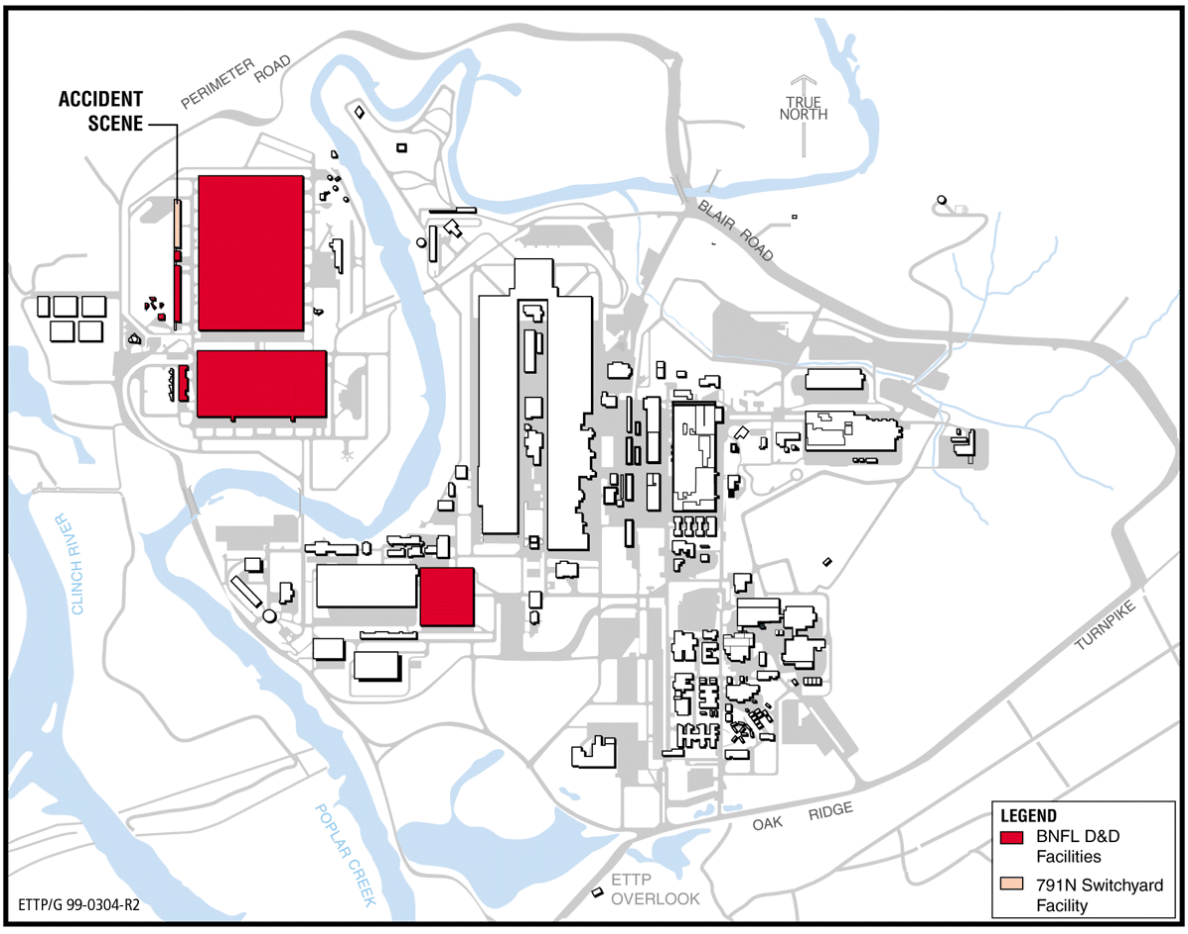

Figure 1-1. ETTP Three-Building D&D and Recycle Project Site and Accident Location.

On March 29, 1999, BNFL initiated an investigation of the accident. A meeting was held on March 31, 1999, to discuss the accident; attendees included BNFL and DOE Oak Ridge Operations Office (ORO) staff. Because the injured worker had been hospitalized for 5 days at that time, the accident met the DOE requirement for investigation as a Type B accident.

On April 2, 1999, Steve Richardson, Acting Manager of DOE-ORO, appointed a Type B Accident Investigation Board (hereafter referred to as "the Board") to investigate the accident in accordance with DOE Order 225.1A, *Accident Investigations* (see ***Appendix A***). Upon appointment of the Board, BNFL suspended its internal investigation of the accident.

1.2 Facility Description

The ETTP Three-Building D&D and Recycle Project site, which is part of the former K-25 complex, is located approximately 13 miles west of the main population of Oak Ridge, Tennessee, yet within the political boundary of the city.

The scope of the ETTP Three-Building D&D and Recycle Project is to dismantle, remove, decontaminate, and economically maximize the recycle of process equipment and material within gaseous diffusion plant buildings K-29, K-33, and K-31, and the switchyards for K-33 and K-31. The contractor, BNFL, is accomplishing the D&D of the three buildings by dismantling and removing the process equipment and related support systems, recycling the metals to the extent economically practical, and cleaning up the interior of the buildings to specified endpoint criteria. BNFL's agreement with DOE for this work is under a fixed-price contract.

IDM contracted with BNFL to demolish the K-31 and K-33 switchyards and associated buildings under subcontract no. 5248-SC98-1201, *Demolition—Switchyards K-31 and K-33*. Under this subcontract, IDM's mission is to remove buildings, transformers, switch gear, and associated electrical appurtenances contained in the switchyards. The subcontract assumes the cost of demolition will be offset by the sale of scrap material recovered by the project; therefore, no funding was provided in the subcontract.

1.3 Scope, Purpose, and Methodology

The Board began its investigation on April 2, 1999, and submitted the final report to the DOE-ORO acting manager on May 7, 1999.

The scope of the Board's investigation was to review and analyze the circumstances of the accident to determine its cause. The Board also evaluated the adequacy of the safety management system (SMS) and work control practices of BNFL and IDM.

The purpose of this investigation was to determine the cause of the accident, including deficiencies, if any, in the SMS and to assist DOE in understanding lessons learned to improve safety and reduce the potential for similar accidents in the future.

The Board conducted its investigation using the following methodology:

- Facts relevant to the accident were gathered through interviews, document and evidence reviews, and examination of physical evidence.

- Event and causal factors charting[1], along with barrier analysis[2] and change analysis[3] techniques, were used to analyze facts and identify the accident's cause.

Based on analysis of the information gathered, judgments of need for corrective actions to prevent recurrence were developed.

2.0 FACTS AND ANALYSIS

2.1 Background and Chronology

2.1.1 Background and Incident Description

On June 3, 1997, BNFL contracted with IDM for demolition of the K-31 and K-33 switchyards and associated buildings. Under provisions of its subcontract, IDM was required to perform all demolition activities using an SMS. On July 13, 1998, IDM submitted to BNFL a notice of intent to proceed, along with a project quality assurance (QA) plan, project schedule, health and safety plan (HASP), summary work plan, and other deliverables. The scope of work included in the summary work plan divided the project into 13 primary work tasks. IDM implemented SMS through the enhanced work planning (EWP) process. Based on a review by BNFL, the IDM EWP process was determined to be acceptable.

On July 20, 1998, the DOE project manager/contracting officer's representative (PM/COR) gave BNFL written notice to proceed on the Switchyard Demolition Project. IDM then began development of instruction guides (IGs) for all tasks and subtasks to be performed as part of the project. IDM developed 12 primary task IGs; 23 subtask IGs, including 2 subtask IGs developed for demolition of Building K-791 North in the K-33 Switchyard; and 23 task hazard analyses (THAs). IG 4.1, *Removal of Buss Ducts*, was completed on September 28, 1998, and IG 12.2a, *Demolish K-791 North End Section*, was completed on February 3, 1999; both IGs included the appropriate THAs.

On August 5, 1998, IDM workers cut through a live electrical cable in Building K-761, and on August 17, 1998, they cut through another cable (communication) in the same building. Investigation of the first incident identified deficiencies in EWP, THA, and worker training. These incidents were precursor events.

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

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

[3]Change analysis is a systematic approach that examines barrier/control failures resulting from planned or unplanned changes in a system.

BNFL contracted for an independent safety and health assessment of IDM in September 1998. The results were transmitted to BNFL in a letter dated September 22, 1998. The assessment found no major infractions or violations.

On November 18, 1998, BNFL provided a report to IDM detailing the results of a QA assessment to verify IDM's implementation of project QA requirements. The QA assessment identified deficiencies in the EWP process, IG issuance, and maintenance of documents and records. IDM's response to the assessment was submitted to BNFL on March 15, 1999. On March 25, 1999, a BNFL safety officer scheduled a meeting with IDM project personnel for March 29, 1999, to discuss a recent increase in project safety violations.

2.1.2 Chronology of Events

The following are facts associated with the significant events preceding the accident. ***Figure 2-1*** summarizes the chronology of significant events and associated causal factors.

- In January 1999, IDM performed the initial demolition of Building K-791 North in the K-33 Switchyard by cutting the steel supports for the roof slab and pulling the section down to the lower floor slab. The roof slab, including the ACB cabinets, was brought to rest on top of the lower floor slab. The height from the ground to the top of these two adjacent slabs at the accident scene is 5¼ feet.

- On March 25, 1999, the IDM PM met with the IDM foreman and IDM asbestos supervisor to discuss task assignments planned for overtime work on March 26, 1999. The IDM foreman was assigned the removal of ACB cabinets from the roof slab and the demolition of the roof slab of Building K-791 North in the K-33 Switchyard using the trackhoe/shear. Removal of the ACB cabinets required detaching buss bars, ACBs, and switches from the cabinets. The IDM foreman had planned to use one ironworker, one ironworker apprentice, and two laborers to perform the overtime work. A trackhoe/shear operator was assigned to demolish the concrete roof slab and remove the buss bars from the cabinets using a horizontal pull with the shear.

- On March 26, 1999, the IDM PM, health and safety officer (HSO), and project engineer were not on-site. Under IDM procedures, in this situation, the site supervisor (foreman) assumes the role of HSO.

- At 7:00 a.m. on March 26, 1999, the IDM asbestos supervisor conducted a safety meeting in which hotwork was the topic of discussion. The IDM foreman gave work assignments, answered questions, and addressed the comments of the workers. The initial work assignment for the ironworkers consisted of cutting rebar from concrete rubble. The work assignment changed when the trackhoe/shear operator stopped work because the rebar cutting was in a hazardous location. At 7:30 a.m., the IDM foreman met with the trackhoe/shear operator, the ironworker, the ironworker apprentice, and the firewatch (laborer) at the Building K-791 North job site (see ***Exhibit 2-1***) to discuss work assignments and give directions regarding removal of the buss bars and demolition of the remaining concrete roof slab.

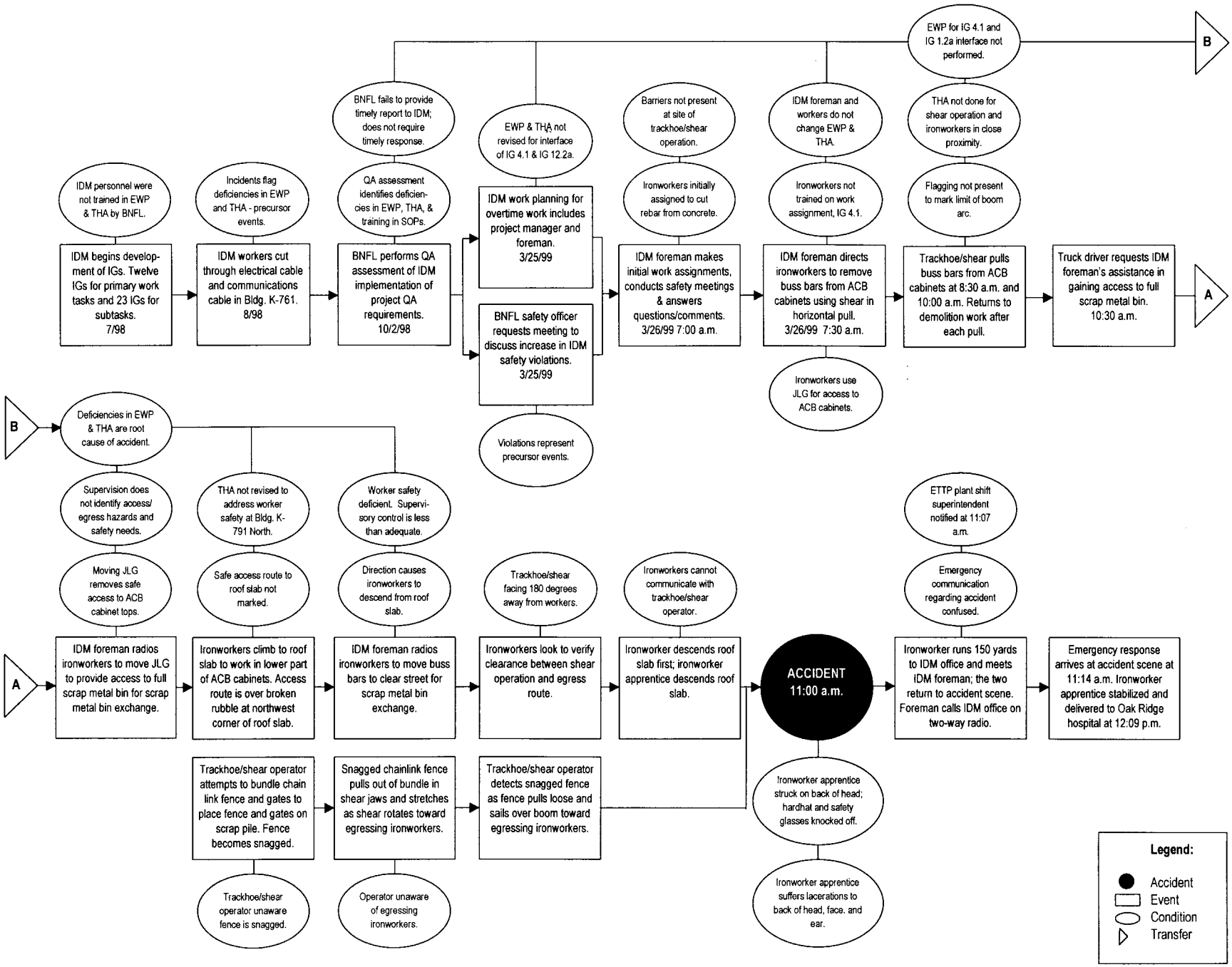

Figure 2-1. Summary Events and Causal Factors Analysis

Exhibit 2-1. Broad View of Accident Site at Building K-791 North Job Site (from NW to SE).

- Following the briefing at the job site, the IDM foreman returned to the site office, and the ironworkers began their task. The ironworkers began unbolting the buss bars in the top of the ACB cabinets and removing associated hardware in the lower section of the cabinets. The ironworkers used a manlift with a hydraulic boom and crew bucket (JLG) for access to the buss bars in the ACB cabinet tops.

- At 8:30 a.m., the trackhoe/shear pulled buss bars from the ACB cabinets using a steel wire choker. Another buss bar pull was made at 10:00 a.m. When not performing buss bar pulls, the trackhoe/shear was breaking concrete and removing metal from the roof slab on the east side of the ACB cabinets (see ***Exhibit 2-2***).

Exhibit 2-2. Near View of Accident Site at Building K-791 North Job Site (from W to E).

- At approximately 10:30 a.m., a truck driver from Southern Alloys and Metals Corporation of Rockwood, Tennessee, arrived at the job site to pick up a full scrap metal bin and leave an empty scrap metal bin. The truck driver requested the IDM foreman to provide street access to the full scrap metal bin. Using a two-way radio, the IDM foreman directed the ironworkers to move the

JLG to provide street access for the truck driver. The truck driver also requested that the full scrap metal bin be realigned for easier access. The ironworkers parked the JLG across the street and exited the crew bucket. They then flagged down the trackhoe/shear operator and used hand signals to direct the operator in realigning the full scrap metal bin. The trackhoe/shear then returned to breaking concrete and collecting scrap metal.

- The ironworkers, on their own initiative, then climbed to the top of the roof slab and continued working in the bottom of the ACB cabinets. The truck driver requested that the IDM foreman have the buss bars and other items blocking the street moved (see ***Exhibit 2.3***). The IDM foreman contacted the ironworkers using the two-way radio and directed them to move the buss bars and clear the street. The ironworker walked to the north end of the roof slab and verified the distance to the trackhoe/shear. At that time, the trackhoe was approximately 40 feet away and facing 180 degrees away from the ironworker, and the ironworker perceived his egress route to be clear from the trackhoe/shear. As the ironworker climbed from the roof slab over the broken rubble to the street, the ironworker apprentice was preparing to egress the roof slab.

Exhibit 2-3. View of Buss Bars that Blocked the Street.

- The trackhoe/shear was attempting to bundle a section of chainlink fence with metal railing attached on each end for placement in a scrap metal pile. After the fence and railing were gathered into a bundle, the trackhoe/shear rotated in a counterclockwise direction to move the bundle to the scrap metal pile located beside the road. The trailing end of the fence became snagged on an obstruction, and approximately 30 feet of the fence plus the attached railing were pulled from the jaws of the shear. The remaining fence material and its associated railing were still in the grasp of the shear jaws. As the trackhoe/shear continued its counterclockwise rotation, the fence was stretched, and the trackhoe/shear operator noticed an increase in tension in the fence. The operator attempted to stop the shear but could not stop the rotation before the fence pulled free from the obstruction.

- At approximately 11:00 a.m, as the ironworker apprentice was attempting to egress the roof slab, the fence pulled free from the obstruction, and the trailing end flew over the boom and shear and struck him on the back of the head (see ***Exhibit 2-4***). The fence knocked the ironworker apprentice's hardhat and safety glasses from his head, and he received scalp, ear, and

facial lacerations. He was knocked unconscious and fell facedown on the roof slab, with his lower torso and legs hanging over the edge (see simulation in ***Exhibit 2-5***). The ironworker, who had egressed the roof slab ahead of the ironworker apprentice, was approximately 15 feet away at the time of the accident.

Exhibit 2-4. View of Fence with Attached Railing.

Exhibit 2-5. View of Accident Scene with Simulation of Ironworker Apprentice.

2.1.3 Notification and Emergency Response

Notification of and response by site emergency personnel from the discovery of the accident to the completion of emergency response activities consisted of the following facts.

- The ironworker was the first to reach the injured worker, followed by the trackhoe/shear operator and the firewatch. The ironworker attempted to call for help using the two-way radio worn by the ironworker apprentice but could not establish clear communication with the IDM foreman. He then ran toward the IDM office to summon help. As he was running toward the

IDM office, he met the IDM foreman coming toward the accident scene. During this time, the trackhoe/shear operator was applying pressure to the cuts on the back of the worker's head.

- The IDM foreman and the ironworker returned to the accident scene, where the foreman called the IDM asbestos supervisor on the two-way radio. The IDM asbestos supervisor then phoned the ETTP plant shift superintendent (PSS).

- At 11:07 a.m., the ETTP PSS received notification of the accident. Emergency Medical Services (EMS) responders were en route to the accident at 11:08 a.m. and arrived at the accident scene at 11:14 a.m.

- The EMS responders stabilized the injured ironworker apprentice and transported him from the accident scene at 11:25 a.m. At 11:40 a.m., the injured ironworker apprentice and the EMS responders arrived at the Oak Ridge hospital, where the injured man was transferred to the care of the hospital staff. The EMS responders departed the Oak Ridge hospital at 12:09 p.m.

2.1.4 Personnel Safety

Following are the facts concerning the safety of workers performing demolition at Building K-791 North in the K-33 Switchyard. Issues related to worker safety at the job site are IDM procedures, safety barriers, communications, EWP and THA, supervision, and management.

Procedures

IDM Standard Operating Procedure (SOP) 11.0, Procedure Code MSO, *Mobile Shear Operation Safety Procedures*, provides guidelines to ensure the safety of all workers involved in the process of shear operations at a job site. This procedure specifies, "no person shall be within close proximity of the overall shear operation." The procedure does not specify or define "close proximity," leaving it to the professional judgment of the trained craft journeymen workers. The procedure does not require the presence of a spotter to assist the shear operator and does not require the use of in-cab communications between the operator and other personnel at the work site.

Subtask IG 12.2a, *Demolish K-791N North End Section*, "Task Hazard Analysis," specifies, "keep all persons not assigned to operation out of the area" and "place barricades to close off area."

Subtask IG 4.1, *Removal of Bus Ducts*[4], specifies, "no other work in area."

[4]This guide was originally written to remove the buss ducts and associated buss bars from beneath the upper floor in Building K-791 North. Because the initial removal effort was performed as a manual task by unbolting and removing the buss bars, IDM made the determination that this guide was directly applicable to removal of buss bars from the ACB cabinets.

Safety Barriers

Safety barriers, such as flagging or other barricades used to delineate the safe work limit of the shear, were required by the IG 12.2a THA. There was no flagging or other safety barriers in place at the specific job location.

Safe Egress Route

When the ironworkers left the JLG, which provided them safe access and egress, Title 29 of the *Code of Federal Regulations* (CFR), Parts 1926.34(a) and 1051(a) became applicable. Subsection 34(a) requires that exits be arranged and maintained to provide free and unobstructed egress from a structure when it is occupied. A safe egress route was not delineated for the ironworkers when they started to egress the roof slab at the hazardous northwest corner.

Subsection 1051(a) requires that a stairway or ladder be provided at all personnel points of access where there is a break in elevation of 19 inches or more, and no ramp, runway, sloped embankment, or personnel hoist is provided. There was not a ladder provided for the ironworkers' use in egressing the 5¼-foot distance from the rooftop slab to the street.

Communications

The THAs in both IG 12.2a and IG 4.1 require the use of two-way radios for emergency response communications. This requirement was not met at the job site because there was not a two-way radio in the trackhoe/shear.

Enhanced Work Planning and Task Hazard Analysis

BNFL requires IDM to perform all work using EWP. The IDM site-specific QA plan requires the use of the EWP process to conduct "Enhanced Work Plan" sessions involving safety personnel, PMs, foremen, and craft labor. IGs are to be developed that define the scope of work for the task, methods of accomplishment for the task, a THA to identify hazards, and the necessary controls to effectively manage the hazards. Work is to be controlled by the IGs and THAs that are developed. Field changes are subject to controls commensurate with those applied to the original scope of work and are approved by the PM. Based on reviews and monitoring by BNFL, IDM's EWP process was determined to be acceptable.

IG 4.1, *Removal of Bus Ducts*, and IG 12.2a, *Demolish K-791N North End Section*, were developed as independent tasks with THAs that prohibited other operations in close proximity or in adjoining areas. The work planned for overtime on March 26, 1999, consisted of elements of IG 4.1 and IG 12.2a combined into one task. The work elements consisted of shear operations to demolish concrete and pull buss bars from ACB cabinets. The work, as planned, did not provide sufficient guidance to assist the craft labor in establishing a task-specific definition of "close proximity to the shear operation." IGs were not used in providing task directions, and controls (discussed in Section 2.2.2) were not used to mitigate hazards for this new task. The ironworkers did not sign the IGs.

Supervision

The IDM foreman attended a safety meeting, made work assignments, and visited the job site to give directions to the ironworker, ironworker apprentice, firewatch (laborer), and trackhoe/shear operator. The IDM foreman did not use IG 12.2a and IG 4.1 in directing the four workers, nor did he perform a THA on the work assigned.

The IDM foreman did not visit the job site to coordinate activities associated with the exchange of scrap metal bins. The directions given by the IDM foreman to the ironworkers to move the JLG took away safe access/egress to the roof slab. The ironworkers decided independently to climb to the roof slab to continue work on the ACBs. The foreman directed the ironworkers via two-way radio to move buss bar from the street.

Management

On March 25, 1999, the IDM PM met with the IDM foreman to discuss the tasks to be performed for the overtime work on the following day. The IDM PM gave directions to remove buss bars from the ACB cabinets in order to remove the cabinets and continue demolition of Building K-791 North in the K-33 Switchyard. Removal of the buss bars reduced the weight of the ACB cabinets and made them easier to move.

2.1.5 Assessments

Assessments that were required and performed at the K-33/K-31 Switchyard Demolition Project by BNFL and IDM are summarized below.

Management Assessments by IDM

The IDM site-specific QA plan requires IDM to perform management assessments and independent assessments.

IDM managers are required to periodically assess the performance of their organizations to determine how well leadership is being provided to enable the organization to continuously meet contractual and regulatory requirements, and public expectations. Results of these assessments are to be documented and used as input to the continuous improvement process to include verification of corrective actions, including actions identified to prevent recurrence or to otherwise improve performance.

Management assessments are performed on a daily basis by the IDM PM during site walkdowns. These assessments cover safety, work performance, and work status, and are informal and usually not documented.

QA assessments are performed on personnel training and qualifications to determine if workers are trained and qualified for work being performed. Included in these assessments are reviews of worker training files and medical records. These assessments are formal, with results documented in assessment reports. The assessment reports, which are approved by the IDM PM, include a task

description, list of findings and corrective actions, and the signature of the QA engineer. Review of two QA assessments performed by IDM did not indicate any findings that correlate to the accident.

Safety surveillances are performed by the IDM HSO. The safety surveillances are performed on a daily basis and are documented by the IDM HSO in a daily log. Copies of the logs for March 22–25, 1999, were reviewed. Entries in the logs reflect daily safety-related activities and the results of safety surveillances, which indicated work was being performed safely and any infractions encountered were corrected and noted in the log.

The IDM corporate safety director performs safety assessments of the K-33/K-31 Switchyard Demolition Project. These assessments are not formally scheduled but occur at least monthly. The monthly safety self-assessments include site safety inspections, reviews of training records, and medical records. The results are informal and not documented, and safety deficiencies are orally directed to the IDM HSO for correction. There is not a formal process for verification of corrective actions.

Independent Assessments by IDM

Independent assessments by IDM are required by the IDM QA plan. These assessments are to be planned and held periodically by the QA manager and others. Personnel performing independent assessments are required to not have direct responsibilities in the areas they are assessing. These assessments are to be conducted to ensure organizational independence. Assessments are to be made using the graded approach on activities that most directly relate to final objectives. The types and frequencies of these assessments are to be based on the status, complexity, and importance of the activities being assessed. Results of these assessments are to be documented and used as input to the continuous improvement process to include verification of corrective actions, including actions identified to prevent recurrence or to otherwise improve performance.

There is no evidence to indicate that IDM has performed independent assessments on the K-33/K-31 Switchyard Demolition Project.

Assessments of IDM by BNFL

Independent assessments of this project have been performed by BNFL. These assessments consisted of documented on-site safety surveillances by BNFL safety personnel, QA assessments, surveillances of the EWP process, and BNFL surveillances of the IDM safety meetings.

During September 1998, BNFL performed a QA assessment that focused attention on work control processes, qualifications and training, and management assessment, as described in the IDM QA and site health and safety plans. Findings from this assessment identified deficiencies in QA records, the EWP process, hazard analysis and control, and training. Although the QA assessment report was transmitted to BNFL on October 2, 1998, it was not transmitted to IDM until November 18, 1998. The memorandum from BNFL to IDM did not require a specific date for IDM to develop a corrective action plan. IDM responded to the QA assessment report on March 15, 1999.

BNFL contracted for an independent safety and health assessment of IDM in September 1998. The results were transmitted to BNFL in a letter dated September 22, 1998. The assessment found no major infractions or violations.

2.2 Hazards, Controls, and Management System

2.2.1 Policies and Procedures

The following are policies and procedures relevant to this investigation.

- MI-QA-005, *BNFL Quality Assurance Program Plan for 10 CFR 830.120*
- *IDM K-33/K-31, Switchyard Demolition Project Summary Work Plan*
- *IDM K-33/K-31, Switchyard Demolition Project Site Specific Health and Safety Plan*
- *IDM K-33/K-31, Switchyard Demolition Project Quality Assurance Plan*
- IDM IG 12.2a, *Demolish K-791N North End Section*
- IDM IG 4.1, *Removal Of Buss Ducts*
- IDM SOP 11.0, MSO, *Mobile Shear Operation Safety Procedures*
- DOE Policy 450.4, *Safety Management System Policy*

The BNFL QA program plan requires the use of a defined EWP process to meet DOE contractual requirements of integration of environment, safety, and health (ES&H) into work planning and execution. This requirement was passed down from BNFL to IDM via its contract.

The IDM contractual deliverables to BNFL included a project work schedule, project work plan, site-specific HASP, and a QA plan.

The IDM QA plan follows the BNFL QA program plan, which uses EWP in defining tasks and addressing hazards to meet the SMS requirement. IDM approached the demolition project by breaking the basic tasks defined in the summary work plan into subtasks and developing an IG for each of the subtasks. Each IG defined the subtask scope of work and delineated the associated hazards in a formal THA section. The IDM EWP process was reviewed by BNFL prior to commencement of the contract and found to be an acceptable system.

2.2.2 Work Planning and Controls

IDM is required through BNFL subcontract no. 5248-SC98-1201, *Demolition—Switchyards K-31 and K-33*, to have an SMS that meets the five core functions of DOE Policy 450.4, *Safety Management System Policy*. These functions are:

- define the scope of work task activities,
- identify and analyze hazards associated with the work,
- develop and implement hazard controls,
- perform work within the controls, and

- provide feedback on the adequacy of controls and continuous improvement in defining and planning work.

These five safety management functions provide the necessary structure for any work activity that could potentially affect the public, the worker, and the environment.

IDM uses the EWP process to ensure an informed development of work methods through coordinated discussions with safety personnel, PMs, superintendents, foremen, and craft labor. The IDM EWP process allows, as work progresses, changes to the guides, as required. If changes are needed, the changes are appended to the original guide, and the THA is updated, as necessary. As new personnel were assigned to a task, IDM policy required them to read and sign the IG and associated THA prior to starting work on that effort.

As part of the accident analysis, the Board reviewed IDM work practices ongoing at the accident scene against the five functions defined above. ***Table 2-1*** provides an outline of the comparison.

Table 2-1. SMS Core Functions and Methods of Implementation for IDM Work Practices (General)

	Define the Work	Identify and Analyze Hazards	Develop and Implement Controls	Perform Work Safely	Provide Feedback
Methods of Implementation	• BNFL/IDM Contract • IDM Summary Work Plan	• Work Smart Standards • IDM Site-Specific HASP • IDM EWP • IDM THA	• Individual Training Records • IDM SOP • IDM IGs with THAs	• IDM Safety Meeting • Assignment of Tasks • Skill of the Craft Labor • IG Training	• Workers' Suggested Changes to IGs or THAs • IDM Review of IGs and THAs • BNFL Assessment/ Oversight • DOE Operational Awareness Visits

Define the Scope of Work

The Board found that IDM had provided a summary work plan that addressed the task-level work to be accomplished. They also provided subtask-level work plans in the form of IGs for both the buss duct removal and shear operation activities. However, the Board found no evidence of a document that defined the scope of work for performing both work-site activities simultaneously and close to each other. The only scope of work for this task was provided verbally to the foreman and crew on the job.

Identify and Analyze the Hazards Associated with the Work

The Board found that IDM had provided a site-specific HASP for work at the task level. However, no documented evidence was found of any form of hazard assessment for the subtask of shear operations and buss bar operations occurring simultaneously in the same area.

Develop and Implement Hazard Controls

The Board found that IDM had implemented hazard controls for both shear operation and buss bar removal based on their hazard analyses. However, because there was no documented evidence that a formal hazard analysis had been performed for the simultaneous performance of these activities, no documented controls were developed or implemented.

Perform Work within Documented Controls

The Board found no evidence that adequate controls had been established for the subtask of shear operations and buss bar removal being performed in the same area simultaneously.

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

The Board found no evidence that feedback was used for the work performed that day. It was determined that a BNFL safety officer conducted two walkthroughs of the site the morning prior to the accident; at that time, however, the only IDM employee present was the trackhoe/shear operator.

2.2.3 Management Systems

Management systems and controls are utilized by BNFL and IDM to conduct normal operations, which include switchyard demolition by IDM and the three-building D&D and recycle effort by BNFL.

Contractual Background

DOE entered into a fixed-price contract (DE-AC05-97OR22576.001) with BNFL on August 25, 1997, for the ETTP Three-Building D&D and Recycle Project. The BNFL contract was amended on June 30, 1998, to add Option 1, "Removal and Disposal of Switchyards and the Equipment Building Removal."

Included in the BNFL contract was the requirement for the contractor to manage and perform work in accordance with a documented SMS.

On June 3, 1998, BNFL contracted with IDM to demolish the K-31 and K-33 switchyards under subcontract no. 5248-SC98-1201, *Demolition—Switchyards K-31 and K-33*. The subcontract also contained the provision for an SMS program. The cost of the work performed under this subcontract was to be offset by the sale of the assets and materials recovered from the project. The original completion date of the subcontract was January 29, 1999.

Roles and Responsibilities

DOE-ORO

DOE-ORO Manager

The DOE-ORO manager was the signatory authority on the ETTP Three Building D&D and Recycling Project contract. The manager has the ultimate responsibility for providing personnel and assets to assess the performance and contract adherence of the contractors doing work on the Oak Ridge Reservation. The manager tasks his assistant managers with assessment and support efforts to monitor contractor performance at all Oak Ridge sites.

Assistant Manager for Assets Utilization (AMAU) Organization

The DOE PM/COR for the ETTP Three Building D&D and Recycling Project reports directly to the AMAU. The PM/COR is responsible for the project management of the BNFL contract, including subcontractors. Prior to issuing a notice to proceed to BNFL for the ETTP Three Building D&D and Recycling Project, DOE conducted an operational readiness review (ORR) in May 1998 to determine BNFL's preparedness to commence operations. After a thorough review of the discrepancies and deficiencies noted in the ORR, a decision was made to allow the contractor to proceed, and a notice to proceed was officially issued to BNFL with the expectation that the ORR discrepancies and deficiencies would be corrected. A follow-on review is scheduled to be conducted at the end of the next principal work evolution.

When Option 1, "Removal and Disposal of Switchyards and the Equipment Building Removal," of the BNFL contract was authorized, BNFL subcontracted with IDM to perform the demolition effort. In reviewing the work scope for this option, the PM/COR concluded that the IDM effort had less risk than the rest of the BNFL operations because it was not as broad in scope, involved demolition work, and did not involve the performance of work in a radiation hazard area. It was BNFL's responsibility to oversee the subcontractor for safe work practices. The DOE PM/COR, recognizing the need for some level of awareness by DOE staff, requested occasional support from the facility representatives and negotiated monthly visits by the Assistant Manager for Environment, Safety, and Quality (AMESQ) organization. The DOE PM/COR reviewed the IDM site-specific HASP, with support from the matrix ES&H site personnel at ETTP. A notice to proceed with the Option 1 statement of work was issued to BNFL, which, in turn, issued a notice to proceed to IDM to commence demolition and salvage efforts.

Facility Representatives

Two facility representatives are matrixed from the Environmental Management organization to the DOE PM/COR for the ETTP Three Building D&D and Recycling Project. They are assigned to what are considered to be the most hazardous facilities for the project, specifically, buildings K-33, K-31, and K-29.

The facility representatives are responsible for providing the daily health and safety oversight of the contractor's operations, including the operations by subcontractors. The facility representatives had determined that the IDM operation was a standard industrial demolition project and was of a lower

risk than the ongoing operations in the K-33, K-31, and K-29 buildings. They had not been initially tasked to perform any functions outside of their assigned areas and concluded that the IDM operations were outside the scope of their responsibilities; however, the DOE PM/COR for the project had requested that they occasionally provide general oversight of IDM work. As a result, the facility representatives occasionally walked through the IDM site to monitor safe work practices. In support of the operational awareness visits performed by AMESQ staff, they would provide information to the AMESQ personnel on project issues and areas of concern.

AMESQ Organization

The AMESQ organization provides matrix environmental, safety, and QA support to DOE-ORO line managers for assessing contractors' effectiveness in meeting ES&H performance criteria. The ETTP Three-Building D&D and Recycle Project is primarily supported by the AMESQ Operations Division, Environmental Management Support Team. AMESQ's assistance to the DOE PM/COR consists of a monthly operational awareness visit. Because the AMESQ support staff is not structured for process review (i.e., EWP), it is mainly focused on Occupational Safety and Health Act compliance of ongoing activities observed during the monthly operational awareness visits. Environment, safety, and quality (ESH&Q) matrix staff have been limited in performing their assigned oversight roles by only being allowed site visits 1 day a month. Until recently, these monthly visits had been restricted to predefined areas and issues, as negotiated with the DOE PM/COR and Environmental Management Support Team leader. Contractor and subcontractor performance and compliance information were provided on a monthly basis to the DOE PM/COR for the ETTP Three-Building D&D and Recycle Project.

BNFL

The BNFL PM has program management responsibility for the overall ETTP Three-Building D&D and Recycling Project, including all subcontractors. The demolition effort being performed by IDM was viewed as a less hazardous effort than the work being performed within the K-33 or K-31 buildings because IDM was not working in a radiation hazard area and the work was considered a general industrial effort. The PM expected IDM to perform work in accordance with contractual work smart standards. Initially, BNFL performed more of a programmatic oversight role in monitoring IDM's effort than one of specific job oversight. This graded approach resulted in the contractual requirement for IDM to have a full-time HSO on-site. In contrast, the subcontractors working "inside the fence," i.e., in the K-33 and K-31 buildings, were not required to provide a full-time HSO. BNFL personnel performed the direct safety oversight for those subcontractors.

The BNFL PM met weekly with the IDM PM to discuss any operational or scheduling issues. Daily contact and interface with IDM was through the BNFL subcontract technical representative (STR). The STR usually walked the IDM site once or twice a week to obtain firsthand knowledge of how the demolition effort was progressing and meet with the IDM PM to discuss operational issues. At the time of the incident, the BNFL STR was serving as the acting BNFL PM.

The BNFL environmental, safety, health, and quality assurance (ESH&QA) manager is responsible for oversight of the company's on-site health and safety program. This responsibility includes establishing health and safety policies and procedures, supporting project activities, and verifying safe

work practices and conditions. The ESH&QA manager has a number of direct reports, including the radiation safety officer, the QA manager, and an HSO.

The radiation safety officer and site HSO have joint responsibility for the radiation/safety technicians used to provide safety oversight of the subcontractors performing work "inside the fence" in the K-33 and K-31 buildings. The QA manager is responsible for independent oversight through QA audits performed internally to the company and for subcontractors. The HSO is responsible for monitoring overall work practices and conditions on the project. The HSO and his/her staff are also the points of contact for the radiation/safety technicians if a question arises regarding how to correct a construction or industrial safety deficiency or discrepancy.

2.3 Controls and Analysis

The subsections to follow provide the barrier analysis, change analysis, and causal factor analysis.

2.3.1 Barrier Analysis

The safety barriers between the ironworker and ironworker apprentice and the trackhoe/shear within the K-33 Switchyard included physical barriers, administrative barriers, and management barriers. A description of why these barriers failed is contained in ***Table 2-2***.

Table 2-2. Barrier Analysis

Barrier	Purpose	Performance
Work site barricade (flagging)	To delineate the safe work zone of trackhoe/shear operation.	Barrier failed because the requirement for flagging was not identified, and flagging was not used to delineate a safe work zone.
Safe egress route	To provide a safe route of access/egress for ironworkers to/from the roof slab.	Barrier failed because hazards in access/egress from roof slab were not identified.
IDM SOP 11.0, MSO, *Mobile Shear Operation*	To ensure safety of workers during shear operations at a work site.	Barrier failed because the procedure did not provide for a clear definition of close proximity to the trackhoe/shear, and there was no communication between ironworkers and trackhoe/shear operator.
Communications (two-way radios)	To facilitate notification and transmission of information during emergencies and to provide communication between equipment operators and workers.	Barrier failed because two-way radios were not used effectively during accident notification and were not provided for communication between ironworkers and the trackhoe/shear operator.
Training on IGs	To instruct workers on the performance of job tasks, hazards present at the job site, and methods of hazard mitigation.	Barrier failed because there is no indication that the ironworkers were trained on the task to be performed.

Barrier	Purpose	Performance
Stop work authority	To stop work and seek corrective actions when in the presence of a previously unidentified and unmitigated hazard.	Barrier failed because stop work authority was not used by the ironworkers for the interface of the two IGs in use.
THA	To identify hazards expected to be encountered while performing specific work tasks, provide controls to mitigate hazards, and revise hazard analysis to conform to changing conditions.	Barrier failed because a THA was not performed for the interface of two operations at the same job site, and hazard controls were not in place to protect personnel.
Personnel protective equipment (hardhat, safety glasses, and safety shoes)	To protect workers from injuries to the head, eyes, and feet from impact-type injuries to these body areas.	Barrier was successful because the hardhat deflected part of the blow from the chainlink fence and prevented the ironworker apprentice from receiving a more serious injury.
Prejob briefing	To provide directions to workers regarding task assignments, hazards present, and hazard controls to be used.	Barrier failed because work assignments changed, and the prejob briefing did not address hazards associated with those changes.
JLG	To provide ironworkers access and egress to the ACB cabinets for buss bar removal.	Barrier failed because the ironworkers were directed to move the JLG to provide the truck driver access to the full scrap metal bin. This removed safe access for work on the ACB cabinets.
Supervision	To assist in work planning, conduct safety meetings, make work assignments, provide directions to workers regarding task performance and hazard mitigation, and make corrections, as required.	Barrier failed because IGs were not used in giving task direction to ironworkers, hazards at the job site were not identified, flagging was not provided, and communication was not provided between ironworkers and the trackhoe/shear operator. Work progress was not coordinated, and corrections were not provided when required.
EWP	To provide detailed planning of work by all persons involved, analyze hazards expected to be encountered by workers, and provide controls to mitigate hazards.	Barrier failed because the work to be performed was part of two mutually hazardous IGs, detailed planning was not provided for this job task, job hazards were not identified, and hazards present were not controlled.

2.3.2 Change Analysis

Change analysis considers failures in barriers from planned or unplanned changes in a system that disturb normal operations. ***Table 2-3*** shows details of the change analysis performed by the Board.

Table 2-3. Summary Change Analysis

Planned/Normal	Actual	Difference	Analysis
Ironworkers were originally assigned to remove rebar from concrete on March 26, 1999.	The IDM foreman reassigned the ironworkers to remove buss bars from the ACB cabinets.	Changes in work assignments were made to avoid contact with the trackhoe/shear while removing rebar.	No formal documentation indicates that the ironworkers were adequately trained in the new work assignment.
Flagging is installed to delineate a safe work zone between the trackhoe/shear and ironworkers.	Flagging was not installed.	The safe work zone between ironworkers and the trackhoe/shear was unmarked.	The access/egress route chosen by the ironworkers took them past the limit of the safe work distance from the trackhoe/shear.
A JLG is used for access to the ACB cabinets for buss bar removal.	The JLG was parked across the street to provide access for the truck driver to exchange empty scrap metal bins for full ones.	The ironworkers did not have a safe access route to the top of the roof slab.	The ironworkers chose an unsafe route for access/egress to the roof slab.
The truck driver delivers and picks up scrap metal bins.	The truck driver arrived on-site to exchange an empty scrap metal bin for a full one, and access was blocked.	The truck driver was blocked by the JLG and the material in the street.	The truck driver's arrival adversely impacted hazard controls at the work site by causing the ironworkers to park and leave the JLG.
Workers can stop work when in the presence of an unidentified and unmitigated hazard.	The workers continued task.	The workers did not recognize hazards involved in continuing work.	The workers were not provided adequate information to allow them to determine close proximity and safe access/egress routes.
The ironworkers planned to perform buss bar removal in the top of the ACB cabinet using a JLG.	The ironworkers continued work in bottoms of the ACB cabinets without the JLG.	The ironworkers used an unplanned access route to the roof slab to work on the ACB cabinets.	The ironworkers exercised independent initiative in gaining access to the roof slab to work in the ACB cabinets.

Table 2-3. Summary Change Analysis (continued)

Planned/Normal	Actual	Difference	Analysis
EWP normally provides for detailed work planning, hazard analysis and mitigation, job-specific training, and detailed task direction.	Elements of two mutually hazardous IGs, IG 12.2a and IG 4.1, were combined into one job. A THA for this interface was not performed.	Detailed planning was not provided for the new job, and a formal THA was not performed.	EWP deficiencies did not control changes to ACB cabinet access. Changes in the access route to the roof slab were caused by parking the JLG. Failure to address safe access to the roof slab would have been corrected by a THA.
Supervision provides task directions for workers, identifies hazards associated with work, controls activities associated with work, and provides corrections where required.	Supervision did not identify hazards associated with the interface of the two work tasks or the interruption by the metal recycler.	Supervision did not coordinate or control efforts at the job site.	Failure to control and coordinate the tasks at the job site allowed work to be performed that placed workers at risk.
Training on IGs provides detailed task-specific directions to workers.	The IGs were not signed by workers.	The lack of signed documentation suggests that workers were not sufficiently trained on work assignments and the associated hazards.	The lack of documentation suggests that workers did not identify hazards associated with the task.
IDM SOP 11.0, MSO, *Mobile Shear Operations*, prohibits other operations in close proximity to shear.	This procedure does not define "close proximity" or require a method of communication.	Ironworkers felt that they were not in close proximity and that they did not need communications.	This procedure does not provide guidance and definition to preclude subjective interpretation.

2.3.3 Causal Factor Analysis

The direct cause of the accident was an ironworker and an ironworker apprentice crossing the safe work zone of the trackhoe/shear operation while the equipment was in motion; however, there were also causal factors, i.e., contributing causes and a root cause. Contributing causes are causes that, if corrected, would not by themselves have prevented the accident, but are important enough to be recognized as needing corrective action to improve the quality of the process. Root causes are the fundamental causes and associated corrective actions that, if corrected, would prevent recurrence of an event or adverse action. The causal factor analysis presented in ***Table 2-4*** uses techniques from management and oversight risk tree based root causes analysis and the DOE Workbook, *Conducting Accident Investigations*, Revision 1, November 21, 1997.

Table 2-4. Causal Factor Analysis

Contributing Causes	Discussion
Lack of definition of requirements in IDM SOP 11.0, MSO, *Mobile Shear Operations*	Failure to clearly define "close proximity" in this procedure allowed the ironworkers to be in an unsafe work zone.
Worker safety	Failure to implement requirements for worker safety at the north end of the roof slab resulted in the lack of a safe egress route from the roof slab and a lack of safety barriers to delineate a safe work zone for the shear operation.
THA	Failure to perform a THA on the revisions to work resulting from the interface of IG 4.1 and IG 12.2a was a contributing cause to the accident.
EWP	The EWP process for the work resulting from the interface of IG 4.1 and IG 12.2a was deficient in that a step-by-step process to complete the work addressing methods of accomplishment, a THA, and controls to mitigate the hazards were not produced for hazardous changes to IGs. Control procedures commensurate with the original scope of IG 4.1 and IG 12.2a were not applied to field changes resulting in the interface of these IGs.
Supervision/management	Supervision at the work site was less than adequate because the IDM foreman did not address hazards caused by the interface of two existing IGs and did not coordinate changes at the work site caused by the exchange of empty/full scrap metal bins. IDM management failed to ensure that field changes at the work site were subject to control measures commensurate with those applied to the original scope of work. IDM management failed to ensure that changes caused by the interface of work elements from two IGs were adequately addressed by revisions to the EWP as required by the IDM QA plan.

Table 2-4. Causal Factor Analysis (continued)

Contributing Causes	Discussion
Worker training	There is no evidence ironworkers were trained on the procedures (SOP 11, IG 4.1, and IG 12.2a) required at the job site. Lack of training on job-specific procedures resulted in the workers being unaware of the THA mitigations in the IGs.
Worker actions	The ironworkers did not exercise stop work authority for the work resulting from the interface of IG 4.1 and IG 12.2a, did not realistically understand hazards present at the work site, and could not communicate with the trackhoe/shear operator.
Communications	There were no means of communication present at the work site to enable ironworkers and the trackhoe/shear operator to exchange information regarding work site activities or to provide for clear, expeditious communications during notification and emergency response.
Root Cause	**Discussion**
Implementation of EWP	**IDM** • Failed to implement requirements for EWP and THA where hazardous changes had been introduced to existing IGs. The IDM EWP process requires that field changes be subject to control procedures commensurate with those applied to the original scope of work. This process should have required formal revisions to IG 4.1 and IG 12.2a, including a THA and appropriate revisions to controls at the work site. **BNFL** • Failed to apply a sufficiently formal set of controls to the IDM subcontract to cause the removal of hazards from the work site. • Failed to enforce requirements for improvements to the IDM EWP process and THAs when a QA assessment identified a need for improvements. The BNFL EWP process does not specifically require the same control procedures for field changes as required for the original scope of work. This led to a failure to enforce the need for improvements in EWP and THA at IDM. Although BNFL monitored several EWP sessions during which IDM developed IGs, there is no evidence of follow-up surveillance of the EWP process to ensure that hazardous changes to existing IGs were properly mitigated. **DOE** • Failed to develop an independent surveillance system to identify deficiencies in the BNFL and IDM EWP processes. • Failed to recognize that BNFL applied an informal set of controls to the IDM subcontract based on their perception of risk associated with the job.

3.0 CONCLUSIONS AND JUDGMENTS OF NEED

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

Table 3-1. Conclusions and Judgments of Need

Conclusions	Judgments of Need
IDM An EWP process was in place at IDM that, if properly implemented, could have identified revisions required for IG scope of work, THA, worker safety, and stop work applications.	**IDM** • IDM needs to be trained on the EWP process and its implementation.
Deficiencies existed in the IDM ironworkers' ability to cope with changes at the work site because they were not trained on the procedures and IGs required, were unable to respond safely to changes in directions from the foreman, were unable to communicate with the trackhoe/shear operator regarding their respective locations, and did not understand the need to enact stop work authority.	• IDM workers need to be trained on procedures and IGs. • IDM workers need to understand the use of stop work authority. • IDM needs to provide communications for the trackhoe/shear operator and workers in the vicinity of the operations.
Management processes existed at IDM that, if properly implemented, could have recognized the need to revise IG 4.1 and IG 12.2a for work scope changes and THA, provided directions on evaluation of hazards present at the work site, and emphasized the need for stopping work when questions existed. Deficiencies in worker safety existed at the work site because the supervisor did not recognize the impact of changes in work assignments, changes in work scope on hazards and controls, and changes in the work environment caused by an unplanned visitor.	• IDM management needs to implement the requirements of EWP as defined in their QA plan, especially in regard to work scope changes and THAs, and emphasize the need for stopping work when questions are raised at the specific work site.
BNFL BNFL's safety program surveillance of IDM activities noted safety findings but did not examine the work processes that resulted in the findings. Such an examination, if adequately implemented, could have led to a root cause determination that might have prevented this accident.	**BNFL** BNFL management needs to implement a safety program which requires their staff to fully investigate all findings to reach a decision on the most basic causes for the safety violation.

Table 3-1. Conclusions and Judgments of Need (continued)

Conclusions	Judgments of Need
BNFL did not recognize its QA assessment findings of IDM and safety findings from surveillances of IDM activities as potential precursors symptomatic of a breakdown in the EWP process.	BNFL management needs to: • Ensure that the appropriate staff receive copies of all findings relevant to their area of oversight. • Assess the significance of all findings in regard to ongoing operations. • Track and trend safety findings.
BNFL's QA program allowed 46 days to pass prior to the issuance of a memorandum to IDM regarding the QA assessment findings. BNFL did not provide IDM with a firm due date for response and did not initiate a verification of IDM corrective actions.	BNFL's QA program should establish formal guidelines under their implementation of the graded approach that define time frames for: • Submittal of reports to subcontractors. • Response to findings from subcontractors. • Verification of subcontractors' corrective actions.
DOE-ORO DOE line management failed to recognize that BNFL applied an informal set of controls to the IDM subcontract commensurate with BNFL's perception of the risk associated with the job. As a result, DOE line management assumed a level of review was being applied to IDM that would have assured review commensurate with the hazard. Using this assumption, DOE line management did not emphasize oversight of IDM to either the facility representatives or the ESH&Q matrix support staff.	**DOE-ORO** DOE line management needs to develop an oversight program that allows both flexibility and independence, while ensuring its scope is commensurate with both the task hazard and the oversight provided by the contractor. This program should not limit the support staff in either process or area for review, but instead should encourage cooperation between both DOE and contractor staff.
DOE findings from the operational awareness visits had no apparent flow to upper management unless the line manager felt they needed to be transmitted forward. In addition, concerns or trends of significant issues have not been emphasized for lessons learned.	AMESQ should ensure that DOE findings from this project are provided to the ESH&Q corporate staff accountable for developing lessons learned for ORO. Trends identified from the lessons learned analyses should be disseminated across ORO for use by all program managers.
No clear line of independent oversight in the ESH&Q area exists. Staff and managers suffer from unclear roles and responsibilities.	DOE-ORO management needs to develop an oversight program for this type of project that clearly defines ESH&Q roles and responsibilities. This program would then need to be communicated to all affected employees.

4.0 BOARD SIGNATURES

Judith M. Penry, Chairperson
DOE Accident Investigation Board
U. S. Department of Energy
Oak Ridge Operations Office

5/6/99
Date

William Mark Belvin, Member
DOE Accident Investigation Board
U. S. Department of Energy
Oak Ridge Operations Office

5/6/99
Date

James S. Campbell, Member
DOE Accident Investigation Board
U. S. Department of Energy
Oak Ridge Operations Office

5/6/99
Date

W. Dean Sheridan, Member
DOE Accident Investigation Board
U. S. Department of Energy
Oak Ridge Operations Office

5/6/99
Date

5.0 BOARD MEMBERS, ADVISORS, AND STAFF

Chairperson	Judith M. Penry, DOE-ORO
Member	William M. Belvin, DOE-ORO
Member	James S. Campbell, DOE-ORO
Member	W. Dean Sheridan, DOE-ORO
Advisor	Rachel Blumenfeld, DOE-ORO
Technical Editor	Kimberlee A. Davis, PAI, Oak Ridge Office
Administrative Support	Carolyn Alvarez, PAI, Oak Ridge Office

APPENDIX A

Appointment Memorandum for Type B Accident Investigation

United States Government **Department of Energy**

Oak Ridge Operations Office

memorandum

DATE: April 2, 1999

REPLY TO
ATTN OF: SE-32:Mullins

SUBJECT: **TYPE B INVESTIGATION - EMPLOYEE INJURY FROM FLYING DEBRIS - BNFL INC. AT THE EAST TENNESSEE TECHNOLOGY PARK, OAK RIDGE, TENNESSEE**

TO: Judith M. Penry, Assistant Manager for Financial Management, FM-70

You are hereby appointed Chairman of the Investigation Board to investigate the March 26, 1999, injury of an employee of IDM Environmental Corp., subcontractor to BNFL Inc. at the East Tennessee Technology Park. I have determined that the accident meets the requirements for a Type B Accident Investigation as required by DOE Order 225.1A, "Accident Investigations."

You are to perform a Type B investigation of this incident and to prepare an investigation report. The report shall conform to requirements detailed in DOE Order 225.1A and DOE G 225.1A-1, Implementation Guide for Use with DOE 225.1A, Accident Investigations. The Board will be comprised of the following members:

James Campbell, OR Technical Support Division, Trained Investigator
Mark Belvin, OR Operations Division, ORNL Site Office, Member
Dean Sheridan, OR Operations Division, EM Support Team, Member

The scope of the Board's investigation is to include, but is not limited to, 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 focus on and specifically address the role of DOE and contractor organizations and Integrated Safety Management Systems, including oversight of subcontractor, 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.

If additional resources are required to assist you in completing this task, please let me know and it will be provided. Rachel Blumenfeld has been appointed to serve as the Board's legal liaison. You and members of the Board are relieved of your other duties until this assignment is completed.

The Board will provide my office, John D. Rothrock, Acting Assistant Manager for Environment, Safety, and Quality, and Robert Brown, Acting Assistant Manager for Assets Utilization with weekly reports on the status of the investigation and not include any findings or arrive at any premature conclusions until an analysis of all the causal factors have been completed. Draft copies

of the factual portion of the investigation report will be submitted to my office and BNFL Inc. for factual accuracy review prior to the report finalization.

The final investigation report should be provided to me by May 7, 1999. Any delay to this date shall be justified and forwarded to this office. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report. If you have any questions, please contact me or John Rothrock at 423-576-0831.

Steven D. Richardson
Acting Manager

cc:
Steve Wyatt, M-4, OR
R. W. Poe, M-2, OR
J. D. Rothrock, SE-30, OR
R. R. Nelson, EW-90, OR
R. J. Brown, AU-60, OR
W. M. Seay, EW-96, OR
R. Blumenfeld, CC-10, OR
J. Fowler, CC-10, OR
Jack Howard, AU-60, OR
LeeAnn Smith, BNFL Inc. Project Manager
Daniel Quinn, IDM Project Manager
David Michaels, EH-1, HQ/FORS
James Owendoff, EM-1, HQ, 5A-014/FORS
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B. Holder, EH-24, OR