Final Report April 1996

# Type A Accident Investigation Board Report on the January 17, 1996, Electrical Accident with Injury in Building 209, Technical Area 21 Los Alamos National Laboratory

Office of Environment, Safety and Health

# Type A Accident Investigation Board Report on the January 17, 1996, Electrical Accident with Injury in Technical Area 21 Tritium Science and Fabrication Facility Los Alamos National Laboratory

April 1996

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

This report is an independent product of the Type A Accident Investigation Board appointed by Tara O'Toole, M.D., M.P.H., Assistant Secretary for Environment, Safety and Health (EH-1).

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

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

This report neither determines nor implies liability.

On January 23, 1996, I established a Type A Accident Investigation Board to investigate the electrical accident in Technical Area 21 of the Tritium Science and Fabrication Facility at the Los Alamos National Laboratory that resulted in serious injuries to a maintenance employee of Johnson Controls World Services, Inc. The Board's responsibilities have been completed with respect to this investigation. The analysis, identification of direct, contributing, and root causes, and judgments of need reached during the investigation were performed in accordance with DOE Order 225.1, *Accident Investigations*. I accept the findings of the Board and authorize the release of this report for general distribution.

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

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# ACRONYMS AND INITIALISMS

| | |
|---|---|
| AL | Department of Energy Albuquerque Operations Office |
| ANSI | American National Standards Institute |
| CFR | Code of Federal Regulations |
| CPR | Cardiopulmonary resuscitation |
| DOE | U.S. Department of Energy |
| EH | Department of Energy Office of Environment, Health and Safety |
| EPA | U.S. Environmental Protection Agency |
| ESA | LANL Engineering Sciences and Applications Division |
| ESA-3 | LANL Tritium Science and Technology Group |
| ESH | LANL Environment, Safety, and Health Division |
| ESH-1 | LANL Radiological Protection |
| ESH-3 | LANL Facility Risk Management Group |
| ESH-5 | LANL Industrial Hygiene and Safety Group |
| ESH-18 | LANL Water Quality and Hydrology Group |
| ES&H | Environment, safety, and health |
| FM | Department of Energy Office of Field Management |
| FSS | LANL Facilities, Security, and Safeguards Division |
| FSS-3 | LANL Facilities Support Operations Group |
| FSS-6 | LANL Facility Project Delivery Group |
| FSS-9 | LANL Operations and Maintenance Services Group |
| JCI | Johnson Controls World Services, Inc. |
| kV | Kilovolt |
| LAAO | Department of Energy Los Alamos Area Office |
| LANL | Los Alamos National Laboratory |
| ML | Management Level |
| OSHA | Occupational Safety and Health Administration |
| NPDES | National Pollutant Discharge Elimination Systems |
| PPE | Personal protective equipment |
| SFE | Santa Fe Engineering |
| TA | Technical Area |
| TSE | Tritium Science and Engineering |
| TSFF | Tritium Science and Fabrication Facility |
| U of C | University of California |
| UPCS | Utilities Power Control Section |
| WSC | Waste Stream Corrections |

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# PROLOGUE

## OFFICE OF ENVIRONMENT, SAFETY AND HEALTH

## INTERPRETATION OF SIGNIFICANCE

The electrical accident with injury at the Los Alamos National Laboratory (LANL) on January 17, 1996, resulted from failures of Department of Energy (DOE), contractor, and subcontractor management. Significant, sitewide, programmatic weaknesses in the Laboratory's safety management program and failure to correct them were the principal causes of the accident. This was particularly true of the inadequacies in work planning, authorization, and control procedures that contributed to the injury.

Neither applicable DOE standards nor LANL work control and project management procedures were followed. The use of more restrictive project controls and engineering reviews could have alerted supervisors and workers to the hazards. The support organization, inappropriately assigned responsibility for the work, did not have the internal procedures, experience using codes and standards, or expertise needed to perform complex facility modification work. A single Standing Work Order was used, an application not intended for large maintenance tasks, which did not provide for an adequate description of the facility and the work task hazards. As a result of a pervasive misinterpretation of LANL administrative requirements, personnel failed to take appropriate measures to determine the location of dangerous underground utilities and prevent the exposure of employees to hazards associated with those utilities. Finally, commitments and schedule pressures allowed the work to be performed on a work package that lacked sufficient detail and supervision. Although not a complete list of the serious problems, correction of any one of the previously mentioned conditions may have prevented the accident.

This accident highlights the importance of a comprehensive approach to safety that stresses clear goals and policies, individual and management accountability and ownership, implementation of requirements and procedures, and thorough and systematic oversight by contractor and Department management. There is also a need to ensure proper and uniform classification of work planning and control procedures, including reviews, approvals, and work supervision requirements.

In addition, Departmental and LANL management systems have not been effective at resolving long-standing, well defined programmatic issues or translating lessons learned into safe day-to-day operation. The numerous failures and longstanding weaknesses that led to the accident, their similarity with other precursor accidents at LANL, and the inadequate execution of corrective actions by Laboratory management indicate a lack of management accountability and ownership for safety.

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# EXECUTIVE SUMMARY

## INTRODUCTION

An electrical accident was investigated in which a crafts person received serious injuries as a result of coming into contact with a 13.2 kilovolt (kV) electrical cable in the basement of Building 209 in Technical Area 21 (TA-21-209) in the Tritium Science and Fabrication Facility (TSFF) at Los Alamos National Laboratory (LANL). In conducting its investigation, the Accident Investigation Board used various analytical techniques, including events and causal factor analysis, barrier analysis, change analysis, fault tree analysis, materials analysis, and root cause analysis. The Board inspected the accident site, reviewed events surrounding the accident, conducted extensive interviews and document reviews, and performed causation analyses to determine the factors that contributed to the accident, including any management system deficiencies. Relevant management systems and factors that could have contributed to the accident were evaluated in accordance with the guiding principles of safety management identified by the Secretary of Energy in an October 1994 letter to the Defense Nuclear Facilities Safety Board and subsequently to Congress.

## ACCIDENT DESCRIPTION

The accident occurred at approximately 9:34 a.m. on January 17, 1996, in Building TA-21-209, during the excavation of a sump pit in the floor of the building to correct a waste stream outfall deficiency. On that day, two mason tenders arrived at the job site at approximately 8:40 a.m. and resumed the excavation work, begun on the previous day. The mason tenders (crafts persons) were employed by Johnson Controls World Services, Inc. (JCI), the primary LANL subcontractor for construction and maintenance. The mason tenders alternately operated a jackhammer, pry bar, and shovel to loosen and remove the rubble from the sump pit. At about 9:34 a.m., at a depth of 39 inches, the mason tender operating the jackhammer pierced the conduit containing an energized 13.2 kV electrical cable. The accident victim was transported to the Los Alamos Medical Center, where cardiac medications were administered. At approximately 10:10 a.m., the accident victim resumed a normal heart rhythm and blood pressure. The accident victim remains in a deep coma.

## CONCLUSIONS AND ANALYSIS

Techniques used by the Board to determine accident causation produced evidence of significant deficiencies in the safety management program at LANL with respect to this accident.

The Board determined that the significant sitewide programmatic weaknesses that resulted in this accident have a high degree of similarity with weaknesses previously identified in other Type A accident investigations at LANL, external assessments by the U.S. Department of Energy (DOE) Los Alamos Area Office (LAAO) and the DOE Albuquerque Operations Office (AL), as well as internal oversight by LANL. LANL management has not ensured that identified corrective actions have been implemented in most of these cases. The Board found that management systems instituted at LANL have not been effective in resolving longstanding, well defined programmatic issues or translating lessons learned into safe day-to-day operations at the Laboratory. This is indicative of inadequate LANL line management accountability and ownership, as well as an inability to learn from previous incidents to prevent their recurrence.

The line managers who should have implemented the environmental modifications within their facilities did not do so. Instead, an environmental support organization was given responsibility for management of the project and proceeded to implement the modifications. Division level management was aware of this, but did not take action to restore responsibility to the appropriate facility operations organizations. The Waste Stream Corrections Project Team, led by the environmental support organization, indicated that field direction of the work would be simpler and more cost effective than using more restrictive project controls and engineering reviews that could have alerted supervisors and workers to the hazards. Thus, for this project, information was only passed on to JCI and was not subjected to an engineering review to determine the adequacy of information provided.

Because this construction work was being accomplished via a maintenance process, there was no mechanism in place to capture the facility design modifications that were being done to TSFF, a Category 3 nuclear facility. There was no plan to update the as-built drawings for this facility. The result was a loss of configuration control that would open the door for similar accidents in the future. The Board concluded that modifications to facility systems were not being captured or analyzed against the existing safety analysis report or other system design documents.

Many of the decisions relating to the Waste Stream Corrections Project, particularly the assumption of design responsibilities by the environmental support organization engineers in the project team, were due to cost and schedule pressures. The normal function of the organization (Water Quality and Hydrology Group) was to provide project support and oversight of environmental issues. It did not have the internal procedures, experience using codes and standards, or field construction expertise needed to perform complex facility modification work. Both the managers and the staff involved overestimated the capability of the project team to engineer and manage a construction project of this magnitude. The project team did not understand the processes required to implement design changes. As a result, the project team implemented an undocumented modification process that did not (1) adequately develop the designs, (2) require preparation of detailed work packages, (3) provide the guidance needed to assure adequate safety reviews, (4) manage changes to the work packages during installation, (5) document the completed work, and (6) formally turn over the new and modified systems to the facility operations organization. The overall process did not meet the requirements of the LANL Quality Assurance Management Plan or DOE orders. Although the decision to have a support organization assume the project lead and the decision to field-direct much of the work may not have been directly conveyed to senior LANL management, senior LANL management shares the responsibility because of its lack of involvement.

In implementing the facility modifications, neither applicable DOE design standards nor LANL work control and project management procedures (to the extent they were defined) were followed. LANL management has not communicated its expectation for, nor have LANL management programs emphasized use of, such procedures in conducting Laboratory activities. Consequently, Laboratory-wide procedures (1) have not been updated, (2) do not provide adequate guidance, and where they exist, (3) are not always followed by LANL or JCI personnel. Further, because Laboratory-wide procedures for many programs, including work control and planning and configuration management, are neither current nor comprehensive, multiple Division or Group-level procedures are being prepared and used. The standards and requirements in these procedures vary significantly among the different organizations at the Laboratory and do not necessarily reflect the requirements or expectations set by higher-tier documents within LANL, such as Director's Policies.

In this regard, Director Policy 102, "Formality of Operations," states that the Laboratory will establish programs and procedures to control conduct of operations, and that Laboratory personnel will be trained in the use of its procedures. It also states that management shall require all personnel to use applicable

procedures and shall maintain oversight. The Board found multiple cases where the LANL management systems have failed to comply with this basic operating philosophy. The Director's Policies and lower tier Program Requirement Documents serve as guiding instructions, but no procedure, program, or process is in place to provide any assurance that these expectations are actually implemented on a sitewide basis.

The Board found that there are no Laboratory-wide operating procedures that implement the Program Requirements Documents for either configuration management or conduct of operations (a subset of which is work planning and control), and there is no plan to develop such procedures. Without specific implementing procedures, there is no assurance that higher-level policy and requirements documents are translated into actual implementation at the facility level. By not issuing sitewide operating procedures, LANL management has not achieved effective, consistent implementation of the requirements and expectations contained in Director's Policies at the working level. The Board believes that because of the lack of requirements and implementing procedures to control work and establish expectations, LANL's formality of operations must be strengthened.

The Board determined that the actions taken by LANL management in implementing the facility modifications related to this accident were being driven by time constraints. Ad hoc procedures were created to expedite the completion of the facility modifications needed to meet an Environmental Protection Agency Administrative Order deadline of October 1996. For example, for the work performed under the Waste Stream Corrections Project, the environment, safety, and health (ES&H) organization utilized a new process that used project summaries instead of the formal ES&H questionnaire process normally used under the LANL Administrative Requirement procedures. The project summaries are distributed to subject matter experts for review and comment; they are then are reviewed by the ES&H organization to ensure that all safety concerns are addressed. This ad hoc process, however, was never formally approved by LANL senior management. In addition, for this project, both the service request and the ES&H technical review were completed prior to completion of subject matter expert reviews, one of which addressed the fact that the complexity of the Waste Stream Corrections Project dictated more diligent controls and engineering reviews. The Board further determined that 16 Waste Stream Corrections Project subtasks were approved for work by the ES&H Division in the absence of detailed work packages and prior to completion of subject matter expert reviews. The failure of management to require LANL organizations to use formal, approved procedures contributed to the incomplete closure of identified safety concerns raised by the subject matter experts for the project on which the accident occurred.

A single Standing Work Order was used for the Waste Stream Corrections Project to correct over 2,000 waste stream deficiencies at all LANL sites, which contain many diverse facilities and buildings. Over 1,028 Standing Work Orders were being used at LANL at the time of the investigation. The purpose of Standing Work Orders is to allow routine activities, such as snow removal and lamp replacement, to be authorized, funded, and performed without the use of detailed work packages. In accordance with LANL Administrative Requirements procedures, Standing Work Orders do not need to have ES&H reviews because they are to be used for routine, repetitive, non-complex tasks. Standing Work Orders were not designed or intended to be used for large maintenance tasks, complex facility modifications, or major construction activities such as those encountered in the Waste Stream Corrections Project. Although an ES&H review was performed in the early stages of the Waste Stream Corrections Project, it was based on the very limited information provided in project summaries, which did not adequately describe the detailed facility and work task hazards to be encountered. The Board found that because the Standing Work Order format was too broad to permit the detailed work activities to be defined, ES&H reviews were completed without adequate understanding of the specific hazards associated with the work tasks. The Board considers the use of Standing Work Orders at LANL to be excessive, and their use may

circumvent adequate ES&H reviews on the projects for which they are being used. This use of Standing Work Orders to capture the complex, non-repetitive work covered in the Waste Stream Corrections Project clearly exceeds their intended purpose.

Although LANL Administrative Requirement 1-12 clearly requires that excavation permits be obtained prior to any groundbreaking activities inside or outside buildings, a widespread misinterpretation by LANL and JCI personnel generally limited requests for excavation and penetration permits to areas located outside buildings. Board interviews with both LANL and JCI personnel found that the interpretation was common in both organizations, and knowledge of the specific requirements of Administrative Requirement 1-12 appeared limited. As a result of this incorrect interpretation, both LANL and JCI personnel failed to take appropriate measures to (1) determine the locations of dangerous underground utilities, (2) prevent the exposure of employees to hazards associated with those utilities, and (3) conduct work in a manner designed to avoid damage to the utilities, as required by 29 CFR 1926.

The Board had several concerns relating to the post-accident emergency response. Of major concern was the lack of a temporary power emergency plan for Building TA-21-209. Emergency power for critical needs was addressed several years earlier by LANL, and some TSFF critical systems were connected to the Tritium Systems Test Assembly emergency diesel generators. However, immediately after the accident in TSFF, LANL facility operating personnel and LAAO personnel determined that power to the building had to be restored as soon as possible. This decision was based on the possibility of tritium releases from the tritium effluent system and the possible need for freeze protection. Because there was no temporary emergency power plan for the facility, the generator capacity, power line size, and connection points to the existing Building TA-21-209 electrical panels were not known. To resolve these unknowns, LANL and JCI engineers used the biggest generator they could find; used "welding cables" because they were the largest conductor available; located and grounded the temporary diesel generator next to hydrogen bottles in clear view of a "caution explosive" danger sign; and routed (draped) cables over light fixtures and existing cable trays. The Board considers that a higher level of safety assurance could have been obtained had LANL developed, in advance, a well thought out temporary emergency power plan for the TSFF.

The Board had concerns involving the Facilities Management Unit concept at the Laboratory. Under this concept, the facility operating organizations are to be responsible for all work in their facilities and are to manage projects, such as the Waste Stream Corrections Project, through completion. However, procedures that implement the Facilities Management Unit program have not been issued, and not all LANL sites have adopted this approach. The Board generally endorses LANL's Facilities Management Unit concept purpose and policy. The assignment of facility operations and facility safety responsibility to a specific person within the facility management/operations organization helps in managing resources for optimum efficiency and effectiveness. However, the transition to the Facilities Management Unit model is not complete, even though it was conceived several years ago. The Board found that LANL senior management has not aggressively or formally endorsed the Facilities Management Unit transition process. This support is needed to bring about the changes in roles, responsibilities, authorities, and accountabilities that will be necessary to effectively implement the model throughout the Laboratory. The Board strongly believes that the success of this model will depend in large part on the ability of LANL senior management to clearly and formally state their expectations and hold individuals accountable for its implementation.

## DIRECT CAUSE

The direct cause of the electrical accident with injury was the chisel bit of the air-powered jackhammer coming into contact with the 13.2 kV energized electrical cable in the sump pit being excavated in the basement of Building TA-21-209.

## CONTRIBUTING CAUSES

Contributing causes of the accident are as follows:

- The excavation procedures in effect at the time of the accident only required the performance of utility surveys and an ES&H review. There was no requirement for an engineering review of drawings or a physical walkdown of the work site to determine the existence of electrical cables or piping in the immediate work area.

- High-level procedures contain requirements directed to line managers but do not provide adequate infrastructure, responsibility, and accountability to implement the numerous requirements.

- LANL management has not instituted Laboratory-wide procedures that outline organizational responsibilities and authorities governing the conduct of ES&H or engineering design reviews.

- Modifications to facility systems are not being captured by or analyzed against the existing safety analyses or system design documents.

- JCI safety and maintenance personnel do not routinely perform safety inspections of ongoing maintenance activities.

- Lessons learned from previous electrical incidents at LANL have not been effectively implemented into LANL or JCI operating procedures or formal training programs.

- There was a lack of LANL facility line management involvement in planning and execution of the Waste Stream Corrections Project.

- The Facilities Management Unit concept is in a transitional state where roles, responsibilities, authorities, and accountabilities are not well understood.

- LANL management does not adequately understand the importance of providing appropriate detail in work packages and preparing modifications to as-built drawings for subsequent safe operation and maintenance of facility systems.

## ROOT CAUSES

Root causes of an occurrence are conditions that, if corrected, would prevent a similar occurrence. The root causes of this accident, as determined by the Board, are as follows:

- Laboratory-wide procedures have not been developed to define the requirements for work planning and control within all LANL organizations and to establish the performance expectations of LANL subcontractors.

- A standing work order process, normally used for routine, maintenance tasks, was incorrectly used to accomplish non-routine, complex modification and construction work associated with the Waste Stream Corrections Project.

- The requirements for excavation and/or penetration permits inside of buildings/facilities were not adequately defined in LANL and JCI procedures, resulting in confusion as to their applicability to the work being performed in the Waste Stream Corrections Project.

- The management systems instituted at LANL have not been effective in correcting longstanding, well defined programmatic weaknesses identified through internal and external assessments, past occurrences, and previous accident investigations, or in translating lessons learned into safe day-to-day operations at the Laboratory.

- Actions taken by LANL management in implementing the facility modifications related to the Waste Stream Corrections Project were being driven by time constraints associated with Environmental Protection Agency commitments; as a result, ad hoc procedures and processes were created to expedite completion of the project.

- LANL and JCI management systems have not ensured that DOE or LANL policies and procedural requirements are being met, nor have these systems ensured that individuals are held accountable for poor safety performance.

- Senior LANL management allowed an ES&H support organization to assume line management responsibility for the design and construction of facility modifications associated with the Waste Stream Corrections Project.

## JUDGMENTS OF NEED

During the accident investigation, the Board developed Judgments of Need that must be addressed in order to prevent a recurrence of similar accidents in the future. The following is a summary of the Judgments of Need, which have been categorized according to the guiding principles of safety management established by the Secretary of Energy.

### Guiding Principle 1: Line Managers Are Responsible and Accountable for Safety.

- LANL senior management needs to formally embrace and support the Facility Management Unit concept.

- LANL management needs to develop and standardize Laboratory programs that apply to all Facilities Management Units.

- LANL management needs to improve its lessons-learned program to allow management to be proactive in identifying adverse worker and programmatic safety trends.

- The Manager, Albuquerque Operations Office; the Manager, Los Alamos Area Office; and the DOE Office of Environment, Safety and Health (EH) Residents Office at Los Alamos need to track all corrective actions taken as a result of this accident investigation to ensure closure.

**Guiding Principle 2: Comprehensive Requirements Exist, Are Appropriate, and Are Executed.**

- The Manager, Albuquerque Operations Office, and the Director, Los Alamos National Laboratory, need to reassess the continued use of Standing Work Orders at the Laboratory.

- LANL and JCI management need to develop Laboratory-wide work planning and control procedures.

- LANL and JCI management need to emphasize requirements for penetration and excavation permits for work inside Laboratory facilities and/or buildings.

**Guiding Principle 3: Competence Is Commensurate with Responsibilities.**

- LANL and JCI management need to implement effective training programs in the assessment of hazards and the use of personal protective equipment.

- LANL and JCI management need to develop and implement a process to ensure acceptance of and individual accountability for safety through the proper application of graded incentives and disciplinary actions.

- LANL needs to institute programs within the Laboratory and JCI to change the existing culture that discriminates against employees who raise work-related safety issues.

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# TYPE A ACCIDENT INVESTIGATION BOARD REPORT ON THE JANUARY 17, 1996, ELECTRICAL ACCIDENT WITH INJURY IN TECHNICAL AREA 21 TRITIUM SCIENCE AND FABRICATION FACILITY LOS ALAMOS NATIONAL LABORATORY

## 1.0 SCOPE OF INVESTIGATION

### 1.1 INTRODUCTION

*On January 17, 1996, a worker at Los Alamos National Laboratory suffered severe burns and cardiac arrest when he contacted an electrical cable. He remains in a deep coma.*

On January 17, 1996, at approximately 9:34 a.m., a crafts person received serious injuries as a result of coming into contact with a 13.2 kilovolt (kV) electrical cable in the basement of Building 209 in Technical Area 21 (Building TA-21-209) at Los Alamos National Laboratory (LANL). Building TA-21-209 houses the Tritium Science and Fabrication Facility, where lithium salt parts are fabricated for the underground nuclear test program. The work in progress at the time of the accident was the excavation of a sump pit in the floor of the building to correct waste stream deficiencies. The crafts person is an employee of Johnson Controls World Services, Inc. (JCI), which is the primary subcontractor to LANL for construction and maintenance work across the Laboratory.

The accident victim suffered severe burns and cardiac arrest. On-scene attempts to re-establish cardiac rhythm with a defibrillator were unsuccessful. The accident victim was subsequently transported to the Los Alamos Medical Center, where cardiac medications were administered. At approximately 10:10 a.m., the accident victim resumed a normal cardiac rhythm and blood pressure. The accident victim remains in a deep coma.

On January 23, 1996, Dr. Tara O'Toole, Assistant Secretary for Environment, Safety and Health (EH-1), appointed a Type A Accident Investigation Board to investigate this accident (see Appendix A). The Assistant Secretary's declaration of a Type A investigation was based on the serious nature of the incident, the recurrence of both electrical and conduct of operations incidents at LANL, and her concern for the need to develop programmatic lessons-learned to reverse this adverse trend in worker safety.

### 1.2 SCOPE AND CONDUCT OF INVESTIGATION

*A Type A Accident Investigation Board was convened to find the causes of the accident and render judgments of need to prevent similar accidents in the future.*

The scope of the Board's investigation included a review and analysis of the events leading up to the accident and identifying and analyzing the accident's direct, probable, and root causes. The investigation was conducted in accordance with DOE Order 225.1, *Accident Investigations*. In addition, the Board was charged with preparing a report of

the accident, and with providing judgments of need to prevent similar accidents from occurring in the future. The Board also observed and documented safety and health concerns that were not a direct cause of the accident.

During the investigation, the Board inspected and photographed the accident site and reviewed the events leading to the accident. The Board conducted extensive interviews and document reviews, and performed engineering and root cause analyses. Interviews were conducted with work participants, emergency responders, doctors, management, and other personnel. Document reviews included U.S. Department of Energy (DOE) orders, LANL policies and procedures, JCI policies and procedures, Santa Fe Engineering contractual documents, facility design and modification drawings, and related records. The Board evaluated relevant management systems and other factors that could have contributed to the accident, and performed an events and causal factor analysis and a change analysis of the events, causes, and safety systems related to the accident.

In support of the Board's efforts, JCI performed an electrical loads analysis of the fault caused by the accident, conducted compressive strength tests of both the concrete (surrounding the electrical cable conduit) and adjacent tuff soil (volcanic rock), and conducted an underground utility location survey (after electric power had been restored to the facility).

## 1.3 ACCIDENT INVESTIGATION BOARD MAKEUP AND APPROACH

*The Board's activities were consistent with Department of Energy concerns for worker safety and the significance of the accident.*

The Accident Investigation Board consisted of a Chairperson; three Board Members, including one trained accident investigator; five advisors; and an administrative staff to coordinate the investigation and report preparation. The advisors provided expertise in accident analysis, electrical safety, work planning, construction safety, management systems, conduct of operations, materials testing, and medicine. Appendix B contains the qualifications and experience of the Board Members, advisors, and administrative support staff.

The Board's activities were consistent with the Assistant Secretary's concerns for worker safety at LANL and the overall significance of the accident relative to safety throughout the DOE complex. The basic objectives of the Board were to identify the facts pertinent to the accident, to determine the significance of the facts by analysis, to establish the direct contributors and root causes of the accident, and to identify the judgments of need to prevent a recurrence of a similar accident.

The Board also examined programmatic weaknesses that contributed to the accident. To achieve this objective, the Board conducted 63 interviews with workers, electrical safety specialists, supervisors, and management personnel. The Board also reviewed related procedures, work control documents, design drawings, safety program initiatives, and corrective actions taken in precursor events. The accident investigation was initiated on January 21, 1996, with a review of the accident scene and the damaged equipment, and a walkthrough of the events leading up to the accident. The Board concluded its investigation and conducted a closeout briefing at LANL on February 12, 1996.

## 1.4 SITE AND FACILITY DESCRIPTION

*Los Alamos National Laboratory's primary mission is application of scientific and engineering capabilities to assure national security.*

LANL is operated by the University of California (U of C) under contract to DOE. Its primary mission is to apply scientific and engineering capabilities to assure national security through nuclear weapons technology. The complex is located in Los Alamos County in the mountains of north central New Mexico (Figure 1-1). The LANL facilities occupy 43 square miles and consist of 32 technical areas. Figure 1-2 shows Technical Area 21, the location at which the accident occurred.

The LANL organization, depicted in Figure 1-3, is a matrix of Divisions and Offices managed by Division or Office Directors (referred to in this report as the LANL Division management level) reporting directly to the Director and Deputy Director of the Laboratory (referred to in this report as senior LANL management). For the events leading up to this accident, three Divisions had major roles: the Environment, Safety, and Health (ESH) Division; the Facilities, Security, and Safeguards (FSS) Division; and the Engineering Sciences and Applications (ESA) Division. Within these Divisions are Groups such as the Water Quality and Hydrology Group (ESH-18), and the Operations and Maintenance Services Group (FSS-9). These organizations were assigned specific responsibilities for the work in Building TA-21-209 at the time of the accident.

*The accident occurred during excavation operations in the basement of a tritium handling facility.*

The Tritium Science and Fabrication Facility (TSFF) is a tritium research and development facility that is operated by the Tritium Science and Technology Group (ESA-3). The primary mission of the facility, which has been operating since 1974, has been the fabrication of lithium salt parts for the underground nuclear test program. The facility is located in Building 209 in Technical Area 21 (Building TA-21-209), and was designed to handle large quantities of tritium in the form of metal tritides or gas. The utilities for the TSFF, including electrical service, are located in the basement of Building TA-21-209, where the accident occurred.

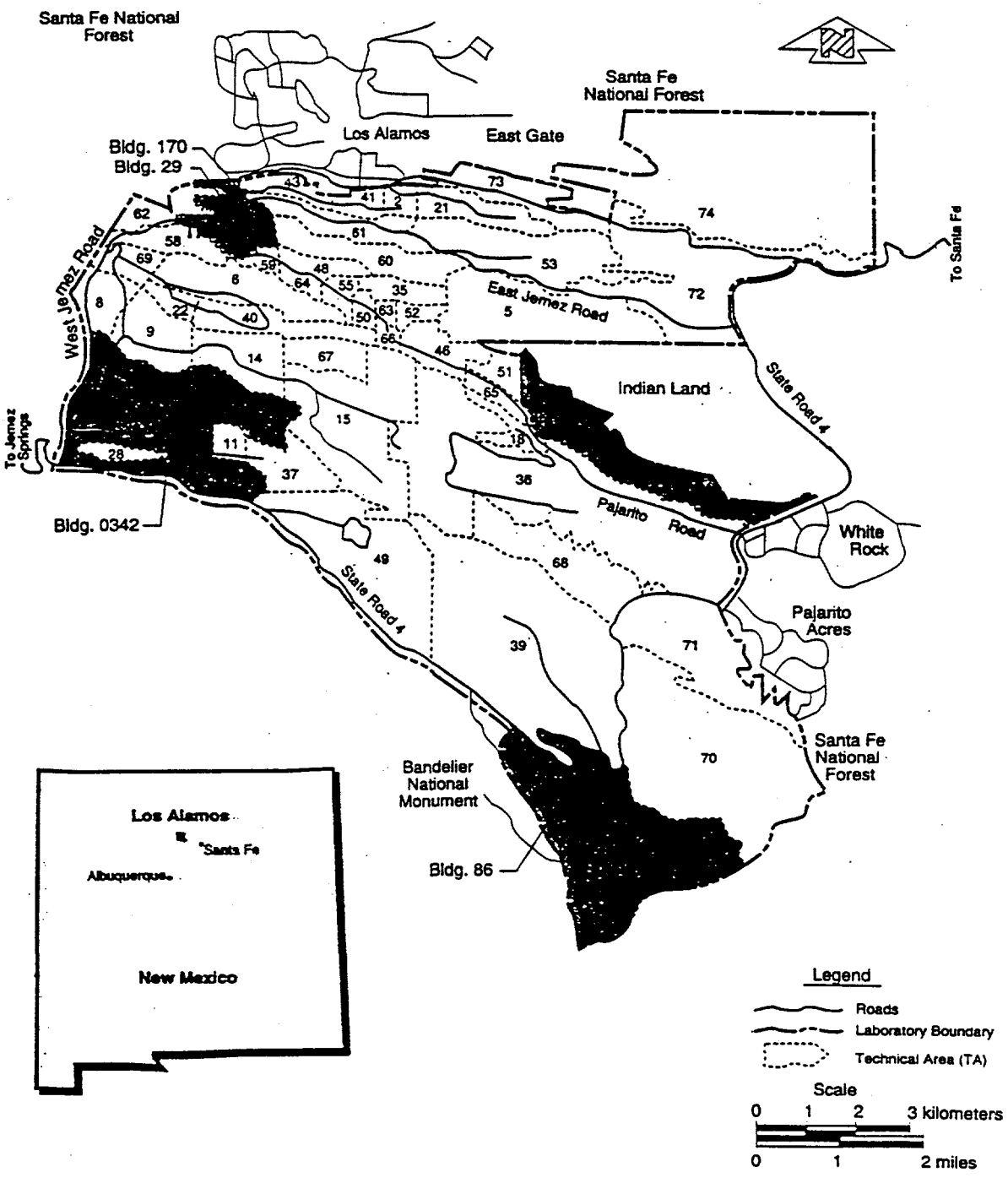



**Figure 1-1. Los Alamos National Laboratory Site Map**

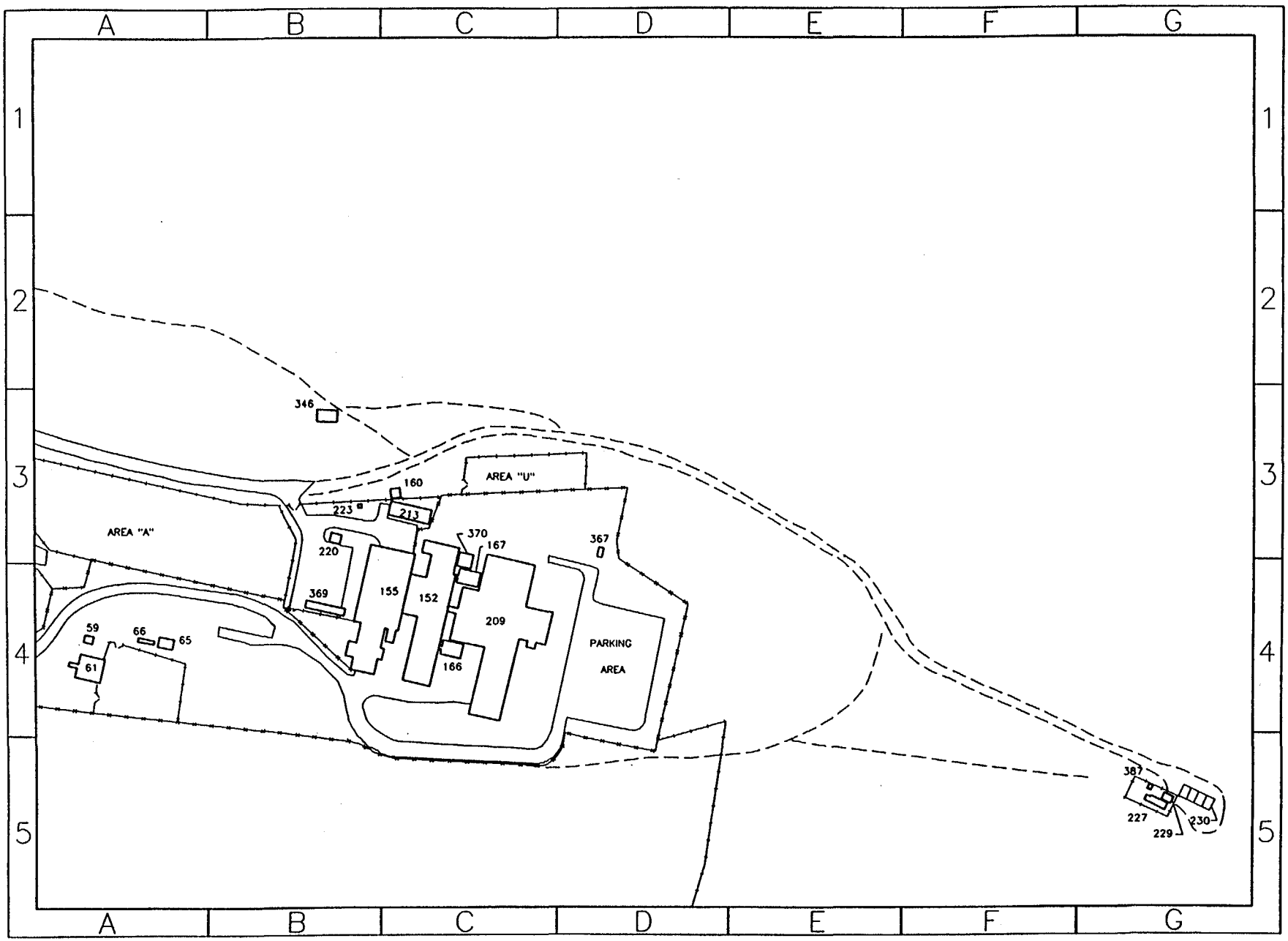



**Figure 1-2. Technical Area 21**

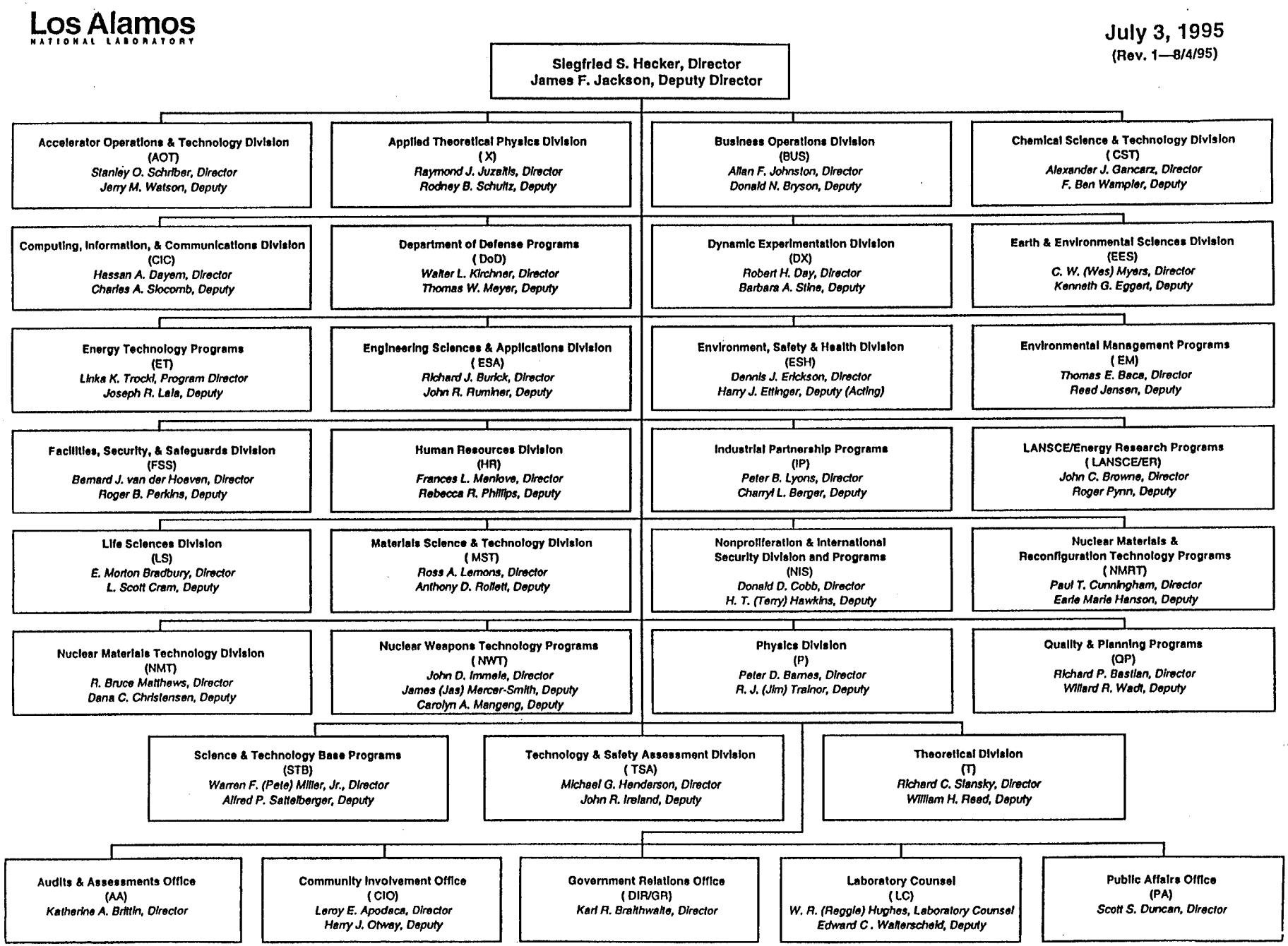



**Figure 1-3. Los Alamos National Laboratory Organization Chart**

### 1.5 ACCIDENT INVESTIGATION BOARD REPORT

The results of the Board's investigation, including facts, analysis, findings, probable causes, and judgments of need related to the electrical accident and injury that occurred in Building TA-21-209 are presented in this report. To clarify what occurred before, during, and after the accident, and to maximize the lessons learned from the accident, the Board has included appropriate photographs, diagrams, figures, tables, and copies of relevant documents. The corrective actions developed and implemented to address the results of this investigation will be evaluated and tracked to closure by the DOE's Office of Environment, Safety and Health (EH).

## 2.0 FACTS

### 2.1 FACTUAL ACCOUNT OF ACCIDENT AND CIRCUMSTANCES

#### 2.1.1 Accident Background

*The activities that led to the accident were performed as part of a project to correct environmental deficiencies. An environment, safety, and health support organization with no project management experience and no direct facility operations responsibility was assigned as project lead.*

The LANL National Pollutant Discharge Elimination System (NPDES) permit came up for renewal in 1991. During the renewal process, the Environmental Protection Agency (EPA) issued an Administrative Order to LANL management requiring an assessment of the Laboratory's facilities in accordance with the Clean Water Act and NPDES regulations and requirements. An assessment schedule was established and agreed upon by the EPA. The Water Quality and Hydrology Group (ESH-18) was assigned the responsibility to perform assessments to identify and correct NPDES deficiencies. A waste stream characterization assessment was conducted, and recommendations for corrective actions, including building modifications, were made over a three-year period by ESH-18 with assistance from an engineering firm, Santa Fe Engineering (SFE). Approximately 7,500 deficiencies were identified during the assessment.

Initially, the recommendations resulting from the waste stream corrections assessment were provided to LANL facility managers, who were expected to manage the modifications of their facilities resulting from corrective actions. By September 1995, approximately 50 percent of the deficiencies were corrected in accordance with the EPA Administrative Order deadline (October 1996). However, based on the rate at which the deficiencies were being addressed, the Administrative Order deadline to correct all deficiencies was not expected to be met. To expedite the corrective action process, ESH-18 grouped approximately 2000 deficiencies/corrective actions into a single Standing Work Order for its Waste Stream Corrections Project. Although ESH-18 had not previously functioned as a project manager for a project of this size, LANL management allowed ESH-18 to take the project lead in handling the Waste Stream Corrections Project because there was a

perceived need at the LANL Division/Group level to have one central organization held responsible for correcting waste stream deficiencies. Since the decision was made at this level, the Director and Deputy Director, LANL, were not aware of this decision.

*Several environment, safety, and health concerns were identified early in the project.*

ESH-18 teamed with Facility Risk Management Group (ESH-3) early in the project to identify the environment, safety and health (ES&H) concerns relating to the project through its Project Summary process. A Project Summary (called an ESH Identification Process) was created and distributed to subject matter experts for review. The review of the ESH Identification Process by the subject matter experts identified several ES&H concerns associated with the project, including the lack of specific information to adequately scope the proposed work or assess all of the ES&H concerns.

In September 1995, ESH-18 implemented its own alternative work authorization process, which included a tailor-made administrative form that did not provide for further review of ES&H concerns. ESH-18 was budgeted approximately $3.4 M and, on October 1, 1995, established waste stream correction tasks, including major projects to be given to the Facility Project Delivery Group (FSS-6), which is normally responsible for coordinating major construction projects and identifying ES&H concerns. However, in early December 1995, a decision was made by ESH-18 to remove FSS-6 from the work authorization process and instead involve the Operations and Maintenance Services Group (FSS-9) in the flow of information to JCI.

*The work authorization process that was developed for this project did not include some of the customary reviews of hazards and other environment, safety, and health concerns.*

At approximately the same time that ESH-18 was receiving the subject matter experts' comments and concerns from their review of the ESH Identification Process involving safety and health issues, work packages associated with ESH-18's Waste Stream Corrections Project were authorized without prior resolution of these concerns. On December 20, 1995, the Waste Stream Corrections subtask FMU70-009 for work in Building TA-21-209 was approved. Another Waste Stream Corrections subtask was also approved for similar work at LANL Fire Station #1. Work packages for the subtasks were not prepared, and therefore further hazards assessments and ES&H reviews were not performed.

*Lack of clarity about the need for permits limited the effectiveness of safety reviews at the site where the accident occurred.*

On January 16, 1996, the day before the accident, the Waste Stream Corrections Project work began at LANL Fire Station #1 by JCI, the maintenance service contractor. A JCI pipefitter foreman (acting) was made responsible for the work, and two JCI cement mason tenders (one of whom was injured at Building TA-21-209 the next day) were directed by the JCI pipefitter foreman to begin cutting a concrete slab and excavating a sump pit. Two JCI safety engineers inspected the excavation work at separate times of the day and discovered that an excavation permit was not posted at the site. Both engineers cited the incident in reports. However, there was a significant discrepancy between the two reports. The first report stated that "Masons did not

have an excavation permit on site," and the other stated "No violations noted. Hole was less than 5 feet in depth and appeared to be quite stable." The second safety engineer incorrectly conveyed to the mason tender and the foreman that no excavation permit was required. Although an excavation permit was not posted at the Fire Station #1 excavation, both safety engineers assumed that an excavation permit existed for the work being performed. However, it was later determined that no permit was ever issued. Neither the foreman nor the cement mason tender was provided with either of the construction inspection reports until after the accident in Building TA-21-209. Although the foreman was present at the fire station during the safety inspection, once he was informed by the second safety engineer that no excavation permit was required, he did not take further action to obtain a permit for similar excavation work at Building TA-21-209.

### 2.1.2 Accident Chronology

*The accident victim was cutting concrete slabs and excavating under the floor in order to reroute the sanitary sewer. No detailed engineering drawings were provided to assist in selecting the location for cutting and excavation.*

On January 10, 1996, preparations began in the basement of Building TA-21-209 for the Waste Stream Corrections Project work. The objective of the work was to reroute the floor sanitary sewer to the existing building sanitary sewer system. The work involved installing four sump pits by first cutting and removing concrete floor slabs approximately 36 by 36 inches, and then excavating the soil underneath to a depth of approximately 36 inches. JCI pipefitters were assigned to coordinate the project and determine the sump pit excavation locations using preliminary design drawings (Appendix G-1) prepared by SFE. The drawings provided were "one line" drawings, not dimensioned, and not drawn to scale. No detailed engineering drawings were provided specifying the sump locations. Based only on the preliminary design drawings, the pipefitters observed that one of the planned sump pits needed to be relocated due to its proximity to the basement doors. This request was approved verbally by ESH-18 without field-verifying the sump's proposed new location. Unknowingly, the pipefitters marked the sump location directly above the 13.2 kV electrical service to the building. An example of similar concrete markings photographed in the basement of Building TA-21-209 is shown in Figure 2-1. On January 11, 1996, a JCI cement mason foreman and his cement mason tender visited the Building TA-21-209 site to determine the scope of work. The mason tender was given primary responsibility for all cement slab cutting. His instructions were only verbally communicated to him by the pipefitters, without accompanying drawings or written specifications.

On the afternoon of January 16, 1996, the mason tender who had visited the work site previously and another mason tender proceeded to the Building TA-21-209 basement and cut the cement slab previously marked by the pipefitters. Once the cement slab was removed, the two mason tenders excavated approximately 12 inches of soil before the end of their shift. As at the fire station excavation, an excavation permit had never been obtained for the work being performed.

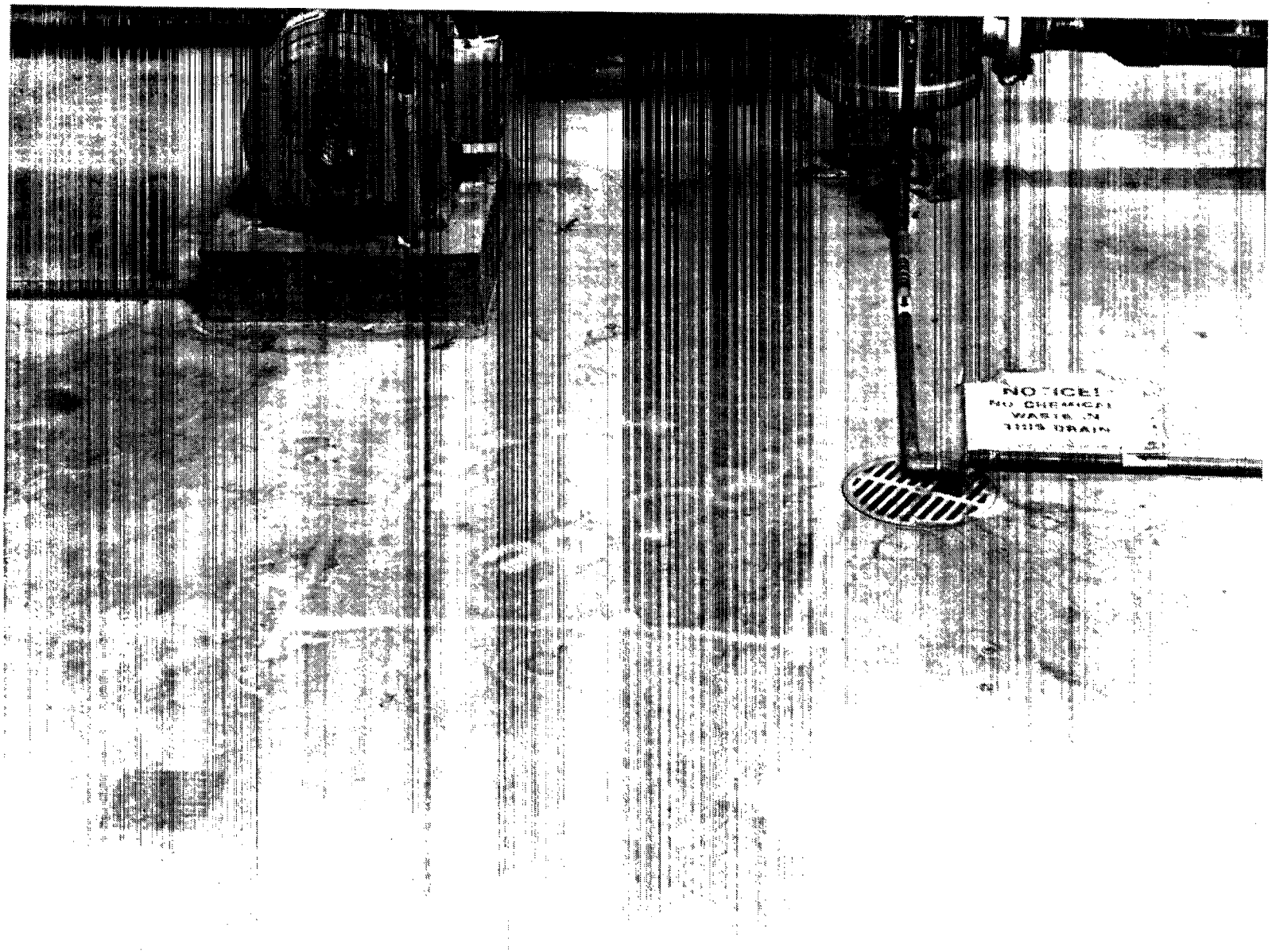



**Figure 2-1. Concrete Markings Similar to Those at the Excavated Sump Pit Accident Site**

On January 17, 1996, at about 8:40 a.m., the excavation work resumed at the Building TA-21-209 basement. The work was performed by the mason tender who cut the slab the previous day and by a cement mason who had not previously worked at Building TA-21-209. A general view of the work site is shown in Figure 2-2. Also on January 17, 1996, at approximately the same time that work commenced at the Building TA-21-209 basement, the pipefitter foreman approached the cement mason foreman about the safety inspections at Fire Station #1 the previous day to discuss whether an excavation permit was needed. The pipefitter foreman had been present at both Fire Station safety inspections and wanted clarification on whether an excavation permit was required there. Each foreman assumed that an excavation permit was not required for indoor use, and that if one was required, the other was responsible for obtaining it. The cement mason foreman called the JCI utility specialist who was responsible for locating underground utility lines. The utility specialist explained that an excavation permit was not required indoors, and that their electrical line locator equipment could not accurately locate indoor utility lines due to the high electromagnetic fields within the buildings. Although the utilities specialist had reinforced the contention that an excavation permit for indoors was not required, the cement foreman continued to seek a procedural reference excluding the requirement for indoor excavation because of the pipefitters' concern over the fire station construction safety inspection. Although the cement mason foreman had knowledge of the ongoing excavation work at Building TA-21-209 and was still uncertain as to the need for an excavation permit, he took no action to stop the work at Building TA-21-209.

*Uncertainty about the need for an excavation permit arose before the accident at both the accident site and another site.*

By 9:30 a.m. the masons at Building TA-21-209 had excavated to a depth of 39 inches (Figure 2-3) by using an air-powered jackhammer, a pry bar, and a shovel to loosen and remove the rubble from the sump pit. At 9:34 a.m., the jackhammer being used by the mason tender broke through a concrete-encased conduit containing a 13.2 kV electrical cable. The jackhammer bit penetrated the conduit several times before coming into contact with the cable, as illustrated in Figure 2-4. The accident victim was observed by the other mason tender to "shake" from the electrical contact, a buzzing sound like that of "an electric welder" was heard, and a bright flash of light was emitted, followed by an apparent explosion from within the sump pit. Power was apparently lost to Building TA-21-209 at approximately 9:34 a.m., as shown in Figure 2-5. Figure 2-6 shows the conduit that was struck by the jackhammer.

*The accident victim's jackhammer penetrated a 13.2 kV electrical cable, severely injuring him and cutting power to the building.*

The accident victim slumped into the pit, and the mason tried without success to pull him out. Although an emergency telephone was located ten feet away, the mason tender then ran out of the basement, first to a back entrance south door which was locked, and then to the main entrance, where he met a facility person at the door and entered the

*Personnel in the building called 911 and started cardiopulmonary resuscitation.*

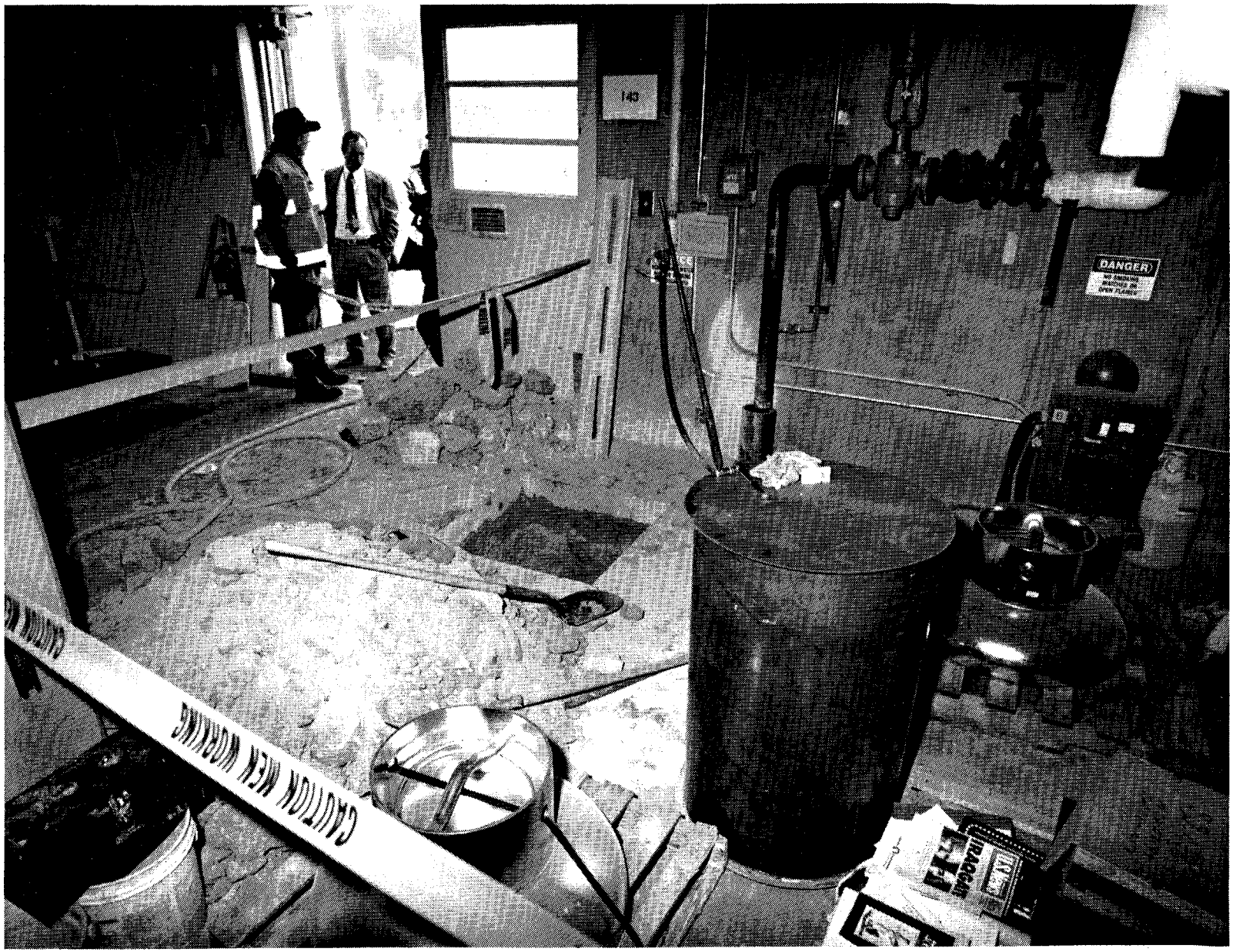



**Figure 2-2. General View of the Accident Work Site**

**Figure 2-3. Sump Pit Excavated to a Depth of 39 Inches**

**Figure 2-4. Conduit Penetrated by Jackhammer Bit**

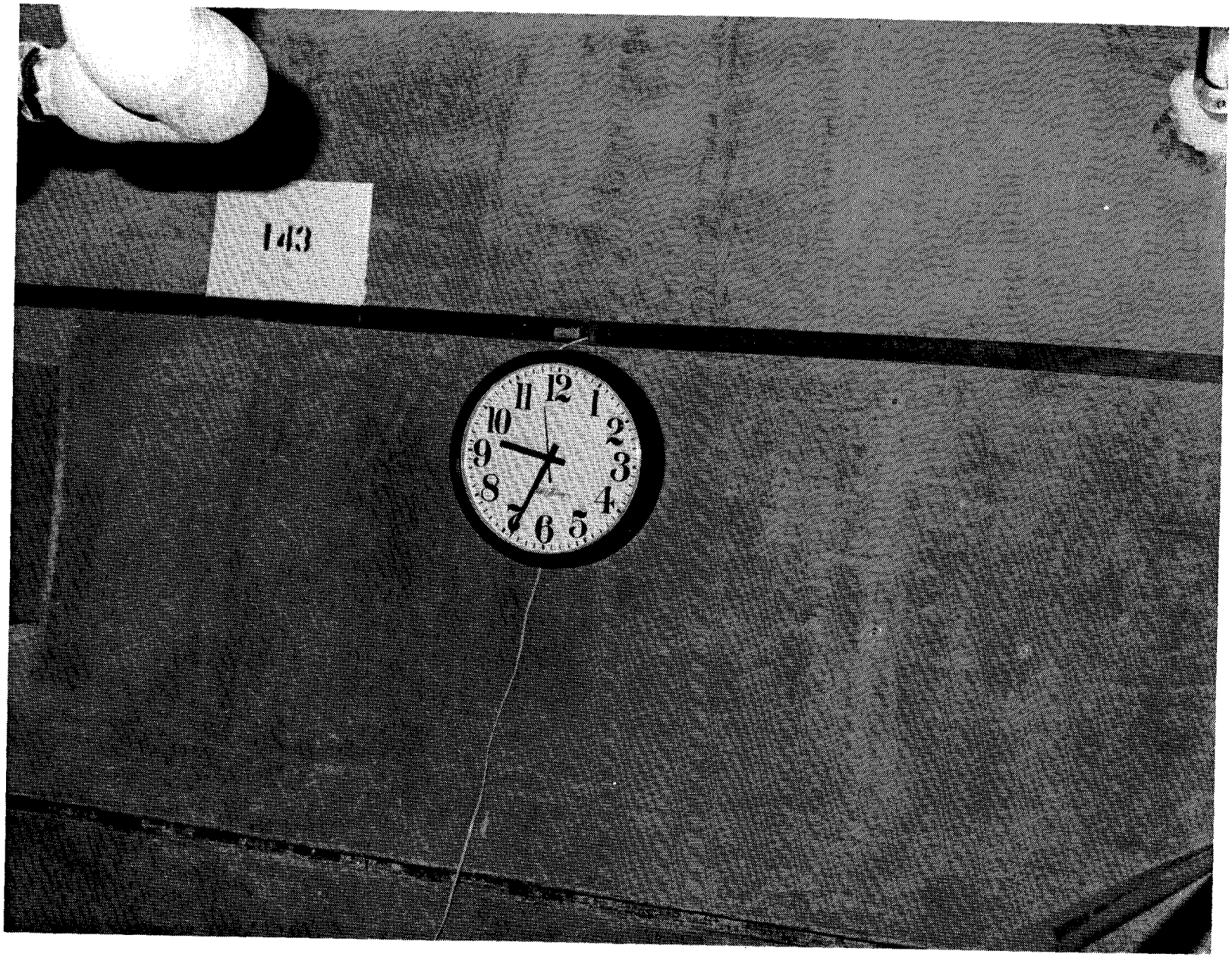



**Figure 2-5. Stopped Clock Indicating Time of Accident and Power Loss to Building TA-21-209**

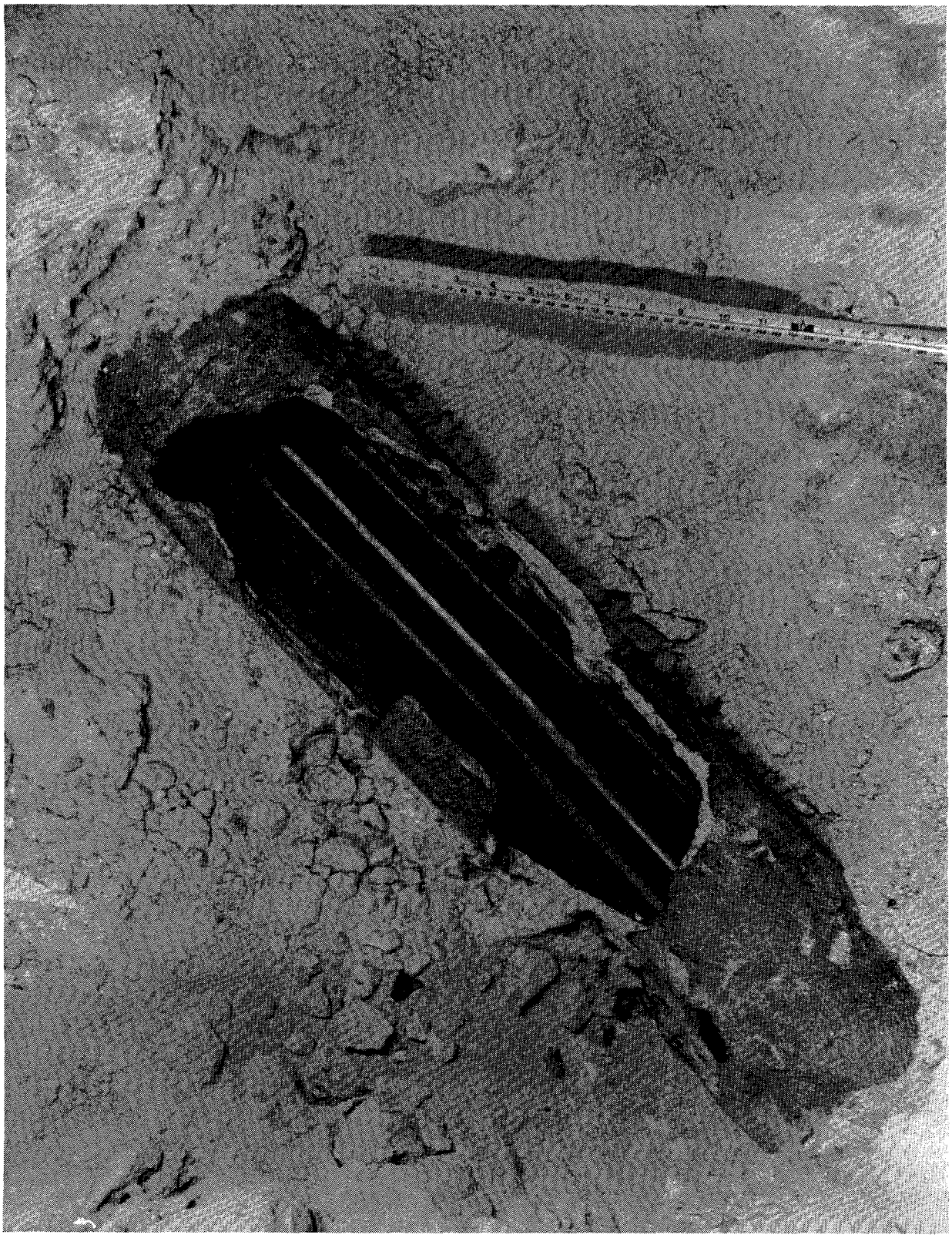


**Figure 2-6. Cutaway View of Conduit Cable Penetrated by Jackhammer**

building to seek help. With power out at the building, it was necessary for building personnel to use flashlights to gain access to the stairway leading to the victim. The building's public address system was inoperative due to the power outage, and verbal communication was necessary to request help. Two building employees immediately called 911. Several personnel trained in cardiopulmonary resuscitation (CPR) went into the basement to assist the accident victim.

### 2.1.3 Emergency Response Chronology

At 9:35 a.m. two separate calls were placed to 911 from the office area of Building TA-21-209. The emergency management system was activated at 9:35 a.m. Upon arrival at the basement excavation site, facility personnel observed that the victim apparently suffered burns mainly to his trunk and legs, was unresponsive and making gasping and gurgling sounds, and had no pulse. The victim was arched backwards within the pit with the jackhammer leaning against his legs. Facility personnel informally assessed the potential for electrical hazards based on the site's conditions (i.e., no lights or electrical sparks/sounds) and concluded that there were no such hazards. Immediately following this informal assessment, the victim ceased making gasping and gurgling sounds. The facility personnel then used a shovel handle to move the jackhammer away from the victim and immediately pulled him from the pit. Facility personnel began CPR at approximately 9:40 a.m.

*Six Los Alamos Fire Department units responded to the scene and began treatment.*

Between 9:36 a.m. and 9:40 a.m. six Los Alamos Fire Department units departed for the scene, including a rescue unit (Rescue 1), ambulance (Medic 1), Battalion Chief (Battalion 1), Fire Captain (Captain 3), training company (Station 2), and engine company (Engine 6). A Rescue 1 emergency medical technician arrived first at 9:41 a.m. and observed that two lay rescuers were attempting CPR. Lay rescuer 1 was performing chest compressions. The Rescue 1 emergency medical technician used a pocket mask and began performing ventilations. Lay rescuer 2 took over chest compressions. The Medic 1 ambulance arrived at 9:42 a.m., followed immediately by the Battalion Chief. At 9:42 a.m. Captain 3 and Station 2 personnel arrived, as well as Engine 6. Station 2 emergency medical technicians took over chest compressions, breathing, and airway management. The injured worker was administered oxygen via a bag valve mask. An initial attempt to insert a breathing and esophageal tube was unsuccessful. The Medic 1 emergency medical technician hooked up defibrillator leads and analyzed the rhythm, which was interpreted as fine ventricular fibrillation. A sequence of three shocks was administered, thirty seconds apart. After the third shock, the patient was observed to be asystolic (no cardiac electrical activity).

A decision was made to immediately transport the injured worker to Los Alamos Medical Center. He was transported by gurney to the waiting Medic 1 ambulance. At the urging of Building TA-21-209 employees, the injured worker's co-worker, who was coughing and emotionally upset, was transported in the front of the ambulance (and later treated and released). Medic 1 departed the scene at 9:48 a.m. In transport, CPR was continued by two emergency medical technicians, and the breathing and esophageal tube was successfully inserted. A third emergency medical technician started an intravenous line. The ambulance stopped once en route in order to obtain an accurate rhythm reading, but the victim was still asystolic, and no additional shocks were administered. Medic 1 arrived at Los Alamos Medical Center at 9:54 a.m., traveling 2.9 miles in 6 minutes.

*The victim was taken to the Los Alamos Medical Center emergency room, where normal pulse, blood pressure, and breathing were established.*

On arrival at Los Alamos Medical Center, the emergency room physician and nurses assumed care of the patient, with continued assistance from the emergency medical technicians. The injured worker was observed to be in fine ventricular fibrillation. He was intubated at 9:58 a.m. A second intravenous line was started, and the injured worker was administered cardiac medications consisting of bretylium, epinephrine, and lidocaine, in that order, between 10:00 a.m. and 10:05 a.m.

At 10:06 a.m. the patient's electrical rhythm reverted to sinus rhythm (normal rhythm pattern), but no pulse was detected—a condition referred to as electromechanical dissociation. After an additional dose of epinephrine, the injured worker had a palpable pulse beginning between 10:07 a.m. and 10:10 a.m., with normal blood pressure noted shortly thereafter. Spontaneous respiration was noted at 10:25 a.m. He then received calcium gluconate, magnesium sulfate, and potassium. He was admitted to the intensive care unit and attached to a ventilator at 11:05 a.m.

*The victim was then taken to the intensive care unit.*

### 2.1.4 Accident Scene Preservation

#### 2.1.4.1 Accident Scene

The accident scene was secured and controlled by LANL Emergency Management and Response Group personnel at approximately 9:45 a.m. on the day of the accident. A yellow and black plastic ribbon was placed around the accident site, and both still photographs and video pictures were taken of the scene.

*There was some urgency in restoring electrical power to the building where the accident occurred.*

The responsibility for the accident scene was turned over from the LANL Incident Commander to the Los Alamos Area Office (LAAO) Type B Accident Investigation Board Chairperson designated by the Albuquerque Operations Office (AL) at approximately 1:30 p.m. that same day. At that time, the LANL Tritium Science and Engineering Deputy Group Leader, his staff, and the Facility Manager expressed

a sense of urgency to restore electrical power to the facility based on the assessment that the power outage could lead to small releases of tritium to the atmosphere from the tritium effluent system. This was discussed with LAAO and AL personnel, and verbal approval was given by the Type B Accident Investigation Board Chairperson to begin restoring normal electrical power to the area. A portable electrical generator was set up outside Building TA-21-209 by JCI maintenance personnel, and emergency power was restored at 3:00 p.m.

Excavation work in the sump pit resumed on January 18, 1996, in order to repair the damaged cable and restore normal electrical service. This excavation activity was also performed without an excavation permit or utility survey, although the power was locked out and tagged out. This excavation was performed in coordination with the LAAO designated Type B Accident Investigation Board Chairperson, who had initiated a Type B investigation of the accident.

### 2.1.4.2 Evidence Chain of Custody

*Some lapses were noted in maintaining the chain of custody for evidence.*

The physical evidence collected at the scene was turned over informally by LANL to LAAO on January 19, 1996, whereupon some of it was kept in a locked room (Room 121) in Building TA-21-209. Other items were kept in the trunk of an LAAO employee's government car. The victim's clothing and personal protection equipment (rubber gloves, rubber boots, and outer overalls) were collected by JCI Safety and were turned over to and retained by LANL Industrial Hygiene personnel in their offices. No chain of custody was established for the physical evidence pertinent to the accident by JCI, LANL, or LAAO until requested by the Headquarters Type A Accident Investigation Board on January 21, 1996.

The Type A Accident Investigation Board arrived at the accident scene on January 21, 1996. The Board observed the accident scene and some of the physical evidence, which was in Room 121 of Building TA-21-209 and controlled by LAAO. No inventory of the physical evidence was prepared by JCI or LANL or requested by LAAO at the time of turnover. The Board requested that a chain of custody be established before the physical evidence was delivered to the Board. On January 22, 1996, the physical evidence was turned over to the Board by LAAO with a note dated January 22, referencing a LANL memorandum, also dated January 22, containing a list of the physical evidence. Neither the note nor the memo included the personal protection equipment items or personal clothing items that were also turned over to the Board at the same time by LANL Industrial Hygiene.

## 2.2 CONDUCT OF OPERATIONS

### 2.2.1 Work Planning, Authorization, and Control

#### 2.2.1.1 Work Planning

**ES&H Questionnaire Process**

*The Laboratory uses a questionnaire that is sent to new project initiators to identify projects that may pose environment, safety, and health risks.*

LANL Administrative Requirement 1-10, "Environment, Safety and Health Questionnaire," (August 30, 1991), requires that all new projects be assessed for ES&H concerns. The procedure identifies those projects requiring an ES&H review, the review process, and line management's resolution of ES&H concerns arising from the review. The ESH Division's Risk Assessment Group is responsible for gathering information from new project initiators, via a questionnaire, and distributing the information to the ES&H Questionnaire Committee for review. The ES&H Questionnaire Committee is composed of subject matter experts representing various ES&H disciplines.

LANL personnel initiating new projects are required to complete the questionnaire contained in Administrative Requirement 1-10 for projects that may include new construction and building modifications, groundbreaking, or soil disturbance, or for projects that may involve high energy sources. The Risk Assessment Group in ESH-3 then distributes the completed questionnaire to the Questionnaire Committee for review, evaluation, and comment on matters such as project siting, occupational safety, fire protection, industrial hygiene, and health physics. The Committee is also required to determine whether Federal, state, or local statutes and regulations apply to the proposed project.

If subject matter experts identify potential ES&H concerns during their review of the questionnaire, Administrative Requirement 1-10 requires the Risk Assessment Group to send the project initiator an ES&H checklist, which lists the possible ES&H concerns related to the project and the appropriate contact for each concern. The project initiator is responsible for contacting the personnel listed and for maintaining a permanent file to document the resolution of the concerns raised during the review. The permanent file is required to meet the DOE audit requirements specified in Administrative Requirement 1-5, "Environment, Safety, and Health Audits and Appraisals."

**Development of an Informal ES&H Review Process**

*A project summary process was developed to supplement the questionnaire process.*

In 1992, the LANL Associate Director for Operations designated the ESH Division as the office of primary responsibility for the ES&H Questionnaire process. In November 1993, a Quality Improvement Team was formed to identify needed improvements in the ES&H Questionnaire process. In December 1993, the Quality Improvement

Team issued a report on the ES&H Questionnaire process, recommending process improvements for project-related data gathering and turnaround times for subject matter expert reviews.

In December 1993, the Facilities Review Section in ESH-3 developed the ESH Identification Process to (1) implement the Quality Improvement Team's recommendations, and (2) alleviate problems with poor response from project initiators who were responsible for completing the forms contained in Administrative Requirement 1-10.

The ESH Identification Process involves the Facilities Review Section conducting face-to-face interviews with project initiators to gather information for inclusion in a nested logic database. Following data collection, ESH-3 documents the data in an ESH Identification Project Summary, and distributes the Summary to subject matter experts for review. The Facilities Review Section forwards the results of subject matter expert reviews to the project initiator to address any ES&H impacts. Administrative Requirement 1-10 has not been revised to reflect the changes in the process, procedures, and practices that the Facilities Review Section implemented in the new ESH Identification Process and, as of the date of the accident, the new process was in direct conflict with Administrative Requirement 1-10.

#### 2.2.1.2 Work Authorization

*For this project, initial reviews identified some potential hazards.*

On August 24, 1995, ESH-18 initiated ESH Identification Process #95-0188 for the Waste Stream Corrections Project. The ESH Identification Project Summary was completed by ESH-3 technicians, and ESH-18 provided factual accuracy review/comments to ESH-3 on September 15, 1995. Information provided by ESH-18 characterized the Waste Stream Corrections Project as a construction-related activity and identified explosives, industrial hygiene, operational safety, and radiological safety as potential hazard areas that could be encountered during the project. Subject matter expert review comments were provided to ESH-18 via ESH-3 memorandum, "Project Summary Closure Letter," dated November 13, 1995.

On or about September 6, 1995, FSS-9 representatives completed Service Request #02447 for Waste Stream Corrections. This service request was later assigned Standing Work Order #06006, to "Provide labor and materials to perform modifications to drain systems within Laboratory buildings as directed by ESH-18 to correct environmental code deficiencies as recommended by the waste stream surveys schedules." The Standing Work Order noted that "manpower will be requested by the account controller as needed." The Waste Stream Corrections service request received final management approval on September 21, 1995. On September 28, 1995, ESH-3 Facility Safety personnel completed their ES&H review of the Waste Stream Corrections service request.

On October 5, 1995, JCI forwarded a "Request for Davis-Bacon Determination" for the Waste Stream Corrections Project to the LAAO Determining Official for review. The JCI transmittal specified, in part, "Perform modifications to original waste systems within the Laboratory to correct environmental deficiencies... This determination will be used on all Facility Management Unit standing work orders for this work." On October 10, 1995, the LAAO Determining Official responded that the Waste Stream Corrections Project was "uncovered" (maintenance) work.

Both the Waste Stream Corrections service request (September 21, 1995) and ESH-3's technical safety review of the service request (September 28, 1995) were completed before the subject matter expert reviews were completed for the Project Summary (November 13, 1995). The subject matter experts' safety input could have been useful in the other reviews.

*There was concern about the lack of detailed information about some conditions.*

In a November 1, 1995, memorandum to Distribution, "Update of ESH ID #95-0188, Waste Stream Corrections," ESH-3 stated that attempts had been made to address the entire Waste Stream Corrections Project on a Laboratory-wide scale, but because of this wide-scale approach, several subject matter experts were concerned about the lack of detail contained in the Project Summary. The memorandum outlined ESH-18's plans for organizing the project to address those concerns, including:

- Small job tickets would be used for corrections costing less than $2,000, with JCI performing the work.

- Standing Work Orders, work tickets, and service requests would be used for corrections inside buildings, excluding excavations of any kind, with the work conducted by JCI and managed by FSS-9.

- Corrections involving major cost projects would be managed by FSS-6, and would address all excavations, either inside or outside, including dirt or concrete. This work would be accomplished by Basic Ordering Agreement contractors, and would involve a total of approximately 15 projects. ESH-18 later updated this information to state that the Waste Stream Corrections Project would utilize JCI rather than Basic Order Agreement contractors for the work managed by FSS-6.

- ESH-18 would be responsible for addressing any administrative corrections to permits.

*The project was performed as a series of small jobs that normally require radiological and risk management reviews.*

The memorandum also noted that "Small job tickets, service requests, and work tickets, authorizing work by JCI are currently reviewed by ESH-3 or a facility management team. If identified risks or hazards cannot be adequately addressed on the ESH Review page of the small

job ticket or service request, the ESH Identification Process can be initiated by ESH-3, the facility manager, or the project contact."

The small job ticket and work ticket forms normally used by LANL and JCI personnel allow for ESH-1 (Radiological Protection) and ESH-3 reviews. For the Waste Stream Corrections Project, ESH-18 developed its own tailored small job ticket form, whose purpose was to track project costs and NPDES permit compliance status. However, the tailored form did not include space for either ESH-1 or ESH-3 reviews. In addition to the ESH-3 reviews noted above, the JCI ES&H Manual, Procedure 12-21-112, "Hazard Assessment Requirements," dated November 7, 1995, requires JCI craft supervisors to conduct a preliminary hazard analysis prior to any work conducted by JCI personnel.

*A lack of detailed design drawings allowed the excavation site to be placed directly over the electrical line.*

Board interviews with ESH-18 project leaders and reviews of archived records indicate that ESH-18 began work on Waste Stream Corrections subtasks prior to completion of subject matter expert reviews of the Project Summary. Using the ESH-3 November 13, 1995, memorandum, "Project Summary Closure Letter, ESH ID #95-0188," as a baseline to determine completion of the ESH Identification Process, records indicate that between September 11, 1995, and November 8, 1995, ESH-18 issued 16 Waste Stream Corrections Project subtasks for work without detailed work packages. Some of the work packages involved hazards associated with plumbing and electrical modifications and installations.

### 2.2.1.3 Work Control

*No detailed reviews were performed.*

ESH-18 provided the Board with information to indicate that, on December 6, 1995, project engineers from ESH-18 and SFE were in Building TA-21-209 to scope portions of the Waste Stream Corrections Project. Their written statements indicated they were approached by the building manager and informed by him of their activities in scoping out portions of the Waste Stream Corrections project.

On December 20, 1995, ESH-18 issued Waste Stream Corrections Project FMU70-009 to FSS-9. It was one of 15 subtasks under FMU70, and involved the work in the basement of Building TA-21-209. It had a target completion date of January 13, 1996. No detailed work package was prepared, and no further ES&H reviews were required. Concurrent with the release of the project for work, JCI pipefitters and masons scoped the job and laid out sites where excavation would be required to install sumps. The planned location of one sump appeared, on preliminary design drawings, to interfere with a door in the basement of Building TA-21-209. A JCI pipefitter contacted an ESH-18 representative to request approval for a deviation to relocate the sump. The ESH-18 representative contacted an SFE representative responsible for that subtask, who approved the change by telephone. The approval by ESH-18 to deviate from the

preliminary design drawings was documented by JCI personnel on the FSS-9 Work Order Form. The approved sump relocation placed the sump location directly over an energized 13.2 kV electrical line.

### 2.2.2 Procedures

*The Laboratory has a hierarchy of documents governing operational activities.*

LANL utilizes a hierarchial arrangement of documents designed to communicate the expectations of management and the methods by which Laboratory activities should be conducted. The highest-level documents are called Director's Policies. These documents define management expectations and delineate the goals and directions of the Laboratory. The middle-level documents are called Program Requirements Documents. These documents provide the basic information needed to implement programs established by the Director's Policies. The lowest-level documents in this procedural hierarchy are the Laboratory-wide and generic procedures. These describe the specific steps for conducting operational activities within the facility.

The LANL ES&H Manual presents the policies, requirements, and procedures needed to ensure health, safety, and environmental protection at the Laboratory. This is a controlled document that consists of Director's Policies, Committee Charters, Administrative Requirements, Technical Bulletins, and Support Services. The Administrative Requirements are the primary documents used to set forth Laboratory requirements for ES&H. This Manual also contains or references other program documents, such as Laboratory Manuals, Procedures, and Standards. While the general information section of the ES&H Manual does not describe or define the use and authority of the Laboratory Manuals, Procedures, and Standards, many of the Administrative Requirements are being replaced by the Laboratory Standards. The version of the ES&H Manual that was reviewed by the Board was dated January 31, 1995.

The JCI procedures system is governed by two primary documents: (1) Standard Practice Instructions, and (2) the JCI ES&H Manual. The Standard Practice Instructions are published with the intent of defining JCI policies and procedures.

*Both the Laboratory and the construction and maintenance contractor have policies and procedures governing excavations, but they are not uniformly applied.*

A list of the applicable LANL and JCI policies/procedures that were reviewed by the Board are provided in Appendix E. The following facts were obtained from the Board's review of the policies and procedures:

- According to Director's Policy 102, the Central Policy Office is responsible for coordinating the development, review, revision, and issuance of Laboratory-wide operating procedures that implement each Director's Policy and its accompanying Program Requirements Document.

- The Administrative Requirements do not reflect the changes made in the LANL organization. The Administrative Requirements identify Groups and organizations that no longer exist. Specifically, the change from Engineering Groups to Facilities, Security, and Safeguards (FSS) Division Groups is not mentioned.

- The procedural hierarchy for Laboratory Manuals and Laboratory Standards is not defined. The ES&H Manual and the LANL Procedure Writer's Guide does discuss how Director's Policies, Program Requirements Documents, and Laboratory Procedures are to be used, but fails to describe how Laboratory Standards and Manuals are to be used.

- Administrative Requirement 1-10 requires an assessment of all new projects for ES&H concerns. However, there is no mechanism to assure that these assessments are performed.

- The Administrative Requirement 1-10 section entitled "Resolving ESH Concerns" states that "The initiator shall contact the personnel listed on the ES&H checklist and develop and maintain a permanent file that documents the resolution of the issues raised by the ES&H Questionnaire Committee and meets DOE audit requirements."

- Administrative Requirement 1-11 states that "The purpose of standing work orders is to allow routine activities to be authorized, funded, and performed." Many of the jobs currently being worked under Standing Work Orders are not routine, repetitive tasks.

- Administrative Requirement 1-11 does not require ES&H reviews for Standing Work Orders.

- Administrative Requirement 1-11 allows work to be accomplished without a work ticket (work package) for Standing Work Orders.

- The Administrative Requirement 1-11 section entitled "Resolving ES&H Concerns" states that "The author of the work request is responsible for completing any action as a result of the work request review process, including securing the necessary work permits, requesting ES&H reviews, or initiating any contacts listed on the ES&H section of the request."

- Administrative Requirement 1-12, "Excavation or Fill Permit Review," defines excavation as "any ground breaking with power equipment or hand tools."

- Administrative Requirement 1-12 does not specify the type or the extent of investigation required to issue an excavation permit.

- JCI ESH Manual Procedure #12-22-006, "Excavations," and JCI Standard Practice Instruction 80-10-011, "Excavation/Trenching," define excavation as "any man-made cut, cavity, trench or depression in the earth's surface, formed by earth removal."

- 29 CFR 1926.650 defines excavation as "any man-made cut, cavity, trench, or depression in the earth's surface, formed by earth removal."

- DP 116, "Stop Work and Restart," states that the Central Policy Office is responsible for developing the procedures to govern stop-work and restart actions associated with ES&H concerns.

- Laboratory Procedure LP116-01.0, "Stop Work and Restart," requires that a stop-work log be maintained in the Division Leader's Office.

- Administrative Requirement 1-14, "ESH Facility Design Review," requires a multidisciplinary review of documents relating to the design, construction, and modification of facilities.

- Director's Policy 102 states that "The Central Policy Office is responsible for coordinating the development, review, revision, and issuance of Laboratory-wide operating procedures that implement each Director's Policy and its accompanying Program Requirements Document."

- There are no Laboratory-wide operating procedures for the Program Requirements Documents for configuration management or formality of operations.

- Director's Policy 102 requires each organization at the Group level to annually evaluate the ES&H quality aspects of its operation through an internal self-assessment. The last self-assessment at the TSFF was conducted in 1993.

- Groups in the FSS Division have not performed an internal self-assessment as described in Director's Policy 102.

- The LANL Quality Management Plan for 10 CFR 830.120 and Program Requirements Document 110-01.0 states that "Design procedures will address design input, development, analysis, validation, and output to ensure that final designs and the resulting systems or facilities meet specified technical requirements, standards, and codes. Design changes, including those made during fabrication or construction, subsequent modifications, and nonconforming items will be subject to design standards and controls consistent with those applied to the original design. The adherence to the program will preclude the use of unverified design data and assure that appropriate

verification or qualification testing is completed before design data are used in subsequent activities."

- JCI ES&H Manual Procedure #12-21-112, "Hazards Assessment Requirements," paragraph 5.B, states that "All work projects conducted by JCI are required to have a Preliminary Hazard Assessment form filled out by the project supervisor."

- JCI Standard Practice Instruction 70-10-001 identifies only the performance of a utility survey. No reference is made to the review of building prints or drawings in an effort to locate buried electrical conduits or other utility lines. The type of equipment to be used to locate such lines is not specified.

- JCI Standard Practice Instruction 80-10-011, "Excavation/Trenching: Protective Systems and Safety," paragraph 14, requires an excavation permit to be completed prior to any excavation work.

- JCI Standard Practice Instruction 12-02-010, "Work Order Review," paragraph 2, requires all new work orders to be sent to the Work Order Review Coordinator on a daily basis. Paragraph 5 requires the Work Order Review Coordinator to review all work orders and assign further review. Paragraph 7 requires the Work Order Review Coordinator to attach a Work Order Review Form.

- The work control process is governed by multiple procedures and split among JCI and the FSS and ESH Divisions.

- FSS-6 has a formal set of procedures that describe the processes and methods governing engineering design reviews and other associated project work.

- Because of a lack of Laboratory-wide operating procedures for many programs, Division- or Group-level procedures are being written. The standards and requirements contained in these procedures vary significantly among the different organizations in the Laboratory and do not necessarily reflect the requirements or expectations set by the higher-tier documents.

### 2.2.3 Configuration Management

#### 2.2.3.1 Configuration Management Policy

*The Laboratory has no configuration management program to ensure that the physical configuration of its facilities is accurately documented.*

The Laboratory's configuration management program is described in Director's Policy 112, "Configuration Management," dated September 1991. The purpose of the configuration management program is to ensure that the physical configuration of facilities is accurately reflected in the documentation used to operate and maintain the facility. Director's Policy 112 requires that all activities involving

modifications in existing "designated" facilities must comply with this policy. Configuration management programs are not required for "non-designated" facilities. However, Director's Policy 112 does not provide any amplifying information on what criteria are used to classify facilities as "designated" or "non-designated."

Responsibility for the Laboratory's configuration management program resides with FSS-3. Program Requirements Document 112-01.1, "Configuration Management," dated September 1, 1995, describes a philosophy, not a detailed program. The configuration management program is not funded out of the LANL overhead budget. Facility-specific configuration management programs will only be developed and used if the facility requests and funds the activity through a specific charge account. The Tritium Science and Engineering Facility Management Group stated it is working on a Group-wide configuration management program, but there is no specific configuration management program at the present.

### 2.2.3.2 Design

*A contractor provided design support for facility modifications in conjunction with the project.*

SFE was under contract from ESH-18 to perform four detailed tasks: (1) provide support to FSS, ESH-18, and operating Groups to evaluate and prioritize projects to correct deficiencies identified under the Laboratory's Waste Stream Characterization Program; (2) prepare preliminary design documents, in accordance with the Laboratory's Design Standards Manual, for piping, plumbing, and mechanical modifications to Laboratory buildings and wastewater systems for selected corrective actions and submit documents for finalization and approval to FSS and ESH-18 representatives; (3) in conjunction with FSS and ESH-18 personnel, provide field direction, observation, and verification of the adequacy of constructed modifications; and (4) provide other support as may be required to meet Waste Stream Characterization and NPDES Permit regulatory requirements related to non-complying waste streams and elimination of outfalls.

FSS-6 normally performs design reviews for facility modifications and construction projects. ESH-18, in consultation with JCI and FSS-9, made a decision not to utilize the design and project services of FSS-6 for the Waste Stream Corrections Project.

## 2.3 ELECTRICAL SAFETY

*Electrical safety has been a concern within the Department of Energy, but there are no Departmental requirements for contractors to have an electrical safety program.*

Electrical safety in the DOE complex has always been of considerable concern. A large number of electrical occurrences in 1992 prompted DOE to initiate a special task force to assess electrical safety throughout all its contractor sites. Several outcomes of that initiative directly or indirectly influenced electrical safety.

- **Report of the Task Group on Electrical Safety of Department of Energy Facilities, dated January 1993, #DOE/EH-0298.** This report was written based on visits to seven different DOE contractor sites. Teams of DOE and contractor personnel gathered information based on predetermined lines of inquiry regarding electrical safety. Results of the report not only identified DOE the important electrical safety issues to concentrate time and resources on, but also provided contractors with an invaluable tool with which to assess themselves and direct their efforts and resources.

- **Department of Energy Model Electrical Safety Program, dated September 1993.** The model Electrical Safety Program offered guidance to contractors on developing a sound plan for implementing recognized electrical safety practices. The program provided for the assignment of responsibilities, implementation of recognized standards and regulations, and an interface between line management and the worker in the production or research and development arena.

- **U.S. Department of Energy Electrical Safety Guidelines, dated November 1994, #DOE/ID-10600.** The DOE Electrical Safety Guidelines were already in the development stage during the task group initiative and appeared shortly after the printing of the task group report. This set of guidelines provided a much-needed tool to specifically direct DOE contractors on the implementation of positive electrical safety practices.

The information in these three documents offers the basis for investigating electrical accidents within the DOE. The information is DOE-specific; however, it is only guidance, because there are no Departmental requirements for contractors to develop an electrical safety program. Accident issues relating to electrical safety in the DOE complex can be readily compared to issues raised in these three documents. The documents serve as sound guidance for objectively ascertaining how electrical safety issues play a role in the events leading up to and following an accident. They also provide guidance in developing the analysis of facts, developing the findings, and determining judgments of need.

### 2.3.1 Electrical Emergency Response Plan

*There was no formal guidance or written procedures for safely providing temporary power by portable generator.*

The Board examined the issue of electrical safety for activities before, during, and after the accident. Factual accounts of events, procedures (or lack thereof), training, implementation of training or procedures and processes, and the interaction of safety (either JCI or LANL) were reviewed.

Formal guidance or written procedures do not exist to direct JCI Maintenance on how to evaluate, size, and safely provide temporary

power by portable generator to sites that have experienced an unscheduled power outage. Formal guidance or written procedures do not exist to direct JCI maintenance in identifying the critical power needs that exist during the re-energization of a building being provided with temporary power from a portable generator.

It was recognized by LANL personnel that the effluent treatment system was not on the emergency power system. Emergency power procedures or plans were not developed or available to determine what would be needed to maintain the effluent treatment system in a safe condition during prolonged outages. For the TSFF, some critical emergency power needs were identified, such as power for the exhaust fans. However, not all critical systems were identified.

The JCI Utilities Power Control Section (UPCS) responded to the accident at Building TA-21-209 in accordance with formal procedures. However, the investigation revealed that emergency response by JCI UPCS takes a minimum of one hour during non-standard working hours in the event of an unexpected power loss.

### 2.3.2 Pre-accident Electrical Safety Issues

*Some elements of an electrical safety program were in place.*

A complete, formally written, comprehensive electrical safety program for LANL or JCI does not exist, although multiple components of a program have been developed and successfully implemented. LANL has defined and/or designated some elements of the program, such as an "Authority Having Jurisdiction," electrical safety inspections, and energized work permits, as required to be included in a programmatic planning document. However, this document should also include descriptions of the purpose, scope, ownership, objectives, responsibilities, interfaces, and implementation guidance for those elements.

*Electrical safety training was not conducted.*

Electrical safety training for the accident victim and other non-electrical crafts personnel was not conducted regarding safety-related work practices to recognize the electrical hazards from accidental contact (direct or indirect, above or below ground, passing through or near the job site). Additionally, the required use of electrical personal protective equipment was not procedure-driven for JCI employees who use jackhammers in work areas where the exact location of underground electric lines is unknown.

*No determination was made as to whether the workplace contained hazards from electrical power circuits.*

Before beginning work, the JCI ES&H personnel, the supervisor, or the foreman for the work at Building TA-21-209 did not ascertain by inquiry, direct observation, drawing review, physical walkthrough of the site, or instruments whether any part of an energized electric power circuit, exposed or concealed, could bring any person, tool, or machine into physical contact with the electrical power circuit.

Occurrence report ALO-LA-LANL-HRL-1994-0004 involves two incidents of concrete cutting and penetrating energized cables at LANL Buildings TA-43-1 (October 26, 1994) and TA-46-161 (January 9, 1995). Based on the occurrence report and root cause analysis, two corrective actions were identified: (1) develop a JCI concrete sawing safety procedure(s) and provide personnel training, and (2) establish personal protective equipment requirements during concrete sawing. The referenced occurrence report was closed and finalized with applicable signatures. However, corrective actions to resolve all electrical safety issues discovered in the two incidents were not tracked by LANL to closure and therefore, not completed.

*Two previous incidents of electrical contact during concrete cutting led to corrective actions, which were not completed.*

Because of these prior accidents, JCI changed its policy for the use of personal protective equipment when cutting concrete, but did not incorporate this change in its procedures or training. JCI did not implement the corrective action lessons learned from other similar reported incidents that required the preparation of procedures and improved training in the use of electrical personal protective equipment for cutting and/or jackhammering concrete or soil (Table 2-1). Because these procedures were not written, JCI did not provide personal protective equipment training to each employee in accordance with 29 CFR 1910.132 (f) (1-4) or JCI Procedure 12-29-040.

**Table 2-1. Previously Reported Electrical Incidents**

| Precursor Electrical Safety DOE Order 5000.3B Reported Occurrences | |
|---|---|
| Occurrence Report | Activity |
| • ALO-LA-LANL-TA55-1991-0027 Occurrence date August 6, 1991 | • Masonry Saw Cuts Live Electrical Line |
| • ALO-LA-LANL-ESHSUPT-1992-0003 Occurrence date March 6, 1992 | • Hand Drill Cuts Live Electrical Line |
| • ALO-LA-LANL-TRITFACILIS-1994-0003 Occurrence date February 25, 1994 | • Hand Drill Cuts Live Electrical Line |
| • ALO-LA-LANL-HRL-1994-0004 Occurrence date October 26, 1994 | • Masonry Saw Cuts Live Electrical Line |
| • ALO-LA-LANL-HRL-1994-0004 Occurrence date January 9, 1995 (Involves TA-46-161) | • Masonry Saw Cuts Live Electrical Line |

The original construction drawings and specifications for the conduit holding the 13.2 kV power feeder to Building TA-21-209 were reviewed. Specifications called for conduit of "rigid steel." The actual conduit used in the installation of the underground power feeder was made from an asphalt-impregnated fibrous material. The original

*The cable conduit did not conform to specifications.*

specifications also required concrete encasement of the conduit, and this was incorporated into the final installation (Figure 2-7). Further, the electrical design portion of the SFE preliminary design work for Waste Stream Corrections did not comply with the design requirements of DOE Order 6430.1A. Finally, the work package for the Waste Stream Corrections Project was not supported with complete electrical engineering system design drawings or documentation.

*Safety inspections of maintenance activities are not routinely performed.*

The Board reviewed safety inspections for maintenance activities conducted by JCI, as well as pertinent JCI and LANL work forms and manuals related to electrical safety. JCI Safety and JCI Maintenance do not have a defined process to formally schedule safety inspections of maintenance activities. Many JCI safety inspections of maintenance activities are provided only as they are encountered by JCI Safety personnel in the performance of other duties. The JCI Roads and Grounds Pre-Job Safety Checklist does not address electrical hazards. In addition, the LANL "Small Job Ticket" and "Work Ticket" forms address electrical hazards in the ES&H review sections, only where the voltage exceeds 480 volts. The JCI ES&H Manual contains a "Pertinent Safety Sections" matrix. This matrix identifies different safety procedure sections of the manual and indicates the different crafts that require the use and knowledge of particular safety procedures and equipment. Many crafts persons, including masonry workers, are not included on the matrix for personal protective equipment and/or required to have electrical safety training.

### 2.3.3 Accident Electrical Safety Issues

*The accident interrupted the power supply to the building. The public address system was not operational after the accident.*

Fault current from line to ground at the time of the accident was calculated by JCI Utilities Power Control Section to be a maximum of 2600 amperes. In-line fuse links for phase A (contacted during the accident) vaporized on the utility pole outside Building TA-21-209 at 9:34 a.m. due to the magnitude of the fault. An electrical flash occurred from the vaporization of the phase A fuse link, resulting in a phase-to-phase fault. This caused phase B and C fuse links to clear and open within 244 milliseconds (Figure 2-8).

The public address system at Building TA-21-209 is not connected to emergency power (uninterruptible power source or generator) and was not operational after the power was interrupted due to the accident.

*The accident victim was not using electrical personal protective equipment.*

The accident victim at Building TA-21-209 was not using electrical personal protective equipment, such as rubber dielectric gloves, at the time of the accident on January 17, 1996. 29 CFR 1926.416(a)(3) requires that, in work areas where the exact location of underground electric power lines is unknown, employees using jackhammers, bars, or other hand tools that may contact an energized power line shall be provided with insulated protective gloves. Although not used during the accident, rubber dielectric gloves were used as electrical personal

**Figure 2-7. Concrete Encasing the Conduit**

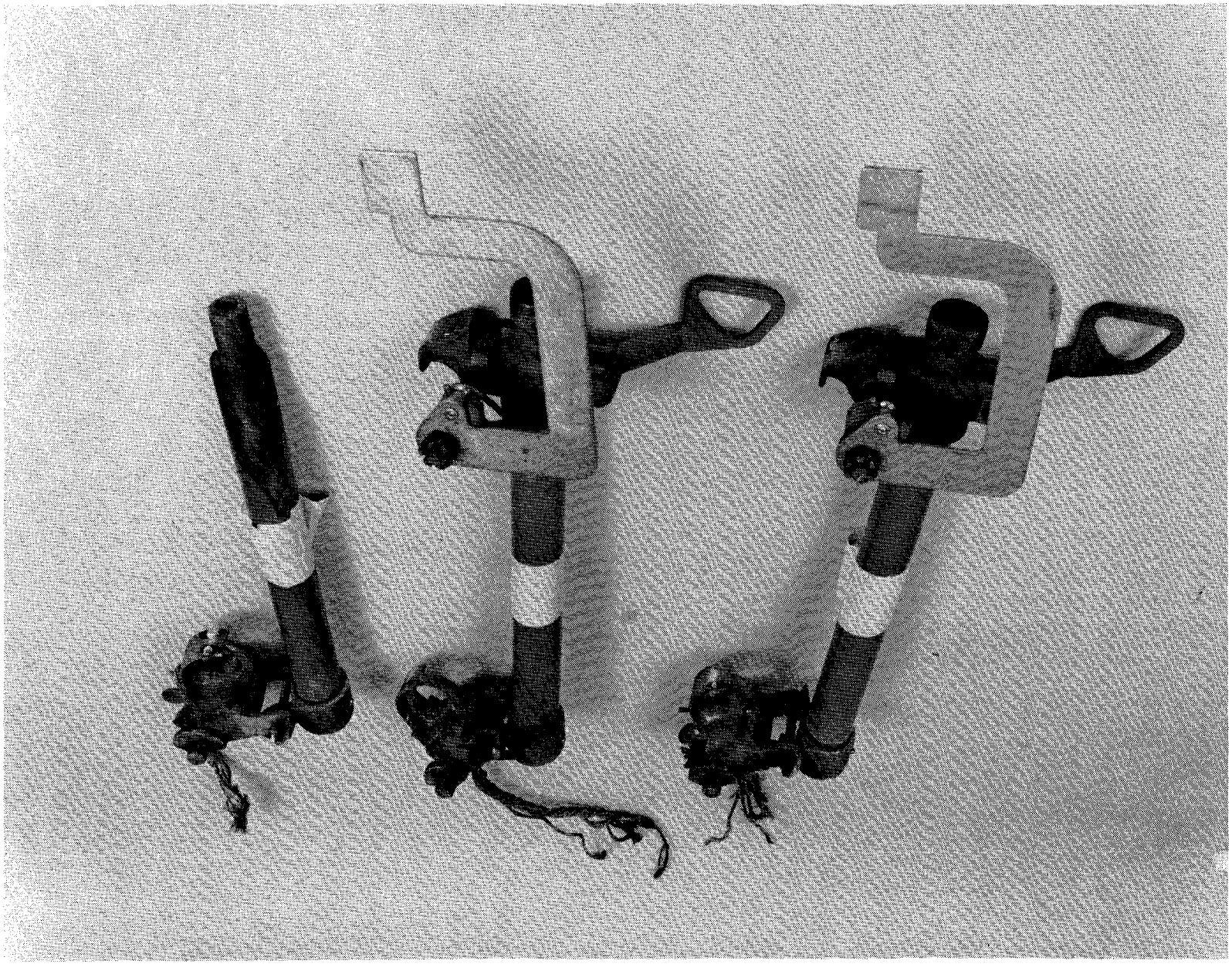


**Figure 2-8. Fuse Links Damaged by the Phase-to-Phase Fault**

protective equipment by the accident victim while he performed the concrete cutting work on January 16, 1996, at Building TA-21-209. However, outer leather gloves were not worn to prevent damage to the dielectric gloves.

JCI ES&H Manual procedure 12-25-008 "PPE For Electrical Work" (rev. June 17, 1994) under section 2.0.1 requires:

- Leather covered rubber gloves to be worn by workers to protect from electrical shock.

- Rubber gloves to be tested according to American National Standards Institute (ANSI) standards, which is indicated to be every nine months.

29 CFR 1910.137 (July 1, 1994) requires that rubber insulating personal protective equipment gloves be tested before first issue and every six months thereafter. The rubber insulating gloves worn by the accident victim while concrete cutting were last tested at 20 kV with a test date stamp of October 19, 1992. The JCI ES&H Manual nine-month rubber glove testing requirement was violated by JCI Maintenance. The JCI ES&H Manual 12-25-008 procedure, with regard to the nine-month rubber glove retest intervals, does not comply with the six-month testing interval requirement of 29 CFR 1910.137. In addition, JCI had no documented system for recalling personal protective equipment for retesting at planned intervals to meet requirements.

JCI ES&H Manual procedure 12-29-040, "PPE Training and Certification," describes how employees are to receive training on the identification of need, use, and care of personal protective equipment. JCI procedure 12-29-040 requires "Hands-on Training" for personal protective equipment and "When is Personal Protective Equipment Needed."

### 2.3.4 Post-accident Electrical Safety Issues

At the request of the Board, an underground utilities detector test was performed on January 25, 1996, to verify whether underground utilities can be located inside buildings. The test was witnessed by a member of the Board, as well as LANL and JCI personnel. The electronic utilities detector used in this test verified the presence of the 13.2 kV primary line that was penetrated during the accident on January 17, 1996. The readings on the detector when it was "swept" over the 13.2 kV line path, both through the concrete floor and directly over the excavated hole with the power lines exposed, were much higher than any "noise" readings due to the background sources inside Building TA-21-209.

*The electrical cable cut during the accident was identifiable by an underground utilities detector.*

The Board reviewed how emergency power was supplied to Building TA-21-209 following the accident. In providing temporary emergency generator power at Building TA-21-209, there was no emergency plan or procedure describing what critical power systems required temporary power. In addition, no plan or procedure describing what size generator was required, where and/or how to connect power, where to locate and ground the generator, how to introduce and route generator power cables into the building, or how long the building could be without power (i.e., for critical safety systems and/or freeze protection).

### 2.3.5 Electrical Safety Policy and Procedure Issues

*Policies and procedures relevant to the accident either did not exist or were not followed.*

LANL and JCI have developed ES&H manuals that address DOE orders, Federal regulations, and standards. These manuals are recognized by, and applicable to, both organizations as official policy for performing work safely. They are also applicable to subcontractors contracted to perform work on all LANL projects and facilities.

There are no JCI or LANL policies or procedures for concrete cutting or for electrical safety involving concrete cutting operations, and therefore none were available for use on January 17, 1996, at Building TA-21-209.

Section 4.0(e) of JCI Procedure 12-22-006 (Rev. July 1995), "Excavations," requires that the JCI Utilities Department be contacted for location and marking of underground utilities prior to any excavation. JCI Utilities was not contacted for location of underground utilities prior to Waste Stream Corrections Project work at Building TA-21-209. However, on the morning of the accident, a JCI Utilities specialist was contacted and asked by the masonry foreman whether an excavation permit was required for excavation inside a building, specifically Fire Station #1. In relation to the Waste Stream Corrections Project, the JCI Utilities specialist indicated that, normally, a permit is not required for excavation inside a building, but if a requester wants one, a permit will be issued. JCI Utilities also indicated that the underground utilities detector is not reliable in locating utilities inside buildings. 29 CFR 1926.651 (B) requires the identification of buried utilities prior to any form of excavation. The intent of this regulation is to review drawings, physically examine the work site, or perform electrical measurements to determine whether electrical or other stored energy sources exist.

The JCI Utilities Power Control Section (UPCS) has developed job-specific procedures for all levels of electric utility work within the Section. Applicable UPCS procedures during the accident at Building TA-21-209 were implemented as written. JCI and LANL lock-out/tagout procedures were exempt from being used on the 13.2 kV

primary feeder into the basement of Building TA-21-209, because JCI UPCS has developed operating instructions satisfying JCI, LANL, and industry standards incorporating lockout/tagout (UOI 63-00-180, "Clearances"). Appropriate lockout/tagout actions by JCI UPCS personnel were implemented according to UPCS operating instructions during the de-energization and re-energization of the primary line feeder into the basement of Building TA-21-209 after the accident.

## 2.4 EMERGENCY MEDICAL RESPONSE

The accident victim was a healthy 35-year-old male with no history of alcohol or drug abuse and no known medical conditions, other than severe nearsightedness. The victim consistently wore corrective lenses when working.

The victim was initially observed by lay rescuers to groan and have shallow, gasping respirations prior to respiratory arrest. Pulse was noted to be absent whenever checked. Because lay rescuers assumed that gasping sounds indicated the victim was breathing, and because of the potential back injury (i.e., arched back), CPR was not initiated. A number of Building TA-21-209 employees who were interviewed indicated that they were certified in CPR. However, in some cases, their CPR certification had expired.

*The building employees who first responded to the accident did not confirm that the power was off before removing the victim from the pit.*

The lay rescuers did not ask building personnel to confirm that power had been cut before administering first aid-CPR, and building personnel did not volunteer this information to onsite lay rescuers. They did indicate that physical signs, such as no lights within the building, were proof enough to allow safe removal of the victim from the sump pit. The emergency medical technicians en route to the scene did inquire, through the 911 radio dispatcher, whether the power was cut. They were assured that it was cut by one of the facility building managers.

Two 911 calls originated from the office area of Building TA-21-209 at the same time. The 911 operator indicated to the initial caller that he would have to terminate the 911 call in order to radio emergency response personnel.

*The Los Alamos Fire Department ambulances do not have advanced cardiac life support capability.*

Emergency response to LANL is provided by the Los Alamos Fire Department. Specifically, the Fire Department is under contract with DOE to provide both fire and emergency medical services to LANL. All firefighters are certified by the state as emergency medical technicians, all of whom are trained and certified in the use of defibrillators. Each ambulance is assigned one "Intermediate," an emergency medical technician with additional training and certification to start intravenous lines, administer intravenous fluids, give subcutaneous epinephrine, and administer inhaled medications. Intermediates

are not permitted to administer cardiac medications. Within the Los Alamos Fire Department, there are no paramedics and no emergency medical technicians certified to administer cardiac medications; the four emergency medical technicians are certified in advanced cardiac life support. Los Alamos Fire Department ambulances are fully equipped with all equipment and medical supplies that Intermediates are permitted to use. However, the ambulances do not have advanced cardiac life support capability. Los Alamos Fire Department personnel, as well as physicians involved in emergency response operations at Los Alamos, indicated that they receive many emergency calls for cardiac problems, including heart attacks or cardiac arrests.

The victim was intubated at Los Alamos Medical Center at 9:58 a.m. He was administered cardiac medications consisting of bretylium, epinephrine, and lidocaine, in that order, between 10:00 a.m. and 10:05 a.m. At 10:06 a.m., the victim reverted to normal rhythm pattern, but no pulse was detected. After an additional dose of epinephrine, the victim had a palpable pulse between 10:07 a.m. and 10:10 a.m. Normal blood pressure resumed shortly after 10:10 a.m.

The accident victim's pupils had been noted to be fixed and dilated prior to resuscitation. Following resuscitation, they were observed to be smaller (4 mm diameter) and reactive. Corneal (blink) reflexes were intact, but other reflexes were absent and the injured worker was unresponsive, with no purposeful movements. Muscle jerks were initially observed, as well as movements of the eyes; these were interpreted by the medical staff as possibly representing seizure activity. The accident victim was administered dilantin, an anti-seizure medication. He was also administered an intravenous steroid and other supportive medications. A tomographic scan of the head showed no abnormality. On that evening, the accident victim had an approximately seven-hour period of relatively low blood pressure (systolic blood pressure $< 100$ mm Hg; diastolic blood pressure $< 60$ mm Hg; mean arterial blood pressure $< 73$ mm Hg).

On January 18, 1996, a decision was made to transfer the accident victim to the Burn and Trauma Unit (Burn Unit) of the Bernalillo County Medical Center of the University of New Mexico, Albuquerque, for long-term evaluation of and care for both his central nervous system and his burns. He was transported by helicopter without incident.

At the Burn Unit, the extent and severity of burns were estimated (Figure 2-9). A large oblong third-degree burn was noted on the inner front surface of the left thigh. A second oblong third-degree burn was noted on the outer posterior surface of the upper left thigh and adjacent buttock. Smaller second-degree burns were noted in the middle of the left buttock, on the palmar side of the left hand at the base of the thumb, and on the palmar side of the right hand at the base of the

BERNALILLO COUNTY MEDICAL CENTER

**BURN ESTIMATE AND DIAGRAM**

AGE vs. AREA

| Area | Birth 1 yr. | 1-4 yr. | 5-9 yr. | 10-14 yr. | 15 yr. | Adult | 2° | 3° | Total | Donor Areas |
|---|---|---|---|---|---|---|---|---|---|---|
| Head | 19 | 17 | 13 | 11 | 9 | 7 | | | | |
| Neck | 2 | 2 | 2 | 2 | 2 | 2 | | | | |
| Ant. Trunk | 13 | 13 | 13 | 13 | 13 | 13 | | | | |
| Post. Trunk | 13 | 13 | 13 | 13 | 13 | 13 | | | | |
| R Buttock | 2½ | 2½ | 2½ | 2½ | 2½ | 2½ | | | | |
| L. Buttock | 2½ | 2½ | 2½ | 2½ | 2½ | 2½ | 1% | | 1% | |
| Genitalia | 1 | 1 | 1 | 1 | 1 | 1 | | | | |
| R U. Arm | 4 | 4 | 4 | 4 | 4 | 4 | | | | |
| L U. Arm | 4 | 4 | 4 | 4 | 4 | 4 | | | | |
| R. L. Arm | 3 | 3 | 3 | 3 | 3 | 3 | | | | |
| L. L. Arm | 3 | 3 | 3 | 3 | 3 | 3 | | | | |
| R Hand | 2½ | 2½ | 2½ | 2½ | 2½ | 2½ | 1 | | 1 | |
| L Hand | 2½ | 2½ | 2½ | 2½ | 2½ | 2½ | 1 | | 1 | |
| R Thigh | 5½ | 6½ | 8 | 8½ | 9 | 9½ | | | | |
| L. Thigh | 5½ | 6½ | 8 | 8½ | 9 | 9½ | 3° | 7% | 7% | 40% |
| R Leg | 5 | 5 | 5½ | 6 | 6½ | 7 | | | | |
| L. Leg | 5 | 5 | 5½ | 6 | 6½ | 7 | | | | |
| R Foot | 3½ | 3½ | 3½ | 3½ | 3½ | 3½ | | | | |
| L Foot | 3½ | 3½ | 3½ | 3½ | 3½ | 3½ | | | | |
| | | | | | | TOTAL | | | | |

BURN DIAGRAM

AGE 35 Y.O.
SEX MALE
WEIGHT ____

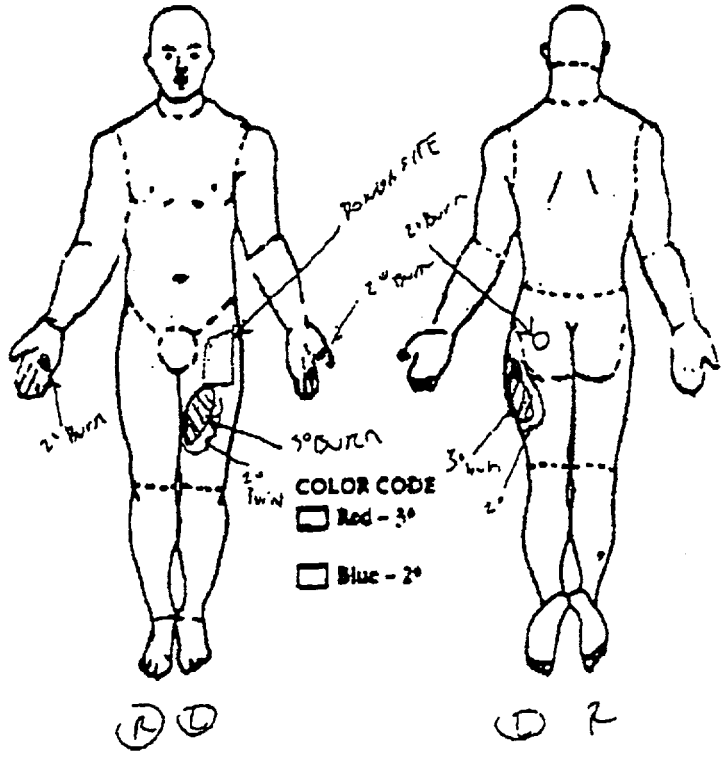



**Figure 2-9. Burn Estimate and Diagram for the Accident Victim**

fourth and fifth fingers. A minor burn of the right foot was noted at Los Alamos Medical Center, but not at the Burn Unit. The total second- and third-degree burn area was six percent of body surface area, an extent not considered to be life-threatening.

The victim was transferred to a total health care facility on February 5, 1996. As of the closeout of the Board, the victim was still comatose.

## 2.5 OCCUPATIONAL SAFETY AND HEALTH

*The Department of Energy and the Occupational Safety and Health Administration have promulgated requirements to protect construction personnel from accident, injury, and illness.*

During planning for the Waste Stream Corrections Project, the ESH Identification Project Summary identified the proposed project as a construction activity. On or about September 21, 1995, Service Request #02447 was approved and issued for "Waste Stream Corrections." Standing Work Order #06006SLA, "Waste Stream Corrections," was issued on October 3, 1995, for Laboratory-wide Waste Stream Corrections work. The Board reviewed applicable rules, regulations, and orders regarding safety requirements for construction activities, as defined by Occupational Safety and Health Administration (OSHA) and DOE.

OSHA and DOE have promulgated rules, regulations, and orders designed to provide assurance that personnel employed in construction occupations will be protected from accident, injuries, and illnesses. DOE Order 5480.4, *Environment, Safety and Health Standards,* incorporates OSHA requirements as contained in 29 CFR 1910, *General Industry,* and 29 CFR 1926, *Construction,* as mandatory DOE standards. OSHA Construction Safety regulations contained in 29 CFR 1926.20(a)(1) define construction-related activities as "construction, alteration, and/or repair, including painting or decorating."

DOE Order 5480.9A, *Construction Project Safety and Health Management,* April 13, 1994, defines construction activities as "any combination of erection, installation, assembly, demolition, or fabrication activities involved to create a new facility or to alter, add to, rehabilitate, dismantle, or remove an existing facility." The order further defines construction as also including "the alteration and repair (including dredging, excavating, and painting) of buildings, structures, or other real property, as well as construction, demolition, and excavation activities conducted as part of environmental restoration or remediation efforts."

DOE Order 4330.4A, *Maintenance Management Program,* October 17, 1990, defines maintenance as "Day-to-day work that is required to maintain and preserve plant and capital equipment in a condition suitable for it to be used for its designated purpose and includes preventive, predictive, and corrective (repair) maintenance."

Various OSHA construction regulations (1926.57(a), 1926.55(a), 1926.55(b), and 1926.55) require employers to take necessary actions to limit workers' exposures to hazardous substances, and may include engineering controls or the use of respiratory protection devices. In addition, sampling is required to determine the concentrations of contaminants in the workplace. JCI personnel had requested the JCI Maintenance Group to notify them when the organization would be conducting activities that could present a potential for personnel exposures to crystalline silica. JCI personnel stated that they had not been contacted prior to the work in Building TA-21-209 and, consequently, had not evaluated the feasibility of engineering controls or conducted workplace air sampling to determine airborne concentrations or the need for respiratory protection during jackhammering operations.

*The hazards of crystalline silica dust in the work area had not been evaluated.*

LANL Industrial Hygiene personnel stated that jackhammering operations would be the type of dust-producing activity that presents the potential for exposures to crystalline silica. JCI Environment, Safety, and Health (ESH) personnel had received information from Technical Area 54 regarding previous personnel exposures to crystalline silica, and were in the process of identifying those work activities that presented the potential for such exposures. JCI ESH personnel noted that several work activities that could present a hazard to workers (e.g., trenching and vegetation removal) had already been evaluated. Some of the evaluations were hampered by wet weather, which moistened the soil and lowered dispersion of dust.

LANL and JCI personnel stated that neither organization conducted surveys or assessments of the Building TA-21-209 workplace to determine whether personal protective equipment would be required during sump excavation activities there, since they had not been notified of the proposed work activity. Additionally, neither LANL nor JCI conducted surveys in the basement of Building TA-21-209 before proceeding with the installation of the sump to determine whether hazards associated with opening excavations were present. 29 CFR 1926.651(b) requires LANL and/or JCI to determine the estimated location of utility installations prior to excavation activities. This includes utilities such as sewer, telephone, fuel, electric, water lines, or any other underground installations.

*Neither the Laboratory nor the contractor conducted surveys to determine whether personal protective equipment would be required.*

Finally, JCI craft personnel stated that preliminary hazard analyses were not conducted during any phase of the Waste Stream Corrections Project. JCI craft personnel also stated that they were not aware of either the requirement or the form for completing the preliminary hazard analysis until after the accident at Building TA-21-209 on January 17, 1996.

*No preliminary hazard analyses were conducted.*

## 2.6 PERSONNEL RESOURCES AND TRAINING

*The Board identified many issues related to training.*

Training of the personnel involved in the work being performed at the Building TA-21-209 accident site was evaluated against requirements found in the orders and standards, as well as requirements applicable to LANL and JCI. The Board looked at training issues and developed its factual statements from information derived from interviews, document reviews, and process/procedure analyses. The following factual statements reflect training issues:

- JCI did not perform a job needs analysis for maintenance workers involved in the work, or similar work, being performed at the accident site.

- Corrective actions to Occurrence Report ALO-LA-LANL-HRL-1994-0004 required LANL and JCI to identify and revise concrete saw cutting procedures and safety training requirements. The corrective actions were not completed at the time of the accident.

- JCI did not perform a job and task analysis or a preliminary hazard analysis for maintenance workers involved in the work, or similar work, being performed at the accident site.

- Not all training at JCI, particularly job-specific procedural, personal protective equipment, and electrical safety training, is conducted by the JCI training organization. As a result, job-specific procedural, personal protective equipment, and electrical safety training at JCI is not conducted by qualified trainers (either through in-service or on-the-job training).

- Documentation of job-specific procedural, personal protective equipment, or electrical safety training for JCI personnel involved in the accident does not exist in the training organization database that maintains the individual workers' training records.

- Oversight of the contractual requirements for the JCI training program by LANL is performed at a high programmatic level, not at the craft level.

- Post-accident activities have included a concentrated effort to dispense information under the premise of "training." This informational awareness was neither facilitated through the Training Department nor conducted by qualified trainers. Evaluations of training effectiveness, such as practice tests, have not been performed.

## 2.7 MANAGEMENT SYSTEMS

### 2.7.1 Johnson Controls World Services, Inc.

JCI management personnel stated that the Standing Work Order was created to allow routine, non-complex tasks to be performed without creating a specific job ticket or work order for each task. They also stated that the sump pump installation subtask during which the accident occurred could have been executed under the Standing Work Order without a job ticket being created. An FSS-9 tailored work order form was prepared for the sump pump installation subtask, but typically the form is primarily used for cost-tracking purposes.

*The contractor regarded the excavation work as a routine, non-complex task.*

JCI management personnel stated that there is no written procedure that requires a work order or task package to be assigned to a specific level in the JCI organization. It was also stated that it is the supervisor's responsibility to assure that the data provided with the work package is sufficient to allow the execution of the technical requirements of the work in a safe manner.

In the case of the task that led to the electrical shock accident, three JCI foremen were involved in executing the work: the pipefitter, electrical, and mason foremen. The lead supervisor for this job was the pipefitter foreman. Both the pipefitter foreman and the electrical foreman received a copy of the work package for the sump pump installation subtask; however, the mason foreman did not. The JCI mason foreman stated that he received a telephone call from the pipefitter foreman on or about January 11, 1996, that verbally informed him of the requirement to construct four sump pump pits in the basement of Building TA-21-209. He further stated that he did not receive anything in writing defining the work.

JCI senior management stated that the applicable JCI procedure requires an excavation permit for any digging either outside or inside a building. The procedure requiring excavation permits for excavations located inside buildings was not being implemented, although JCI senior management was unaware of this fact. The controversy over when an excavation permit is required for excavations located inside buildings has been a longstanding issue at working JCI management levels. The issue has never been resolved. On the day of the accident, this issue was raised between the foremen and the utility specialist within JCI for similar work being performed at Fire Station #1. After a significant amount of confusion and differing opinions, the foreman and the specialist concluded that no excavation permit was required.

*The question of whether an excavation permit is needed for work inside a building has been a longstanding issue.*

Other issues arose regarding utility location surveys, safety reviews, and use of design drawings. The JCI General Manager stated that a utility location survey would not have been effective in locating an underground electrical cable or other stored energy source because of

*Other issues arose regarding utility location surveys, safety reviews, and use of design drawings.*

the presence of the steel reinforcing bars imbedded in the concrete, which would hinder ascertaining the locations of such electrical sources. When asked if the levels of safety reviews would have been different if the work had been categorized as construction rather than maintenance, the JCI General Manager stated that, in accordance with JCI procedures, it would have been the same. However, JCI procedures do indicate a different level of safety review and hazard analysis, depending upon whether the work is classified as construction or maintenance.

JCI and LANL management systems do not require the preparation of detailed design drawings of modifications to electrical and other stored energy systems as required by LANL Administrative Requirement 1-14 and DOE Order 6430.1A, *General Design Criteria*. In addition, as-built drawings are not prepared to reflect modifications to electrical or stored energy systems unless specified and funded in the work order by charge account.

### 2.7.2 Santa Fe Engineering

*Only preliminary design drawings were prepared for the work that led to the accident.*

SFE personnel prepared preliminary design drawings for assigned work packages. These drawings did not contain dimensions, were not to scale, and were primarily intended to illustrate the approximate location of required utility connections, such as drain piping. The drawings prepared for the sump construction activity indicated the general location of four sump pits in the basement floor of Building TA-21-209. These locations were selected based on their proximity to drain piping to which the pumps would be connected, and not by physical dimensions from fixed structures.

SFE management personnel stated that the scope of their contract with LANL did not require detailed design drawings for the various work packages, including the sump construction in Building TA-21-209. They further stated that they did not have access to the LANL data bases required to produce detailed design drawings. In addition, they had no institutional knowledge of the facilities required to develop detailed design drawings and specifications related to construction projects. This statement conflicts with the "General Notes" section of the SFE-prepared drawing entitled Building TA-21-209 Basement Piping Modifications, Project ID FMU70-009, which states "LANL engineering drawings used for reference in this project are as follows: R-2594, C-31988, C-32008, C-32009, C-32010, C-32011, C-32012, C-31964, and C-31965."

SFE management personnel also stated that they believed that LANL, specifically ESH-18, would develop, or cause the development of, detailed design packages for each task based on the preliminary drawings provided by SFE management. However, ESH-18 personnel stated that SFE personnel were co-located with ESH-18 and knew that

the preliminary designs were acceptable to both ESH-18 and Operations and Maintenance Services (FSS-9).

### 2.7.3 Los Alamos National Laboratory

#### 2.7.3.1 Waste Stream Characterization Project

*The project on which the accident occurred involves three Laboratory support organizations.*

Three LANL support organizations are involved in Waste Stream Corrections Project implementation at the Laboratory. ESH-18 is responsible for providing environmental expertise to LANL facility line organizations that have responsibility for ensuring compliance with Clean Water Act regulations. FSS-6 is a LANL project and design engineering support organization that manages large construction projects. The third support organization is FSS-9, which provides engineering support for maintenance, operations, and minor modifications.

The LANL NPDES permit came up for renewal in 1991. During the renewal process, which began in 1990, LANL management committed to an assessment of waste streams flowing to NPDES outfalls, so that the EPA could properly process the permit for the outfalls. ESH-18 created the Waste Stream Characterization Project to manage the assessment and the followup actions needed to comply with the NPDES requirements at LANL. This compliance assessment was conducted over three years and identified all of the waste streams contributing to outfalls at LANL.

To perform the NPDES compliance assessment, ESH-18 used the services of a Basic Order Agreement contractor, SFE. A final report was issued at the end of March 1994 that identified and characterized all waste streams at LANL. The report provided recommendations for modifications and/or other actions required to comply with the environmental regulations. The recommendations were forwarded to Division directors, who were expected to correct the deficiencies in their facilities.

ESH-18 assisted the facility managers, FSS-9, and FSS-6 by recommending design alternatives to meet the environmental regulations because the facility operations organizations had limited funding and staffing to correct the deficiencies. In some cases, ESH-18 helped facility managers by providing funding for completing the modifications.

*The project team leader had determined that the scheduled completion date would not be met.*

Some deficiencies were corrected by the line organization, and the 25 percent and 50 percent completion milestones were met. In August 8, 1995, however, the ESH-18 Project Team Leader determined that LANL would not meet the EPA schedule commitments (October 1996 completion) at the current rate of progress. LANL management determined that this was an institutional problem and should be resolved as a project. Initially, management considered submitting the

NPDES project requests for $5 million in the General Plant Projects budget. The proposal was taken to the Facility Managers Council for comment. The Facility Managers Council recommended that the projects be submitted in the General and Administrative budget. The $5 million Fiscal Year 1996 General and Administrative budget proposal was approved instead at $3.4 million. This money was allocated to the ES&H Division budget, and the Waste Stream Corrections Project was formed by ESH-18, which was also assigned responsibility for managing its implementation.

Correspondence within FSS-6 showed that there were serious concerns about being able to complete the work in the remaining time. One of the FSS-6 staff wrote, "My estimate is that it will be almost impossible to get this work done by the deadline (October 1996), even if they started last month." Funding was also a concern, as expressed in another note: "Our original approach was based on an $8 million to $10 million problem, which was then revised to $5 million, and now is $3 million to $3.5 million. In the next few weeks, we will be meeting with ESH-18 to clarify the approach, especially since there are some changing factors."

*An environment, safety, and health support organization was selected to manage the project.*

FSS-6 and ESH-18 staff met in late August to get the project organized and started since "time was of the essence." The WSC Project Team Leader made it clear that ESH-18 intended to manage the project. The use of FSS-6 Basic Order Agreement contractors was considered for some of the larger efforts. FSS-6 project managers offered to manage the overall project and provide project controls and engineering, but were turned down. The Waste Stream Corrections Project Team Leader preferred to use ESH-18 and SFE engineers in conjunction with an FSS-9 work coordinator to direct field work, rather than the FSS-6 "construction inspectors." The Waste Stream Corrections Project Team indicated in a meeting with the FSS-6 project managers that field-directing much of the work with FSS-9 work coordinator would be simpler and more cost effective. In a meeting on August 28, Waste Stream Corrections Project staff indicated there was a concern that there might be FSS requirements with this level of design, which would not add value. FSS indicated that it would actively work with ESH to assure that FSS was maximizing the effectiveness of G&A funds and not doing anything that did not add value. The issue was not resolved.

In October 1995, the Waste Stream Corrections Project Team grouped approximately 2,000 compliance actions into a service request (#02447). A Standing Work Order (#06006) was established based on a determination that the work involved relatively minor modification and construction work. The project team also decided that the scope of effort required to resolve these issues was within the technical and managerial capability of the Waste Stream Corrections Project Team.

The decision to keep the project management function within ESH-18 was made in August 1995. On December 4, 1995, the Waste Stream Corrections Project Team Leader informed FSS-6 that the design activity would be assumed by the Waste Stream Corrections Project engineers and that there was no further need of support from FSS-6 at present.

*Lead responsibilities for such functions as project management and design were also assigned to the environment, safety, and health support organization.*

Prior to the decision to manage the corrective actions, the Waste Stream Corrections Project Team had responsibility for resolving only those issues that involved analytical or administrative activities. The Waste Stream Corrections Project Team had not previously performed field engineering activities related to the design, construction, and turnover of facility modifications. However, the Waste Stream Corrections Project Team Leader had engineering experience in field modification work prior to coming to work at LANL.

The ESH-18 Group Leader, who supervises the Waste Stream Corrections Project Team Leader, was informed by the Team Leader of the decision to assume the design responsibilities for completing the corrective actions. The ESH Division Leader was informed about the transfer of responsibility for field implementation of the 2,000 deficiencies to his organization.

The Waste Stream Corrections Project Team decided to use SFE because of their previous support in the assessment and scoping of the corrective actions, and because SFE was readily available through a contract with ESH-18. ESH-18 prepared a tasking agreement with SFE to support the field modifications needed to resolve approximately 2,000 deficiencies.

### 2.7.3.2 Facility Management Unit

LANL management has established a Facility Managers Council to discuss, evaluate, and resolve methods and issues in order to achieve effective implementation of facilities management. The Council is made up of Laboratory Division directors, who own the facilities, and the facility managers, who report to the Division directors. The council developed a model that breaks down the Laboratory's facilities into 21 Facility Management Units. Each Unit defines roles and assigns responsibilities for managing the facilities.

*The Facility Management Unit model places much responsibility on the facility managers.*

In September 1995, the Facility Managers Council adopted a memorandum of understanding that transferred maintenance accounts to the facility managers and likewise assigned responsibility for management of the funds. In addition, the memorandum of understanding assigned the Division directors ("owners") responsibility for maintenance management in their assigned facilities. The memorandum of understanding also held facility managers accountable for management

of maintenance within established standards and applicable requirements for their Facility Management Units.

Director's Policy 124, "LANL Director's Policy for Facility Management," was issued October 5, 1995. This policy supports the Facility Management Unit plan and establishes that:

- It is the responsibility of the facility managers to maintain the appropriate authorization basis and to operate their facilities in an efficient and effective manner, while meeting all applicable regulatory, legal, security, and industrial standards.

- FSS is responsible for the Facility Management Program and its continuing implementation.

- Section 4.3 of the Laboratory Facility Management Program, effective February 5, 1996, states that the facility manager accepts ownership responsibility for the Laboratory facility/facilities as delegated to him/her by the owning Division director. The facility manager's responsibilities are to:

  - Approve the established operating envelopes and establish the authorization agreement

  - Review, approve, and assess operations within the facility

  - Efficiently and effectively maintain the facility authorization agreement, consistent with the facility mission

  - Efficiently and effectively maintain the facilities structures, systems, and components capabilities and assets.

Procedures that implement the Facility Management Unit program, as defined in the memorandum of understanding and/or the Director's Policy, have not been issued.

### 2.7.3.3 Determination of Management Level

*The Laboratory's graded approach to determining the management level of an activity eliminated some process controls from the task.*

The #06006 work package was designated as a Management Level 4 (ML-4) activity by FSS-3 using the "Graded Approach to the Conduct of Maintenance," Laboratory Standard LS121-01.0, as the reference for making the determination. The work package controls used for the sump modifications were consistent with the ML-4 requirements established in the Configuration Management Plan, which controls the design activities of FSS-6.

ML-4 work performed in FSS-6 does not require a technical baseline according to the Configuration Management Plan, 002-CMP, Rev. 0. The technical baseline contains: (1) system and design specifications, (2) design and as-built configuration, and (3) start-up and operational

activities. This baseline is the reference set of technical data and is controlled through the configuration management process by the project leader. Table 2 of the Configuration Management Plan excludes the requirement to identify the technical baseline for ML-4 activities. This eliminates the process controls described above.

Within the Laboratory, there are multiple systems for determining the management level of an activity. The FSS-6 classification procedure uses different criteria than the procedure used by FSS-3 for the work done in Building TA-21-209. However, the FSS-6 procedure is not applicable to other Groups within FSS or to other Divisions, such as ESH. Similarly the "Design Management Procedures" used in FSS-6 are not applicable to others. ESH-18, which has no design process procedures, is not required to comply with those of FSS-6.

### 2.7.3.4 LANL Internal Programmatic Reviews

*The Laboratory Assessment Office conducted five internal reviews between 1994 and 1995.*

Between 1994 and 1995, the assessments listed below were conducted by the Laboratory Director's independent oversight organization, the Laboratory Assessment Office. This office is chartered by Program Requirements Document 111-01.0. These assessment reports are representative of issues being identified by LANL and their applicability to the electrical accident of January 17, 1996:

- "Environmental, Safety, and Health; Quality; and Safeguards and Security Review of the Business Operations Division," AA-2-94-60, not signed out.
- "LAO-2 Assessment of Johnson Controls World Services, Inc.," LAO-2-94-02, dated March 18, 1994.
- "AA-2 Assessment of the Los Alamos National Laboratory Quality Assurance Management Plan (Director's Policies 110 and 115 and Program Requirements Document 110-01.0)," AA-2-94-31, dated August 29, 1994.
- "AA-2 Assessment of the Construction Safety Program," AA-2-94-73, dated November 18, 1994.
- "AA-2 Assessment of the Tritium Systems Test Assembly and the Tritium Sciences and Fabrication Facility," AA-2-94-49, dated March 28, 1995.

### 2.7.3.5 LANL Accident Investigations

*The current major accident investigation was the fifth to be conducted since October 1992.*

Between October 1992 and January 17, 1996, five major accident investigations were conducted at LANL. Three of these accidents occurred between December 1994 and January 17, 1996, a period of 13 months.

- On October 15, 1992, a shielding block was dropped at the Meson Physics Facility due to the failure of a lifting fitting. The accident resulted in a property loss of approximately $470,000.

- In December 1993, a worker received a plutonium intake due to high airborne contamination levels.

- In December 1994, a security guard was killed during a routine training exercise when live ammunition was used by a co-worker.

- In November 1995, a research assistant was severely injured when operating a forklift, which rolled off an elevated platform.

- On January 17, 1996, a JCI mason was severely injured while operating a jackhammer, which came into contact with an underground 13.2 kV electrical cable.

### 2.7.3.6 Safety Recrimination at Los Alamos National Laboratory

*Craft workers told the Board they feared recrimination if they raised safety issues.*

The Board was approached by craft workers because of their concerns about recrimination when raising safety concerns. The union stewards indicated that there is reluctance on the part of the workers to raise safety issues on the job because of the fear of recrimination. Further, craft workers indicated that they cannot raise safety issues, because they have been trained not to "question blue badges" and warned that if they cannot do the job, other workers would be found who would do it.

The policy of the Department, as adopted from the OSHA standards, is that "No contractor shall discharge or in any manner discriminate against any employee by virtue of the filing of a complaint, or in any other fashion exercising on behalf of himself or herself or others in any action set forth in these standards."

### 2.7.4 Los Alamos Area Office

*The Facility Representatives at the Area Office are assigned so many collateral duties that they cannot fulfill their primary mission of observation and monitoring.*

The Facility Representative Program performs day-to-day oversight of contractor line management in their assigned facilities to ensure that: (1) the facilities are operated safely and efficiently; (2) the contractor's management system is effectively controlling its conduct of operations; and (3) effective lines of communications between DOE and its operating contractors are maintained during periods of normal operation and following events in accordance with DOE orders and requirements.

The Facility Representative Program Manual, Revision 2, April 1995, states that Facility Representatives should be spending 60 to 80 percent of their time observing operations activities in the facilities to which they are assigned. It also states that the Facility Representatives should be free of collateral duties and programmatic influences.

LAAO management utilizes the Facility Representative Program to provide DOE with day-to-day monitoring of LANL facilities, operations, and maintenance activities. AL sent a memorandum to Don Pearman, Jr., Associate Deputy Secretary for Field Management (FM-1) on December 1, 1994, that identified the need for 30 Facility Representatives at LAAO. The current authorized staffing level is 11.

The LAAO oversight program does not focus on construction activities. The LAAO Facility Representatives are not generally involved in the design and construction of projects under their cognizance. The LAAO Environment and Projects Division, which has construction oversight responsibilities, limits its activities to the review of cost and schedule tracking of General Plant Projects and Line Item construction projects, through monthly progress reports submitted by the Laboratory, meetings between LANL/LAAO/AL, and some field oversight of General Plant Projects and Line Item construction activities.

In December 1994, the Facility Representative assigned to the Tritium Facilities at LANL completed the Facility Representative qualification program for the Weapons Engineering Tritium Facility in Technical Area 16 (Building TA-16-205). He was immediately assigned to a Type B Investigation Board for an accident investigation at Technical Area 48 until February 1995. His availability to be in the Tritium Facility at Technical Area 21 was also impacted when he was reassigned to Technical Area 55 in April 1995.

In November 1995, the Facility Representative was assigned to a Type A Investigation Board, which convened because of a forklift accident. This investigation concluded in late January 1996. In addition to these activities, the Facility Representative has participated in three readiness assessments, including one at the Mound facility, over the past 13 months. In all, due to various interferences, the Facility Representative has spent only four weeks observing activities at Building TA-21-209 and has conducted only five walkthrough surveillances.

The Facility Representative's oversight is usually based on reviews of activities in the field against maintenance and operating procedures, as well as other applicable requirements. Broad direction for surveillance is provided in a Standing Instruction, such as "observe maintenance activities." The Facility Representative is expected to prepare for these surveillances by referring to the Facility Operations Branch Appraisal Guide and by reviewing applicable requirements. By using personal experience and judgment, the Facility Representative decides which elements of maintenance will be observed.

When the Facility Representative encounters deficiencies, the LANL Facility Manager or designee is immediately notified verbally. Generally, issues are not documented by memorandum until the quarterly report, unless they are considered to be major issues. The

decision of when to formally document a deficiency is left to the Facility Representative's judgment. Surveillance observations are documented in the Facility Representative's log book and discussed with the Assistant Area Manager for Facility Operations. Findings, observations, and strengths are discussed with LANL management prior to issuing LAAO quarterly reports.

### 2.7.4.1 Pilot Oversight Program

*The Under Secretary established a pilot oversight program for line environment, safety, and health management in 1995.*

On August 31, 1995, Charles Curtis, the Under Secretary of Energy, sent a memorandum that established the "Pilot Oversight Program for Line Environment, Safety, and Health Management" at DOE laboratories. The key features of this pilot program included:

- On behalf of the Department, the Operations/Project Office will conduct one ES&H appraisal for no more than two weeks at each Laboratory, except in the case of Sandia National Laboratories.

- Results of assessments conducted by independent DOE organizations, such as the Inspector General and EH, and by external organizations, such as the EPA, will be considered in determining the scope of the annual ES&H appraisal.

- The Operations/Project Office will use the output of the Laboratory's self-assessment, in conjunction with other mutually agreed upon performance objectives, criteria, and measures, input from the Department's routine interactions with the Laboratories and day-to-day monitoring of activities, and, except for Sandia, the results from the annual ES&H appraisal, to determine the effectiveness of the Laboratory's management of ES&H.

The Curtis memorandum also provided a copy of the Albuquerque Operations Office (AL)/LANL proposed pilot program description, which defines the purpose, objective, process, guiding principles, and assumptions for the AL/LANL pilot oversight program. Statements in this document included:

- The oversight of the Laboratory will be based on performance and rely substantially, but not exclusively, on Performance Objectives, Criteria, and Measures in the contract between DOE and U of C.

- AL will conduct a functional ES&H assessment of LANL annually.

- The term "assessment," as used in the document, refers to appraisals and audits conducted to evaluate ES&H performance of activities, except day-to-day operational monitoring of activities performed by DOE Facility Representatives or program reviews.

- The Laboratories, U of C, and DOE operations offices will become partners in setting the scope of the program and monitoring performance.

- One purpose of this pilot is to improve communication between the contractor and DOE regarding the expectations of DOE and the quality of the contractor's performance. Problems or concerns with the contractor's performance should be brought to the attention of the Laboratory as soon as they are known so that the Laboratory can begin to correct the problem.

The first ES&H annual appraisal was conducted by AL in late October. However, the report was not issued until January 31, 1996, because of difficulties in writing the report and reaching agreement with LANL management on a conduct of operations issue in the report.

*Several conduct of operations issues were identified in appraisals related to this program.*

A memo (9WB-008) prepared by two LAAO Facility Representatives on October 31, 1995, highlighted several conduct of operations problems at LANL, including lockout/tagout, lack of procedures, inadequate procedures, failure to follow procedures, maintenance, and work control. These issues were extracted from occurrences at LANL over the past year. The memo indicated that during the past year, there were 159 accidents at LANL resulting in 132 personnel injuries and 57 lost work days. The memo highlighted the lack of formality and discipline regarding these types of occurrences. One passage in the memo states: "I am concerned that continued poor performance in the area of conduct of operations may result in additional severe consequences to the health and safety of the public, the environment, and laboratory employees, as well as the potential for facility shutdowns with associated programmatic impacts. LANL's current level of performance in the area of conduct of operations is unacceptable. A need exists for additional formality and discipline in operations. Operations are occurring without procedures and when procedures do exist, they are often inadequate or employees are just not following them." The memo asked for an action plan and formal presentation that would institutionalize conduct of operations at LANL.

*Management wished to handle the issues informally as part of a "teaming concept."*

The October 31, 1995, memorandum from the LAAO Acting Area Manager was never sent. In lieu of sending the memo, the Acting Area Manager met with the LANL Deputy Director in early November of 1995 and informally discussed many of the issues. LANL management requested that the memorandum not be sent since the Facility Management Unit model was increasing ownership for conduct of operations issues, and the activities at Technical Area 55 had shown improvement in conduct of operations. The LAAO Acting Area Manager agreed to this, but directed that the memorandum be shared with the LANL Division directors.

A similar memorandum was prepared by AL and sent to LAAO on September 1, 1995. The AL letter presented a trend analysis of occurrence reports from January 1, 1995, through August 1995 and found that 43 percent (74 out of 174) of the occurrences had direct, contributing, or root causes related to conduct of operations deficiencies. In the memorandum, AL offered to work collectively as a "team" with LAAO and LANL management in reducing the number of conduct of operations related occurrences.

The Board was unable to find any acknowledgement from LAAO about the receipt of this memo. The Board was also unable to determine whether the conduct of operations issues cited in the memo were formally transmitted to LANL management by the LAAO Acting Area Manager.

*There are concerns about the effectiveness of the teaming concept.*

Although there has been no written guidance providing LAAO with AL's expectations for implementation of the "teaming concept," there have been discussions within LAAO encouraging a more cooperative approach in identifying ES&H findings/problems to LANL management. Recently, LAAO management also suggested changing the Facility Representative's quarterly report cover memorandum format to eliminate the standard 30 day response requirement. The explanation given for doing this was to foster a spirit of "teaming."

The Facility Representatives and their management expressed concerns about how the "teaming concept" is being implemented. They are unsure as to how they are expected to interact with the facility managers, document their findings, and take decisive actions, such as directing the contractor to stop work.

### 2.7.5 Albuquerque Operations Office

*The Operations Office appraisal procedure is inconsistent with the pilot oversight program.*

The Functional Area Appraisal Procedure developed by AL and approved by the Assistant Manager (Office of Technical Management and Operations) is not consistent with the definition of the Pilot Oversight Program contained in the memorandum from the Deputy Secretary of Energy dated August 31, 1995.

This procedure states that: "Potential findings become formal findings when agreed upon by the assessor, Area or Project Office, and contractor." The procedure further states that the Team Lead Assessor has the responsibility to: "Facilitate a discussion of any potential findings and risk categories that would not be agreed upon and determine if the discussion should be elevated through the Division Directors, Area or Project Office management and contractor management."

### 2.7.6 DOE Headquarters

EH provides ES&H oversight of DOE facilities through the EH Site Resident program. Each DOE field office has a Senior Resident and several EH Residents, depending on the scope and location of the various facilities. The Senior EH Resident for AL, including Sandia National Laboratory and LANL, is located in Oak Ridge, TN. Only one EH Resident is located at Los Alamos.

*In 1995, the EH Resident at the Laboratory noted a trend of construction-related electrical exposures and reported it informally to the Area Office.*

The EH Resident performs scheduled surveillances and reviews a variety of management information pertinent to LANL operations. In late 1995, the EH Resident reviewed a series of Occurrence Reporting and Processing System reports and identified a trend of safety-related incidents involving concrete cutting and wall penetrations that resulted in electrical exposure to workers. These incidents were generally attributed to a failure to follow the principles of conduct of operations. A memorandum was prepared and discussed with LAAO personnel, but was not formally transmitted. The EH Resident has a background in health physics and approximately one year of oversight experience as an EH Resident. The EH Resident participates in a weekly conference with the Senior Resident and EH Headquarters to report concerns and share experiences. The EH Resident provides issues, concerns, and observations discovered through onsite surveillance to the LAAO Area Manager on a weekly basis.

# 3.0 ANALYSIS

## 3.1 SYSTEMS ANALYSIS

### 3.1.1 Objectives and Methodologies

The Board's analysis objectives were to identify and analyze root causes and factors resulting in the accident. The two main analysis objectives were (1) determining the most likely accident scenario leading up to the near fatal injury resulting from contacting a 13.2 kV electrical cable and associated response from facility and emergency medical personnel, and (2) analyzing management structure, policies, procedures, and common practices at LANL, its contractors, and the oversight of DOE Headquarters and field and area offices.

*The Accident Investigation Board focused on pre-accident work controls and management issues to determine the root causes of the accident.*

The first objective focused on the pre-event work control conditions and interactions of the cement mason tender, co-workers, foremen, and safety personnel during the excavation of a sump pit at Building TA-21-209. The second objective of the analysis was pursued to determine whether programmatic and procedural breakdowns resulted in the near-fatal accident.

The Board used several analytical tools and techniques to analyze the causes and effects of the accident. Based on these analyses, the Board determined the contributing and root causes (deficiencies that, if corrected, would prevent recurrence of this and similar accidents) of the accident.

### 3.1.2 Events and Causal Factors

*A causal factors analysis was performed.*

The events and causal factors chart is used to determine the sequence of events leading to the accident and to show the relationship between events and associated causal factors. A causal factors analysis is shown in Table 3-1, and an events and causal factors chart is depicted in Figure 3-1. Causal factors that arose from analysis of the events and causal factors chart are as follows:

- Conduct of Operations—This causal factor is discussed in Section 3.2.

- Electrical Safety—The conditions present with the JCI crafts personnel during the pre-event to the post-event associated with this causal factor are discussed in Section 3.3.

- Emergency Response—Emergency response activities by building and emergency response personnel associated with this causal factor are discussed in Section 3.4.

- Training—This causal factor is discussed in Section 3.6.

- Management Systems—JCI, LANL, and DOE management systems associated with this causal factor are discussed in Section 3.7.

### 3.1.3 Barrier Analysis

*A barrier analysis and a change analysis were performed.*

Barriers and controls are the physical and administrative constraints that prevent an unwanted flow of energy. The barrier and control analysis looks at the barriers that management control systems have provided between the hazards and the person, place, or equipment, and then evaluates the effectiveness and presence of those barriers. Table 3-2 is the barrier and control analysis, and Figure 3-2 summarizes the performance of these barriers and controls in place during the accident.

### 3.1.4 Change Analysis

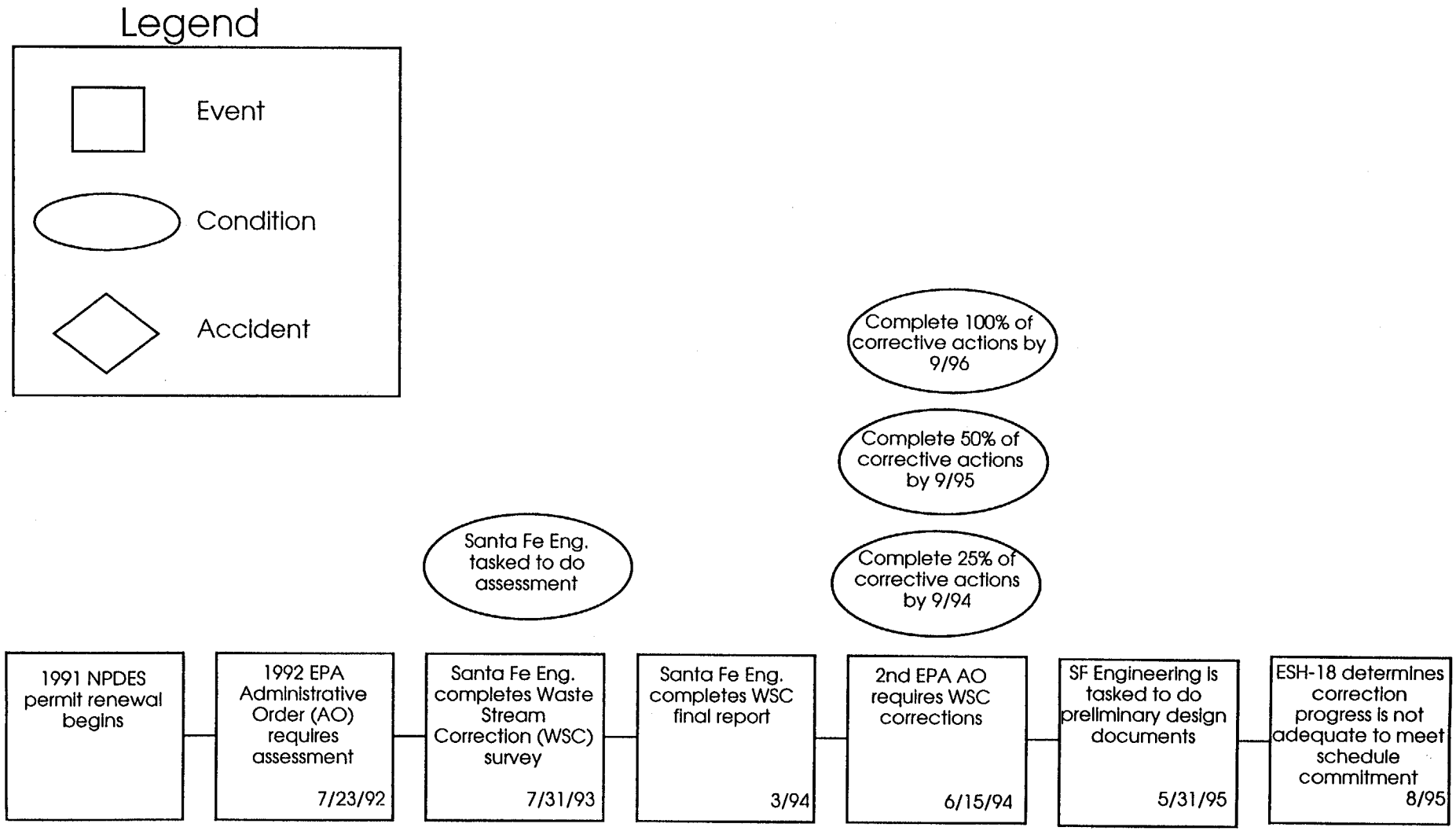
Change analysis was performed to address the changes or departure from normal processes that led to the accident. The change analysis confirmed the results of the earlier events and causal factors analysis and the barrier analysis. The results of the change analysis are summarized in Table 3-3.

**Table 3-1. Causal Factors Analysis**

| Causes | Discussion |
|---|---|
| Management Systems | LANL management has not instituted a Laboratory-wide work control procedure that formalizes the work control process for construction and maintenance tasks. The following deficiencies exist:<br><br>• Management fostered an attitude that allowed multiple Groups to go outside the bounds of the established work control process for the sake of expediency.<br>• LANL management allowed project schedule to take precedence over established procedures.<br>• Management allowed deviations from the approved ES&H review process.<br>• Policy was in place that stated if no ES&H subject matter expert (SME) response was received, concurrence was assumed.<br>• Management allowed the project lead to be accomplished by a Group which was inexperienced in project management.<br>• The Water Quality and Hydrology Group (ESH-18) failed to follow the work process plan that was disseminated to multiple lab organizations.<br>• A sitewide misperception existed as to the requirements for indoor excavation.<br>• Facility management did not have access control to their facility. |
| Conduct of Operations—Work Control | LANL and JCI conduct of operations processes relating to work control were deficient because of the following:<br><br>• ESH-18 design review processes were not procedurally governed.<br>• ESH-18 approves and issues preliminary design documents for construction.<br>• Work is authorized to commence prior to resolving SMEs' comments.<br>• Inaccurate description of work tasks leads to Davis-Bacon determination on non-covered work.<br>• Lack of formality existed in the approval process for modifications.<br>• Informal communication (verbal) was used to direct work activities pertaining to modifications.<br>• Work packages were not provided to craft personnel.<br>• Workers did not obtain approval of the Facility Manager.<br>• Maintenance failed to inform JCI safety prior to starting work. |
| Occurrence Reporting System | LANL management did not ensure that adequate actions were taken resulting from previous occurrences, internal and external assessments, and accident investigations. Corrective actions to precursor events were not completed. |
| Hazards Analysis | A preliminary hazard analysis (PHA) was not provided for the "maintenance" work in Building TA-21-209, and the JCI foreman was not aware of the requirements for a PHA to be performed. The attention JCI provided to safety for maintenance activities was not as rigorous as that provided for construction. A PHA and an activity hazard analysis are required for construction activities, while maintenance activities only require a PHA. |

**Table 3-1. Causal Factors Analysis**

| Causes | Discussion |
|---|---|
| Conduct of Operations—Procedures | LANL and JCI conduct of operations relating to procedures were deficient because of the following:<br>• Excavation procedures were not implemented.<br>• Preliminary task scoping procedure was not followed.<br>• Resolution of ES&H SME comments was not accomplished.<br>• ESH-18 developed and utilized a unique tailored work form.<br>• Facility Risk Management Group (ESH-3) failed to identify all associated hazards during the review process.<br>• The Standing Work Order process was not used properly.<br>• A required preliminary hazard analysis was not performed.<br>• Approval for lateral relocation of sump was not obtained.<br>• Workers failed to inform the Facility Manager prior to starting work.<br>• JCI did not have in place a formal procedure to identify the required personal protective equipment for specific tasks exposing "unqualified" workers to electrical hazards. |
| DOE Oversight | DOE oversight at all levels has not been effective at correcting known deficiencies. Corrective actions from recurring incidents related to similar work activities and assessment have not been corrected or elevated to management. |
| Supervision | JCI supervisors do not have a comprehensive knowledge of work control and work from verbal instructions and direction. JCI supervisors were not aware of several procedures in such areas as excavations, personal protective equipment, and hazards analysis. |
| Training | Training implementation was informal, was not based on appropriate structured development, delivery, or measurement of learning. Implementation of performance based training for critical training and activities did not meet the requirements of DOE Order 5480.20, the maintenance training requirements from DOE Order 4330.B, and the requirements of JCI procedure 12-29-040, *PPE Training and Certification Program.* |
| Electrical Safety | JCI crafts personnel did not receive training on or implement the specific requirements for work by "unqualified workers" as specified in 29 CFR 1910.331-335. There is no formal procedure in place identifying the need for this hazard awareness type training. |

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Page 1

**Figure 3-1. Events and Causal Factors Chart (Page 1 of 11)**

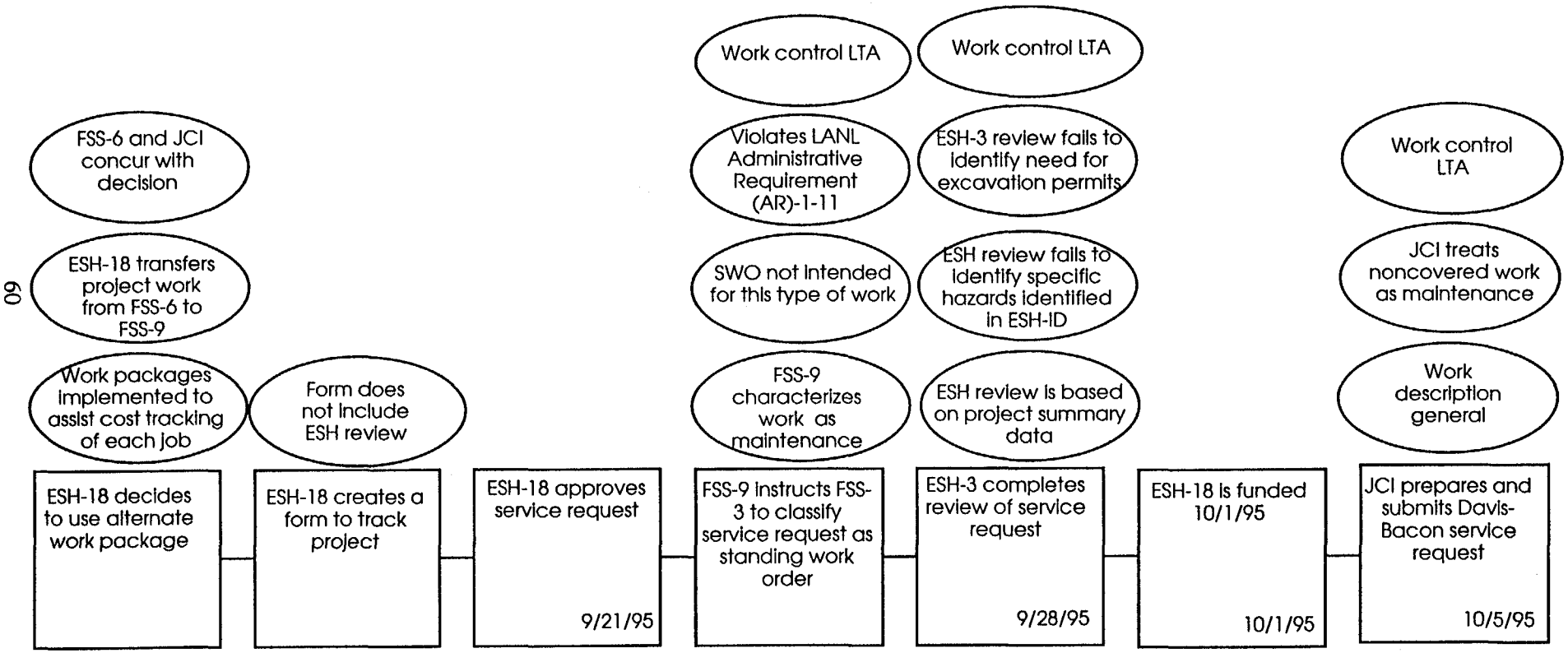




**Figure 3-1. Events and Causal Factors Chart (Page 2 of 11)**

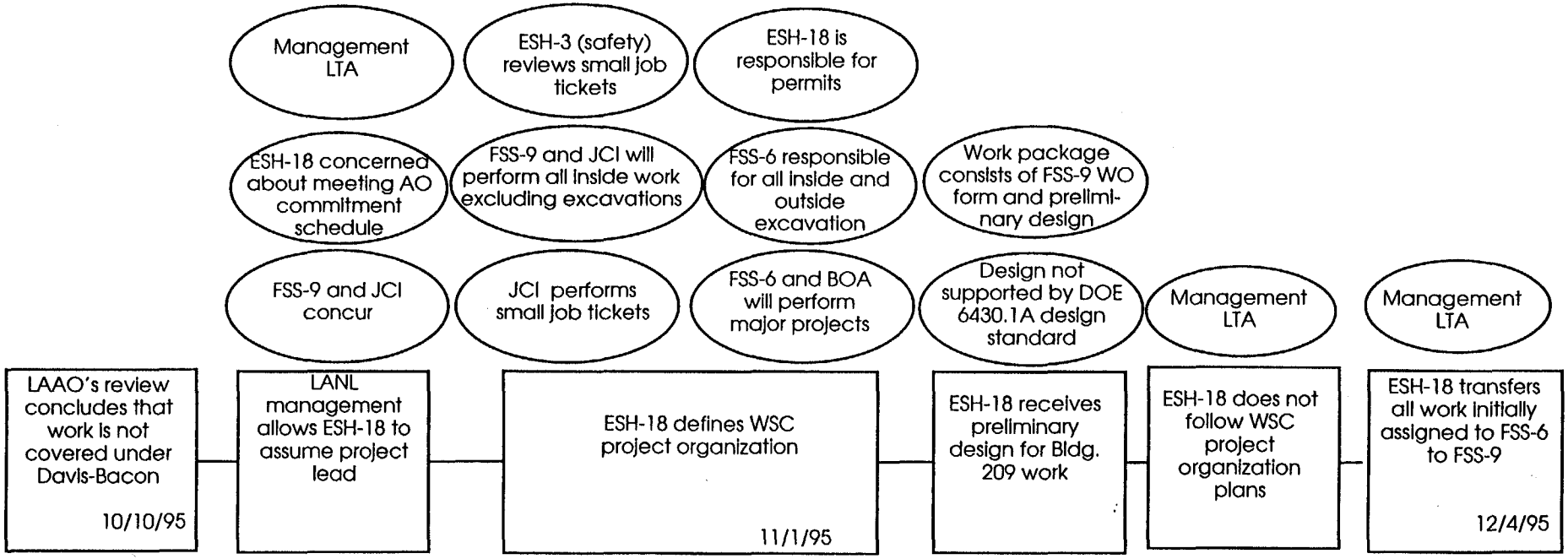




**Figure 3-1. Events and Causal Factors Chart (Page 3 of 11)**

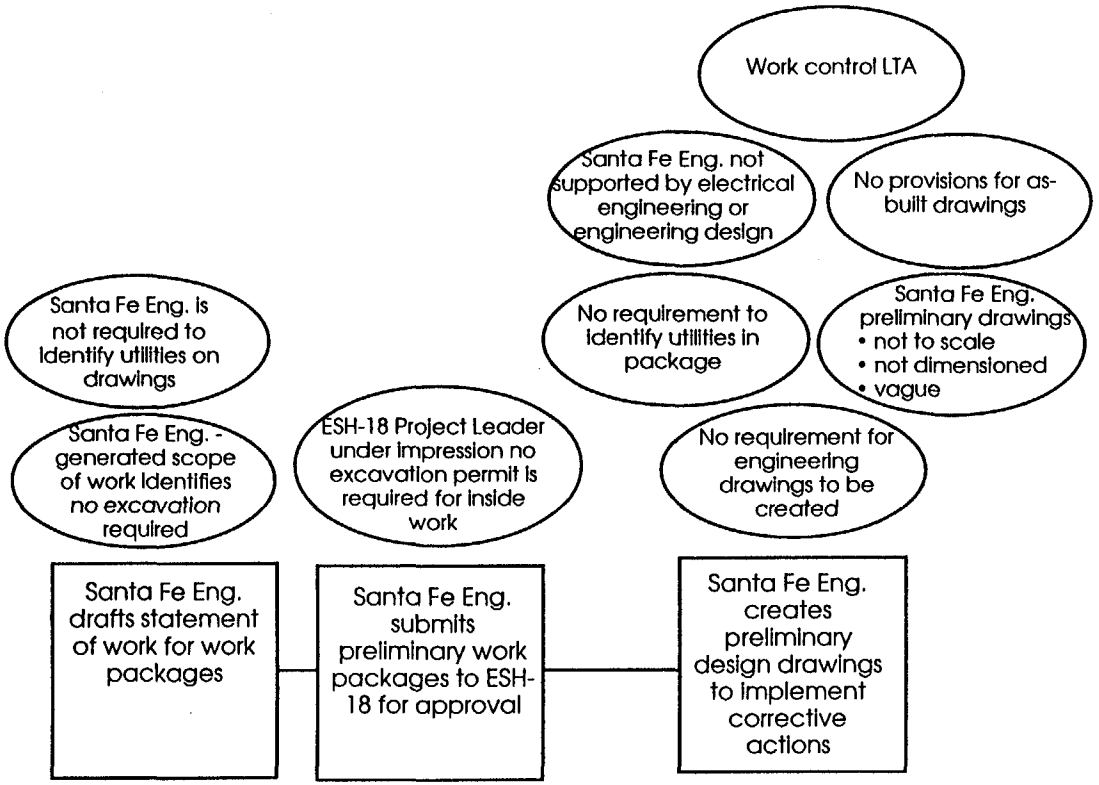




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**Figure 3-1. Events and Causal Factors Chart (Page 4 of 11)**

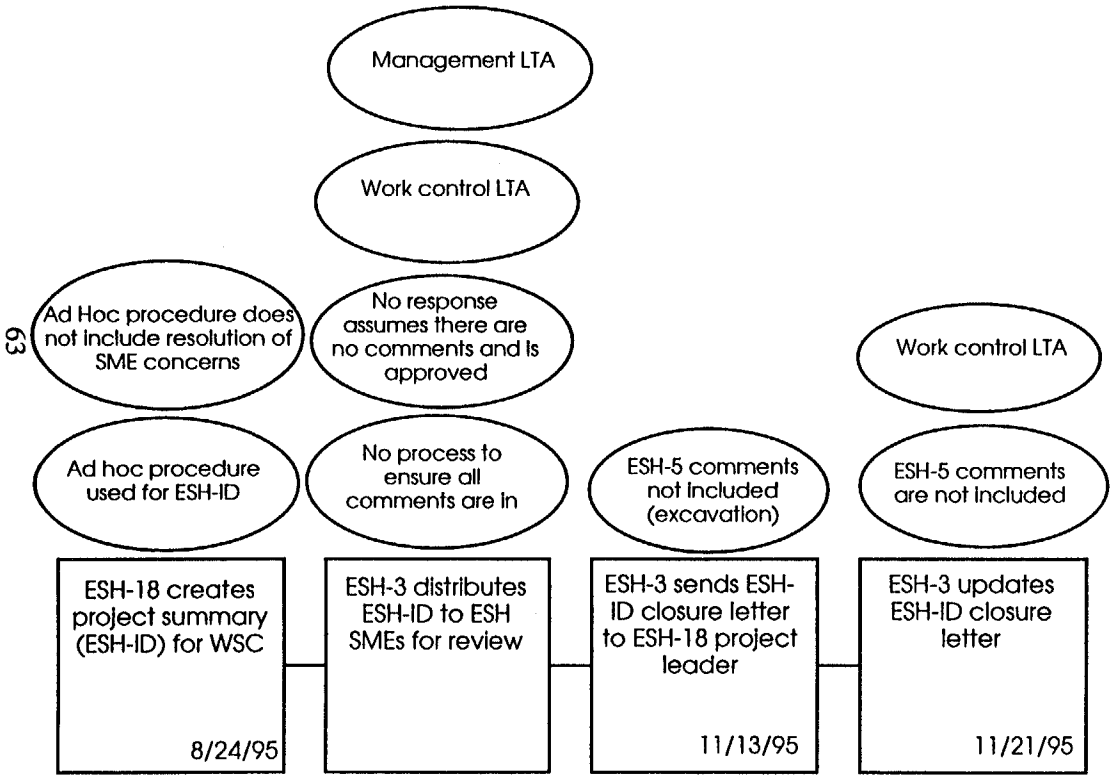






**Figure 3-1. Events and Causal Factors Chart (Page 5 of 11)**

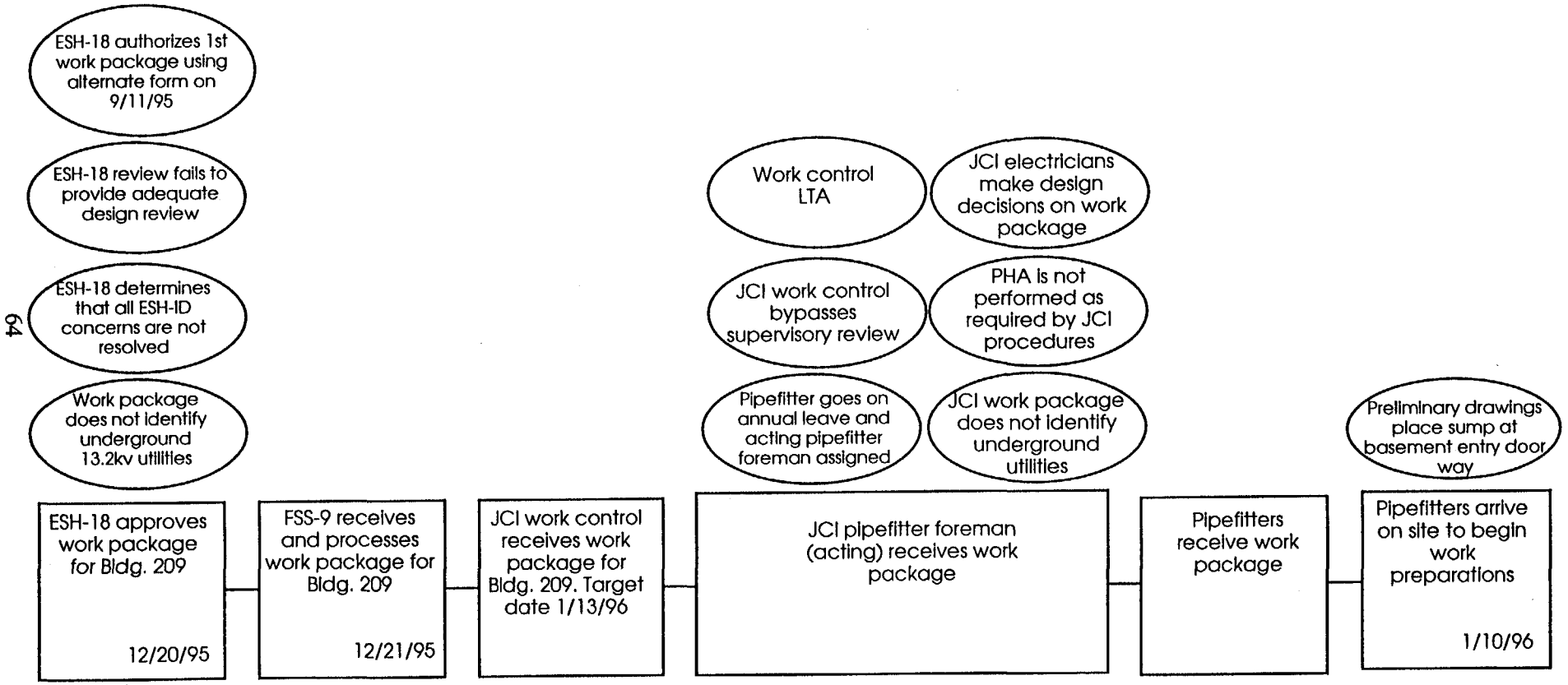




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**Figure 3-1. Events and Causal Factors Chart (Page 6 of 11)**

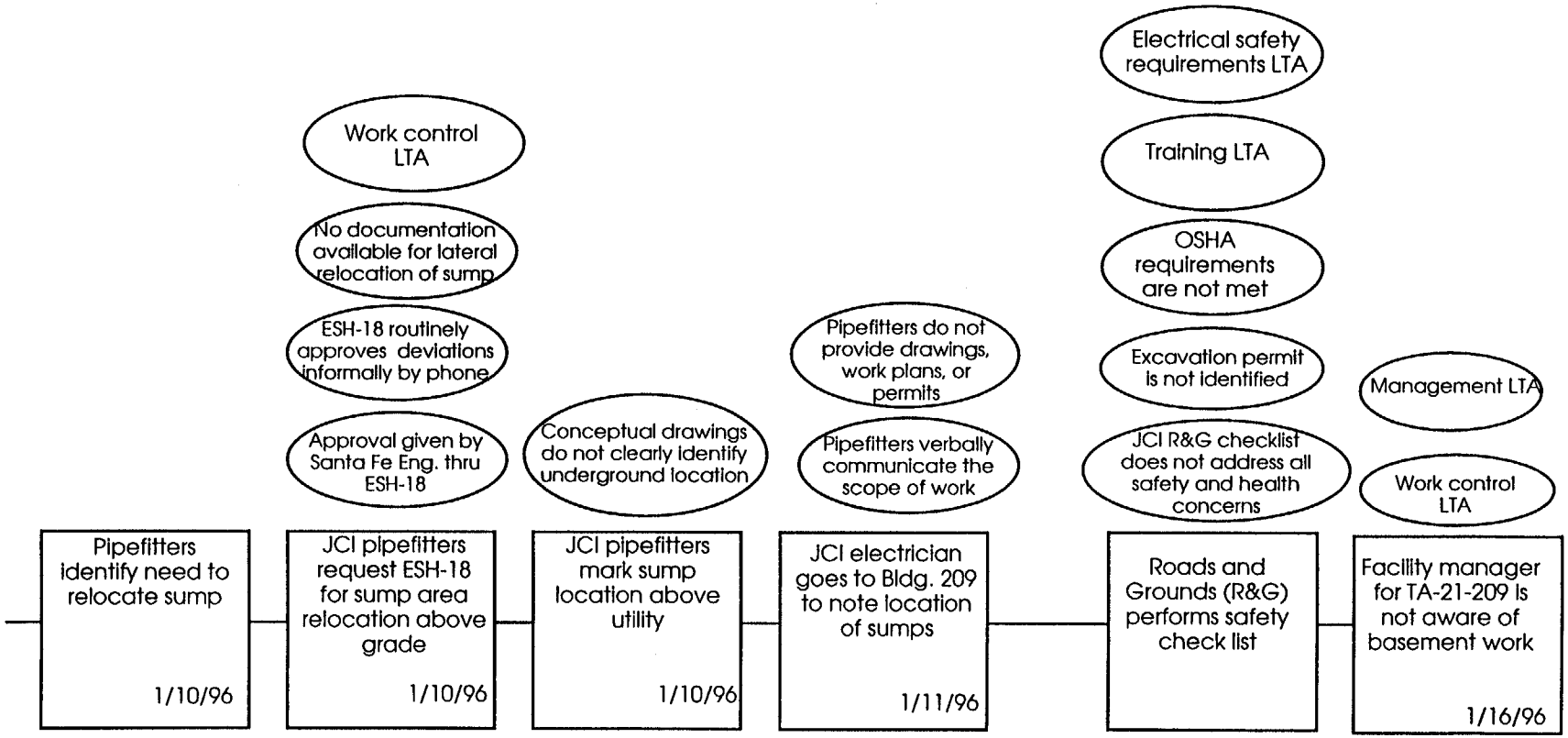


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**Figure 3-1. Events and Causal Factors Chart (Page 7 of 11)**

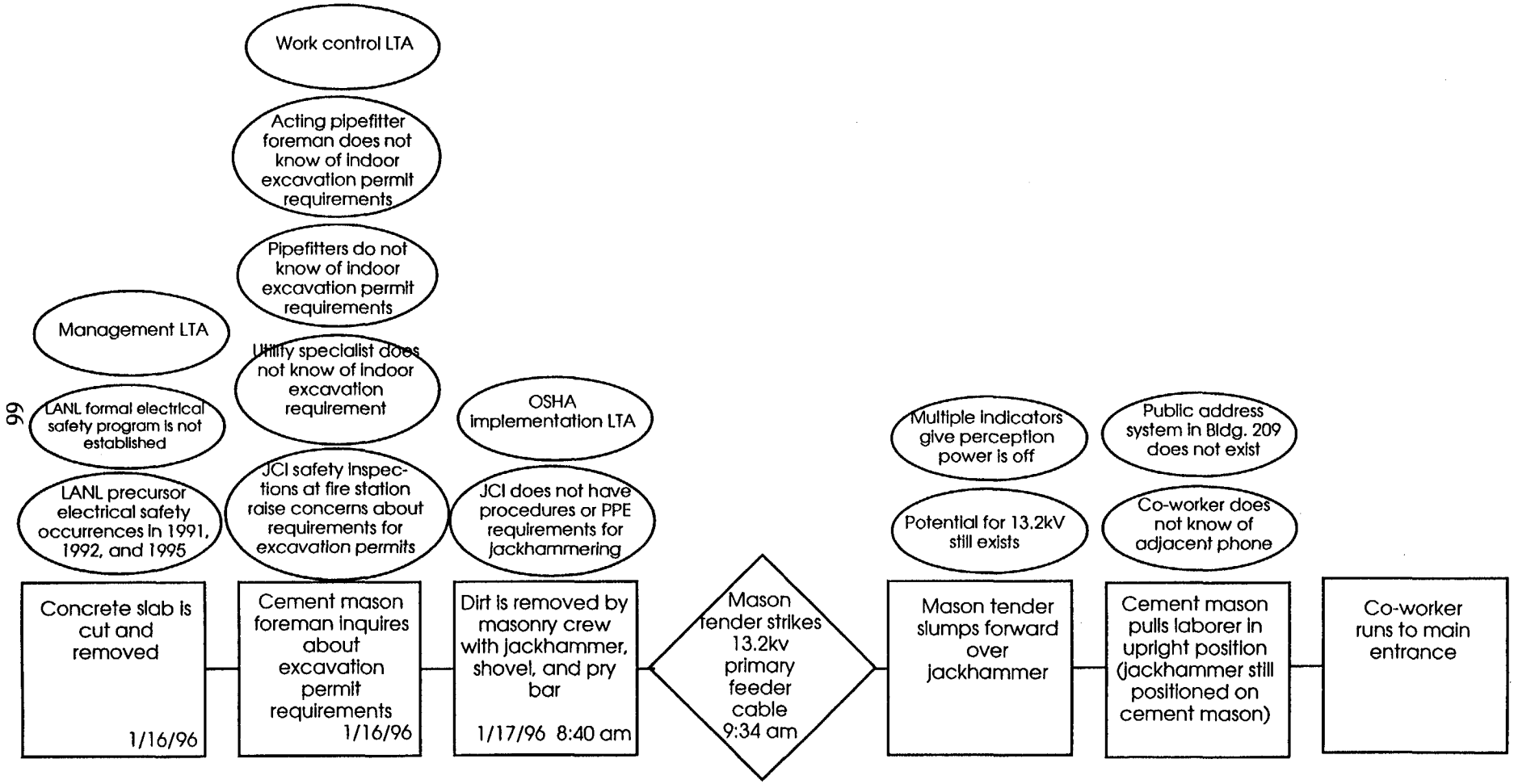




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**Figure 3-1. Events and Causal Factors Chart (Page 8 of 11)**

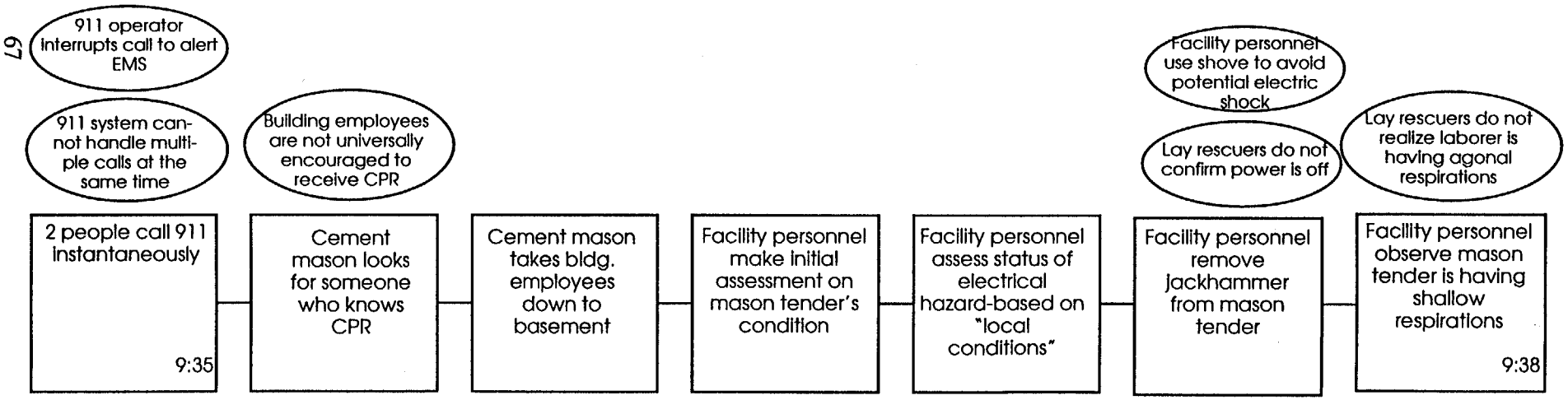





**Figure 3-1. Events and Causal Factors Chart (Page 9 of 11)**

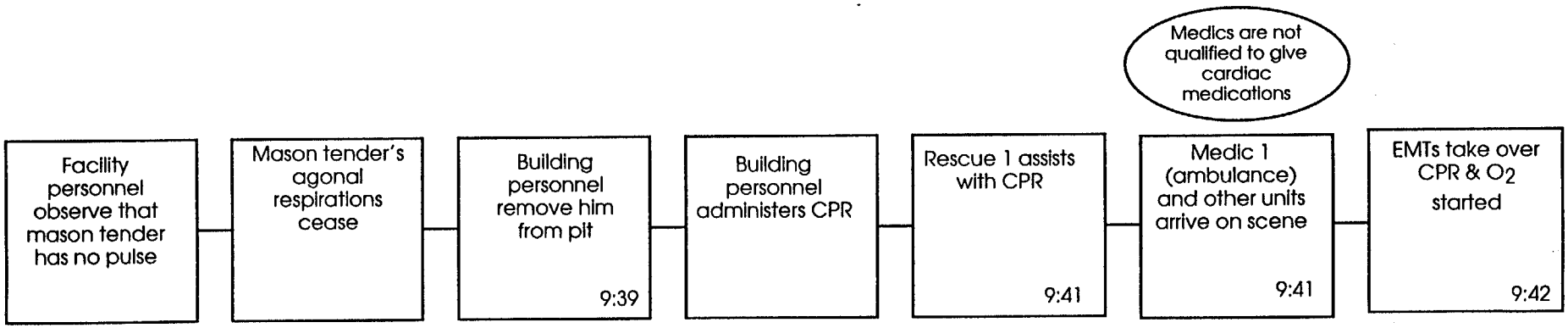





**Figure 3-1. Events and Causal Factors Chart (Page 10 of 11)**

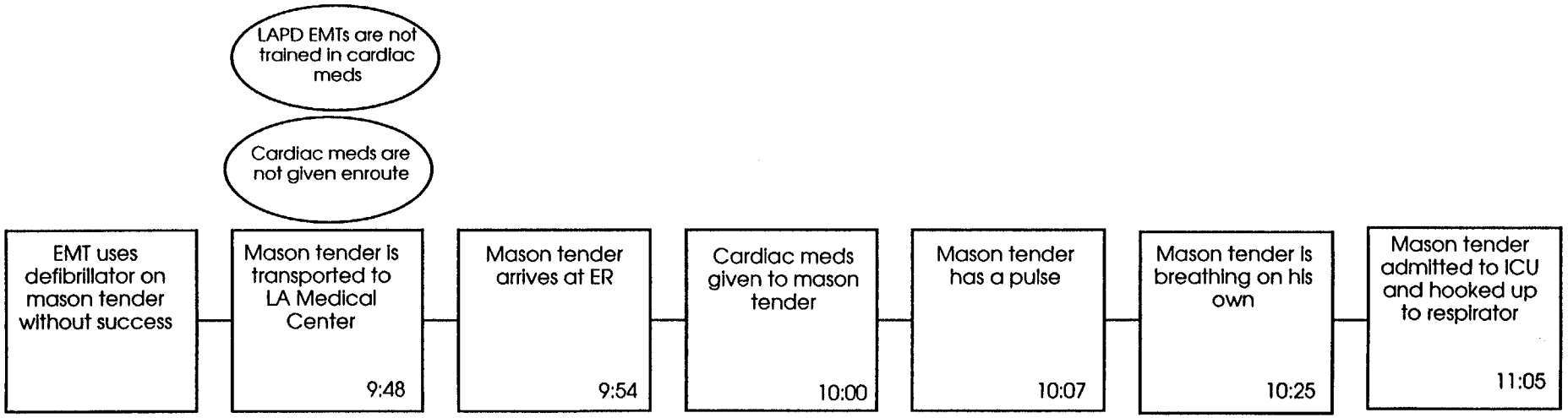





**Figure 3-1. Events and Causal Factors Chart (Page 11 of 11)**

**Table 3-2. Barrier and Control Analysis (Page 1 of 4)**

| Hazard | Direct Barrier or Control Failure | Possible Contributing Factors to Barrier or Control Failures | Possible Root Causes of Failures | Loss or Potential Loss Event | Evaluation |
|---|---|---|---|---|---|
| Contact with 13.2 kV electric cable | Failure of design to identify electrical cable at sump location | Architect/engineering firm was not tasked to provide engineering drawings or specifications<br><br>The design was only intended to provide preliminary information<br><br>As-built drawings were not used by ESH-18 to identify utility lines | Water Quality and Hydrology Group (ESH-18) was not knowledgeable in project management to request engineering designs or specifications | Contact with 13.2 kV line | A planning organization was given responsibility for the project in no order to meet Environmental Protection Agency (EPA) schedule commitments |
| | Failure of mason to detect electrical cable during excavation | Color and texture of concrete and tuff are similar<br><br>Compressive strength are similar for concrete and tuff | Job specific hazard awareness training | | Hazard awareness was not adequately provided to the cement mason foreman |
| | Failure of excavation procedure to identify electrical cable | Confusion among JCI crafts personnel, foremen, and supervisors on requirements for an excavation permit indoors<br><br>Facility Risk Management Group (ESH-3) review fails to identify the need for an excavation permit during the service request process<br><br>ESH-18 did not know of excavation permit requirement of Administrative Requirement 1-12 | Implementation and training on procedures<br><br>Lack of understanding of responsibilities | | Implementation of procedures were not enforced<br><br>ESH-3 personnel assumed a more detailed specific safety and health review would be performed |

**Table 3-2. Barrier and Control Analysis (Page 2 of 4)**

| Hazard | Direct Barrier or Control Failure | Possible Contributing Factors to Barrier or Control Failures | Possible Root Causes of Failures | Loss or Potential Loss Event | Evaluation |
|---|---|---|---|---|---|
| Contact with 13.2 kV electric cable | Failure to assess potential construction hazards | The Waste Stream Corrections tasks were classified as a Standing Work Order (SWO) and not subject to the same safety and health assessment as a construction project | Lack of oversight and conduct of operations | Contact with 13.2 kV line | Implementation of conduct of operation and training was not conducted |
| | | A Preliminary Hazard Analysis was not performed as required by JCI procedures | | | |
| | | The JCI Roads and Grounds Safety checklist was completed but does not address all hazards<br><br>JCI safety inspection was not conducted at Building TA-21-209 | | | |
| | Failure of a utility survey to identify an electrical cable | The utilities survey group did not believe that an excavation permit was required for indoor excavations and that a survey could not be conducted indoors because of the background noise | Implementation and training on procedures | | Procedures were not enforced |
| | Failure of physical barriers to isolate contact with electrical cables | JCI mason was not wearing personal protective equipment (PPE) as required by 29 CFR 1926.416(a)(3) | Implementation of JCI procedures | | Procedures were not enforced |

**Table 3-2. Barrier and Control Analysis (Page 3 of 4)**

| Hazard | Direct Barrier or Control Failure | Possible Contributing Factors to Barrier or Control Failures | Possible Root Causes of Failures | Loss or Potential Loss Event | Evaluation |
|---|---|---|---|---|---|
| Contact with 13.2 kV electric cable | Failure of conduit material to conform to specifications | Conduit was made of an asphalt material. The original building specifications required the installation of rigid steel conduit<br><br>Tests performed showed that the conduit encasement was of low strength concrete, 1130 psi | Inspections/engineering modification | Contact with 13.2 kV line | |
| | Failure of supervision and management oversight | LAAO/AL have not been effective at correcting known deficiencies | Management system is not effective in correcting change | | Lack of management attention to close out corrective actions |
| | | LANL management allowed ESH-18 to have project lead | Established policies and procedures were not implemented | | LANL management allowed project schedule to take precedence over established procedures |
| | | LANL management allowed a preliminary design package to be used for construction | | | |
| | | LANL management allowed deviations from Administrative Requirements 10, 1-11, 1-12, and 14 and the Quality Management Plan | | | |

**Table 3-2. Barrier and Control Analysis (Page 4 of 4)**

| Hazard | Direct Barrier or Control Failure | Possible Contributing Factors to Barrier or Control Failures | Possible Root Causes of Failures | Loss or Potential Loss Event | Evaluation |
|---|---|---|---|---|---|
| Contact with 13.2 kV electric cable | Lessons learned process failure | JCI did not ensure that crafts personnel were aware of work place hazards (preliminary hazard analysis, excavation, and worker training)<br><br>JCI Safety did not review "Maintenance" work package | | Contact with 13.2 kV line | |
| | | LANL management did not ensure that adequate actions were taken resulting from previous occurrences | The corrective action process was not implemented | | Between 1991 and the present there were 5 similar occurrences which referenced the need for training and proper personal protective equipment |
| | Failure of configuration control | ESH-18 allowed relocation of sump pit without a modification review<br><br>Facility Managers were not aware of modifications to facility | ESH-18 was not experienced in project management | | |

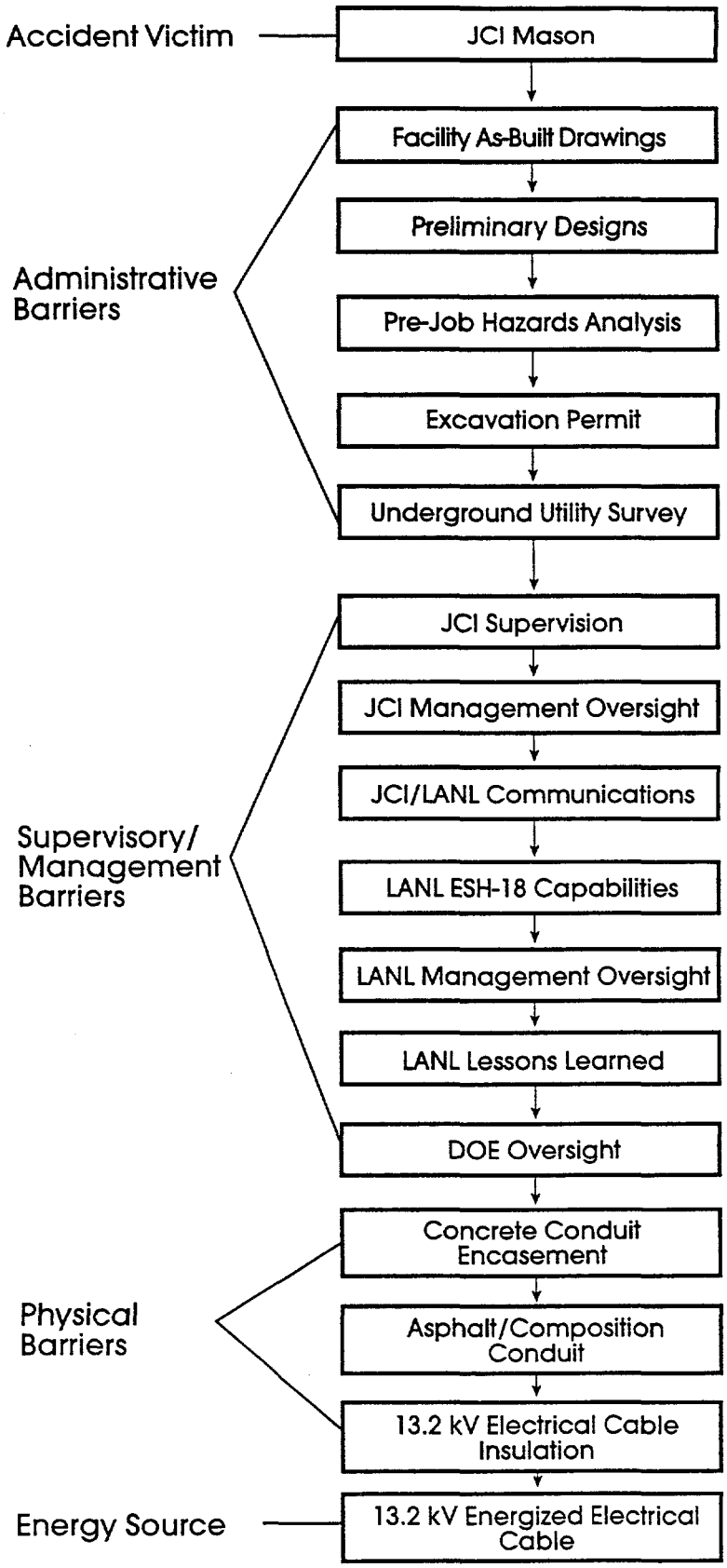



**Figure 3-2. Barrier Analysis Summary**

| Table 3-3. Change Analysis | | |
|---|---|---|
| **Prior or Ideal Condition** | **Present Condition** | **Difference** |
| Water Quality and Hydrology Group (ESH-18) serves as a oversight/support organization to assist line management in Waste Stream Corrections Project. | ESH-18 assumes line responsibility for Waste Stream Corrections Project. | Support organization takes responsibility of line function for project management. |
| Architect/Engineer provides complete design package. | Only preliminary designs are provided in accordance with the contract. | Detailed technical specifications are not provided. |
| Project design and ES&H reviews are performed by appropriate Groups to ensure adequate review and the safety and health of employees. | ESH-18 assumes design role and removes ES&H review from task. | Design and ES&H reviews were not performed. |
| Construction packages are approved by Facilities Project Delivery Group (FSS-6). | ESH-18 approved work packages. | Established review process is bypassed. |
| Experienced pipe fitter oversees project. | Acting pipefitter oversees project. | Possible lack of experience as a foreman. |
| A preliminary hazard analysis is performed on all work. | No preliminary hazard analysis was performed on maintenance task. | Hazards associated with the work being performed are not identified. No review of as-built drawings. No excavation permit. No underground utility survey. |
| Project modifications are approved based on engineering specifications and design. | Project modifications were approved without consideration of engineering designs or recognition of hazards. | Project modifications were approved without a technical basis. |
| Sump location is placed in a non-hazardous designed location. | Sump location was placed above a 13.2 kV electrical line. | Lack of design allowed sump location to be placed above 13.2 kV electrical line. |
| Facility managers are aware of and authorize all work in facility. | Facility Management Unit (FMU) program is not being implemented, and confusion exists with roles and responsibilities. | Facility managers are not aware of work being performed. |
| Crafts personnel are trained to recognize potential hazards. | There is no formal training for electrical hazard recognition. | Training to recognize potential hazards did not occur. |

### 3.1.5 Accident Scene Preservation

#### 3.1.5.1 Accident Scene

*Restoration of electrical power took precedence over accident scene preservation.*

The accident scene was not preserved until the Board arrived on site because of the assessment that restoration of normal electrical service to Building TA-21-209 was time-critical. This judgment was based on plant conditions immediately after the accident, as opposed to a safety-related requirement stated in the facility operations safety analysis report or in an emergency recovery plan associated with the loss of power for Building TA-21-209.

#### 3.1.5.2 Evidence Chain of Custody

*The chain of custody for evidence was not maintained.*

The physical evidence pertinent to the accident was not gathered, inventoried, or controlled in a disciplined, documented manner.

#### 3.1.5.3 Meteorological Conditions

At 9:30 a.m., on the morning of the accident, the outside temperature was 36 degrees F. The relative humidity was 70 percent. The wind speed was 6.4 miles per hour, out of the east southeast, and the sky was clear. No precipitation had been recorded in the previous hour.

The Board concluded that the meteorological conditions at the time of the accident did not influence the actions taken by the workers or responders and, therefore, did not contribute to the accident.

### 3.1.6 Concrete and Tuff Examinations

*Tests on floor and ground materials indicate that the accident victim might not have been able to tell by "feel" that he was hitting the conduit.*

The Board requested that JCI perform compressive strength tests on the concrete surrounding the 13.2 kV electrical cable conduit, and representative samples of undisturbed tuff material from the excavation. The preparation of the test specimen and the physical testing of the prepared samples was witnessed by a Technical Advisor to the Board. The results of the tests are contained in JCI Document EMT D 96.095, "Concrete and Tuff Examinations." The report is included in Appendix G-2.

The tests show that the average compressive strength of the concrete was approximately 1,130 pounds per square inch (psi), which is relatively low for concrete. Typical compressive strength values for concrete, based on the application, range from 2,500 psi to 4,000 psi. The average compressive strength for the tuff was 320 psi.

The Board concluded that, while there was a significant difference in the compressive strength values of the concrete and tuff (1,130 vs 320), the difference could easily have been overlooked by the JCI mason tenders performing the excavation work because of the quantity of rubble and dust in the excavation.

### 3.1.7 Integrated Accident Event Matrix

*The Board developed an integrated accident event matrix.*

An integrated accident event matrix was developed based on interview transcripts, emergency communication records, utility records, and observations by Board members. The event sequence depicted in the matrix allowed the Board to identify and understand the actions taken by the workers, the interactions between the workers prior to the accident, and the interactions between the emergency responders and the victim after the accident occurred. The matrix is included in Appendix G-3.

## 3.2 CONDUCT OF OPERATIONS

### 3.2.1 Work Planning, Authorization, and Control

#### 3.2.1.1 Work Planning

#### ES&H Questionnaire Process

*The Laboratory uses a questionnaire that is sent to all new project initiators to identify projects that may pose environment, safety, and health risks.*

LANL policies and procedures require all new projects to be assessed for ES&H concerns. LANL Administrative Requirement 1-10, "Environment, Safety, and Health Questionnaire," August 30, 1991, identifies projects requiring an ES&H Questionnaire, discusses completion of forms, defines the review process, and mandates line management's resolution of ES&H concerns arising from the subject matter expert review. Elements of the Facility Risk Management Group (ESH-3) are responsible for gathering and distributing the information to support the ES&H Questionnaire.

In 1992, the LANL Associate Director for Operations designated the ESH Division as the Office of primary responsibility for the ES&H Questionnaire process. In November 1993, a Quality Improvement Team was appointed by the ESH Division Director to focus on improvements to the ES&H Questionnaire process. In December 1993, the Quality Improvement Team issued a report on the Questionnaire process, "Environment, Safety, and Health Questionnaire—Continuous Quality Improvement Team Report," and made recommendations for improving the overall process, including improvements in methods for data gathering and turnaround times for reviews by subject matter experts.

Initiators of new projects at LANL are required to complete the Administrative Requirement 1-10 Questionnaire for projects that may include new construction and building modifications, ground breaking and soil disturbance, or involve high energy sources. Administrative Requirement 1-10 requires Facility Risk Management (ESH-3) to distribute the completed questionnaire to the ES&H Questionnaire Committee members for reviews related to siting, occupational safety, fire protection, industrial hygiene, and health physics. The Committee, made up of subject matter experts, is also required to

determine whether Federal, state, or local statutes and regulations apply to the project.

If ES&H concerns are identified by the ES&H Questionnaire Committee, Administrative Requirement 1-10 requires ESH-3 to send the project initiator a listing of such concerns, and the appropriate personnel to be contacted for each concern. Administrative Requirement 1-10 requires project initiators to then contact the personnel listed, and develop and maintain a permanent file that documents the resolution of the concerns raised by the ES&H Questionnaire Committee. The permanent file is required to meet DOE audit requirements as contained in Administrative Requirement 1-5, "Environment, Safety, and Health Audits and Appraisals."

*A project summary process was developed to supplement the questionnaire process.*

In lieu of the formal ES&H Questionnaire process implemented under Administrative Requirement 1-10, ESH-3 now utilizes the ESH Identification process, which involves face-to-face interviews with project initiators to obtain ES&H-related project data. Data outputs, namely ESH Identification Project Summaries, are distributed to subject matter experts for review, and comments are returned to ESH-3. ESH-3 then forwards comments to the project initiator for planning purposes and to address any ES&H impacts that have been identified during the subject matter experts review process. The ESH Identification process is ad hoc, was never formally approved by LANL senior management, and is inconsistent with the management-approved Administrative Requirement 1-10 procedure.

The Waste Stream Corrections Project was initiated through the ESH Identification process. The Waste Stream Corrections Project Summary, ESH ID #95-0188, dated August 24, 1995, characterized the Waste Stream Corrections Project as a construction-related activity, and identified potential safety hazards, including explosive safety, industrial hygiene, operational safety, and radiological safety. A copy of the Waste Stream Corrections ESH Identification is included in Appendix G-4.

*For this project, initial reviews identified some issues that remained unresolved.*

The Board confirmed statements by Water Quality and Hydrology Group (ESH-18) project managers that attempts were made to resolve subject matter expert comments via telephone and memoranda communications. However, they did not maintain a permanent file for subject matter expert comment resolution and, as a result, substantive ES&H comments from one subject matter expert with direct Waste Stream Corrections Project concerns were not resolved prior to initiation of the Waste Stream Corrections Project.

### 3.2.1.2 Work Authorization

A service request was initiated for the work to be performed under the Waste Stream Corrections Project. The stated purpose of the service request for the Waste Stream Corrections Project was to "Provide

labor and materials to perform modifications to drain systems within Laboratory buildings as directed by ESH-18 and to correct environmental code deficiencies as recommended by the waste stream surveys. Schedules and manpower will be requested by the account controller as needed."

*Technical and management review processes did not fully address all safety information and potential hazards.*

Both the service request (September 21, 1995) and the ESH-3 technical review (September 28, 1995) performed as part of the ESH Identification process were completed prior to completion of subject matter expert reviews of the ESH Identification Project Summary (November 13, 1995), where subject matter experts' inputs regarding safety aspects of the project could have been utilized. The ESH-3 technical review identified only noise as a hazard. The review did not require excavation permits or other similar approvals, and it did not require "as-built drawings" to be developed for the project. A copy of the ESH-3 technical review of the Waste Stream Corrections Project is included in Appendix G-5.

Following the technical review by ESH-3, there is no evidence that the Waste Stream Corrections ESH Identification Project Summary was referenced to obtain additional safety information regarding potential hazards. Consequently, the Project Summary was not used as a living document for preparing, evaluating, and controlling the Waste Stream Corrections Project at any level.

On October 5, 1995, JCI transmitted a "Request for Davis-Bacon Determination" for the Waste Stream Corrections Project to the LAAO Determining Official. The transmittal stated in part, "Perform modifications to original waste systems within the Laboratory to correct environmental code deficiencies. This determination will be used on all Facility Management Unit Standing Work Orders for this work." The LAAO Davis-Bacon Determining Official returned the Standing Work Order to JCI on October 10, 1995, with a determination that the work was "uncovered."

During Board interviews, the LAAO Determining Official stated that, based upon the information provided by JCI in their October 5, 1995, submittal, the work was uncovered, and therefore would be considered a maintenance activity, not a construction activity. During interviews with the Board, the Determining Official stated that Standing Work Orders may only include maintenance activities. In addition, the Determining Official stated that the information provided by JCI was insufficient to determine the content of the proposed work and, if the Waste Stream Corrections Project had been properly described, his determination would have been the work was "covered" (as construction).

*The project was performed as a series of small jobs.*

In a November 1, 1995, memorandum to Distribution, "Update of ESH ID #95-0188, Waste Stream Corrections," ESH-3 stated that attempts were made to address the entire Waste Stream Corrections

Project on a Laboratory-wide scale. Because of this wide-scale approach, several reviewers (subject matter experts) were concerned about the lack of detail contained in the ESH-3 data (ESH Identification Project Summary). The memorandum presented the ESH-18 plans for organizing the project to address subject matter expert concerns, including:

- Small job tickets would be used for corrections costing less than $2,000, with JCI performing the work.

- Standing work orders, work tickets, and service requests would be used for corrections inside buildings, excluding excavations of any kind, with the work being conducted by JCI and managed by Facilities Operations and Maintenance Services (FSS-9).

- The Facilities Project Delivery Group (FSS-6) would manage corrections involving major cost projects, and this would consist of all inside or outside excavations in either dirt or concrete. Plans called for the work to be done by Basic Ordering Agreement contractors, and it would involve a total of approximately 15 projects. ESH-18 later updated this information to indicate that these corrections would utilize JCI rather than Basic Order Agreement contractors for the work managed by FSS-6.

- ESH-18 would be responsible for addressing any administrative corrections to permits.

The memorandum further noted that "Small job tickets, service requests, and work tickets authorizing work by JCI are currently reviewed by ESH-3 or a Facility Management team. If identified risks or hazards cannot be adequately addressed on the ES&H Review page of the small job ticket or service request, the ESH Identification process can be initiated by ESH-3, the facility manager, or the project contact."

*Commitments regarding worker safety and implementation of project and configuration management programs were not fulfilled.*

The Board determined that commitments made by ESH-18 in the memorandum were never fully implemented for the Waste Stream Corrections Project. As a result, the processes outlined in the commitments that were necessary to ensure an adequate level of worker safety were never fulfilled. The implementation of project and configuration management programs never occurred.

For the Waste Stream Corrections Project, ESH-18 developed its own tailored small job ticket/work ticket form entitled "FSS-9 Work Order," which had been in use since September 13, 1995, and contained each Waste Stream Corrections subtask to be accomplished by JCI. The ESH-18 tailored form included information relevant to the project, and focused predominantly on tracking project costs and NPDES permit compliance. However, the tailored form did not require ESH-3 to review and approve the proposed work activity with

regard to ES&H implications. As a result, no ESH-3 reviews were conducted for the work to be accomplished under specific subtasks assigned to JCI.

*No preliminary hazard analyses were conducted.*

In addition to the ESH-3 reviews required as part of the small job ticket/work ticket review and approval process, the JCI ES&H Manual, Procedure 12-21-112, "Hazard Assessment Requirements," November 7, 1995, paragraph 5(b), requires JCI project supervisors to conduct a preliminary hazard analysis prior to any work conducted by JCI personnel, including maintenance. No preliminary hazard analyses were conducted for any phase of the Waste Stream Corrections Project, nor were any conducted for any JCI maintenance activity in either organization at any time.

Board interviews and reviews of archived records indicate that ESH-18 issued work packages to FSS-9 for work on Waste Stream Corrections subtasks before the subject matter experts completed their reviews of the WSC ES&H ID Project Summary. The ESH-3 memorandum of November 13, 1995, "Project Summary Closure Letter, ESH ID #95-0188," was used as a baseline to determine completion of the ESH Identification process. Records indicate that between September 11, 1995, and November 8, 1995, ESH-18 issued 16 Waste Stream Corrections Project subtasks for work without detailed work packages. Some of the work packages involved hazards associated with plumbing and electrical modifications and installations.

The normal work authorization and control process is depicted in the flow diagram included as Figure 3-3. The work authorization and control process utilized for the Waste Stream Corrections Project is depicted in the flow diagram included as Figure 3-4.

### 3.2.1.3 Work Control

*The Building Manager did not receive specific information regarding project scope and time frame.*

ESH-18 provided the Board with information indicating that on December 6, 1995, project engineers from ESH-18 and SFE were in Building TA-21-209 to scope portions of the Waste Stream Corrections Project. Their written statements indicated that they were approached by the Building Manager, and they informed him of their activities. Based upon their statements, the information provided to the Building Manager was non-specific regarding the Waste Stream Corrections Project. It did not include discussions of the project's scope or the possible time frame for the modifications to take place in Building TA-21-209. Building TA-21-209 facility management personnel have stated that they recall no contact by either ESH-18 or SFE regarding the work in the basement of Building TA-21-209.

On December 20, 1995, Waste Stream Corrections Project FMU70-009, one of 15 subtasks under Facility Management Unit 70, was released for work in the basement of Building TA-21-209, with a

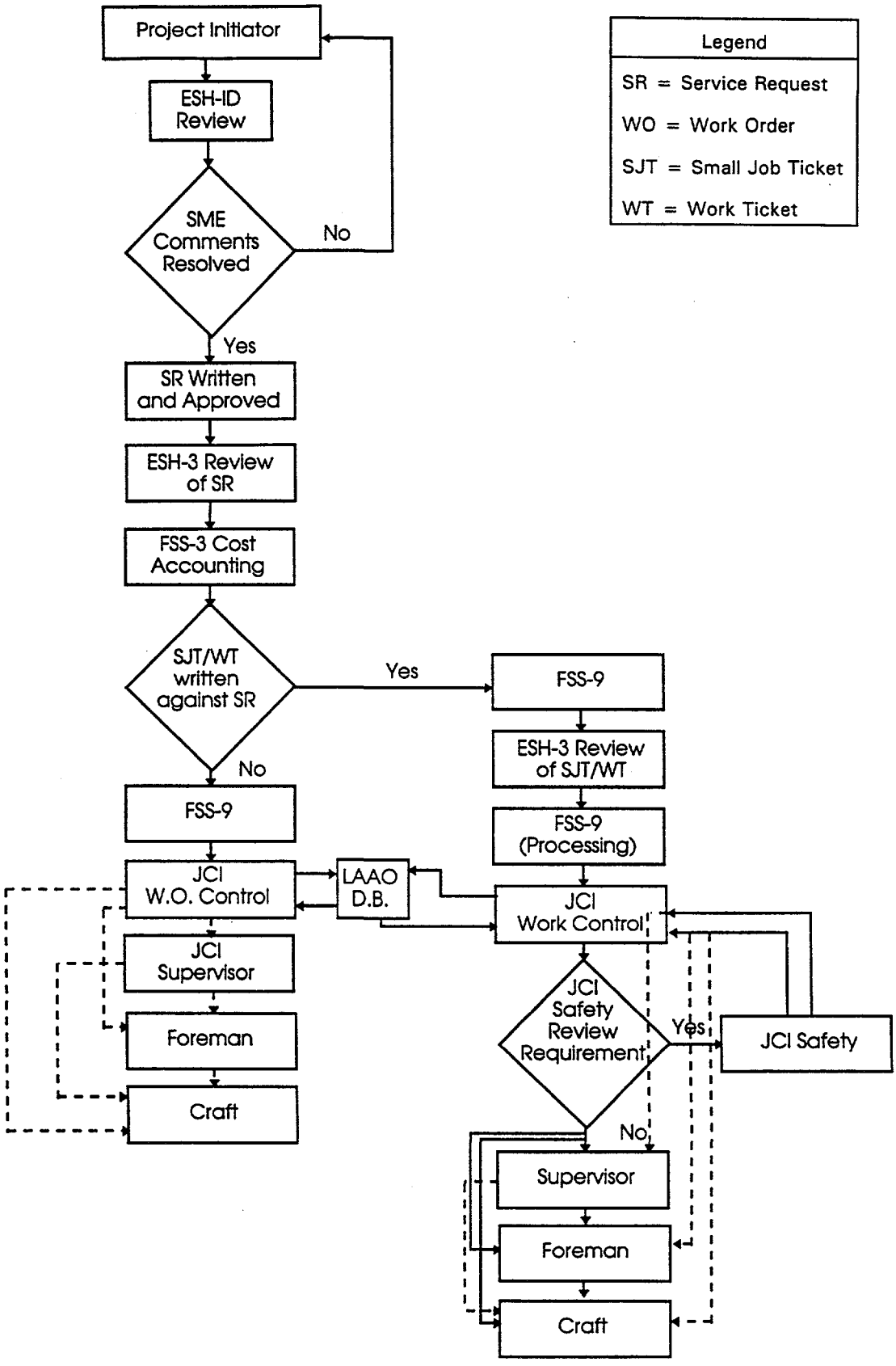



**Figure 3-3. Work Control Process as Determined by the Board**

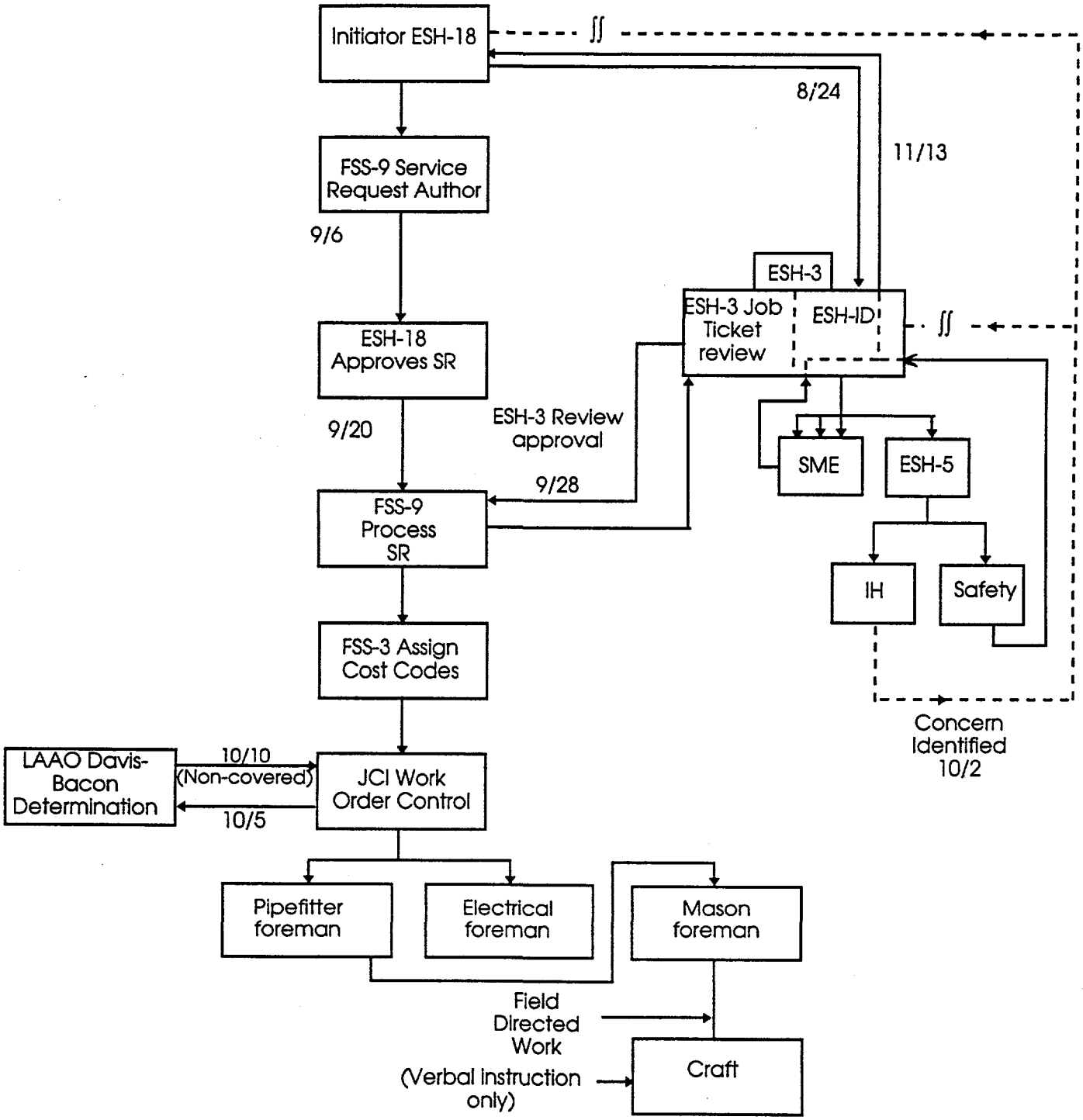



**Figure 3-4. Work Authorization and Control for the Waste Stream Corrections Project**

target completion date of January 13, 1996. Concurrent with the release of the project for work, JCI pipefitters and masons scoped the job and laid out sites where excavations would be required to install sumps.

*A lack of detailed design drawings allowed the excavation site to be placed directly over the electrical line.*

The planned location of one sump appearing on preliminary design drawings interfered with a door in the basement of Building TA-21-209. One JCI pipefitter contacted an ESH-18 representative to request approval for a deviation to relocate the sump. The ESH-18 representative contacted the SFE representative responsible for that Waste Stream Corrections subtask, who approved the change by telephone. The approval to deviate from the preliminary design drawings, which had been informally approved by ESH-18, was documented by JCI on the FSS-9 Work Order Form. ESH-18 and SFE personnel believed they were providing a deviation approval to relocate the sump above grade. This approved deviation, however, placed the sump location directly over an energized 13.2 kV electrical cable. No other LANL ES&H or engineering organizations were contacted or involved in the decision processes for this deviation. The work in Building TA-21-209 was similar in nature to work being conducted at Fire Station #1, where sump relocation deviations were also requested. The Board has identified confusion among individuals and Groups involved in the Waste Stream Corrections Project as to which deviations were actually being approved. This confusion relates to the informality established by ESH-18 for the approval of deviations, the informal communications and deviation approvals by telephone, the failure to rely on a paper trail to document the deviation approval process, and a general failure to field-verify deviation requests prior to approval.

### 3.2.2 Procedures

*Laboratory Director's Policies and Program Requirements Documents provide guidance but do not assure that expectations are met sitewide.*

Director's Policy 102, "Formality of Operations," defines the basic requirements for establishing formality in Laboratory operations. It states that the Laboratory will establish programs and procedures to control conduct of operations, and Laboratory personnel will be trained on the use of its procedures. It also states that management shall require all personnel to use applicable procedures and shall maintain oversight. The Board found multiple cases where the LANL management systems have failed to comply with this basic operating philosophy. The Director's Policies and Program Requirements Documents serve as guiding instructions, but fail to provide any assurance that these expectations are actually implemented on a sitewide basis.

*There are no Laboratory-wide procedures implementing Laboratory requirements for configuration management or conduct of operations.*

There are no Laboratory-wide operating procedures that implement the Program Requirements Documents for either configuration management or conduct of operations (a subset of which is work planning and control), and there is no plan to develop such procedures. Instead, Laboratory efforts have been focused on compliance activities,

"necessary and sufficient" programs, and the Integrated Standards Based Management System. Development of Laboratory-wide operating procedures is viewed as a compliance-based activity by the Laboratory, and the Laboratory is instead focusing on developing the new performance-based systems. With the development of the Integrated Standards Based Management System program and previous efforts, resources have been diverted from the existing procedures program. The result is that no Laboratory-wide implementing procedures for the conduct of operations and configuration management Program Requirements Documents have been issued.

The existence of the Director's Policies and Program Requirements Documents does not assure that these programs are actually implemented at the facility level. By LANL management's inaction to issue any sitewide operating procedures, management has effectively allowed the requirements and expectations identified in the Director's Policies to remain in the book instead of implementing them in the facilities.

*Administrative Requirements are not up to date and are not uniformly implemented.*

Problems were also noted concerning the Administrative Requirements. The Administrative Requirements do not reflect the reorganization of the Laboratory, which took place nearly three years ago. Because of this, the responsibilities and authorities of the various organizations are in question. LANL management has allowed Laboratory personnel to ignore or change the requirements without revising the applicable documented procedures (e.g., ESH-3 did not follow Administrative Requirement 1-10; ESH-18 began work prior to receiving an ESH final review; ESH-18, in coordination with Operations and Maintenance Services and JCI, developed a tailored work control form in lieu of approved work tickets/small job tickets).

Discrepancies involving the implementation of several Administrative Requirements, as well as the use of Standing Work Orders, were examined and analyzed by the Board. Administrative Requirement 1-10, "Environment, Safety, and Health Questionnaire," requires an assessment of all new projects for ES&H concerns. It also describes the process to be used to complete the forms. Personnel interviews and a review of the process indicated that ESH-3 has elected to utilize a new, informal process and procedures for ES&H hazard identification and forgo the use of Administrative Requirement 1-10. ESH-3 management has recognized this deviation from the defined, documented Administrative Requirement process and has allowed this condition to continue without requiring a formal procedure revision. A significant deficiency in the new informal procedures is that it does not address the actions to resolve the ES&H comments and concerns of subject matter experts. Failure of management to require its staff to use formal, approved procedures contributed to the incomplete closure of identified safety concerns with the Waste Stream Corrections Project.

An ES&H review at the early stage in the Waste Stream Corrections Project was very limited. The detailed facility and tasks hazards were not adequately identified in Waste Stream Corrections Project Summaries at this stage. Yet for a Standing Work Order, the ES&H reviews are based on the information provided in these project summaries. Further, the broad nature of the Standing Work Order format does not permit the detailed work activities to be described. Because of this process, ES&H reviews are being completed without adequate understanding of the specific hazards associated with the jobs.

Administrative Requirement 1-11, "Work Request Review," is the primary document that defines the LANL work control process. Administrative Requirement 1-11 provides the definition of a Standing Work Order. The purpose of Standing Work Orders is to allow routine activities to be authorized, funded, and performed expeditiously. Such activities include snow removal, lubrication, and relamping. Standing Work Orders were not designed for performance of large maintenance tasks, facility modifications, or construction activities. A Standing Work Order is defined as a written work request for a defined period of time, for a specific scope, and that can be accomplished without a work ticket. Standing Work Orders are presently excluded from the ESH review requirements. The Board considers the use of Standing Work Orders to capture the complex, non-repetitive work covered in the Waste Stream Corrections Project as exceeding the intended use.

*The Board disagrees with the site's decision to treat the excavation work as a routine, non-complex task with minimal review requirements.*

Personnel interviews and a review of other Standing Work Orders have indicated that Standing Work Orders are routinely used at LANL to accomplish complex activities. It is now routine for small job tickets and work tickets to be written as a Standing Work Order. Because Standing Work Orders are being used to complete more complex tasks, the ESH Identification process is being used improperly to capture some of the potential ES&H concerns that may result from the activity. The use of Standing Work Orders appears to be excessive and may circumvent the purposes of adequate ES&H reviews.

There are 1,028 Standing Work Orders currently in effect at LANL. These Standing Work Orders give blanket approval for all types of facility maintenance and modification activities. A review of the active Standing Work Orders indicate that they have been written for: (1) unspecified maintenance and modification actions for both nuclear and non-nuclear facilities; (2) security system upgrades; (3) asbestos abatement program work (a job in which a 480 V line was intentionally cut without using lockout/tagout); (4) electrical breaker maintenance; (5) correcting electrical deficiencies; and (6) exhaust stack monitoring system repairs and upgrades. Based on the lack of detail contained in the Standing Work Order description and the complexity of the task assigned to the Waste Stream Corrections Standing Work Order, a review of all Standing Work Orders is warranted.

Most of the major DOE sites (including Savannah River, Rocky Flats, and Hanford) have shifted away from using Standing Work Orders. The main reason for this shift is that the job conditions routinely do not meet the descriptions as annotated in the Standing Work Order. This results in either stop-work actions or unacceptable work conditions. Therefore, the sites have elected to use unique work orders for even what appear to be "routine" jobs.

*Deviation from procedures appears to be an accepted practice at the site.*

The only forms identified in Administrative Requirement 1-11 to be used for the work request reviews are the small job ticket/work ticket (Form 1336), the service request (Form 1337), and the service request supplement (Form 1338). There is no ESH-3 procedure that describes the method to be used to review these forms. Fabrication and utilization of alternate forms is not recognized by the Administrative Requirement. Several organizations (ESH-18, FSS-6, FSS-9, and JCI) were involved in the discussions about the generation of a new form, but none of them recognized that this activity was outside the approved work control process. There is an apparent attitude, as revealed by the numerous procedures violations, that deviation from procedures is an accepted practice at LANL. Director's Policy 102, "Formality of Operations," requires that personnel operate by approved procedures and, if necessary, formally revise those procedures. Acceptance of this philosophy by LANL personnel was not observed by the Board.

*The site's determination that excavation permits are not needed for interior work led to incomplete recognition of hazards.*

Although LANL Administrative Requirement 1-12 clearly requires that excavation permits be obtained prior to any ground-breaking activities inside or outside buildings, a longstanding and widespread interpretation generally limits requests for excavation and penetration permits to those areas located outside buildings. Board interviews with both LANL and JCI personnel found that the interpretation was common in both organizations, and knowledge of the specific requirements of Administrative Requirement 1-12 appeared limited. As a result of this incorrect interpretation, both LANL and JCI personnel failed to take appropriate measures to: (1) determine the locations of dangerous underground facilities, (2) prevent the exposure of employees to hazards associated with those facilities, and (3) conduct work in a manner designed to avoid damage to dangerous facilities, prior to the electrical shock accident at Building TA-21-209, as required by 29 CFR 1926.956(c).

29 CFR 1926.651(b) requires the employer to determine the estimated location of utility installations such as sewer, telephone, fuel, electric, and water lines, or any other underground installations prior to opening an excavation. Although the Board identified several instances where JCI and LANL personnel had questioned the need for an excavation permit for work in Building TA-21-209, it does not appear that Administrative Requirement 1-12 was consulted for guidance. Additionally, pre-accident telephone inquiries from the field to JCI organizations were documented and focused on the need for excavation permits. Witness statements indicate that callers were verbally

informed that an excavation permit was not required for excavation activity inside buildings. As a result, LANL and JCI personnel failed to take appropriate action to determine whether utilities were present in the vicinity of the excavation in Building TA-21-209 where the electrical accident occurred.

*Other issues involve utility location surveys, safety reviews, and use of design drawings.*

Administrative Requirement 1-12, "Excavation and Fill Permit Review," details the procedures necessary to obtain and complete the ES&H review of all excavation/fill permits. It defines excavation as "any ground breaking with power equipment or hand tools." It also defines an excavation permit as "Permit required to begin any excavation (for example, exploratory boring, new facility construction, utility repair or installation, or **penetration of slabs on grade inside buildings**) or fill project on DOE property." It also describes the review process to be used in approving excavation permits. It states that an excavation permit is obtained from the Utility Services branch of JCI.

The actions that are performed by JCI are governed by Standard Practice Instruction 70-10-001, which involves performing a utility survey. However, there is no specific requirement for any review of the engineering drawings associated with the facility or work location, or for any walkdown of the facility to physically observe piping and electrical penetrations. Concurrent with the JCI utility survey, the excavation permit request is to be faxed to ESH-3 in order to undergo the required ES&H review.

Under Administrative Requirement 1-12, ESH-3 is responsible for distributing the permit through the "appropriate ES&H Groups." However, this distribution is not defined and is left up to the judgment of the ESH-3 staff. Administrative Requirement 1-12 states that the purpose of the ES&H review is to "ensure the proposed activity does not infringe on areas regulated or protected by the EPA or conflict with DOE orders or Federal and state statutes and regulations." While this statement does not preclude the use of inside excavation permits, it does indicate that the ES&H review process is focused toward the impacts that the excavation may have on outside areas. At the completion of the ES&H review, the permit is then returned to JCI. Administrative Requirement 1-12 states that "Upon completion of the review, the support services contractor returns the permit, either with comments necessary to proceed with the project, or with a disapproval." This procedure fails to provide a logical flow for completing reviews.

Procedures governing the use of the JCI excavation permit review process are: (1) JCI ES&H Manual Procedure #12-22-006, "Excavations," Rev. 3, dated July 27, 1995; and (2) JCI Standard Practice Instruction, 80-10-011, Excavation/Trenching: Protective Systems and Safety." While JCI ES&H Manual Procedure #12-22-006 does not prohibit excavation permits for inside work, all references made to

work conditions are associated with outside excavation. The procedure does not specifically require excavation permits for masonry cutting of facility structures when it occurs inside. While the source of the widespread misconception that excavation permits are not required for inside work was not identified, the existence of this widespread belief was confirmed by the Board. Definitive improvements are needed in the methods that should be utilized to detect buried utilities, and clarification of the excavation permit policy is warranted.

Administrative Requirement 1-14, "ES&H Facility Design Review," specifies the ES&H facility design review procedures. The design review process described in Administrative Requirement 1-14 was not used to evaluate the quality of facility modifications being made by the Waste Stream Corrections Project. Failure to perform this review was associated with the fact that the Waste Stream Corrections Project was improperly classified as a maintenance activity, instead of a construction activity.

*The contractor's safety review process is not documented.*

JCI Standard Practice Instruction 12-02-010, "Work Order Review," describes the process that the JCI Safety Group must use to review work orders. This process establishes a single point of contact in JCI (Work Order Review Coordinator) who is responsible for ensuring that all work receives an adequate ES&H review. The process described in Standard Practice Instruction 12-02-010 is not being accomplished. Instead, different work packages are receiving different levels of review. For instance, all construction packages are sent to JCI Safety for review; however, none of the LANL Standing Work Orders are sent to JCI Safety. There is no procedure describing the logical flow of all work packages through the JCI system. This has resulted in an undocumented JCI safety review process. This also illustrates another case that is recognized by management that personnel are not complying with established procedures.

### 3.2.2.1 Los Alamos National Laboratory's Policy for Disseminating Sitewide Stop-Work Orders

*Communication of sitewide stop-work orders is not effective.*

The Board became aware of cases in which a stop-work order issued by the Laboratory following the accident was not being observed. Some penetration work that had not undergone the specified ES&H review was still being performed. In addition, the LAAO Facility Representatives found multiple cases in which JCI workers were not aware of the stop-work order that was in effect.

Director's Policy 116 provides information associated with stop-work orders and restart actions. However, it does not provide any detailed information on how sitewide stop-work orders are communicated to all employees. The method that LANL management used to communicate the stop-work order following the accident at Building TA-21-209 was ineffective. This process utilized a master management e-mail system. This is an open-loop system. The stop-work order was sent to all

Group leaders and above. There was no response required or verification that the order was received. It is the opinion of the Board that communication of vital information should require a formal confirmation that the order was received in the appropriate personnel. The Board also found that the Director's Policy 116 requirement to log this stop-work order in the Division Leader's office was not followed by any of the four divisions that were checked.

*The interface between various organizations with work control responsibilities is not well defined.*

The work control process at LANL is governed by multiple procedures. The interface among the different organizations (requestor; Facilities, Security, and Safeguards; and JCI) is not well defined. ES&H personnel incorrectly assumed that by inserting the comment "SSS-safety" in the ES&H review section of the Standing Work Order, JCI Safety would perform a task-level ES&H review. The responsibilities of the different organizations is also not well defined. The LANL work control process is complicated and detached. Because of a lack of process description and ineffective communication among the different organizations, these assumptions and expectations for ES&H reviews were not properly relayed. A single, comprehensive human-engineered process that defines the flow and responsibilities of each organization in LANL and JCI should be developed.

### 3.2.3 Configuration Management

#### 3.2.3.1 Configuration Management Policy

*Configuration management is an optional process at the Laboratory.*

The LANL configuration management program represents an optional process. There is no document describing the criteria for identifying designated facilities. The Program Requirements Document for configuration management also mentions the application of a graded approach. The Tritium Science Engineering Group's Review Board Procedure (dated March 28, 1995) describes a configuration management plan for its facilities. If used properly, this plan should maintain control of the facility configuration. However, the plan was not used for any of the work associated with the Waste Stream Corrections Project modifications.

#### 3.2.3.2 Design

*Only preliminary design drawings were prepared for the work that led to the accident.*

Interviews and memoranda confirm that the documents provided by SFE were preliminary designs. The drawings had no dimensions or approvals. While there was no specific tasking of SFE to develop and submit work packages for the jobs, "Scope of Work" documents were submitted to ESH-18. These scope-of-work documents were attached directly to the ESH-18-generated work order forms. The resulting work packages were reviewed by the ESH-18 technical reviewer and passed to JCI through FSS-9. The ESH-18 review and subsequent field validations focused on whether the modifications corrected the identified WSC deficiency, and did not provide an engineering design review as required by Administrative Requirement 1-14, "ESH Facility

Design Review," or Program Requirements Document 110-01.0, "Quality Assurance Management Plan." FSS-9 only passed the information to JCI and did not perform an engineering review to determine the adequacy of the information provided.

When the work packages were received by JCI via FSS-9, they were considered "approved for construction." Because this construction work was being accomplished by a maintenance process, there was no mechanism in place to capture the facility design modifications that were being done to this Category 3 nuclear facility. There was no plan within ESH-18, FSS-9, JCI, or SFE to update the as-built drawings for this facility. The result was a loss of configuration control. Modifications to facility systems were not being captured or analyzed against the existing safety analysis report or other system design documents.

Because these designs were considered preliminary by SFE, no specific construction information was provided. SFE has stated that its piping design work was done to support plumbing code. However, there was no assurance that any of the sump pump installations would have complied with electrical, plumbing, or uniform building codes, because of the lack of specification associated with materials and installation.

Based on testimony and the review of documents, the Board has determined that expediency was the primary driver for shifting the work from FSS-6 to FSS-9. Work could be accomplished through FSS-9 by verbal field direction and would only require hand sketches. The FSS-6 process had a higher degree of formality and would require more elaborate documentation, thus increasing costs and extending completion time. When the decision was made not to utilize FSS-6, ESH-18 assumed the responsibility for performing or ensuring the completion of any design reviews associated with the Waste Stream Corrections Project—an action it was not prepared to perform.

*To save on time and cost, control of the work was shifted to a group that had fewer requirements for formality and documentation.*

## 3.3 ELECTRICAL SAFETY

The Board examined the issue of electrical safety for activities leading up to, during, and following the accident. Analyses of events, procedures (or lack thereof), training, implementation of training on procedures and processes, and interactions of safety activities (either at JCI or LANL) were examined.

### 3.3.1 Electrical Emergency Response Plan

Building TA-21-209 personnel did not have a documented procedure for restoring power by means of temporary generators and defining critical power system needs in the case of unexpected power loss to the building. The determination of where to connect temporary generator

*There were no documented procedures for safely providing temporary power by portable generator.*

power into the facility electrical grid resulted from Group discussions between various LANL and JCI personnel on site immediately after the accident. Critical power systems were verbally defined by Building TA-21-209 personnel on site. These field determinations were made by individuals with several years' experience and knowledge of the building requirements. The power requirements of the building's critical systems were not previously known by any personnel on site or formally documented in an emergency plan or procedure.

*Some safety concerns were noted in how the generator was connected and grounded.*

JCI maintenance personnel delivered the highest capacity temporary generator (350 kilowatts) available to provide temporary electrical power to Building TA-21-209. Welding cables were used to provide power from the temporary generator to the transformer secondary power bus without any site personnel's specific knowledge of the cable's ampacity rating. Cables were introduced into the building through an existing penetration in the west wall (Figure 3-5), draped over existing cable trays (Figure 3-6), and draped over an existing chain link fence up to the transformer secondary load bus without regard for cable damage. Grounding of the generator was accomplished through connection to an existing ground pad adjacent to hydrogen gas cylinders and a nearby sign indicating 'Danger Hydrogen' (Figures 3-7 and 3-8). JCI personnel verified that the building transformer secondary power bus was disconnected from the switchbox, and the 13.2 kV electrical line was isolated from the building transformer and exterior utility pole (Figure 3-9). A proximity meter was used to test for any presence of voltage on the secondary circuit of the building transformer before initializing connection of the temporary generator.

*Emergency power demand requirements were not known.*

JCI maintenance personnel made all connections necessary to provide generator power to Building TA-21-209. Since emergency power demand requirements were not known, the current for initial generator startup was preset at 80 amperes. The generator was then adjusted to meet critical power system requirements. Critical power systems were powered up by energizing one circuit at a time. During routine generator maintenance and refueling, the building system was initially de-energized and re-energized at 80 amperes and then adjusted as necessary to full power requirements. There were no instructions or procedures for operating the generator. This work was accomplished safely by JCI maintenance personnel because of their several years' experience and their knowledge of portable generators.

The Board's primary concerns regarding the 480-volt secondary system re-energization after the accident were:

- Decision makers in the field had no guidance regarding the available fault current on the system or on the main breaker of the generator set.

**Figure 3-5. Electrical Cables Extending From the Mobile Generator Through the Wall to Temporarily Restore Power**


**Figure 3-6. Electrical Cables Draped Over Electrical Utility Trays**

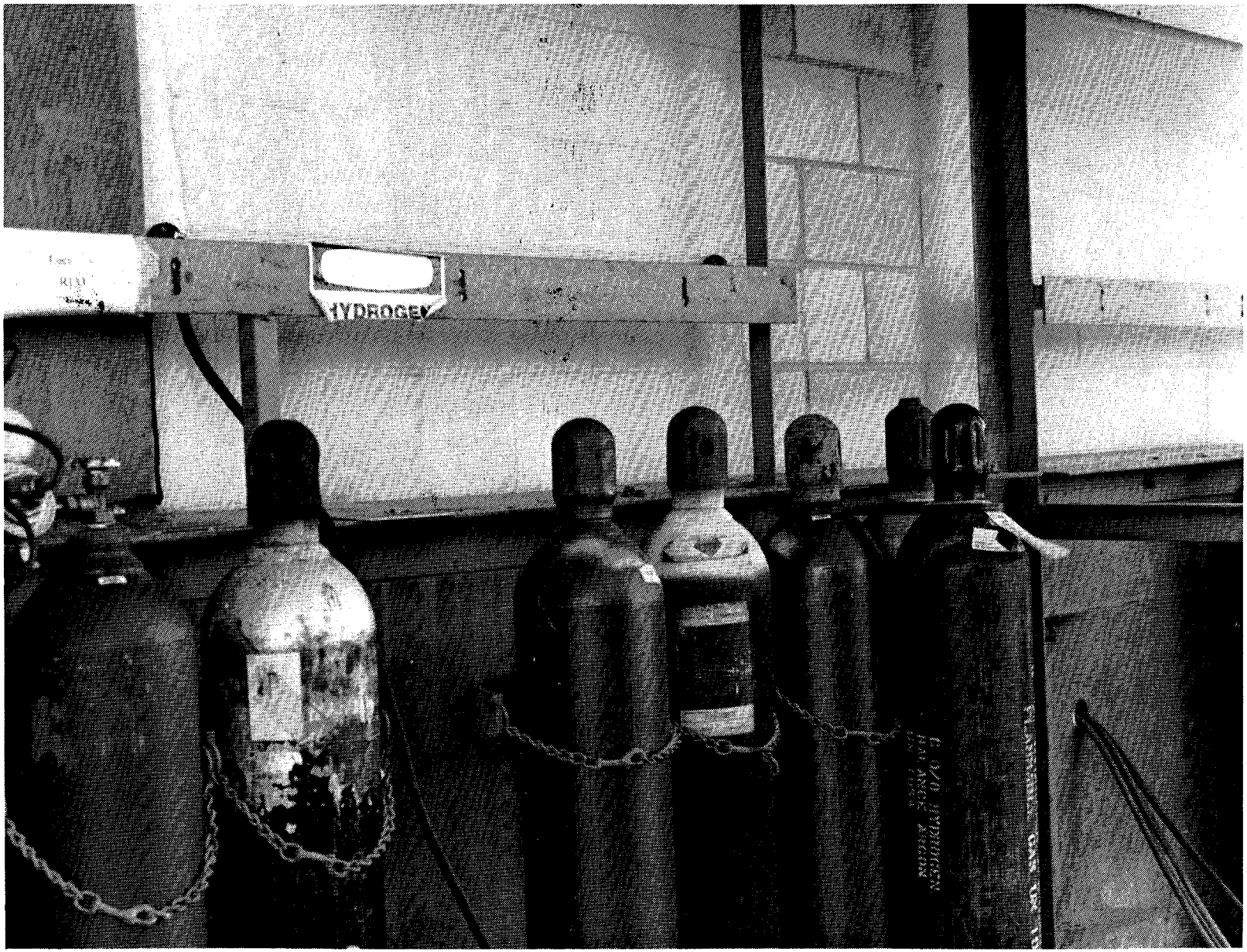



**Figure 3-7. Electrical Cables Grounded Near Hydrogen Bottles and Warning Sign**


**Figure 3-8. Electrical Generator, Cables, and Adjacent Hydrogen Bottles**

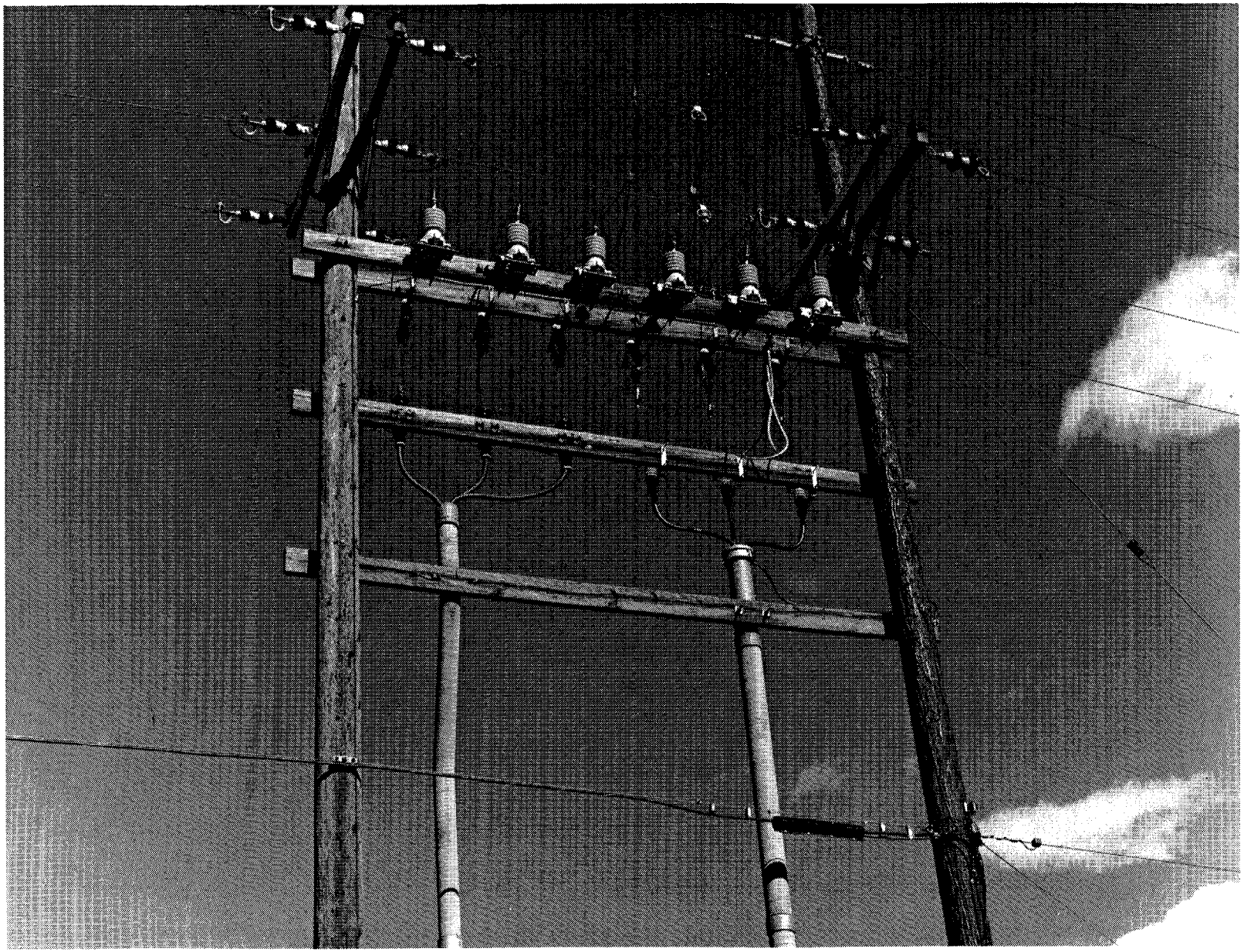


**Figure 3-9. Utility Pole at Which 13.2 kV Primary Power Line was Isolated Following the Accident**

- The handling capacity of the "welding cables" was not known.
- The connection points to supply temporary building power were determined in the field.
- The grounding location for the temporary generator was determined in the field.
- The critical loads for the temporary generator were determined in the field.
- Concern for strict adherence to the National Electrical Code and Occupational Safety and Health Administration (OSHA) standards were given secondary consideration to re-energizing the building.
- The size of the main breaker on the generator was not known. Only its voltage output and its kVA capacity were identified.

While the hazards associated with restoring power were kept at a low level through the experience and knowledge of the JCI and LANL personnel at the site, the capability to assure a higher level of safety while restoring power would have been facilitated by an established emergency power requirements plan. This issue should also be addressed at any other LANL buildings/facilities that may need temporary emergency power to satisfy critical system power requirements. In this particular case, JCI and LANL staff who had intimate knowledge of the building system were available in a short period. This may not always be the case.

*Due to budget cuts, the electrical emergency crew cannot respond promptly to outages during off-shifts.*

The response time for the JCI Utilities Power Control Section (UPCS) was approximately five minutes after notification of the power outage at Building TA-21-209. During an unscheduled outage of the electrical utilities distribution system, the response time for the UPCS is critically important. Timely site evaluation of the system conditions will ensure the best response for dealing with safety, facility, and re-energization. During the Board's investigation, it was discovered that, due to budget cutbacks, response time during non-standard working hours (4:00 p.m. to 7:30 a.m.) is a minimum of one hour due to the absence of a trouble crew on off-shifts. This has been the case for the past six months. This time is critical in controlling and containing hazards associated with the loss of electrical power to LANL buildings.

### 3.3.2 Pre-accident Electrical Safety Issues

*The site lacks a formal, comprehensive electrical safety program.*

The lack of a formal, comprehensive electrical safety program to direct and plan electrical safety at LANL and JCI results in a "fire-fighting" approach to solving electrical safety problems. Beneficial development and utilization of a programmatic planning document allows for the incorporation of purpose; scope; ownership; authorities; interfaces;

accountabilities; training; order, standard, and regulation implementation; and specific procedural documents to further guide the electrical safety process. Both the "DOE Report on the Electrical Safety Task Group" and the "DOE Electrical Safety Guidelines" provide for the development of a comprehensive electrical safety program at each DOE contractor site. The DOE has identified and provided a "Model Electrical Safety Program" and delivered seminars to further assist contractors in developing their own programs. It is the Board's understanding that LANL management began the process of developing an electrical safety program document, but redirected its efforts in dealing with electrical safety issues prior to completing the document. The appraisal report for the "Pilot Oversight Program for Line Environment, Safety and Health Management at Los Alamos National Laboratory," dated January 1996, further identifies the absence of a formal, overall electrical safety program document. Additionally, LANL's Industrial Hygiene and Safety Group (ESH-5) self-assessment effort identified this need in 1993. The LANL memo, dated January 14, 1993, identifying the final approval of Action Plan #4 for the Tiger Team findings (TSA-4) WS.4-3 (H1/C1) Cat. II, indicated "...Establish and Implement an Electrical Standards policy/program..." The required completion date was indicated as March 31, 1993. LANL Administrative Requirement 7-1, "Electrical Safety," is recognized by the Groups responsible for its implementation as "old," "out of compliance," and "needs revision." This policy does not adequately reference the electrical safety program elements that are currently required or being implemented.

*The training provided is insufficient to prevent electrical accidents involving unqualified persons.*

Incorporation of the 29 CFR 1910.333-.335, *Safety-Related Work Practices,* into the manner in which LANL and JCI train "unqualified persons" has not been adequately addressed. While the requirements of this OSHA electrical safety standard are being addressed for "qualified workers," serious electrical accidents are occurring involving "unqualified persons." LANL's self-assessment in January 1993 identified as one of its action needs to "Prepare a written guide detailing specific requirements and practical application of 29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V." There is no record that this guide was prepared, issued, or implemented.

*The lack of an excavation permit allowed the electrical hazard to go unrecognized.*

29 CFR 1926.416(a)(3) directs the employer, prior to work, to "...ascertain by inquiry or direct observation, or by instruments, whether any part of an energized electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool or machine into physical or electrical contact with the electric power circuit. The employer shall post and maintain proper warning signs where such a circuit exists. The employer shall advise employees of the location of such lines, the hazards involved, and the protective measures to be taken." This process would be supported by the JCI excavation permit procedure "Excavations-12-22-006, dated July 27, 1995" and the JCI excavation permit administered by the JCI Utilities Department. An excavation permit for the Waste Stream

Corrections work at Building TA-21-209 was never issued, thus allowing the electrical hazard to go unrecognized. If the as-built drawings for Building TA-21-209 had been reviewed as part of the process for acquiring a permit, the location of underground utilities might have been determined. Appendix G-6 depicts the "as-built" facility drawing available from LANL's Facilities Support Operations Group (FSS-3) archives.

The identification of electrical hazards and the use and appropriate application of personal protective equipment to mitigate known or unknown hazards have been addressed in 29 CFR 1910.331 through .335, 29 CFR 1910.132, 29 CFR 1926.416, and 29 CFR 1910.651. These requirements are very specific in their meaning and intent. The recognition of shock hazards was additionally acknowledged by a JCI safety alert memo, dated March 10, 1992. The Board recognizes significant effort in meeting these requirements for "qualified persons." The applications to "unqualified persons" have not received the same attention. The OSHA standard requirements are not being met. JCI did not comply with this procedure. There is no evidence that the accident victim had ever been trained or certified according to JCI Procedure 12-29-040.

*Corrective actions for electrical safety deficiencies are not always communicated or verified.*

DOE occurrence reporting requirements are derived from DOE Order 5000.3B. The administration of this process at LANL appears to be well planned. However, tracking corrective action completion, and the understanding of what organizations are involved as to ownership and implementation, failed in a particularly significant occurrence at LANL (ALO-LA-LANL-HRL-1994-0004). The importance of this occurrence is directly related to the accident being investigated by the Board. Interaction between LANL and JCI management appears to need significant improvement in both communication and documentation. Verbal confirmations are the normal medium by which corrective action issues are closed. Specific identification of the responsible party did not occur in regard to the accident being investigated. The involvement of electrical safety specialists in dealing with electrical safety corrective actions, as well as the root cause analysis process, would enhance the effectiveness and quality of the occurrence reporting product.

*Safety inspections of maintenance activities are not routinely performed.*

JCI safety engineers responsible for inspection oversight maintenance work at LANL do not have a formal process for scheduling work that requires their inspection. Inspection schedules are based on an informal working agreement between the safety engineers and the maintenance schedulers, leaving the opportunity for work to be missed and safety issues to go unnoticed.

*The drawings used to direct installation of electrical equipment were inadequate.*

The SFE preliminary design drawings for the Waste Stream Corrections Project, which the JCI electricians in the field were to use for installing electrical equipment, did not reflect the requirements of DOE Order 6430.1A. The location of the circuit power source (power panel

and circuit breaker number) was left to the electricians' judgment. The drawing for the Building TA-21-209 work reflected circuit breaker size, conduit size, and conductor size, but did not call out the equipment grounding conductor required by DOE Order 6430.1A. The order requirements exceed the National Electrical Code. This issue is important because of failures of the conduit system to provide an adequate ground path. The drawings simply directed the power to the "closest panel w/space." Decisions must rest with an engineer who has specific knowledge of the electrical system characteristics, in order to safely provide a finished installation.

*Work documentation did not adequately address electrical hazards.*

The recognition of electrical hazards can begin with the use of the appropriate work documentation in the pre-planning stages of a project. The LANL small job ticket or work ticket contains an ES&H review section. However, this section addresses electrical hazards only greater than 480 volts. 29 CFR 1910.333(a)(1) recognizes 50 volts or greater as hazardous, and requires the selection and use of safety-related work practices. The JCI Roads and Grounds Pre-Job Safety Checklist does not address electrical hazards at all. In both documents, electrical hazards are not adequately addressed.

### 3.3.3 Accident Electrical Safety Issues

*The cable conduit did not conform to specifications.*

Fault current at the time of the accident was calculated by JCI Utilities Power Control Section using generally approved methods. It was calculated at approximately 2,600 amperes at 13.2 kV. This value would estimate a worst-case analysis of current exposed to the accident victim at Building TA-21-209 on January 17, 1996. A review of the original construction drawings indicated that according to specifications, the conduit encasing the 13.2 kV electrical cable should have been rigid steel. However, the actual installation was an asphalt-impregnated fiber-based conduit. The steel conduit would have provided an additional barrier of protection against contacting the electrical cable.

*The accident victim was not using electrical personal protective equipment.*

Rubber dielectric gloves were used as electrical personal protective equipment while the accident victim performed concrete cutting work on January 16, 1996, at Building TA-21-209. However, the accident victim did not use these gloves during the jackhammer work on January 17, 1996, at Building TA-21-209. In addition, during the concrete cutting work, no leather protective gloves were worn over the dielectric gloves to prevent damage. JCI ES&H Manual procedure 12-25-008, "Personal Protective Equipment for Electrical Work" (rev. June 17, 1994), under Section 2.0.1 requires that:

- Leather covered rubber gloves be worn by workers to protect from electrical shock

- Rubber gloves be tested in accordance with ANSI, which is indicated to be every nine months.

29 CFR 1910.137 (July 1, 1994) requires rubber insulating gloves to be tested before first issue and every six months thereafter.

The rubber insulating gloves worn by the accident victim while cutting concrete on January 16, 1996, were tested at 20 kV with a test date stamp of October 19, 1992. The JCI ES&H Manual nine-month rubber glove testing requirements was violated by JCI Maintenance. The JCI ES&H Manual 12-25-008 procedure, with regard to the nine-month rubber glove retest intervals, does not comply with the 29 CFR 1910.137 six-month testing interval requirement. In an appraisal report, dated January 1996, of the "Pilot Oversight Program for Line Environment, Safety and Health Management at LANL" (Assessment ID: LANL-PAD-95-01), a potential finding statement regarding JCI SPI 80-10-002 indicates inadequate implementation for periodic testing of rubber insulating gloves.

29 CFR 1926.416 (a)(3) requires that in work areas where the exact location of underground electric powerlines is unknown, employees using jackhammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves. JCI ES&H Manual procedure 12-29-040, "Personal Protective Equipment Training & Certification," describes how employees are to be trained on the use and care of personal protective equipment. JCI Procedure 12-29-040 requires training for "Hands-on Training" of personal protective equipment and "When is Personal Protective Equipment Needed." JCI did not comply with this procedure. There is no evidence that the accident victim had ever been trained or certified according to Procedure 12-29-040. On the project on which the accident occurred, JCI was not in compliance with 29 CFR 1926.416 (a)(3).

### 3.3.4 Post-accident Electrical Safety Issues

*The electrical cable cut during the accident was identifiable by an underground utilities detector.*

On Thursday, January 25, 1996, at approximately 10:00 a.m., an underground utilities locator test was conducted at the accident site at Building TA-21-209. The locator tool used is a Power Line Detector, Model 50/60. The tool operates by detecting magnetic fields produced by current flowing through a live conductor. In previous statements made by those interviewed during the investigation, it was noted that this tool does not perform reliably inside buildings because of "noise" from magnetic fields produced by such things as power lines in walls, rebar in concrete, and interior lamps using power, all of which may cause the instrument to give inaccurate readings.

During the locator test indoors in the basement of Building TA-21-209, noise readings were present. However, when compared to locator tool readings at positions above the 13.2 kV electrical cable, above the

concrete floor, and above exposed earth, it was obvious there was a magnetic field source dominating noise sources. These readings would have raised definite concern as to the existence of the underground power utility cable before excavation.

A second area in the basement of Building TA-21-209 that was marked for excavation was then monitored with the utilities locator tool. There was an operating pump motor and an electrical junction box nearby. High readings were measured by the locator tool, indicating either the existence of an underground utility and/or magnetic field noise generated by the pump motor and electrical junction box.

### 3.3.5 Electrical Safety Policy and Procedure Issues

The JCI Utilities Power Control Section (UPCS) has successfully developed and implemented utility operating instructions (UOI 63-00-180, "Clearances") satisfying JCI, LANL, and industry standards incorporating lockout/tagout requirements.

*After the accident, the cable was appropriately isolated and re-energized.*

On January 17, 1996, following the electrical accident at Building TA-21-209, a JCI lineman isolated the 13.2 kV electrical cable. Clearance instructions require that clearance limits are to be used in conjunction with lock and clearance tags when isolating a circuit above 600 volts, to ensure that the circuit will not re-energize while working on it. Two clearance limits were used to isolate the removal of the 13.2 kV primary cutouts (blades) and circuit breaker. Cutouts were removed, phase lines were grounded, and a clearance limit tag was issued. The circuit breaker at the primary of the Building TA-21-209 transformer was "opened," grounded, locked, and issued a clearance limit tag.

Switching instructions for de-energization and re-energization of the 13.2 kV electrical cable incorporated all required safety procedures, including appropriate use of personal protective equipment by the lineman. Knowledge of applicable utility operating instructions by JCI UPCS line supervisors was evident.

*In violation of procedures, no excavation permit was issued.*

According to JCI ES&H Manual procedure 12-22-006, "Excavations," an approved excavation permit must be obtained and kept on site prior to any excavation work, except for emergencies as provided in JCI Standard Practice Instruction 70-10-001. This procedure was violated because an excavation permit was not issued. This JCI procedure was also violated in previous waste stream characterization projects where excavation permits were not issued and underground utilities were not located. JCI Procedure 12-22-006 and 29 CFR 1926.651 (B) require the identification of buried utilities prior to any form of excavation. JCI Utilities is the party responsible for these identification requirements. JCI Utilities was never contacted to locate buried utilities at Building TA-21-209 prior to the accident.

There is no documentation that Occurrence Report ALO-LA-LANL-HRL-1994-0004 corrective actions were completed and implemented. The occurrence reporting process failed because certifying officials closed out corrective actions based on verbal confirmation. The final evaluation part of the occurrence reporting process did not take place.

*Corrective actions resulting from the occurrence reporting process were improperly closed.*

## 3.4 EMERGENCY MEDICAL RESPONSE

Because the accident victim was having gasping respirations, lay rescuers assumed that he was not in cardiac arrest, even though they were never able to feel a pulse. Gasping respirations probably represented agonal respirations, which are respirations observed in a dying patient, and can continue to occur for several minutes after the heart has stopped.

*The building employees who first responded to the accident may not have fully understood the victim's condition.*

Although some lay rescuers considered the continued presence of electrical hazards, they did not ask for positive confirmation that power had been cut. Rescuers assumed that power was cut since the lights were out and there was no physical evidence that the accident victim or his jackhammer were still in contact with the energized cable (e.g., sparks). Although the rescuers should be commended for providing first aid, they should be adequately trained to ensure that all energy sources are removed prior to beginning emergency first aid/CPR. Some employees indicated that their Group leaders had discouraged them from receiving CPR training or had not encouraged such training.

*These first responders also did not confirm that the power was off before removing the victim from the pit.*

The Assistant Director of Operations for Protective Technologies Los Alamos, the organization that administers the LANL 911 service, indicated that operators can handle up to four 911 calls at a time. When two or more calls are received at once, the 911 operator may have to operate both the telephone and the radio. This will necessitate an interruption in the 911 call. Because there are only two regular 911 operators (with two backups), the 911 operator had to interrupt one of the calls about the accident in order to alert Emergency Medical System responders by radio.

*The Laboratory's 911 service cannot always handle two simultaneous calls effectively.*

Los Alamos Fire Department personnel and Los Alamos Medical Center physicians involved in emergency response indicated that a significant proportion of emergency calls in Los Alamos are for cardiac problems, including heart attacks or cardiac arrests. Physicians who were interviewed estimated that a Los Alamos Fire Department emergency medical technician cardiac medication capability would potentially benefit only one to two patients per year. Emergency medical technicians/paramedics represent the highest level of emergency medical technician certification, and can administer cardiac medications under the supervision of a doctor. Los Alamos Fire Department currently has no emergency medical technicians certified at that level. The consensus of the physicians was that having an emergency medical technician/paramedic with this capability would

*The victim's heart might have recovered sooner if the emergency medical technicians had been certified to administer cardiac drugs.*

be desirable, but could not be justified given the relatively small number of cardiac patients benefitting from it. However, emergency medical technicians can become additionally trained and certified in "special skills for cardiac drugs." According to one of the emergency medical technicians interviewed, this certification can be accomplished in six months. In this case, administration of cardiac medications on site or in transport might have converted the accident victim's heart to a normal sinus rhythm sooner, although this is uncertain.

## 3.5 OCCUPATIONAL SAFETY AND HEALTH

*The Department of Energy and the Occupational Safety and Health Administration have promulgated requirements to protect construction workers.*

OSHA and DOE have promulgated rules, regulations, and orders designed to provide assurance that personnel will be protected from accidents, injuries, and illnesses. The rules and regulations applicable to the accident investigation, particularly as they apply to defining construction and maintenance activities and conducting safety-related surveys, are discussed below.

DOE Order 5480.4, *Environment, Safety and Health Standards*, invokes requirements of OSHA contained in 29 CFR 1910, "General Industry," and 29 CFR 1926, "Construction," as mandatory DOE standards. OSHA construction safety regulations contained in 29 CFR 1926.20(a)(1) define construction-related activities as "construction, alteration, and/or repair, including painting or decorating." DOE Order 5480.9A, *Construction Project Safety and Health Management*, dated April 13, 1994, defines construction activities as "any combination of erection, installation, assembly, demolition, or fabrication activities involved to create a new facility or to alter, add to, rehabilitate, dismantle, or remove an existing facility." The order further defines construction as also including "the alteration and repair (including dredging, excavating, and painting) of buildings, structures, or other real property, as well as construction, demolition, and excavation activities conducted as part of environmental restoration or remediation efforts." DOE Order 4330.4A, *Maintenance Management Program*, dated October 17, 1990, defines maintenance as "day-to-day work that is required to maintain and preserve plant and capital equipment in a condition suitable for it to be used for its designated purpose and includes preventive, predictive, and corrective (repair) maintenance."

These definitions establish the boundaries for the activities that may be considered maintenance and those that may be considered construction. During the planning phases for the Waste Stream Corrections Project, activities were characterized as construction. The scope of work included elements normally associated with construction, including installation of new components and systems, modifications, and alterations. Following JCI's submission of a request for the Davis-Bacon determination to LAAO, the LAAO Determining Official evaluated the information contained in the request and determined that waste stream corrections work was "uncovered." However, information

contained in the JCI submission did not adequately characterize the scope or cost of the various subtasks contained in the Waste Stream Corrections Project, and indicated that Waste Stream Corrections work would be accomplished under Standard Work Orders, which are normally used to conduct maintenance activities.

*No preliminary hazard analyses were conducted.*

As a result of the LAAO Davis-Bacon determination, Waste Stream Corrections activities were assigned to the JCI Maintenance Group. The Board determined that the level of JCI safety attention provided to maintenance activities is much lower than that provided for construction. For example, all construction activities must receive a preliminary hazard analysis/activity hazard analysis, whereas maintenance activities are required to receive only a preliminary hazard analysis. However, the Board determined that for the work in Building TA-21-209, a preliminary hazard analysis had not been conducted by the project supervisor, who was also unfamiliar with the requirement and form for conducting those analyses. In addition, construction work packages generally receive a review by the JCI ES&H Group, whereas maintenance packages do not always receive this review.

Compliance with 29 CFR 1926.651(b) required LANL and/or JCI personnel to determine the estimated location of utility installations prior to opening an excavation. This includes utilities such as sewer, telephone, fuel, electric, and water lines, or any other underground installations.

*No utility location surveys were performed.*

LANL and JCI personnel stated that neither organization conducted surveys or assessments in the basement of Building TA-21-209 to determine whether utility installations, such as high-pressure steam, natural gas, or electrical installations were around the locations marked for excavation. Both LANL and JCI organizations responsible for conducting such surveys stated reservations as to whether available survey equipment (e.g., utility locator tools) would be effective in locating underground installations, due to the amount of reinforcing steel and concrete in the floor slab, which would hinder accurate locator tool readings. At the request of the Board, and following re-energization of the electrical cable involved in the Building TA-21-209 accident, LANL and JCI personnel conducted surveys in the area surrounding the accident scene to determine whether routinely accepted industry methods for locating buried electrical cables would be effective. As witnessed by a Board member, the surveys were shown effective in identifying the location of the energized 13.2 kV electrical cable at the accident scene.

Various OSHA construction regulations, 29 CFR 1926, 55, 55(a), 55(b), and 57(a), require employers to take actions necessary to limit the exposures of their workers to hazardous substances, and may include engineering controls or the use of respiratory protection

devices. In addition, sampling is required to determine the concentrations of contaminants in the workplace.

*The hazards of crystalline silica dust in the work area were not evaluated even though the potential for overexposure was well known.*

Following a June 1994 occurrence at Technical Area 54 involving the overexposure of four personnel to crystalline silica, the Laboratory transmitted information to the JCI ES&H Group regarding potential work activities that might involve similar exposures. JCI ES&H personnel had undertaken an evaluation of various jobs that could involve similar exposures, and had requested JCI Maintenance to notify them when dust-producing activities would be conducted so that onsite evaluations could be made. JCI ES&H personnel were never notified of the sump excavation work in Building TA-21-209. Consequently, air sampling was not conducted there to evaluate the potential for personnel exposures to crystalline silica, engineering controls such as local exhaust ventilation were not established, and respiratory protection devices were not used to limit the potential for personnel exposures.

## 3.6 PERSONNEL RESOURCES AND TRAINING

DOE Order 5480.20 is not specific as to training requirements for maintenance personnel. However, Chapter I of that order states that training for operators and maintenance personnel should be based on a needs or job analysis. After a training need is identified, training is then developed, implemented, and evaluated.

*Electrical safety training was not subject to a systematic process.*

In the application of the graded approach to training by JCI, this process is sacrificed in favor of time and fiscal resource savings. Periodic safety meetings providing informational awareness are mistaken for training. The electrical safety training components for the use of personal protective equipment have definite skill and ability (psychomotor) components. No skills-based training on the use of insulated blankets and electrical protective gloves was provided to the workers involved in the Building TA-21-209 work prior to the accident. The JCI Personal Protective Equipment Training and Certification Program (Number 12-29-040) requires this training. In addition, this document requires that training be driven by a preliminary hazard analysis or hazard assessment worksheet for each work area or work task. The preliminary hazard analysis was not performed, and the hazard assessment worksheet for Building TA-21-209 work did not address any electrical hazard potentials.

*Specific training is required for workers who face the risk of electrical shock.*

The OSHA regulations, 29 CFR 1910.331 through 335, specify that unique training shall be given to employees who face the risk of electrical shock. Training for unqualified persons should be based on the specific construction and operational hazards or on the hazards associated with the equipment or tools they work with. Personnel involved in the accident at Building TA-21-209 had not received the specific training mandated by 29 CFR 1910.332 on hazards unique to their work.

DOE Order 4330.4B requires the implementation of a maintenance training and qualification program aimed at developing and maintaining the knowledge and skills required for effective maintenance. The JCI Training Manual, dated August 1992, addresses the DOE order requirements. However, lack of effort to institute the specific training measures at the craft level contributes to the ineffective implementation of the order. In particular, the training measures include the verification through specific measurements that training is producing measurable changes in work practices. Performance measures used in training evaluation are typically developed by training personnel in cooperation with first- and second-line supervisors, safety personnel, and human resource personnel. Additionally, the use of "trained-trainers" for the specific training at the craft level is required.

*Training records for construction workers in the accident area did not indicate a need for required training in electrical safety, personal protective equipment, and excavation safety.*

Training requirements are driven by orders, standards, regulations, and procedures. The ability to administer these requirements and manage the training process for each employee requires diligent recordkeeping. The records allow for the implementation of training on a defined and timely schedule. The training database used by JCI keeps the required general training records. However, it lacks the input for specific training needs, which may or may not have been identified by line management, the safety organization, or the workers' foreman/ supervisor. Training records for the employees involved at Building TA-21-209 did not indicate the specific training required by the OSHA standards and by JCI requirements, not only in electrical safety and personal protective equipment, but in excavation safety as well.

*The effectiveness of post-accident training on the use of personal protective equipment cannot be determined.*

The post-accident response to immediately "train" personnel on the use and application of personal protective equipment is commendable. However, this training was not conducted or facilitated by the Training Department, nor did it include the prescribed components to define it as training. This training was conducted by JCI Safety staff and JCI Maintenance supervision. There is no evidence that an evaluation step was incorporated into the training to allow feedback necessary for revision of the processes, procedures, and materials that are essential to more efficient and effective training. There is no evidence that the training measured the level of learning critical to evaluate the training quality and the employees' ability to apply what was learned. Transference of required skills and knowledge to the job setting requires a measurement both during the training process and during the work process.

The Support Services Subcontract 9-X86-Y7575-1 between LANL and JCI requires compliance with the applicable sections of the LANL Health and Safety Manual. LANL's Administrative Requirement 7-1, "Electrical Safety," identifies training requirements. Those requirements include workplace and employee task hazard analysis. They also specify the requirement for line managers to "ensure that their

employees receive the electrical safety training appropriate to the work tasks..." LANL oversight regarding the JCI training program, procedures, processes, and implementation is done at a high programmatic level that does not provide for the measurement of training quality or satisfactory implementation at the craft level. Evaluation of training implementation at the craft level, particularly in safety requirements, would provide a significantly enhanced safety training program at JCI.

*Some local training requirements are not comprehensive.*

The JCI ES&H Manual addresses safety training in Section 12-21-030, "Safety Promotion and Training." The document assigns management the responsibility "to see that the appropriate safety training is made available to all its employees in a timely manner. This training should be, where necessary, job specific to cover the hazards involved in particular job tasks." The deficiencies that the Board sees in this requirement are:

- The Training Department is not mentioned or required to be involved.
- There are no requirements regarding who shall conduct the training (i.e., trainer's qualifications).
- In-service or on-the-job instruction is not defined, nor is the need for measuring learned skills.

## 3.7 MANAGEMENT SYSTEMS

### 3.7.1 Johnson Controls World Services, Inc.

*Weaknesses were identified in the construction contractor's work control system.*

The Board interviewed management at JCI in an attempt to understand the work control system and how perceived weaknesses in that system could have contributed to the accident. The Board focused on work control documentation, supervisory and management responsibilities, communications, and the design documentation used for construction projects such as the sump pit work.

Based on the personnel interviews and document reviews, the Board concluded that:

- JCI management does not have an effective process for assigning work and holding supervisors responsible and accountable for assigned work.
- JCI management systems for task definition and review do not assure that required data are available so work can be accomplished safely.
- JCI supervisors do not routinely review work packages assigned to their organizations and perform a hazards analysis because the work packages may be given directly to the foreman.

- Confusion exists among JCI superintendents, supervisors, and foremen regarding the need for an excavation permit for work performed inside a building. These personnel also assume that the only method for assuring safety is performing a utility survey.

- The Board concluded that an evaluation for the presence of underground utilities should include a review of as-built facility drawings for piping and utilities in addition to a facility walkdown to determine the presence of utilities.

- JCI upper management perceived that the level of safety review would have been the same whether the work was categorized as maintenance or construction. However, had the task been categorized as construction, a preliminary hazard analysis and an activity hazard analysis would have been performed, and a review would have been conducted by a JCI construction safety engineer.

- JCI management does not have a configuration management system that requires baseline documentation and change control of facility modifications. In addition, there is no requirement to prepare as-built drawings of building modifications to document changes.

- The JCI design process for construction tasks performed under standing work orders does not meet the requirements of Administrative Requirement 1-14 and DOE Order 6430.1A.

- The principles of DOE Order 5430.19 are not being effectively implemented by JCI management.

### 3.7.2 Santa Fe Engineering

*Contractual requirements for the design contractor were insufficient for safe task execution.*

The Board reviewed the intent of the SFE contract as further defined by the task order developed by ESH-18 and concluded that:

- The preliminary design engineering drawings provided by SFE effectively met the intent of the scope of the task order in their contract with LANL.

- The level of detail and types of information provided by SFE were inadequate to execute the construction task safely.

- SFE participation, by telephone, in the decision to move the sump location from the doorway to the location where the accident occurred could have contributed to the accident by providing LANL and JCI personnel with false verification of engineering and safety significance.

### 3.7.3 Los Alamos National Laboratory

#### 3.7.3.1 Waste Stream Correction Management

*Significant gaps between regulatory requirements and implementation were noted.*

The waste stream characterization assessment found significant gaps between regulatory requirements and implementation at LANL. ESH-18 took aggressive actions to ensure that the Waste Stream Corrections actions (building modifications) were defined for the facility organizations. Some line division managers assessed the need to complete the actions, while others were selective in implementing corrective actions. Progress on the completion of corrective actions was tracked by the Waste Stream Corrections Project Team in ESH-18 to ensure that milestones were being met. The Waste Stream Corrections Project Team informed LANL organizational Group and Division level management that the facility organizations were not making adequate progress on completing the corrective actions. It appeared that LANL would not meet the EPA milestone dates. ESH Division management assessed this to be an institutional problem. When funding was allocated, ESH-18 was assigned to coordinate the project.

*The project was assigned to an organization with limited experience in managing major, complex projects.*

The assignment of the multi-million dollar Waste Stream Corrections Project to ESH-18 significantly changed that organization's role. The staff of ESH-18 were previously consultants to line division managers, providing recommendations on how to bring facilities into compliance. The recommendations were usually written descriptions but occasionally contained sketches. The Waste Stream Corrections Project Team had successfully managed smaller projects in the past, including the Waste Stream Characterization Project. When the fiscal year 1996 budget responsibility for the Waste Stream Corrections Project was assigned to ESH-18, the organization took on project lead responsibility for a project that was much larger and more complex than the characterization project. During the implementation phase of a project of this magnitude, a high degree of coordination is required between the facility organizations, engineering support groups, maintenance engineering, and the construction organizations. In addition, the Waste Stream Corrections Project Team Leader also needed to maintain communications with state and Federal environmental regulators, DOE, and LANL management concerning project status. The Waste Stream Corrections Project Team Leader did not recognize the complexity of the tasking and failed to develop a detailed project plan that defined interfaces and established roles, responsibilities, and schedules for accomplishing the work.

In addition to the administrative burden, there was constant pressure created by budget and time constraints, as well as the economic and political impact of not meeting regulatory commitments. It is the opinion of the Board that these factors influenced the decision to assign project responsibility to ESH-18. Further, these factors also drove the

development of an ad hoc process that eliminated many of the engineering and safety reviews needed to assure worker safety.

When LANL Division level management transferred responsibility for correcting the waste stream outfall deficiencies to ESH-18, the result was that ownership for the work was transferred from the facility line management organizations to an environmental support organization. Although there were some communications between the Waste Stream Corrections Project Team and Building TA-21-209 facility management, that management organization was not in control of modifications to the facility. Consequently, it was not directly involved in reviewing the work packages or the physical performance of the work. If the facility management organization had been directly involved in the modification process, it might have questioned the design details and identified the hazards present at the work site. When LANL management allowed the facility line management to transfer responsibility for the Waste Stream Corrections facility modifications to the ESH-18 support organization, an administrative barrier for preventing the accident was eliminated.

During the formation of the #06006 Standard Work Order package, ESH-18 considered using FSS-6 or FSS-9 engineers to develop detailed construction packages but decided that ESH-18, in conjunction with SFE, could perform the work faster and cheaper. The decision to perform the work within ESH-18 was based on the belief that there were necessary and sufficient engineering and project management resources within ESH-18 and SFE to accomplish the assigned task. However, weaknesses in project administration, along with the time constraints, were more than the Waste Stream Corrections Project Team Leader could manage with the tools and processes available.

Complex design projects are normally managed from within FSS-6, which was originally designated the lead responsibility for managing such modifications as the piping, sump, and pump installation in Building TA-21-209. The redesignation of the design responsibilities to the ESH-18 engineers in the Waste Stream Corrections Project Team was made due to cost and schedule pressures felt by the Waste Stream Corrections Project Team Leader. ESH-18 did not have the internal procedures, the experience using codes and standards, or the field construction expertise needed to perform facility modification work. The ESH-18 Manager indicated that he did not fully comprehend the fact that his organization had accepted the responsibility for the construction packages. The ESH-18 Manager assumed that FSS-9 would prepare detailed work packages. He did not confirm this assumption. Both the managers and the staff involved overestimated the capability of the Waste Stream Corrections Project Team to engineer and manage a construction project.

The Waste Stream Corrections Project Team did not understand the complexity of the processes required to implement design changes.

The Waste Stream Corrections Project Team, along with the FSS-9 work coordinator and the JCI Work Controller, implemented an undocumented modification process that did not (1) provide the guidance needed to assure adequate safety reviews, (2) adequately develop the designs, (3) require preparation of detailed work packages, (4) manage changes to the work packages during installation, (5) document the completed work, and (6) formally turn over the new and modified systems to the facility operations organization. The overall process met neither the LANL Quality Assurance Management Plan requirements (Section 4.6, "Design") nor those of DOE Order 6430.1a, *General Design Criteria* (Section 0140, "Quality Assurance").

*The engineering drawings provided to the construction contractor were insufficient to ensure safe task execution.*

JCI should have been given detailed civil, mechanical, and electrical engineering drawings that provide the specific information needed to locate the sumps, route and tie the new piping into the utility piping, and route and connect the electrical components into the existing electrical system. The process also should have required "as-built" drawings of the modifications to Building TA-21-209 so that future operation, maintenance, and engineering activities could be conducted safely with drawings that reflect the new configuration. The initial premise that these were minimal modifications was incorrect.

Detailed drawings might have prompted someone in the modification review cycle to ask about subterranean utilities. The individual preparing a detailed plan might have added a precaution about locating utilities prior to excavating, even if it was not recognized that an excavation permit was required. The work group supervisor, foreman, or craft workers for this job may have seen references to the 13.2 kV electrical cable located three feet below the floor.

As it was, the JCI craft workers assigned to construct sump pump additions to Building TA-21-209 were not given specific guidance on the location of the excavation or provided adequate instructions by their foremen or supervisors about the precautions to be taken during the work. Further, the ad hoc process developed in combination with the FSS-9 Work Coordinator and the JCI Work Controller did not define how the design, construction, changes to construction work packages, as-built drawings, and facility acceptance and turnover of the project would be developed and reviewed for ES&H engineering concerns.

*Management has not emphasized adherence to procedures.*

LANL management has established a culture that condones selective use of procedures. By not intervening, even when the desirable outcomes are being achieved, management has sent a message that bypassing existing requirements is acceptable. Although this section of the report has focused on the Waste Stream Corrections Project Team's actions, it is LANL senior management that has set the stage for the deficiencies found in this analysis by lack of direct involvement in decisions made at the Division level.

### 3.7.3.2 Facility Management Unit Model

*The Facility Management Unit model has not been effective in defining and communicating roles and responsibilities.*

Because of a lack of direction from LANL senior management, the process for implementing the Facility Management Unit model has not been effective in ensuring that individuals understand their roles and responsibilities during the transition. The logical flow of responsibility as described in the Facility Managers' memorandum of understanding clearly assigns responsibility for facility operations and maintenance activities to the Facility Manager. However, actual implementation of this flow becomes unclear in Building TA-21-209, because there are other individuals involved in a process that is not clearly defined, namely, the Area Coordinator, Building Manager, Facility Manager Designee, and Facility Manager. Figure 3-10 illustrates the reporting relationships of these individuals.

From the structure indicated in Figure 3-10 it is clear that the Facility Manager does not exercise supervision over the "Facility Manager Designees." Interviews revealed confusion over facility responsibility, especially for individuals outside the Engineering Sciences and Applications Division. Internally, the responsibilities of the Facility Manager are not being implemented as described in Director Policy DP-124; the program's organizations do not accept the facility manager role as it relates to their operations. In addition, there is confusion about the requirement to notify the Facility Manager or Building Manager immediately prior to beginning work in their facility. As a result, the following occurred:

- The Engineering Sciences and Applications (ESA) Division Facility Manager for Building TA-21-209 was not aware of the Waste Stream Corrections work being performed in Building TA-21-209.

- The Building Manager and Area Coordinator for the Engineering Sciences and Applications Division, Facility Management, were aware of the Waste Stream Corrections work being performed in Building TA-21-209, but did not communicate this to their management.

- The Facility Manager Designee for the Engineering Sciences and Applications Division—Tritium Science and Engineering (TSE) was aware of the Waste Stream Corrections work being performed in Building TA-21-209, but is not responsible for work in the building, as defined under the Facility Management Unit program.

- The Deputy Group Leader, rather than the facility management organization, approved the burn permit that was needed to solder copper drain lines being installed in Building TA-21-209.

Because of the decision to have ESH-18 provide project management for the Waste Stream Corrections Project, the responsibilities defined

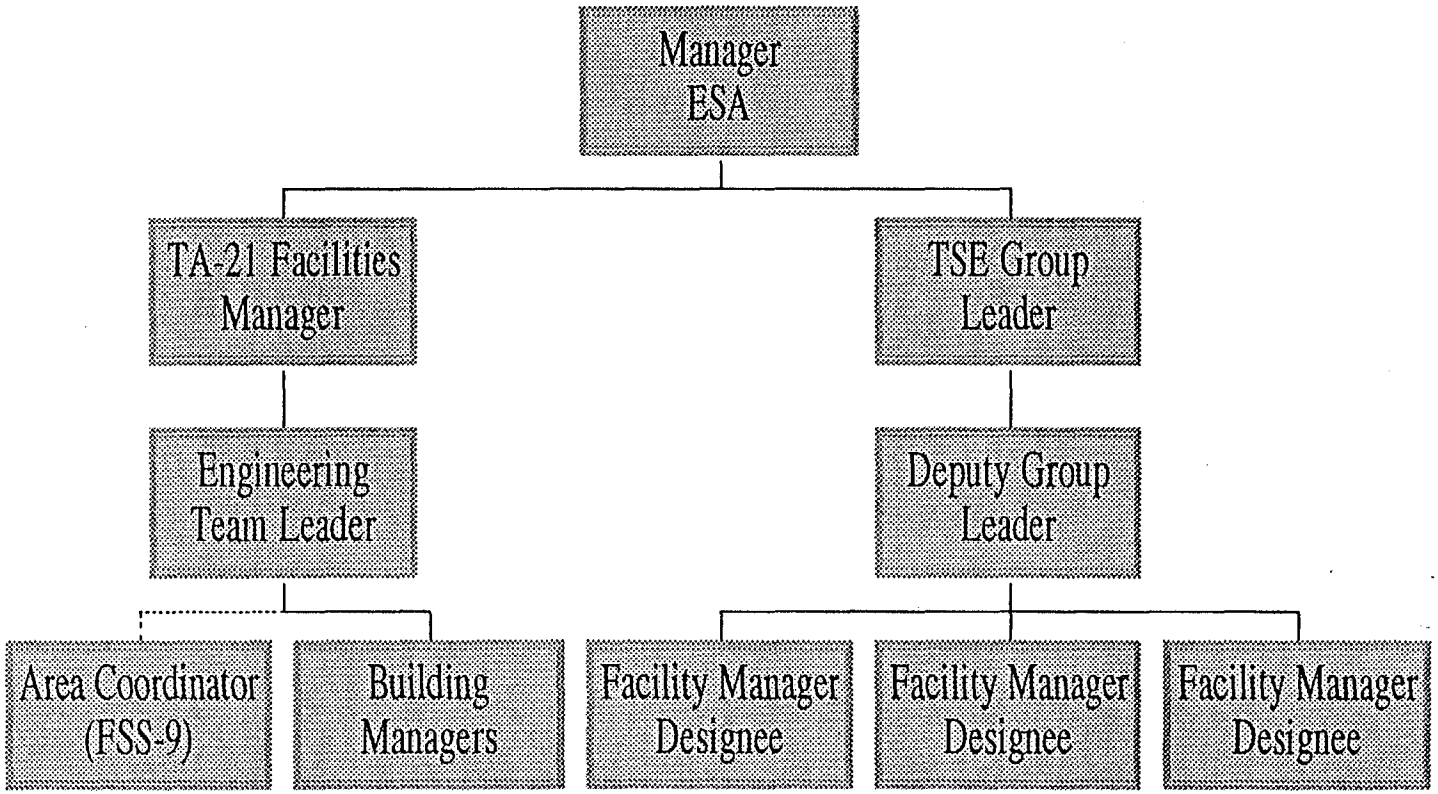



**Figure 3-10. Flowdown of Responsibilities for Facility Operations and Maintenance at Building TA-21-209**

in Director's Policy 124 and the Laboratory Facility Management Program document were not assigned or assumed by anyone in the Engineering Sciences and Applications Division (Facility Manager, Building Manager, Area Coordinator, or Facility Manager Designee). This was contrary to the Facility Management Unit model in that the process did not ensure that the Engineering Sciences and Applications-Facility Management organization fulfilled its responsibilities for the Waste Stream Corrections work in Building TA-21-209.

Through interviews with the Engineering Sciences and Applications - Facility Management Facility Manager, Building Manager, and Area Coordinator, and the Engineering Sciences and Applications Division (LANL) Tritium Science and Engineering Facility Manager Designee, the Board concluded that verbal assignments of responsibility for facility operations within Engineering Sciences and Applications Division (LANL) have created confusion about facility management responsibilities.

Their responsibilities are inconsistent with the requirements of the memorandum of understanding, Director's Policy 124, and the Laboratory facility program documents. Further, there is a wide gap between the assignment of responsibility for facilities to a facility manager and having the actual authority, infrastructure, and facility-specific information needed to carry out that responsibility. In the case of Building TA-21-209, the Facility Manager is assigned the responsibility for safety at this facility and possibly many other facilities, and therefore does not necessarily reside in that facility. In addition, the Facility Manager does not have the processes needed to control as-built drawings of the facility, maintain control of modifications, or control the lockout/tagout status lists for each of the facilities under his cognizance.

The Laboratory Director has not aggressively endorsed the Facility Management Unit transition process. This support is needed to bring about the changes in roles, responsibilities, authorities and accountabilities necessary to effectively implement the facility management unit model at LANL.

The Board endorses LANL's Facility Management Program purpose and policy. The assignment of facility operations and facility safety responsibility to a facility management/operations organization will, as noted in Director's Policy 124, help to manage "resources for optimum efficiency and effectiveness" and help to define a "planning and change process to drive us [LANL] to improve the match between our facilities and evolving program needs." The success of this model will depend on the ability of LANL senior management to clearly and formally state expectations and hold individuals accountable for their actions.

### 3.7.3.3 Conduct of Operations Management

*Conduct of operations principles have not been effectively implemented with respect to worker safety.*

The AL Assistant Manager for Management and Administration was quoted in a February 3, 1996, newspaper article as saying "DOE officials are particularly bothered by worker safety conditions at the Lab [LANL], particularly over the past year or so... Worker safety is being regarded gravely... We're really taking a closer look at that aspect." In the same article a LANL spokesman was quoted as saying "The three serious accidents in the past fourteen months is unacceptable by any standards... We need to renew our commitment to safety."

The Board agrees with the conclusions reached in the article quoted above. The Board also concluded that these conditions exist because the principles of conduct of operations have not been effectively implemented as they relate to worker safety at LANL. The ineffective implementation is directly correlated to the fact that there is no Laboratory-wide implementation plan for conduct of operations, as required by DOE Order 5480.19, dated July 1990.

### 3.7.3.4 Determination of Management Level

*The Laboratory's approach to determining the management level of an activity eliminated some process controls from the task.*

FSS-3 determined that the appropriate management level for the #06006 work was Management Level 4, using the "Graded Approach to Maintenance Management," Laboratory Standard, LS121-01.0. The intent of this maintenance procedure is to define the level so that the level of safety specified for maintenance activities can be determined. This procedure does not provide guidance on the activity of constructing a new system. It was inappropriate to use this procedure in defining the management level for this work project. In addition, the organization making this determination was different than the organization responsible for the project. Neither the ESH-18 Group Manager nor the Waste Stream Corrections Project Team Leader Manager was aware that any management level designation was made. This is because the decision was made after the responsible manager (requester) approved the service request. Table 3-4 is a copy of the matrix criteria from Laboratory Standard LS121-01.0 which was used by FSS-3 to classify the Waste Stream Corrections service request. This matrix does not provide for a graded approach to regulatory compliance and, therefore, only considers maintenance impacts.

FSS-6 uses a different procedure, namely "1.01 Graded Approach to Project Management," to make the determination of management level. A copy of this matrix is provided in Table 3-5. Following the FSS-6 procedure, the Waste Stream Corrections Standing Work Order should have been classified as Management Level 2, because the sump systems and piping modifications were being installed to meet EPA

**Table 3-4. Matrix Criteria Used to Classify the Waste Stream Corrections Service Request**

| | Safety and Health Risk | Environmental Consequences | Security | Regulatory Compliance | Complexity | Importance to Laboratory Mission | Cost and Schedule Risk |
|---|---|---|---|---|---|---|---|
| Management Level 1 (ML 1) (1) | Safety class items, as defined by DOE Order 6430.1A | Long-term irreversible damage to environment | | | | Significant importance to Laboratory mission | |
| Management Level 2 (ML 2) (2) | Safety significant items for protection of workers<br><br>Minor offsite impact | Temporary or minor damage to environment | Protection of Security Category I and II quantities of special nuclear materials | Potential non-compliance with statutory requirements without implementing appropriate controls | Very complex system(s) and/or operations | Moderate importance to Laboratory mission | Potential for a major impact to cost and/or schedule |
| Management Level 3 (ML 3) (3) | Systems important to safety<br><br>Minimal offsite impact | Minimal damage to environment | Protection of Security Category III quantities of special nuclear materials | Potential non-compliance with project agreements, such as memoranda of understanding, without implementing appropriate controls | Moderately complex system and/or operations | Minor importance to Laboratory mission | Potential for a minor impact to cost and/or schedule |
| Management Level 4 (ML 4) (4) | Systems not important to safety | No environmental impact | Protection of Security Category IV or lower quantities of special nuclear materials | N/A | Simple system(s), no complex operations | No importance to Laboratory mission | No potential impact to cost and/or schedule |

**Table 3-5. "Graded Approach to Maintenance Management" Used by Facilities Project Delivery Group (FSS-6) to Classify Work Management Levels**

| Category of Consequence | Maintenance Philosophy | Public Safety | Worker Safety | Environmental Consequences | Security of SNM | Mission Impact | Master Equip. List |
|---|---|---|---|---|---|---|---|
| M1 | Rigorous and formalized maintenance program to minimize probability of failure | Potential death or serious injury to a member of the public | | Severe damage to the environment beyond boundaries of Laboratory | | | Systems and equipment in these categories will be included in the master equipment list |
| M2 | Formalized program that employs all reasonable maintenance activities to control risks | Major injury, irritation or annoyance | Potential death or serious (disabling) injury or illness of Laboratory worker | Localized contamination within Laboratory boundaries | May allow loss or theft of Category 1 quantities of special nuclear material or National Security Information | May result in total loss of major facility or major process capability or have severe mission or economic impact | |
| M3 | Good business/ maintenance practices, economic benefits, prudence | No public impact | Minor illness or injury | Contamination limited to immediate facility area | May allow loss or theft of Category 2 or 3 quantities of special nuclear material or classified information | Damage to a facility or process with serious mission or economic impact | |
| M4 | Repair as needed | No public impact | No injury or illness | Contamination release within allowable units | No loss of special nuclear material or secure data | No damage or minor damage resulting in inconvenience | Need not be included in master equipment list |

### 3.7.3.5 LANL Internal Programmatic Reviews

*Internal programmatic reviews were effective in identifying deficiencies, but corrective actions were not pursued aggressively.*

Assessments by the Laboratory Assessment Office covering a period of approximately two years (1994-1996) were reviewed to evaluate the quality of the assessments being performed and LANL management's effectiveness in correcting adverse conditions found. The assessments were effective in analyzing and describing for the Laboratory Director the programmatic deficiencies that are at the root of many of the safety performance trends being experienced by LANL. Although these findings were not prioritized, they were performance oriented. The facts supported the findings, the causal factors were clearly stated, and the recommendations were generally appropriate for the findings. The assessments recognized issues that have general applicability to the Laboratory. Tables 3-6 through 3-9 provide a comparison of the findings, supporting facts, and causal factors identified by the LANL internal assessment program with the facts and probable causes identified by the Type A Accident Investigation Board.

It is evident from the tables that the specific programmatic deficiencies identified in internal LANL investigation were previously identified in the assessments made in 1994 and 1995. Although these programmatic deficiencies were communicated to LANL senior management, timely and effective corrective actions have not been implemented. The Board believes that corrective actions are not being implemented in a timely and effective manner, because LANL senior management has not aggressively promoted an atmosphere in which research and safety are equally emphasized and has not held Division and Group level managers responsible and accountable for safety.

### 3.7.3.6 LANL Accident Investigations

*Five major internal accident investigations were conducted between October 1992 and the present.*

Accident reports covering the period of October 1992 to the present were reviewed. In all, there were five major accident investigations conducted during that period. Each had multiple findings and contributing causes that were similar to many of those identified in the January 17, 1996, accident. A summary of one of these accidents is presented below to provide a common basis for analysis. The October 15, 1992, accident investigation was conducted because a 20-ton shielding block was dropped at the Meson Physics Facility when a lifting fitting failed. The investigation was conducted due to the high property loss of $470,000. Table 3-10 provides a comparison of the findings, and Table 3-11 provides a comparison of the causes identified in the October 1992 accident and the January 1996 accident at Building TA-21-209.

**Table 3-6. Past Occurrence Report Findings, Supporting Facts, and Causal Factors Identified by LANL Internal Assessments Versus Those Identified by the Board in the Building TA-21-209 Accident: Report AA-2-94-60**

| Source Document | Environmental, Safety and Health; Quality; and Safeguards and Security Review of the Business Operations Division (BUS), AA-2-94-60, not signed out. | Type A Accident Investigation of Electrical Accident |
|---|---|---|
| Supporting Facts | The deficiencies noted in the construction activities for Building 142 are similar to those documented for the PF-4 facility addition at Building TA-55, ventilation modifications at CMR Building, the WETF addition, and the new construction of the DAHRT Facility. | Deficiencies noted in this activity are similar to deficiencies noted two years ago in the assessment. |
| Causal Factor/ Probable Cause | The Laboratory does not have an effective management system. | The Laboratory does not have an effective project management system. |

**Table 3-7. Past Occurrence Report Findings, Supporting Facts, and Causal Factors Identified by LANL Internal Assessments Versus Those Identified by the Board in the Building TA-21-209 Accident: Report LAO-2-94-02**

| Source Document | LAO-2 Assessment of Johnson Controls World Services, Inc., LAO-2-94-02, dated March 18, 1994 | Type A Accident Investigation of Electrical Accident |
|---|---|---|
| Supporting Facts | Work orders did not always thoroughly describe the work done and the codes and standards followed. | The work package provided to JCI for the Building TA-21-209 building modifications did not provide sump locations, nor the plumbing tie-ins, nor the electrical connections for the pumps, nor did it require an excavation permit. |
| Supporting Facts | Procedures for configuration control in progress did not exist nor was configuration control being implemented. | There were no procedures established in the Waste Stream Correction project to manage changes or to require preparation of as-built drawings. |
| Supporting Facts | There were no procedures for management review of audits, reviews, and self-assessments; such reviews were not routinely conducted. | JCI Safety conducts job-site safety reviews but no JCI organization has performed a safety program review of the work control processes or compliance with procedures. |
| Causal Factor/ Probable Cause | Line managers failed to recognize the importance of implementing and enforcing Quality Assurance program requirements. | |
| Finding | There was no published Laboratory maintenance plan; therefore, there was no auditable method of communicating maintenance requirements to JCI. | There still is no published (final) LANL maintenance plan. |
| Supporting Facts | FSS and ESH Groups communicated many Laboratory work requirements, safety requirements, and job tasks verbally or by memorandum. | The changes to the location of the sump were conveyed over the telephone without any documentation. |
| Causal Factor/ Probable Cause | The Laboratory management did not assign a high priority to the implementation of DOE Order 4330.4A. | |

**Table 3-9. Past Occurrence Report Findings, Supporting Facts, and Causal Factors Identified by LANL Internal Assessments Versus Those Identified by the Board in the Building TA-21-209 Accident: Report AA-2-94-73**

| Source Document | AA-2 Assessment of the Construction Safety Program, AA-2-94-73, dated November 18, 1994. | Type A Accident Investigation of Electrical Accident |
|---|---|---|
| Finding | There was inadequate oversight of the construction safety program. | |
| Causal Factor/ Probable Cause | Responsibilities for oversight of the construction safety program were divided, and the various organizations had not fulfilled their oversight roles. The draft Program Requirements Document 110-01.0 had never been approved and distributed. | Responsibility for performing a safety review was eliminated by use of an ad hoc form; Facilities Operations, Maintenance, and Modification Groups coordinator did not submit work packages for internal safety review; JCI supervision was bypassed for on its review. |
| Finding | The process for ensuring contractor compliance with safety standards was ineffective. | Project Team Leader assumed JCI would perform a safety review but did not verify. The work packages did not conform to electric code, plumbing code or building code. |
| Causal Factor/ Probable Cause | The Laboratory had not been aggressive in implementing existing procedures that could be used to ensure contractor complied with safety standards. | |
| Source Document | AA-2 Assessment of the Tritium Systems Test Assembly and the Tritium Sciences and Fabrication Facility AA-2-94-49, dated March 28, 1995. | |
| Finding | The quality assurance program had not been fully implemented (Program Requirements Document 110-01.0, Par. 5.3 and Section 4.5. | |
| Supporting Facts | Timely resolution of quality assurance issues had decreased over the past year, and no initiation of corrective action was evident. | Engineering Sciences and Application Division did not complete assigned actions to correct National Pollutant Discharge Elimination System deficiencies between March 1994 and October 1995. |
| Supporting Facts | There was inadequate documentation to demonstrate that the quality assurance program had been applied before tritium and facility work began. | Tritium Science and Fabrication Facility or building management did not participate in the design or construction decisions effecting the facility as required in Director's Policy DP-124 and in the Memorandum of Agreement signed by the Facility Management Council. |

**Table 3-10. Similarities of October 1992 Type A Accident Investigation Findings to January 1996 Type A Accident Investigation Findings**

| October 1992<br>Type A Accident Investigation Findings | January 1996<br>Type A Accident Investigation Findings |
|---|---|
| The design specification, qualification testing, acceptance criteria and inspection documentation for the concrete shielding blocks were not available. | **Design specification finding**<br>There were no detailed drawings showing the piping or electrical installations. There was no intent to "as-build" the installation. |
| Configuration control was not maintained on either the eyebolts or the concrete shielding blocks. | **Configuration control finding**<br>Although there were sketches to work by, field direction changed sump locations without documenting the changes. There was no intent to "as-build" the installation. |
| The facility had neither an inspection nor a maintenance plan for the hardware that failed. | **Lack of project plan**<br>There were no provisions made for operating and maintaining the installed systems after the work was completed. There were no turnover provisions considered. |
| The infrastructure for implementation of the responsibilities of the Director's Policies did not exist nor were the management authorities delineated. | **Unclear lines of responsibility**<br>The Facility Management Unit Memorandum of Understanding and a Director Policy describe a transfer of responsibility to the facility manager but there is no implementation of procedures to do this. The facility manager should have been involved in the modification to Building TA-21-209 but was not. |
| LANL Director Policies are neither uniformly implemented nor enforced. | **Policy implementation/enforcement**<br>Within Facilities, Security, and Safeguards there are two processes for determining the management level of work. They have different criteria. |
| The LANL Administrative Requirements do not adequately implement the LANL Director's Policies and are not uniformly enforced. | **Need for sitewide policies**<br>Many procedures needed to assure consistent operations have not bene prepared. Where procedures do exist, procedure compliance is optional. |
| LANL Administrative policies and programs are decentralized and inhibit their effectiveness. | **Design description**<br>Work control, design, and conduct of operations procedures are not implemented in sitewide procedures. |
| LANL has not incorporated lessons learned from previous accidents and incidents into an overall loss prevention program. | **Lessons learned from previous accidents are not incorporated**<br>The findings of this accident and previous accidents at LANL demonstrate that LANL management has not been effective at implementing corrective actions from lessons learned. |
| LANL has not sufficiently incorporated DOE Order 5480.19, "Conduct of Operations." | **The requirements of DOE Order 5480.19 are not fully implemented at the Laboratory.**<br>LANL management has not ensured the timely implementation of DOE Order 5480.19, "Conduct of Operations". |

The November 1992 accident investigation report indicated that the root cause was a lack of configuration control reviews. The investigation's analysis of standards and directives determined that "although the LANL Director has established centralized management guidance, through the issuance of the Director's Policies, the infrastructure and implementation of the responsibilities and authorities do not exist. The guidance and operating procedures at the division and Group level are developed independent of other LANL requirements and validation and are not necessarily consistent." The report summary indicated that policies and procedures at every level in the organization are open to interpretation, may be selectively followed, are not enforced by managers, or are not available.

*Several judgments of need from those investigations are pertinent to the January 1996 accident.*

The following judgments of need noted in the November 1992 accident report are common to the January 1996 accident:

- A need exists for LANL to complete a preliminary hazard analysis on all shielding block operations.
- The need exists for LANL management to further develop the responsibilities, authorities, and enforcement of the LANL Director's Policies and Administrative Requirements.
- The need exists for the development and integration of LANL's standards and directives regarding crane policy, procedures, inspections and maintenance, and crane management ownership, responsibilities, and authorities.
- A need exists for LANL to establish a lessons learned program from previous accidents/incidents and integrate it into their overall loss prevention program.
- The need exists to further implement a formal conduct of operations program at LANL.

*The Laboratory's management systems are ineffective in resolving longstanding, well defined programmatic issues.*

The cover memorandum that transmitted the report to LANL management stated that "This investigation indicates inadequate LANL line management accountability and ownership, as well as an inability to learn from previous incidents and prevent their recurrence. This accident investigation, as well as other recent incidents, indicate that LANL's formality of operations must be strengthened... Further implementation must begin without delay." This direction was not followed. It is clear from the number of serious accidents (three) that have occurred in the past 13 months and by the deficiencies identified in this investigation that LANL's management systems are ineffective at resolving longstanding, well defined programmatic issues or translating lessons learned into day-to-day operations at LANL.

### 3.7.5 Albuquerque Operations Office

*The Operations Office's emphasis on contractor agreement with the findings, conclusions, and judgments of need of its appraisals limits the objectivity and effectiveness of the appraisals.*

Although the August 31, 1995, Curtis Memo on the pilot oversight program indicated a degree of "teaming" with the Laboratories in terms of agreeing to the scope of the Annual ES&H Appraisal and the performance objectives, criteria, and measures to be used, there were no requirements in the memorandum or its attachments that indicated the Laboratory must agree to the findings, conclusions, or judgments of need of the appraisal prior to its issuance. In the Board's view, the need for agreement on the findings of the report jeopardizes the objectivity of the appraisal and removes DOE line management from its responsibility for the safety of the facilities/operations under its cognizance.

The Functional Area Appraisal Procedure developed by AL and approved by the Assistant Manager, Office of Technical Management and Operations, is not consistent with the definition of the pilot oversight program contained in the memorandum from the Deputy Secretary of Energy, dated August 31, 1995. This memorandum states that "The scope of assessments is agreed upon by DOE Operations Office and each University of California Laboratory." It does not assume or imply that a requirement exists for the contractor to agree on findings, as stated in the AL procedure and quoted in the following paragraphs.

This AL appraisal procedure, as applied to Team Assessors, states that "Potential findings become formal findings when agreed upon by the assessor, Area or Project Office, and contractor." The procedure further states that the Team Lead Assessor is responsible to "Facilitate a discussion of any potential findings and risk categories that would not be agreed upon and determine if the discussion should be elevated through the Division Directors, Area or Project Office management, and contractor management."

For preparing the appraisal report, the procedure says to "Cite findings that were approved during the appraisal and those that were approved by the appraisal team, the area or Project Office, and the contractor after being elevated to the appropriate management levels for resolution." The AL-developed procedure also contains a "Finding Record Form" that requires agreement by the contractor and DOE before a potential finding statement is accepted as a finding. The AL-developed Functional Area Appraisal Procedure is not consistent with the memorandum from the Deputy Secretary of Energy dated August 31, 1995. It is the judgment of the Board that this procedure significantly reduces the independent objectivity and effectiveness of the assessment team by requiring that the findings be accepted by the contractor.

8. LAAO did not require LANL personnel to preserve the scene of the accident until the Board arrived at the scene.

9. The physical evidence pertinent to the accident was not gathered, inventoried, and controlled in a disciplined, documented manner.

10. LAAO did not require JCI, LANL, and the Type B Accident Investigation Board to establish a documented chain of custody for the physical evidence pertinent to the accident.

**Probable Causes**

1. The Los Alamos Fire Department's concern for the cost of training emergency medical technicians to administer cardiac medications versus the number of cardiac patients who would need such services has prevented the technicians from receiving this training.

2. Resource constraints have reduced the capability of Protective Technologies-Los Alamos to receive 911 calls and radio dispatch assistance simultaneously.

3. CPR training does not provide sufficient practice in the indicators of cardiac arrest and application of CPR techniques.

4. Deficiencies in emergency response training exist in regard to positively identifying the absence or disconnection of stored energy sources prior to administering first aid.

5. LAAO did not recognize the need to preserve and document the physical conditions of the accident scene.

6. LAAO personnel were not trained in DOE accident investigation techniques, processes and procedures.

7. There is no procedure requiring LAAO to train accident investigation team leaders.

## 4.2 ELECTRICAL SAFETY

**Findings**

1. Emergency response time by the JCI Utilities Power Control Section is a minimum of one hour during non-standard working hours.

2. A JCI job-specific procedure identifies the use of personal protective equipment to be used during jackhammering.

**Probable Causes**

1. An emergency plan for critical power needs does not exist to provide guidance to JCI maintenance personnel responding to unscheduled power outages and providing temporary electric power by portable generators to meet building-critical needs.

2. Backshift support for emergency electrical utilities service was eliminated because of funding.

3. A formal, complete, comprehensive electrical safety program document for LANL or JCI is not in place.

4. JCI did not recognize the need to prepare a procedure to reflect the requirements of 29 CFR 1926.416(a)(2).

5. JCI did not incorporate all the requirements of 29 CFR 1910.132(f)(4) into its procedure.

6. The JCI procedure requiring certification and training involving personal protective equipment did not appear in the JCI ES&H Manual until November 28, 1995.

7. JCI personnel misinterpreted the excavation permit requirements.

8. JCI Utilities Power Control Section personnel at all levels have accepted their job-specific operating instructions as procedures and requirements.

9. JCI Safety and Maintenance personnel do not routinely perform safety inspections of maintenance activities.

10. JCI ES&H Manual Procedure 12-25-008 does not satisfy the requirements of 29 CFR 1910.137 for rubber glove testing.

11. The JCI Maintenance organization does not have a systematic program for keeping track of rubber glove test dates, retest due dates, or inventory control.

12. LANL policies and requirements are not factored into JCI procedures and policies.

13. The validation process for closure of corrective action items identified in LANL occurrence reports is not effectively implemented.

14. Lessons learned from previous electrical incidents have not been effectively implemented into LANL or JCI procedures or training programs.

10. JCI craft workers involved in the accident had not been provided with formal documentation on the scope or safety review/ requirements for the work they were to perform.

**Probable Causes**

1. Administrative Requirements have not been kept up to date to reflect changes in LANL organizations, procedures, and practices.

2. Laboratory-wide procedures have not been developed to establish performance expectations and define the requirements for conducting work planning and control within various LANL organizations.

3. LANL does not have a good internal assessment process to discover deviations from procedures.

4. There is neither enforcement of safety requirements by LANL or JCI management, nor accountability for poor safety performance.

### 4.3.2 Procedures

**Findings**

1. Laboratory-wide operating procedures have not been written for a majority of the Administrative Requirements, which is in violation of Director's Policy 102. Specific to this incident, there are no Laboratory-wide operating procedures to implement the Director's Policies for (1) conduct of operations, (2) configuration management, (3) work planning and control, and (4) ES&H design reviews.

2. LANL management has allowed Laboratory personnel at the Division and/or Group level to ignore or change requirements without revising applicable procedures.

3. Line managers did not ensure that Administrative Requirement 1-11 was met. Forms other than the "approved" work control forms were used to issue work. Standing Work Orders were being used for non-routine, non-repetitive tasks, in direct conflict with Administrative Requirement 1-11 and with their intended purpose.

4. LANL and JCI staff were not aware that an excavation permit was required by Administrative Requirement 1-12.

5. The Administrative Requirements contained in the LANL ES&H Manual are not well understood or complied with by either the staff or management levels within LANL.

7. The master management e-mail method used to promulgate the sitewide stop-work order does not incorporate message receipt confirmation. The process is "open loop" and does not assure the stop-work order notice is received and placed in effect.

### 4.3.3 Design and Configuration Management

**Findings**

1. Preliminary design documents were used for construction activities.

2. Design reviews for the Waste Stream Corrections Project work did not comply with the design review requirements contained in Administrative Requirement 1-14 and the Quality Management Plan for 10 CFR 830.120.

3. The process for obtaining approval for design changes is informal and does not require field verification of changes requested prior to approval.

4. The LANL configuration management program is ineffective at maintaining configuration control of facilities.

5. As-built drawings are not required to be updated for facility modifications, particularly those "modifications" being handled as maintenance activities.

6. The Water Quality and Hydrology Group did not recognize its responsibilities for design review after assuming the project lead role.

7. The graded approach in the configuration management program does not require controls for non-vital systems.

**Probable Causes**

1. LANL management has not instituted Laboratory-wide procedures outlining organizational responsibilities and authorities governing the conduct of design reviews.

2. High-level procedures are written, and requirements are directed to line managers without adequate infrastructure, responsibilities, and accountability to implement the numerous requirements.

3. Management does not uniformly enforce the requirements described in Administrative Requirements and Director's Policies.

4. There is no Laboratory-wide configuration control procedure.

## 4.5 MANAGEMENT SYSTEMS

### 4.5.1 Johnson Controls World Services, Inc.

**Findings**

1. Failure to categorize the work as construction resulted in removing the administrative barrier of an independent safety review by the JCI construction safety engineer, as well as conduct of both a preliminary hazard analysis and an activity hazard analysis.

2. Failure to prepare as-built drawings of electrical and other stored energy system changes due to past facility modifications resulted in the loss of configuration control of a potentially life threatening system.

3. JCI does not have a documented process for work package assignment and/or for detailing supervisor or foreman accountability to assure technical and safety adequacy of the information provided in the work package.

4. JCI does not routinely prepare design drawings for modifications to existing buildings, particularly for work packages that flow from LANL through the JCI Maintenance Division.

**Probable Causes**

1. The Standing Work Order system does not require a safety review for individual tasks performed under the work order.

2. The Standing Work Order system is used as a convenient method for performing work without preparing a job ticket.

3. The safety-related implications of maintaining configuration control of stored energy systems is not recognized.

### 4.5.2 Santa Fe Engineering

**Findings**

1. SFE preliminary drawings did not consider electrical system tie-in requirements.

2. SFE preliminary drawings were not adequate as a basis to perform construction activities in a safe manner.

3. SFE provided guidance/concurrence on sump pump relocation informally without considering engineering or safety significance.

10. The processes for determining and assigning work management-level classifications do not provide consistent results at LANL.

11. The work being performed at the accident site should not have been classified as Management Level 4 by the Facilities Support Operations Group, because of the type of work involved, the complexity, and the necessity to comply with EPA regulations.

12. The design controls required by the assigned Management Level 4 classification do not require adequate configuration management, design, and turnover of systems.

13. The lessons learned from previous significant accidents have not been implemented at LANL to eliminate programmatic deficiencies that have repeatedly been identified as either root or contributing causes to the accidents.

14. LANL management programs have not been effective in holding individuals accountable for completing assigned tasks, particularly those involving corrective actions related to programmatic deficiencies identified during assessments.

15. The Laboratory Director has not formally promoted the Facility Management Unit model to the management team.

16. LANL management is not ensuring that the rights of LANL subcontractor employees to a safe work environment are being protected.

**Probable Causes**

1. Responsibility for the design and construction of NPDES modifications was transferred to a support organization that did not have the necessary and sufficient engineering or project management tools and experience to perform the required tasks to assure safety during field construction.

2. The Standing Work Order process does not require a safety review for individual subtasks performed under the overall Work Order.

3. The Standing Work Order process is utilized by LANL personnel as a convenient method of performing work without a job ticket and work package, allowing most work to be field directed.

4. The Facility Management Unit responsible for Building TA-21-209 did not take an active role in the design, development, or field implementation of the Waste Stream Corrections modifications being managed by the Water Quality and Hydrology Group.

2. LAAO Facility Representative personnel do not understand the "teaming concept" and whether or not it affects their responsibilities and accountabilities for line management safety oversight of LANL.

**Probable Causes**

1. LAAO management reassigned the Facility Representative to Technical Area 55 and to other temporary assignments in an attempt to allocate scarce resources in a priority manner. Technical Area 55, Readiness Assessments and Accident Investigations, was given priority over day-to-day oversight at the Tritium Facilities, which included Building TA-21-209.

2. The scope of the "teaming concept" has not been adequately defined and explained to LAAO personnel to ensure that it does not inhibit the performance or objectivity of day-to-day line management oversight.

### 4.5.5 Albuquerque Operations Office

**Findings**

1. The Functional Area Appraisal Procedure developed by AL to implement the pilot oversight program requires agreement from the contractor on all findings.

2. The Functional Area Appraisal Procedure reduces the independence and effectiveness of the assessment team.

**Probable Cause**

The Functional Area Appraisal Procedure is not consistent with the definition of the program provided by the Deputy Secretary of Energy.

### 4.5.6 DOE Headquarters

**Findings**

1. The EH Resident Office was not staffed to the level originally planned.

2. The EH Resident's surveillance duties have been reduced because of other priorities.

3. The single Los Alamos EH Resident does not possess all of the education and experience required to provide effective oversight of all of the major activities at LANL.

# 5.0 JUDGMENTS OF NEED

Judgments of need are managerial controls and safety measures believed necessary to prevent or mitigate the probability or severity of a recurrence. They flow from the conclusions and probable causes and are directed at guiding managers in developing followup actions. The judgments of need are categorized according to the Guiding Principles of safety management established by the Secretary of Energy.

## GUIDING PRINCIPLE 1: LINE MANAGERS ARE RESPONSIBLE AND ACCOUNTABLE FOR SAFETY

### PROJECT MANAGEMENT SYSTEMS/ORGANIZATION

- LANL management needs to formally embrace and support the Facility Management Unit concept to assure that all levels of the LANL organization are committed to the program's purpose and policy, expedite its implementation, and prevent Division Director level decisions from circumventing the program's objectives.

- LANL management needs to reassess the structure of facility line management organizations to assure that definitive responsibility for all facility/building operations and safety is assigned to one individual or his/her designee. In keeping with the Facility Management Unit model, this individual should:

  - Have detailed knowledge of the facility/building

  - Preferably be housed in or very near the facility/building

  - Maintain controlled copies of safety analysis, design, and operating documents, including drawings and procedures

  - Control the lockout/tagout status list for the facility/building

  - Be provided with sufficient resources to operate, modify, and maintain the facility/building in a safe condition

  - Be responsible for initiating and having the project responsibility for all work to be performed in the facility/building.

- LANL management needs to develop and standardize Laboratory programs that crosscut all the Facility Management Units, including, but not limited to, maintenance, work planning, work control, configuration management, training, and quality assurance.

- LANL management needs to assure that Laboratory projects, such as the Waste Stream Corrections Project, that involve maintenance, construction, or modifications to facilities/buildings across the various Facility Management Units are structured so that all aspects

- Assurance that all information pertaining to the work being performed is included in the work package (e.g., service requests, preliminary hazard/activity hazard analyses, drawings, permits)

- Requirements for ES&H field inspections

- Identification of personnel responsibility and accountability, particularly those authorized to accept, review, and assign work

- Provisions for maintaining configuration control.

In addition, these procedures should detail similar expectations for the control of LANL-generated work packages within subcontractor organizations performing the work.

- LANL management needs to ensure that the Laboratory develops, as part of the Laboratory-wide work control procedures, a well defined risk-based methodology (graded approach) for assignment of "Management Levels" or "quality levels" for work packages based on the hazards to which craft persons are expected to be exposed, the hazard level of the facility, and the consequences related to failure of the work to be performed correctly and safely.

- LANL and JCI management need to revise Laboratory procedures to emphasize the requirement for permits for penetrations or excavation outside or inside facilities/buildings whenever ground breaking or cutting into walls or floors is to be performed. The penetration or excavation permit process should include:

  - A review of the applicable electrical, mechanical, civil, and utility drawings

  - Walkdowns of the work site to physically observe piping and electrical penetrations

  - Utility surveys (electronic measurements) as part of the permitting process.

## ELECTRICAL SAFETY AND PERSONAL PROTECTIVE EQUIPMENT

- LANL management needs to assess the critical power requirements for Building TA-21-209 and other nuclear facilities to ensure that temporary emergency power requirements are known in the event of loss of external power. Temporary emergency power plans and procedures should be prepared to document the temporary power requirements, diesel generator capacities needed, cable routing, and electrical connection points for these facilities. These plans and

- AL, LAAO, and the Los Alamos EH Residents Office need to track all corrective actions proposed in response to this Type A accident investigation to closure.

## GUIDING PRINCIPLE 3: COMPETENCE IS COMMENSURATE WITH RESPONSIBILITIES

### TRAINING AND RESOURCES

- JCI management needs to provide aggressive and structured monitoring, oversight, followup, and feedback to ensure effective integration of safety procedures and requirements into training courses and materials, which are then implemented in accordance with JCI training procedures.

- LANL management needs to evaluate the effectiveness of the implementation of the JCI training program by observing and measuring workplace performance.

- LANL management needs to implement effective work planning and control procedures and training in the assessment of hazards, identification and use of personal protective equipment required, and training in electrical and other stored energy systems safety-related work practices.

- The LAAO Area Manager needs to assure that LAAO personnel are trained in appropriate DOE accident investigation methods and procedures.

- LANL management needs to consider funding for training and certification of Los Alamos Fire Department emergency medical technicians in the administration of cardiac medication, or to contract for emergency medical technicians already trained and certified for this skill.

- LANL management needs to consider funding or contracting for modifications to Protective Technologies-Los Alamos procedures, equipment, and staffing to enable that organization's 911 operators to stay on the line with callers whenever continuity of communication is needed.

### WORKER EMPOWERMENT AND NON-DISCRIMINATION

- LANL and JCI management need to develop and implement a process to ensure the acceptance of and individual accountability for safety, particularly occupational safety and health, through increasing management and supervisory presence in the field; a better understanding among employees for safety requirements through

## 6.0 BOARD SIGNATURES

Date 2-12-96

Fred Volpe, Board Chairperson
Trained Accident Investigator
U.S. Department of Energy, EH-24
19901 Germantown Road
Germantown, MD 20874

Date 2/12/96

William T. Cooper, Jr., Board Member
U.S. Department of Energy, EH-24
161 Mitichell Road, Chinn I Bldg.
Oak Ridge, TN 37831

Date 2/12/96

Darrell Fong, Board Member
U.S. Department of Energy, AL
P.O. Box 5400
Albuquerque, NM 87185-5400

Date 2/12/96

Ivan E. Trujillo, Board Member
U. S. Department of Energy, LAAO
528 35th Street
Los Alamos, NM 87544

# APPENDIX A

# ACCIDENT INVESTIGATION BOARD APPOINTMENT LETTER

DOE F 1325.8
(8-89)
EFG (07-90)

United States Government **Department of Energy**

# memorandum

DATE: January 23, 1995

REPLY TO ATTN OF: EH-2:Office of Oversight:GPodonsky:3-3777

SUBJECT: Investigation of the January 17, 1996, Electrical Accident at the Los Alamos National Laboratory (LANL) Tritium Science and Fabrication Facility (TSFF)

TO: Bruce Twining, Manager
Albuquerque Operations Office

Due to the seriousness and impact of the subject accident, I believe that a Type A investigation is appropriate. The investigation would be a joint effort between my office and the Albuquerque Operations Office (ALO) with the Board chaired by a member of my management staff. The Board would be staffed by two individuals from Headquarters and two from the ALO complex.

This is a new approach to conducting investigations, but each of our offices have an interest in this accident, and would benefit from a mutual effort. We believe that because of the nature of the accident, and the recent accident experience at LANL, that this investigation should be led by an outside group.

I appoint Fred Volpe from the Office of Oversight as Chairperson. I also appoint as Members of the Board, Darrell Fong, AL, and Ivan E. Trujillo, LAAO. We will identify the two EH-sponsored Board Members shortly. Bryan Drennen, Sandia National Laboratory, would be an excellent advisor to the Board, as would Dan E. Glenn, Assistant Manager for Facility Operations, LAAO.

We would expect that ALO would bear the fiscal burden of this endeavor including travel and per diem expenses of the non-EH sponsored Board Members, its advisors, and the cost of court stenographers. We would look to LANL to provide office, meeting, and interview accommodations, word processing, and for other needs of the investigation contingent.

The scope of the Board's investigation will include, but is not limited to, identifying and analyzing root causes and factors resulting in the accident, and determining judgments of need to prevent recurrence. The investigation will be conducted in accordance with DOE 225.1, Accident Investigations.

DATE January 22, 1996

MEMORANDUM FOR: Larry Kirkman, Acting Manager, DOE/Los Alamos Area Office (LAAO)

FROM: Fred J. Volpe, Jr., Chairperson
Accident Investigation Board
LANL/TSFF Electrical Shock Incident

SUBJECT: **TYPE-A ACCIDENT INVESTIGATION BOARD FOR THE ELECTRICAL SHOCK INCIDENT AT THE LOS ALAMOS NATIONAL LABORATORY (LANL) TRITIUM SCIENCE AND FABRICATION FACILITY (TSFF)**

A Type-A Accident Investigation Board has been established by the Assistant Secretary for Environment, Safety and Health (EH) to investigate the TSFF accident. The Board membership currently consists of the following:

Fred J. Volpe (EH), Chairperson
William T. Cooper Jr. (EH), Member
Darrell Fong (AL), Member
Ivan E. Trujillo (LAAO), Member
Dan E. Glenn (LAAO), Advisor
Dennis Walters (PNL), Advisor
Dave Spence Consultant), Advisor
Bryan Drennan (Sandia), Advisor
Dr. Joseph Falco (BNL), Medical Advisor

The Board also has a number of support personnel who will be on site.

The scope of the Board's investigation includes, but is not limited to, identifying and analyzing root causes and factors resulting in the accident, and determining judgments of need to prevent recurrence. The investigation will be conducted in accordance with DOE 0 225.1. The purpose of the investigation is to develop lessons-learned for the prevention of similar incidents at LANL as well as across the Department of Energy (DOE) complex.

It is our intention to conduct this investigation in an open manner whenever possible, and communicate frequently with the affected organizations. We also wish to minimize our impact on site operations.

The cooperation of DOE, LANL, and Johnson Controls World Services, Inc. (JCI) personnel is requested as the Board conducts its investigation. The investigatory process will include formal interviews of personnel, of which transcripts

# APPENDIX B

# BOARD MEMBERS' AND ADVISORS' QUALIFICATIONS

**NAME:** Fred J. Volpe

**AREA OF RESP:** Accident Investigation Board Chairperson

**ASSOCIATION:** U.S. Department of Energy

**EXPERIENCE:** 29 years

- **U.S. Department of Energy**
  - Deputy Director, Office of EH Residents. Performance of independent management/ technical safety oversight of DOE operations and activities at ten Departmental sites.
  - Director, Division of Nuclear Operations and Analysis. Development and implementation of DOE Nuclear Safety Orders, Rules guidelines and standards.
  - Senior Nuclear Engineer, Office of Nuclear Safety. Performance of independent management/technical reviews and Technical Safety Appraisals of the Department's nuclear safety program.
- **Energy Research and Development Organization**
  - Reactor Instrumentation and Control Engineer, Office of Reactor Safety Research. Design of data acquisition, plant protection, and process instrumentation systems for the Loss of Fluid Test Facility, Power Burst Facility, and the Semi-Scale Facility.
- **U.S. Atomic Energy Commission**
  - Reactor Engineer, Office of Reactor Development and Technology. Design and development of instrumentation and controls for the Fast Flux Test Facility and the Clinch River Breeder Reactor.
- **North American Rockwell Corp.**
  - Instrumentation Engineer. Design, fabrication, and testing of process instrumentation for use in liquid metal sodium fast breeder reactors.

**EDUCATION:** Associate Degree in Engineering; Wilkes College
B.S. Degree Electrical Engineering; Penn State University
Masters Degree Nuclear Engineering; Penn State University

**OTHER:** Fusion Energy Technology (1975)
MORT Training (1982)
Nuclear Power Engineering - Oxford, England (1983)
Accident Investigation Chairman Workshop (1993)

**NAME:** Darrell Fong

**AREA OF RESP:** Accident Investigation Board Member

**ASSOCIATION:** DOE/AL

**EXPERIENCE:** 6 years

- **U.S. Department of Energy**

  **Occupational Safety and Health Division**

  - Currently a Safety Engineer, providing technical assistance to the Department of Energy, Albuquerque Operations Office (AL) and contractors in the area of Occupational Safety.

  - Conduct appraisals, evaluations and monitor contractors' operations and industrial safety programs to determine adequacy in protecting the safety of employees.

  - Provide technical review in the area of Occupational Safety during the design and construction of facilities, and the technical interpretations of the Occupational Safety and Health Act standards, and determine their applicability to AL operations.

  **Management Support Division**

  - Responsible for the development, implementation, and oversight of Safety and Health Programs, policies and procedures for Federal employees.

  - Directed industrial hygiene and safety compliance activities, managed safety and health programs, supervised industrial hygienist and safety engineers/specialists, and performed accident investigations.

  **Kirtland Area Office**

  - Responsible for Fire Protection and Electrical Safety oversight of Sandia National Laboratories.

  - Coordinated, tracked and assisted in environmental, safety and health appraisals of Department of Energy facilities.

**EDUCATION:** Bachelor's of Science, Electrical Engineering

**OTHER:** Certified Safety Professional
Management Oversight and Risk Tree Analysis (MORT) Training

NAME: C. Bryan Drennan

**AREA OF RESP:** Accident Investigation Board Advisor

**ASSOCIATION:** Sandia National Laboratories

**EXPERIENCE:** 25 years

- **Hutchinson Brown & Partners** - Electrical Construction Inspector
  - Contract Compliance, Safety Compliance
- **Holmes & Narver Inc.** - Senior Principle Electrical Designer
  - Electrical Systems Design
  - Senior Project Engineer
  - Construction Inspection Project Manager
  - Electrical Safety Specialist
- **Sandia National Laboratories**
  - Member of Technical Staff/Electrical Safety Specialist
  - Program development, inspection, training, occurrence investigation, and standards interpretation

  Special Assignments
  - Member Department of Energy (DOE) Electrical Safety Task Force
  - Principle Trainer for DOE Model Electrical Safety Program
  - Principle Trainer for DOE Construction Electrical Safety
  - Chairman EFCOG Electrical Safety Committee
  - Member State of New Mexico Construction Industries - Electrical Bureau Technical Advisory Committee

**EDUCATION:** B.U.S. Communications, University of New Mexico M.A. Training & Learning Technologies, University of New Mexico
Doctoral Candidate, Training & Learning Technologies/Civil Engineering, University of New Mexico

**OTHER:** Certified Electrical Inspector & Plans Examiner - ICBO, BOCA, IAEI
Certified OSHA 1910, 1926 Instructor

NAME: Daniel E. Glenn

AREA OF RESP: Accident Investigation Board Advisor

ASSOCIATION: Los Alamos Area Office

EXPERIENCE: 14 Years

- **Defense Programs Fellowship to the University of New Mexico**
- **Chief of the Facility Operations Branch at the Los Alamos Area Office (LAAO)**
  - Responsible for the oversight of a wide diversity of both nuclear and non-nuclear facilities.
- **Facility Representative and Chief of the Reactors Operations Branch at the Savannah River Site.**
  - Responsible for the oversight of three Type A production reactors, the K-reactor restart effort, the implemenatation of Conduct of Operations, and the safe-shutdown and lay-up of P-Reactor.
- - **U.S. Navy Nuclear Submarine Officer**

EDUCATION: B.S., Nuclear Engineering, Pennsylvania State University (1982)
M.S., Nuclear Engineering, University of New Mexico (1995)

OTHER: Qualified K-Reactor Facility Representative Supervisor (1991)
Naval Quality Assurance Supervisor (1987)
Naval Nuclear Engineer (1986)

- **NASA Manned Spacecraft Center, Houston, TX**

  - Aerospace Engineer, Space Science Payload System Integration

- **The U.S Air Force, Tinker Air Force Base, Oklahoma City, OK**

  - Structures Engineer, Aircraft Accident Investigation

**EDUCATION:** B.S., Mechanical Engineering, University of Oklahoma
Graduate Studies in Aerospace Engineering

**OTHER:** DOE Exceptional Service Award (1994)
DOE Accident Investigation Chairman Workshop (1993)
Fundamentals of DOE Operations (1990)
Japanese Methods for Productivity and Quality (Deming-1982)

**OTHER:**

Board Certified Internal Medicine (1983)
Board Certified Occupational and Environmental Medicine (1995)
Member, American College of Occupational and Environmental Medicine.
Member, New York Occupational and Environmental Medicine Association.

NAME: Janice E. Hill

AREA OF RESP: Accident Investigation Board Administrative Support

ASSOCIATION: Paragon Technical Services, Inc.

EXPERIENCE: 16 Years

- **Paragon Technical Services, Inc.**

  - Logistical Coordinator. Provide DOE-HQ onsite administrative support for Type A Accident Investigation processes and procedures.

- **Battelle Seattle Research Center**

  - Researcher. Supported DOE-HQ with Type A Accident Investigation processes and procedures, and onsite assessments and reviews. Provided onsite administrative support for the DOE-HQ Type A Accident Investigation of the Security Rappel Training Tower Fatality at the Savannah River Site, the DOE-HQ Type A Accident Investigation of the Electrical Arc Blast Injury at Building 9725 at Oak Ridge Reservation, the DOE-HQ Order Compliance Review at the Los Alamos TA-55 facility, and the EH Oversight Assessment of the Operational Readiness Review of the Rocky Flats Building 707.

- **EG&G Idaho, Inc.**

  - Program Administrator. Provided onsite administrative support for the DOE-HQ Type A Accident Investigation of the Hanford Steam Pit Fatality, the DOE-HQ Spent Fuel Initiative, the Chemical Safety Oversight Review at Los Alamos National Laboratory, and the Special Review of OSHA Programs for the Hanford High-Level Waste Tanks.

  - Report Coordinator. Provided onsite support to the Safety and Health Subteam on the Tiger Team Assessments at Paducah Gaseous Diffusion Plant, the Solar Energy Research Institute, the Los Alamos National Laboratory, the Naval Petroleum Reserves, and the Strategic Petroleum Reserves.

EDUCATION: Completed coursework in computers and speedwriting through the Eastern Idaho Technical College. Completed numerous professional workshops, general management and administrative skill courses.

OTHER: Certified Trainer, Crosby Quality Education System
Member, American Nuclear Society

# APPENDIX C

# MEDICAL INFORMATION RELATED TO THE ACCIDENT

BERNALILLO COUNTY MEDICAL CENTER

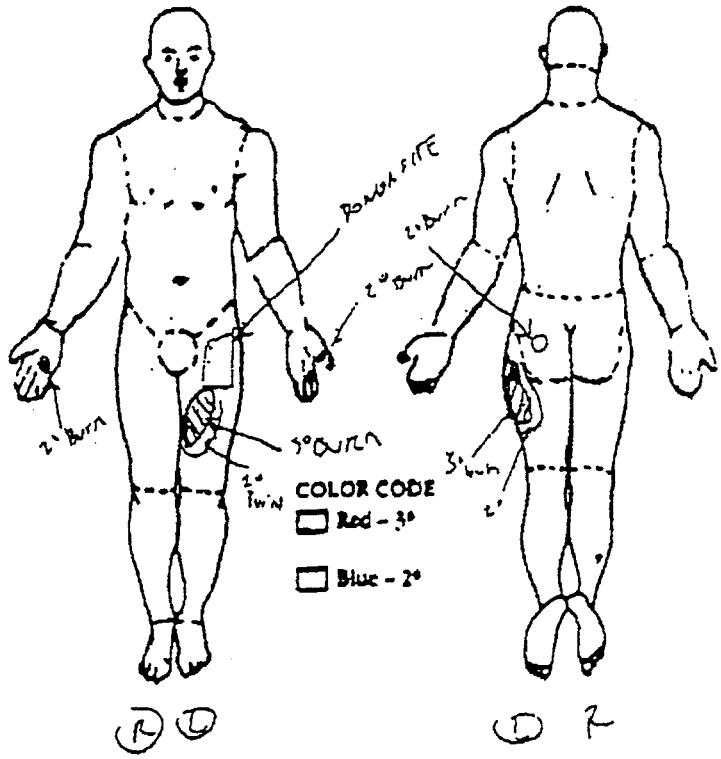
## BURN ESTIMATE AND DIAGRAM

AGE vs. AREA

| Area | Birth 1 yr. | 1-4 yr. | 5-9 yr. | 10-14 yr. | 15 yr. | Adult | 2° | 3° | Total | Donor Areas |
|---|---|---|---|---|---|---|---|---|---|---|
| Head | 19 | 17 | 13 | 11 | 9 | 7 | | | | |
| Neck | 2 | 2 | 2 | 2 | 2 | 2 | | | | |
| Ant. Trunk | 13 | 13 | 13 | 13 | 13 | 13 | | | | |
| Post. Trunk | 13 | 13 | 13 | 13 | 13 | 13 | | | | |
| R Buttock | 2½ | 2½ | 2½ | 2½ | 2½ | 2½ | | | | |
| L. Buttock | 2½ | 2½ | 2½ | 2½ | 2½ | 2½ | 1% | | 1%/2 | |
| Genitalia | 1 | 1 | 1 | 1 | 1 | 1 | | | | |
| R. U. Arm | 4 | 4 | 4 | 4 | 4 | 4 | | | | |
| L. U. Arm | 4 | 4 | 4 | 4 | 4 | 4 | | | | |
| R. L. Arm | 3 | 3 | 3 | 3 | 3 | 3 | | | | |
| L. L. Arm | 3 | 3 | 3 | 3 | 3 | 3 | | | | |
| R Hand | 2½ | 2½ | 2½ | 2½ | 2½ | 2½ | 1 | | 1 | |
| L Hand | 2½ | 2½ | 2½ | 2½ | 2½ | 2½ | 1 | | 1 | |
| R. Thigh | 5½ | 6½ | 8 | 8½ | 9 | 9½ | | | | |
| L. Thigh | 5½ | 6½ | 8 | 8½ | 9 | 9½ | 3° | 1% | 3% | 40% |
| R Leg | 5 | 5 | 5½ | 6 | 6½ | 7 | | | | |
| L. Leg | 5 | 5 | 5½ | 6 | 6½ | 7 | | | | |
| R Foot | 3½ | 3½ | 3½ | 3½ | 3½ | 3½ | | | | |
| L Foot | 3½ | 3½ | 3½ | 3½ | 3½ | 3½ | | | | |
| | | | | | | TOTAL | | | | |

AGE 35 y.o.
SEX MALE
WEIGHT _____

BURN DIAGRAM




**Burn Estimate and Diagram**

# APPENDIX D

# OCCURRENCE REPORT

# JOHNSON CONTROLS WORLD SERVICES INC.
## Preliminary Occurrence Report

Data Deliverable 1.6-DD-002

REPORT NO.: 96-043

DATE AND TIME EVENT WAS DISCOVERED: 17 January, 1996 0930 hours

LOCATION: TA-21, Building 209, Basement

DESCRIPTION OF EVENT OR CONDITION: Employee was excavating with a pneumatic jackhammer inside a building when he struck a 13.2 KVW line electrocuting himself. The second employee was effected by smoke caused by the burning line and emotional shock.

DISCOVERED BY: Roy Romero, Z No.

WITNESSES: n/a

LANL ESH-EM&R REPRESENTATIVE ADVISED: EMO notified by 911 call TIME: 0931 hours

JOHNSON CONTROLS REPRESENTATIVE ADVISED: Manny L'Esperance TIME: 0945 hours

APPARENT CAUSE OF EVENT OR CONDITION: Unlocated power line in area marked for excavation.

IMMEDIATE CORRECTIVE ACTION TAKEN AND RESULTS: All excavation projects halted pending a formal review of procedures.

IS DOCUMENTATION ATTACHED? YES ☐ NO ☒

ORIGINATOR: Manny L'Esperance DATE: 01/17/96

DEPARTMENT MANAGER: [signature] DATE: 1-19-96

GENERAL MANAGER: [signature] DATE: 1-22-96

FORM NO. 11-02-027.2 rev. 2 7/11/95

OCCURRENCE REPORT

Tritium Salt Facility

(Name of Facility)

Tritium Activities

(Facility Function)

Los Alamos National Laboratory / Los Alamos National Laboratory

(Name of Laboratory, Site or Organization)

Name: Dennis Carathers
Title: Facility Manager Telephone No.: (505)667-8439

(Facility Manager/Designee)

Name: HINDE, MICHELE B
Title: OCCURRENCE INVESTIGATOR Telephone No.: (505)665-0033

(Originator/Transmitter)

Name: Michele Brin Hinde Date: 01/17/1996

(Authorized Classifier (AC))

1. OCCURRENCE REPORT NUMBER: ALO-LA-LANL-TSF-1996-0001
   A mason tender was severely injured when he hit a 13,200 volt buried electrical power line with a jack hammer while performing excavation

2. REPORT TYPE AND DATE:

| | Date | Time |
|---|---|---|
| [X] Notification | 01/18/1996 | 1003 MTZ |
| [ ] Initial Update | | |
| [ ] Latest Update | | |
| [ ] Final | | |

3. OCCURRENCE CATEGORY:
   [ ] Emergency [X] Unusual [ ] Off-Normal [ ] Cancelled

4. NUMBER OF OCCURRENCES: 1 ORIG. OR:

5. DIVISION OR PROJECT: Tritium Science & Engineering

6. SECRETARIAL OFFICE: DP - Defense Programs

7. SYSTEM, BLDG., OR EQUIPMENT:
   Electrical Feeder, Technical Area 21, Building 209, Sump

8. UCNI?: No

9. PLANT AREA: TA-21-209

10. DATE AND TIME DISCOVERED:
    01/17/1996 0934 (MTZ)

11. DATE AND TIME CATEGORIZED:
    01/17/1996 1200 (MTZ)

16. DESCRIPTION OF OCCURRENCE: (continued)
by the JCI foreman to be holding the jack hammer and shaking followed by an explosion. The JCI mason tender started to fall into the hole. The JCI foreman pulled the JCI mason tender back and ran for help.

The electrical power supply to TA-21-152, 155,and 209 was disrupted at 0934. The emergency diesel generator started automatically to supply electrical power to the tritium stack monitors and stack ventilation system in TA-21-155 and TA-21-209. The fire protection and security systems were powered by uninterruptable power supply batteries.

17. OPERATING CONDITIONS OF FACILITY AT TIME OF OCCURRENCE:
The facility was under normal operations. Three laborers were performing excavation work in the basement of TA-21-209.

18. ACTIVITY CATEGORY:
Construction

19. IMMEDIATE ACTIONS TAKEN AND RESULTS:
The JCI foreman ran to the nearby ESA-TSE group office to notify facility personnel. The facility secretary immediately called 911. When told the JCI mason tender required CPR, the secretary asked a nearby administrative aide to talk with the EMO personnel on the phone and went with the facility manager designee to administer CPR to the JCI mason tender. Both the secretary and facility manager designee were currently trained in administering CPR. A Tritium Science and Engineering (ESA-TSE) staff member and the acting building manager removed the JCI mason tender from the hole. The facility secretary and the facility manager designee administered CPR until emergency medical personnel arrived.

The emergency medical personnel administered medical emergency care and transported the JCI mason tender and the JCI foreman to the Los Alamos Medical Center at 0954 on January 17, 1996.

Upon notification, the LANL Emergency Management and Response (EM&R) notified the facility manager, JCI area management, LANL electrical safety personnel, LANL utilities, JCI utilities, LANL facility maintenance, occurrence investigation.

An EM&R incident commander cleared non-medical personnel from the TA-21-209 basement, taped off access to the basement, and restricted personnel access to preserve the scene of the incident. Once the electrical safety personnel declared the area safe to enter, two recording technicians photographed and video taped the incident scene.

Under the direction of the LANL safety engineers, utilities

---

| | | |
|---|---|---|
| 25. IS FURTHER EVALUATION REQUIRED?: | Yes [X] | No [ ] |
| IF YES - BEFORE FURTHER OPERATION?: | Yes [X] | No [ ] |
| BY WHOM?: | Dennis Carathers | |
| BY WHEN?: | 02/29/1996 | |

OCCURRENCE REPORT

Tritium Salt Facility
(Name of Facility)

Tritium Activities
(Facility Function)

Los Alamos National Laboratory / Los Alamos National Laboratory
(Name of Laboratory, Site or Organization)

Name: Dennis Carathers
Title: Facility Manager Telephone No.: (505)667-8439
(Facility Manager/Designee)

Name: HINDE, MICHELE B
Title: OCCURRENCE INVESTIGATOR Telephone No.: (505)665-0033
(Originator/Transmitter)

Name: Michele Brin Hinde Date: 01/24/1996
(Authorized Classifier (AC))

1. OCCURRENCE REPORT NUMBER: ALO-LA-LANL-TSF-1996-0001
A mason tender was severely injured when he hit a 13,200 volt buried electrical power line with a jack hammer while performing excavation

2. REPORT TYPE AND DATE:

| | Date | Time |
|---|---|---|
| [ ] Notification | 01/18/1996 | 1003 MTZ |
| [ ] Initial Update | 01/19/1996 | 1617 MTZ |
| [X] Latest Update | 01/24/1996 | 0820 MTZ |
| [ ] Final | | |

3. OCCURRENCE CATEGORY:
[ ] Emergency [X] Unusual [ ] Off-Normal [ ] Cancelled

4. NUMBER OF OCCURRENCES: 1 ORIG. OR:

5. DIVISION OR PROJECT: Tritium Science & Engineering

6. SECRETARIAL OFFICE: DP - Defense Programs

7. SYSTEM, BLDG., OR EQUIPMENT:
Electrical Feeder, Technical Area 21, Building 209, Sump

8. UCNI?: No

9. PLANT AREA: TA-21-209

10. DATE AND TIME DISCOVERED:
01/17/1996 0934 (MTZ)

11. DATE AND TIME CATEGORIZED:
01/17/1996 1200 (MTZ)

16. DESCRIPTION OF OCCURRENCE: (continued)
by the JCI foreman to be holding the jack hammer and shaking followed by an explosion. The JCI mason tender started to fall into the hole. The JCI foreman pulled the JCI mason tender back and ran for help.

The electrical power supply to TA-21-152, 155,and 209 was disrupted at 0934. The Tritium Systems Test Assembly (TSTA) diesel generator started automatically to supply electrical power to all critical safety loads at TSTA and the ventilation exhaust blower at the Tritium Science and Fabrication Facility (TSFF). The tritium stack monitors for the TSFF were powered by an uninterruptable power supply battery in the TSFF. The fire protection and security systems were powered by UPS batteries.

17. OPERATING CONDITIONS OF FACILITY AT TIME OF OCCURRENCE:
The facility was under normal operations. Two laborers were performing excavation work in the basement of TA-21-209.

18. ACTIVITY CATEGORY:
Construction

19. IMMEDIATE ACTIONS TAKEN AND RESULTS:
The JCI foreman ran to the nearby ESA-TSE group office to notify facility personnel. The facility secretary immediately called 911. When told the JCI mason tender required CPR, the secretary asked a nearby administrative aide to talk with the EMO personnel on the phone and went with the facility manager designee to administer CPR to the JCI mason tender. Both the secretary and facility manager designee were trained in administering CPR. A Tritium Science and Engineering (ESA-TSE) staff member, the acting building manager, the facility manager designee, and the facility secretary removed the JCI mason tender from the hole. The facility secretary and the facility manager designee administered CPR until emergency medical personnel arrived.

The emergency medical personnel administered medical emergency care and transported the JCI mason tender and the JCI foreman to the Los Alamos Medical Center at 0954 on January 17, 1996.

Upon notification, the LANL Emergency Management and Response (EM&R) notified the facility manager, JCI area management, LANL electrical safety personnel, LANL utilities, JCI utilities, LANL facility maintenance, occurrence investigation.

An EM&R incident commander cleared non-medical personnel from the TA-21-209 basement, taped off access to the basement, and restricted personnel access to preserve the scene of the incident. Once the electrical safety personnel declared the

19. IMMEDIATE ACTIONS TAKEN AND RESULTS: (continued)
generator for operability on a regular basis during normal operations, at night, and during the weekend. TSFF was monitored by facility staff 11\orps\ORPSTEXTincluding an RCT with a portable tritium monitor. Over the weekend, facility personnel checked the status of the facility without entering the tritium area.

The DOE investigation team scheduled interviews and compiled a list of additional documentation needed by the team. The team secured all physical evidence from the incident scene.

24. EVALUATION: (By Facility Manager/Designee)
The investigation is on-going. The DOE investigation was upgraded to a Type A investigation on January 18, 1996.

25. IS FURTHER EVALUATION REQUIRED?: Yes [X] No [ ]

IF YES - BEFORE FURTHER OPERATION?: Yes [X] No [ ]

BY WHOM?: Dennis Carathers

BY WHEN?: 02/29/1996

# APPENDIX E

# DOCUMENTS REVIEWED

APPENDIX E Procedures Reviewed

DP 101, ES&H Operating Policy

DP 102, Formality of Operations

PRD 102-02.0, Conduct of Operations

DP 103, Environment, Safety and Health

DP 106, Occupational Safety and Health

DP 110, Quality

PRD 110-01.0, Quality Assurance Management Plan

Quality Management Plan for 10 CFR 830.120

DP 112, Configuration Management

PRD 112-01.0 Configuration Management

DP 116, Stop work and Restart

LP 116-01.0, Stop Work and Restart

AR 1-10, Environment Safety and Health Questionnaire

AR 1-11, Work Request Review

AR 1-12, Excavation or Fill Permit Review

AR 1-14, Environment Safety and Health Facility Design Review

ESA-TSE-QP-08, R3, Review Board Procedure

Facilities Engineering Procedure 3-5-1, Eng-5 Field Operations

JCI ESH Manual, 12-22-006, Excavations

JCI ESH Manual, 12-21-112, Hazards Assessment Requirements

# APPENDIX F

# INDIVIDUALS INTERVIEWED

| Individual | Report Designation | Org. | Company |
|---|---|---|---|
| Alaryd, James | ESH-18 Field Engineer | ESH-18 | LANL |
| Alaryd, James | Graduate Research Assistant | ESH-18 | LANL |
| Alvaro, Vigil | Mason-tender | | JCI |
| Ames, Lauren | Santa Fe Engineering, Vice President | SFE | SFE |
| Anderson, James | TA-3 Team Leader | FSS-9 | LANL |
| Barnes, Gaye | Team leader ESH Identification Process | ESH-3 | LANL |
| Bastian, Rich | Director, Quality and Planning Programs | QP | LANL |
| Bell, William | Facility Representative, TA-18 | FO | LAAO |
| Bennett, Gloria | ES&H Trainer | ESH | LANL |
| Beri, Jerry | | | LANL |
| Blauert, Gary | Electrical & Steam Supervisor | | JCI |
| Brittan, Katherine | Director, Audits & Assessments Office | AA | LANL |
| Bruhn, Robert | Safety Engineer | | JCI |
| Burick, Dick | Director, Engineering Sciences and Applications | ESA | LANL |
| Cahalane, Pat | Facility Representative, TA-55, TA-21 | FO | LAAO |
| Carlson, Richard | Team Leader for Operations TSTA | | LANL |
| Chroninger, William | Work Planner and Coordinator | FSS-9 | LANL |
| Corathers, Dennis | Facility Manager, ESA Division | ESA-FM | LANL |
| Diamond, Stephen | Principal Engineer, Field Engineer (NPDES project) | SFE | SFE |
| Domingues, Phil | Cement Mason Foreman | | JCI |
| Dominguez, Phil | Foreman, masons | R&G | JCI |
| Dussart, Steve | Electrical Foreman | | JCI |
| Eddelman, Rick | Safety Reviewer | ESH-3 | LANL |
| Elliot, Al | Team Leader, Occurrence Investigation | ESH-7 | LANL |
| Elliott, Al | Occurrence Reporting | ESH-7 | LANL |
| Erickson, Dennis | Director, Environment, Health, and Safety | ESH | LANL |
| Fogle, Terry | Technical Staff Member | ESH | LANL |
| Fox, Dick | Group Leader | FSS-8 | LANL |
| Frame, Kandy | Acting Building Manager, TA-21, Bldg. 209 | ESA-TSFF | LANL |
| Fresquez, Robert | Supervisor, Operational Safety | Safety | JCI |
| Garcia, Sam | Safety Engineer | | LANL |
| Gill, Bob | Electrical Inspector | ICFKeiser | LANL |
| Goodwin, Dave | Maintenance Training Coordinator | | JCI |
| Green, Donn | Building Manager, TA-21 Bldg. 209 | ESA-TSFF | LANL |
| Hopwood, Roy | Electrical Supervisor | | JCI |
| Horak, Henry L. | Team Leader for TSSF & D&D Activities | | LANL |
| Huchton, Judith | Records & Procedures Team Leader | ESH-13 | LANL |
| Hunsinger, Mark | Occurrence Reporting | Quality | JCI |
| Jackson, Jim | Deputy Director, LANL | LANL | LANL |
| Keyser, Robert | Safety Engineer | | JCI |
| Khoury, Ann | LANL Training Director | HRD | LANL |
| Lopez, Joe | Manager, Health and Safety | Safety | JCI |
| March, Joan | ES&H Trainer | ESH | LANL |
| Martinez, Efren | JCI mason | R&G | JCI |
| Martinez, Efren | victim | R&G | JCI |
| Martinez, Gerald | Utilities Power Control Supervisor | | JCI |
| Martinez, Sam | Line Foreman | | JCI |
| McCorkle, Wally | Group Leader FSS-9 | FSS-9 | LANL |
| McReynolds, Daniel | Manager, Maintenance (Acting) | Maint. | JCI |
| Medina, Jimmy | Union Steward, Laborers Union | | |
| Mullen, William | Assist. Area Mgr. for Facilities Operations (Acting) | FO | LAAO |

| Individual | Report Designation | Org. | Company |
|---|---|---|---|
| Martinez, Efren | JCI mason | R&G | JCI |
| Martinez, Efren | victim | R&G | JCI |
| Romero, Roy | mason's coworker | R&G | JCI |
| Alaryd, James | ESH-18 Field Engineer | ESH-18 | LANL |
| Alaryd, James | Graduate Research Assistant | ESH-18 | LANL |
| Ames, Lauren | Santa Fe Engineering, Vice President | SFE | SFE |
| Barnes, Gaye | Team leader ESH Identification Process | ESH-3 | LANL |
| Bastian, Rich | Director, Quality and Planning Programs | QP | LANL |
| Bell, William | Facility Representative, TA-18 | FO | LAAO |
| Brittan, Katherine | Director, Audits & Assessments Office | AA | LANL |
| Burick, Dick | Director, Engineering Sciences and Applications | ESA | LANL |
| Cahalane, Pat | Facility Representative, TA-55, TA-21 | FO | LAAO |
| Corathers, Dennis | Facility Manager, ESA Division | ESA-FM | LANL |
| Chroninger, William | Work Planner and Coordinator | FSS-9 | LANL |
| Diamond, Stephen | Principal Engineer, Field Engineer (NPDES project) | SFE | SFE |
| Dominguez, Phil | Foreman, masons | R&G | JCI |
| Eddelman, Rick | Safety Reviewer | ESH-3 | LANL |
| Elliot, Al | Team Leader, Occurrence Investigation | ESH-7 | LANL |
| Erickson, Dennis | Director, Environment, Health, and Safety | ESH | LANL |
| Frame, Kandy | Acting Building Manager, TA-21, Bldg. 209 | ESA-TSFF | LANL |
| Fresquez, Robert | Supervisor, Operational Safety | Safety | JCI |
| Green, Donn | Building Manager, TA-21 Bldg. 209 | ESA-TSFF | LANL |
| Hunsinger, Mark | Occurrence Reporting | Quality | JCI |
| Jackson, Jim | Deputy Director, LANL | LANL | LANL |
| Lopez, Joe | Manager, Health and Safety | Safety | JCI |
| McCorkle, Wally | Group Leader FSS-9 | FSS-9 | LANL |
| McReynolds, Daniel | Manager, Maintenance (Acting) | Maint. | JCI |
| Mullen, William | Assist. Area Mgr. for Facilities Operations (Acting) | FO | LAAO |
| Nasise, Joseph | Employee responder | ESA-TSFF | LANL |
| Rae, Stephen | Group Leader, Water Quality & Hydrology | ESH-18 | LANL |
| Roberts, Roy | Pipe Fitter | R&G | JCI |
| Runkle, Gene | Director, Occupational Safety and Health | OSH | ALO |
| Sandoval, Tina Marie | Project Leader, NPDES project | ESH-18 | LANL |
| Swertfeger, Tom | Foreman, pipe fitters | R&G | JCI |
| Trujillo, Levi | Superintendant R&G (Acting), Supervisor, Masons | R&G | JCI |
| Tuggle, Dale | Employee responder | ESA-TSFF | LANL |
| Turner, Bill | Supervisor, Work Control | WC | JCI |
| Van der Hoeven, Bernie | Director, Facilities, Security, and Safeguards | FSS | LANL |
| Varva, George | General Manager | JCI | JCI |
| Vigil, Alvaro | Laborer, mason | R&G | JCI |
| Vozella, Joe | Asst. Area Mgr. Environment & Projects | E&P | LAAO |
| Wendt, Mark | Field engineer | SFE | SFE |
| Williams, Niel | Team Leader, NPDES Program | ESH-18 | LANL |
| Zimmerman, Gail | Training Staff | | LANL |

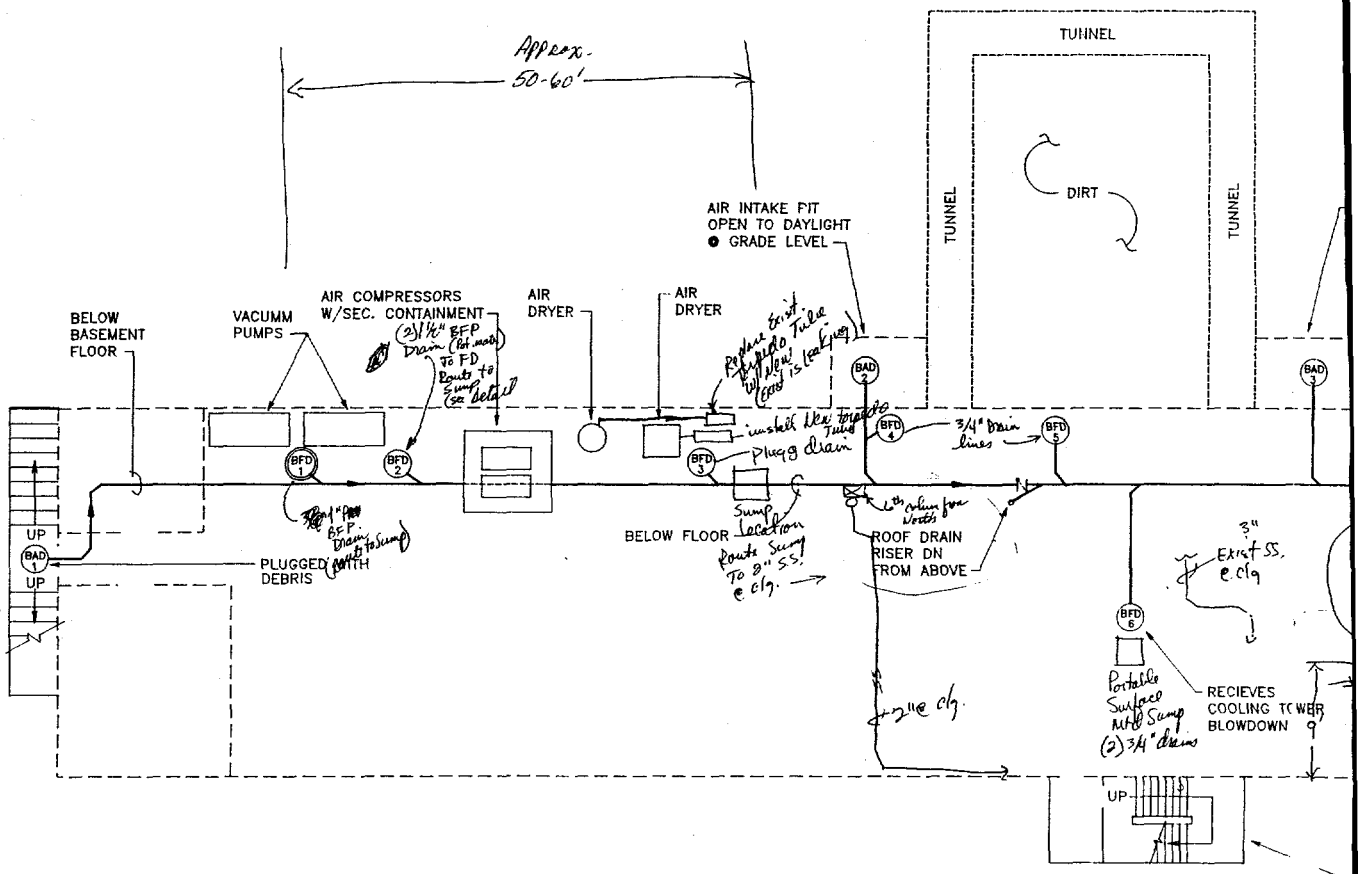
# APPENDIX G

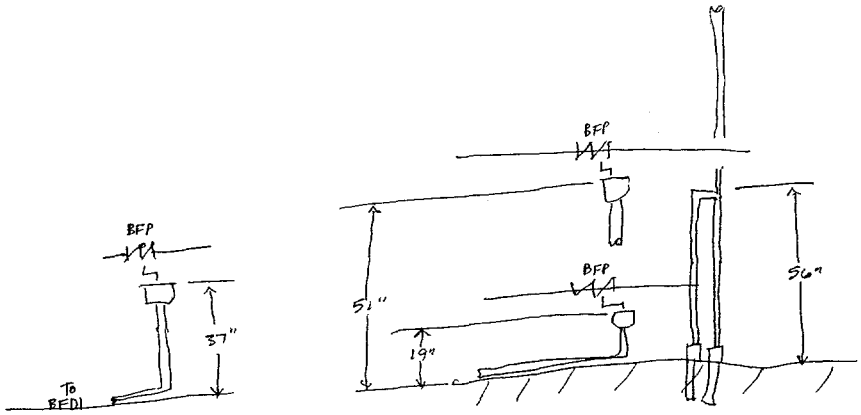
# SUPPORTING GRAPHICS

G-1 Sante Fe Engineering Preliminary Drawing
G-2 Concrete and Tuff Examinations
G-3 Integrated Accident Event Matrix
G-4 Waste Stream Corrections ESH Project Summary
G-5 ESH-3 Technical Review of the Waste Stream Corrections Project
G-6 As-Built Facility Drawing From Los Alamos National Laboratory FSS-3 Archives

# APPENDIX G-1

# SANTA FE ENGINEERING PRELIMINARY DRAWING




**TA-21-209**
**BASEMENT**
– NOT TO SCALE –

| SYMBOL LEGEND | |
|---|---|
| CD | CUP DRAIN |
| C.O. | FLOOR CLEANOUT |
| TD | TRENCH DRAIN |
| WH | WATER HEATER |
| N | CHECK VALVE |

○ DYE TESTED DRAIN

NOTE:

THIS DRAIN SCH
FROM L.A.N.L. D
C-31986, C-3
C-32009, C-3
C-32013, C-3
SITE VISITS.

# APPENDIX G-2

# CONCRETE AND TUFF EXAMINATIONS

Johnson Controls World Services Inc.
Laboratory Support Division
Post Office Box 50
Los Alamos, NM 87544-0050

JOHNSON CONTROLS

February 9, 1996

DOC. NO: EMTD96.096
SS Subcontract No: P-X86-Y7575-1

Mr. David Spence
DOE Type A Investigation Team
MS A316
Los Alamos, NM

Dear Mr. Spence:

**SUBJECT: DOCUMENT TRANSMITTAL**

Per your request, the following document is being delivered to you. By copy of this letter, the document is also being transmitted to R. Brake, ESH-7, for record.

Report titled: "Concrete and Tuff Examinations, TA-21, Building 209, Work Ticket # FMU0101", dated February 9, 1996, consisting of 3 single pages.

Respectfully submitted,

Will Hobbs

Wilbert F. Hobbs
Materials Testing and Inspection Superintendent
MS A199 EMTD
ph: 667-7098 Fax: 667-0795

WFH/wfh

Attachments: a/s

Cy: R. Brake, LANL ESH-7, w/att., MS K999
Melvin L. McCorkle, LANL FSS-DO, MS P908
Don S. McCoy, JCI-EMDO, w/att
EMTD file w/att

JOHNSON CONTROLS WORLD SERVICES INC.
Los Alamos Support Services Project

February 9, 1996
DOC. NO: EMTD96.095

# CONCRETE and TUFF EXAMINATIONS

## TA-21, BUILDING 209

## WORK TICKET # FMU0101

## SCOPE / OBJECTIVE:

On January 22, 1996, Mr. David Spence, a member of the DOE Type A Investigation Board, requested Engineering Materials Testing and Inspection (EMTD) to test pieces of concrete that had been removed from the concrete envelope that surrounded the conduit that carried the power line that is the subject of an accident investigation. The Board also requested tests of a piece of undisturbed tuff (welded volcanic ash) that had been removed from the excavation. The work was authorized by work order through FSS-9.

The concrete and tuff pieces were selected jointly by EMTD and representatives of the Bldg. 209 Facility Manager from the piles of "rubble" that surrounded the excavation. The DOE Board requested compressive strength tests for both materials, using similar specimens and test configurations for each.

DOE's stated purpose for the tests was to develop a comparison of the penetration resistance between the two materials.

It was recognized that the concrete pieces were so irregular in shape and small that standard size specimens could not be prepared; that the samples were also flawed by several 1/2" drilled holes passing through them at random angles; and that the results of such tests should not be considered accurate or unquestionable evidence of strength or resistance to impact.

Cutting, shaping and testing of specimens was witnessed by Mr. Spence.

## CONCLUSIONS:

Compression tests of the prepared specimens revealed relatively low strength concrete and normal strength tuff.

Average compressive strength of concrete, from two tests, was approximately 1130 psi.
Average compressive strength of tuff, from three tests, was approximately 320 psi.

No other conclusions are drawn as to bias, or to the relative differences in strength of the two materials.

Specimen C - **Tuff

Dimensions:
(A)2.18" x (B)2.18" x (C)2.20"
Load area: 4.75 sq. in
Applied force: 2323 lb.
Compressive strength: 489 psi
Adj. for width/ height ratio:
489 x *0.87 = 425 psi

Specimen D - **Tuff

Dimensions:
(A)2.28" x (B)2.14" x (C)2.28"
Load area: 4.87 sq. in
Applied force: 1548 lb.
Compressive strength: 318 psi
Adj. for width/height ratio:
318 x *0.87 = 277 psi

Specimen E - **Tuff

Dimensions:
(A)2.38" x (B)2.45" x (C)8.75"
Load area: 5.86 sq. in
Applied force: 1489 lb.
Compressive strength: 254 psi

* Ideal specimens have a width/height ratio greater than 1:1.8 (ASTM C 39)

** Unit weight of tuff is assumed to be within a range of:
80 to 90 lb./cu ft

Respectfully submitted,

Wilbert F. Hobbs, PE
Materials Testing and Inspection Superintendent
MS A199 EMTD
ph: 7-7098 Fax: 7-0795

# APPENDIX G-3

# INTEGRATED ACCIDENT EVENT MATRIX

# Integrated Accident Event Matrix

| | *January 16, 1996* | | | | | |
|---|---|---|---|---|---|---|
| ***Time*** | ***1:00 p.m.*** | ***2:00 p.m.*** | | ***3:00 p.m.*** | ***4:00 p.m.*** | |
| JCI Mason #1 | Arrive at TA-21-209, position Air Compressor | Set up concrete saw | Cut 36" square from concrete floor | Jack Hammer and remove concrete | Jack Hammer and remove tuff to depth of 12" | End of shift |
| JCI Mason #2 | | | | | | |
| JCI Mason #3 | Arrive at TA-21-209, position Air Compressor | Set up concrete saw | Cut 36" square from concrete floor | Jack Hammer and remove concrete | Jack Hammer and remove tuff to depth of 12" | End of shift |
| Lay Responder #2 | | | | | | |
| Lay Responder #2 | | | | | | |

| | *January 17, 1996* | | | | | |
|---|---|---|---|---|---|---|
| ***Time*** | ***7:30 a.m.*** | ***8:40 a.m.*** // | ***8:45 a.m.*** | ***8:50 a.m.*** | ***8:55 a.m.*** | ***9:00 a.m.*** |
| JCI Mason #1 | Start of Shift | Arrive at TA-21-209 | | Start Air Compressor | Jack Hammer and remove tuff with pry bar and shovel | Jack Hammer and remove tuff with pry bar and shovel |
| JCI Mason #2 | Start of Shift | Arrive at TA-21-209 | | Start Air Compressor | | |
| JCI Mason #3 | Start of Shift | | | | | |
| Lay Responder #1 | | | | | | |
| Lay Responder #2 | | | | | | |
| Lay Responder #3 | | | | | | |

# Integrated Accident Event Matrix

| | *January 17, 1996* | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Time*** | ***9:30 a.m.*** // | ***9:34 a.m.*** | ***9:35 a.m.*** | ***9:36 a.m.*** | ***9:37 a.m.*** | ***9:38 a.m.*** | ***9:39 a.m.*** |
| JCI Mason #1 | Jack Hammer penetrates concrete encasement and asphalt conduit | Jack Hammer bit contacts 13.2 KV cable. Power out in TA-21-209 | | | | | |
| JCI Mason #2 | | Heard a buzzing sound like a welder saw, a bright flash and a big explosion in the pit. He slumped forward like he had passed out. I pulled him back and ran for help | Ran to the back door, couldn't get in (600'), ran to the front door and 911 call made | | | | |
| JCI Mason #3 | | | | | | | |
| Lay Responder #1 | | | | Arrive at accident site in TA-21-209 Assess victim, assess risk of electrical shock | Try to remove Jack Hammer with shovel handle, check victim carotid - No pulse | | |
| Lay Responder #2 | | | | " | | | |
| Lay Responder #3 | | | | " | | | Jump into pit to help lift victim from pit |
| Lay Responder #4 | | | | " | | Concern for back injury | |

# APPENDIX G-4

# WASTE STREAM CORRECTIONS
# ESH PROJECT SUMMARY

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

# Environment, Safety, and Health (ES&H) Project Summary

| ESH-3 USE ONLY | |
|---|---|
| ESH ID Number | Tech ID |
| 95-0188 | CDG |
| Date | |
| 08/24/95 | |

Project or Proposal Title
WASTE STREAM CORRECTIONS

| Completed By (Print Name) | | | Organization | Mail Stop | Phone | Fax |
|---|---|---|---|---|---|---|
| [redacted] | | | ESH-18 | [redacted] | [redacted] | |
| **Line Manager (Name)** | **Signature** | **Date** | **Organization** | **Mail Stop** | **Phone** | **Fax** |
| [redacted] | | | ESH-18 | [redacted] | [redacted] | |
| Facility Manager (Name) | | | Organization | Mail Stop | Phone | Fax |
| ES&H Representative (Name) | | | Organization | Mail Stop | Phone | Fax |
| Construction Project Manager (Name) | | | Organization | Mail Stop | Phone | Fax |

## Project Description

☐ ***Continuation of an existing project or process***

ESH-ID number of project: _____

Original project title: _____

Reason for this review:

- ☐ New stage of construction design review
- ☐ Project or process scope change
- ☐ Other (specify) _____

☒ **New project**

**Objectives, scope of activities, and approach**

Objectives: CORRECT DEFICIENCIES IN DRAIN PIPING AT MANY LANL BUILDINGS SUBJECT TO LANL CWA NPDES PERMIT, AO AND FFCA.
Scope: PLUG DRAINS, RE-PIPE DRAINS, INSTALL PUMPS, ELIMINATE OUTFALLS, VERIFY PLUMBING.
Approach: WILL BE USING ESH-18 PERSONNEL, FSS-9 AND JCI PERSONNEL, FSS-6 COORDINATION OF OUTSIDE CONTRACTORS (BOA), AND INTERNAL FACILITY MANAGEMENT MODEL AND OPERTING GROUPS.

**Related Projects or Phases (titles and any identifying #s)**

**Project Schedule** Start Date 10/01/95 Completion Date 09/30/96

## Exclusions/Mitigating Factors

**None of the information contained in this Project Profile is sensitive unclassified (proprietary, in confidence, etc.) or classified.**

**The project involves human subjects, experiments, construction, process, or other physical activities likely to require ES&H review.**

**Existing documents:**

- ☐ ES&H Questionnaire, Project Summary, or Project Profile ID # - _____
- ☐ Standard Operating Procedure (SOP) ID # _____
- ☐ Special Work Permit (SWP) ID # _____
- ☒ None of the above

## LANL Descriptor Number (provide all that are known)

| DOE Projects | | Non DOE Work for Others (WFO) | | Other (specify type) | |
|---|---|---|---|---|---|
| Master PI Number | | Proposal Number | - - - | | |
| Project ID Number | | Sponsoring Agency | | Identification Number | |
| Service Request Number | | | | | |
| BUS Contract Number | | | | | |

## System Impacts, Applicable Documents, and Permits (continued)

- [ ] Monitors
- [ ] Natural gas (lines, regulators, valves, compressors, safety systems)
- [ ] Security (physical) (includes any activities which might impact operational or industrial physical security, e.g., movement of walls, fences, or other security barriers)
- [X] Sewer or industrial waste treatment (includes settling ponds)
- [ ] Special equipment for handling toxic, hazardous, or radioactive materials, including waste
- [X] Spill prevention
- [ ] Telephone/telecommunications
- [X] Water distribution systems (e.g., potable, sanitary, waste, cooling, discharge, mains, pumps, valves, well house)
- [ ] Other systems of potential ES&H or physical security concern (identify the systems and describe the work and/or impact)

- [ ] None of the above

## Environmental Factors

- [X] The project involves waste generation. The project will generate:
  - [ ] Airborne emissions
  - [X] Liquid effluents/wastes
  - [X] Solid wastes
- [X] The project involves waste transportation and/or disposal. The waste contains:
  - [ ] Hazardous/toxic, radioactive, or mixed wastes
  - [ ] Materials/chemicals identified as being recyclable
  - [X] Sanitary wastes
  - [ ] Other (specify) _____
- [ ] The project involves other waste management factors
  - [ ] Solid Waste Management Units (SWMUs)
  - [ ] Storage tanks for petroleum or wastes
  - [ ] A Waste Research, Development and Demonstration (RDD) project
  - [ ] Other (specify) _____
- [ ] The project involves waste management plans, forms, and/or permits
- [ ] The project involves other potential environmental factors (specify)

_____

- [ ] None of the above

## Safety and Health Factors

The project will involve:

- [ ] Animal subjects
- [ ] Electromagnetic sources (e.g., infrared or ultraviolet, lasers, magnetic fields, radio-frequency or microwave radiation fields, X-ray generating devices)
- [X] Explosives, explosive articles (also contact DX-1, 7-9737)
- [ ] Firearms or firearms ammunition
- [ ] Fissionable materials (includes U-233, U-235, Pu-238, Pu-239, Pu-242)
- [ ] Flammable gases, liquids, or solids
- [ ] Human subjects (also contact ESH-2, 7-7251)
- [X] Industrial hygiene (e.g., allergens, asphyxiants, fatigue, irritants, lighting, noise, temperature extremes, vibrations)
- [ ] Motorized transport of hazardous materials (including radiological)
- [ ] Non-explosive, non-radiological hazardous materials (e.g., biological/medical, chemicals, cryogens, epoxies and epoxy compounds, fibers and particulates, metals and metal compounds, pesticides, preservatives, solvents, unstable or reactive compounds, strong oxidizing agents)
- [X] Operational safety (e.g., falling objects, impacts, confined spaces, large electrical currents or voltages, heat or high temperatures, hydraulic or pneumatic pressures, mechanical-related hazards, soldering and welding)
- [X] Radiological materials
- [ ] Shielding of personnel or equipment
- [ ] Other potential safety or health hazards
- [ ] None of the above

# Project Profile for ESH ID 95-0188
# WASTE STREAM CORRECTIONS

## Section 2: Purpose, Type, and Scope of Project

**Purpose of project**

- **Compliance: Regulatory, Administrative Requirements (AR), etc.**
- **Construction**
  - Design

    The design is, or will be, accomplished through:
    - Architect/Engineer (A/E)

      Description: SANTA FE ENGINEERING

    The design is in the following stage:
    - Conceptual design
  - Internal modification of an existing facility

    Project will involve invasive work which could disturb 'hidden' hazards or have emergency response, safety, or

    Work is NOT covered by an SWP
  - New facility or external addition to an existing facility

    Description of external construction work relevant to ES&H or physical security concerns:

    MANHOLE, SEWER LINE, ADD LIFT STATION
- **Equipment maintenance, modification, transport, or disposal (other than motor vehicles)**

## Section 3: Location, Site, and Facility Data

**LANL: INSIDE**

TA: 8 ALL Bldg: ALL Room:

Project involves ground breaking or soil disturbance inside or immediately adjacent (< 50 ft) to the building

| Function of Building or Room | Past | Present | Proposed |
|---|---|---|---|

In addition to the past functions or uses indicated above, this facility is known to have contained:

Type of construction: Not Specified

Facility hazard classifications and relevant reports

Performance Category: Not Specified

Consequence-of-Failure Type (CFT) quality level: Not Specified

**LANL: OUTSIDE**

TA: 8 ALL Sub-Area: ALL

This is a previously disturbed site

Project involves ground breaking or soil disturbance of any kind or the clearing or cutting of native vegetation

Project has NOT received an excavation review

The site work or ground disturbance will be in preparation for, or related to:

- Other: SEWER LINES

Disturbed area will involve a known or suspected SWMU

Construction equipment or off-road vehicles will be used

A Dredge/Fill Permit will NOT be required

## Section 4: System Impacts

**Project will involve or impact the following systems**

- **Sewer and industrial waste treatment (includes settling ponds)**

  Work is NOT covered by a SWP
  - Drains and lines

## Section 6: Safety and Health Factors

- **Operational safety**

  Project MAY involve some the following potenial physical hazards:

  - Confined spaces
    - Construction work
  - Electrical current/voltage
    - Shock

    Description of hazard: MINOR ELECTRICAL WORK ASSOCIATED WITH PUMPS
- **Radiological materials**
  - Other radiological materials

    Description: POTENTIAL CONTAMINATED WASTE WATER.

# APPENDIX G-5

# ESH-3 TECHNICAL REVIEW OF THE WASTE STREAM CORRECTIONS PROJECT

OS ALAMOS
TIONAL LABORATORY

# ES&H REVIEW
## Service Request/Supplement
Facilities Engineering Division

☐ Service Request Eng File Code 7.23.1
☐ SR Supplement Eng File Code 7.23.1.1

SR No. 02447
Work Order No.

| Building | Room | Date |
|---|---|---|
| 00 | | 9/28/95 |

Y ☐ N Will this job involve, need, or generate any of the following?

☐ Lasers ☐ Radiation ☐ Chemicals ☐ Corrosives ☐ Carcinogens ☐ Spec. Vent (Const.) ☐ Hood Mods/ Shutdowns
☐ X-Rays ☐ Rad. Waste ☐ Beryllium ☐ Microwaves ☐ High Pressure ☐ Electrical>480V
☒ Noise ☐ Asbestos ☐ Explosives ☐ HVAC Mods. ☐ Toxic Materials ☐ Hazardous Waste ☐ Underground Storage Tanks
☐ PCBs ☐ Solvents ☐ Magnets ☐ Soil Disturbance ☐ Heavy Metals ☐ Structural Mods.
☐ SWMU ☐ Other (Specify) _____

Y ☐ N Will this job require any of the following?

☐ ES&H Questionnaire ☐ Entry Into a Radiological Area ☐ Locate Exisiting Underground Utilities
☒ Entry Into a Security Area ☐ Personnel to be on Respirator List ☒ Pre-job Meeting
☐ Entry Into an Explosives Area ☐ Personnel to be on PU List ☒ Lockout/Tagout AS REQD

Y ☒ N Will this job require outages?

☐ Electrical ☐ Fire Protection ☐ Gas ☐ Communications ☐ Water ☐ Steam ☐ HVAC/Chilled Water/Cooling

Y ☒ N Will this job require permits or approvals?

☐ ASR Asbestos-Rad ☐ CWD Chemical Waste Disposal ☐ RCR RCRA ☐ HSC HSWA/CERCLA
☐ ASH Asbestos-Haz ☐ NSC NPDES/Spill Control ☐ AIR Air ☐ Space/Siting
☐ EXC Excavation ☐ RDR Rad-RSWD ☐ Other (Specify) _____

**Special Work Permits**

☐ RAD Rad. Work Permit ☐ LEC LE/CS ☐ HAZ Haz. Activities ☐ SPF Spark/Flame
☐ CELE Electrical ☐ CUO Cont. Unattended Ops. ☐ Other (Specify) _____

Y ☐ N Will this job require crafts contacting any of the following groups?

☒ HS-1 ☒ HS-3 ☐ HS-5/OS ☐ HS-5/IH ☐ HS-6 ☐ HS-12
☐ EM-7 ☐ EM-8/ENV ☐ EM-8/NEPA ☐ EM-13
☐ ENG-3 ☒ ENG-5 ☐ ENG-6 ☐ ENG-7 ☐ EM&R/FP
☒ SSS-Safety ☒ SSS-IH ☐ SSS-ENV
☒ Other (Specify) ESH-18 [redacted]

| | |
|---|---|
| -1 Review Signature (If required) | Date |
| -3 Review Signature (Required) [redacted] | Date 9/28/95 |

mments
CONTACT ESH-1 FOR RADIOLOGICAL CONCERNS
SSS TO SET PPE LEVEL

rm 1340 (6/93)

DER 06006SLA WO CATEGORY R

ID 016938 TASK CODE S001 PRIORITY EST TYPE F WO TYPE SLA SPECIAL CATEGORY

LE WASTE STREAM CORRECTIONS AUTHOR CHRONINGER WILLIA[redacted]ROUP ESH-18 [redacted]BER 00002447

| | TA | BLDG | ROOM | GRID | CLASS A EQUIP | CLASS B EQUIP |
|---|---|---|---|---|---|---|
| RDER ISSUE DATE 10/03/1995 | 99 | 0000 | | ..... | | |
| COMPLETION DATE 09/30/1996 | | | | | | |
| Y MANAGEMENT UNIT 00 | | | | | | |

---------- COST ESTIMATES ---------->

NTINGENCY BALANCE 0 FISCAL YEAR 1996

| | SERVICE REQ ESTIMATE | AUTHORIZATION TO SPEND | FY AUTHORIZATION TO SPEND |
|---|---|---|---|
| BOR | 500,000 | 500,000 | 500,000 |
| TERIALS | 100,000 | 100,000 | 100,000 |
| UIPMENT | 0 | 0 | 0 |
| BCONTRACT | 0 | 0 | 0 |
| A | 0 | 0 | 0 |
| HER | 0 | 0 | 0 |
| NTINGENCY | 0 | 0 | 0 |
| TAL | 600,000 | 600,000 | 600,000 |

<---------- ACCOUNTING SPLITS ---------->

| FIN ACCT | COST CENTER | PROG CODE | COST ACCT | WORK PKG | SPLIT % |
|---|---|---|---|---|---|
| 64000 | 7C1800 | WE3K | 0000 | 0000 | 100.0 |

<---------- ES&H PERMITS REQUIRED ---------->

<---------- ES&H TEXT ---------->

ES&H REVIEW: INVOLVES NOISE; REQUIRES ENTRY INTO A SECURITY AREA; REQUIRES PRE-JOB MEETING AND LOCKOUT/TAGOUT AS REQUIRED; CONTACT ESH-1, FSS-9, SSS-SAFETY, SSS-IH, AND S. RAE, ESH-18. CONTACT ESH-1 FOR RADIOLOGICAL CONCERNS. SSS TO SET PPE LEVEL.

<---------- CRAFT ESTIMATES ---------->

| CRAFT | HOURS |
|---|---|
| CEMENT MASON | 0 |
| ELECTRICIAN | 0 |
| INSULATOR | 0 |
| LABORER | 0 |
| PIPEFITTER | 0 |

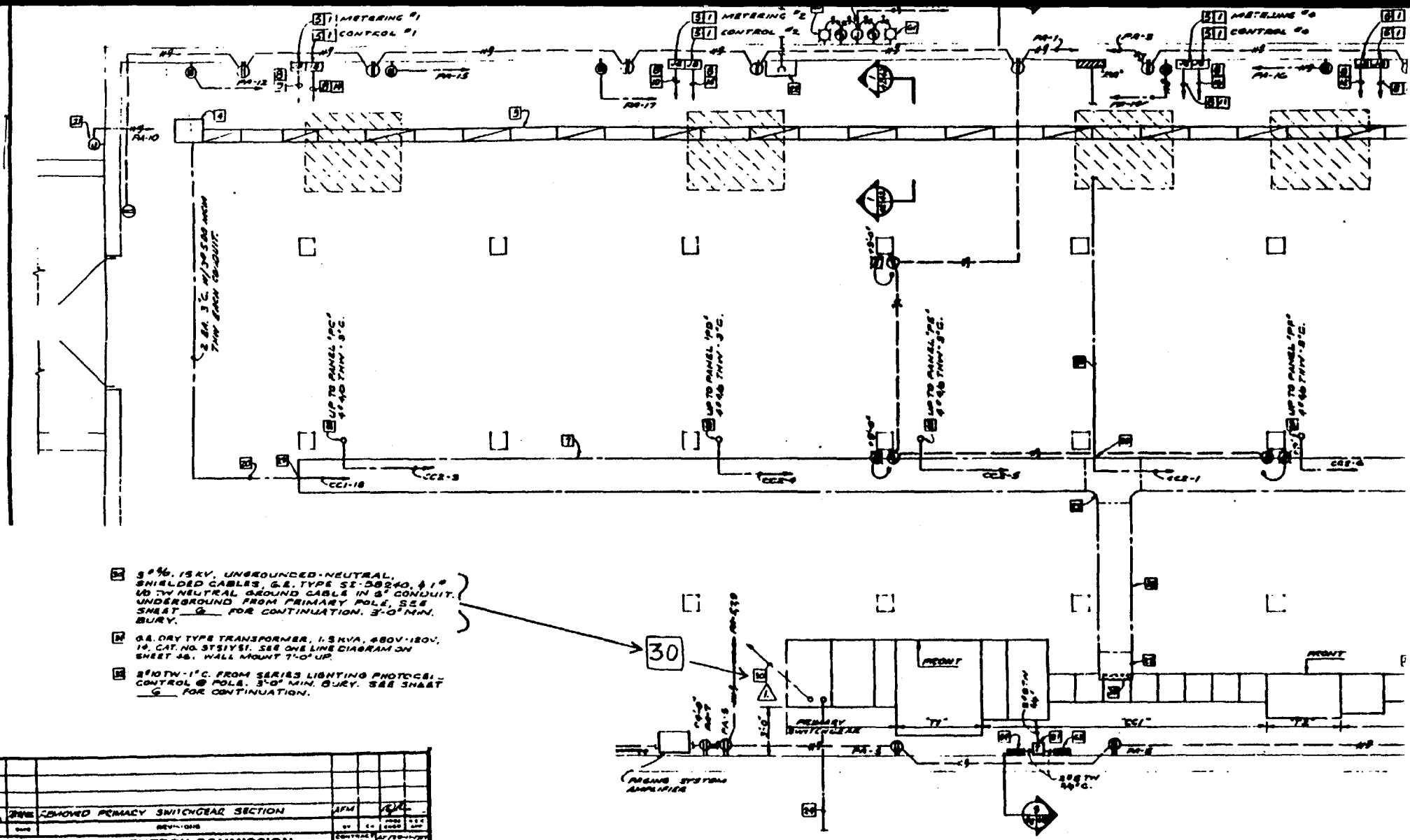
FWO APPROVAL [redacted]

<---------- WORK ORDER SCOPE ---------->

PERFORM WASTE STREAM CORRECTIONS.

# APPENDIX G-6

# AS-BUILT FACILITY DRAWING FROM LOS ALAMOS NATIONAL LABORATORY FSS-3 ARCHIVES




3 #6, 15 KV, UNGROUNDED-NEUTRAL, SHIELDED CABLES, G.E. TYPE SI-38240, & 1 #8 THW NEUTRAL GROUND CABLE IN 3" CONDUIT. UNDERGROUND FROM PRIMARY POLE. SEE SHEET 6 FOR CONTINUATION. 3'-0" MIN. BURY.

G.E. DRY TYPE TRANSFORMER, 1.5 KVA, 480V-120V, 1Ø, CAT. NO. 9T51Y51. SEE ONE LINE DIAGRAM ON SHEET 4B. WALL MOUNT 7'-0" UP.

2#10 TW-1"C. FROM SERIES LIGHTING PHOTOCELL CONTROL @ POLE. 3'-0" MIN. BURY. SEE SHEET 6 FOR CONTINUATION.

## PARTIAL BASEMENT PLAN - AREA (1)

SCALE: 1/8"=1'-0"

| | | | |
|---|---|---|---|
| 2/27/62 | REVISED PRIMARY SWITCHGEAR SECTION | AFM | |

U. S. ATOMIC ENERGY COMMISSION
LOS ALAMOS AREA OFFICE
LOS ALAMOS, NEW MEXICO

HIGH TEMPERATURE CHEMISTRY FACILITY
(BUILDING DP-209 TA-21)
ELECTRICAL
BASEMENT AREA 1; POWER PLAN & DETAILS

NEUNER & CABANISS
ARCHITECT ENGINEERS

LA-GH-705 | SHEET 42 | OF 49

AS BUILT DRAWING

RECOMMENDED NEUNER & CABANISS

RECOMMENDED PROJECT ENG'R A.E.C.

APPROVED CHIEF, ENG'R & CONST. A.E.C.

Excerpts From Original (Copy of) Drawing