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Type B Accident Investigation Board Report on the February 27, 1998, Shipping Violations Involving the Corehole 8 Project at Oak Ridge National Laboratory Oak Ridge, Tennessee

Oak Ridge Operations
U.S. Department of Energy

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RELEASE AUTHORIZATION

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

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

This report neither determines nor implies liability.

INDEPENDENT REPORT

On March 12, 1998, I appointed a Type B Accident Investigation Board to investigate the February 27, 1998, shipping violations involving the Corehole 8 Project at the Oak Ridge National Laboratory, located in Oak Ridge, Tennessee. The responsibilities of the Board have been satisfied with respect to this investigation. The analysis, identification of contributing and root causes, and judgments of need reached during the investigation were performed in accordance with DOE Order 225.1A, *Accident Investigations.*

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

James C. Hall
Manager
Oak Ridge Operations Office

Date Accepted: _____

PROLOGUE

This Type B investigation is an important reminder that even the seemingly routine activities that we are carry out every day in support of the environmental restoration mission have important health and safety implications, and they may go wrong if not given proper attention.

As cleanup of the Oak Ridge Reservation proceeds, there will be hundreds of projects like Corehole 8. I expect that many of these projects will have to be carried out on expedited schedules. Limited budget dollars will demand that we look for ways to streamline the workforce to get the best productivity. The new ORO M&I organization will subcontract more work, and reliance on well- established central organizations such as the Lockheed Martin Transportation and Packaging Management Organization will be substantially reduced. Employees transitioned to the M&I will have to learn new management systems and procedures. The oversight that has been provided in the past by the Lockheed Martin organization will be redefined by the new, more streamlined Bechtel Jacobs Company.

I trust that all contractors supporting Oak Ridge Operations, whether prime to DOE or subcontractor, will take the time to read this report, think about how the above realities could potentially impact the safety and quality of our work, recognize that there is no such thing as a routine health and safety activity, and work with us to achieve an integrated safety management system that will work in spite of change.

James C. Hall
Manager
Oak Ridge Operations Office

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ACRONYMS AND INITIALISMS

CASI	Commodore Advanced Sciences, Inc.
CDM Federal	CDM Federal Programs Corporation
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U. S. Environmental Protection Agency
ES&H	Environment, Safety and Health
FAA	Federal Aviation Administration
FOF	Field Office Facility
IAEA	International Atomic Energy Agency
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IT	International Technology Corporation Geotechnical Laboratory
IWQP	Integrated Water Quality Program
LM	For the purpose of this document, LM refers to Lockheed Martin Energy Systems, Inc. (LMES) and/or Lockheed Martin Energy Research, Inc. (LMER)
LMTPM	Lockheed Martin Transportation and Packaging Management
MOU	Memorandum of Understanding
OR	Oak Ridge Operations Office
ORNL	Oak Ridge National Laboratory
ORPS	Occurrence Reporting and Processing System
PCBs	Polychlorinated Biphenyls
PWP	Project Work Plan
QAE	Quality Assurance Evaluation
QAP	Quality Assurance Plan
QAPjP	Quality Assurance Project Plan
RCT	Radiological Control Technician
SOW	Statement of Work
SSHSP	Site Specific Health and Safety Plan
SwRI	Southwest Research Institute, Inc.
Thermo NUtech	Thermo NUtech Laboratory
Weston	Roy F. Weston, Inc.
WMP	Waste Management Plan

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EXECUTIVE SUMMARY

INTRODUCTION

On February 27, 1998, in the course of carrying out a characterization and monitoring Project at the Oak Ridge National Laboratory, a contractor and their subtier contractors reporting to Lockheed Martin Energy Systems incorrectly shipped radioactive samples to three analytical laboratories. Shipments to all three laboratories involved the use of public roads. Shipments to one of the laboratories also involved an air carrier. All of the laboratories notified the Lockheed Martin Sample Management Office that the samples had not met U.S. Department of Transportation requirements. These notifications prompted several response actions including this Type B investigation. The Federal Aviation Administration (FAA) was also notified by one analytical laboratory and is investigating this incident. The FAA conducted their field investigation in cooperation with this investigation Board.

The Board concluded that the radioactive samples as shipped by this Project did not comply with Federal and State requirements for packaging, offering for transportation, and transportation of hazardous materials. Failure to correctly identify the radiological constituents of the samples and failure to perform radiological dose surveys of the sample packages resulted in misclassification and incorrect packaging.

CAUSAL FACTORS

The Board identified two root causes for the incidents; the elimination of either would have prevented the incidents:

- Failure to comply with regulations and procedures, specifically 49 CFR, ESP-505 Rev. 1, and the MOU
- Lack of trained, competent, personnel commensurate with responsibilities for packaging and transportation

The Board also identified seven contributing causes that may have increased the likelihood of the incidents, without individually causing the incidents:

- Failure to identify packaging and transportation as critical functions
- Incorrect communication of the radionuclides in the samples for limited quantity determination
- Failure to assign a properly trained individual to be responsible for packaging and transportation
- Failure to follow the quality assurance requirements
- Failure to survey the packages for DOT purposes
- Failure to perform quality assurance and transportation safety field surveillance and audit
- Lessons learned from similar incidents were not considered by the Project

CONCLUSIONS AND JUDGMENTS OF NEED

Table ES-1 presents the conclusions and judgments of need determined by the Board. The conclusions are those the Board considered significant and are based upon facts and pertinent analytical results. Judgments of need are managerial controls and safety measures believed by the Board to be necessary to prevent or minimize the probability of a recurrence of

this type of incident. Judgments of need are derived from the conclusions and causal factors and are intended to assist managers in developing follow-up actions.

Table ES-1. ***Conclusions and Judgments of Need***

Conclusions	Judgments of Need
Regulatory requirements and procedures adequate for packaging and transportation of hazardous materials were referenced in Project documents. The requirements and procedures were not adhered to by the Project.	There is a need for DOE Headquarters' Office of Environmental Management, OR, and LM, to evaluate awareness of the shipping regulations and their importance to DOE commitments to health and safety. There is a need for LM to establish a formal approach for implementing a fast track teaming concept to projects. This approach must clearly assign responsibility for implementing project requirements and procedures.
Inadequately trained personnel were performing functions under 49 CFR.	There is a need for LM to develop and implement a program to ensure their incumbent and future hazmat employees and subcontractor hazmat employees are trained in accordance with 49 CFR.
Project personnel failed to develop and implement quality assurance planning as required by procedures.	There is a need for OR and LM to ensure that project personnel are trained on the requirements of ORNL/ER-225 and to ensure that project managers comply with the requirements of this procedure. There is a need for OR to develop and implement a program for assuring that personnel involved in projects are adequately trained on quality assurance requirements.
Lessons learned were prepared, but not analyzed to identify trends and potential systemic problems for management attention.	There is a need for OR and LM to enhance their lessons learned program by preparing, analyzing, and disseminating trends and potential systemic problems from lessons learned in a useful and usable form. There is also a need for OR and LM to ensure that line management incorporates relevant information into their project planning.

1.0 INTRODUCTION

1.1 BACKGROUND

Multiple probable shipping violations involving the Corehole 8 Project (referred to as the "Project") at the Oak Ridge National Laboratory (ORNL) occurred on February 27, 1998. Five shipments were made from ORNL to the Southwest Research Institute, Inc. (SwRI) in San Antonio, Texas, one to International Technology Corporation Geotechnical Laboratory (IT) in Kingston, TN, and one to Thermo NUtech Laboratory (Thermo Nutech) in Oak Ridge. All shipments contained radioactive material, but were improperly offered for transport and transported as non-declared hazardous materials, resulting in probable violations of U.S. Department of Transportation (DOT) regulations.

On March 12, 1998, James C. Hall, Manager, Oak Ridge Operations Office (OR), U.S. Department of Energy (DOE), appointed a Type B Accident Investigation Board (referred to as "the Board") to investigate these incidents in accordance with DOE Order 225.1A, Accident Investigations (See Appendix A).

1.2 PROJECT DESCRIPTION

Located 20 miles west of Knoxville, Tennessee, ORNL was established in 1943 and is now the largest of the DOE's five multiprogram, non-weapons laboratories with an annual operating budget of almost $500 million. ORNL focuses on five areas of research and development: energy production and end-use technologies; biological and environmental science and technology; advanced materials synthesis, processing, and characterization; neutron-based science; and computational science and advanced computing.

Since the initiation of operations at ORNL, radioactive and hazardous wastes have been stored on the Oak Ridge Reservation. Environmental investigations within the main plant of ORNL have identified radiological contamination in the groundwater. One significant source of contamination to the nearby surface water is the Corehole 8 plume. The Corehole 8 plume source is suspected to be an inactive, low-level, liquid waste tank (W-1A) in the North Tank Farm. The scope of the Corehole 8 Project is to install groundwater wells, conduct subsurface soil sampling, and perform geotechnical analysis of the Corehole 8 plume.

At the time of the incidents, samples were being extracted from three soil borings around tank W-1A. Lockheed Martin (LM) has overall responsibility for this Project and utilizes by contract the services of Commodore Advanced Sciences, Inc. (CASI). According to their statement of work, CASI's responsibilities include "all activities to obtain analytical and geotechnical analyses of soil samples." In turn, CASI subcontracted CDM Federal Programs Corporation (CDM Federal) for a field geologist and Roy F. Weston, Inc. (Weston) for field management/supervison of all sampling and drilling activities. LM, CASI, and their subtier contractors used a fast track teaming approach to plan and execute the Project. The specific incidents investigated by the Board were the improper offsite shipping of radioactive soil samples for analysis.

1.3 SCOPE, PURPOSE, AND METHODOLOGY

The Board began its investigation on March 13, 1998, completed the investigation on March 27, 1998, and submitted its final report to the OR Manager on March 27, 1998.

The **scope** of the Board's investigation was to review and analyze the circumstances of the incidents to determine their cause. The Board also evaluated the adequacy of management systems and work control practices of DOE, ORNL, and subtier contractors, as they relate to the incidents.

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

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

- Facts relevant to the incidents were gathered through interviews, document and evidence reviews, and examination of physical evidence.
- Event and causal factors charting[1], along with barrier analysis[2] and change analysis[3] techniques, were used to analyze facts and identify the incidents' cause.
- Based on analysis of the information gathered, judgments of need for corrective actions to prevent recurrence were developed.

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

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

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

2.0 FACTS AND ANALYSIS

2.1 INCIDENT DESCRIPTION AND CHRONOLOGY

2.1.1 Background and Incident Description

The initial planning for this Project commenced on January 30, 1998, and a series of meetings were conducted from February 6 through 23. Although roles and responsibilities for the personnel involved in the Project were discussed at these meetings, no individual was assigned the responsibility for the packaging and offsite transportation of soil samples that were to be analyzed. Training and logistical requirements for personnel working on this Project were also discussed. However, the necessary training as stipulated in Title 49 of the Code of Federal Regulations (CFR) Section 172.702, *Applicability and Responsibility for Training and Testing*, for the packaging and transportation of hazardous materials did not take place. It was during this time that incomplete isotopic characterization information was provided to Lockheed Martin Transportation and Packaging Management (LMTPM), resulting in the improper limited quantity activity determination. On February 20, a management assessment of all Project plans and procedures was completed. A pre-project kick-off meeting was held on February 23, and soil boring commenced on February 24 (see Exhibit 2-1).

Project activities on February 27, the day of the incidents, are included in the chronology on Figure 2-1. None of the shipments (see Exhibits 2-2 and 2-3) on February 27 were performed by

Exhibit 2-1.
Project Drill Site

Exhibit 2-2.
External View of Soil Sample Package (provided by FAA)

personnel trained in DOT Regulations. The soil samples transported to the Federal Express Office were later sent by air to SwRI in San Antonio, Texas, arriving on February 28.

2.1.2 Chronology of Events

Figure 2-1 summarizes the chronology of significant events.

2.1.3 Notification and Response

On March 2, 1998, all three of the offsite analytical laboratories receiving soil samples from this Project notified the LM Sample Management Office that the samples were not in compliance with DOT requirements.

On March 3, 1998, LM notified the Project subcontractors, the ORNL shift superintendent, ORNL LMTPM, and the OR Program Manager of the incidents. On March 4, 1998, SwRI notified the Federal Aviation Administration (FAA) of the incidents, and LM entered the incidents into DOE's Occurrence Reporting and Processing System (ORPS). The Tennessee Department of Environment and Conservation

Exhibit 2-3.
Internal View of Soil Sample Package (provided by FAA)

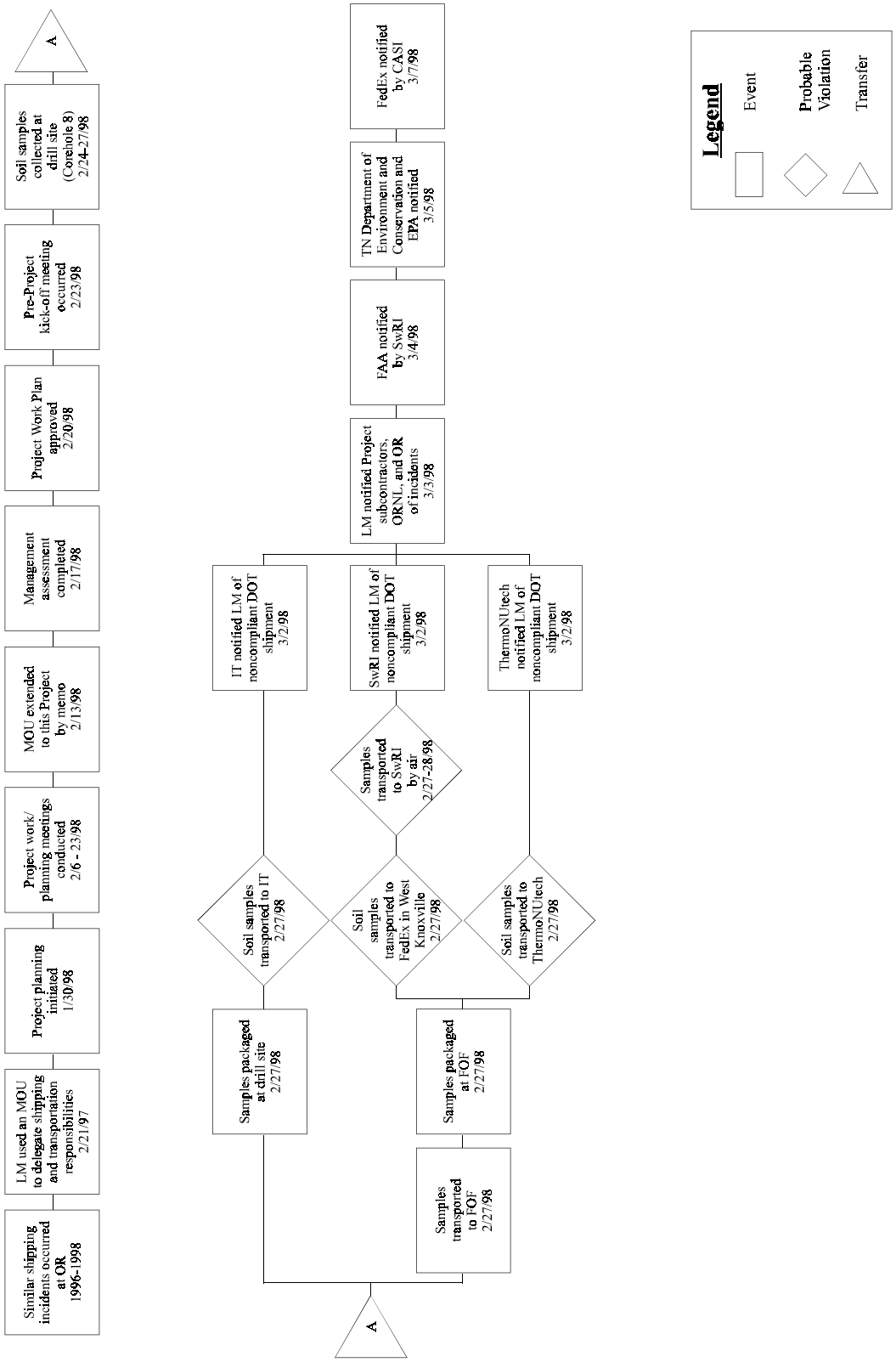

Figure 2-1. ***Chronology of Significant Events***

and the U.S. Environmental Protection Agency (EPA) were notified of the incidents on March 5. CASI notified Federal Express on March 7.

On March 11, LM issued a Red Alert requiring LM organizations to identify all offsite sample shipping activities and to immediately cease all sample shipping by subcontractors. Sample shipping is to be resumed only after confidence in procedural flow-down to subcontractors is established and subcontractors are trained in accordance with 49 CFR. Until further notice, all critical offsite sample shipping will be performed by LMTPM.

On March 19, OR issued a memorandum to its contractors directing that all analytical sample shipments be suspended until self-assessments are completed to ensure the proper shipment of samples. The intent is to make contractors evaluate compliance with DOT regulations. This suspension is to remain in place until self-assessments are completed and the contractor has sent correspondence to the OR Manager, certifying that appropriate controls are in place to resume shipping activities.

2.1.4 Prior Transportation Occurrences

A Board review of ORPS data revealed that, for the period January 1, 1996, through February 27, 1998, LM has reported 12 previous transportation occurrences involving hazardous material shipments with noncompliance in the following areas:

- Improper material identification /classification
- Improper marking, labeling, and placarding
- Missing packaging components
- Inadequate training
- Undeclared hazardous material shipments

Five of the 12 occurrences involved incorrectly identified/classed materials and three of these five occurrences involved inadequately trained personnel.

2.2 Project Controls and Management Systems

2.2.1 Hazardous Material Shipping Considerations

Regulations and Procedures

Figure 2-2 illustrates the overall regulatory framework governing the packaging and transportation of radioactive materials. It is important to note that DOE contractors and sub-tier contractors are directly regulated by the DOT for offsite transportation.

The packaging, offering for transport, and transporting of hazardous materials (including radioactive material) by highway and air is regulated by the DOT in 49 CFR 100-185, *Transportation*, and 49 CFR 325-399, *Federal Motor Carrier Safety Regulations*. Furthermore, depending upon which air carrier is chosen to transport the material, the shipments may be subject to the International Civil Aviation Organization (ICAO) regulations or the International Air Transport Association (IATA) carrier requirements.

For wholly intrastate transport of hazardous materials, these shipments are subject to the Tennessee state laws under TN Code, Annotated, Title 65, *State of Tennessee Motor Vehicle Laws* and Title 1220, *Tennessee Motor Carrier Safety Regulations*.

- LM has incorporated the Federal and state hazardous materials regulations in their Work Smart Standards.

- The Project Sampling and Analysis Plan requires compliance with ESP-505, Rev. 1, Preparing Samples and Laboratory Stan-

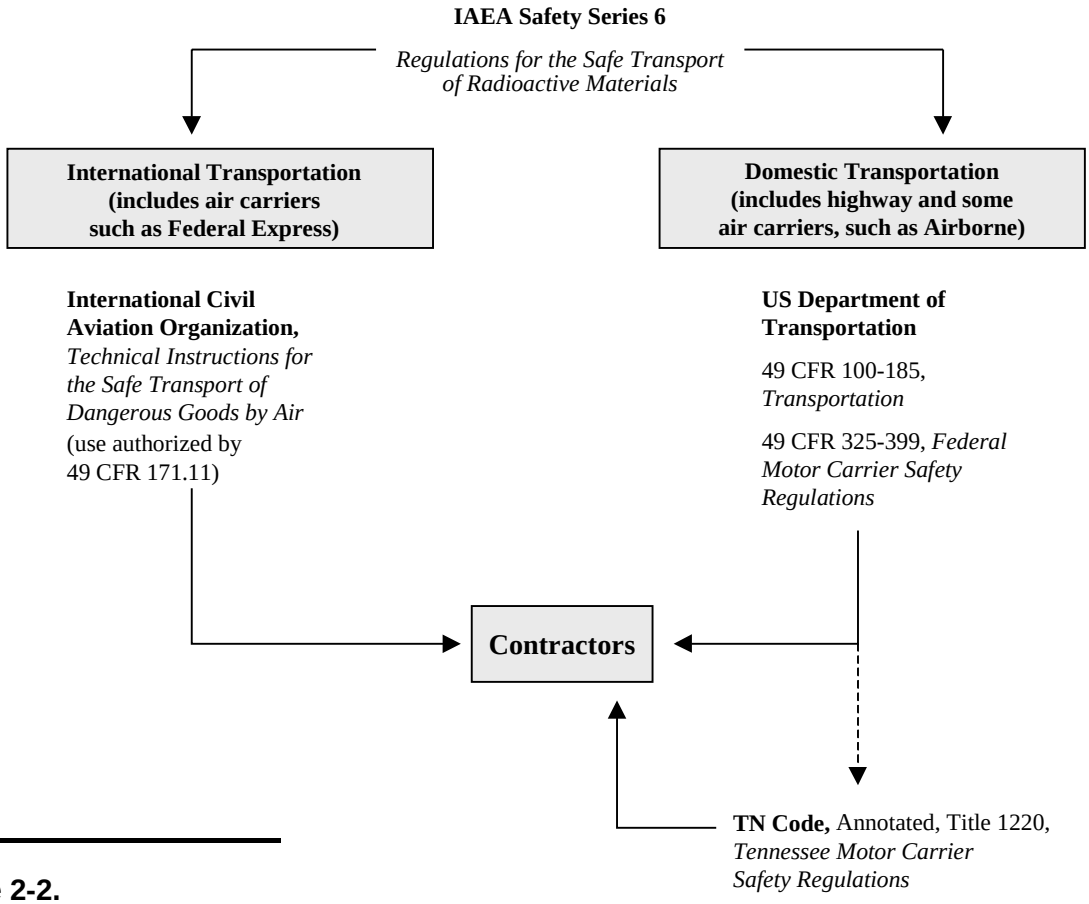

Figure 2-2.
Regulatory Flowdown

dards for Transport and Shipping, for sample preparation and shipment. ESP-505, Rev. 1 requires compliance with the DOT hazardous materials regulations.

- The Requirement for the Memorandum of Understanding (MOU)[4], as amended, that allowed the Project to perform hazardous materials packaging and transportation activities, requires limited quantity radioactive material shipments to be in compliance with 49 CFR. The MOU specified conditions such that if the sample did not meet those conditions, transportation was to be through LMTPM.

LM policy requires compliance with ORNL/M-808, Rev. 3, *ORNL Onsite Transportation Operations Manual*, for onsite shipments of hazardous materials. This manual has requirements that, if complied with, would provide equivalent levels of safety as compliance with 49 CFR. It is the conclusion of the Board that the Project did not fully comply with this manual.

[4] "Requirements for the Memorandum of Understanding (MOU) Between the Lockheed Martin Transportation and Packaging Management (LMTPM) Organization and the Oak Ridge National Laboratory (ORNL) – Environmental Restoration (ER) Surveillance and Maintenance (S&M)/Integrated Water Quality Program (IWQP)," 2/21/97, as amended.

Even though the Federal regulations, LM procedure ESP-505, Rev 1., and the MOU were all referenced in Project documentation, the Board determined that there was noncompliance with the regulations for packaging, offering for transportation, and transportation of these samples. The Board concluded that although an adequate regulatory framework is in place for sample shipments, this Project did not comply with the applicable requirements.

Packaging and Transportation Decision Process

- The regulations governing the transportation of hazardous materials are based upon the accomplishment of specific actions to ensure that materials are transported in a safe manner. Failure to perform any of these actions can result in unsafe shipments. The specific actions are as follows:

  1. **Identify the material**, including all constituents, and the appropriate regulatory agencies, such as the DOT for DOT-regulated materials, the EPA for polychlorinated biphenyls (PCBs) and Resource Conservation and Recovery Act waste, and the Occupational Safety and Health Administration for asbestos. Failure to properly identify all constituents can result in improper classification in step 2.

  2. **Classify the material** in accordance with DOT's classification system (e.g., Class 7 for radioactive materials and Class 9 for PCBs). If environmental samples meet multiple class definitions, the shipper assigns a single hazard class to the material for transportation purposes, in accordance with 49 CFR 173.2a. This classification establishes the required containment, communication, and controls.

  3. **Contain the material** as prescribed by DOT in 49 CFR Part 173, *General Requirements for Shipments and Packagings*. Packaging is based upon the material classification completed in step 2. For radioactive materials, there are three categories of packaging:

     # **Excepted packaging**, which is not tested but should meet a general standard of containment under normal transport conditions
     # **Type A packaging**, which must be documented as having passed established tests demonstrating containment under normal conditions of transport
     # **Type B packaging**, which must be certified as having passed established tests for both normal conditions of transport and hypothetical accident conditions.

  4. **Communicate the hazard** via markings, labels, and placards required by DOT and other agencies, such as the EPA.

  5. **Control the shipment** in transit by, for example, restricting public access to the material, using cargo-only aircraft, or imposing exclusive use provisions.

The samples collected on February 27, 1998, contained radioactive material. Based on interviews, Project documents, and correspondence (ref., letter dated February 16, 1998, from the LM Sample Management Office to IT), samples were anticipated to contain ^{233}U, ^{234}U, ^{90}Sr, ^{137}Cs, and ^{241}Am. Activity levels were expected to be between 500 and 1,000,000 pCi/g (18.5 – 37,000 Bq/g). Since the DOT definition of a radioactive material is greater than 70 Bq/g, the samples were expected to be regulated as Class 7 radioactive material under DOT regulations.

The CASI Laboratory Analysis Coordinator provided LMTPM with soil sample concentration levels of 500,000 pCi/g (18,500 Bq/g) for ^{90}Sr only. Based upon the presumed presence of this single nuclide, a weight limit of 11.66 pounds was established, below which the samples would have met the radioactivity restriction to be offered as a limited quantity under 49 CFR 173.421. Had the limited quantity activity calculation included the presence of the anticipated isotopes (^{233}U and ^{241}Am) and been calculated in accordance with 49 CFR 173.433, the weight limit would have been much lower. Consequently, the 11.66 pound threshold was incorrect and resulted in Type A quantities of material being packaged in unauthorized, less stringent packaging.

The limited quantity provisions of the DOT regulations require that the dose rate at the surface of the package not exceed 0.5 mrem/hr; this was also specified in the MOU. The packages prepared on February 27, measured between 0.4 and 50 mrem/hr. These measurements were made by the LM Radiological Control Technician (RCT), but were not used for shipping determinations.

The Board concluded that the soil samples as shipped by this Project required Type A packaging, however instead the samples were shipped as non-regulated material. The Board concluded that, under the MOU, the Project was not authorized to prepare Type A packages for transportation and, thus, LMTPM should have been contacted to prepare and offer the shipments.

Project Compliance with Regulations and Procedures

- The soil samples shipped on February 27, 1998, failed to comply with the Federal and state requirements for packaging, offering for transportation, and transporting hazardous materials in either inter- or intra-state commerce. Since the material was improperly identified and classed under the DOT regulations,

  # The material was improperly packaged
  # The packages were not properly marked and labeled
  # Required shipping documentation was not prepared
  # The two vehicles transporting samples to IT and Thermo NUtech were not properly placarded
  # The drivers of the vehicles driven to IT and Thermo NUtech were not properly licensed for transporting this material
  # An emergency contact number was not provided and manned while all the samples were in transit
  # Employees performing material classification, packaging, shipment preparation, and transport were not properly trained for those functions
  # Dose rate surveys to ensure compliance with 49 CFR 173.441 were not performed prior to shipments being released offsite.

Table 2-1 details how the soil samples should have been identified, prepared and transported, and how the Project actually accomplished these activities.

The Board concluded that improper identification of the material and the lack of proper training for personnel performing the packaging and transportation activities caused these shipments to be noncompliant.

2.2.2 Work Planning and Control

X It is not evident to the Board that responsibilities for packaging and transportation were properly assigned and understood. Further, a review of Project planning documents and meeting minutes indicated a

	For Compliance with Highway Requirements	For Compliance with Air Requirements (per ICAO)	Actual Project Realization
1. Identification	Radioactive Material (^{233}U, ^{234}U, ^{137}Cs, ^{90}Sr, ^{241}Am)	Radioactive Material (^{233}U, ^{234}U, ^{137}Cs, ^{90}Sr, ^{241}Am)	^{90}Sr was the only nuclide identified as present for material classification
2. Classification	Class 7, Radioactive Material, Type A quantity	Class 7, Radioactive Material, Type A quantity	Class 7, Radioactive Material, limited quantity
3. Containment (pkg)	Type A	Type A	Unauthorized Packaging (8 coolers, 1 wooden box, and 1 plastic trash can)
4. Communication			
P Shipping Paper Description	P Radioactive Material, n.o.s. 7, UN2892, ^{233}U, ^{234}U, ^{137}Cs, ^{90}Sr, ^{241}Am, Solid/oxide, *56.8 MBq, **Radioactive Yellow II label, TI = 0.6, Fissile Excepted, Emergency Contact Number: 423-XXX-XXX	P Radioactive Material, n.o.s. 7, UN2892, ^{233}U, ^{234}U, ^{137}Cs, ^{90}Sr, ^{241}Am, Solid/ oxide, 1 Type A x *56.8 MBq, **Radioactive Yellow-II, TI = 0.6, 60 cm x 60 cm x 90 cm, Fissile Excepted, Emergency Contact Number: 423-XXX-XXX, CARGO AIRCRAFT ONLY	P No documentation provided for highway; declared to air carrier as general freight
P Marking (pkg)	P Radioactive Material, n.o.s., UN2982, Type A	P Radioactive Material, n.o.s., UN2982, Type A	P None on package
P Labeling (pkg)	P **White I, Yellow II, Yellow III	P **White I, Yellow II, Yellow III, Cargo Aircraft Only	P None on package
P Placarding (vehicle)	P ***Radioactive	P Not Applicable	P None on vehicle
5. Control			
P Training	P Training per 49 CFR 172.700-704	P Training per 49 CFR 172.700-704: ICAO	P No one had CFR 172.700-704 or ICAO training
P Modal Restrictions	P None Applicable	P Cargo Aircraft Only	P Carrier couldn't comply as offered
P Segregation from Other Materials	P Segregation per 49 CFR 177.842	P Segregation per ICAO	P Carrier couldn't comply as offered
P Licensing	P 49 CFR 393, TN Code Annotated 65	P Not Applicable	P No commercial drivers license with hazmat endorsement****
P Emergency Contact	P Per 49 CFR 172.604	P Per 49 CFR 172.604; ICAO	P Not maintained during shipment

n.o.s. (not otherwise specified)
*Total activity per package varied
**Labels/Transport Index (TI) varied by package
***Required for vehicles transporting samples to IT and Thermo NUtech
****Required for drivers of vehicles transporting samples to IT and Thermo NUtech

Table 2-1. *Comparison of Project Packaging and Transportation Activities with Regulations*

noticeable lack of emphasis on packaging and transportation of samples, suggesting a lack of awareness, and thus control, of these important activities. Recognizing that the purpose of regulated packaging and transportation is to protect human health, carrier equipment, and the environment, the Board elected to use the five core safety factors as defined in DOE's *Implementation Plan for Integrated Safety Management*, as a guide for analyzing the work planning and control of these activities. The Board recognizes that any one of the following DOE Orders could have been used as an analytical guide:

- DOE Order 430.1A, *Life Cycle Asset Management*
- DOE Order 5700.6C, *Quality Assurance*
- DOE Order 5480.19, *Conduct of Operations*

Define the Scope

- The Transportation Safety Organization did not participate in developing the Statement of Work (SOW).

A review of the SOW indicated that the accompanying critical applications checklist identified transportation safety as a critical application area. However, interviews indicated that the LM Transportation Safety Organization was not included in the review of the SOW. The Board concluded that transportation safety was requested to perform specific tasks related to the management of waste; however, this organization was not involved in the overall Project planning and scope definition.

Identify and Analyze the Hazards Associated with the Work

- The Activity Hazards Analysis did not identify the packaging and transportation of soil samples as potential hazards.

The Activity Hazards Analysis included in the Site Specific Health and Safety Plan (SSHSP) evaluated DOT regulations with respect to the onsite transportation of investigation-derived waste (i.e., drill cuttings), but not soil samples. The Board concluded that Project personnel failed to recognize that packaging and transportation activities needed to be analyzed for both onsite and offsite transportation of soil samples. Failure to analyze the sample packaging and transportation activities precluded the opportunity to identify appropriate methods of control.

- Communication of radiological and chemical constituents in the soil samples was not adequate for sample identification.

The Project SOW and the Project Work Plan (PWP) identified, through process knowledge, the potential for encountering gross alpha, gross beta, gamma, tritium, and radiological isotopes in the soil samples. However, the only information provided to LMTPM for determining DOT packaging requirements was that the samples may have contained up to 500,000 pCi/g of ^{90}Sr.

The Board concluded that incomplete information was provided to LMTPM and, as a result, an improper determination for limited quantity of radioactive material was made.

Develop and Implement Hazard Controls

- No hazards were identified with respect to packaging and transportation of soil samples. Therefore, no controls were specifically developed for this aspect of the Project.

- LM did not develop a Quality Assurance Project Plan (QAPjP), as required by procedure.

- CASI did not meet the quality assurance commitments, as stated in the PWP.

LM did develop a Quality Assurance Evaluation (QAE) to define the quality requirements for the Project. However, a review of the *Quality Assurance Plan (QAP) for ORNL's Environmental Restoration Program* (ORNL/ ER-225) revealed that a QAE is not allowed by LM for a "Characterization and Monitoring" project such as this Project. Instead, ORNL/ER-225 specifically states that a QAPjP is required. Such a plan would have required the Project to clearly define and, thus, better communicate the need for the following documents:

- Organization chart and lines of authority
- Project-specific approval page for functional discipline reviewers
- Project-specific QAPjP
- Quality assurance records and controlled document list
- Performance-based training
- Surveillance plan
- Audit schedule

The absence of an organization chart contributed to confusion over roles and responsibilities for LM, CASI, and sub-tier Project personnel. Had an organization chart been prepared and discussed in meetings, it would have facilitated better planning and communication by the team. Better communications could have avoided problems that contributed to the probable transportation violations.

In addition, a list of training requirements by job function would have been required by a QAPjP. Such a list would have reduced the likelihood of untrained personnel performing packaging and transportation functions.

On February 19, 1998, an LM Quality Assurance Specialist signed off on the QAE, but according to information from interviews, was never informed of the commencement of Project field activities. ORNL/ER-225 requires a Quality Assurance Specialist, together with the LM Project Manager, to ensure that internal surveillance of field operations is planned, executed and documented. On other ORNL projects, a Quality Assurance Specialist has utilized an Environmental Management and Enrichment Facilities Surveillance Checklist for field activities (e.g., the Integrated Water Quality Program). This checklist includes lines of inquiry to determine if samples being packaged and shipped to offsite laboratories meet DOT requirements.

The Board concluded that this Project missed the opportunity to verify that work was being performed in accordance with requirements (viz., 49 CFR, DOE Orders, Project plans and procedures) by not conducting field surveillance. A field surveillance of the packaging and transportation work activities should have been conducted to assess compliance with DOT, DOE and LM requirements.

The PWP states,

> "The Quality Assurance Evaluation Checklist will be prepared prior to commencement of any field activities. The Quality Assurance Evaluation Checklist indicates the organization and responsibilities of the company(ies) of concern, indicates that all personnel possess the required training, ensures that services are in compliance with applicable regulations and verifies that equipment and supplies will be appropriately inspected, tested and assessed."

These commitments described in the PWP were not achieved through the QAE Checklist and, as a result, may have contributed to the probable shipping violations.

The Board concluded that LM and CASI failed to develop and implement adequate quality assurance, leading to confusion in roles and responsibilities, inadequate identification of training requirements, failure to adhere to requirements specified in procedures, and insufficient oversight of field activities as they relate to sample packaging and transportation.

Perform Work within Controls

- A sample management technician, whose responsibilities were to package and transport the samples to the laboratory was not present at the work-site as required by the PWP and the SSHSP. The PWP states,

  > "A sample management technician will coordinate all activities to ensure the samples are properly collected, packaged, and transferred to the appropriate analytical laboratory."

  Furthermore, the SSHSP states,

  > "LMES/LMER will provide sampling technicians during the soil sampling activities. These technicians will be responsible for collecting soil samples with the required quality control/quality assurance samples and delivering them to the laboratory for analysis and testing."

The Board identified an apparent contradiction between these statements. The PWP appears to assign the responsibility for providing a sampling technician to CASI, whereas the SSHSP appears to assign the responsibility to LM. Line management (LM and CASI) neglected to assign a responsible individual to carry out the packaging and transportation function. The Board concluded that the teaming approach used by LM and CASI, combined with the confusion of roles and responsibilities, and the ambiguity of these statements contributed to untrained Project personnel performing the packaging and transportation functions.

- Soil samples were not weighed to determine whether they exceeded limited quantity weight restrictions.

The net weight of soil samples in each limited quantity package could not exceed 11.66 pounds. Subtier contractor personnel involved in packaging activities did not use calibrated measuring equipment to weight the samples. Instead, a conservative best-guess was made that the net weight of soil samples did not exceed 11.66 pounds for shipping packages. The Board concluded that a calibrated scale should have been used to weigh the soil samples and that this lack of attention is indicative of poor conduct of operations.

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

- Prior incidents involving the packaging and transportation of hazardous materials were not analyzed to identify systemic problems.

Since 1996, OR has reported 12 transportation occurrences involving hazardous materials. The Board determined that neither OR nor LM analyzed the lessons learned from these occurrences to identify trends and systemic problems for management attention.

2.2.3 DOE Oversight

- OR did not carry out its responsibility for approval of a QAPjP for this Project.

ORNL/ER-225, which was approved by OR Environmental Management, requires approval of a QAPjP by an OR Quality Assurance Officer, an OR Project Manager, and an OR Pro-

gram Manager. The OR Program Manager for this Project was not aware of this requirement.

It is the Board's conclusion that had OR carried out its responsibility for quality assurance planning, it may have identified the Project's less than adequate approach to implementation of quality assurance requirements, which contributed to the probable shipping violations.

2.2.4 Training

- Requirements in 49 CFR 172.702(a) state,

  "A hazmat employer shall ensure that each of its hazmat employees is trained in accordance with the requirements prescribed in this subpart."

- Requirements in 49 CFR 172.702(b) state,

  "...a hazmat employee who performs any function subject to the requirements of this subchapter may not perform that function unless instructed in the requirements of this subchapter that apply to that function."

Based on a review of training records and interviews, the Board concluded that no training was provided, in accordance with 49 CFR 172.700-704, for the following hazmat employees who performed packaging, shipping, and transportation functions for the Project:

The CASI Laboratory Analysis Coordinator who ordered packagings and prepared the air waybill for radioactive samples
The Weston Field Manager who transported the radioactive samples
The CDM Federal Geologist who packaged, transported, and offered radioactive samples for transport; it is acknowledged by the Board that this individual had read an outdated version of ESP-505, but the Board did not consider this to be adequate training commensurate with the responsibility for packaging and transporting radioactive samples
The CDM Federal Data Coordinator who packaged and transported radioactive samples

During the Project planning, line managers failed to identify a need for packaging and transportation requirements, even though transportation safety was identified as a critical Project element. The Board concluded that Project managers lacked a general awareness of requirements for packaging and transportation of hazardous material commensurate with their accepted responsibilities.

2.3 Barrier Analysis

As applied to these incidents, a barrier is defined as anything that is used to prevent shipping violations and a control, as anything that is used to reduce the likelihood of shipping violations. A barrier analysis was conducted that identified both barriers and controls associated with these incidents. These barriers and controls either failed or were missing, as summarized in Table 2-2.

2.4 Change Analysis

Characteristics of the actual process implemented by this Project were compared to the characteristics of a process that would have been compliant with the regulations for the transportation of hazardous materials. A change analysis was conducted to determine changes or important differences between these two processes that may have contributed to the incidents. The results of this analysis are presented in Table 2-3.

Table 2-2. ***Barriers That Failed***

	Soil Samples	Object
Barriers	***Regulations (49 CFR)*** Barrier failed because the regulations were not followed, thus the material was not correctly identified, resulting in an improper classification for packaging, shipment preparation, and transportation. Had this barrier been successful, the incidents would not have occurred.	
	Training Barrier failed because Project staff were not trained on the requirements of 49 CFR for the packaging and transportation of hazardous material. Had training been received and applied, the incidents would not have occurred.	
Controls	***Project Planning*** Control failed because project planning did not adequately specify requirements and assign qualified personnel for packaging and transportation.	
	Quality Assurance Control failed because quality requirements, as required by LM procedures, were not developed or implemented.	
	Oversight Control failed because no quality assurance field surveillance was performed during the course of the work.	
	Lessons Learned Control failed because there is not adequate analysis and communication of trends and problems to project managers.	
	Probable Shipping Violations	**Consequence**

Table 2-3. ***Change Analysis***

Planned/Normal	Actual	Analysis
Workers are adequately trained to comply with DOT requirements.	Workers were not trained on DOT requirements for packaging, shipping, and transportation.	Project planning failed to recognize the need for workers to be trained commensurate with their responsibilities to comply with all requirements.
Quality Assurance Project Plan prepared and implemented.	Quality Assurance Project Plan was not prepared.	Important quality assurance commitments never identified.
Quality Assurance and Transportation Safety audits and field surveillance performed.	Surveillance and audits not performed.	Quality Assurance and Transportation Safety audits and field surveillance may have identified that shipping requirements were not being met.
LMTPM group responsible for packaging and shipping of radioactive material.	Responsibility for packaging and shipping of samples delegated to the Project under MOU.	Contractors failed to properly package, ship and transport radioactive materials.
Radiation survey for offsite shipment of radioactive material conducted.	Radiation survey for offsite shipment of radioactive material was not conducted.	The actual radiation dose rate would have required the samples to be packaged and shipped by LMTPM.

2.5 CAUSAL FACTORS

The **direct cause** (i.e., the immediate event or condition that caused the inccidents) of the incidents was improper packaging of radioactive soil samples. **Root causes** are the causal factor(s) that, if corrected, would prevent recurrence of the incidents. **Contributing causes** are other events or conditions that, collectively with other causes, increase the likelihood of an incident but that individually did not cause the incident. An Events and Causal Factors Analysis was used to evaluate the causal factors of these incidents. A summary of this analysis is contained in Table 2-4.

Table 2-4. ***Causal Factors Analysis***

Root Causes	Discussion
Failure to comply with regulations and procedures, specifically 49 CFR, ESP-505 Rev. 1, and the MOU.	Regulations and procedures were documented; however, management failed to ensure they were followed.
Lack of trained, competent personnel commensurate with responsibilities for packaging and transportation.	Personnel performing packaging and transportation functions were not trained on 49 CFR; management failed to ensure that personnel were properly trained.
Contributing Causes	**Discussion**
Failure to identify packaging and transportation as critical functions.	Line management failed to involve subject matter experts in Project planning who could have properly identified the needs and requirements.
Incorrect communication of the radionuclides in the samples for limited quantity determination.	Limited quantity determination was based upon a single nuclide, rather than multiple more restrictive nuclides, resulting in improper packaging.
Failure to assign a properly trained individual to be responsible for packaging and transportation.	Project management failed to define and assign appropriate roles and responsibilities during Project planning, thereby allowing untrained personnel to perform critical packaging and transportation functions. Both the PWP and the SSHSP identified the need for a sample management technician for packaging and transportation of samples. LM and CASI line management failed to fill the position.
Failure to follow the quality assurance requirements.	Line management failed to prepare a QAPjP, as required by ORNL/ER-225. Had the QAPjP been prepared and implemented, the probable shipping violations may have been avoided.
Failure to survey the packages for DOT purposes.	Both DOT regulations for offsite transportation and the ORNL Onsite Transportation Operations Manual require dose rates at the surface of the package to not exceed 0.5 mrem/hr for limited quantity packages.
Failure to perform quality assurance and transportation safety field surveillance and audit.	A field surveillance and audit would have provided opportunities to identify and correct noncompliance with regulations and procedures.
Lessons learned from similar incidents were not considered by the Project.	Analysis of lessons learned is not adequate to raise systemic problems to management's attention.

3.0 CONCLUSIONS AND JUDGMENTS OF NEED

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

Table 3-1. ***Conclusions and Judgments of Need***

Conclusions	Judgments of Need
Regulatory requirements and procedures adequate for packaging and transportation of hazardous materials were referenced in Project documents. The requirements and procedures were not adhered to by the Project.	There is a need for DOE Headquarters' Office of Environmental Management, OR, and LM, to evaluate awareness of the shipping regulations and their importance to DOE commitments to health and safety. There is a need for LM to establish a formal approach for implementing a fast track teaming concept to projects. This approach must clearly assign responsibility for implementing project requirements and procedures.
Inadequately trained personnel were performing functions under 49 CFR.	There is a need for LM to develop and implement a program to ensure their incumbent and future hazmat employees and subcontractor hazmat employees are trained in accordance with 49 CFR.
Project personnel failed to develop and implement quality assurance planning as required by procedures.	There is a need for OR and LM to ensure that project personnel are trained on the requirements of ORNL/ER-225 and to ensure that project managers comply with the requirements of this procedure. There is a need for OR to develop and implement a program for assuring that personnel involved in projects are adequately trained on quality assurance requirements.
Lessons learned were prepared, but not analyzed to identify trends and potential systemic problems for management attention.	There is a need for OR and LM to enhance their lessons learned program by preparing, analyzing, and disseminating trends and potential systemic problems from lessons learned in a useful and usable form. There is also a need for OR and LM to ensure that line management incorporates relevant information into their project planning.

4.0 BOARD SIGNATURES

Date: 3/27/98

Stephen H. McCracken, Chairperson
DOE Accident Investigation Board
U.S. Department of Energy
Oak Ridge Operations Office

Date: 3/27/98

Robert A. Crowley, ~~Member~~
DOE Accident Investigation Board
U.S. Department of Energy
Office of Environment, Safety and Health

Date: 3/27/98

Richard H. Lasky, Member
DOE Accident Investigation Board
U.S. Department of Energy
Office of Environment, Safety and Health

Date: 3/27/98

Donna M. Perez, Member
DOE Accident Investigation Board
U.S. Department of Energy
Oak Ridge Operations Office

Date: 3/27/98

James M. Shuler, Member
DOE Accident Investigation Board
U.S. Department of Energy
Office of Environmental Management

Date: 3/27/98

Dana M. Willaford, Member
DOE Accident Investigation Board
U.S. Department of Energy
Oak Ridge Operations Office

5.0 Board Members, Advisors, and Staff

Chairperson	Stephen H. McCracken, DOE-OR
Member	Robert A. Crowley, DOE-HQ, EH-21
Member	Richard H. Lasky, DOE-HQ, EH-23
Member	Donna M. Perez, DOE-OR
Member	James M. Shuler, DOE-HQ, EM-76
Member	Dana M. Willaford, DOE-OR
Advisor	Dennis L. Vernon, DOE-HQ, EH-21
Analytical Support	Jeffrey S. Oakley, Battelle Columbus
Technical Writer	Michael A. Duffy, Battelle Columbus
Administrative Support	Barbara S. Harshman, DOE-HQ, EH-21 Kimberlee A. Davis, PAI-OR

APPENDIX A

APPOINTMENT MEMORANDUM FOR TYPE B ACCIDENT INVESTIGATION

DOE F 1325.8
(8/89)

United States Government

Department of Energy

Oak Ridge Operations Office

memorandum

DATE: March 12, 1998

REPLY TO
ATTN OF: SE-32:Mullins

SUBJECT: **TYPE B INVESTIGATION - SHIPPING VIOLATIONS INVOLVING THE COREHOLE 8 PROJECT - LOCKHEED MARTIN ENERGY SYSTEMS, INC., OAK RIDGE, TENNESSEE**

TO: Steve McCracken, Site Manager, Weldon Spring Site Remedial Action Project, EM-95

You are hereby appointed Chairman of the Investigation Board to investigate the February 27, 1998, shipment of radioactive material packages as nondeclared hazardous materials. The shipment to the Southwest Research Institute and to two laboratories in Oak Ridge in violation of requirements causes me great concern. I have determined that the incident meets the requirements for a Type B Accident Investigation under DOE Order 225.1A.

You are to perform a Type B investigation of this incident and to prepare an investigation report. The report shall conform to requirements detailed in DOE Order 225.1A and DOE G 225.1A-1, Implementation Guide for Use with DOE 225.1A, Accident Investigations. The scope of the investigation is to include, but is not limited to, identifying all relevant facts, analyzing the facts to determine the direct, contributing, and root causes of the incident, developing conclusions, and determining judgments of need that, when implemented, should prevent the recurrence of the incident. The Board will also focus on management roles and responsibilities, performance of activities utilizing Memorandums of Understanding and subtier contractors, application of lessons learned from similar type accidents within the Department (especially those within Lockheed Martin Energy Systems, Inc. (LMES)), and work planning, practices, and procedures.

If additional resources are required to assist you in completing this task, please let me know and it will be provided. Dennis Vernon, DOE-HQ Office of Security Evaluations, will serve as an advisor to the Board. Ray Miskelley has been appointed to serve as the Board's legal liaison. You and members of the Board are relieved of your other duties until this assignment is completed.

The following employees have been appointed to serve as members of the Board:

Donna Perez, ORO Facility Representative, Member
Dana Willaford, ORO Transportation Safety Engineer, Member
James Shuler, DOE-HQ Office of Transportation, EM-76, Member
Robert Crowley, DOE-HQ Office of ES&H Evaluations, EH-22, Trained Investigator
Richard Lasky, DOE-HQ Office of Oversight, Planning and Analysis, EH-23, Member

The Board will provide my office and Robert Poe, Assistant Manager for Environment, Safety, and Quality, with weekly reports on the status of the investigation and not include any findings or arrive at any premature conclusions until an analysis of all the causal factors have been completed. Draft copies of the factual portion of the investigation report will be submitted to my office and LMES for factual accuracy review prior to the report finalization.

The final investigation report should be provided to me by April 13, 1998. Any delay to this date shall be justified and forwarded to this office. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report.

If you have any questions, please contact me or Robert Poe, Assistant Manager for Environment, Safety, and Quality (576-0891).

James C. Hall
Manager

cc:
Steve Wyatt, M-4, OR
R. W. Poe, SE-30, OR
R. R. Nelson, EW-90, OR
E. G. Cumesty, LM-10, OR
Dr. Alvin Trivelpiece, LMER
Dr. Robert Van Hook, Y-12
David Milan, LMES, 701 Scarboro
Peter N. Brush, EH-1, HQ, 7A-097/FORS
Martha A. Krebs, ER-1, HQ, 7B-058/FORS
James Owendoff, EM-1, HQ, 5A-014/FORS
G. S. Podonsky, EH-4, HQ, C-303/GTN
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W. T. Cooper, EH-24, OR